HERBICIDES FOR NEWLY PLANTED FRUIT TREES

Frank N. Hewetson[1/]

Newly planted fruit trees require adequate moisture and nutrients in order to become well established during their first growing season. Weeds must be controlled around these trees so as not to compete for moisture and nutrients. The use of herbicides is the cheapest method now available to control weeds. However, some herbicides, under certain conditions of soil and moisture may be toxic to fruit trees when used before the trees are well established.

In an attempt to find chemicals which would give good weed control around newly planted fruit trees without injuring the tree, an experiment was designed to evaluate eleven commercial and experimental herbicides, in addition to a black plastic cover, applied around newly planted one year old apple, cherry, peach, pear and plum trees. The varieties were respectively Red Delicious, Montmorency, Elberta, Bartlett and Stanley. The trees were planted April 23rd, 1969 and set 7 feet apart so that a 6' x 6' area could be treated around each tree with an untreated one foot strip between plots. There were three replicates for each treatment. Checks consisted of untreated and hoed plots. Treatments were applied on weed free soil on May 15 and May 23rd, 1969, except for the paraquat treatments Nos. 11 and 12, which were applied on June 19 after weeds had started to appear. The data shown in this report were taken on August 20th, when the trees had completed their growth for the season. The treatments and results are shown in Table I. Figures are the average of the three replicates.

The weed population in the area of this experiment consisted primarily of lambsquarters (Chenopodium album L.), pigweed (Chenopodium paganum L.), ragweed (Ambrosia artemisiifolia L.), Pennsylvania smartweed (Polygonum pennsylvanicum L.), buckhorn (Plantago lanceolate L.), broad-leaved plantain (Plantago major L.), various grasses, plus some forty miscellaneous kinds of broadleaved weeds common in the orchard floor flora of this area.

The best weed control was obtained with the black plastic. However, because of the potential danger of mouse injury during the winter months, this material would have to be taken up each fall and then replaced the following spring, making the cost of this method quite high in comparison to herbicide treatments.

Two herbicides which gave good to fair weed control with no injury to any of the trees in this experiment were VCS 438 and RP 17623. In addition to the good weed control, the trees growing in the VCS 438 treated plots stood out as having greener foliage than the surrounding trees.

1/Professor of Pomology, The Pennsylvania State University Fruit Research Laboratory, Arendtsville, Pennsylvania 17303

Diuron, diphenamid plus DNBP, and the combination of paraquat with simazine gave good weed control with all fruit trees, but caused some injury to the plum trees. As in previous experiments, the paraquat/simazine combination was quite superior to either of the two materials used alone, as indicated by treatments 11 and 15.

Incorporation of dichlobenil-4G (Treatment 4) gave somewhat better weed control than when it was broadcasted without incorporation (Treatment 3), but was still not very effective. Incorporation also caused more injury to the plum than when this material was left on the surface of the soil. Dichlobenil-4G gave slightly better weed control than simazine 4G, but not enough to justify the use of one over the other.

G.S. 13638, linuron and nitralin gave unsatisfactory weed control under the conditions of this experiment.

The results of this experiment indicate the potential value of VCS 438 and RP 17623 for weed control around newly planted fruit trees without causing any visible injury to the trees, and a limited use for diuron, diphenamid plus DNBP, and the paraquat/ simazine combination.

First Year Weed Control

Table I

No.	Treatments Materials	Rates (lbs.) (AI/A)	Fruit Tree Apple	Cherry	Peach	Pear	Plum	All
1	Check-weeds	-	0	0	0	0	0	0
2	Check-hoed	-	4.3#	5.0	8.3	5.0	3.3	5.2
3	Dichlobenil-4G	6.0	0.3	2.3	8.7	4.3	2.0*	3.5
4	Dichlobenil-4G Inc.	6.0	0.3	5.5	6.0	5.7	5.3***	4.6
5	RP 17623	4.0	6.3	6.3	7.0	2.7	8.0	6.1
6	Diuron 80W	2.4	9.0	6.7	7.3	7.3	10.0**	8.1
7	Diphenamid + DNBP	7.0	9.0	4.7	5.7	7.3	8.3**	7.0
8	GS 13638 50W	2.0	0.3	0	3.0	2.7	2.3*	1.7
9	GS 13638 50W	4.0	1.3	1.3	2.0	1.3	4.0	2.0
10	Linuron 50W	1.5	0	1.3	3.7	3.0	4.3*	2.5
11	Paraquat	1.0	0	0	1.0	1.0	0.7*	0.5
12	Paraquat + simazine 80W	1.0 4.0	6.7	5.3	7.0	8.7	6.7**	6.9
13	Nitralin Inc.	4.0	3.3	3.0	3.3	2.0	4.0	3.1
14	Simazine 4G	4.0	0	1.0	1.7	0	5.7**	1.7
15	Simazine 80W	4.0	1.0	1.3	5.7	4.3	7.7**	4.0
16	VCS 438	4.0	8.0	7.3	7.0	4.7	8.0	7.0
17	Black plastic	-	9.0	9.0	9.2	8.5	9.5	9.0

0 = no weed control
10 - complete weed control - bare ground

* = slight foliage injury
** = moderate foliage injury
*** = severe foliage injury

BALSAM FIR GROWTH RESPONSES FOLLOWING HERBICIDE TREATMENTS

T. R. Flanagan and M. L. McCormack 1/

Abstract

Balsam firs were treated with herbicides at the time of both spring and fall outplanting. Growth responses during the seasons following treatment were made by measuring terminal branch growth and the numbers of buds developed.

The plantation site selected was an old unmown hayfield having a fairly moist soil and relatively high organic matter content, as described in an earlier paper (1). The trees used were natural seedlings held for 2 years in a transplant bed.

The herbicides, as follows, were applied directly over the trees a few days following outplanting. All were applied at 8 and 16 pounds active per acre. The atrazine and the amitrole-simazine combination were applied only as a spray. The simazine, bromacil, and dichlobenil treatments were applied both as sprays and as granules.

As an indication of growth responses occurring following treatment, measurements were made of terminal branch growth, the numbers of both internodal and lateral branches developed, and of both internodal buds on the current terminal branch as well as lateral buds on the terminal itself.

Although deer browse damage was severe during the two winters following treatments, sufficient measurements were obtained to allow the following conclusions. Where high rates of several herbicides were used, greater numbers of internodal buds were formed. This was particularly noticeable for simazine. Significantly greater lengths of terminal shoots were noted also for several treatments. This measurement was outstanding where the 8 pound rate of simazine was used in the spring. High rates of atrazine, dichlobenil and the amitrole-simazine combination apparently also stimulated terminal shoot growth.

Literature Cited

1 Flanagan, T.R. and M.L. McCormack. 1967. Herbicidal weed suppression in balsam fir Christmas tree plantations. Proc. NEWCC 21:378-383.

1/ Extension Weed Specialist and Associate Forester, University of Vermont, Burlington.

CONTROL OF SUCKERING IN APPLE TREES WITH HERBICIDAL SPRAYS OF PARAQUAT

Vernon J. Fisher[1/]

Abstract: Paraquat was applied in repeated sprays to apple suckers beginning when suckers were either 6 in. tall or 12 in. tall, to determine if chemical desuckering was feasible as a substitute for mechanical desuckering. Many leaves and succulent terminals were killed, reducing the volume of growth by suckers. However, neither total number of suckers nor additive length of suckers was reduced appreciably.

Stems on a fruit tree other than the main trunk, commonly called suckers, are usually cut at ground level as part of the dormant-season pruning operation. Paraquat, when sprayed directly on succulent plant tissue, is extremely phytocidal (2,3). It is used commercially to kill weeds in apple orchards. Repeated use is generally necessary (1,4), although Langer (3) has pointed out that in successive years fewer treatments may be required.

Research was begun at the University of Delaware in 1969 to determine whether Paraquat could be used to chemically desucker apple trees. It was hoped that a single treatment could be applied to eliminate both suckers and weeds.

Treatments were applied to ten-year-old apple trees that had a history of profuse suckering. The experimental orchard contained the cultivars 'Starkrimson Red Delicious', 'Vance Red Delicious', 'Williams Early Red', 'Golden Delicious', and 'Stayman Winesap'. Rootstocks included seedling, East Malling VII, and Robusta No. 5.

One series of Paraquat [2/] treatments was initiated on May 2, when new sucker growth had reached a height of 6 inches. A second series was initiated on May 12, when sucker growth had reached a height of 12 inches. Sprays were repeated on the schedule shown in Table 1. All sprays were applied with a boom using two 8004 Teejet nozzles spaced 21 inches apart, 25 psi, one pass on each side of the tree, delivering aqueous emulsion at 100 gal./A; except that on July 2 suckers were so tall that a hand gun was required. A standard commercial treatment of Paraquat combined with "Sinbar" terbacil was included for comparison.

1/ Associate Professor, Department of Plant Science, University of Delaware.

2/ Paraquat is a product of Chevron Chemical Company. Cooperation by Chevron is gratefully acknowledged.

Results

Paraquat burned suckers quite severely, as indicated by the data on necrosis in Table 1. However, the number of suckers was not reduced appreciably by Paraquat treatment (Table 2). Thus, even though suckers were burned severely, very few of them died, and the initiation of new suckers was at about the same rate as on check trees. As soon as necrotic leaves dropped, there was a strong tendency for lateral buds to unfold their leaves, rather than remaining latent.

The additive length of suckers was slightly reduced by treatment (Table 2). The 2 lb. rate was not superior to 1 lb. Starting treatment with Paraquat when the suckers were only 6 in. tall was not significantly better than starting when they were 12 in. tall.

Temperatures were seasonably warm following the May treatments. The daily maximum temperatures averaged 77 degrees for the ten consecutive days beginning with May 2, and 75 degrees beginning with May 12. Thus, it appears that temperatures that are high enough to enable Paraquat to have its maximum effect are not likely to occur at the season when apple suckers are small and tender. Some benefit is derived from the burning effect of Paraquat in that sucker growth is rendered less effective in harboring pests and hindering orchard operations. However, the suckers will still need to be removed by dormant-season pruning.

Literature Cited

1. Fisher, V. J. 1968. Efficacy of several herbicides in providing full-season control of weeds in young apple orchards. NEWCC 22: 249-254.

2. Fisher, V. J. and H. C. Price. 1966. Paraquat, a promising supplementary herbicide for peach and apple orchards. NEWCC 20: 181-183.

3. Langer, C. A. 1965. Weeds, grass, and poison ivy control around young and old apple trees. NEWCC 19: 121-126.

4. Lord, W. J. 1966. Further studies with Paraquat for weed control in apple orchards. NEWCC 20:184-187.

Table 1. Degree of necrosis of apple suckers due to spraying with Paraquat at various rates and dates, and in combination with Sinbar.

Lb. ai/A[1]	Treatment Dates[2]	Percent necrosis of suckers on various dates (mean of 3 replicates) 5/8	5/12	5/21	6/2	6/11	6/16	7/8	7/16
1	5/2, 5/15, 6/12	43	60[3]	47	40	33	53	-	43
2	5/2, 5/15, 6/12	53	43	50	33	37	60	-	33
1	5/12, 6/12			53	33	30	47	-	20
2	5/12, 6/12			60[4]	37	20	60[5]	-	47
1[7]	5/1, 7/ 2	20	23	3	0	0	0	80[6]	37

1. Applied in 100 gal. water/A; Ortho X77 Spreader-sticker was added at 8 oz./100 gal.
2. Treatment dates were chosen so that treatments that were initiated when the first suckers were 6 in. tall (on 5/1 to 5/2) could be compared with those initiated when suckers were 12 in. tall (on 5/12).
3. This was the highest degree of necrosis obtained from Paraquat treatments that were made on 5/2.
4. Highest degree of necrosis from treatment on 5/12.
5. Highest degree of necrosis from treatment on 6/12.
6. Highest degree of necrosis from treatment on 7/2.
7. On 5/1 the Paraquat was combined with "Sinbar" terbacil 1 lb. a i/A.

Table 2. Sucker growth following treatment with Paraquat

Lb. ai/A[1]	Treatment Dates[2]	Suckers present on various dates (No./tree, mean of 3 reps.)					Additive length of suckers in 1969
		2/1	5/2	5/12	5/21	7/16	ft./tree
1	5/2, 5/15, 6/12	23	22	27	47	46	29 c[4]
2	5/2, 5/15, 6/12	24	26	33	50	39	110 abc
1	5/12, 6/12	50	68	70	144	151	179 ab
2	5/12, 6/12	35	57	61	92	100	72 bc
1[5]	5/1, 7/2	24	57	51	76	72	132 abc
Check		65	73	77	116	124	215 a
LSD 10%							127

1. Applied in 100 gal. water/A; Ortho X77 Spreader-sticker was added at 8 oz./100 gal.
2. Treatment dates were chosen so that treatments that were initiated when the first suckers were 6 in. tall (on 5/1 to 5/2) could be compared with those initiated when suckers were 12 in tall (on 5/12).
3. These suckers were removed to ground level by pruning in February, 1969.
4. Means followed by a common letter were not significantly different at the 10% level of probability.
5. On 5/1 the Paraquat was combined with "Sinbar" terbacil 1 lb ai/A.

LEAF INJURY AND WEED CONTROL RESULTING FROM HIGH RATES OF HERBICIDES AROUND NEWLY PLANTED FRUIT TREES

Frank N. Hewetson[1]

Herbicides are recommended to be used at definite rates per acre. When the rates used are too low, poor weed control will result; when used too high, weed control may be excellent, but injury to the trees may also result. It is desirable, therefore, to have information on the effects of higher than recommended rates of application. This information would be useful in (1) determining the types of injury associated with each herbicide, and (2) determining the relative hazard involved in using each material at these higher rates.

In order to obtain this information, an experiment was designed to study the effect of commercial herbicides used at X (the recommended rates for established trees), 2X and 4X rates on newly planted apple, cherry, peach, pear and plum trees. The varieties of these fruits were respectively Red Delicious, Montmorency, Elberta, Bartlett and Stanley. Two trees of a kind were planted April 21, 1969 in the same 14" hole, set on opposite sides of the hole so that they were about 12" apart. The pairs were set 3' apart in the row. A plot for each treatment consisted of five pairs of trees, each pair representing one of the five fruits previously mentioned. The plots were separated by a 5' unsprayed strip.

The soil in these plots is Arendtsville gravelly loam, a deep well drained soil well suited to growing fruit trees.

The treatments 2 to 19, as shown in Table I, were applied on May 16th and on May 23rd. The amount of dalapon used in treatments 8 to 10 was dependent on the kind of tree being treated. With the apple and pear, one application of the higher rates was used. With the cherry, peach and plum, which are considered to be susceptible to dalapon injury at the higher rates, the amounts per application of this herbicide were reduced to about a third and applied twice about a month apart. The first application was made at the same time as for the apple and pear, while the second one was made on June 22nd. The paraquat treatments were applied on June 19th and again on August 1st. Check plots were hoed on July 14 and again on August 26th. Pictures and notes of leaf condition were made periodically during the season. The notes included in Table I were made on October 9th.

An examination of Table I indicates that there was no injury to the apple from any of the herbicides and concentrations used in this experiment. The plum, on the other hand, was the most sensitive fruit tree used, and thus served as the best indicator of potential herbicide injury to fruit trees.

There was no injury on the leaves of any of the fruit trees from the use of amitrol-T at all rates. With dalapon, the only injury was on leaves of the plum trees at the 4X rate.

1/Professor of Pomology, The Pennsylvania State University Fruit Research Laboratory, Arendtsville, Pennsylvania 17303

Table I. WEED CONTROL AND LEAF INJURY FROM HIGH RATES OF HERBICIDES

Herbicide No.	Material	Rate (lbs AI/A)	Weed Control#	Leaf Injury Apple	Cherry	Peach	Pear	Plum
1	Check - hoed		7.	none	none	none	none	none
2	Amitrol-T	1.0	0	none	none	none	none	none
3	"	2.0	0	none	none	none	none	none
4	"	4.0	0	none	none	none	none	none
5	Dichlobenil 4G	6.0	4.	none		Slight interveinal chlorosis. Large leaves.	Slight edge yellowing of leaves.	Slight edge yellowing of leaves.
6	"	12.0	8.	none	Interveinal chlorosis & edge yellowing.	Edge burning.	Slight yellowing & edge burning of leaves.	Somewhat severe yellowing & edge burning of leaves.
7	"	24.0	9.5	none	As above, only worse.	Interveinal chlorosis & edge yellowing.	As above, only worse	As above, only worse.
8	Dalapon	8.5*	3.	none			none	
	"	(2x2.55)**			none	none		none
9	"	17.0*	3.	none			none	
	"	(2x5.1)*			none	none		none
10	"	34.0*	4.	none			none	
	"	(2x10.2)**			none	none		Slight marginal burning.
11	Diuron	3.2	9.9	none	none	Leaves large and dark green.	none	none
12	"	6.4	10.	none	Veinal chlorosis.	Slight veinal chlorosis.	none	Slight overall or veinal chlorosis.
13	"	12.8	10.	none	As above	Veinal chlorosis.	none	As above, only worse.
14	Simazine	4.0	9.5	none	none	Slight interveinal chlorosis.	none	Edges of leaves yellow.
15	"	8.0	10.	none	Some yellowing of leaf edges.	As above, plus yellow spotting.	A few leaves with yellow edges.	Leaves have yellow edges & interveinal chlorosis.
16	"	16.0	10.	none	Some lower small leaves with yellow edges. Others large & OK.	As above, but bad on one tree & fairly bad on other.	Slightly worse than above.	As above, only much worse.

(((

Table I con't. WEED CONTROL AND LEAF INJURY FROM HIGH RATES OF HERBICIDES

No.	Herbicide Material	Rate (lbs AI/A)	Weed Control#	Leaf Injury: Apple	Cherry	Peach	Pear	Plum
17	Terbacil	2.4	10.	none	Large green leaves.	Large green leaves.	none	Leaves have yellow edges with spotty interveinal chlorosis.
18	"	4.8	10.	none	Veinal chlorosis on all but terminal leaves, which have yellow tips.	As above	Leaves somewhat small. Some have yellow edges and spots.	As above, only worse.
19	"	9.6	10.	none	One tree dead. Other has a few small leaves left.	Leaves small, spotty yellow.	One tree dead. Other still has a few small leaves burned at edges.	Both trees dead.
20	Paraquat	3.0	8.	none	none	Dark green, large leaves.	none	none

# 0 = no weed control
10 = complete weed control - bare ground

* Amount used for apple and pear.
** Amount used for cherry, peach and plum in two applications. First application with apple and pear; the second application on June 25th.

This marginal burning was not excessive and was found on only a few leaves. It would certainly not reduce tree growth. Weed control in the amitrol-T plots was almost negligible, and in the dalapon plots very slight.

Dichlobenil-4G caused slight injury on peach, pear and plum at the recommended rates, while injury increased in intensity on these trees, as well as on the cherry, when the rates were increased to 2X and 4X. Weed control increased with the increase in rates: the recommended rates gave very little weed control by the end of the season, while the 4X gave almost 100% control. The weed control with 2X was commercially satisfactory.

Diuron produced no foliage injury on all the five kinds of fruit at the recommended rates and gave excellent weed control up to the end of the growing season. At the 2X and 4X rates, while the apple and pear were uninjured, the stone fruits were injured relative to the rates.

Simazine was somewhat similar to diuron in its effect on the trees, but produced some injury to the peach and plum trees at the lowest rates and to all fruit trees except the apple at the 2X and 4X rates.

Terbacil at the recommended rates for established apple and peach trees was safe on all fruits but the plum, where marginal and interveinal chlorosis was apparent. In the cherry and peach, this herbicide even improved leaf size and color. However, when the rates were increased to 2X, cherry, pear and plum leaves were injured, while the apple and peach were quite normal. At the 4X rate, this herbicide was so potent that it defoliated and almost killed the cherry, pear and plum trees and produced small yellow leaves on the peach. In contrast, the apple trees came through the season with no apparent injury. Weed control was 100% at all rates.

The paraquat treatment was somewhat in the nature of a check, but did serve to evaluate this herbicide for all five fruit trees when used twice during the season at 3X or 3 lb AI/A. There was no apparent injury to any of the trees in this treatment and the weed control was good except for horse nettle (*Solanum carolinense* L.), which continued to come back until frozen.

The rainfall in 1969 from May 15 to September 30 was well above the 34 year average especially during the early part of the season, as shown in Table II, so the herbicides were subject to excellent soil moisture conditions.

The results from this experiment, while preliminary in nature, did indicate the extent and type of injury which may result from excess rates of various herbicides when used around different kinds of fruit trees. In general, apple trees were the most resistant to injury from the various herbicides, followed by the pear. The plum, on the other hand, was the most susceptible fruit tree. Cherry and peach trees were, in most cases, intermediate in their reaction to the herbicides.

Table II - RAINFALL (in inches) - Arendtsville, Penn.

May 15 to September 30, 1969

Period	1969	34 year average	Departure from 34 year average
May 15 - 30	2.17	1.98	+ 0.19
June	4.86	3.69	+ 1.17
July	5.14	3.48	+ 1.66
August	1.37	3.89	- 2.52
September	3.90	3.34	+ 0.56
May 15 to Sept. 30	17.44	16.38	+ 1.06

INHIBITION OF ROOT GROWTH OF WOODY ORNAMENTALS AND QUACKGRASS BY DICHLOBENIL

J. R. Havis and W. W. Hamilton[1/]

(Abstract)

Dichlobenil is used for control of quackgrass (Agropyron repens), and is known to restrict plant growth. Our objective was to determine the concentration in the soil that causes effects on roots of woody ornamental plants in relation to the concentration required to prevent growth of quackgrass.

Dichlobenil as the 50% w.p. was thoroughly incorporated at a range of concentrations with a sandy loam soil, and these soil mixes were used for potting bare-root liners of the following: Azalea poukhanensis, Cotoneaster adpressa, Euonymus fortunei, Forsythia intermedia, Ilex crenata convexa, Ilex crenata hetzi, Juniperus horizontalis, Pieris floribunda, Pieris japonica and Taxus media. The above species and pieces of quackgrass rhizomes were grown for 6 weeks and 12 weeks.

Quackgrass did not sprout or produce roots at concentrations of 0.7 ppm and higher. The root growth of all liners was reduced 60% or greater in 1 ppm and from 90 to 100% in 2 ppm. When liners were transplanted from soil with up to 3 ppm into soil free of dichlobenil, roots grew normally. However, the quackgrass rhizomes that did not grow in treated soil failed to sprout when transferred to untreated soil.

[1/] Department of Plant & Soil Sciences, University of Massachusetts, Amherst, Massachusetts.

1969 WEED CONTROL IN GROUND COVERS

Arthur Bing [1/]

Introduction

This report is on a continuation of last year's study on preplant and postplant applications of herbicides to control annual weeds in ground cover plantings. Last year I reported (1) good control of annual weeds with preplant treatments of trifluralin and fair control with preplant treatments of diphenamid and EPTC. (See table 1 for a listing of chemicals.) With the exception of carpet bugle planted in EPTC treated soil, the tolerance of carpet bugle, English ivy, Japanese spurge, myrtle and stonecrop was good to all treatments. Postplant treatments on the same plant species with simazine at 1 or 2 lb, simazine 1 lb plus diphenamid 4 lb or DCPA at 15-20 lb/A were effective and safe. In 1969 the same rates of nitralin and trifluralin were compared as preplant treatments. Also, postplant applications of nitralin, alachlor, trifluralin, and trifluralin plus simazine were compared with last season's more successful treatments for weed control and crop tolerance.

Materials and Methods

The sandy loam soil was rototilled to a depth of 5-6 in on May 16 and preplant treatments were made on May 19. The experimental area was 110 ft x 30 ft divided into 11 30 ft x 10 ft plots. Measured amounts of nitralin dispersible or trifluralin liquid for each plot were mixed with water in 2 qt plastic jugs. Materials were applied with a 1 gal stainless steel, pump type sprayer with a flat spray nozzle. Each plot was sprayed uniformly on the soil surface, after which the whole area was immediately rototilled to a depth of 1½-2 in. Duplicate plots of nitralin at 1 and 4 lb/A and trifluralin at 4 lb/A and single plots of nitralin at 2 lb/A and trifluralin at 1 and 2 lb/A were applied. Two plots received no treatment. Two inches of rain fell on the morning of May 20.

On May 22 and 23 single 110 ft rows of carpet bugle, English ivy, Japanese spurge, myrtle and stonecrop were planted, so that each 30 ft x 10 ft plot contained each kind of test plant. (See table 2 for a listing of the ground covers used.) The carpet bugle, English ivy and myrtle were grown in pots in the greenhouse, the spurge was from "heeled in" rooted cuttings and the stonecrop was from field divisions. The plants were set at 1 ft intervals in rows 3 ft apart. The plots were never irrigated because of more than adequate rainfall during the growing season.

The predominant weeds (see table 3) in the plots were rated on June 12 and July 1. All weeds were removed shortly after July 1. A third rating was made on September 16 to measure weed regrowth. A rating of 1 is for a plot full of weeds, 7 and above is for commercially acceptable weed control and 10 is for a complete absence of weed growth. The ground cover plants were observed during the growing season and rated on November 5.

1/ Professor, Cornell Ornamentals Research Laboratory, Farmingdale, New York

Observations were also made of the plants that received preplant treatments in 1968.

For the postplant treatments, the soil was rototilled to a depth of 5-6 in on May 19. A planting identical to that for the preplant treatments, except for longer rows, was made May 26 and 27. The area was cultivated and hand weeded on June 16 before treatments were started. On June 17 all postplant treatments except nitralin were applied as granulars with the augur type spreader developed by Danielson (2). Nitralin was sprayed over the plants and soil with a 1 gal stainless steel, pump type sprayer. The plots were 4 ft in width across the rows. The treatments are listed in table 5 and chemical names in table 1. Duplicate plots were treated with nitralin, diphenamid plus simazine, simazine, trifluralin and trifluralin plus simazine on June 17. Single treatments of alachlor and DCPA were made on June 26. Diphenamid, nitralin and trifluralin were cultivated into the soil immediately after application, the other treatments were not mechanically incorporated.

After weed control ratings were made on July 1, all larger weeds were removed. These were mostly larger purslane and a few lambsquarters that may have been germinated but not removed before treatments were made. Weed control was rated again on September 16. The ground covers were rated for possible injury on November 5.

Results and Discussion

The growing season was very favorable for crop and weed growth because of the frequent and plentiful rain. Weed control in all the preplant treatments was fairly good, but, as can be seen in table 4, nitralin at 4 lb and trifluralin at 2 and 4 lb/A gave lasting control. A rating of 7 and above is good commercial control. Nitralin probably should be used at the 4 lb rate to get adequate control of lambsquarters, purslane and red root pigweed. The Galinsoga population was very low in the experimental area. Previous experiments (1) showed the preplant herbicides to be rather ineffective against Galinsoga, but highly effective against seedling grasses. The high ratings for weed control on September 16 show that these chemicals can be effective for 4 months.

Observations of the ground cover plants during the growing season showed that except for possible injury to myrtle from trifluralin at 4 lb/A there was no injury from any of the preplant treatments.

In general, the postplant treatments gave good control of all weeds except purslane. The ratings of July 1 and September 16 are in table 5. Lambsquarters was controlled by all the treatments except DCPA at 12.4 lb. The early growth of purslane was not completely controlled probably because the seed germinated before the postplant treatments were applied. Purslane was not controlled by alachlor. Red root pigweed was adequately controlled by all treatments. The grasses, mustards and carpetweed populations were spotty and not a problem in the area. The general weed control ratings show that all treatments had a commercially acceptable rating of 7 and above on September 16.

On November 5 the ground cover plants showed no noticeable damage or reduced growth resulting from the postplant treatments.

Other experiments not discussed in this report did not always show the long lasting control from preplant treatments, so it is advisable that the preplant treatment be followed after 6 weeks by one of the following postplant treatments: DCPA 15-20 lb, diphenamid 4 lb plus simazine 1 lb, nitralin 4 and 6 lb, or trifluralin granular at 2 and 4 lb all active ingredient per acre.

Conclusion

Preplant treatments with 2 or 4 lb/A trifluralin or 4 lb/A nitralin can give effective annual weed control for a growing season with no injury to carpet bugle, English ivy, Japanese spurge, myrtle or stonecrop. Postplant treatments of DCPA 16 and 20 lb/A, diphenamid 4 or 6 lb/A plus 1 lb/A simazine, nitralin 4 or 6 lb/A, trifluralin 6 lb/A, and trifluralin 1.5 lb/A plus simazine 1 lb/A gave effective safe weed control.

Perennial weeds would not be effectively controlled by these treatments. Other herbicides are effective against perennial weeds but the residues in the soil must be removed before planting ground covers.

Literature Cited

(1) Bing, A. 1969. Weed control trials with ground covers. Proc. NEWCC 23:70-75.
(2) Danielson, L. L. 1960. A granular herbicide distributor for small experimental plots. Crops Research, USDA, ARS-34-11. Jan.

Table 1. Herbicides and formulations used on ground covers

Common name	Chemical name	Formulation
alachlor	2-chloro-2,6-diethyl-N- = methoxymethylacetanilide	10% granular
DCPA	dimethyl tetrachloroterephthalate	75% wettable powder 2.5% granular
diphenamid	N,N-dimethyl-2,2-diphenylacetamide	5% granular
nitralin	4-(methylsulfonyl)-2,6-dinitro-N,N-dipropylaniline	4 lb per gal water dispersible
simazine	2-chloro-4,6-bis(ethylamino)-s-triazine	4% granular
trifluralin	a,a,a,-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluide	5% granular
EPTC	S-ethyl dipropylthiocarbamate	5% granular

Table 2. Ground cover plants used

Common name	Scientific name
Carpet bugle	*Ajuga reptans* L.
English ivy	*Hedera helix* L.
Japanese spurge	*Pachysandra terminalis* Michx.
Myrtle	*Vinca minor* L.
Stonecrop	*Sedum album* L.

Table 3. Weeds observed in ground cover plots

Common name	Scientific name
Carpetweed	*Mollugo verticilata* L.
Common lambsquarters	*Chenepodium album* L.
Common purslane	*Portulaca oleracea* L.
Mustard	Various sp.
Red root pigweed	*Amaranthus retroflexus* L.
Small flowered galinsoga	*Galinsoga parviflora* Cav.
Smooth crabgrass	*Digitaria ischaemum* (Schreb.) Muhl.

Table 4. Effect of preplant treatments on weeds in ground covers.

Treatments made May 16, 1969.

Ratings made June 12, July 1, and September 16, 1969.

Treatment	Rate lb/A	Weed control ratings *																	
		Crabgrass			Galinsoga			Lambsquarters			Pigweed			Purslane			General		
		6/12	7/1	9/16	6/12	7/1	9/16	6/12	7/1	9/16	6/12	7/1	9/16	6/12	7/1	9/16	6/12	7/1	9/16
Untreated **		4	3	6	10	10	10	2	2	5	2	3	5	3	2	2	3	1	4
Trifluralin	1	10	10	9	10	10	10	8	3	8	8	10	7	10	10	8	8	3	8
Trifluralin	2	10	10	9	10	10	10	9	10	8	9	10	9	10	5	8	9	7	8
Trifluralin **	4	10	10	9	10	10	9	10	10	9	10	10	10	10	8	9	10	9	9
Nitralin **	1	10	10	9	10	10	10	10	4	6	8	4	5	8	4	4	8	5	5
Nitralin **	2	10	10	10	10	10	10	10	7	5	10	7	3	10	7	4	9	7	4
Nitralin **	4	9	9	9	10	10	9	8	8	9	8	8	8	8	7	9	9	7	8

* 1 = no control, 10 = no weeds

** average of duplicate plots

Table 5. Effect of postplant treatments on annual weeds in ground covers.
Treatments made June 17, 1969.

Treatment	Rate	Weed control ratings * made July 1 and September 16, 1969.									
		Lambs-quarters		Purslane		Red root pigweed		Mustards		Carpetweed	General
		7/1	9/16	7/1	9/16	7/1	9/16	7/1	9/16	7/1	9/16
Alachlor	3.3	8	10	4	6	10	9	10	9	10	7
	6.6	9	10	4	7	8	9	10	9	9	8
DCPA	12.4	4	10	8	8	9	10	10	10	10	8
	16.5	10	10	6	9	8	9	10	9	10	8
	20.7	9	10	8	9	8	10	10	8	10	9
Diphenamid **	4	10	10	6	8	9	9	10	10	10	9
+ simazine	1										
Diphenamid **	6	9	10	7	9	8	9	10	10	10	9
+ simazine	1										
Nitralin **	2	9	9	7	9	9	9	9	8	10	8
	4	9	10	6	9	9	10	10	9	10	9
	6	10	9	8	9	9	10	10	9	10	9
	8	10	10	8	10	10	10	9	9	10	10
Simazine **	2	9	10	6	8	7	9	10	10	10	9
Trifluralin **	1½	9	10	6	9	9	10	10	10	10	10
+ simazine	1										
Trifluralin **	6	10	10	8	9	10	10	10	9	10	9
Untreated **		5	7	1	3	5	8	9	7	8	4

* 1 = no control, 10 = no weeds

** average of duplicate plots

EFFECTS OF CULTIVATION ON SEVERAL HERBICIDES IN NURSERY CROPS

W. J. Bennett and J. R. Havis 1/

Chemical weed control programs for nursery crops have been adopted at an increasing rate over the past few years. Effective herbicides have been developed and tested and nursery operators have shown cost reductions for weed control when compared to mechanical methods. Many operators want to continue some degree of cultivation as an aid in moisture management and because of custom or tradition. The effects of cultivation on several of the standard herbicides used in nurseries has not been clearly determined. Nurserymen are interested in knowing if cultivation can be practiced. One earlier report (1) showed residual weed control following cultivation with certain herbicides. These trials were established to test various cultivation practices on soil treated with several herbicides to determine residual effectiveness. Comparisons of wettable and granular formulations were also made.

Methods

Trials were established in a commercial nursery in Westfield, Mass. on May 22, 1969. A nursery block of canadian hemlock (Tsuga canadensis) established three years was cultivated and hoed to provide weed free conditions prior to herbicide applications. Soil type was a fine sandy loam. Applications were made on plots 10' x 30' across ten rows of plants. Plots were replicated three times. Five cultivation treatments were designed to include six feet of the 30 foot plots for each treatment. The need for cultivation was determined by weed growth in check plots in uncultivated strips which extended across all chemical treatments for a distance of 280 feet. Treatments compared tractor cultivation and rototilling at 2" or 4" depths with each machine.

Weed control ratings were based on 9.0 for perfect control; 7.0 for acceptable commercial control and 1.0 for no control. Herbicide treatments are listed in Table 1.

Evaluations were made six times during the growing season; June 13, July 7, August 13, September 2, and September 17. Cultivation treatments were done on June 17, July 8, and August 18. The August 18 cultivation included hand removal of weeds from the no cultivation treatment due to excessive growth of weeds at that time.

Weeds present during the course of these trials included the following: crabgrass (Digitaria sanguinalis), galinsoga (Galinsoga ciliata), purslane (Portulaca oleracea), carpetweed (Mollugo verticillata), buckhorn plantain (Plantago lanceolata), milkweed (Asclepias syriaca), rough pigweed (Amaranthus retroflexus), sheep sorrel (Rumex acetosella), fleabane (Erigeron annuus), and lamb's quarters (Chenopodium album).

1/ Regional Nursery and Floriculture Specialist, West Springfield, Mass.
Professor of Plant and Soil Science, Amherst, Massachusetts

Table 1. Herbicides and Rates in Cultivation Trials

No.	Chemical	Formulation	Rate (lbs. Aia)
1	Simazine	80% W.P.	2
2	Simazine	4% Gr.	2
3	Diphenamid	50% W.P.	6
4	Diphenamid	5% Gr.	6
5	Trifluralin	2½% Gr.	2
6	Trifluralin	4lb/gal liquid	2
7	DCPA*	75% W.P.	10
8	DCPA	5% Gr.	10
9	Check		

* Trade Name

Cultivation treatments were as follows:

NC = No cultivation
T2" = Tractor cultivator at 2" depth
T4" = Tractor cultivator at 4" depth
R2" = Rototiller at 2" depth
R4" = Rototiller at 4" depth

Results and Discussion

Results of herbicide effectiveness under various cultivation practices are shown in Table 2. The ratings of June 30, taken just prior to the second cultivation, show weed control as affected by the first cultivation; the ratings of July 13 show weed control as affected by two cultivations; and the ratings of September 17 show the effects of three cultivations. When any cultivation treatment or date is compared with no cultivation, it is seen that the first two cultivations were beneficial to all herbicides. The third cultivation does not show marked benefit except for chemicals 1 and 2 (simazine W.P. and granular respectively). Chemicals 1 and 2 showed continued improvement through the third cultivation. The third cultivation did not improve control with any of the other chemicals.

Differences in weed control between tractor cultivation and rototilling were negligible.

The effects of cultivation depth were inconclusive. There were several instances where increased depth increased effectiveness and one instance where increased depth reduced effectiveness.

Differences between wettable powder and granular formulations showed greater variation. Granular simazine, and diphenamid were more effective than wettable powders. Liquid trifluralin and wettable DCPA were more effective than granulars.

* Dacthal (Trade name)

Table 2. Weed Control Ratings as Affected by Cultivation on Various Herbicides in Nursery Stock

Herbicides and	Times of Rating	NC[1]	T2"	T4"	R2"	R4"
1[3]	6/30	7.0[2]	8.0	8.0	7.0	8.0
	7/13	5.0	7.0	7.7	7.0	7.7
	9/17	6.3	7.3	7.3	7.3	7.0
2	6/30	6.0	7.7	7.7	7.3	8.0
	7/13	4.0	7.0	7.0	6.7	8.0
	9/17	6.7	7.7	8.0	8.0	8.0
3	6/30	6.0	7.0	7.0	6.7	8.7
	7/13	3.3	5.7	6.7	6.0	5.7
	9/17	5.7	5.7	4.7	5.7	5.3
4	6/30	6.0	7.0	7.7	6.7	7.7
	7/13	2.3	4.7	6.7	6.7	5.7
	9/17	5.3	5.7	5.7	6.3	6.0
5	6/30	7.0	8.0	8.0	8.7	9.0
	7/13	4.3	7.7	8.0	8.3	8.7
	9/17	6.0	6.7	6.3	6.7	7.3
6	6/30	7.0	8.3	8.3	9.0	9.0
	7/13	5.0	7.0	7.7	8.3	7.7
	9/17	6.0	5.7	6.7	6.7	7.0
7	6/30	4.0	6.0	8.0	8.0	7.7
	7/13	4.7	6.7	6.7	7.7	7.7
	9/17	6.0	6.0	6.3	7.3	7.0
8	6/30	3.0	6.3	7.0	7.7	7.0
	7/13	3.7	5.7	6.0	6.7	6.7
	9/17	5.0	5.7	6.0	6.3	6.0
9	6/30	2.0	5.0	5.7	5.7	6.3
	7/13	1.0	3.7	4.7	5.7	4.7
	9/17	3.7	5.0	5.3	5.3	5.0

1/ Cultivation Treatments - NC = No Cultivation
T2"= Tractor 2" depth
T4"= Tractor 4" depth
R2"= Rototiller 2" depth
R4"= Rototiller 4" depth

2/Ratings - 9.0 = perfect control; 7.0 = acceptable commercial control; 1.0 = no control

3/See Table 1 for herbicide list

Simazine was more effective than any other herbicide used under the conditions of these trials. Trifluralin was the next most effective herbicide although overall ratings were considerably less than simazine. DCPA followed closely behind trifluralin in effectiveness. Diphenamid showed the poorest results of all herbicides.

Cultivation in general improved the effectiveness of all herbicides. In Table 2, column NC, all chemicals except 1 and 2 (simazine WP and granular respectively) gave poor weed control when not cultivated. This might be expected because of heavy rainfall during June and July this year. The wet season probably accounts for the exceptionally poor results with a readily leachable herbicide such as diphenamid wettable powder. Table 2 also shows that all chemicals gave improved weed control when cultivated even under unfavorable weather conditions. A case in point is trifluralin (chemical 5 and 6 in Table 2). By August 13 control was very poor without cultivation. However, any method of cultivation resulted in commercially acceptable control without additional herbicide applications.

Summary

Trials were established in May 1969 to determine the effects of cultivation practices on several standard herbicides used in nursery crops. No differences were found between tractor cultivation and rototilling. Effects of depth of cultivation were inconclusive in that several instances showed increased effectiveness at increased depth and others showed reduced effectiveness at increased depth. Differences between wettable and granular formulations were variable. Granular simazine and diphenamid were both more effective than the wettable formulations. Granular trifluralin and DCPA were less effective than liquid trifluralin or wettable DCPA.

Simazine was the most effective herbicide under all cultivation treatments. Trifluralin followed simazine in effectiveness although the ratings were considerably less overall. DCPA closely followed trifluralin in ratings and diphenamid was the least effective under the conditions of these trials.

In general, cultivation improved the effectiveness of all herbicides.

Literature cited

1. Ahrens, J. F., 1969 Control of established winter annual weeds, dandelion and vetch in taxus. Proc. NEWCC 23: 83-88.

PHYTOTOXICITY OF ZONAL APPLICATIONS OF DICHLOBENIL IN DOUGLAS-FIR

J. F. Ahrens and O. A. Leonard[1]

Dichlobenil (2,6-dichlorobenzonitrile) is used to control annual and perennial weeds in woody ornamental nursery stock, vineyards and orchard crops. In normal practice, dichlobenil is applied on the soil surface or lightly incorporated into the soil of established plantings. When used in this manner, many woody plants tolerate herbicidally effective doses of dichlobenil (1,5). When incorporated into the root zone ahead of planting or when used under soil or rainfall conditions that allow excessive leaching to root zones, however, dichlobenil affects root growth and injures some species (2,3,6,7). Field experiments and reports from growers indicate that newly-planted seedlings of pines, spruces and douglas-fir are especially sensitive to injury (4).

Field observations of treated conifers have indicated that dichlobenil possibly causes injury to stem tissue at or just below the soil line as well as to roots. In seedling conifers, this portion of the plant derives from hypocotyl tissue which we will refer to as the transition zone. The purpose of this work was to determine the concentrations of dichlobenil required to injure seedlings of Douglas-fir when localized in the soil around the transition or root zones.

Materials and Methods

Graded two-year-old seedlings of Douglas-fir /Pseudotsuga menziesii (Mirb) Franco/ were planted into gallon containers of steam-sterilized Yolo fine sandy loam. Metal food cans 3¼ in. in diameter and 1½ in deep were used to position applications of dichlobenil in soil around the transition or root zones of the seedlings, in the manner shown in Figure 1. Samples of steam-sterilized Yolo fine sandy loam soil weighing 200 grams (dry weight equivalent), packed into these cans, provided a zone of soil about 1¼ in thick. The tops of the cans were removed and 1¾ in holes were punched into the bottoms. Treated or untreated soil was then added to the cans during planting.

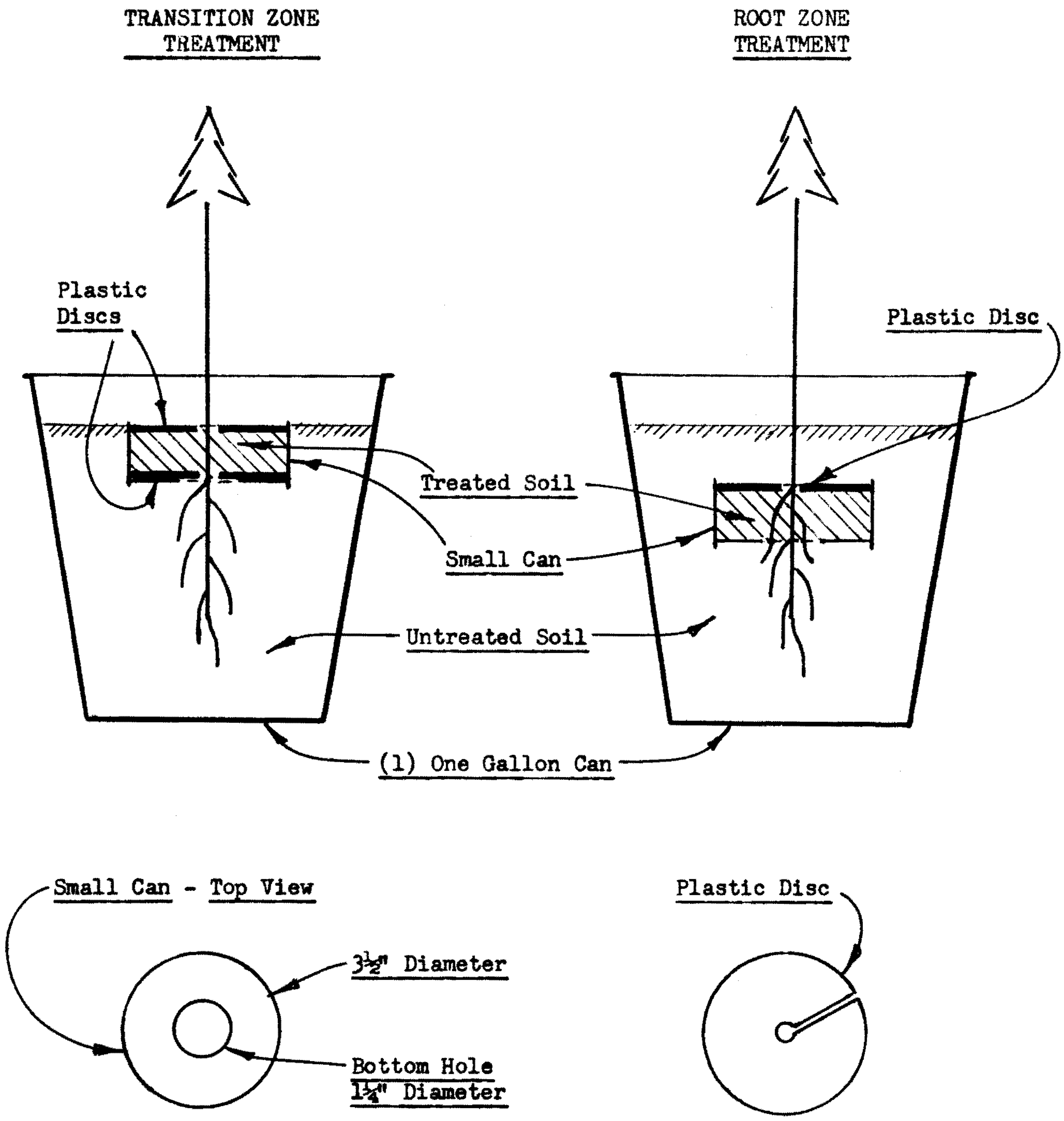
In preparing the treated soil, granular dichlobenil was ground with a mortar and pestle and added to the 200 gram soil samples to obtain concentrations of 2,4,8,16,32 or 64 ppm. The samples were then mixed by thorough shaking in 4x6x12 in polyethylene bags for 2 minutes. All treatments were replicated four times.

Treatments in the transition zone were placed so that the treated soil layer would be just above the uppermost lateral root of the seedling. Treatments in the root zone were placed so that the treated soil layer would include the uppermost lateral root and a layer beneath it. To minimize

---

[1] Associate Plant Physiologist, The Connecticut Agricultural Experiment Station, Windsor and Botanist, University of California, Davis.

Figure 1. Method of applying zonal treatments of dichlobenil around seedlings



herbicide volatility and movement from the treated zones, slitted polyethylene discs were cut to fit the small cans and placed above and below the treated soil zones as shown in Figure 1. Three sets of controls included untreated soil in the two zones, also placed in the small cans and untreated soil throughout the large container.

The seedlings were planted on April 9, 1969 and held under cover and partial shade outdoors in Davis, California. They were watered, according to need, on the edges of the large containers, to minimize leaching of dichlobenil from the small cans. However, the soil in the small cans was kept moist at all times.

On June 24, 1969, 11 weeks after planting, the new growth was cut off and weighed and the seedlings were carefully broken out of the containers. Injury in the upper stem, transition zone and root zone was evaluated by lightly scraping the bark with a razor blade to determine whether the cambium tissue was browned.

Results and Discussion

Within 6 weeks of planting, wilting of new growth and some mortality was observed in the plants treated with the higher levels of dichlobenil. After 11 weeks it was apparent that all dichlobenil treatments were causing some wilting and mortality. The fresh weights of new growth and the numbers of plants with wilted or browned foliage in Table 1 reflect this injury, which increased with increasing dosages.

Observations of browning of the cambium told us where injury occurred from the dichlobenil treatments. Among the twelve control plants, browning was observed in a portion of the main root in only one and no browning of cambial tissue was observed in the transition zone of any plant. Even at the lowest concentrations of dichlobenil, however, browning was observed in every plant in the zone that was treated. Among the eight plants treated in the transition zone at 4 or 8 ppm of dichlobenil, three plants showed browning only in the treated area. The other five showed browning of cambial tissue in roots or upper stems as well as in the transition zone.

Similarly, among the four plants treated with dichlobenil at 2 ppm in the root zone, three plants showed browning only in the root zone. With time, however, the plant slowly dies from apparent destruction of the cambial tissue, and browning advances up or down from the treated zone. The data clearly show that dichlobenil injured tissue both in the root and the transition zones of Douglas-fir.

Lest the concentrations of dichlobenil selected in the experiment be considered too high, let us calculate the potential concentrations of normal applications in the field. Normal rates of dichlobenil range from 4 to 8 lb/A. Assuming approximately one million pounds of soil per acre 3 in deep, and no herbicide loss, this is equivalent to 4 to 8 lb/A 3 in deep or 9½ to 19 lb/A 1¼ in deep.

Table 1. Effect of dichlobenil applied in the transition zone or root zone of Douglas-fir.

Zone of treatment[1]	Concentration of dichlobenil ppm	Fresh weight of new growth grams[2]	No. of plants with browned or wilted foliage[2]	No. of plants in which browning of cambium was observed[2]		
				Upper stem	Transition zone	Root
None	0	14.1	0	0	0	1
Trans.	4	8.4	3	1	4	2
Trans.	8	4.4	3	2	4	3
Trans.	16	2.5	4	4	4	4
Trans.	32	1.4	4	4	4	3
Trans.	64	0.1	4	4	4	4
Root	2	9.0	2	1	1	4
Root	4	2.5	4	1	2	4
Root	8	0.8	4	4	4	4
Root	16	1.4	4	2	2	4

[1]Trans.- Transition zone - a zone of 1¼ in thickness above uppermost lateral root.
Root - Root zone - a zone of 1¼ in thickness below and including the uppermost lateral root.

[2]Four plants received each dichlobenil treatment. Three sets of controls were averaged to obtain the fresh weight per four control plants.

- -

In the case of Douglas-fir seedlings, therefore, it seems quite possible that injury could occur in the field from soil surface applications of dichlobenil, without leaching of the herbicide to root zones, especially when the surface soil is frequently wet during the growing season. However, these observations should be verified in further experiments with Douglas-fir, other conifers and deciduous woody plants. From other observations and reports of work with dichlobenil in other species, it does not seem likely that acute injury from dichlobenil on stem tissue at or just below the soil line occurs in all species or plant ages (6). Maturity of the bark and soil conditions could well be important factors in its occurrence.

Summary

Dichlobenil was applied in soil layers around seedlings of Douglas-fir grown in Yolo fine sandy loam in containers. Applications of dichlobenil either in the root zone or in the transition zone of the main stem caused browning of cambial tissue, wilting and mortality. Browning of cambial tissue occurred first in the plant part surrounded by dichlobenil-treated soil.

Literature Cited

1. Ahrens, J. F. 1966. Chemical control of weeds in deciduous shrubs. Proc. NEWCC 20:209-213.

2. Ahrens, J. F. 1966. Trials with dichlobenil and diphenamid for controlling weeds in container-grown nursery stock. Proc. NEWCC 20:232-236.

3. Ahrens, J. F. 1967. Improving herbicide selectivity in transplanted crops with root dips of activated carbon. Proc. NEWCC 21:64-70.

4. Ahrens, J. F., T. R. Flanagan and M. L. MacCormack, Jr. 1969. Chemical control of weeds in Christmas tree plantings. Conn. Agr. Exp. Sta. Bull. 700. 27 pp.

5. Bingham, S. W. 1968. Influence of herbicides on Japanese holly and hand labor for weed control. Weed Sci. 16:478-481.

6. Bingham, S. W. and J. R. Jones. 1967. Phytotoxicity of certain herbicides to several woody ornamentals. Proc. Amer. Soc. Hort. Sci. 91:786-791.

7. Leonard, O. A., L. A. Lider and A. H. Lange. 1964. Toxicity of several herbicides to grape rootings applied to the roots and to the shoots. Am. Jour. Enol. Vitic. 15:206-213.

POSTEMERGENCE CONTROL OF YELLOW NUTSEDGE WITH SOME S-TRIAZINE HERBICIDES ALONE AND WITH SEVERAL EXPERIMENTAL SURFACTANTS

L. F. Hist and R. D. Ilnicki[1/]

Abstract

A study was conducted on an established stand of nutsedge (Cyperus esculentus) at the Adelphia Research Center of the New Jersey Agricultural Experiment Station. Applications of 2-(4-chloro-6-ethylamino-s-triazin-2-ylamino)-2-methylpropionitrile (SD 15418), 2-chloro-4-hydroxymethylamino-6-isopropylamino-s-triazine (ACD 15M), 2-chloro-4-cyclopropylamino-6-isopropyl-s-triazine (S 6115), and 2-chloro-4-ethylamino-6-isopropylamino-s-triazine (atrazine) were made at 1½ and 3 lb/A on August 1 when nutsedge was 7-12 in tall and had 3-9 leaves. Other weeds in the experimental area included fall panicum (Panicum dichotomiflorum), which was 5-10 in tall, and redroot pigweed (Amaranthus retroflexus), which was 4-6 in tall. These herbicide treatments were made in 40 GPA, alone and in combination with several experimental adjuvants.

The surfactants and rates of application included the following: AL 411A at 1 qt/A; AL 830 at 1 qt/A; #7 Oil at 2 GPA; and mixtures of #11 Oil with linseed oil, safflower oil, cottonseed oil, and soybean oil all at 2 qt/A.

Control of nutsedge and fall panicum with SD 15418 at 3 lb/A alone or with adjuvants was excellent. There was no effect on pigweed with this treatment when applied alone and only slight increases in control where the adjuvants containing linseed oil, safflower oil, cottonseed oil, and soybean oil were used. Significant control of the three weed species was not obtained with ACD 15M at either rate alone or when in combination with any of the surfactants.

Best control of nutsedge and pigweed was obtained with S 6115 either with or without adjuvants; however, fall panicum control was greatly enhanced by the addition of the adjuvant containing cottonseed oil.

Atrazine effectively controlled pigweed when applied alone or with the adjuvants. This herbicide at 3 lb/A failed to give significant nutsedge or fall panicum control, alone, or with any of the adjuvants.

Further work is planned for the future using these same herbicides and additional spray adjuvants.

1/ Senior Laboratory Technician and Research Professor in Weed Science, respectively, Department of Soils and Crops, Rutgers University, New Brunswick, New Jersey.

ENHANCING ATRAZINE ACTIVITY WITH ADDITIONS OF MINERAL AND VEGETABLE OILS

L. A. Almodovar and R. D. Ilnicki[1/]

Abstract

Annual grasses often present a problem in corn culture. They invade corn fields in midsummer, usually after preemergence herbicides are no longer effective or because of failure to control them initially with preemergence herbicides.

It is well known that 2-chloro-4-ethylamino-6-isopropylamino-1,3,5-triazine (atrazine) is a safe herbicide to use in corn when applied either as a preemergence or postemergence spray. Failure to successfully control grasses from postemergence sprays has offered a challenge to research workers to increase its effectiveness by use of spray adjuvants, either surfactants or oils.

It is also known that postemergence activity of atrazine can be increased by mineral oils in the spray in volumes of 1 to 2 gallons per acre. Little information is known of the effect vegetable oils have on atrazine activity on such grassy weed species as crabgrass (*Digitaria sanguinalis*) and yellow foxtail (*Setaria glauca*).

Two paraffinic oils were included in these studies. One was of low (#7) and one was of medium (#11) viscosity. Included in the vegetable oils were oils from rape, peanut, sunflower, linseed, safflower, cotton, soybean, and corn.

A series of greenhouse experiments conducted during 1969 considered: (a) different spray volumes; (b) various rates of atrazine; and (c) atrazine in combination with different rates of mineral or vegetable oils. Crabgrass and yellow foxtail were used as test species, usually sprayed at the two-leaf stage of growth.

The weeds were sprayed with an endless belt sprayer calibrated to deliver the required amount of herbicide and herbicide mixtures, usually during the first week after weed emergence.

[1/] Research Assistant and Research Professor in Weed Science, respectively, Department of Soils and Crops, Rutgers University, New Brunswick, New Jersey.

Results from the different experiments showed the following: In all experiments atrazine without oils did not kill crabgrass. The green color of the grasses was intensified by atrazine, as has been observed in other plants. Oils alone did not kill the grassy weeds, although in some instances some yellowing occurred. Since no fertilizer was applied to the soil it was difficult to ascertain exactly the yellowing caused by the oils. Yellow foxtail was more susceptible to atrazine with oils, especially with #11 Oil. Atrazine alone at $1\frac{1}{2}$ lb/A also effected good control. The three different spray volumes of 10, 20, and 40 GPA generally effected the same degree of weed control, perhaps the 10 GPA being more effective than the other two spray volumes.

Field corn (Zea mays var. N.J. No.9) was not affected by any of the herbicide treatments and combinations. Two experimental surfactants, AL 209 and AL 411A, were also evaluated at 1% v/v with atrazine at 3/4 lb/A. These effected poor control, however, when used with atrazine at $1\frac{1}{2}$ lb/A fair control of crabgrass was produced. At concentrations of $\frac{1}{2}$ or 2% v/v the control was less effective than at 1% v/v.

Safflower oil produced very good grass control at $\frac{1}{4}$, $\frac{1}{2}$, or 1 GPA in combination with atrazine at 3/4 lb/A. Linseed and cottonseed oils produced excellent control at $\frac{1}{2}$ GPA plus 3/4 lb atrazine. Soybean was the least effective of the group, although it produced fair control of crabgrass at the three rates used. All these oils produced excellent grass control when combined with $1\frac{1}{2}$ lb/A of atrazine. Rape effected very good control of crabgrass and yellow foxtail at the three rates evaluated in combination with 3/4 lb atrazine. Peanut oil produced very good control at $\frac{1}{2}$ and 1 GPA but was less effective at $\frac{1}{4}$ GPA. Corn and sunflower oils produced very good control at all rates evaluated. These oils were much more effective when the higher rate of atrazine was used.

In still another experiment in which all oils were evaluated at the same time using $\frac{1}{2}$ GPA of vegetable oils and $\frac{1}{2}$ and 1 GPA of mineral oils, sunflower and soybean were not effective in combination with 3/4 lb/A of atrazine, but gave good control with $1\frac{1}{2}$ lb/A atrazine.

When the spray applications were delayed one week, poor weed control resulted in nearly all instances; atrazine at $1\frac{1}{2}$ lb/A with rape oil gave good control. Linseed, #7 and #11 oils at 1 GPA gave fair control.

SYNERGISTIC RESPONSES TO ATRAZINE IN COMBINATION WITH OTHER HERBICIDES -- A PRELIMINARY REPORT[1,2]

M. R. Lynch, R. D. Sweet[3] and C. T. Dickerson, Jr.[4]

INTRODUCTION

There are many reports on the post-emergence use of atrazine (2-chloro-4-ethylamino-6-isopropylamino-1,3,5-triazine) in combination with non-phytotoxic oils (3, 5, 6, 9, 10, 11). In general, good control of annual broadleaves and grasses at rates as low as 0.5 lb. of atrazine was reported, provided the treatments were applied at the early seedling stage of weed growth and very poor control, particularly of grasses, when treatments were applied at later stages of weed growth.

More recent research (1, 6, 7) indicated that addition of as little as 3 ounces of 2,4-D (2,4-dichloroplenoxyacetic acid) to the atrazine-oil combination, greatly enhanced the activity of the mixture, particularly on annual grasses. Dickerson and Sweet (7) reported that 1 lb. of atrazine when combined with 3 ounces of 2,4-D and 1 gallon of oil was 14 times as effective as 4 lbs. of atrazine alone and almost twice as effective as 4 lbs. plus oil, for the post-emergence control of nutsedge (*Cyperus esculentus*). These results certainly indicate a response very much more than "additive" and undoubtedly could be termed "synergistic".

The term "synergism" as it applies to biological systems has not, to date, been defined with sufficient clarity to be widely accepted by scientists, although some contributions have been made (2, 8, 12). When more than one herbicide is applied to plants, the activity of the chemicals may be synergistic, neutral or antagonistic. Plant responses, obviously, depend not only on which chemicals have been added, but also on which plant species are involved. Furthermore, the entire response complex is greatly influenced by a myriad of modifying factors such as dosage, formulation, placement, temperature, moisture, age of plant, etc. The appreciation of these many modifying factors has been the basis for the reluctance of most herbicide research workers to classify particular plant responses to herbicides as synergistic, neutral or antagonistic. For the purposes of this paper the term "synergism" will be used to indicate a response in excess of that expected from an additive effect of the several chemicals used **separately** under the same conditions.

1/ Paper No. 598 of the Department of Vegetable Crops, Cornell University, Ithaca, New York.
2/ This work was partially supported by a grant-in-aid from Geigy, Monsanto and Shell Chemical Company.
3/ Research Assistant and Professor, respectively.
4/ Present address: Monsanto Company, 2200 Hamilton Street, Allentown, Pennsylvania.

The objective of the work reported here was to investigate the plant responses on application of combinations of a number of herbicides with oil and atrazine, to determine which were "synergistic", "neutral" or "antagonistic". A long term objective is to determine some of the chemical and physiological reasons for the three types of interaction of herbicides in plants and to contribute to the mathematical definition of these responses.

EXPERIMENTAL

Since the research reported herein was of the systematic screening type and the number of treatments were very extensive, no attempt is made to report all the results in detail. Rather, treatments were selected to indicate the combinations that gave a "synergistic" response of potential value for selective weed control in sweet corn (*Zea mays* var. *rugosa*).

General Methods

During 1968 and 1969 four field experiments were conducted near Ithaca, New York. One greenhouse experiment was also conducted in 1968. As a means of eliminating the many complicating and confounding soil influences, all treatments were applied post emergence. In all five experiments the sweet corn variety Gold Cup was used. In addition, beans (*Phaseolus vulgaris*) variety Tendercrop and Japanese millet (*Echinochloa crusgalli*, var. *frumentacea*) were sown in each experiment to give an indication of weed control attained. The chemicals used, their formulations and rates of application are indicated for each experiment in Table 1.

Results

Experiments 1 and 2 indicated that combinations of atrazine and oil with 2,4-D, daxtron, nitralin, trifluralin, or diphenamid gave greatly increased weed control as compared to the atrazine oil combination, with no visual effect on sweet corn growth at the lowest rates used.

The greenhouse experiment (No. 5) was than conducted to compare all possible combinations of the chemicals used in the previous experiments in combinations of 1, 2 or 3 chemicals. Linuron and DNBP were also included in this experiment. Plants were seeded and grown in small styrofoam trays containing a loam-sand-peat potting compost. This experiment confirmed the results of the previous experiment, however, some sweet corn injury resulted in all treatments where linuron (1/4 lb/A) was applied. In addition to the combinations of promise indicated by experiments 1 and 2, this greenhouse experiment showed that the following combinations were also worthy of further study: daxtron + nitralin; daxtron + linuron; trifluralin + diphenamid; and trifluralin and linuron.

Table 1. Chemicals applied, their formulations and rates of application.

Chemical	Formulation	Rate of Application expt. 1	expt. 2	expt. 3	expt. 4	expt. 5[2/]
Atrazine	80 w.p.	0 to 1/2[1/]	1/2	1/4	1/4	1/4
Oil	11 N + 1% Triton	0 to 2 gal[1/]	1-1/2 gal.	1 gal.	1 gal.	1-1/2 gal.
2,4-D	4 lb/gal (amine)	1 to 1/16*	1 to 1/16*	1/16	1/16	1/16
Daxtron	1-1/2 lb sol. liq	1 to 1/16*	1/2 to 1/32*	1/32	1/32	1/16
dalapon	85% sol. liq.	4 to 1/4*	1 to 1/16*	--	--	--
nitralin	75 w.p.	1 to 1/16*	1/2 to 1/32*	1/8	1/16	1/8
trifluralin	4 e.c.	1 to 1/16*	1/2 to 1/32*	1/8	1/8	1/8
diphenamid	50 w.p.	1 to 1/16*	1/2 to 1/32*	1/8	1/8	1/8
Ramrod	65 w.p.	4 to 1/4*	4 to 1/4*	--	--	1/2
linuron	50 w.p.	--	1/2 to 1/32*	1/8	1/16	1/4
DNBP	3 lb H_2O sol.	--	1 to 1/16*	--	--	1/8
CIPC	4 e.c.	--	1 to 1/16*	--	--	--
Lasso	4 e.c.	--	--	1/2	1/4	--

1/ An error in applying the chemical resulted in rate curves with the limits indicated, instead of a constant rate.
2/ Greenhouse experiment.
* Chemical was applied to give a logarithmic rate curve with the limits indicated.

Table 2. Effect of herbicide combinations on fresh weight (ounces) of beans.[1/]

Herbicide Treatment	Rate of Application	Alone	With Oil 1 gal.	With Atrazine 1/4 lb.	With Atrazine and Oil
control		64	53	33	19
Daxtron	1/2 oz.	57	52	32	1
Lasso	4 oz.	73	77	16	5
diphenamid	2 oz.	73	83	39	5
nitralin	1 oz.	63	53	26	4
2,4-D	1 oz.	65	60	17	2
trifluralin	2 oz.	59	64	27	12
nitralin and Daxtron	1 + 1/2 oz.	63	57	14	1
diphenamid and trifluralin	2 + 2 oz.	55	63	24	9

LSD .05 for comparison of means across colums = 9 oz.

1/ Data represents total fresh weight of 10 plants/plot, average of 3 replications.

In experiments 3 and 4, the herbicide Lasso was also included. Results of experiment 4 in terms of fresh weight of beans are presented in Table 2. Response of Japanese millet closely parallelled that of beans. There was no difference in fresh weight of sweet corn in any of the treatments in Table 2. However, in both experiments linuron at 1/16 lb/A **consistently** gave some sweet corn injury when combined with atrazine and oil. The results of experiment 3 closely parallelled those of experiment 4.

All herbicide combinations where atrazine and oil were included were essentially weed free at the time data was collected, 4 weeks after chemical application. The reduction in bean fresh weight achieved, together with general weed control, with all these herbicides when combined with one gallon of oil and 1/4 lb. of atrazine was remarkable, particularly in the light of the very low rates used. Atrazine plus oil gave a 3.4 fold reduction in bean fresh weights. Addition of 0.5 oz./A of daxtron to the mixture resulted in a 60 fold reduction in fresh weight of beans. Addition of one ounce of 2,4-D to the atrazine oil combination gave a 30 fold reduction in the weight of beans. Similarly, addition of nitralin gave a 16 fold reduction, addition of lasso or diphenamid a 13 fold reduction and addition of trifluralin a 5 fold reduction in fresh weight of beans. These increases in activity are very striking especially since all these herbicides, at the low rates used, had no effect on the fresh weight of beans when applied alone.

DISCUSSION AND SUMMARY

Previous work (7) indicated that addition of 3 ounces of 2,4-D and 1 gallon of non-phytotoxic oil to atrazine at rates of 1/2 lb/A greatly enhanced weed control as compared to atrazine alone when applied early post-emergence.

Similarly, effective weed control seemed to be feasible with even lower rates of a number of other herbicides when combined with 1/4 lb/A of atrazine and one gallon of non-phytotoxic oil. Such combinations were found to be from 2 to 19 times as effective in reducing the fresh weight of beans as atrazine and oil alone. Extensive research will be required to determine at what point the responses observed were in fact synergistic. Such experiments should be designed to shed some light on the type of synergism involved.

The type of response to a herbicide or combination of herbicides is a function of their individual modes of action and interactions between them as well as a host of modifying factors such as timing, dosage, etc. Two basic types of synergistic interactions are recognizable, complementary and dissimilar. Complementary synergism occurs when two compounds act through their effects on different aspects of the same process, or on different but closely related processes. Dissimilar synergism occurs when two compounds act through their effects on different but not closely related processes. It should be recognized that gradations between these basic types and combinations of them are likely to occur with any particular herbicide combination. In addition, interactions due to the surfactants and other "inert" ingredients of one herbicide with all the components of the other herbicides in the combination must be considered. Frequently a combination of herbicides gives a response that can be termed an additive effect. This occurs when two herbicides, frequently closely related structurally, act through their effect on exactly the same part of the same process.

Studies involving the kinetics of the plant response to the application of herbicide combinations should provide further valuable information concerning the type of synergism involved.

The preliminary research reported indicated that many of the combinations resulting in greatly enhanced weed control, do so without loss of sweet corn selectivity. Further work, involving a selection of varieties, grown to maturity, needs to be conducted to verify this observation.

The increase in weed control observed when low rates of atrazine are combined with 1 gallon of non-phytotoxic oil and very low rates of a number of herbicides calls for continued research, to capitalize on synergism for increasing the extent and spectrum of weed control and for reducing soil residue levels. In addition, these observations warrant intensive basic studies to determine the reasons for synergism.

LITERATURE CITED

1. Bayer, G. H. 1966. 1965 Weed Control in Field Corn. Proc. NEWCC 20: 261-266.

2. Colby, S. R. and R. W. Feeney. 1967. Herbicidal Interactions of Potassium Azide with Calcium Cyanamid. Weeds 15(2): 163-167.

3. Cole, R. H. and W. L. Currey. 1966. Comparisons of Atrazine, Atrazine-Surfactant and Atrazine-Oil Mixtures. Proc. NEWCC 20: 297-300.

4. Dearborn, C. H., R. D. Sweet and J. R. Havis. 1968. Weeding Sweet Corn with 2,4-D: Effects of Timing, Rates and Varieties. Proc. Amer. Hort. Sci. 51: 536-540.

5. Dexter, A. G., O. C. Buenside and T. L. Lavy. 1966. Factors Influencing the Phytotoxicity of Foliar Applications of Atrazine. Weeds 14(3): 222-228.

6. Dickerson, Jr. C. T. and R. D. Sweet. 1967. Atrazine and Oil for Post-Emergence Weed Control. Proc. NEWCC 21: 106-113.

7. __________ and __________. 1968. Atrazine, Oil and 2,4-D for Post-Emergence Weed Control. Proc. NEWCC 22: 64-75.

8. Gowing, D. P. 1960. Comments on Tests of Herbicide Mixtures. Weeds 8: 379-391.

9. Jones, G. E. and G. H. Anderson. 1964. Atrazine as a Foliar Application in an Oil Water Emulsion. Proc. NEWCC 20: 27-29.

10. Liu, L. C., R. D. Ilnicki, J. B. Regan, and E. J. Visinski. 1966. Naphthenic and paraffinic Oils as Adjuvants in Atrazine and Linuron Sprays for Weed Control in Corn. Proc. NEWCC 20: 309-316.

11. Peters, R. A. 1966. Crabgrass Control in Corn -- 1965. Proc. NEWCC 20: 277-281.

12. Tammes, P. M. L. 1964. Isoboles, a Graphic Representation of Synergism in Pesticides. Neth. J. Plant. Path. 70: 73-80.

WEED CONTROL IN FIELD CORN WITH SELECTED PREEMERGENCE AND POSTEMERGENCE HERBICIDES[1/]

William B. Duke and Barry J. Brecke[2/]

ABSTRACT

Field experiments were conducted for two years at various locations in New York to evaluate the response of corn (Zea mays L.) and annual and perennial weeds to soil and/or foliar applications of selected herbicides such as: 2,6-diethyl-N-(methoxymethyl)acetanilide (alachlor), 2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine (atrazine), 2,4-bis(isopropy-lamino)-6-(methylthio)-s-triazine (propazine), 2-(4-chloro-6-ethylamino-s-triazine-2-ylamino)-2-methylpropionitrile (SD 15418), 2-chloro-N-(isopropoxymethyl)-2',6'-acetoxylidide (CP 52665), 2-chloro-2',6'-diethyl-N-(butoxymethyl)acetanilide (CP 53619), 2-(2,4-dichlorophenyl)-1-methoxy-1-methylurea (linuron), 2-(4-bromo-3-chlorophenyl)-1-methoxy-1-methylurea (CP 6313), 2,6-dichloro-O-anistic acid (dicamba), BAS 2903-H (structure undisclosed) and several combinations of these materials.

Primary weeds included in these studies were witchgrass (Panicum capillare L.), yellow foxtail (Seteria glauca (L) Beauv.), green foxtail (Seteria virides (L.) Beauv.), fall panicum (Panicum dichtomiflorum Michx.), redroot pigweed (Amaranthus retroflexus L.), common ragweed (Ambrosia artemisiifolia L.), and at one location in 1969, yellow nutsedge (Cyperus esculentus L.). Combinations of atrazine with alachlor or BAS 2903-H were most effective for control of all annual grasses and broadleaves followed in order of effectiveness by alachlor + linuron, atrazine + linuron, atrazine + prometryne and SD 15418 + atrazine. Distinct advantages for combining herbicides were obvious. For example, plots receiving atrazine alone, were usually infested with grasses while plots treated with alachlor or BAS 2903-H had high levels of broadleaf weeds. SD 15418 was found to have good grass and broadleaf activity, with the notable exception of redroot pigweed, and not residual activity on succeeding oats or alfalfa. C-6313 was shown to be slightly injurious to corn.

Combinations of butylate and atrazine gave adequate nutsedge activity. Alachlor plus atrazine gave early season nutsedge control but gave out after 8 weeks. A split application of atrazine preemergence followed by atrazine post-emergence was one of the better treatments. CP 53619 was very active on both nutsedge and corn.

Postemergence applications of alachlor plus atrazine and non-phytotoxic oil were not effective unless treatments were made when weeds were less than

1/ Contribution from the Department of Agronomy, New York State College of Agriculture, Cornell University, Ithaca, New York.

2/ Assistant Professor and Research Assistant, respectively, Department of Agronomy, Cornell University, Ithaca, New York.

two inches tall. Corn injury was noticed for a short period, about four days, following applications of this combination. Dalapon and atrazine definitely injured corn. Advantage was seen for combining 2,4-D or dicamba with atrazine postemergence, but crop tolerance was lowered.

COMBINATIONS OF ALACHLOR AND PROPACHLOR WITH ATRAZINE OR LINURON FOR WEED CONTROL IN CORN

L. F. Hist and R. D. Ilnicki[1/]

Abstract

There are a number of effective herbicides available to growers for use in corn culture. A critical examination would reveal that these herbicides have shortcomings with regard to full spectrum weed control that may, at times, outweigh the advantages they effect.

A popular corn herbicide, 2-chloro-4-ethylamino-6-isopropylamino-s-triazine (atrazine), which is a safe herbicide, may be used preemergence, but often fails to control annual grasses effectively. On the other hand, 3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea (linuron) is effective on a large number of weeds found in association with corn but may be injurious if improperly applied.

The recently developed acetanilide herbicides, 2-chloro-N-isopropyl= acetanilide (propachlor) and 2-chloro-2',6'-diethyl-N-(methoxymethyl) acetanilide (alachlor) have been successful in corn culture but are more effective on grassy than on broadleaf weeds.

An experiment was conducted in which these herbicides were evaluated for preemergence weed control, alone, and in the following combinations: alachlor + atrazine, alachlor + linuron, propachlor + atrazine, and propachlor + linuron. In addition, some of these combinations were evaluated both as liquid sprays and as granulars. Further, alachlor + linuron, respectively, were compared in the following ratios: 2:1, 3:1, and 4:1.

All combinations effected better weed control than did the respective compounds alone. Generally, there did not seem to be any great difference in weed control between granular preparations and liquid sprays. The best results of the various combinations were those in which the rates of the component herbicides were similar to those usually used alone. Perhaps the best ratio of alachlor to linuron was 3:1, there being no advantage in increasing or decreasing the amount of alachlor to linuron.

[1/] Senior Laboratory Technician and Research Professor in Weed Science, respectively, Department of Soils and Crops, Rutgers University, New Brunswick, New Jersey.

A COMPARISON OF SD-15418 (BLADEX) AND ATRAZINE ON SWEETCORN[1,2]

J. A. Ivany and R. D. Sweet[3]

INTRODUCTION

In recent years much emphasis has been placed on using herbicides in the lowest effective quantity. This was done to reduce longevity in the soil and thus prevent injury to succeeding cover or cash crops.

In the northeastern United States and elsewhere atrazine (2-chloro-4-(ethylamino) 6-(isopropylamino)-s-triazine) has a history of carryover when applied at rates in excess of 3 pounds active per acre (1, 5). In sweetcorn (*Zea mays* var. *rugosa*) production atrazine carryover has been minimized by using it in combination with other herbicides and various oils (2, 3, 4, 6, 7). Applications at the optimum time for weed control (2, 4) has reduced rates of toxicant needed and, therefore, reduced carryover. In the above cases less than one pound of atrazine has been needed to obtain weed kill.

In addition companies have been trying to develop an herbicide as effective as atrazine, but with a shorter soil residual period. A new compound from the Shell Oil Company, SD-15418 (Bladex), 2-(4-chloro-6-ethylamino-s-triazine-2-ylamino)-2-methylpropionitrile was tested in 1967 by the authors and appeared to be such a compound. Additional work was initiated in 1968 and continued in 1969 to compare SD-15418 with atrazine in sweetcorn culture.

MATERIALS AND METHODS

Several field experiments were conducted during the 1968 and 1969 growing season on a Howard gravelly loam soil near Ithaca, New York. The purpose was to compare crop and weed response to Bladex and atrazine applied pre- and post-emergence at various rates alone and in combination with oil. Also, comparisons were made of three formulations of Bladex and combination of Bladex with other herbicides.

All field plots were 6 feet by 20 feet. In every plot one row each of two sweetcorn varieties, Gold Cup and Deep Gold, was planted 36 inches apart using a John Deere corn planter. In 1968 one row each of Japanese millet (*Echinochloa crusgalli* var. *frumentacea*) and yellow foxtail (*Setaria lutescens*) was planted between the corn rows. Two rows of Japanese millet were used in 1969.

1/ Paper No. 595 of the Department of Vegetable Crops, Cornell University, Ithaca, New York.

2/ This research was partially supported by grants in aid from the Shell and the Geigy Chemical Companies.

3/ Research Assistant and Professor, respectively.

All sprayable chemical formulations were applied with a hand-held small plot sprayer at 40 psi pressure in 45 gallons of water per acre. Granules were applied by shaking from a paper bag spreading them as evenly as possible over the plot. Pre-emergence treatments were applied June 12, the day after seeding, in 1968 and June 18, the day of seeding, in 1969. Post-emergence applications were made 20 days after seeding in 1968 when the corn was 6-8 inches tall with 5 leaves and the grass 2-3 inches tall with 4 leaves. In 1969 post-emergence treatments were applied July 3 when the corn was 4 inches tall with 3 leaves and the grass 2 inches tall with 2-3 leaves.

As a measure of treatment effect, the seeded species were visually rated for injury both years. The ratings were made on July 11 in 1968 and July 21 in 1969. The natural stand of weeds was very uneven over the experimental area so no ratings were made on these.

In order to obtain a measure of longevity of the two herbicides in soil the experimental area was replanted both years. In 1968 a cover crop was sown over the entire area in late October and no plot showed damage. In 1969 the area was disked and reseeded to snapbeans and Japanese millet on August 13. The plots were examined six weeks later for carryover effects.

RESULTS AND DISCUSSION

The data presented in tables 1 and 2 are the average ratings of two replications in 1968 and three in 1969. The ratings were very uniform within a treatment.

Examination of the corn and grass ratings presented in Table 1 indicates the formulations of Bladex were about equal for crop tolerance when applied pre-emergence. However, the WDL (water dispersible liquid) gave greater injury to the seeded grasses. The 80 percent wettable powder formulation of Bladex was used post-emergence and thus can be compared directly to atrazine.

Atrazine alone caused no crop injury and gave excellent kill of both foxtail and millet. Bladex, depending on corn variety gave slight injury and excellent foxtail kill. It was weak on millet at the low rate but gave good kill at the high rate.

In post-emergence applications in combination with oil, however, a marked difference occurred between atrazine and Bladex. Table 1 shows atrazine plus oil gave both acceptable crop tolerance and grass kill. However, Bladex plus oil was much more active on corn and resulted in severe injury with about the same grass kill.

Work in past years by the authors as well as many other investigators showed atrazine could be used in combination with other herbicides. In this way the amount of atrazine needed could be reduced and subsequent carryover reduced. In Table 2 a comparison is presented of Bladex alone and in combination with other herbicides. The 4 WDL form of Bladex was used in this test. All treatments except 2,4-D alone gave good millet kill. Note, however, that the Gold Cup variety was

Table 1. Response of Sweetcorn and Grass to Certain Treatments.

					1968 Crop Rating*			
No.	Treatment	Timing	lbs./A	Form.	Gold Cup	Deep Gold	Jap. Millet	Yellow Foxtail
1	Atrazine	ppi	2	80 wp	9.0	8.5	2.0	2.0
2	SD-15418	"	1	"	9.0	9.0	4.0	5.0
3	"	"	2	"	8.5	9.0	3.0	5.0
4	"	pre	1	"	8.5	9.0	5.0	4.0
5	"	"	2	"	9.0	7.5	2.5	3.5
6	"	"	1	10% gran.	8.0	8.5	6.5	2.5
7	"	"	2	"	7.5	7.0	2.5	1.0
8	"	"	1	4 wdl	8.5	8.5	3.0	1.5
9	"	"	2	"	8.0	8.0	2.0	1.5
10	Atrazine	"	1	80 wp	9.0	8.5	4.5	2.0
11	"	"	2	"	9.0	8.5	2.5	1.0
12	SD-15418	early post	1	"	7.0	8.0	7.5	1.0
13	"	" "	2	"	6.0	7.0	4.0	1.0
14a	"	" "	1	"	4.5	5.0	4.0	1.0
b	Oil	" "	1 gal.	-				
15a	SD-15418	" "	2	80 wp	4.0	4.0	3.0	1.0
b	Oil	" "	1 gal.	-				
16	Atrazine	" "	1	80 wp	9.0	9.0	4.5	1.5
17	"	" "	2	"	9.0	9.0	3.0	1.0
18a	"	" "	1	"	8.5	8.5	3.0	1.0
b	Oil	" "	1 gal.	-				
19a	Atrazine	" "	2	80 wp	7.5	7.5	2.0	1.0
b	Oil	" "	1 gal.	-				
20	Check				9.0	9.0	9.0	9.0

* See table 2 for explanation of ratings.

Table 2. Response of Sweetcorn and Grass to Certain Treatments.

No.	Treatment	Timing	lbs./A Rate	Form.	1969 Crop Rating* Gold Cup	Deep Gold	Jap. Millet
1a	SD-15418	pre	2	4 wdl	8.6	9.0	1.0
b	Atrazine	"	2	80 wp			
2	SD-15418	"	2	4 wdl	9.0	9.0	4.0
3	Atrazine	"	2	80 wp	9.0	9.0	3.6
4a	SD-15418	"	2	4 wdl	8.6	9.0	1.0
b	Ramrod	"	4	65 wp			
5	"	"	4	"	9.0	9.0	1.0
6a	SD-15418	"	2	4 wdl	9.0	9.0	1.0
b	Lasso	"	4	4 ec			
7	"	"	4	"	8.6	9.0	1.0
8a	SD-15418	"	2	4 wdl	6.0	9.0	1.6
b	2,4-D	post	½	4 ec			
9	"	"	½	"	7.0	9.0	6.0
10a	SD-15418	pre	2	4 wdl	9.0	9.0	1.0
b	Sutan	ppi	4	6 ec			
11	"	"	4	"	9.0	9.0	1.3
12a	SD-15418	pre	2	4 wdl	7.3	9.0	1.0
b	Planavin	ppi	1	75 wp			
13	"	"	1	"	6.3	9.0	1.0
14	Check				9.0	9.0	9.0

* Rating: 1 = complete kill
7 = slight injury but acceptable crop
9 = perfect crop

injured by the treatments containing 2,4-D and planavin. In general, however, Bladex performed well in combination with other herbicides.

Examination of the 1969 plots after reseeding with snapbeans and Japanese millet indicated the only plots showing appreciable carryover were Bladex plus atrazine and atrazine alone. Bladex alone showed evidence of slight carryover. The period after treating and prior to reseeding, except for the first 2-3 weeks, was much drier than normal. This perhaps contributed to the relative longevity of all herbicides.

CONCLUSIONS

The data presented indicates Bladex was as effective as atrazine when applied either pre-emergence alone or in combination with other herbicides. Its advantage over atrazine, however, was a shorter soil residual period which reduced the chance of injury to subsequent cover or sensitive crops. This consideration is important where atrazine would normally be used at rates higher than 2 pounds per acre and where sensitive crops are to follow in the rotation.

A disadvantage of Bladex was that it could not be used alone or combined with oil for post-emergence application because of damage to the corn.

REFERENCES CITED

1. Buchholtz, K. P. 1965. Factors influencing oat injury from triazine residues in soil. Weeds 13: 362-367.

2. Currey, W. L. and R. A. Peters. 1969. Timing of post-emergence herbicide applications for crabgrass control in corn. Proc. NEWCC. 23: 189-197.

3. Dickerson, C. T., Jr. and R. D. Sweet. 1968. Atrazine, oil and 2,4-D for post-emergence weed control in sweetcorn. Proc. NEWCC. 22: 64-75.

4. ____________ and ____________. 1967. Atrazine and oil for post-emergence weed control in sweetcorn (*Zea mays* var. *rugosa*). Proc. NEWCC. 21: 106-113.

5. Scott, T. W., T. W. Bateman and S. N. Fertig. 1967. Effect of triazine residues on sugar beets. (Abstract). Proc. NEWCC. 21: 344.

6. Wilson, H. P. and R. D. Ilnicki. 1968. Combinations of oils and surfactants for enhancing the post-emergence activity of atrazine in corn. Proc. NEWCC. 22: 110-114.

7. ____________ and ____________. 1968. The effects of phytobland oils and spray volume on post-emergence activity of atrazine and combinations of atrazine with linuron in corn. Proc. NEWCC. 22: 272-278.

ACTIVITY OF HERBICIDES IN SWEET CORN [1/]

H. P. Wilson and R. L. Waterfield, Jr. [2/]

To be useful to sweet corn growers of Virginia, herbicides must meet several qualifications. They must control a broad spectrum of annual broadleaved weeds and grasses while maintaining an adequate margin of crop safety. Failure to control one or more species often results in heavy infestations of the uncontrolled weeds. Since many vegetable growers double-crop their land, herbicides must not persist to the extent that succeeding crops are injured or accumulate residues. This restriction means that some of the otherwise satisfactory chemicals cannot be used at rates necessary to effect control of all species.

The objective of research reported in this paper was to determine if any of several experimental or standard herbicides could be used alone or in combinations for controlling weeds in sweet corn. Of primary concern was broad-spectrum control and short term residual activity.

Materials and Methods

Experiments were conducted in 1968 and 1969 at the Eastern Shore Branch, Virginia Truck Experiment Station, Painter. A Sassafras sandy loam soil with approximately 1% organic matter was chosen as the research site. Herbicides were applied to plots measuring 5 ft by 20 ft containing two rows of sweet corn (var. NK 199). Experiments were designed as randomized complete blocks with three or four replications. Applications of preplant herbicides were made immediately prior to planting on May 12, 1968 and May 13, 1969. Incorporation was with a power driven rototiller with tines adjusted to cut to a depth of approximately 2 in. Preemergence herbicides were applied the days following planting each year. Water dilutions of herbicides were applied with a portable plot sprayer using propane as the pressure source; the delivery rate was 55 gpa. Herbicides researched are presented in the Appendix.

Soil was moist in 1968 when preplant incorporated herbicides were applied but the surface was dry with adequate moisture below the following day when preemergence treatments were made. No rainfall was recorded for a period of 4 to 5 days when ½ in fell over a two-day period. In 1969, the soil was dry when treatments were made and remained in that condition for 7 days when 1½ in of rain fell.

Control of individual species was rated using the scale 0 to 10 where 0 represents no weed control or crop injury and 10 represents complete reduction

---

1/ Contribution from the Plant Physiology Department, Virginia Truck Experiment Station. Paper No. 147, Journal Series. Approved for publication November 25, 1969.

2/ Plant Physiologist and Research Assistant, respectively, Virginia Truck Experiment Station, Eastern Shore Branch, Painter, Va.

of plant stand or vigor. Weeds predominant in the research area were crabgrass (Digitaria spp.), fall panicum (Panicum dichotomiflorum Michx.) and lambsquarters (Chenopodium album L.).

Yields of sweet corn were determined by harvesting marketable ears from all plots on July 25 and July 31. Data were analyzed statistically and converted to tons per acre for comparisons.

Results and Discussion

Crop and weed responses to herbicides applied preplant incorporated are presented in Table 1. Results from 1968 will be discussed first.

Weed control with SD-15418 was good at rates from 1 to 3 lb/A; slight injury was detected at the 3 lb/A rate however. Butylate was effective in providing grass control at 4 lb/A but even that rate failed to control lambsquarters. Both formulations of nitralin controlled weeds but caused a prohibitive amount of sweet corn injury. No differences could be observed between nitralin formulations with respect to crop injury and weed control. Combinations of nitralin with atrazine effected broad spectrum weed control with no apparent crop injury. Considering the amount of injury caused by single applications of nitralin, it is questionable if a satisfactory margin of safety for this combination exists. It also seems likely that the higher rate combinations of these herbicides could produce residual injury to succeeding crops planted in the treated area.

In 1969, combinations of atrazine with butylate were markedly more effective than either of the herbicides applied alone. The high yields obtained with the use of these combinations emphasizes this good weed control and the benefit derived from using the combination where a spectrum of broadleaved weeds and grasses exists. The low sweet corn yields obtained where combinations of linuron with butylate were applied can be attributed to unsatisfactory control of the high population of lambsquarters. These results indicate that linuron may be less effective than atrazine as a component of combinations with butylate.

Presented in Tables 2 and 3 are weed and crop responses to preemergence applications. Herbicides which produced good weed control when applied alone while causing no crop injury included SD-15418, RP-17623, C-6313 at 2 lb/A, alachlor and linuron. The high rates of C-6313 and NC 4780, as well as combinations of alachlor with 2,4-D, injured sweet corn. Alachlor effected better grass control than did either formulation of propachlor. Combinations of alachlor with atrazine effected excellent control of grasses as well as a few scattered broadleaved weeds not included in the tables. It was determined that rates of 1½ lb/A alachlor with 3/4 lb/A atrazine would effect excellent control of annual weeds on the light soils of eastern Virginia. Combinations of diphenamid with dinoseb effected good weed control but there was a trend towards increased crop injury as rates increased.

In 1969, SD-15418 controlled lambsquarters but failed to provide adequate control of fall panicum, especially at the low rate of 1½ lb/A. The poor grass control was reflected in low sweet corn yields. Notwithstanding that alachlor effected control of grasses, even high rates of 4 and 6 lb/A failed to control lambsquarters. Comparisons of the two formulations of BAS 2903 H indicated that the emulsifiable concentrate was more effective under the dry conditions prevalent than was the granular. Grass control with this herbicide was better than control of lambsquarters indicating that broad-spectrum control might result from combinations of BAS 2903 H with an herbicide specific for broadleaved weeds.

Combinations of herbicides were the outstanding treatments researched in 1969 as indicated by superior weed control, satisfactory margins of crop safety and high yields of marketable ears. Effective treatments were alachlor in combination with atrazine, dinoseb, linuron and SD-15418. The combination of alachlor with dicamba was slightly less effective than other combinations. Worthy of comment is the good performance of combinations of alachlor with dinoseb. These combinations provided good control of grasses and broadleaved weeds at low rates of the component herbicides. Neither would be expected to persist to cause injury to succeeding crops. It is suggested that alachlor + dinoseb has merit not only in sweet corn but in other cropping situations as well for control of annual weeds.

Summary

Herbicides were researched preplant incorporated and preemergence to sweet corn over a two-year period. Noteworthy findings related to preplant incorporated treatments include: 1) butylate effectively controlled grasses but provided broad-spectrum control only when combined with atrazine; 2) although combinations of nitralin with atrazine effected good weed control while causing no apparent crop injury, the margin of safety is questionable since single applications of nitralin injured sweet corn; 3) satisfactory weed control was provided by SD-15418 but corn was injured at the rate of 3 lb/A; and 4) combinations of linuron with butylate failed to control lambsquarters.

With reference to preemergence treatments, the following statements apply: 1) broad-spectrum control was consistently obtained only with herbicide combinations; 2) promising combinations include alachlor with atrazine, SD-15418, dinoseb, linuron and dicamba; 3) alachlor + dinoseb should be considered for short-term weed control in other crops as well as sweet corn; and 4) the emulsifiable concentrate formulation of BAS 2903 H was more effective under dry conditions than the granular and has potential for use especially in combinations with herbicides specific for broadleaved weeds.

Appendix

Chemistry of herbicides researched in sweet corn in 1968 and 1969.

Herbicide	Chemistry
Alachlor	2'-chloro-2,-6-diethyl-N-methoxymethylacetanilide
Atrazine	2-chloro-4-(ethylamino)-6-isopropylamino)-s-triazine
BAS-2903-H	N-isobutynyl-2-chloroacetanilide
Butylate	S-ethyl diisobutylthiocarbamate
C-6313	3-(4-bromo-3-chlorophenyl)-1-methoxy-1-methylurea
Dicamba	3,6-dichloro-o-anisic acid
Dinoseb	2-sec-butyl-4,6-dinitrophenol
Diphenamid	N,N-dimethyl-2,2-diphenylacetamide
Linuron	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea
NC-4780	2-trifluoromethyl-6-chloroimidazo (4,5-6) pyridine
Nitralin	4-(methylsulfonyl)-2,6-dinitro-N,N-dipropylaniline
Propachlor	2-chloro-N-isopropylacetanilide
RP-17623	2-tertiobutyl-4-(2,4-dichloro-5-isopropyloxyphenyl)= -5-oxo-1,3,4-oxadiozoline
SD-15418	2-(4-chloro-6-ethylamino-S-triazin-2-ylamino)-2-methyl= propionitrile

Table 1. Weed Control and Crop Responses to Herbicides Applied Preplant Incorporated to Sweet Corn in 1968 and 1969.

Herbicide	Rate, lb/A ai	Crop Response 1/ St	Crop Response 1/ Vigor	Weed Control 1/ Lambs-quart.	Weed Control 1/ Fall Pan.	Weed Control 1/ Crab-grass	Yield, T/A First	Yield, T/A Total
1968								
SD-15418	1	0.0	0.0	10.0	8.8	8.8	2.47	2.97
	2	0.0	0.4	10.0	9.5	9.8	2.47	2.80
	3	0.2	1.6	10.0	9.8	10.0	2.03	2.43
Butylate	2	0.0	0.0	3.7	7.0	7.0	1.96	2.28
	4	0.0	0.0	5.5	8.6	9.3	1.74	2.28
Nitralin	3/4	1.3	3.2	8.1	9.6	10.0	2.32	2.65
(75W)	1	2.5	2.1	9.5	9.7	9.9	1.60	1.96
Nitralin	3/4	1.4	1.0	8.3	9.7	10.0	1.67	2.32
(4 lb/gal)	1	2.2	1.7	9.6	9.7	10.0	1.92	2.25
Nitralin	1/4 + 3/4	0.0	0.6	10.0	9.3	8.8	2.18	2.54
+	1/4 + 1 1/2	0.0	0.1	9.9	9.6	9.8	2.80	3.41
Atrazine	1/2 + 3/4	0.3	0.6	10.0	9.7	9.8	1.67	2.07
	1/2 + 1 1/2	0.2	0.4	10.0	9.8	9.8	3.12	3.41
Check		0.1	2.0	0.0	0.0	0.0	1.64	2.32
LSD 0.05							N.S.	N.S.
1969								
Butylate	2	0.0	0.0	0.0	6.6	10.0	0.04	0.07
	4	0.0	0.0	1.3	10.0	10.0	0.02	0.33
Atrazine +	1 + 3	0.0	0.0	9.9	9.7	9.9	1.76	2.61
Butylate	1 + 4	0.0	0.0	10.0	9.9	9.9	2.96	3.54
Linuron +	1/2 + 3	0.0	0.0	5.0	10.0	10.0	0.31	0.33
Butylate	1 + 3	0.0	0.0	8.0	10.0	10.0	1.05	1.32
Atrazine	1	0.0	0.0	9.9	0.0	0.0	0.09	0.09
Linuron	1	0.0	0.0	9.1	0.0	0.0	0.00	0.00
Check		0.0	0.0	0.0	0.0	0.0	0.00	0.00
Check		0.0	0.0	0.0	0.0	0.0	0.00	0.00
LSD 0.05							1.10	0.94
0.01							1.60	1.31

1/ Scale: 0 to 10; 0 = no effect and 10 = complete reduction in crop stand or vigor or weed stand.

Table 2. Weed Control and Crop Responses to Herbicides Applied Preemergence to Sweet Corn in 1968.

Herbicide	Rate, lb/A ai	Crop Response 1/ St	Crop Response 1/ Vigor	Weed Control 1/ Fall Pan.	Weed Control 1/ Crab-grass	Yield, T/A First	Yield, T/A Total
SD-15418	1	0.3	1.1	9.2	9.7	2.14	2.90
	2	0.0	0.4	9.9	9.8	2.40	3.74
	3	0.5	1.0	10.0	9.9	2.07	2.76
NC 4780	3/4	0.2	0.7	9.1	9.1	2.69	2.63
	1 1/2	0.5	0.7	10.0	9.9	2.11	3.48
	3	3.2	2.1	10.0	10.0	1.31	2.03
RP-17623	1/2	0.1	0.5	8.1	8.7	1.89	2.76
	1	0.5	1.3	9.6	9.7	2.18	3.34
C-6313	2	0.3	0.3	9.8	9.5	2.80	3.99
	4	1.3	2.2	10.0	10.0	2.76	3.63
Propachlor (65W)	4	0.2	0.7	8.7	5.2	1.49	2.11
	6	0.4	0.3	9.4	8.3	2.76	3.19
Propachlor (26.25G)	4	0.2	0.7	8.3	7.4	2.18	2.98
	6	0.3	0.4	8.5	7.8	1.27	2.40
Alachlor	1	0.2	0.2	10.0	9.8	3.74	4.57
	1 1/2	0.2	0.7	9.8	9.9	2.36	3.27
	2	0.4	0.2	10.0	10.0	3.16	4.14
Alachlor	1 + 3/4	0.1	0.0	9.9	9.8	3.48	4.21
+	1 + 1	0.0	0.0	9.8	9.8	2.76	3.56
Atrazine	1 1/2 + 3/4	0.5	0.7	9.9	9.9	3.34	4.25
	1 1/2 + 1	0.1	0.1	10.0	9.9	2.94	4.07
Alachlor	1 + 3/4	1.4	1.8	9.5	9.7	1.74	2.72
+	1 + 1 1/2	1.8	2.8	9.8	9.7	1.74	2.11
2,4-D	1 1/2 + 3/4	1.1	1.9	9.9	9.8	2.47	3.23
	1 1/2 + 1 1/2	1.8	3.0	9.8	9.7	1.16	1.78
Diphenamid +	1 + 3/4	0.1	0.8	9.7	9.5	1.45	2.87
Dinoseb	2 + 1 1/2	0.9	2.4	9.9	9.9	1.82	2.54
Linuron	1	0.2	0.1	9.3	9.9	2.76	3.74
Check (Cult.)		0.3	1.3	0.0	0.0	1.52	2.14
Check		0.7	2.1	0.0	0.0	0.40	0.69
Check		0.6	1.1	0.0	0.0	0.51	0.94
LSD 0.05						0.93	1.07
0.01						1.23	1.42

1/ Scale: 0 to 10; 0 = no effect and 10 = complete reduction in crop stand or vigor or weed stand.

Table 3. Weed Control and Crop Response to Herbicides Applied Preemergence to Sweet Corn in 1969.

Herbicide	Rate, lb/A ai	Crop [1/] Response	Weed Control[1/] Lambs-quart.	Fall Pan.	Crab-grass	Yield, T/A First	Total
SD-15418	1 1/2	0.4	9.2	5.9	9.8	1.42	1.47
	3	0.2	9.8	9.1	9.6	0.25	2.70
Alachlor	2	0.2	3.7	9.7	9.9	0.60	0.89
	4	0.7	5.0	9.6	10.0	2.23	2.67
	6	2.5	8.9	10.0	10.0	2.18	2.98
BAS 2903H	4	0.0	6.3	8.5	8.0	1.29	1.47
(4 lb/gal)	8	0.7	7.3	9.1	9.9	1.96	2.52
BAS 2903H	4	0.0	4.0	4.0		1.00	1.25
(20G)	8	0.0	5.0	7.3		0.83	1.34
Atrazine +	1 + 2	0.0	10.0	9.9	10.0	3.05	3.97
Alachlor	2 + 4	1.1	10.0	9.9	10.0	3.30	4.52
Alachlor +	1 1/2 + 3	0.2	9.7	9.5	9.7	2.40	3.96
Dinoseb	2 + 3	0.4	9.3	9.7	10.0	2.80	3.65
Alachlor +	1 + 1/2	0.2	9.5	9.8	10.0	2.23	3.61
Linuron	1 1/2 + 3/4	0.9	9.9	9.8	9.7	2.74	3.92
SD-15418	1 + 1	0.0	9.3	9.5	9.6	3.10	4.03
+	1 + 1 1/2	0.0	9.5	9.8	9.8	3.01	3.43
Alachlor	1 1/2 + 1	0.0	9.9	9.8	9.9	3.29	3.87
Alachlor +	1 + 1/4	0.5	7.7	9.7	10.0	1.96	2.80
Dicamba	1 + 1/2	0.3	9.3	9.5	9.8	2.67	3.09
Check		0.0	0.0	0.0	0.0	0.04	0.04
Check		0.0	0.0	0.0	0.0	0.05	0.05
Check		0.0	0.0	0.0	0.0	0.07	0.07
LSD 0.05						N.S.	1.95
0.01						N.S.	2.61

[1/] Scale: 0 to 10; 0 = no effect and 10 = complete reduction in crop vigor or weed stand.

SD-15418 CORN HERBICIDE - 1969 FIELD RESULTS

R. W. Skrei[1]

ABSTRACT

SD-15418 is a promising new pre-emergent herbicide for the control of annual grasses and annual broad leaved weeds in corn. Data from three years of testing at many land grant universities indicate that SD-15418, when applied at a rate of two to four lbs (cai) per acre, is a highly selective and active herbicide.

During the 1969 season, Shell Chemical Co. with the cooperation of hybrid seed corn companies, conducted an extensive field research program to further evaluate the compound. A total of 30 seed companies cooperated in the program. Tests were conducted at approximately 100 locations in 14 states. The size of the plots ranged from 3-6 acres each.

The primary purpose of the program was to evaluate the performance of SD-15418 as a pre-emergent corn herbicide under varying grower conditions. Some of the data recorded from each location included:

Date of planting and application
Rainfall record
Organic matter content (Soil samples were taken
at each location.)

Results from this program confirmed the earlier data that SD-15418 is a highly selective and active corn pre-emergent herbicide.

This product is currently under review by the U.S.D.A. for registration on field corn, sweet and popcorn.

1/ Shell Chemical Co., N.Y., N.Y.

WEED CONTROL IN HIGHWAY PLANTINGS

Arthur Bing [1] and David Fasser [2]

A great effort is being made to improve man's environment. Highway beautification is a part of this improvement program and is accomplished by large scale plantings of trees and shrubs along the highways and in the median strips of divided parkways and thruways. Before shrubs and trees were planted, the only maintenance necessary was cutting of the grass and an occasional fertilization. After trees and shrubs are set out in large, closely planted groups, mowing is not possible. Until these plants are well established, weeds quickly become a prominent feature of the landscape.

The weed population consists of annual and perennial weeds whose seeds are easily blown in from adjacent weedy areas or are brought in with the soil used for fill and topsoil during construction. 2,4-D and related compounds safely control most non-grassy weeds in turf areas; however, these cannot be used when shrubs and trees are in the area. Plants spaced irregularly in roadside landscapes makes mowing or cultivation impractical. The use of herbicides to control germination of annual weed seeds only accelerates the take-over of the area by more persistent perennial weeds.

The use of more potent herbicides to control perennial weeds has limitations. Herbicides applied to plantings on slopes may wash down to desirable grass and create unsightly dead areas. The wide variety of plants used along roadsides makes it difficult for the landscaper to select herbicides that will be tolerated by all species that may be in a large area.

Experiments with nursery and landscape plants have been reported by Ahrens (1) and Bing (2). Dichlobenil, diuron, simazine or a mixture of simazine and amitrole have given long-lasting control of some perennial weeds and most annual weeds in nursery and landscape plantings. The use of mulches with herbicides has been reported by Bing (2), Dunham, Fretz and Rubin (3), and Haramaki, Nuss and Williams (4) to be very effective for weed control in landscape plantings.

To determine the effectiveness and value of several herbicides for highway plantings, a series of experiments on newly planted deciduous shrubs along Northern State Parkway, Long Island, New York was conducted in cooperation with Landscaping by Country Gardens, Inc. and the New York State Department of Transportation.

Materials and Methods

The areas used in this experiment were located on mild to negligible slopes in the wide median strip of the parkway. These areas were covered with established turf but variably infested with the perennial weeds listed in Table 1.

[1] Professor, Cornell Ornamentals Research Laboratory, Farmingdale, New York
[2] Landscape Architect, N. Y. S. Department of Transportation, Babylon, New York

All the areas to be planted were sprayed in late August and some again in late November with paraquat (see Table 2 for a listing of chemicals mentioned in this article) at a rate of 1 qt per 100 gal of water per acre. Paraquat was used because the contract specified removal of existing turf prior to planting shrub beds. This killed most of the grasses and burned back the weeds. Container grown trees and shrubs (Table 3) were planted by the contractor from mid-August until December in large groups of individual species along the miles of parkway. The plant pits were back filled with existing soil; however, there remained a very uneven soil surface with large stones and clumps of sod. After the planting operation, wood chip mulch was applied to entire shrub bed areas at a depth of about 3 in. The placement of mulch was not completed until well into June, 1969 and some areas were again rather weedy by the time the mulch was applied.

On December 3, a planted area was selected that had a heavy population of perennial weeds, many of which were quite green and appeared well recovered from the paraquat treatment. The area was ready for the mulch application. The deciduous landscape plants were nearly defoliated at this late date. The following granular herbicides were applied on 2,000 sq ft plots: dichlobenil granular at 4, 6, 8, 10 lb/A; diuron granular 2 lb/A; and simazine 4 and 8 lb/A. A spray mixture of 15% amitrole and 45% simazine was applied on 1,000 sq ft plots at 5, 7 and 10 lb/A. The granulars were applied with a Cyclone lawn spreader. The spray was applied with a 1 gal pump type, stainless steel sprayer with a flat spray nozzle. The application of materials was finished by 2:30 p.m. The weather was clear and the temperature was 45-50°F. That evening and the following morning there was 1.75 in of rain. By morning much of the treated areas was under 1 to 4 in of water. The mulch was applied after the rain.

With the value of this series of treatments in doubt, a duplicate series was made on December 11 on a higher, better drained area which had been treated with paraquat in early September. Between December 3 and 11 the soil had frozen but had thawed by treatment time. On the day of treatment the weather was clear with an air temperature of 25-30°F. The plots were all 1,000 sq ft in size and the same treatments were made in the same manner as those made on December 3 with mulch applied after treatment.

On June 3 and 4, 1969 an unmulched area was selected that had been planted in late fall but had no further treatments. The weeds, many up to 2 ft tall, between the plants were mowed with a small rotary mower. The following treatments were applied: triplicate plots of dichlobenil at 2 and 4 lb/A; duplicate plots of dichlobenil at 6, 8, and 10 lb/A; and single plots of simazine at 4, 6, and 8 lb/A. The more promising of the December treatments were replicated most times. The weather was sunny with a slight breeze and an air temperature of 80°F on June 3 and 70°F on June 4. The areas were covered with mulch immediately after treatment.

Some of the parkway areas treated in August with paraquat and wood chip mulch had not remained free of weeds. By June 12, the predominant weeds were buckhorn plantain, curly dock, fall hawkweed, quackgrass and red sorrel. Duplicate plots were treated with each of the following sprays: paraquat $\frac{1}{4}$, $\frac{1}{2}$ and 1 lb/A; amitrole 1 and 2 gal of 21.1% (1 and 2 lb/A) and a mixture of 15% 45% simazine at 7 lb/A. Amounts sprayed on the weed covered areas are approximate because of variability in weed cover and size of landscape plants. The weather was hazy at 70°F.

Results and Discussion

Due to the variability in distribution of species of landscape plants and weeds in the various treatment areas, only broad general observations could be made during the growing season.

Dichlobenil at all rates and the 3 different times of application gave excellent weed control. Diuron and simazine were effective in controlling annual weeds and some perennial weeds. Diuron did not control established buckhorn plantain or red sorrel. Simazine at 4, 6, and 8 lb/A was ineffective against red sorrel. The simazine-amitrole mixture at 5 lb/A did not control dandelion.

Species of landscape plants varied in their tolerance to herbicide treatments. The data from the December and June treatments are summarized in Table 4. A "T" stands for no injury, "st" shows some injury but good chance for survival and "S" means that plants in at least one plot of that treatment were severely injured. A blank space in the table indicates no treatment on that species. Both Viburnum species reacted the same. Privet did not tolerate simazine. Russianolive did not tolerate simazine at the higher rates. Thicket serviceberry tolerated simazine granular but not the simazine-amitrole spray mixture. Tatarian honeysuckle was sensitive to dichlobenil at rates over 6 lb/A. The Viburnum species and witchhazel in the test were severely injured by dichlobenil at 4 and 6 lb/A. Dogwood, Forsythia, and Russianolive were tolerant to dichlobenil at all rates tested. Forsythia and privet were tolerant to diuron. Thicket serviceberry was tolerant to simazine at 4, 6, and 8 lb/A and to dichlobenil at 4 lb/A. Dichlobenil may be effective at less than 2 lb/A when used under a heavy mulch. This needs further study.

Paraquat at $\frac{1}{4}$ lb/A gave poor weed control. Many weeds, especially red sorrel, recovered soon after the initial burning of foliage. Weed control from $\frac{1}{2}$ lb/A of paraquat was good in one plot and poor with some re-growth, especially of red sorrel, in another. At 1 lb/A paraquat gave good weed control with no injury to privet or spicebush.

Amitrole at 2 lb (1 gal)/A caused no injury to Viburnum but weed control was poor. At 4 lb/A amitrole caused some damage to Viburnum and gave good temporary control of weeds but re-growth was substantial. The simazine-amitrole mixture at 7 lb/A did not injure common spicebush but the weeds were only temporarily injured. The temporary control of perennial weeds by single applications of paraquat in these experiments and the fairly successful control by the repeated applications used by the contractor indicates that frequent repeat applications will safely prevent unsightly weed growth and may eliminate many perennial weeds.

Conclusions

The mulch alone is not effective in controlling established perennial weeds. Under a mulch, dichlobenil at 2 lb/A showed the most promise for perennial weed control. None of the treatments used were safe for all landscape plants.

Table 1. Perennial weeds observed in highway plantings

Common name	Scientific name
Buckhorn plantain	*Plantago lanceolata* L.
Curly dock	*Rumex crispus* L.
Dandelion	*Taraxacum officinale* Weber
European woodsorrel	*Oxalis europea* Jord.
Fall hawkweed	*Leontodon autumnalis* L.
Hawkweed	*Hieracium vulgatum* Fries
Quackgrass	*Agropyron repens* (L.) Beauv.
Red sorrel	*Rumex acetosella* L.
Yellow toadflax	*Linaria vulgaris* Hill

Table 2. Herbicides and formulations used

Chemical name	Common name	Formulation
2,6-dichlorobenzylonitrile	dichlobenil	4% granular
2-chloro-4,6-bis(ethylamino-s-triazine	simazine	4% granular
3-(3,4-dichlorophenyl)-1,1-dimethylurea	diuron	2% granular
3-amino-s-triazole	amitrole	21.1%
1,1'-dimethyl-4,4'-ipyridinium ion	paraquat	2 lb/gal
	amitrole + simazine	15% + 45% wettable powder
(2,4-dichlorophenoxy)acetic acid	2,4-D	various

Table 4. Tolerance of landscape plants to herbicides covered with a wood chip mulch.

Treatment		Plant tolerance *								
Common name	Rate lb/A	Dogwood	Forsythia	Privet	Russian-olive	Service-berry	Honey-suckle	Viburnum	Witch-hazel	Spice-bush
Dichlobenil	2				T		T			
	4	T	T		T	T	T	S	st	
	6	T			T		T	S	S	
	8	T	T		T		st	S		
	10	T	T				S			
Diuron	2		T	T						
Simazine	4			S	T	T				
	6					T				
	8			S	S	T				
Simazine 45% +	5		T	T	T					
amitrole 15%	7					st				T
	10			S	T	st				
Paraquat	$\frac{1}{4}$			T				T		
	$\frac{1}{2}$			T						T
	1			T						T
Amitrole	1 gal							T		
	2 gal							st		

* Plant tolerance is a summary of plantings treated on December 3 or 11 observed on May 14 and July 24 or treated on June 3, 4 or 12 and observed July 24. T - no injury, st- some injury but a good chance for survival, S- severe injury in at least one plot. A blank space shows that treatment was not made on the plant.

Table 3. Landscape plants treated.

Common name	Scientific name
Weeping Forsythia	*Forsythia suspensa* Vahl.
Gray dogwood	*Cornus racemosa* Lam.
Ibolium privet	*Ligustrum ibolium* E. F. Coe
Russianolive	*Elaeagnus angustifolia* L.
Thicket serviceberry	*Amelanchier canadensis* Medic.
Common spicebush	*Lindera benzoin* Blume
Tatarian honeysuckle	*Lonicera tatarica* L.
Viburnum	*Viburnum carlesi* Hemsl. and *Viburnum tomentosum* Mig.
Common witchhazel	*Hamamelis virginiana* L.

Literature Cited

(1) Ahrens, J. F. 1961. Chemical control of weeds in nursery plantings. Bul. Conn. Ag. Expt. Sta. 638:1-41.

(2) Bing, A. 1965. The use of herbicides with mulches. Proc. NEWCC 19:167-172.

(3) Dunham, C. W., T. A. Fretz and V. A. Rubin. 1969. Weed control in landscape plantings with dichlobenil-licorice root mulch. Proc. NEWCC 23:81-82.

(4) Haramaki, C., J. R. Nuss and P. H. Williams. 1969. Herbicide incorporated hardwood bark mulch for woody ornamentals. Proc. NEWCC 23:76-80.

SOME EXPERIENCES WITH DICAMBA[1] IN CONTROLLING REVEGETATION OF DEFORESTED LAND IN WEST VIRGINIA

James H. Patric and John Campbell[2]

ABSTRACT

To maintain barren conditions on deforested land in West Virginia, liquid and pelleted formulations of dicamba were applied in 1969. A liquid formulation (per-acre application of 1.5 lb. a.e. dicamba with 1 lb. a.e. each of 2,4-D and 2,4,5-T in 80 gallons of water) provided quick and more complete kills at less cost than larger amounts of 2,4-D and 2,4,5-T in water. Our experiences with pelleted dicamba suggest that heavier applications of this formulation will be needed to maintain barren conditions and that application early in the growing season is at least as important as amount applied.

Methods

Liquid formulations of dicamba were applied with gasoline-powered mist blowers. Pelleted formulations were applied with hand-operated grass seeders. All treatments were applied on warm, sunny days.

The application rates initially recommended by the manufacturer were found to be faulty, so the trials were repeated with revised application rates (Table 1).

Results

The common plants on the experimental watersheds can be grouped according to their responses to dicamba (Table 2). These groupings apply to both liquid and pelleted formulations. Although most grasses and sedges were unaffected by dicamba, it was not applied during early spring when grasses attain much of their growth and usually are most responsive to herbicides.

---

[1] Dicamba (3,6-dichlor-o-anistic acid) is manufactured by the Velsicol Chemical Corporation, Chicago, Illinois. Mention of the product name and manufacturer does not imply endorsement by the U.S. Department of Agriculture; this information is provided solely for the convenience of readers.

[2] Forest hydrologist and forest technician, respectively, Northeastern Forest Experiment Station, Forest Service, U.S. Department of Agriculture, Parsons, West Virginia.

Table 1.--Dicamba tests at Fernow Experimental Forest, 1969

Formulation	Treatment planned	Rate applied	Plot size	Replic-ations	Dates applied	Description of test sites	Comments
	--Lb.a.e. per acre--		Acre	Number			
1.25 lb. dicamba and 2.5 lb. 2,4-D a.e. per gallon	1.6	4.8*	0.5	3	6-17 to 6-20	Deforested land	Herbicide over-applied. Rates should have been based on dicamba and 2,4-D, not dicamba alone.
	2.4	7.2*		3			
	3.2	9.6*		3			
1.5 lb. dicamba and 1.0 lb. each of 2,4-D and 2,4,5-T a.e. per gallon	3.5	3.5	30	0	7-22 to 8-8	Deforested land	Applied on land maintained barren during four previous growing seasons.
10% a.e. dicamba and 90% filler in pellets	0.5	.05*	0.1	4	6-11 to 6-13	Brushy clearings reverting to forest	Herbicide under-applied. Applicators unaware that pelleted formulation was only 10% acid equivalent.
	1.0	.10*		4			
	2.0	.20*		4			
	4.0	.40*		4			
	6.0	.60*		4			
	8.0	.80*		4			
10% a.e. dicamba and 90% filler in pellets	0.5	0.5	0.1	4	8-14 to 8-15	Same brushy clearings treated 6-11 to 6-13	Applied after most vegetative growth had ceased.
	1.0	1.0		4			
	2.0	2.0		4			
	4.0	4.0		4			
	6.0	6.0		4			
	8.0	8.0		4			
10% a.e. dicamba and 90% filler in pellets	2.0	2.0	5.5	0	8-18 to 8-21	Deforested land	Applied after most vegetative growth had ceased.

*Incorrectly applied. See comments.

Table 2.--Plants on the experimental watershed grouped by their responses to dicamba

Common name	Scientific name
	LEAST SUSCEPTIBLE PLANTS
*American beech	Fagus grandifolia Ehrh.
*Chestnut oak	Quercus prinus L.
Fern	Athyrium spp. Roth and other genera
Grass	Eragrostis spp. L. and other genera
*Hickory	Carya spp. Nutt
Sedge	Carex spp. L.
*Striped maple	Acer pensylvanicum L.
*Sugar maple	Acer saccharum Marsh.
*White ash	Fraxinus americana L.
*Witch hazel	Hamamelis virginiana L.
	INTERMEDIATE PLANTS
Blackberries	Rubus spp. L.
*Black birch	Betula lenta L.
*Black cherry	Prunus serotina Ehrh.
*Blackgum	Nyssa sylvatica Marsh.
*Chestnut	Castanea dentata Marsh.
*Cucumber tree	Magnolia acuminata L.
Deer tongue grass	Panicum clandestinum L.
Dock	Rumex spp. L.
Fireweed	Erechtites hieracifolia (L.) Rab.
*Flowering dogwood	Cornus florida L.
Loosestrife	Lysimachia producta (Gray) Fern.
*Red maple	Acer rubrum L.
*Red oak	Quercus rubra L.
*Sassafras	Sassafras albidum (Nutt.) Nees
*Serviceberry	Amelanchier arborea Michx.
*Sourwood	Oxydendrum arboreum (L.) DC.
Violet	Viola spp. L.
	MOST SUSCEPTIBLE PLANTS
American elder	Sambucus canadensis L.
Azalea	Rhododendron calendulaceum Michx.
Bindweed	Convolvulus spp. L.

CONTINUED

Table 2.--Continued

Common name	Scientific name
	MOST SUSCEPTIBLE PLANTS
*Black locust	_Robinia pseudoacacia_ L.
Blueberry	_Vaccinium_ spp. L.
May apple	_Podophyllum peltatum_ L.
Mullein	_Verbascum thapsus_ L.
Nettle	_Urtica dioica_ L.
*Pin cherry	_Prunus pensylvanica_ L.f.
Pokeweed	_Phytolacca americana_ L.
*Prickly ash	_Aralia spinosa_ L.
Sheep sorrel	_Rumex acetosella_ L.
Smartweed	_Polygonum hydropiper_ L.
*Staghorn sumac	_Rhus typhina_ L.
Teaberry	_Gaultheria procumbens_ L.
Twisted stalk	_Streptopus roseus_ Michx.

*Tree species. Names for trees from Little, 1953. Names for other plants from Gray's Manual, 1950.

Table 3.--Days needed for plants to respond to all liquid formulations of dicamba sprayed on foliage during midsummer

Plant susceptibility	Leaf-cupping and stem-twisting	Discolored	Dead
Most susceptible	1/2	3-7	7-10
Intermediate	1-3	3-10	10-21
Least susceptible	3-7	10+	*

*No further damage after 21 days.

Spray concentration did not greatly influence timing of plant response to liquid dicamba (Table 3). Even though highest concentrations often caused quickest response, differences in response time were neither large nor consistent. These results suggest that lower concentrations of liquid dicamba applied early in the growing season also can provide adequate vegetative control.

We try unusually heavy applications of herbicide to attain our objective of barren experimental watersheds. This year our

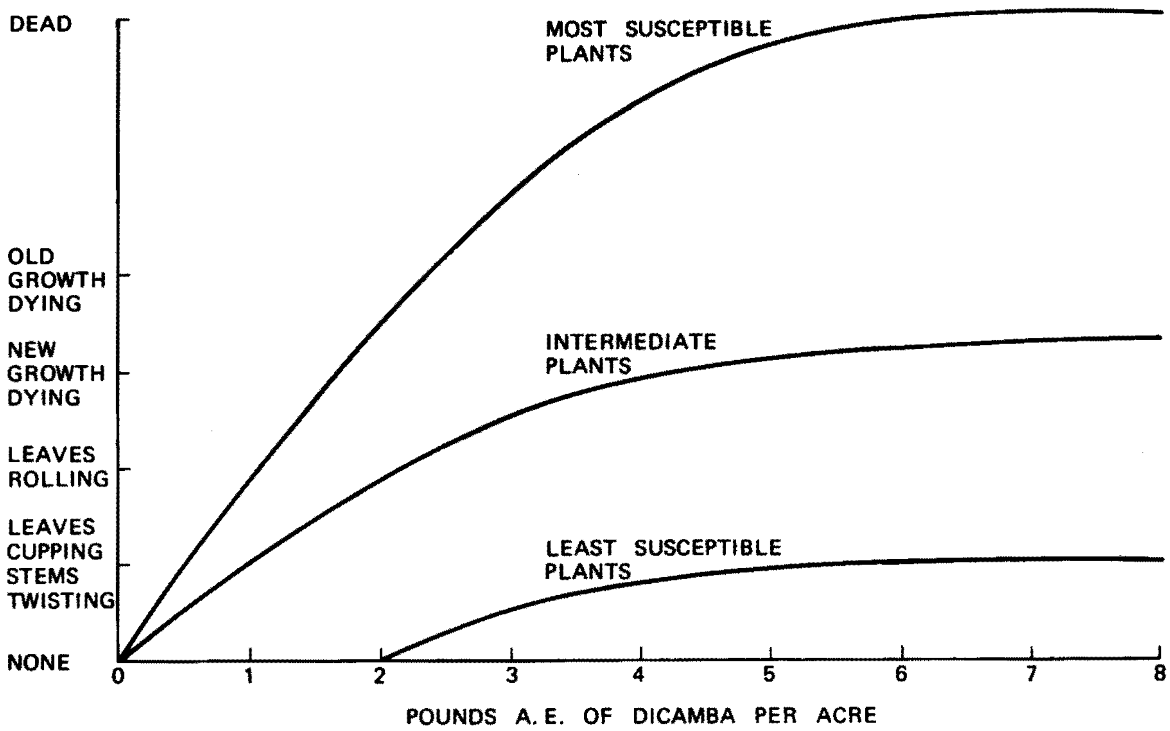
Figure 1.--Excellent revegetation control after mistblowing dicamba with 2,4-D and 2,4,5-T on a deforested watershed. A similarly deforested watershed shows in the background. Photo taken in August.

routine treatment was 8 lb. a.e. each of 2,4-D and 2,4,5-T, costing \$18.68 per acre. Quick and more complete control of vegetation was obtained with 1.5 lb. a.e. of liquid dicamba and 1 lb. a.e. each of 2,4-D and 2,4,5-T at a cost of \$12.09 per acre. Satisfactory control of vegetation was obtained when this formulation was applied late in July (Fig. 1).

Our tests with pelleted dicamba showed that applications of less than 2 lb. a.e. per acre or greater than 6 lb. a.e. per acre have little value (Fig. 2). However, very light pellet applications in June (Table 1) did provide data on responses by sensitive species to minimum treatments which we otherwise could not have observed.

Plants are less responsive to pellets spread on the soil surface than to liquid formulations sprayed directly on the foliage (Fig. 2 and Table 3). This interpretation must be qualified by recognizing that tests with pellets at proper treatment levels took place only after mid-August, when most plant growth had ceased. Our observation that pellets applied before dew had dried from leaves caused greater kill than pellets applied when leaves were dry lends support to this interpretation.

Figure 2.--Plant group response to late summer applications of pelleted dicamba. Early summer application of dicamba pellets would have raised the slope of these curves.



We also observed that 0.4 and 0.6 lb. a.e. per-acre applications in mid-June caused much more damage to all plants than did the 0.5 a.e. per-acre application in mid-August. At neither time did these light applications kill any but the smallest plants of the most susceptible species.

In all tests of pelleted dicamba, responses were greatest among smallest plants. Although we killed a few trees up to 4 inches diameter, they were always of the most susceptible species.

These observations suggest that most success with pelleted dicamba will follow late-spring applications when soil moisture is high and plants are growing most rapidly.

One plant reaction to pelleted dicamba defies close definition (Fig. 3). Apparently any application over 0.5 a.e. per acre at any time of year suspends plant growth, at least for a few weeks. The fireweed (Fig. 3) was starting to flower when 2.0 lb. a.e. per acre of pelleted dicamba was spread on the ground in late August. Flowering and seed-set proceeded normally in the control area, but neither had occurred in the surrounding treated area by

Figure 3.--Flowering fireweed was allowed to develop normally on the plot shown. Pelleted dicamba on surrounding areas has inhibited flower and seed formation.

the first frost in mid-October. The characteristic leaf-cupping caused by dicamba may be additional evidence of suspended growth, because this effect persists throughout the life of the leaf. A phenomenon perhaps related is that vegetative density decreased after spreading of dicamba pellets, even though there was no plant mortality. These plant reactions strengthen our belief that pelleted dicamba will provide best vegetative control if applied early in the growing season.

Conclusions

1. Liquid dicamba (1.5 lb. a.e. per acre) plus 2,4-D and 2,4,5-T (1 lb. a. e. each per acre) gave quick, more complete, and less expensive control of most species than did 8 lb. a.e. per acre each of 2,4-D and 2,4,5-T. Except at very high application rates, dicamba is ineffective on grass.

2. In our tests, liquid formulations provided more effective control of vegetation than did pelleted dicamba.

3. Pellets provided best control with smallest plants of susceptible species.

4. Pelleted dicamba seems to retard development of susceptible plants even when it does not kill them. This effect varies with dosage, plant susceptibility, and moisture availability.

5. Our results suggest that best results with pelleted dicamba would be obtained during the period of most rapid growth. Timing of application is far less critical with liquid formulations.

Literature cited

Fernald, Merritt Lyndon.
1950. Gray's Manual of Botany. 8th ed., 1932 pp., illus. American Book Co., New York.

Little, Elbert L.
1953. Checklist of native and naturalized trees. U.S. Dep. Agr. Handbook 41. 472 pp., illus.

Patric, J. H., and Campbell, John.
1969. A substitute for 2,4,5-T in eastern hardwood sprout and brush control. NE. Weed Control Conf. Proc. 23: 320-328.

Reinhart, K. G.
1965. Herbicide treatment of watersheds to increase water yield. NE. Weed Control Conf. Proc. 19: 546-551.

A THREE YEAR STUDY OF TOTAL VEGETATION CONTROL MATERIALS

George H. Bayer 1/

A large number of soil sterilants or materials useful for total vegetation control are available today.

Notwithstanding the classification given these compounds, it is recognized that they do not sterilize the soil nor render it totally void of vegetation for any extended length of time. Their initial and residual activity, as with other herbicides, is dependent upon the interaction of rate, timing, weed species present, potential invading weed species, rainfall, soil type, etc.

The objective of this study was to evaluate the relative activity of a number of herbicide and herbicide combinations on specific species.

Materials and Methods

The treatments were applied as single applications prior to vegetative growth in April of 1967-1969 - no repeat applications were made. The experimental site was an old alfalfa sod which had been invaded and was now a complex consisting of alfalfa (Medicago sativa), common timothy (Phleum pratense), orchardgrass (Dactylis glomerata), Canada bluegrass (Poa compressa), curly dock (Rumex crispus), burdock (Arctium minus), dandelion (Taraxacum officinale), prickly lettuce (Lactuca scariola), common mallow (Malva neglecta), and redroot pigweed (Amaranthus retroflexus).

The plot size was either 6 x 20 or 6 x 30, and treatments were replicated twice. The liquid materials were applied with a hand carried, CO_2, milk bottle sprayer at 40 psi. and delivering 60 gallons of solution per acre. Granulars were applied by hand or with a hand carried duster.

Ratings by specie were made each year at the end of the growing season - approximately five and seventeen months after application (see tables I, II, and III). A three division scale was used - S = susceptible or essentially 100% control, I = intermediate or variable control, R = resistant species or no control. In addition the percent bare ground was estimated at the end of each season.

1/ Product Development Manager, Chemical Division, Agway Inc., Syracuse, New York

Rainfall was adequate and did not appear to be a differentiating factor. Each year the two months following application (April & May) had between 5½ and 8 inches of rain. In total the effective rainfall for 1967 was 31.75 inches. The following year (1968) had 44.23 inches, and from January through September of 1969 the rainfall was 20.66 inches.

Results and Discussion

Single Herbicide Treatments

When applied at sufficient rates, several of the single herbicide treatments provided good seasonal control although residual control was generally poor.

Nia 11092 (see table I) at 8 and 16 lbs. gave essentially bare ground the first season but allowed bluegrass and timothy to come in the following season.

Bromacil was especially effective in 1969, but the 1967 treatments indicate that bluegrass and deep rooted perennials invade during the second season.

Prometone as an oil formulation (Total) gave good initial knockdown but was ineffective against the established alfalfa. The second year mixed annual grasses and deep rooted perennials became a problem. The granular formulation of prometone (Pramitol 5P) was used at relatively high rates of triazine and could be classified as a mixture due to the borate-chlorate base of this granule. The effectiveness was outstanding, and seasonal control was perfect except for alfalfa.

Another borate-chlorate base granular is Monobor chlorate Granular D which contains 1.2% diuron. This treatment gave fair seasonal control but allowed both broadleaf and grass species to regrow the second season.

Two Herbicide Combination Treatments

Atrazine plus fenac (Rack 10G) initially controlled about one half the species present. Residual was only fair the second season.

A water soluble formulation of amitrole plus bromacil, 66-152, was fairly good on annual grasses and dandelion the first season, but residual activity was poor.

Fenavar granular and 68-40 are similar formulations containing bromacil and fenac. Both gave fair to good control the first season. The 68-40 formulation which was applied in 1968 failed to show any residual activity.

Nia 11092 was used in combination with fenac as a granular (68-85) and failed possibly due to low rates.

Amizine, a commercial formulation of amitrole and simazine, gave good initial activity at the higher rate.

Three Herbicide Combination Treatments

Three way mixtures of bromacil, amitrole and fenac were tested as 66-151 and 67-138. Initial activity was good and directly related to rate. However, even at the highest rate residual was poor.

A combination of Nia 11092, amitrole and fenac (68-46) gave very poor initial control and no residual.

An excellent three way combination was 66-116B (Fenamine) which contains atrazine, amitrole plus fenac. Initial knockdown was excellent since all species were susceptible except alfalfa.

Treatments with Compounds of Unknown Chemistry

AP 920 was first tested in 1969. Therefore, residual activity is unknown. High activity was evident on all species the first season. A wettable powder formulation gave better initial kill than the granular.

Amchem 68-72 WP and 69-82 G have similar but unknown (at this time) chemistry. The wettable powder is somewhat faster acting, but both gave good control at the higher rates.

Summary

The majority of the treatments tested provided good to excellent control of the predominant species for one season. These include combinations of atrazine + amitrole + fenac, bromacil + amitrole + fenac, plus borate-chlorate. Single herbicide treatments which gave good kill include Nia 11092, bromacil and AP 920. Granular materials were generally slower to act than those applied in a solution.

Rate was critical in determining the degree of control, specie selectivity and percent bare ground. Doubling the base rate greatly increased control during the initial season but affected residual control to a far lesser extent.

Initially alfalfa and burdock were the most resistant species. Species which invaded or multiplied in plots treated the previous year included annual grass, annual broadleaf weeds and perennial broadleaf weeds.

Since many of the treatments gave good initial control the first season but "broke" the second season, it is possible that a re-treatment at a relatively low dosage could have extended control.

Further work needs to be done to expand the knowledge of control by chemical x rate x time.

TABLE I

Control by species and percent bare ground following herbicide treatments applied in the spring of 1967 and evaluated in the fall of 1967 and 1968.

Herbicide	Fenamine - Amchem 66-116B				Amchem 67-138				Amizine 1.32 EC			
ai/A	8.5		17.0		9.0		18.0		6.0		12.0	
Year	'67	'68	'67	'68	'67	'68	'67	'68	'67	'68	'67	'68
Species												
timothy	S1/	R	S	S	S	S	S	S	S	R	S	R
orchardgrass	S	R	S	S	S	S	S	S	S	S	S	S
bluegrass	-	-	-	R	-	R	-	R	-	-	-	-
curly dock	-	R	-	-	I	S	S	S	-	-	S	S
burdock	-	-	-	-	-	R	-	-	-	-	-	-
dandelion	-	R	-	R	-	-	-	-	-	-	-	-
prickly lettuce	-	R	-	I	-	R	-	R	-	-	-	R
alfalfa	S	R	S	R	I	R	I	R	R	R	I	R
common mallow	S	S	S	R	S	-	S	S	S	S	S	S
redroot pigweed	-	-	-	R	-	-	-	R	-	-	-	-
% bare ground	80	0	98	10	80	8	98	12	65	15	80	15

Herbicide	Nia 11092 (Tandex 80W)						Rack 10G			
ai/A	4.0		8.0		16.0		8.0		16.0	
Year	'67	'68	'67	'68	'67	'68	'67	'68	'67	'68
Species										
timothy	S	R	S	R	S	I-R	S	R	S	S
orchardgrass	S	-	S	-	S	-	S	-	S	S
bluegrass	-	R	-	R	-	R	-	R	-	-
curly dock	-	-	-	-	-	-	S-I	-	S-I	-
burdock	-	-	-	-	-	-	I	I	S-I	I
dandelion	-	-	-	R	-	-	-	-	-	R
prickly lettuce	-	R	-	R	-	R	-	S-I	-	S
alfalfa	I	R	I	S	S	S	S-I	I-R	S-I	I-R
common mallow	S	-	S	-	S	R	S	R	S	R
redroot pigweed	-	-	-	-	-	-	-	R	-	R
% bare ground	65	0	97	10	99	12	75	10	92	50

Herbicide	Hyvar X 80W				Total		Monobor-chlorate Granular D			
ai/A	5.0		10.0		10.0		5.2		10.4	
Year	'67	'68	'67	'68	'67	'68	'67	'68	'67	'68
Species										
timothy	S	I	S	-	S	I	R	R	S-I	I
orchardgrass	S	-	S	-	S	I	R	R	S-I	I
bluegrass	-	R	-	R	-	-	-	R	-	-
curly dock	R	-	I	-	S	R	R	-	S	-
burdock	-	R	-	R	-	-	-	-	-	-
dandelion	-	-	-	-	-	-	-	I	-	I
prickly lettuce	-	-	-	R	-	-	-	-	-	-
alfalfa	R	-	I	R	I	R	R	R	S-I	I
common mallow	-	-	-	-	-	-	I	-	S	-
redroot pigweed	-	-	-	-	-	-	-	-	-	-
% bare ground	50	15	65	20	70	5	17	5	50	5

1/ S = Susceptible, I = Intermediate, R = Resistant

TABLE II

Control by species and percent bare ground following herbicide treatments applied in the spring of 1968 and evaluated in the fall of 1968 and 1969.

Herbicide	Amchem 66-152				Amchem 66-151				Amchem 68-40				Amchem 68-46				Amchem 68-85				Total	
ai/A	4.0		8.0		6.5		13.0		4.8		9.6		6.0		12.0		4.8		9.6		10.0	
Year	'68	'69	'68	'69	'68	'69	'68	'69	'68	'69	'68	'69	'68	'69	'68	'69	'68	'69	'68	'69	'68	'69
Species																						
timothy	S[1/]	R	S	R	S	R	S	R	I	R	S	R	I	R	S	I	R	R	I	I	S	S
orchardgrass	S	R	S	R	-	R	-	R	I	R	-	R	-	R	-	R	-	R	-	R	-	R
bluegrass	-	R	-	-	-	R	-	R	I	R	-	R	-	R	-	R	-	-	-	R	-	-
curly dock	-	-	-	-	S	-	S	-	R	R	I	-	I	R	I	R	-	R	R	R	-	-
burdock	R	R	R	R	S-I	R	S-I	R	R	R	I	-	R	-	-	-	R	R	-	R	-	-
dandelion	I	-	S	I	S	R	S	I	S-I	R	S	I-R	R	R	I	R	R	R	I	R	S	S
prickly lettuce	-	R	-	R	-	R	-	-	-	-	-	R	-	R	-	R	-	-	-	-	-	-
alfalfa	R	-	I	-	I	R	I	-	R	-	I	R	I	R	I	-	R	-	R	-	R	I
common mallow	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-
redroot pigweed	R	-	I	-	-	-	S	-	R	-	I	-	I	R	I	R	-	R	-	R	-	R
% bare ground	5	0	50	0	15	0	85	2	15	0	85	2	5	0	15	2	0	5	0	2	55	2

Herbicide	Rack 10G				Amizine WP				Fenamine EC				Monobor-Chlorate Granular D			
ai/A	8.0		16.0		6.0		12.0		8.5		17.0		5.2		10.4	
Year	'68	'69	'68	'69	'68	'69	'68	'69	'68	'69	'68	'69	'68	'69	'68	'69
Species																
timothy	R	R	R	R	S-I	R	S	I-R	S	R	S	R	S-I	I	S	I
orchardgrass	R	R	R	R	-	R	-	R	-	R	-	R	-	I	-	I
bluegrass	-	R	-	R	-	R	-	R	-	R	-	-	-	R	-	-
curly dock	S	-	S	-	-	-	-	-	-	-	S	-	-	-	-	-
burdock	I	R	I	I	-	R	I	-	-	R	S	R	-	-	-	-
dandelion	I	R	S	R	I	R	S	R	I	R	S	R	I	R	-	R
prickly lettuce	-	-	-	-	-	-	-	R	-	R	-	R	-	-	-	-
alfalfa	I	-	S	-	R	-	I	R	I	R	-	R	I	R	I	R
common mallow	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
redroot pigweed	S	R	S	R	R	R	S	R	I	-	S	-	-	-	-	R
% bare ground	0	0	5	0	15	0	92	2	60	0	98	2	45	3	63	20

1/ S = Susceptible, I = Intermediate, R = Resistant

TABLE III

Control by species and percent bare ground following herbicide treatments applied in the spring of 1969 and evaluated in the fall of 1969.

Herbicide	AP 920 WP			AP 920 G			Fenavar G		Fenavar WS		Amchem 68-72 WP		Amchem 69-82 4G		Total
ai/A	6.0	8.0	10.0	6.0	8.0	10.0	4.5	9.0	6.0	12.0	8.0	16.0	8.0	16.0	10.0
Species															
timothy	S 1/	S	S	R	S	S	R	S	S	S	S	S	R	S	S
orchardgrass	S	S	S	-	-	-	R	I	S	S	S	S	-	S	S
bluegrass	-	-	-	-	-	-	-	-	-	-	-	-	R	S	-
curly dock	S	S	S	-	-	-	-	-	-	-	S	S	-	-	-
burdock	R	S	S	-	I	I	I	I	R	S	S	S	R	S	I
dandelion	S	S	S	I	S	S	S	S	S	S	S	S	S	-	S
prickly lettuce	S	S	S	-	S	S	-	-	-	S	-	-	R	S	-
alfalfa	I	I	I	R	I	I	R	R	R	I	R	I	-	R	R
common mallow	S	S	S	S	S	S	-	-	-	-	S	S	S	S	-
redroot pigweed	S	S	S	R	I	I	R	S	I	S	S	S	S	-	S
% bare ground	65	90	95	10	50	80	3	45	8	88	50	90	25	93	28

Herbicide	Amchem 66-152 WS		Amizine 1.32 EC		Amizine WP		Fenamine EC		Monobor-Chlorate Granular D		Pramitol 5P		Hyvar X 80W
ai/A	4.0	8.0	6.0	12.0	6.0	12.0	8.0	16.0	5.2	10.4	22.0	44.0	16.0
Species													
timothy	S	S	S	S	S	S	S	S	I	S	S	S	S
orchardgrass	S	S	S	S	S	S	S	S	-	S	S	S	S
bluegrass	S	S	S	S	S	S	S	S	-	-	S	S	R
curly dock	-	-	-	-	-	-	-	-	-	-	-	-	-
burdock	R	-	R	I	-	-	R	S	I	I	-	-	S
dandelion	S	S	I	I	S	S	S	S	-	-	S	-	S
prickly lettuce	-	-	-	-	-	-	-	-	-	-	S	S	S
alfalfa	R	R	R	R	R	R	R	R	R	R	I	I	S
common mallow	S	S	S	-	-	-	-	-	-	-	-	-	S
redroot pigweed	-	-	I	-	S	S	R	S	I	-	S	-	-
% bare ground	10	12	3	15	40	38	19	95	10	42	87	98	99

1/ S = Susceptible, I = Intermediate, R = Resistant

APPENDIX

Chemical names, code numbers, and chemical descriptions of herbicides used in these experiments.

Amchem 66-116B (Fenamine) - 1.- atrazine + .33 amitrole + .55 fenac per gallon.

Amchem 66-151 - amitrole + bromacil + fenac - WS.

Amchem 66-152 - amitrole + bromacil - WS.

Amchem 67-138 - A water soluble mixture of bromacil, amitrole and fenac.

Amchem 68-40 - A granular formulation of 2.67% bromacil + 3.33% fenac.

Amchem 68-46 - amitrole + Nia 11092 + fenac - WP.

Amchem 68-72 WP - Chemistry unknown.

Amchem 68-85 - Nia 11092 + fenac - G.

Amchem 69-82 - Chemistry unknown.

Amizine 1.32 EC - A liquid amizine 1.32 #/gal. (5.1% amitrole + 10.5% simizine).

Amizine WP - 15% amitrole + 45% simazine.

AP 920 G - Chemistry unknown.

AP 920 WP - Chemistry unknown.

Fenavar G - 2.67% bromacil + 3% fenac.

Fenavar WS - bromacil + fenac.

Hyvar X 80W - bromacil.

Monobor-chlorate Granular D - 66.5% sodium metaborate tetrahydrate + 30% sodium chlorate + 1.25% diuron.

Pramitol 5P - 40% sodium chlorate + 50% sodium metaborate + 5% prometone.

Rack 10G - 6.66% atrazine + 3.4% fenac.

Tandex 80W - Nia 11092, 80% m-(3,3-Dimethylureido) phenyl tert-butylcarbamate.

Total - 1.6% prometone.

PICLORAM BASALLY APPLIED FOR BRUSH CONTROL ON UTILITY RIGHTS-OF-WAY

C. S. Williams, B. C. Byrd, W. G. Wright[1/]

Introduction and Background

The advantages of basally applied herbicides are well recognized and include: more selective and positive control of undesired species, less incidence of off-right-of-way damage, and utility of dormant season application which affords an aesthetic value in terms of unnecessary "brown-out" of foliage. The less desirous aspects of basal treatment are the need for oil which is costly and messy to handle and the greater time required to treat an area (although this is a less critical factor during the dormant season).

Each of these factors must be weighed by the individual utility but it appears obvious that the safety and flexibility offered by use of basally applied herbicides dictates their continued and increased usage on utility rights-of-way.

To date, products employed for the control of brush species, applied basally or as a dormant stem, usually have been the ester forms of 2,4,5-T, alone or in equal proportions with 2,4-D. The rate of application for 2,4,5-T varies from 8-16 lb/100 gals and for 2,4-D + 2,4,5-T from 12-16 lb/100 gals, diesel fuel comprising the carrier. Total volume applied depends on brush density, species, the applicator, and the equipment employed. Generally, ash, oak and more difficult to control species require the higher rates. Whether the herbicide is applied with a back sprayer, hydraulic equipment or mist blower will also have an effect on the rate of herbicide and total volume applied.

Finally, an individual applicator, using his own method or technique, is often the principal determining factor in achieving satisfactory control of one or many species.

Keeping the above in mind, from 1966 through 1969 trials were conducted with a new formulation of picloram + 2,4,5-T containing 1 lb picloram + 4 lb 2,4,5-T per gallon as the isooctyl and propylene glycol butyl ether esters respectively.[2/] Amine formulations of picloram have been shown to be effective as foliage sprays, but the same formulations have been less effective on brush when applied as a basal or dormant stem spray (1). The objective of these trials was to determine the effectiveness of picloram + 2,4,5-T on several species at various rates, locations and times of application, applied as a basal or overall dormant stem spray.

1/ Agricultural Department, The Dow Chemical Company, Midland, Michigan.
2/ TORDON 155 Mixture herbicide was the formulation employed. TORDON is a trademark of The Dow Chemical Company.

Locations

The various locations and conditions relating to the applications are presented in Table 1. Method of application in most cases was with a back-pack sprayer. Only in Maine and Ohio was the brush cut the year preceding treatment. No sites had received herbicide treatments closer than three years prior to these applications with picloram + 2,4,5-T.

All basal applications were sprayed 18 inches up the main stem and included good coverage of the root collar. Dormant stem applications provided complete stem coverage and were made during the defoliated period for deciduous trees, and prior to leaf out. Diesel fuel was employed as a carrier in all treatments. Application rates ranged from 54-275 gpa, dependent primarily on density of the brush.

Results and Discussion

The effect of picloram + 2,4,5-T on brush species when applied during the foliage season is shown in Table 2. The data provides some interesting observations:

1. Evaluations made the year of treatment often are meaningless for some species - ash, cedar, elm, hickory and red oak. (Note Indiana data.)

2. Picloram + 2,4,5-T at 1 + 4 lb aehg provided 100% control of aspen, cedar, locust and white oak, white pine and sumac. Slightly less than 100% control was obtained on cherry, elm, red maple, red oak and sassafras with these same rates. While birch control was poor, this may be due to too early an evaluation. Ash control was satisfactory with 2.5 lb picloram + 10 lb 2,4,5-T aehg. These results were better than 8 lb of 2,4-D + 8 lb 2,4,5-T aehg and equivalent to 2,4,5-T at 16 lb aehg.

3. There was little effect of location on results. Use of a power sprayer in Maryland provided control equivalent to that obtained from a back-pack sprayer used in West Virginia the same date.

4. The results with 0.5 + 2 lb aehg of picloram + 2,4,5-T respectively, while only evaluated in Maine, bears further investigation as results appear satisfactory on some species.

The use of picloram + 2,4,5-T applied during bud break (Table 3) indicates the following:

1. Dormant stem treatments of 0.5 lb picloram + 2 lb 2,4,5-T aehg

were considerably better than basal applications at the same rate, as might be expected. Especially noteworthy are the excellent results on ash, oak, sassafras and sumac. Comparable results from dormant stem treatments were shown for 8 or 16 lb aehg 2,4,5-T.

2. In comparison to growing season applications (Table 2), basal bud break treatments resulted in complete control of birch and sassafras with results comparable or better on most other species. Rates above 1 lb picloram + 4 lb 2,4,5-T appear necessary only for ash. Use of 2,4,5-T also performed better with application made at bud break.

3. There appeared to be no effect of location on rate required and in Ohio the use of a power sprayer produced results similar to a back-pack unit employed in Pennsylvania.

When herbicide application was made during the winter season (Table 4) results were as follows:

1. Control with 1 lb picloram + 4 lb 2,4,5-T aehg applied basally, was 100% on hickory, locust, red maple, and sumac. Results on other species were excellent, except for ash where 2.5 + 10 lb aehg appeared necessary for satisfactory control.

2. Dormant stem treatments with 0.5 + 2 lb aehg picloram + 2,4,5-T resulted in excellent control of all species except red oak (60%).

3. Location appeared to play a role in the control of red oak (Mississippi vs. Michigan and Minnesota) where the treatment was applied basally. There was no apparent effect of location on dormant stem applications.

Conclusions

The use of picloram + 2,4,5-T applied as a basal or dormant stem spray offers a method of adequately controlling most brush species found on utility rights-of-way. Particularly noteworthy is the virtually complete control obtained with 1 lb picloram + 4 lb 2,4,5-T aehg on the principal species which tend to resprout after treatment (aspen, locust, maple, oak, sassafras, sumac). Similar results were obtained with dormant stem treatments of 0.5 lb picloram + 2 lb 2,4,5-T aehg.

Control of ash was excellent with the lowest rate of picloram + 2,4,5-T when applied as a dormant stem treatment, but basal applications required 2.5 lb picloram + 10 lb 2,4,5-T aehg, except during bud break. While ash was the most resistant species, birch and cherry control was erratic, due possibly to poor penetration of the bark by the herbicide. Complete kill of birch has been noted to take longer and possibly this accounts for the results presented.

Basal applications made during the winter or summer periods produced similar results, while better control of ash, birch and sassafras was obtained when treatment was made at bud break. On other species, there appeared to be little effect due to season of application.

There was no apparent effect of location, site condition or equipment used on the control achieved.

Basal applications of picloram + 2,4,5-T at 1 + 4 lb aehg respectively should substitute adequately for 16 lb aehg 2,4,5-T. The lower limits of dormant stem rates are less positive, but 0.5 lb picloram + 2 lb 2,4,5-T aehg appears comparable to 8 lb aehg 2,4,5-T.

While these results are indicative of the performance of picloram + 2,4,5-T applied as a basal or dormant stem treatment, they are by no means conclusive. It is recognized that the effectiveness of any application made in this manner is greatly dependent upon the applicator who is able to recognize the species, rate, site condition and environmental factors that may be decisive in the type of control achieved.

Literature Cited

(1) Coble, H. D., R. P. Upchurch and J. A. Keaton, 1969. Response of woody species to 2,4-D, 2,4,5-T and picloram as a function of treatment method, Weed Science 17 (1) 40-46.

Table 1. Location, method of application and site condition for picloram + 2,4,5-T treatments.

City	State	Sprayer	Site Condition
Corbin	Kentucky	Back-pack	Black pine' 30' tall 4" dbh
Indianapolis	Indiana	Back-pack	Brush 6-25' tall 2-4" dbh
Sanford	Maine	Back-pack	Cut in 1967 Brush 4' tall
Oakland	Maryland	Power sprayer	Brush 12-20' tall 1-3" dbh
Woburn	Massachusetts	Back-pack	Brush 20' tall 3" dbh Very dry Brush hardened off
Alpena	Michigan (6-66)*	Back-pack	Brush 30' tall 3-5" dbh
Bay City	Michigan	Back-pack	Ash 6-8' tall 2"dbh
Chase	Michigan (8-66)	Back-pack	Brush 20' tall 2-4" dbh
Sanford	Michigan (11-65) (4-66)	Back-pack	Red oak 3-6' tall 2-4"dbh Aspen 8-12' tall 2-4"dbh
Mound	Minnesota	Back-pack	Brush 20' tall 3"dbh Light snow cover on ground
Starkville	Mississippi	Back-pack	Shortleaf pine 4-9'tall 2-4" dbh Red oak 12-30' tall 2-5" dbh
Killbuck	Ohio	Power sprayer	Cut in 1967 brush 6-8' tall
Allentown	Pennsylvania	Back-pack	Brush 20' tall dbh 1-2"
Fairmont	West Virginia	Back-pack	Brush 6' tall dbh 1-2"

* Dates identify location with treatment in Tables 2, 3 and 4.

Table 2. Percent control of brush species with picloram + 2,4,5-T applied during the growing season as a basal treatment.

Species	Location &	Date Applied	Date Eval.	Chemical	lb aehg applied							
				2,4-D	-	-	-	-	-	-	-	8
				2,4,5-T	2	4	6	8	10	12	16	8
				Picloram	0.5	1	1.5	2	2.5	3	-	-
Ash	Ind.	8-68	12-68		-	-	-	-	10	15	-	-
			5-69		-	-	-	-	80	85	-	-
	Mich.	6-66	7-67		-	-	75	-	-	-	30	-
Aspen	Ind.	8-68	12-68		-	100	-	-	100	-	-	-
			5-69		-	100	-	-	100	-	-	-
	Mich.	6-66	7-67		-	-	94	-	-	-	93	-
	W.Va.	7-67	5-68		-	100	-	100	-	100	-	-
Birch	Maine	8-68	7-69		20	65	-	-	-	-	85	-
Cherry	Ind.	8-68	12-68		-	50	80	60	70	95	-	-
			5-69		-	50	75	60	75	80	-	-
	Maine	8-68	7-69		75	90	-	-	-	-	-	-
	Md.	7-67	7-68		-	100	-	100	-	100	-	-
			7-69		-	100	-	100	-	100	-	-
	Mich.	8-66	7-67		-	-	56	-	-	-	28	-
	W.Va.	7-67	5-68		-	100	-	100	-	100	-	-
Cedar	Ind.	8-68	12-68		-	20	-	-	20	20	-	-
			5-69		-	100	-	-	100	100	-	-
Elm	Ind.	8-68	12-68		-	100	60	100	60	65	-	-
			5-69		-	95	95	95	100	98	-	-
	Mich.	8-66	7-67		-	-	60	-	-	-	-	-
Hickory	Ind.	8-68	12-68		-	-	-	-	20	25	-	-
			5-69		-	-	-	-	100	100	-	-
	W.Va.	7-67	5-68		-	100	-	100	-	100	-	-
Locust	Ind.	8-68	12-68		-	100	100	100	-	-	-	-
			5-69		-	100	100	100	-	-	-	-

Table 2. Percent control of brush species with picloram + 2,4,5-T applied during the growing season as a basal treatment. (Continued)

Species	Location &	Date Applied	Date Eval.	Chemical	lb aehg applied							
				2,4-D	-	-	-	-	-	-	-	8
				2,4,5-T	2	4	6	8	10	12	16	8
				Picloram	0.5	1	1.5	2	2.5	3	-	-
Maple,	Maine	8-68	7-69		85	95	-	-	-	-	-	-
Red	Mich.	8-66	7-67		-	-	60	-	-	-	-	-
	Pa.	6-67	6-68		-	100	-	100	-	100	-	70
			5-69		-	100	-	100	-	100	-	85
	W.Va.	7-67	5-68		-	100	-	100	-	100	-	-
Oak,	Ind.	8-68	12-68		-	-	100	-	100	-	-	-
Chestnut			5-69		-	-	100	-	100	-	-	-
Oak,	Ind.	8-68	12-68		-	-	10	20	10	10	-	-
Red			5-69		-	-	100	95	100	100	-	-
	Maine	8-68	7-69		80	90	-	-	-	-	95	-
	Md.	7-67	7-68		-	95	-	100	-	100	-	-
			7-69		-	98	-	100	-	100	-	-
	Pa.	6-67	6-68		-	93	-	100	-	100	-	50
			5-69		-	98	-	100	-	100	-	65*
	W.Va.	7-67	5-68		-	100	-	100	-	100	-	-
Oak,	Md.	7-67	7-68		-	100	-	100	-	100	-	-
White	Pa.	6-67	6-68		-	100	-	100	-	100	-	90
			5-69		-	100	-	100	-	100	-	100
	Maine	8-68	7-69		95	-	-	-	-	-	98	-
Pine	Maine	8-68	7-69		100	-	-	-	-	-	90	-
Sassa-	Ind.	8-68	12-68		-	75	-	20	100	85	-	-
fras			5-69		-	95	-	90	100	100	-	-
	Pa.	6-69	6-68		-	100	-	100	-	100	-	100*
			5-69		-	100	-	100	-	100	-	100*
	W.Va.	7-67	5-68		-	100	-	100	-	100	-	-
Sumac	Pa.	6-69	6-68		-	100	-	100	-	100	-	-
		5-69	5-69		-	100	-	100	-	100	-	-

* Evidence of resprouting

Table 3. Percent control of brush species with picloram + 2,4,5-T applied during bud break as a basal or overall dormant stem (D.S.) spray.

Species	Location & Date Applied		Date Eval.	Chemical	lb aehg applied							
				2,4-D	-	-	-	-	-	-	-	6
				2,4,5-T	2	4	6	8	12	16	8	6
				Picloram	0.5	1	1.5	2	3	-	-	
Ash	Mich.	4-66	6-66		22	66	-	28	-	45	37	-
	(D.S.)	4-66	6-66		100	100	-	100	-	100	100	-
	Ohio	4-68	5-69		-	85	95	98	-	-	-	85
	Pa.	3-68	5-69		-	85	-	100	-	-	-	-
Aspen	Mich.	4-66	10-66		95	100	-	100	-	100	100	-
	(D.S.)	4-66	10-66		100	100	-	100	-	100	100	-
	Ohio	4-68	5-69		-	100	100	100	-	-	-	95
Birch	Pa.	3-68	5-69		100	100	-	-	-	-	100	-
Cherry	Ohio	4-68	5-69			90	95	100	-	-	-	85
	Pa.	3-68	5-69		90	-	-	75	-	-	65	-
Hickory	Ohio	4-68	5-69		-	95	100	100	-	-	-	95
Locust	Ohio	4-68	5-69		-	100	100	100	-	-	-	98
Maple, Red	Ohio	4-68	5-69		-	98	100	100	-	-	-	90
	Pa.	3-68	5-69		98	98	-	100	-	-	30	-
Oak, Red	Mich.	4-66	10-66		58	100	-	88	-	90	100	-
	(D.S.)	4-66	10-66		85	100	-	93	-	100	90	-
	Miss. (D.S.)	3-66	10-66		100	100	-	100	-	-	-	-
	Ohio	4-68	5-69		-	90	98	100	-	-	-	92
	Pa.	3-68	5-69		90	95	-	-	-	-	100	-
Pine, Black	Ky.	4-67	5-68		-	-	-	-	100	-	-	-
Pine, Shortleaf	Miss.	3-66	10-66		92	90	-	100	-	-	-	-
Sassafras	Ohio	4-68	5-69		-	100	100	100	-	-	-	95
	Pa.	3-68	5-69		100	100	-	100	-	-	-	-
Sumac	Pa.	3-68	5-69		100	100	-	100	-	-	100*	-

* Evidence of resprouting

Table 4. Percent control of brush species with picloram + 2,4,5-T applied during the winter as a basal or dormant stem (D.S.) spray.

Species	Location & Date Applied		Date Eval.	Chemical	lb aehg applied							
				2,4,5-T	2	4	6	8	10	16	12	8
				Picloram	0.5	1	1.5	2	2.5		-	-
Ash(B)	Mich.	12-65	6-66		-	28	35	55	84	57	-	30
	(D.S.)	12-65	6-66		98	99	100	100	-	100	-	100
	Mass.	9-68	6-69		-	50	-	75	-	-	-	
Cherry	Mass.	9-68	6-69		-	85	-	95	-	-	-	-
Elm	Minn.	11-67	6-68		-	98	-	100	-	-	90	-
Hick-ory	Mass.	9-68	6-69		-	100	-	100	-	-	-	-
Locust Black	Mass.	9-68	6-69		-	100	-	100	-	-	-	-
Maple, Red	Mass.	9-68	6-69		-	100	-	100	-	-	95	-
	Minn.	11-67	6-68		-	100	-	100	-	-	-	-
Oak, Red	Mass.	9-68	6-69		-	100	-	100	-	-	-	-
	Mich.	11-65	10-66		-	-	100	70	100	96	-	56
	(D.S.)	12-65	10-66		60	100	100	100	-	100	-	93
	Minn.	11-67	6-68		-	100	-	-	-	-	-	-
	Miss.	1-66	10-66		-	63	62	75	-	86	-	50
	(D.S.)	1-66	10-66		100	100	100	100	-	100	-	100
Pine	Miss.	1-66	10-66		-	10	13	-	65	11	-	31
	(D.S.)	1-66	10-66		90	100	100	100	100	100	-	90
Sumac	Minn.	11-67	6-68		-	100	-	100	-	-	95	-

ANTAGONISM BETWEEN BROMACIL AND PICLORAM

J. P. Sterrett and W. Hurtt[1]

ABSTRACT

It has been known for several years that 4-amino-3,5,6-trichloropicolinic acid (picloram) effectively controls herbaceous and woody broad-leaved plants whereas 5-bromo-3-sec-butyl-6-methyluracil (bromacil) is an excellent grass killer. When combinations of picloram and bromacil in pellet form were applied to the soil with the hope of controlling a wider spectrum of plants they were less effective than when bromacil was applied alone, especially on grasses. As a result of this anomalous behavior a study was conducted in controlled environmental chambers to investigate possible antagonism between bromacil and picloram.

In one experiment two levels of picloram (0.25 and 0.5 ppm), two levels of bromacil (0.1 and 1.0 ppm), and all combinations were applied to the culture solution of 8-day-old bean plants (*Phaseolus vulgaris* L. var. Black Valentine). The plants were grown at 25 ± 2 C and 55 ± 10% RH under 1200 ± 100 ft-c of mixed incandescent and fluorescent light. A 16-hr photoperiod was used. Fresh and dry weights of both shoots and roots were obtained after an 8-day-treatment period. The high level of both bromacil and picloram caused 70 to 80% inhibition of dry weight of both shoots and roots. All combinations were found to be non-additive, and the greatest amount of antagonism was found between the high level of picloram and the low level of bromacil.

Since the data from the field studies showed that the highest degree of antagonism between picloram and bromacil occurred with grasses, another experiment was initiated with oats (*Avena sativa* var. Clintland) which were also grown in solution culture. The oats were germinated in moist paper towels at 18 C and placed in aerated nutrient solution when the roots were 2 to 3 cm long. The plants were grown to the 3- to 4-leaf stage at 20 ± 1 C and 55 ± 5% RH under the same light regime as the bean plants. Treatments which were incorporated in the nutrient solution consisted of seven levels of picloram (0.4 to 12.8 ppm), five levels of bromacil (1.0 to 8.0 ppm), and all combinations. Fresh and dry weight data were obtained for both shoots and roots. The three highest levels of bromacil had essentially the same severe effect. Only the two highest rates of picloram showed substantial injury. The three highest levels of picloram in combination with the lowest level of bromacil caused the highest degree of antagonism. The combinations which contained the high rates of bromacil did not exhibit antagonism.

[1] Plant Physiologists, Plant Sciences Laboratories, Fort Detrick, Frederick, Maryland 21701

THE EFFECTIVENESS OF MAINTENANCE PROGRAMS OF m-(3,3-DIMETHYLUREIDO)PHENYL tert-BUTYLCARBAMATE, VARIOUS HERBICIDES, AND THEIR COMBINATIONS AS SOIL STERILANTS IN THE NORTHEAST

Edward S. Hagood[1/]

Introduction - The discovery of m-(3,3-Dimethylureido)-phenyl tert-butylcarbamate (NIA 11092)[2/] in February of 1964 by the Niagara Chemical Division, FMC Corporation, introduced an experimental compound for testing. A publication (Proc. NEWCC 23:303-319,1969) by this author discussed the herbicidal activity of NIA 11092, the absence of its selectivity in crops, and its development as a soil sterilant, as indicated by seven western New York tests. Results of these 1964 through 1968 tests, when applied in the presence of 48 herbaceous and 17 woody species, suggested patterns of use, formulations, rates and combinations of treatments as soil sterilants. Each test indicated the effectiveness of a program of NIA 11092 treatments.

Rates of 21 sterilants or combinations of sterilants were compared (duration of studies - two to four growing seasons) in the 1969 publication. The two most effective of these, NIA 11092 and bromacil, were selected and their programs were extended for a total of three to five growing seasons. The purpose of this publication is to compare the two selected sterilants at practical and economical rates over extended periods of time. Programs such as these are standard operating procedures in the use of soil sterilants.

Materials and Methods - The identity of each species infesting each test is recorded in the tables. Both the common and botanical names are recorded in the earlier publication.

The sprayer for all treatments was a tractor-mounted unit. Components of the sprayer included a gasoline-driven diaphragm pump, cylindrical tank, by-pass agitation, pressure gauge and appropriate hose to serve a 12-foot boom. Two 3-nozzle booms or a spray gun were employed per plot to treat the sites infested with brush and trees.

[1/] Research and Development, Niagara Chemical Division, FMC Corporation, Middleport, New York.

[2/] Formulations containing NIA 11092 are being developed and sold by the Niagara Chemical Division, FMC Corporation under the trademark "Tandex®".

The weight of chemicals (stated as lb/A of the active ingredient) required for each rate of each treatment was determined. This weight was multiplied by the number of replicates per test plus two, so that one weight plus diluent might be used to fill the sprayer system and one could be discarded after spraying all replicates. The volume of water required to spray each plot was determined. This volume was also multiplied by the number of replicates plus two. Each table shows the active ingredients and additives used. During the spraying operation the boom was moved back and forth across each plot until each volume was uniformly applied at a pressure of 40 psi.

Evaluations of weed, brush and tree kill or injury were made several times to determine the rapidity of action and persistence of each treatment.

Results and Discussion - Four tests were selected from the seven western New York studies and each will be discussed separately. The seven studies resulted in the same responses.

The site of the soil sterilant study, as summarized in Table I and Graphs 1-4, is upon a spur line of the Penn-Central Railroad at Millers, New York. A minimum of maintenance through the years had resulted in severe infestations of 34 herbaceous and woody species at the time of the first applications, July 17, 1967. Rates of 42 experimental or standard sterilants or their combinations were applied in this six-replicate study. Twelve of these were maintained and evaluated through 26 months or for about three growing seasons. This report is concerned with these maintenance programs and their effectiveness.

NIA 11092 and bromacil were applied and compared at rates of 7.5, 5.0 and 3.0 lb/A. These programs and their results are presented graphically in "Test 4". Five evaluations of the NIA 11092 treatments indicated control of 93.1, 90.0, 80.0, 93.2 and 97.7% The 80% control, which occurred just prior to the maintenance rate of 5 lb/A, indicates that the original rate of 7.5 lb/A of NIA 11092, while adequate in control for 13 months, was losing its effectiveness. The NIA 11092 maintenance program of 5 and 3 lb/A resulted in effective vegetation control.

NIA 11092 and bromacil were applied and compared at rates of 10, 3 and 2 lb/A. The programs and their results are presented graphically in "Test 3". Five evaluations of the NIA 11092 program demonstrated control of 90% or better of the 34 species for the duration of the study. Partial escapes following the NIA 11092 sprays were sweet clover, Canada thistle, dandelion and wild carrot. After 13 months the 10 lb/A rates of NIA 11092 and bromacil were equivalent in their control. Thereafter NIA 11092 in its maintenance program was more effective than equivalent rates of bromacil. The escapes following bromacil were common mullein and wild snapdragon.

NIA 11092 and bromacil were applied and compared at rates of 15 + 0 + 3 lb/A. These results are presented graphically in "Test 2". Five evaluations of the NIA 11092 program demonstrated control of 88.6, 99.8, 98.5, 66.5 and 95.0% during the 26-month period. Based upon weed control following 7.5 or 10 lb/A of NIA 11092 in the first application, 15 lb/A is in excess of the rate required for the control of herbaceous species. The omission of the NIA 11092 maintenance program during the second summer extended the 15 lb/A rate beyond its capabilities, as indicated by a 66.5% control during the spring of the third growing season. Control was then returned to the 95% level through the application of 4 lb/A of NIA 11092. A comparison of NIA 11092 and bromacil, each at a rate of 15 lb/A, over a 23-month period, indicates approximately equivalent control through the first four periods of evaluation. A program of 10 + 3 + 2 lb/A of NIA 11092 was more effective and less expensive than a program of 15 + 0 + 4 of the same sterilant.

NIA 11092 and bromacil were applied and compared at rates of 20 + 0 + 2 lb/A. These results are presented graphically in "Test 1". Five evaluations of the NIA 11092 program indicated control of 88.3, 99.8, 99.0, 78.2 and 97.7%. Based upon weed control following 7.5 or 10 lb/A of NIA 11092, 20 lb/A is in excess of the need for the control of herbaceous species. While a maintenance program during the second growing season probably would increase the effectiveness, it is less essential than in the 15 + 0 + 4 lb/A program. A comparison of NIA 11092 and bromacil, each at a rate of 20 lb/A over a 23-month period, indicates approximately equivalent control through the first four periods of evaluation. The maintenance rate of 2 lb/A of NIA 11092, applied after 23 months, resulted in a return to effective control. The NIA 11092 program of 20 + 0 + 2 lb/A was more expensive and less effective than the 10 + 3 + 2 lb/A program.

NIA 11092 was combined with bromacil in the following programs (Table I) - (1) 5 + 5, 0 + 0, 2 + 2; (2) 7.5 + 7.5, 0 + 0 1 + 1; and (3) 10 + 10, 0 + 0, 1 + 1 lb/A. The latter two were effective, while the need for a maintenance application during the second growing season is indicated for the first. Since the escapes or partial escapes were different for NIA 11092 and bromacil, alternating the application of each sterilant or combinations of the two are of promise.

The site of the soil sterilant study, as summarized in Table II and Graphs 5 and 6, is upon the main line of the Penn-Central Railroad at Gasport, New York. Thirty herbaceous and three woody species infested this site at the time of the first treatment, June 22, 1966. Ten treatments of NIA 11092 or bromacil were compared in a four-replicate study. This report is concerned with five of these, their maintenance programs, and their effectiveness over a period of 38 months.

NIA 11092 was applied at 8.8, 3, 3 and 2 lb/A at the start and at the 12th, 24th and 36th month intervals, respectively. Bromacil was applied at 10, 3, 3 and 2 lb/A. These programs and their results are presented graphically in "Test 6". Seven evaluations indicated that both the NIA 11092 and bromacil programs resulted in quite satisfactory and equivalent control. The partial escapes following the NIA 11092 program were dandelion, chicory, wild carrot and milkweed. Of these dandelion and chicory were dominant. The escapes following bromacil were common mullein, field bindweed, wild snapdragon, chicory, many flowered aster and milkweed.

NIA 11092 was applied at 17.6, 3 and 2 lb/A at the start and at the 24th and 36th month intervals, respectively. Approximately an equivalent weight of bromacil was applied, 20 lb/A at the start and 2 lb/A after 36 months. These programs and their results are presented graphically in "Test 5". These data indicate that neither 17.6 lb/A of NIA 11092 nor 20 lb/A of bromacil maintained the first year's effectiveness throughout the second year. To control effectively herbaceous species and to reduce costs, the starting rate should have been approximately 10 lb/A. The next treatment probably should have been 3 lb/A, applied after 12 months. This program should have maintained satisfactory NIA 11092 control by maintaining the level of residues at the surface of the soil.

The site in the soil sterilant studies, as summarized in Tables III and IV and Graphs 7 and 8, was infested at the time of the first treatment, either August 14, 1965 or July 7, 1966, with 17 woody (up to 30 feet in height) and 17 herbaceous species.

In an attempt to answer the question of placement of the NIA 11092 sprays, as applied for tree and brush control, 17.6 lb/A of the active was applied in four treatments as follows: (1) 3/3 on the ground; (2) 2/3 on the ground, 1/3 on the foliage; (3) 1/3 on the ground, 2/3 on the foliage; and (4) 3/3 on the foliage. Table III compares these placements and the maintenance programs which followed. While "Test 7" presents graphically placement of 2/3 on the ground and 1/3 on the foliage, each placement was equally effective (See Table III). Since only a small amount of NIA 11092 is absorbed through the foliage, the results indicate that placement, runoff, rainfall, defoliation, or a combination of these placed the NIA 11092 at the surface of the silty clay loam soil. Excellent control of trees and brush, which followed the 17.6 lb/A NIA 11092 treatment, indicated a movement of the compound through the soil, root absorption, and apparent systemic activity.

Following all placements of the 17.6 lb/A rate of NIA 11092, the control of the herbaceous species ranged from excellent to 82% at 24 months. After 24 and 36 months the maintenance programs for NIA 11092 were 3 + 2 or 5 + 2 lb/A. These programs controlled an average of from 94.6 to 97.2% throughout the remainder of the 38-month period.

Seventeen woody (maximum height 30 feet) and 17 herbaceous species (Table IV) infested this Middleport, N.Y. test at the time of the first soil treatment, August 14, 1965. Other Niagara experimental compounds and their rates were compared with the first NIA 11092 treatment (three replicates) of 20 lb/A. These were less effective and not maintained. The NIA 11092 treatment upon a silty clay loam soil was maintained after 22, 35 and 47 months with 5, 3 and 2 lb/A, respectively, of NIA 11092. The vegetation control over the 49-month period is presented graphically in "Test 8".

Within one month after the first treatment, the leaves of the woody species were from 15 to 100% defoliated. Extent of the defoliation varied with species. The remaining leaves were partially chlorotic and necrotic. Time of death of the woody species was uncertain. When evaluated during the spring of 1966, the treatment providing 97.6% control allowed several species to establish small, somewhat necrotic leaves. These also were defoliated in time. When evaluated during June, 1967; July, 1968 and August, 1968, the control of the woody species was 99.0% or higher. This kill was attributed to the first treatment, 20 lb/A of NIA 11092.

During the 49-month history of this sterilant study, the first NIA 11092 20 lb/A treatment, when maintained with 5 lb/A (22nd month), 3 lb/A (35th month) and 2 lb/A (47th month), had average and minimum control of 94.6 and 90.0% of the herbaceous species.

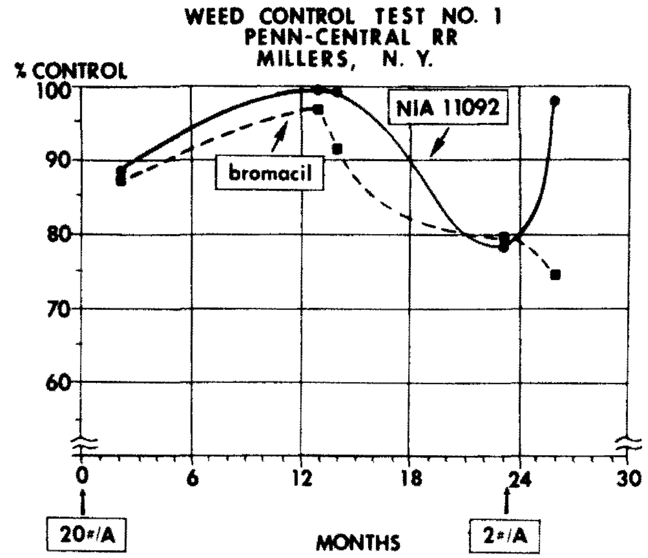
Summary - Five years of field data indicate that a new herbicidal compound, m-(3,3-dimethylureido)phenyl tert-butylcarbamate (NIA 11092), is (1) herbicidally active, (2) non-selective in crops and (3) persistent in its control. NIA 11092 is worthy of development and use as a soil sterilant.

The purpose of this publication is to report upon studies, which have indicated effective, economical, and practical programs. NIA 11092 should be applied at 8 to 10, 3, 3 and 2 lb/A during a four-year period for the control of herbaceous species growing under conditions of the Northeast. For the control of trees and brush the first year's application rate should be raised to 17.5 to 20 lb/A.

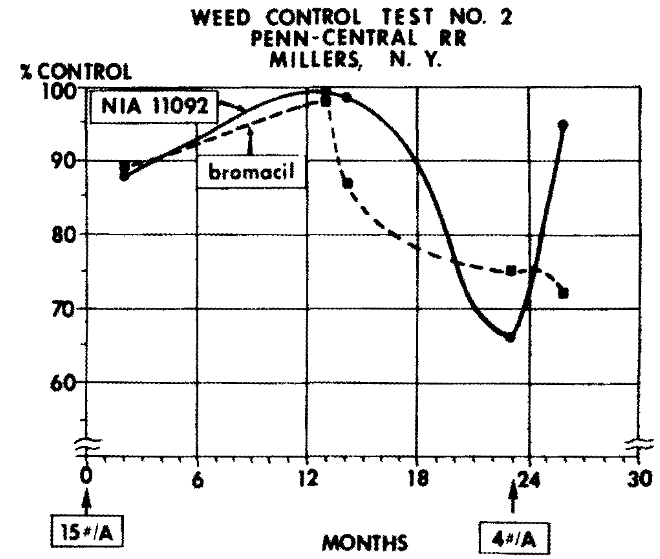
Foliar- or soil-applied sprays have been equally effective with the action of the chemical following movement into the soil, root absorption and apparent systemic activity. Approximately one month is required for the initial responses of the woody species, such as partial defoliation and leaf necrosis.

NIA 11092 plus bromacil, each at one-half of the above rates or the alternation of NIA 11092 and bromacil upon a yearly basis are promising programs.

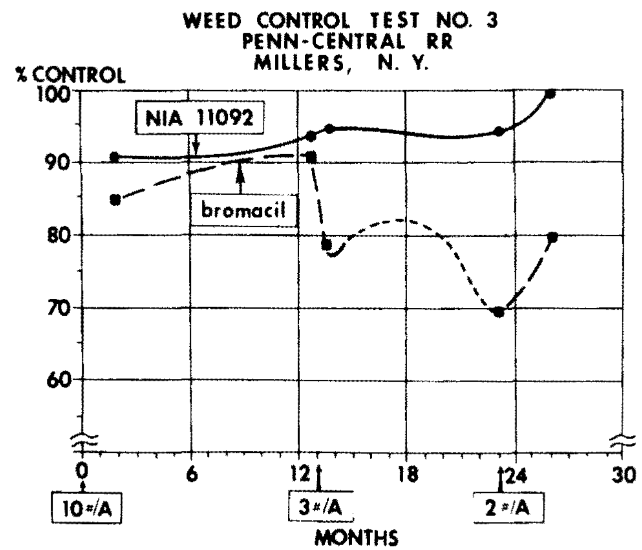
8



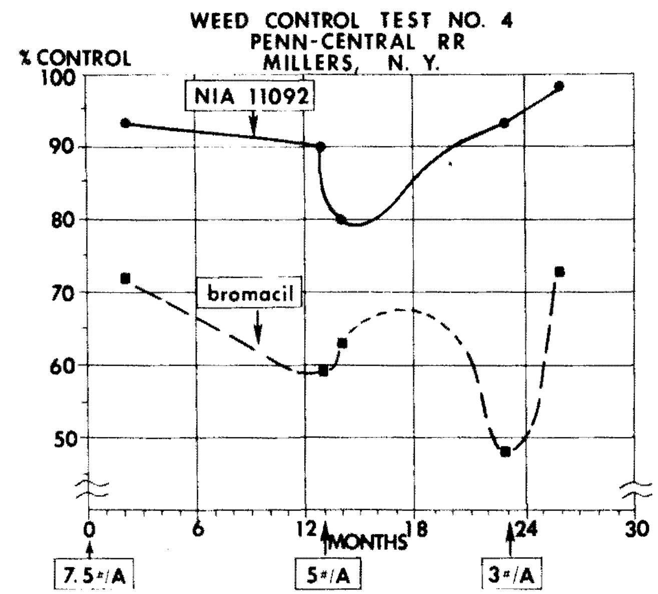
WEED CONTROL TEST NO. 1
PENN-CENTRAL RR
MILLERS, N. Y.
% CONTROL
NIA 11092
bromacil
MONTHS
20#/A
2#/A



WEED CONTROL TEST NO. 2
PENN-CENTRAL RR
MILLERS, N. Y.
% CONTROL
NIA 11092
bromacil
MONTHS
15#/A
4#/A

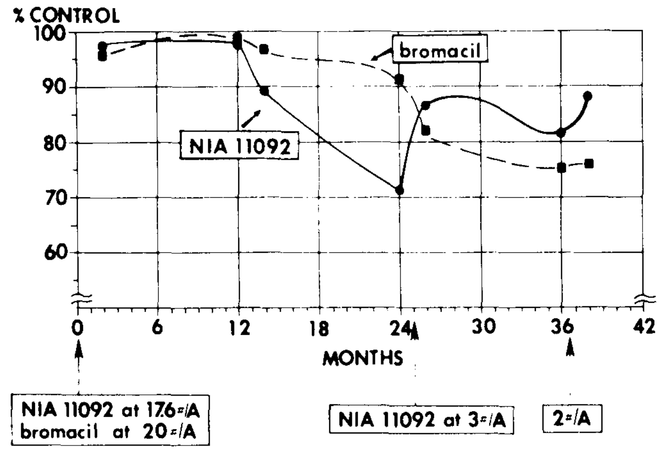


WEED CONTROL TEST NO. 3
PENN-CENTRAL RR
MILLERS, N. Y.
% CONTROL
NIA 11092
bromacil
MONTHS
10#/A
3#/A
2#/A

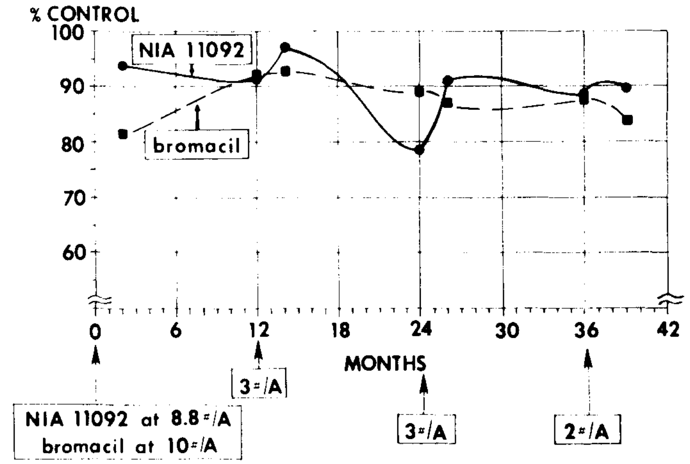


WEED CONTROL TEST NO. 4
PENN-CENTRAL RR
MILLERS, N. Y.
% CONTROL
NIA 11092
bromacil
MONTHS
7.5#/A
5#/A
3#/A

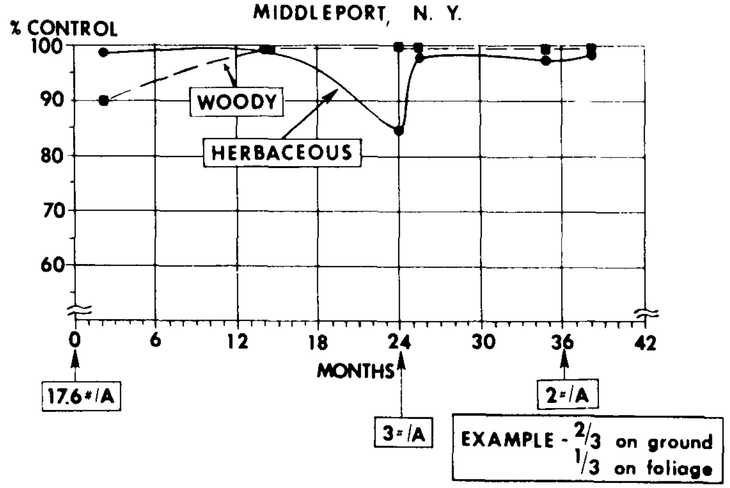
WEED CONTROL TEST NO. 5
PENN-CENTRAL RR
GASPORT, N. Y.



WEED CONTROL TEST NO. 6
PENN-CENTRAL RR
GASPORT, N. Y.



TEST NO. 7
WOODY & HERBACEOUS WEED CONTROL WITH NIA 11092
MIDDLEPORT, N. Y.



TEST NO. 8
WOODY & HERBACEOUS WEED CONTROL WITH NIA 11092
MIDDLEPORT, N. Y.

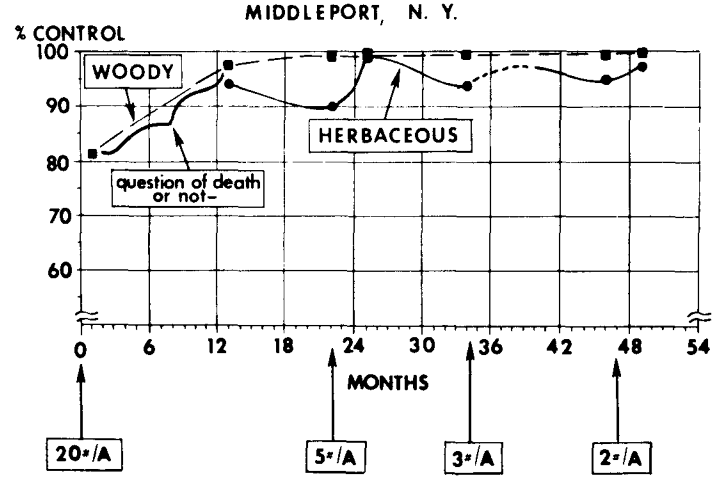


TABLE I

Infestation: (7/17/67) 1 Brambles, 2 field goldenrod, 3 curled dock, 4 common milkweed, 5 wild strawberry, 6 Queen Anne's lace, 7 dogwood (trees), 8 vetch, 9 common mullein, 10 moth mullein, 11 poison ivy, 12 bull thistle, 13 cinquefoil, 14 chicory, 15 alsike clover, 16 spotted knapweed, 17 peppergrass, 18 dandelion, 19 sweet clover, 20 Canada thistle, 21 wild snapdragon, 22 elderberry, 23 horsetail, 24 yarrow milfoil, 25 St. John'swort, 26 self heal, 27 burdock, 28 timothy, 29 quackgrass, 30 orchardgrass, 31 foxtail, 32 teasel, 33 ragweed, 34 apple.

Treated: 7/17/67, Millers, N.Y. - Penn-Central Railroad; Maintenance rates applied 8/15/68 and 6/25/69

Application: Plots 12'x16½', 6 reps

Evaluations: 8/14/67, 9/15/67, 6/24/68, 7/30/68, 8/9/68, 9/23/69, 9/4/69

Treatments 7/17/67	Rate Lb/Acre	Surfactant	% Control 9/15/67	% Control 7/30/68	% Control 8/9/68	Mainten-ance Rates Lb/Acre 8/15/68	% Control 6/23/69	Mainten-ance Rates Lb/Acre 6/25/69	% Control 9/4/69	Partial Escapes
NIA 11092*	7.5	WK	93.1	90.0	80.0	NIA 11092* 5 lb/acre 0.25% WK	93.2	NIA 11092* 3 lb/acre 0.25% WK	97.7	6,19,20, 29,3
NIA 11092*	10	WK	90.2	93.0	94.7	NIA 11092* 3 lb/acre + 0.25% WK	94.2	NIA 11092* 2 lb/acre + 0.25% WK	99.2	19,20,8, 18,6
NIA 11092*	12.5	WK	91.5	98.0	96.0	0	51.5	NIA 11092* 4 lb/acre + 0.25% WK	91.2	17,21,23, 3,20,29, 19,5,8,4

TABLE I Continued

Treatments 7/17/67	Rate Lb/Acre	Surfactant	% Control 9/15/67	% Control 7/30/68	% Control 8/9/68	Mainten-ance Rates Lb/Acre 8/15/68	% Control 6/23/69	Mainten-ance Rates Lb/Acre 6/25/69	% Control 9/4/69	Partial Escapes
NIA 11092*	15	WK	88.6	99.8	98.5	0	66.5	NIA 11092* 4 lb/acre + 0.25% WK	95.0	19,23,8, 21,17,20, 5,3,4,9
NIA 11092*	20	WK	88.3	99.8	99.0	0	78.2	NIA 11092* 2 lb/acre + 0.25% WK	97.7	19,20,17, 21,23,3, 5,8,9
bromacil**	7.5	TMN	72.0	59.0	63.6	bromacil* 5 lb/acre + 0.25% WK	48.0	bromacil* 3 lb/acre	73.3	21,33,34, 30,20,9,1
bromacil**	10	TMN	84.8	91.0	78.0	bromacil* 3 lb/acre + 0.25% WK	69.8	bromacil* 2 lb/acre	79.2	9,21
bromacil**	15	TMN	89.3	98.0	87.3	0	75.0	bromacil* 4 lb/acre	72.8	9,33,21, 19
bromacil**	20	TMN	87.1	97.0	92.6	0	79.2	bromacil* 2 lb/acre	74.8	21,9,19, 1

TABLE I Continued

Treatments 7/17/67	Rate Lb/Acre	Surfactant	% Control 9/15/67	% Control 7/30/68	% Control 8/9/68	Mainten-ance Rates Lb/Acre 8/15/68	% Control 6/23/69	Mainten-ance Rates Lb/Acre 6/25/69	% Control 9/4/69	Partial Escapes
NIA 11092* bromacil**	5+5	TMN	89.0	96.0	90.3	0	51.7	NIA 11092* 2 lb/acre bromacil* 2 lb/acre	87.3	21,19,3, 23,20,2,9
NIA 11092* bromacil**	7.5+ 7.5	TMN	87.8	99.0	98.8	0	79.3	NIA 11092* 1 lb/acre bromacil* 1 lb/acre	91.0	21,23,9, 19
NIA 11092* bromacil**	10+10	WK	89.1	98.0	97.0	0	85.0	NIA 11092* 1 lb/acre bromacil* 1 lb/acre	92.0	9,23,21, 19

*80% WP
**50% XWS

(((

TABLE II

Infestation: (6/22/66) 1 Sedge, 2 wild carrot, 3 quackgrass, 4 timothy, 5 bentgrass, 6 wild buckwheat, 7 cocklebur, 8 dandelion, 9 St. John'swort, 10 indianhemp, 11 evening primrose, 12 upright cinquefoil, 13 prostrate cinquefoil, 14 milkweed, 15 poison ivy, 16 barnyardgrass, 17 green foxtail, 18 yellow foxtail, 19 moth mullein, 20 wild snapdragon, 21 chicory, 22 daisy fleabane, 23 goldenrod, 24 sumac, 25 willow, 26 horsetail, 27 brambles, 28 many flowered aster, 29 ragweed, 30 sweet clover, 31 bull thistle, 32 common mullein, 33 bindweed.

Location: Penn-Central Railroad, Gasport, N.Y.; four replicates

Applications: 6/22/66 and maintenance rates on 6/22/67, 7/2/68, and 7/2/69

Evaluations: 6/21/67, 9/18/67, 6/24/68, 6/23/69 and 9/5/69

Method of Application: Tractor mounted sprayer, 12 ft boom, dilute sprays

Treatment Rates -, Lb/Acre Surfactant, 6/22/66	% Kill 6/21 1967	Maintenance Rates, Applied 6/22/67, Lb/Acre, Surfactant	% Kill 9/18 1967	% Kill 6/24 1968	Maintenance Rates, Applied 7/2/68, Lb/Acre, Surfactant	% Kill 6/23 1969	Maintenance Rates, Applied 7/2/69 Lb/Acre, Surfactant	% Kill 9/5 1969	Partial Escapes
NIA 11092* 4.4 lb 1% WK	55.3	NIA 11092* 5 lb 1% WK	92.3	76.7	NIA 11092* 3 lb 0.25% WK	84.8	NIA 11092* 2 lb 0.25% WK	87.5	8,21,2
NIA 11092* 8.8 lb 1% WK	91.0	NIA 11092* 3 lb 1% WK	97.3	78.5	NIA 11092* 3 lb 0.25% WK	88.3	NIA 11092* 2 lb 0.25% WK	89.8	2,14,8,21
NIA 11092* 17.6 lb 1% WK	97.8	None	89.3	71.3	NIA 11092* 3 lb 0.25% WK	81.5	NIA 11092* 2 lb 0.25% WK	88.0	14,21,2

TABLE II Continued

Treatment Rates -, Lb/Acre Surfactant, 6/22/66	% Kill 6/21 1967	Mainten-ance Rates, Applied 6/22/67, Lb/Acre, Surfactant	% Kill 9/18 1967	% Kill 6/24 1968	Mainten-ance Rates, Applied 7/2/68, Lb/Acre, Surfactant	% Kill 6/23 1969	Mainten-ance Rates, Applied 7/2/69 Lb/Acre, Surfactant	% Kill 9/5 1969	Partial Escapes
bromacil** 10 lb	91.3	bromacil** 3 lb	91.6	89.0	bromacil** 3 lb	87.5	bromacil** 2 lb	83.7	33,21,14, 32,20,28
bromacil** 20 lb	98.7	None	96.7	92.3	None	75.3	bromacil** 2 lb	76.0	32,23,21, 20,33

*80% WP
** 50% XWS

TABLE III

Infestation: (7/7/66) Thornapple, apple, ash, grape, silky dogwood, elm, aspen, chokecherry, maple, cherry, blackberry, dewberry, poison ivy, ligustrum, sumac, elderberry, beech (maximum height 25 ft.)
Perennials: Hopsedge, dandelion, sedge sp., quackgrass, yarrow, selfheal, St. John's-wort, catnip, upright cinquefoil, red sorrel, wild snapdragon, chicory, goldenrod
Biennials: Wild carrot, teasel
Annuals: Timothy, horseweed
Location: Middleport, N.Y.
Application: Soil and foliar, and all combinations as dilute sprays
Treated: 7/7/66, 7/8/68, and 7/7/69
Evaluated: 9/14/67, 7/5/68, 8/27/68, 6/23/69 and 9/5/69

Treatment - Rate Lb/Acre, Surfactant, 7/7/66	Placement Of Spray	% Tree & Brush Kill 9/14/67	% Weed & Grass Kill 9/14/67	% Tree & Brush Kill 7/5/68	% Weed & Grass 7/5/68	Maintenance Rates, Applied 7/8/68, Lb/Acre, Surfactant	% Tree & Brush Kill 8/27/68	% Weed & Grass Kill 8/27/68	% Tree & Brush Kill 6/23/69	% Weed & Grass Kill 6/23/69	Maintenance Rates, Applied 7/7/69, Lb/Acre, Surfactant	% Tree & Brush Kill 9/5/69	% Weed & Grass Kill 9/5/69
NIA 11092* 17.6 lb/A 1% WK	3/3 on ground	100	99	99	82	NIA 11092* 5 lb/A 0.25% WK	99	99	99	95	NIA 11092* 2 lb/A 0.25% WK	98	99
NIA 11092* 17.6 lb/A 1% WK	2/3 on ground 1/3 on foliage	99	99	100	86	NIA 11092* 3 lb/A 0.25% WK	99	98	100	98	NIA 11092* 2 lb/A 0.25% WK	100	99

TABLE III Continued

Treatment - Rate Lb/Acre, Surfactant, 7/7/66	Placement Of Spray	% Tree & Brush Kill 9/14/67	% Weed & Grass Kill 9/14/67	% Tree & Brush Kill 7/5/68	% Weed & Grass Kill 7/5/68	Maintenance Rates, Applied 7/8/68, Lb/Acre, Surfactant	% Tree & Brush Kill 8/27/68	% Weed & Grass Kill 8/27/68	% Tree & Brush Kill 6/23/69	% Weed & Grass Kill 6/23/69	Maintenance Rates, Applied 7/7/69, Lb/Acre, Surfactant	% Tree & Brush Kill 9/5/69	% Weed & Grass Kill 9/5/69
NIA 11092* 17.6 lb/A 1% WK	1/3 on ground, 2/3 on foliage	97	99	99	87	NIA 11092* 5 lb/A 0.25% WK	99	99	99	95	NIA 11092* 2 lb/A 0.25% WK	99	96
NIA 11092* 17.6 lb/A 1% WK	3/3 on foliage	98	96	100	82	NIA 11092* 3 lb/A 0.25% WK	99	94	100	86	NIA 11092* 2 lb/A 0.25% WK	100	92

*80% WP

TABLE IV

Infestation: (8/14/65)	Thornapple, apple, ash, grape, silky dogwood, elm, aspen, chokecherry, maple, cherry, blackberry, dewberry, poison ivy, ligustrum, sumac, elderberry, beech (maximum heights 30 ft.)
Perennials:	Hopsedge, dandelion, sedge sp., quackgrass, yarrow, selfheal, St. John's-wort, catnip, upright cinquefoil, red sorrel, wild snapdragon, chicory, goldenrod
Biennials:	Wild carrot, teasel
Annuals:	Timothy, horseweed
Location:	Middleport, N.Y.
Application:	Soil treatments, dilute sprays, 40 psi, tractor-mounted sprayer, three replicates
Treated:	8/14/65, 6/28/67, 7/8/68 and 7/7/69
Evaluated:	6/28/67, 7/5/68, 6/23/69 and 9/5/69

Treatment, Rate, Date - 8/14/65	% Kill of Woody Species-6/28/67	% Kill of Weeds & Grasses-6/28/67	Maintenance Rate 6/28/67	% Kill of Woody Species-7/5/68	% Kill of Weeds & Grasses-7/5/68	Maintenance Rate 7/8/68	% Kill of Woody Species-6/23/69	% Kill of Weeds & Grasses-6/23/69	Maintenance Rate 7/7/69	% Kill of Woody Species-9/5/69	% Kill of Weeds & Grasses-9/5/69
NIA 11092* 20 lb/acre + 1% WK	99	90	NIA 11092* 5 lb/acre + 0.25% WK	99	95	NIA 11092* 3 lb/acre + 0.25% WK	99	96	NIA 11092* 2 lb/acre + 0.25% WK	100	97

*80% WP

A PROPOSED MECHANISM OF ACTION FOR CACODYLIC ACID IN PLANTS

Frank B. Anastasia,[1] Roy M. Sachs,[1,2] and William A. Wells[1]

ABSTRACT

Using plants grown in solution culture, root-applied inorganic sodium arsenite (As III) and sodium arsenate (As V) are 100- and 10-fold more effective growth inhibitors, respectively, than cacodylic acid (dimethylarsinic acid). Although equivalent amounts of total arsenic were found in both As V and cacodylic acid treated plants, an 84% reduction in plant growth was observed in the As V-treated group while no growth reduction was observed in the cacodylic acid group. A similar comparison between the As III and cacodylic acid treatments shows that As III is over nine times more effective than cacodylic acid per ug arsenic found in treated tissue.

Chromatographic analyses of plant extracts from cacodylic acid treated plants shows that up to 30% of the arsenic present is as As V. Non-organic As V has been found in both the roots and tops of cacodylic acid treated Black Valentine bean plants. In the case of root applied cacodylic acid, the greatest amount of free As V occurred in the roots. Greater than 50% of the total root arsenic exists as "free" inorganic As V. Arsenic III has not been found in cacodylic acid treated plants, suggesting that further reduction from As V to III does not occur naturally. These data suggest that the methyl groups of cacodylic acid may be hydrolyzed in plant tissue, thus forming a more phytotoxic form of arsenic (As V).

It is well known that cacodylic acid is more effective than inorganic As V when foliar-applied. An apparent explanation for this phenomenon is that foliar absorption and movement of cacodylic acid is greater than that for inorganic As V. As with root applied cacodylic acid a substantial amount of the arsenic found in leaves, up to 20% at 24 hours after treatment, exists as inorganic As V. This is additional evidence favoring the hypothesis that at least one of the herbicidal roles of cacodylic acid in plants is to act as a source of inorganic As V. It remains to be shown whether cacodylic acid itself is non-herbicidal.

[1] Plant Physiologists, Plant Sciences Laboratories, Fort Detrick, Frederick, Maryland 21701
[2] On leave from the University of California, Davis, California 95616

UTILIZATION OF KNAPSACK MIST BLOWERS FOR CHEMICAL BRUSH CONTROL

Richard L. Dolton[1]

The Potomac Edison System relies heavily on the use of chemical herbicides for the control of brush on its rights of ways as we have found this method to give the most economical and lasting results.

Unfortunately, there is no one chemical or method of application that gives "one shot" root kill. Successful chemical brush control is the result of planning, programming, and the utilization of the best method of application and formulation available for the species, height and density of brush present.

Potomac Edison uses aerial application, along with the standard stem-foliage application using four-wheel drive trucks equipped with high pressure spray equipment. In addition, dormant cane and basal applications were utilized using the four-wheel drive spray trucks.

As brush density decreased, we were faced with the dilemma of light or medium density brush composed of resistant species remaining on the rights of ways. We had the formulations and equipment to handle this situation, however, it was felt that there had to be a more economical method than those at hand. We started out to find one.

In May 1966, we discussed the feasibility of the knapsack mist blower technique with Mr. Paul S. Asplundh relative to chemical brush control. As a result of this conversation, we had an interesting session with Mr. Larry Otto of The Asplundh Tree Expert Company.

Mr. Otto was firmly convinced of the merits of the mist blower and Potomac Edison decided that work with this equipment should be tried on an experimental basis.

During May and June of 1966, experimentation was started on approximately 20 acres utilizing a solo mist blower by our Western Division Forester using a stem-foliage application.

The basic experiment is in the data below.

<u>Transmission Line</u> - RJU, Structures 10-20
- <u>Date</u> - 5/28/66 - 6/11/66
- <u>Crew</u> - 1 foreman, 2 sprayers
- <u>Equipment</u> - 2 solo mist blowers, 1 supply truck
- <u>Species</u> - mixed hardwoods; oak, maple, ash, hickory, locust, sassafras, and some pine
- <u>Acres</u> - 20.2
- <u>Gallons of Acid</u> - 69
- <u>Gallons of Acid/Acre</u> - 3.5 gallons
- <u>Cost/Acre</u> - $52.47

---

[1] System Forester, The Potomac Edison Company, Hagerstown, Maryland

#1 Chemical: Asplundh 182A brushkiller, 216 D and T ester formulation
Mix: 1 gallon chemical plus 3 gallons of water

#2 Chemical: Weedone 64 brushkiller, 416 D and T ester formulation
Mix: 1/2 gallon chemical plus 3-1/2 gallons of water

Results were checked the latter part of July 1966 for coverage and an excellent "brown-out" had resulted. There was some off right of way damage noted especially on locust. Off right of way damage was no greater than might be expected if conventional spray rigs had been used, however, its presence started us thinking about thickening agents.

Use of the mist blower indicated that a possible different application was open to us giving a better kill, possible 80% kill, using a lot less chemical mix per acre.

At this point we were not ready to apply the technique on a system wide application as we needed to find out more about drift, possible mixes that might give a higher degree of kill, and the feasibility of using the mist blower for basal spraying. With these factors in mind, further experimentation was carried out.

Various companies and individuals aided us in our experimental work.[2]

On the basis of the observations relative to drift, there was no doubt that a thickening agent was going to be necessary, if the mist blower was going to be used for stem-foliage work. Experiments were set up to determine which of three thickening agents showed the most promise.

Two of the agents tried presented real difficulties at the recommended concentrations. They would not flow through the orifices of the mist blower.

When thinned out, one product became rather lumpy, and the other had too many fine particles, and free water left. These fine particles had a tendency to bounce off the foliage of the brush.

Drift-off the test plots was measured using sensitivised paper.

Vistik at the rate of 2.5 - 3.0 lbs. per 100 gallons of water performed best. This gives a viscosity reading of between 18-20 seconds measured by the vistik viscosity cup. To every 100 gallon of mix, we added approximately 1/4 lb. of soda ash (sodium carbonate) to speed the solution rate of the vistik.

Another advantage noted given by the use of the thickening agent was a rather sticky film which minimized loss of chemical from the foliage.

We now felt safe to proceed with stem-foliage mist blower work and during 1968, five crews worked on distribution spraying and four crews on transmission spraying. A total of four spray claims were all that resulted from spraying nearly 200 miles of line.

---

[2]Dr. W. E. Chappel, The Asplundh Tree Expert Company, The F. A. Bartlett Tree Expert Company, Amchem Products, Inc., The Dow Chemical Company and Hercules, Inc.

Application procedure for mist blower stem-foliage follows very much the pattern for hydraulic methods to the point of wetting the stems, branches, and foliage. It is not necessary to obtain the characteristic run-off or drip of chemical that is so needed in hydraulic spraying. The plant being sprayed only needs to be wet.

The basic crew make up was composed of three men, two mist blowers, and a four-wheel drive Ford Bronco spray truck for transmission line spraying. A pickup truck was used for distribution spraying. The truck carried 75-100 gallon tank with 2-paddle agitation.

Real economics is realized here in both men and equipment as a hydraulic crew needs two pieces of equipment, a spray truck and a supply truck. Usually at least five men are necessary for hydraulic spraying. There is a savings of approximately $6.00 per hour on men and equipment when using a mist blower crew.

After testing many formulations and chemicals, we are now using the following mixtures and chemicals on the Potomac Edison System.

Stem-Foliage Spraying

1. Eight gallons of Tordon 101 plus eight (8) gallons of Weedar to eighty-four gallons of H_2O.

2. Twelve and one-half (12-1/2) gallons of Tordon 101 to eighty-seven and one-half (87-1/2) gallons of H_2O.

Mixture number two is used on lines having a brush problem with a very high percentage of root suckering species such as locust, sassafras, and ailanthus.

Random samplings were conducted by Mr. Curtis G. Foreback and myself on some of the stem-foliage mist blower spraying that was done in June and July of 1968.

Results are listed below:

Stem-Foliage Application

Plot #1 Tordon 101 - 12-1/2 gallons of Tordon to 87-1/2 gallon of H_2O.
Sprayed July 1968, Evaluated October 1969

Species	0	1	2	3	4
Rock Oak				1	2
Red Oak			1	3	5
White Oak					5
Red Maple				1	6
Wild Cherry					1
Dogwood					3
Hazelnut					7
Sugar Maple					2
Birch					13
Total			1	5	44

88% of stems dead

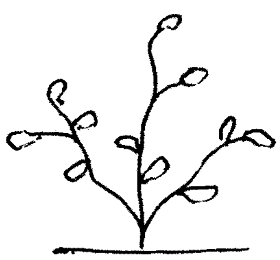
49 dead to ground line
or 98%

Plot #2 Tordon 101 & Emulsamine - 8 gallons of Tordon 101 plus 10 gallons of Emulsamine to 82 gallons of H_2O.

Species	0	1	2	3	4
Pine					7
Red Oak		11			25
Crataegus Sp.		2		1	2
White Oak					6
Birch					1
Total		13		1	41

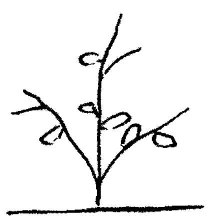
42 dead to ground line or 76%

Key - 0-4



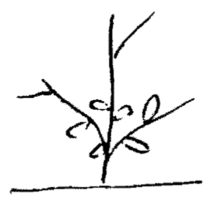
0

No Affect



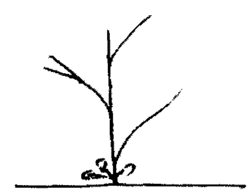
1

Less than 50% Defoliated



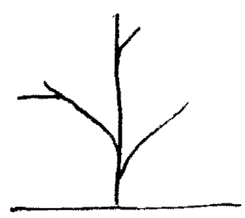
2

More than 50% Defoliated



3

Dead to Ground but Sprouting



4

Dead - No Sprouts

At first we were somewhat concerned over the differentiation in kill on red oak between plot #1 and #2 A careful examination indicated that this was due to substandard application rather than chemical deficiency. These plots were chosen at random from a sprayed line rather than being established formal plots. Human error is much more pronounced than in the formal plot. The brush height on these areas averaged 5' - 6' and the density medium.

Stem foliage mist blower application may require 10-25 gallons of mix per acre depending on the height and density of the brush. During 1968, Potomac Edison averaged 18 gallons of chemical mix per acre at a cost of $58.00 per acre of brush sprayed. Probably this would average out to brush of medium to heavy density approximately five feet in height.

Our next thought on the use of mist blowers for chemical application turned logically to their use for dormant basal work.

Little was known in this area relative to mixtures, therefore, a great deal of work was necessary to determine an economical mixture yielding a high degree of kill.

We are now using the following mixtures:

<u>Basal Spraying</u>

1. Fourteen (14) gallons of Ester D and T brushkiller (4 lbs. ac/gal.) to eighty-six (86) gallons of No. 2 fuel oil or transformer oil.

2. Three and one half (3-1/2) gallons of Tordon 155 to ninety-six and one half (96-1/2) gallons of No. 2 fuel oil or transformer oil.

Listed below are two plots selected at random.

<u>Basal Application</u>

<u>Plot 1-A</u> <u>Weedone</u> - 14 gallons of Weedone to 86 gallons of oil, Sprayed April 1969, Evaluated October 1969

Species	0	1	2	3	4	Root Suckering	
Red Oak		10			33		
White Oak							
Hickory					1		
Crataegus Sp.					1		57 dead to
Sassafras					7		ground line
Black Gum						8	85%
Pine (Yellow)					1		
Red Maple					3		
Birch					1		
Total		10			49	8	

<u>Plot 2-A</u> <u>Tordon 155</u> - 3-1/2 gallons of Tordon 155 to 96-1/2 gallons of oil. Sprayed April 1969, Evaluated October 1969

Species	0	1	2	3	4	Stems Green	
White Oak		1			12		
Walnut					2		
Red Maple					12		
Elm					2		
Black Birch					6	3	
Black Cherry					1		
Spice Bush					10		
Crataegus Sp.				1	5		120 dead to ground
Sumac					1		line 88%
Red Bud					5		
White Ash						1	

Plot 2-A - Continued

Species	0	1	2	3	4	Stems Green
Basswood					5	
Black Locust		5			20	
Pine (Yellow)					3	
Red Oak		10			42	
Hickory					1	
Total		16		1	117	4

It will be noted that some species sprayed would ordinarily be saved during a selective basal, however, we were interested in the spectrum of the herbicides used.

We are more than satisfied that mist blower basal application is a most valuable method. I am always a bit uneasy in presenting evaluations after only one growing season, however, stems rated 4 when cut with a knife were completely dead, no signs of green.

Costs for basal application will average between \$65 - \$70 per acre. Hydraulic basal on the same height and density of brush will average in cost approximately \$90 - \$125 per acre.

The economics of cost are the factor which make mist blower basal applications so important. Lines having tall, dense brush, can now be handled more economically by mist blower than any other method of treatment we have to date.

As with stem-foliage application, technique is most important in basal application. Stems are wettened from root collar to 12 - 14 inches above ground line, however, it does not appear necessary to obtain the rundown of chemicals on the stem that is needed in hydraulic basal spraying. <u>Mist blowers should operate at idling speed or just above</u> to cut down on chances of drift.

If the above precaution is followed, off right of way damage should be negligible.

It was noted that some off right of way damage was present when using an ester formulation prior to and during bud break. Therefore, a safe rule might be to stick with Tordon 155 from the beginning of April for basal work. Little damage was observed from Tordon 155 with the exception of a slight cupping on adjacent low shrubs, trees, and brush that might have been caused by the 2, 4, 5 T in the Tordon through volatilization or slight drift.

We will continue to test new chemicals or formulations working toward a better kill.

We have used two different mist blowers on our property; one is the KWH, and the other, the Solo.

The machine weighs between 23 - 25 lbs. empty and has a tank capacity of three gallons giving a weight of approximately 50 lbs. when full.

We were a bit concerned at first that a load such as this might prove quite tiring to the men packing them. Inquiries were made among the crews using the mist blowers, and without exception all of the men said they would rather use the machines than to drag hose. Again this year, they reiterated that they would prefer to do the spray work with mist blowers.

Both of the machines that we used performed adequately for the job involved.

We feel that there are many things to be learned relative to the mist blower and its application to chemical brush control.

We are firmly convinced from the evidence of our field work that the proper application of the knapsack mist blower can result in savings of $30 to $40 per acre sprayed in relation to chemical brush control.

DISTRIBUTION OF ^{14}C-PICLORAM WITH TIME IN THE BLACK VALENTINE BEAN

W. Hurtt, W. A. Wells, and C. P. P. Reid[1]

ABSTRACT

Bean plants (Phaseolus vulgaris L.) were grown in aerated nutrient culture at 25.3 ± 0.2 C, 50 ± 2% RH, and a 16-hr photoperiod of 1600 ± 100 ft-c of light. Five 10-µl droplets of ^{14}C-carboxyl labeled 4-amino-3,5,6-trichloropicolinic acid (picloram) containing 0.2% Tween 20 were applied to each primary leaf of seven-day-old plants with three trifoliolate leaves. The total dose per plant was 25 µg (0.1 µc). Duplicate plants were harvested at varying time intervals up to five days after treatment and processed for autoradiography by standard freeze-drying procedures. The plants were then exposed to X-ray film for five weeks.

Six hours after treatment marked epinastic symptoms were readily observable. Continued acropetal translocation of picloram twelve hours after treatment was evidenced by approximately 180 degrees curvature of the upper stem. The appearance of label in the roots showed that basipetal translocation of ^{14}C had also occurred. However, the heaviest labeling was found in the terminal bud and the trifoliolate leaf just below the terminal bud. At 24 hours the image of the entire stem was quite prominent. Evidence for movement to regions of high metabolic activity was shown by the density of the axillary bud images. Continued accumulation of label in the stem was evident at 48 hours. Excellent evidence for bidirectional movement of picloram was observed in the three-day plants which showed heavy labeling both above and below the primary leaf node. Four- and five-day plants differed only in that they showed an increased accumulation of C^{14} in the terminal bud and stem.

[1]Plant Physiologists, Plant Sciences Laboratories, Fort Detrick, Frederick, Maryland 21701

THE SIGNIFICANCE OF HERBICIDES TO NON-TARGET ORGANISMS

W. R. Mullison[1]

I. INTRODUCTION

When herbicides are applied they may reach areas or organisms not intended to be treated. This is an investigation of some possible hazards of herbicides to nontarget organisms and considers the main ways in which weedkillers may contact such organisms. This requires a study of the behavior of herbicides in air, soil and water, their persistence in these media, and their possible accumulation and metabolism in living organisms. Analytical methods are becoming increasingly sensitive and in more and more cases trace amounts of various herbicides are likely to be found. However, the real question is interpreting the significance and importance of the occurrence of such small quantities as fractions of parts per million and parts per billion. The organization of this information is such that specific herbicides may be discussed in more than one place.

II. SPRAY DRIFT AND VOLATILITY

Two prime methods of movement of herbicides during and following application are spray drift and volatility.

It is generally agreed that spray drift off the target area is the most important hazard to non-target organisms (11,15,28). Herbicides are usually applied as sprays, and air currents may carry small droplets through the atmosphere beyond the target area. To illustrate, a water droplet 100 microns in diameter, as in a mist, will take 10 seconds to fall 10 feet in still air; it will travel 40.9 feet in falling 10 feet in a 3 mile-per hour breeze (5). Liquid droplets obey chiefly physical laws, and their behavior is affected by ambient conditions (7,11,19,26,28, 31). In addition, their behavior is governed by the chemical and physical nature of the weed killer formulation.

The size of the spray droplets produced are dependent upon the pressure employed and the size and shape of the orifice. Droplet size, orientation of nozzle, amount of wind, and evaporation rate are all pertinent, as are specific gravity, surface tension, viscosity, and vapor pressure. Whether the sprays themselves are conventional liquid sprays, oil-in-water

---

1 The Dow Chemical Company, Midland, Michigan

or water-in-oil emulsions, thickened or particulate sprays are also important. Weather conditions are contributing factors. These include temperature, barometric pressure, relative humidity, wind speed and direction, temperature inversion or fog. Add to these factors of personal judgment, commitment and technical competence and one can see that spray drift is an involved problem.

Evidence suggests that the application of droplets 5 to 50 microns in diameter is optimum for biological activity, particularly for insecticide and fungicide use. Application distance (spray nozzle to target) and this effect on deposition becomes a problem with such small droplets (9,24,26). If the droplets are smaller, the hazard goes up quite drastically, even at low wind speeds of 2 miles per hour (11,21,28). Production of the majority of droplets larger than 500 microns may reduce performance; therefore, safe and effective operation becomes a practical matter of a compromise (11,28), and 150 to 300 microns is generally considered best (11,28).

Use of systemic herbicides permits use of larger droplets which are within the limits of a "drift-safe" size since with this type of weedkiller it is not necessary to achieve the complete plant coverage desirable with other types.

To avoid problems of drift, various types of application systems have been developed besides spraying: "wipe-off" devices, aerosol foams, single-plant applicators in stick or tube form and granular or pelleted materials. One patent (8) entails the use of an "ooze bar", which is also a "wipe-off" device. Commercial operations have found these approaches, with the exception of dust-free granular or pelleted materials, usually impractical for large scale operations. As a result, droplet size control is the most common approach being used today in minimizing spray drift.

Manipulating the formulation to control viscosity holds great promise. While safer, it is more expensive and has been accepted for use only in areas which have sensitive, high-value crops nearby. In such areas thickening agents (e.g. Vistik® and Dacagin® brands) or particulating agents (Norbak® brand) are added to the formulation. Spraying is done here only under essentially "no wind" conditions and application is made at pressures less than 30 p.s.i. and with orifices larger than .05 inch in diameter (6,14,15,19,21,30).

Practically speaking, whether damage results from volatility or spray drift, the end result is the same. Since 2,4-D weedkillers are so potent, it was difficult for inexperienced people to realize the hazards from careless use. As a result, a number of papers (10,13,23,27,29) were written to caution applicators about their use.

Some weedkillers, such as certain esters of the phenoxy herbicides, have quite low vapor pressures (18). The activity of these compounds is so great that their volatility can be demonstrated in the field on sensitive crops such as cotton and grapes, and is of sufficient magnitude to cause damage under certain conditions. Higher temperature increases the volatility, and a rough rule of thumb is not to spray with any ester of 2,4-D in an area near susceptible crops when the temperature is above 90°F.

This general subject of 2,4-D volatility has been reviewed (12,16,22,25). As a result, in the early 1950's low volatile esters of 2,4-D, such as the isooctyl, the propylene glycol butyl ether and the butoxy ethanol, were developed. These are roughly 10 to 20 times less volatile than the lower alkyl esters of 2,4-D, such as the isopropyl of n-butyl ester (17). Through the combination of regulation, the use of low volatile esters, and experience, damage from this cause is now very infrequent.

In other herbicides, volatility is considered to be important not from the damage standpoint, but as a method of movement into the air. Such herbicides are: EPTC (1,4); CIPC; IPC (4,21); triallate (1,4); and trifluralin (1,2). In contrast, monuron, with a vapor pressure of 5×10^{-7} at 25°C is considered to have negligible volatility (1,20).

III. HERBICIDE DISAPPEARANCE IN SOILS

Herbicide residues in soil pose certain problems or hazards. Some of the main ones are: 1) Injury to sensitive crops or other plants that are grown subsequently, or to the initial stages in succession of plant life; 2) accumulation in foliage, seeds, berries and fruit consumed as food by animals, birds, fish and man; and, 3) possible leaching of herbicides into streams, lakes and reservoirs which might affect aquatic life and the quality of water used for human consumption.

There are a number of factors that are involved in residual effects of weed killers. Numerous experiments indicate that the soil temperature and moisture are highly important. This is probably largely due to their effect on creating optimal conditions for the action of soil microorganisms which plays a major role in the degradation of herbicides in the soil (62).

The chemical nature of herbicides is so varied that generalizations are to be avoided at this point. The various kinds of herbicides will be discussed in groupings below.

Amitrole

Sund (61) states that amitrole has been reported to persist from one to five months based on residual phytotoxicity tests.

The chemical becomes highly a sorbed to soil particles. He reported 50% of 3-amino-1,2,4-trizole was decomposed in 3 weeks when applied to 4 soil types having a wide range of sand and silt.

Bondarenko (34), conducting radioisotope studies on the breakdown of amitrole, found that the rate of evolution of $C^{14}O^2$ reached a maximum in 13 days and decreased rapidly until the 42nd day; the decomposition decreased gradually until the 240th day at which time the rate of evolution of $C^{14}O^2$ was extremely slow.

Benzoic Acids

There is considerable variation amongst the reports as to residual activity of 2,3,6-TBA. House et al.(2) says, applications ranging from 15 to 20 lb/A will last 12 to 32 months. Kearney and Kaufman (4) report that in a sandy clay loam in Nebraska, sufficient 2,3,6-TBA persisted from a 20 lb/A application to kill soybeans five years after treatment. Persistence was less, but still high, in lighter loam soils. Part of this variation is probably because soybeans are very sensitive to this herbicide. They also report that Amiben is degraded to a greater extent than is either 2,3,6-TBA or dicamba.

Dicamba in high organic matter soils, is detoxified completely at pH 5.3, but is highly persistent at pH 7.5. This differential response to pH is attributed to the more favorable environment for adaptation or growth of microorganisms capable of degrading the chemical at the lower pH. In other soils, rapid degradation was obtained at pH 7.5.

Cacodylic Acid and Disodium Methanearsonate

Ehman (39) sprayed pasture sods (4 ft x 4 ft. x 10 in.) with 3.81 g of a formulation containing 65% cacodylic acid. The sods were watered with about 1/2 inch of rainfall at one, two and four weeks. Some of the sod clay samples leached arsenic in the first 24 hours. In general, the cacodylic acid was strongly bound to the clay, silt loam and sand sods. After one week, the cacodylic acid became evenly distributed throughout a 10-inch depth.

Ehman (38) found that when disodium methanearsonate or cacodylic acid was applied to the top of a soil column which was leached with 60 inches of water, less than 10% of the applied chemical showed up in the leachate. When sandy loam was used in the soil column, the figure was less than 6%. It is evident that DSMA and cacodylic acid are strongly sorbed in soils.

Diquat and Paraquat

Stubs (112) has reported that diquat is almost completely sorbed to soil and unavailable to plants, and probably paraquat undergoes the same reaction. This is explained in that both of these compounds form divalent cations in solution, and strong negative interactions with negative-charged soil particles are to be expected. Funderburk (40) reports that diquat and paraquat are both degraded by soil microorganisms. They are also broken down in the presence of ultraviolet light; paraquat is the more persistent of the two.

Halogenated Aliphatic Acids

Rai (55) shows that TCA, the sodium salt of trichloroacetic acid, causes a temporary soil sterility that lasts from 40 to 108 days, depending upon the soil. Loustalot (47) is reported by Thiegs (62) to have demonstrated the favorable effect of warm, moist conditions on the disappearance of sodium trichloroacetate. Behrens (33) reports that TCA and dalapon will not have phytotoxic effects 4 to 6 weeks after application when used as recommended.

Thiegs (63) has clearly shown the rapid degradation of dalapon (2,2-dichloropropionic acid) is caused mainly by soil microorganisms. Magee (49) isolated eight kinds of bacteria capable of decomposing dalapon and also many unidentified actinomycetes, molds and bacteria that could overcome the inhibiting action of dalapon. In western Europe, autumn applications of dalapon and trichloroacetic acid are recommended for the control of perennial grass weeds. There is sufficient retention in the winter months to prevent the growing of grasses in the cereal the following spring. However, problems may develop under conditions of low moisture which retard the loss.

Sheets (57) reports that dalapon applications ranging from two to 15 lb/A are residual in the soil for one to three months as measured by phytotoxicity. Day (16) states that in 43 soils dalapon disappearance varied from complete in less than 2 weeks to retention of 2/3 of the dalapon after 8 weeks.

Thiegs (62) reports additional confirmation from other workers on dalapon dissipation. Thus, it seems to be clearly established in the literature as well as found in field practice that dalapon and TCA breaks down rapidly in the soil under warm moist conditions.

Phenoxyaliphatic Acids

Some of the earliest work on the persistence of chlorophenoxyacetic acids and their esters was undertaken by DeRose

(36,37) and Allard (32) using the germination of soybeans as a bioassay. Rates of application varied from 2.2 to 27.3 ppm. In the greenhouse, the 2,4-D persisted for 67 days and was still high at 11 months. In the field from 5 to 20 lb/A of 2,4-D and MCPA rapidly disappeared while 2,4,5-T persisted for 93 days. 2,4-D in amounts of 20 lb/A usually disappears in two months (2). The latter findings were essentially corroborated (44,51,52,57).

Behrens (33) shows that 2,4-D, TCA, and dalapon disappear rather rapidly from the soil. They seldom persist more than a month or six weeks when they are used at the recommended levels for weed control.

Forest litter retention of herbicides is of importance considering possible problems of contaminated runoff to streams or lakes. This is especially important if the reservoir or sources of water are for human consumption. Their possible ecological significance through having an insidious effect on wildlife, aquatic vegetation and fish must also be considered.

Norris (53,54) reports studies of persistence in forest litter of triethanol amine salts of labeled 2,4-D and 2,4,5-T when applied in water to the surface at a rate of 2 lb ae/A. The following observations were made of the percent degradation of 2,4-D and 2,4,5-T as measured by radioactive CO_2 liberation:

Degradation of 2,4-D and 2,4,5-T in Forest Litter

	Time	
Compound	315 Hr.	690 Hr.
2,4-D	89%	--
2,4,5-T	23%	53%

Norris felt that the slower rate of decomposition of the 2,4,5-T may have been due to a lag in accommodation of microorganisms to the chemical.

In another study, forest litter was selected from five types of forest trees. These litter samples were treated with 3 lb ae/A of (1) 2,4-D acid, (2) triethanolamine salt of 2,4-D, (3) isooctyl ester of 2,4-D, (4) isooctyl ester of 2,4-D plus 1 lb/A of DDT or (5) isooctyl ester plus 4 gal/A diesel oil. In 15 days, the recovery of 2,4-D applied as the salt varied from 60% to 75% for all the types of litter. The esters persisted longer than the acid, 65% versus 55%. The addition of 1 lb of DDT/A seemed to stimulate herbicidal degradation.

Picloram

Picloram is a long lasting herbicide whose movement and rate of degradation varies widely depending on the soil types and the local climatic conditions. For example (2) 1 lb/A in Montana and South Dakota yielded a 50% recovery in one season, whereas 4 to 8 lb/A in Texas yielded less than 0.1% recovery. This is greatly influenced by the texture of the soil, the amount of organic matter present, and the pH of the soil.

On sandy soils at high rates (over 2 lb), picloram may penetrate to depths of 2 to 4 feet. In soils of heavier texture with high organic content, it appears to stay in the uppermost 6 - 12 inches. Goring (41) reports that Tordon® herbicide may leach as far down as 48 inches. Herr (46) also finds that soil type is important. In light-textured soils at high dosages, picloram moves more completely to the lower 2 to 3 feet than it does in heavy soils. In the latter it was still retained in the upper 6 inches for up to 15 months.

Hemphill (45) in Missouri treated a heavy stand of field bindweed with 3 lb/A of picloram in June of 1965. Only sweet corn or several vegetable crops grew on this soil in 1966. In 1967 all crops grew normally, including beans and tomatoes. No picloram could be detected by either chemical assay or bioassay to a depth of four feet. Merkle et al. (50) reported on the treatment of a thick growth of running live oak with picloram. It was estimated that only 10% of the applied material actually reached the soil. Nonetheless after 5.9 inches of rainfall picloram was detected at a depth of 24 inches six weeks after application.

The pH is an important factor in the adsorption of picloram by soils. In experimental work (42), at pH 2 the adsorption of this chemical varies greatly from 10% to 100% depending upon the soil type. But at pH 8, adsorption was about 10% regardless of soil type. Grover (42a) also found this pH effect on the adsorption of picloram.

Loss from the soil of picloram may be large under conditions favorable for microbial activity. During the first year the average loss is about 80% (41,43). Merkle et al. reports no detectable residues were found in the upper 24 inches of soil after one year when picloram was applied at 8 lb/A. In later work (50a) he states that leaching is an important means of dissipating this herbicide in light soils.

Substituted Ureas

Working with diuron, Weldon (64) found the herbicide localized in the top 1/2 inch of soil. It was not found below 4 inches in depth. 80% of monuron, diuron, atrazine, simazine, and related herbicides were found to have disappeared during the year following application in most climatic and edaphic conditions (35,47,56). Repeat treatments disappeared at about the same rate as did the originals (57). Again, the soil character was important in rate of disappearance; no residues were found by Shipman (60) after 5 months in sandy loam after applications of 5 lb/A with fenuron. But 60% persisted in silty clay loam. Light has been found to inactivate certain herbicides including diuron, monuron, and 2,4-D (57).

The utilization of monuron in citrus orchards or asparagus planting is advantageous; but, if the land use were to be changed, there probably would be a danger of damage if it were to be immediately planted with a sensitive crop.

s-Triazines

Various investigators (2,57,58,59) have reported the persistence of simazine for 7 to 18 months. Atrazine, propazine, and norazine were only slightly less persistent. Evaluations (58) of 29 s-triazines were carried out with corn, grain, sorghum, soybeans, cotton, and crabgrass as test plants. While there were variations, many of the effects were quite long-lasting.

Sheets (57) indicated in a summary that cereals planted in the fall after crops that have received summer applications of diuron, atrazine, simazine, diphenamid and some related herbicides are subject to damage. There has been some trouble after the use of atrazine on corn, in that damage has occurred 10 to 12 months after its application when planted to soybeans, sugarbeets, oats and forage grasses and legumes. Fenac residues sometimes persist from one to two years and tobacco, cotton, peanuts and soybeans have been damaged following the use of fenac on corn. Diphenamid has lasted 10 to 12 months and injured seedling oats.

Trifluralin

Chemical assays and crabgrass bioassays indicated that trifluralin does not leach or move laterally in soil. It is degraded continuously during the growing season to less than 50 ppb in most soils approximately 60 days after application. Repeated application at recommended rates does not result in a build-up of trifluralin with time in soil. Trifluralin degradation proceeds slightly more rapidly in nonautoclaved than in autoclaved soil. Examination of several trifluralin treated soils failed to show specific microorganisms which caused its degradation (4).

Generalizations

Sheets (57) is of the opinion that massive accumulation of herbicides is highly unlikely. One must bear in mind that this statement is in regard to the levels commonly used on agricultural lands that received repeated dosages of herbicides.

The persistence of a herbicide in the soil depends on a number of factors, which include its chemical composition, rate of application, type of soil-leaching characteristics, and receptivity to decomposition by soil microorganisms and climatic conditions, such as rainfall, temperature, and exposure to sunlight. Microorganisms play a major role in the degradation of herbicides in soil.

A summary of the persistence of commonly used herbicides in soil is given in the following table which has been modified from Hull (3) quoting Sheets and Harris (57).

TABLE I

PERSISTENCE OF VARIOUS HERBICIDES IN SOIL

Herbicide	Field (F) or Greenhouse (G)	Lb/Acre[a/]	Residual Phytotoxicity (months)
Amitrole	F	3-18	1-3
	F	8.9	4.5
Atrazine	F	2-4	4-7
	F	2-3	4-7
	F	3-8	12
	G	3.2-4	4-8
Dalapon	F	7.4-20	1
	F	20	3-4
	G	6-8	1-2
Diuron	F	3.6-4	5-7
	F	1-2	4-8
	F	2	15
Fenac	F	4-5	12
Monuron	F	2-4	5-6
	F	4-6	12
	G	2-5	1-3
Endothall	G	6	1
	F	12	1
Simazine	F	2-5	12
	F	0.45-4.5	3-7
	F	4	18
	G	3.2-4.0	4-14
TCA	G	8-60	1-3
	F	12.5-67	7-12
	F	16-30	4
2,3,6-TBA	F	15-20	12-32
	F	3-4	5-12

a/ Rates originally reported in ppm were multiplied by 2 to give pounds per acre.

1 Modified from Sheets, T. J., and C. I. Harris, Herbicide residues in soils and their phytotoxicities to crops grown in rotations. pp. 123-124 from Residue Reviews, 11 F. A. Gunther (Ed.), Springer-Verlag, New York, 1965.

IV. DEGRADATION OF HERBICIDES

The degradation of herbicides is of the greatest importance. Without it, repeated applications of herbicides would build up in the soil or would be built up in the bodies of animals thus accumulating in our environment. Fortunately, degradation occurs rapidly and fully with certain of the weed killers. This subject is well covered in "Degradation of Herbicides", an excellent volume by Kearney and Kaufman(4). Leng's paper "Review for the Metabolism of Phenoxy Compounds in Plants and Animals"(69) is a summation for the phenoxy compounds. Since there are such excellent references for so many of the herbicides, their degradation will not be discussed here with the exception of DNBP and picloram which will be briefly discussed as they are not covered in either of these references.

DNBP

Klingman(5) reports that 4,6-dinitro-o-sec-butylphenol is very rapidly broken down in the soil, lasting only 3 to 5 weeks under warm, moist conditions. Warren(74) reviews the literature and concludes that once within the soil and under suitable conditions of temperature and moisture, it will be attacked and quickly decomposed by soil microorganisms. At least 2 species of Pseudomonas have been reported to utilize DNBP as a source of carbon and energy(71). In terms of time interval, microbiological breakdown in soil occurs rapidly under warm, moist conditions. Herbicidal action usually is lost within 2 to 4 weeks under conditions conducive to microbial activity(5). Also reported is lack of any residue from one year to the next and, consequently, any build-up from yearly applications. This material is not readily adsorbed by plant roots or translocated within the plant from the leaves as it acts as a contact herbicide. Towers(73) points out that plants respond to the application of phenolic substances by converting them to glycosides. These are then transferred to sites of low metabolic activity where they remain until the death of the cell.

Williams(75) discusses the metabolism of phenolics in animals and lists the main reactions as sulfate conjugation, glucuronic acid conjugation, and oxidation of the aromatic ring. He also discusses the reduction of aromatic nitro compounds to amino compounds which would readily be used in animal metabolism.

Picloram

Picloram is another relatively new selective herbicide. It is adsorbed by soils in amounts proportional to their content of organic matter(42). It is leached from soils by water and is decomposed slowly by microorganisms. Rate of decomposition depends on rate of application, amount of moisture, and the temperature(41,43). It is low in animal toxicity but is an extremely active herbicide and will produce visible symptoms on susceptible plants at very low concentrations. It can be decomposed by ultraviolet radiation(66). It will move in surface runoff water either in solution or with eroding soil particles. It has no detrimental effect on soil microflora(65). Investigations with small and large animals and birds have shown that picloram is relatively innocuous with no alarming pharmacological or toxicological properties(70,97). Metabolic studies in animals, plants, and soil have shown that no primary breakdown products accumulate in significant amounts(67,68,72). In view of its long lasting effect in soil and its extreme potency on certain plants, it should be used with care.

Herbicide degradation in soils may occur by means of hydrolysis, through microbiological metabolism, or by photodegradation. The latter 2 will be discussed here.

An herbicide may provide a carbon source for microbes, which derive energy from catabolic reactions. Considerable information is available on degradation of some herbicides, and almost none on others. There is general agreement that the hydrolysis of esters and salts of the phenoxyaliphatic acids takes place quickly and that there is translocation and rapid disappearance of these materials; no one has been able to identify the real metabolic products. There is also ample evidence that ingested phenoxy compounds are eliminated unchanged and within short periods of time by higher animals in the urine. Losses of herbicides from soils are enhanced by conditions that favor growth and proliferation of microorganisms, including warm, moist soil and a favorable supply of mineral nutrients and organic matter.

Herbicides are known to undergo several specific types of reactions in soil microorganisms including dehalogenation, dealkylation, hydrolysis, hydroxylation, ß-oxidation, cleavage of aromatic ethers, conjugation, complex formation, and ring cleavage. Conjugation and complex formation lead to inactivation without destroying the basic herbicide structure. The others are usually part of a series of reactions leading to decomposition. Position, type and number of substituents are important factors affecting microbial decomposition.

Most microorganisms that effectively decompose herbicides are aerobic. However, disappearance from aquatic soils and associated water suggests that anaerobic microbial organisms are involved. Information on pathways, mechanisms and products of anaerobic microbial metabolism is almost completely lacking.

At least 10 genera of bacteria, three of actinomycetes and 10 of fungi have been shown to decompose herbicides. Decomposition usually is characterized by three phases: a lag phase, in which little decomposition occurs; a rapid decomposition phase; and a slow decomposition phase which proceeds at a decreasing rate. It is thought that microbes are incapable of metabolizing many herbicides immediately. However, in the presence of a new energy source (the herbicide), enzymes that catalyze decomposition of the herbicide are formed from a closely related enzyme already present in the microorganisms. Once the adapted microbes proliferate, decomposition proceeds. Degradation of certain herbicides appears to occur non-enzymatically, but this is considered to be of minor importance in consideration of the total process.

Pathways of decomposition by microorganisms have been established in part for 2,4-D, silvex, MCPA, 2,4-DB, dalapon, IPC, CIPC, chloroxuron, diuron, monuron, atrazine, simazine, trifluralin, paraquat and some others, but knowledge of the process is far from complete.

Photodecomposition is now being studied more intensively. Quantitative effects effects of direct solar radiation on decomposition at the soil surface remain to be determined. It is difficult to differentiate between losses from volatility, hydrolysis leaching and other factors and losses from photodegradation. If the herbicide is incorporated into the soil, the amount of photodegradation would be markedly decreased. A number of herbicides have been shown to decompose when exposed to ultraviolet light. The importance of the process in the field is unknown at present.

V. EFFECT OF HERBICIDES ON WATER. FISH AND PLANKTON

WATER

One of the questions involving herbicides is whether they will contaminate our water supply. Watersheds and drainage from cropped areas which have been treated with herbicides might in turn result in secondary effects involving the health of domestic animals, wildlife, or aquatic life itself. Most of the work done on this problem has been with relation to phenoxyaliphatic acids, amitrole, paraquet, and diquat.

Amitrole

Marston[101] studied amitrole in a stream draining a municipal watershed in Oregon. Application was made by air to control the weed salmonberry (Rubus spectabilis Pursh) at a rate of 2 lb ai/A. Water samples were taken from 3 stations on the creek draining the area both after treatment started and for the next

5 days. A maximum concentration of 155 ppb was found 30 minutes after application began; it decreased to 26 ppb at the end of the 2 hour application period. Six days later there was no detectable amount at any station. At 1.8 miles below the sprayed area no amitrole was detected at any time, even immediately following the spraying. They concluded that any of the water sampled during their study would probably have been safe for use in home irrigation systems. They also concluded that there was not sufficient amitrole present to cause toxicity to any warm blooded animals either during or after the aerial spraying.

Tarrant(167) also investigated amitrole as an herbicide for salmonberry in studies in Oregon for 2 successive years. Spraying was accomplished by helicopter using 2 lb/A in 10 gal of water. Levels of amitrole in stream water at the spray site decreased from 400 ppb in samples taken 5 minutes after spraying to ppb after 10 hours. Amitrole was not detected after 3 days. In another test with amitrole, Norris(154) treated 260 acres with 2 lbs of amitrole-T/A; no amitrole was detected between 3 and 150 days after treatment. Stream water that contained 42 and 45 ppb at the end of 6 hours was down to 5 and 9 ppb, and the remainder totally disappeared in 48 hours.

Dalapon

There has been little work on dalapon in water, presumably because of its very low toxicity to fish (e.g., zero mortality to goldfish after 24 hours of exposure at 100 ppm(3)) and its rapid decomposition in soil(3).

Diquat and Paraquat

Frank(91) studied weedkiller residues in pond water and hydrosoil for dichlorobenil, fenac, 2,4-D, endothol, paraquat and diquat. Following treatment, fenac and dichlorobenil residues persisted in soil and water for periods exceeding 160 days. Low concentrations of 2,4-D were found in water for 24 days and in soil for 55 days. Endothall, paraquat and diquat were less persistent and were not found in the water after 24, 8 and 4 days, respectively. Paraquat and diquat persisted at high concentrations in the hydrosoil for 85 and 160 days respectively.

Yeo(117) studied the dissipation of diquat and paraquat in water and their effect on fish. In reservoirs, diquat applied at 1000 ppb dissipated to 9 ppb in 12 days. In fish-growing pools, diquat at 4000 ppb dissipated to 600-900 ppb. Dissipation of paraquat was slower than diquat and exhibited unpredictable fluctuations. 250-2500 ppb of paraquat applied to reservoirs resulted in 0-180 ppb after 13 days. In fish growing pools, 100-300 ppm paraquat resulted in 80-300 ppm after 12 days.

Gilderhus[93] treated fingerling and adult blue gills to diquat at various concentrations and frequencies of treatment in outdoor pools for 24 weeks. Chronic effects on fish were assessed on the basis of survival, growth, hematological measurements, pathology of different tissues and the spawning success of adult fish the year after exposure. Numbers and trends among bottom fauna and plankton were evaluated in respect to the herbicide treatments. The treated fish did not show any changes or differences that could be attributed to diquat. The herbicide was toxic to cladocera in the pool and laboratory tests.

Beasley[81] found 1.2 to 7.9 ppm of paraquat and a trace to 1.7 ppm of diquat persisting in hydrosoils where the pools had been treated four years previously with 0.3 lb/A. Frank[91] applied 1.14 ppm and 0.62 ppm of paraquat and diquat to ponds, and found that both chemicals still persisted in the hydrosoils 160 days after treatment. Blackburn[82] reported diquat at 2.5 ppm persisted for 8 and 11 days. He reported no toxicity to fish and that it appeared to have little effect on natural fauna and plankton present.

Grzenda[94] found that paraquat persisted in ponds from 6 to 23 days and diquat fell from 0.81 on the first day to 0.01 ppm on the 7th day. In another pond, the concentration fell from 1.25 ppm on the 1st day to 0.08 ppm on the 9th day and down to 0.01 on the 27 day.

Phenoxy Aliphatic Herbicides

There have been few reports dealing with the effects of herbicides on watersheds and reservoirs used for human consumption. One U. S. Government publication[114] lists 0.1 ppm for 2,4-D, 2,4,5-T and 2,4,5-TP as permissible criteria for surface water for public water supplies. No data for other herbicides is mentioned, but this phenoxy aliphatic class is probably the most widely used aquatic weedkiller at present. The same reference also has a very useful table giving their likely concentration in irrigation water after a typical herbicide application rate. It also gives the crop injury threshold in ppm.

Reigner[109] discussing the use of 2,4,5-T gives data concerning the vegetation along two stream banks treated with acid and ester formulations. Water samples were taken following treatment and periodically for 3 weeks. Odor tests were conducted as well. They concluded that 2,4,5-T, if applied with normal precautions, could be used on municipal watersheds without creating any water contamination.

Reinhart[110] applied 1325 gallons (740 gallons of diesel oil plus 52 gallons of a 2,4,5-T ester formulation containing 6 lbs/gal ae in 740 gal of diesel oil plus water) on 30 acres of a timber watershed. This was a basal spray applied to all trees 1 inch in diameter or larger at breast height. This treatment is heavier than would be used in a riparian area and diesel oil would not be used as a diluent. Nonetheless, an odor panel found no contamination in numerous water samples taken from the stream draining the tested area.

Norris cites work by Linden(100) who applied diesel oil at rates in excess of 50, 250, and 500 gal/A which was followed by leaching with 100 ml of rainwater; only 1.5 to 2 ppm of diesel oil were found in sandy loam at a depth below 2½ inches. These investigators felt that the application of diesel oil to the soil surface at rates of greater than 50 gal/A presented no threat to ground water quality.

Winston and Ritty(116) discuss what happens to phenoxy herbicides when applied to a watershed. They report at least 8 species of bacteria known to use phenoxy herbicides as an energy source. They conclude that the phenoxy herbicides are decomposed into inorganic chloride ions and water; therefore, when properly applied to watershed areas, they do not constitute a water pollution hazard.

Cochrane(84) applied 8 lbs of silvex ae/A as the propylene glycol butyl ether ester to water overlying 3 soil types in plastic ponds. The ester hydrolyzed almost totally to the acid in 2 weeks. The acid gradually dissipated over a 19 week period. Apparent absorption of both the ester and the acid occurred on the hydrosoil and was followed by gradual diminution of both. The authors conclude that a possibility exists that silvex acid and/or a degradation product may be desorbed and re-admitted to the water. They also conclude that it should not be applied to water that is being used as a source of supply for human consumption until such time as the safety of such use is proved.

Faust(87,88) investigated the effect of 2,4-D and 2,4-dichlorophenol on drinking water quality. Some of the chlorinated phenols are possible serious sources of contamination of water as far as odor and taste are concerned. 2,4-dichlorophenol is one of the most potent as at 8 ppb it causes an objectionable medicinal taste and at 2 ppb it causes an odor problem in water. In laboratory studies using 2,4-D in glass carboys filled with lake water, 9.5 and 16.7 ppb of 2,4-DCP were released in 7 days and maximum concentrations of 14.7 - 20.7 ppb developed in 148 and 218 days. In other carboy tests with aeration and small amounts of organic matter, this phenol disappeared rapidly. About 40-50% of 2,4-dichlorophenol ions persist up to 80 days under conditions of an acid pH and surface water unfavorable for biological oxidation. They point out that the phenol may be present as an impurity in the formulation as a result of the manufacturing process as well as by the chemical hydrolysis and/or biological degradation of herbicide in water.

Krammes(98) reported on aerial spraying of a cleared watershed to control young sprouted growth; later they stump-sprayed. Presumably they used a similar formulation in diesel oil although the actual concentration was not stated. Water samples from the runoff were taken over a 5 month period; all samples were below 1 ppm and no trace of diesel oil was found. In other work, brush on a steep slope was sprayed to convert it to grass. The application rate was 1-1/2 lb 2,4-D and 1-1/2 lb 2,4,5-T as low volatile esters/A in a 20-gal mixture of water which had 1 gal of diesel oil. A follow-up hand treatment of brush was made with 1/2 gal of a 2 lb ae each of 2,4-D and 2,4,5-T in 100 gal of water that contained 1 gal of diesel oil. Surface water was sampled and for practical purposed no herbicide was found. In soil samples, small amounts of weed killer were detected 8 days after treatment. None were found 1-1/2 months after the initial spraying.

Aldhous(116) treated a forest of Sitka spruce to control Calluna vulgaris using the nonyl ester of 2,4-D at 4 lb/gal ae in 12 gal of H_2O. Water samples were taken from a ditch that drained about 3 A. Samples were taken before spraying and 1, 2, 4, 7 and 28 days after treatment. Analysis by thin-layer chromatography showed 0.0, 1.5, 1.6, and 0.0 ppm, respectively.

Aly(78) studied lake bottom soil that had been previously treated with 2,4-D. In 35 days the herbicide disappeared from the soil. It took 65 days to disappear from untreated hydrosoil. Frank(91) found 2,4-D applied as a 20% granular formulation persisted longer in the hydrosoil than in water, but it could not be detected after 55 days.

Averitt(79) conducted some tests both in the field and laboratory, investigating the rate of disappearance of 2,4-D in water. In the field it was injected into the propeller wash of a small boat. The first day the concentration was 689 ppb; it fell on the 4th day to 80 ppb. Thereafter it slowly declined to a level of 10 ppb on the 31st day. In the plastic box tests it dropped from a high of 972 ppb to 11 ppb in 22 days.

Smith(111) reports concerning applications on a large commercial scale on aquatic fauna and water quality. This was done on TVA property. Applied were 888 tons of a 20% 2,4-D butoxy ethanol ester on a granular herbicide to 8000 A of Eurasian watermilfoil in 7 reservoirs at rates varying from 40-100 lbs of 2,4-D ae/A. Eight of the 9 water treatment plants sampled showed 2,4-D concentrations of less than 1 ppb. The 9th showed concentrations of 2 and 1 ppb. Since 1960 in cooperation with state fish and wildlife representatives they have routinely surveyed treatment areas for dead or distressed native fish following herbicide applications. None were found. They concluded "these data indicate that high application rates of 2,4-D for watermilfoil control on TVA reservoirs have not produced adverse effects on aquatic fauna or water quality."

S-Triazines

Avraman[80] studied the effect of prometrin on the gustatory properties of water, the sanitary regimen of bodies of water and on mammals. Within its solubility limits, the herbicide did not affect the color of the water and was devoid of odor. The gustatory threshold was determined as 1.2 ppm. The threshold concentration on the sanitary regimen of bodies of water was 5 ppm. Short-term and long-term toxicological data for mice and rats was obtained. The LD_{50} value for mice was 1331-2945 mg/kg. and 2743-3509 mg/kg for rats. Long-term studies indicated that daily doses of 0.0625 mg/kg had no significant effect on rabbits and rats. He recommends a level of 1 ppm as the maximum permissible concentration in water.

Martynyuk[102] investigated simazine, atrazine, propazine, pyramine, NaTCA, DCMU and trichloropropionitril in water. Water containing these herbicides at concentrations from .1 to 5.0 ppm did not differ from control samples in its organoleptic properties even after heating to 60-70°C. With the exception of TCA, when there was an increase in the concentration of herbicides to 50-200 ppm, the organoleptic properties of the drinking water changed sharply. This was particularly true for trichloropropionitril and pyramine. Ground water containing 600-1000 ppm of these herbicides stored in bottles for 8-20 months at temperatures of 6-22°C showed no drop in concentration with the exception of DCMU. 5-20 mg/liter of calcium hypochlorite was used to treat ground water containing 50-100 ppm of these herbicides which completely decontaminated the water.

Substituted Ureas

Walker[115] in experiments with monuron, diuron, fenuron, neburon and TCA in mixtures with them showed excellent potential in controlling certain aquatic plants. Monuron and fenuron were less toxic to fish than biuron and neburon. The mixtures of these urea herbicides with TCA were somewhat more toxic than the urea herbicides alone. There were species differences in response; fingerlings were more sensitive than adults. Fish food organisms were reduced appreciably in the treated areas.

Frank[89] investigated the disappearance of monuron and neburon in an aquatic environment. Appreciable loss did not occur until 16 and 8 weeks, respectively. Loss at a faster rate followed until about 50% of the herbicides disappeared: other further losses occurred, but at a decreasing rate. Approximately 15% of the monuron and 39% of the neburon remained after 128 weeks.

He(90) also studied effects of irrigation water flowing over canal-bottom plots treated with fenac and dichlorobenil before entry of the irrigation water. Concentrations of fenac and dichlorobenil in the first water to flow over the plots were 8.8 and 8.6 ppm, respectively. The bulk of the residue was transported from the plots in a very short time and safe levels were reached after 1 hour of water flow.

Grzenda[94], in a progress report on public health aspects of weed control in potable water supplies gives the following data:

Herbicide	Time After Treatment (In Days)	Concentration
silvex ester	120	low
2,4-D	62	1 ppb
fenac	19	1 ppm
diquat	23	10 ppb
paraquat	10	not detected
3-aminotriazole	70	.5 ppm

Johnson[96] discusses the monitoring studies on pesticide residues being carried out cooperatively by several government departments; He states that of the many pesticidal chemicals now in use and occurring in natural ecosystems, DDT and its metabolites and other chlorinated hydrocarbon insecticides are considered most important to fish, wildlife and estuaries. He does not list a single herbicide.

Brown[124] discusses monitoring 11 streams in the western part of the U.S.A. They were checked monthly for 12 pesticides (9 insecticides and 3 weed killers, which were 2,4-D, 2,4,5-T and silvex). No herbicide was found at any time.

FISH AND PLANKTON

Lawrence[99] has an excellent compilation of aquatic herbicide data and it also includes an extensive compilation of fish toxicity data. Nishiuchi[104] reports on the toxicity of 76 different pesticides to 3 kinds of fresh water fish and 2 kinds of fresh water daphnia. He concluded that, while some herbicides are toxic to the species tested, most herbicides are generally non-toxic to both fish and daphnia. It was also noted that the insecticide endosulfan was remarkably toxic to both fish and daphnia.

Alabaster[76] points out that it is impossible to predict the toxicity of formulated pesticides knowing only the toxicity and percentage of the active ingredient. Many additives are markedly toxic--some more so than the active pesticidal ingredient; thus, he concludes it is essential to test the actual formulation in question. This is an excellent paper, and one table gives the toxicity of 67 commonly used herbicides to fish.

The toxicity of herbicides to fish is a complicated problem. In some cases, as with the phenoxy herbicides, the esters are markedly more toxic than, say, their sodium salts. In addition, their toxicity is not a measure of their actual hazard, because of the way in which they are used. If the herbicide is applied to vegetation and is strongly absorbed and/or moves little (e.g., like trifluralin), then the actual hazard to fish, practically speaking, is non-existent except, perhaps, for accidental contamination.

The specific papers reviewed have been limited to the phenoxyaliphatic acids and picloram.

<u>Phenoxyaliphatic Acids</u>

Petruk[106] studied the effect of 2,4-D and TCA on saprophytic microorganisms in ponds. The 2nd or 3rd day after the sodium salt of 2,4-D was administered, the microorganism count in the pond increased appreciably, but after 12 to 14 days, it gradually diminished and approached its original value on the 23rd to 25th day. Similar results occurred with TCA. The timing of the increases and decreases of the microorganism count strongly suggest that the herbicides were being used as a food source.

Cowell[86] reported on the use of silvex and sodium arsenite in their effect on plankton. At the dosages used, neither herbicide had any effect on the phytoplankton and silvex was not too toxic to zooplankton at concentrations of 2ppm. Sodium arsenite at 4 ppm produced drastic reductions in zooplankton. Sodium arsenite treatment decreased rotifers by a 1 to 2 order of magnitude and copepods and cladocerans from 1 to 7. Silvex treatments did not show such differences.

Pierce[107,108] has conducted a series of investigations with silvex. Plankton was represented by the following classes: Myxophycea, Chlorophyceae, Flagellata, Rotifera, Annelida and Crustacea. Usually several species were present within each group. Benthic organisms were represented by the following groups: Gastropoda, Pelecypoda, Amphipoda, Epbernerida, Annelida, Odonata and Diptera. Certain large aquatic vertebrates, such as fish, frogs and turtles, were also present. Conclusions were that the silvex treatment at 1.2 ppm temporarily decreased the plankton population (50 species) but within 2 weeks it was back to normal. It had no effect on the benthic organisms or the fish and other larger aquatic vertebrates.

Cowell(85) used silvex at concentrations of 2 ppm in a study on aquatic vegetation and plankton in farm ponds in New York. He concluded that it gives excellent control of Potamogeton and Lemna, but not satisfactory control of the alga Chara. He also stated that there were no adverse effects on the phyto and zooplankton and that no fish kill had been observed.

Gaylor(92) reported on 3 years' work with silvex as a herbicide for aquatic weed control in Oklahoma. Results are given for 8 species of aquatic weeds with good results for 3 of the most troublesome. No fish were observed to be killed, although observations were made that the fish hunted new habitats when their old plant cover was destroyed.

Mullison(103) reviewed the literature on the effect of silvex on wildlife and fish. Toxicological data were given concerning silvex for rats, guinea pigs, rabbits, mice, chic en, dogs and 2 species of fish. The use of silvex apparently does not constitute a hazard to game birds such as bobwhite quail, mallard ducks and ring-neck pheasants. There seems to be considerable species variation in regard to fish tolerance of ester formulations of silvex. Certain fresh water species appear to be able to tolerate small quantities; others are not. In most situations, when an ester form would be used to kill aquatic weeds, particularly emergent aquatic weeds, fish kill would be expected to be minimal--which means only a few fish being killed. So far, in actual proper practice, fish populations have not been reported as being seriously effected.

The potassium salt of silvex is less toxic to fish than the silvex ester. Reports of the effects of Kuron® weed and brush killer on plankton have been variable. Some field studies in fresh water, where some injury has been observed, indicate that this is a temporary effect and that shortly the populations are back to normal.

Picloram

Hardy(95) points out that picloram at 1 ppm did not retard the growth of algae or Daphnia. Guppies kept in water with the same concentration and fed Daphnia reared in such treated water were normal in appearance, behavior and reproductions. The Daphnia, too, developed and reproduced normally with no biological magnification of the picloram in them. Butler(83A) studied the effects of herbicides on the productivity of phytoplankton and reported on the effects of two picloram formulations. In one case there was 0 decrease in productivity and in the other a slight decrease of 8.4%.

Kenaga[145], using various formulations of picloram, studied and reviewed its effect on 15 species of fish and 3 gam birds. The extensive data indicates that it presents an extremely low potential hazard, if any.

VI. ECOLOGICAL RELATIONSHIPS

Coulter[118] has reviewed and discussed various uses of weed killers to aid wildlife production. The main uses have been to open up wooded areas and clear aquatic areas for fishing or to provide a better habitat for water birds.

House et al[2] has the most detailed account found in the ecological significance of the use of herbicides including quite a discussion on ecological effects from their use in Vietnam by the U. S. Armed Forces.

Tschirley[121] made a special trip to Vietnam to assess the ecological consequences of the extensive use of herbicides at high concentrations by the U. S. Armed Forces. This program is called "defoliation" by the Army, and the chemical agents used are called "defoliants", although their scientific classification would be "herbicides". It is not surprising that he came to few clear conclusions on this complicated matter. This program obviously has ecological effects, but what they are is largely unknown at this time. A few points mentioned were that the mangrove-type forests are killed where treated. Fish catch, according to the official Vietnam statistics, has increased. Large mammals have been seen recently in war zones E and D, the areas of greatest defoliant activity.

Pfeiffer[119,120] also made a trip to Vietnam to assess the ecological effects of the use of herbicides. Again, the conclusions, other than that there had been profound ecological effects, are not clear. Direct toxic effects of herbicides to animals were not noted. They did observe numerous birds, particularly fish-eating birds. One of the major ecological effects from the war was the occurrence of many bomb holes from the saturation bombing. Many of these were 45 feet in diameter and 30 feet deep.

He expects virtual elimination of woody vegetation at defoliation sites, and resultant severe changes in animal ecology in such areas. One interesting sidelight is that tigers have learned to associate the sound of gunfire as indicating the presence of dead wounded people and are drawn to the scene. Thus, the tiger population is probably increasing as did the wolf population in Poland during World War II.

Barrons(122) reports on the ecological benefits to man from brush control with herbicides. He emphasizes the selectivity of herbicides particularly the phenoxyaliphatic acids, picloram and Cacodylic acid. He discusses the ecological effects of the first two so they are common ones used in brush control. The benefits he mentions are increased growth of grass, absence of long term sterility, more favorable water retention and favorable effects on certain types of wildlife such as rabbits, grouse and turkeys. He also mentions the benefits from controlling previous vegetation. The use of brush killers was a suggested factor in an integrated program to control the tsetse fly in Africa.

Way(123) recently reviewed the toxicity and hazards of some commonly used auxin herbicides (phenoxyaliphatic acids and 2,3,5-TBA) to man, domestic animals and wildlife. He points out that the primary effect of these herbicides on wildlife is not logical but ecological. The use of herbicides may result in various types of ecological succession similar to those observed when vegetation has been removed by other means. The main problem is their altering the environment through the elimination of certain plant species and the resultant changes in the food and habitat for wildlife. Thus it makes no difference in the making of a pasture from a forest whether the trees and brush are cleared with saws and axes or cleared by herbicides. The primary effect on wildlife comes as a result of changing the forest to a meadow. Ascertaining the positive or negative value of such changes is very difficult as it is an extremely complicated problem.

This change in type of vegetation present has both a direct and indirect effect on food chain for animals, birds and lower forms of animal life as well as directly affecting their habitat. The long term effect on wildlife may be beneficial or detrimental, depending on the species involved. Studies in other countries have shown that herbicidal treatment of forested areas improves wildlife habitat and is favorable to certain animal populations.

When aquatic weeds are controlled with herbicides, direct toxic effect on fish and bottom organisms are relatively minor if the herbicides have been properly used. However, the indirect effects of herbicides resulting from the destruction of the vegetation may produce important changes on the biota of the aquatic environment. Whether these changes are beneficial or deleterious depends on a number of factors; for example, fish would be in trouble if the herbicide destroyed the specific plants upon which this fish feeds. On the other hand, serious oxygen depletion of an aquatic environment may occur when mats of floating weeds completely cover the surface of the water and shade the photosynthetic plants in the water. In this case, an important benefit to fish and other aquatic biota can often be produced through the application of herbicides for improving the fish habitat.

The relating of the pertinent multiple variable for quantification of an ecosystem is a formidable task and ecology suffers from the difficulty in projecting a long-range view quantitatively with any degree of certainty as to the total development or outcome of an ecological disturbance.

In the process of civilization's advancement, many of man's activities have been done with immediate benefits in view, such as the cutting of forests and the plowing of the land. These practices have been carried out to serve immediate human needs. Many people have pointed out that if man did not disturb nature the world could not support our present human population. Herbicides are merely a relatively new and useful tool of mankind used in agriculture or elsewhere to modify our environment for our benefit.

Discussion and Conclusions

Most commercial herbicides now in use are low in toxicity to man and animals. Further, they are now used in such a way that little normally accumulates to create a hazard in our environment.

The fate of herbicides sprayed onto plants and not entering them may be varied. They may get into the atmosphere by means of spray drift and volatilization; they may be adsorbed onto soil particles on the surface or may leach downward to lodge in the sub-soil; theoretically, they might continue downward and enter into the ground water, although there is no evidence that this occurs permanently under normal conditions of use; or, during their travels, they may be disintegrated by soil microorganisms or light.

All herbicides have some degree of volatility. From a practical standpoint, however, this is generally negligible; the more usual method for herbicides to get into the atmosphere is by spray drift. To prevent this, current research is directed towards reducing spray drift by agglomerating fine spray droplets or preventing their formation. If presently approved spraying practices are followed, no hazards are created. Violations of these established rules, however, can readily cause trouble.

Actually, there is relatively little movement of herbicides in the soil that is not associated with soil water. Absorption into plants and adsorption onto clay particles and organic matter usually occur quickly, the actual rate depending upon the sorptive properties of the herbicides and the soil in question. This prevents accumulation either into lower soil water or as runoff, following rains, into streams or irrigation ditches. What little is left free for the time being may follow either gravitational movements downwards or capillary forces upward. But there is little doubt that the most likely source of water contamination by herbicides is not through spraying the crops but through dumping of unused portions from spray tanks, the dumping of rinse water from cleaning out the equipment, and from disposal down drains of portions of old stocks which are being cleared away.

Extensive investigations into the effects of herbicides on soil microorganisms have shown clearly that soils are not permanently sterilized to the detriment of future agronomic uses; beyond this, conclusive effects are not clear. Both retardation and stimulation of microbial life have been found to occur. Changes in actual species composition of a population have not been investigated a great deal, but a few investigators have stated that no long-lasting changes have occurred.

Herbicides tend to be toxic to lower plant life forms by their very nature. As all plants may be weeds, it would be expected that lower as well as higher forms of plant life would be affected. Their effect on plankton has not been extensively studied; but the investigations which have been made indicate that any deleterious effects are usually temporary. Most herbicides, particularly those used in agronomic practice, are of low toxicity to fish, and it is quite possible that the other ingredients in the formulation are more toxic than the weed killer itself. This means that the completed formulation must be tested for toxicity to fish rather than just the active ingredient.

At present, there is little evidence that concentration of weed killers in food chain organisms occurs with herbicides. There is considerable evidence indicating that herbicides are degraded in many ways in plants and animals which is of great value in preventing situations where biological magnification would occur. Biological magnification does not appear to be a problem with our present commercial weed killers.

The activity of most herbicides is fortunately short-lived, and many of our widely-used ones, such as 2,4-D, are readily decomposed by microorganisms. That these microbes use the herbicide as an energy source is well established, and it is widely recognized that this is the major factor in the decomposition of these chemicals. Degradation is brought about mainly by aerobic microorganisms. There is some circumstantial evidence that anaerobic decomposition occurs, but this field requires further investigation. Chemical decomposition, apart from that caused by microorganisms, plays only a minor role in their breakdown. Photodecomposition is known to occur, but the importance of its role remains to be determined.

A few herbicides are resistant to breakdown and, if not strongly adsorbed by soil colloids, are subject to leaching. With these, it might be that contamination of the ground water is a possible hazard. Such chemicals need careful studying. Applications of such herbicides should be carefully considered, and they should be used only when a specific use is absolutely necessary.

Organic herbicides have been extensively studied and used for a relatively short period of time, approximately the last thirty years. Nonetheless, during this time, their ecological effects in modifying man's environment have been well recognized. In fact, that is why they are used: to convert brushland to pasture, to improve wildlife habitats, to change a heterogeneous low-producing grain field to a high-producing monoculture crop, to mention but a few. Thus herbicides are used for the selective killing of unwanted plants according to man's desires and for his benefits. Fears that they will render the soil permanently sterile are unfounded, as they break down in the soil. They are a relatively new tool for controlling unwanted plants, and, as with any other of man's tools, it is the wisdom with which they are used that determines whether they will have a long-range beneficial or harmful ecological effect.

BIBLIOGRAPHY

I. INTRODUCTION

(1) Fryer, J. D. and S. A. Evans, Ed. "Weed control handbook, Vol. I, principles." xx + 494, Gr. Brit., Blackwell, 1968.

(2) House, W. B., L. H. Goodson, H. M. Gadberry, K. W. Dockter, "Assessment of ecological effects of extensive or repeated use of herbicides: final report." Midwest Res. Inst., xv + 369, Aug. 15-Dec. 1, 1967.

(3) Hull, H. M., et al., Ed. "Herbicide handbook of the Weed Society of America." xi + 293, New York, Humphrey, 1967.

(4) Kearney, P. C. and D. D. Kaufman, Ed. "Degradation of herbicides." xi + 394, New York, Dekker, 1969.

(5) Klingman, G. C. "Weed control: as a science." viii + 421, New York, Wiley, 1963.

II. SPRAY DRIFT AND VOLATILITY

(6) Akesson, N. B. and W. E. Yates. "Application aspects of viscous emulsions as an agricultural spray formulation." Paper No. 61-617 presented at the ASAE Meeting, Winter, 1961, Chicago, Illinois.

(7) Akesson, N. B. and W. E. Yates. "Problems relating to application of agricultural chemicals and resulting drift residues." Annual Rev. Entomol., 9:285-318, 1964.

(8) Biron, R. A. "Herbicide dispenser." U. S. Patent 3,320,694. 1967.

(9) Brown, A. W. A. "Insect control by chemicals." Wiley, 1962.

(10) Brown, C. A., Q. L. Holdeman and E. S. Hagood. "Injuries to cotton by 2,4-D." Louisiana State Univ., Bulletin No. 426, 19 pp, Feb., 1948.

(11) Byrd, B. C. and K. G. Seymour. "Wind tunnel studies of thickened and particulate mixtures." Paper No. 64-609D presented at the ASAE meeting, 1964, New Orleans, La.

(12) Carter, E. P. "Volatility of ester forms of hormone type herbicides, III." Jour. of Assoc. of Official Agric. Chemists, 43(2):367-70, 1960.

(13) Clore, W. J. and V. F. Bruns. "The sensitivity of the concord grape to 2,4-D." Amer. Soc. Hort. Sci., 61:125-34, 1953.

(14) Coutts, H. H. and W. E. Yates. "Analysis of spray droplet distributions from agricultural aircraft." Paper No. 65-157 presented at the ASAE Meeting, June, 1965, Univ. of Georgia.

(15) Courshee, R. J. "Investigations on spray drift, Part II: The occurrence of drift." Jour. Agr. Eng. Res., 4:229-41, 1959.

(16) Day, B. E., E. Johnson and J. L. Dewlen. "Volatility of herbicides under field conditions." Hilgardia 28: 255-267, 1959.

(17) Flint, G. W., J. J. Alexander, and O. P. Funderburk. "Vapor pressures of low-volatile esters of 2,4-D." Weed Sci., 16:541-3, October, 1963.

(18) Hamaker, J. W. and H. O. Kerlinger. "Vapor pressure of pesticides." Adv. in Chem. Series 86, A symposium April 13-14, 1967, 39-54 pp, Washington, D. C., 1969.

(19) Holmsen, T. W., et al. "Evaluation of chemical drift control agents by direct bioassay." Proc. NEWCC, 21:449-56, 1967.

(20) Klingman, D. L. "Drift control additives and their effectiveness." N. Central Reg. Herbicide Workshop, 1966.

(21) Laning, E. R. and T. W. Holmsen. "Minimizing spray drift of herbicides." Indus. Vegetation Manag. 1(2) July, 1969.

(22) Leonard, O. A. "Volatility studies with 2,4-D." Proc. of 13th Annual Cal. Weed Control Conf., 93-99, 1961.

(23) Linn, M. B., F. W. Slife and B. J. Butler. "Prevent 2,4-D injury to crops and ornamental plants." Univ. of Illinois, Circ. 808, 16 pp, Urgana, Illinois, 1959.

(24) Metcalf, C. L. and W. P. Flint. Revised: "Destructive and useful insects." 8, McGraw-Hill, 1962.

(25) Mullison, W. R., W. W. Allen and R. C. Scott. "Progress report of the N.A.C.A. Committee to study test methods for defining low volatile esters of 2,4-D." Proc. NEWCC 7:81-6, 1953.

(26) Potts, S. F. "Concentrated spray equipment, mixtures and application." II, Dorland, New Jersey, 1958.

(27) Prior, M. R. "The misuse of 2,4-D." Weed Cir. No. 36,1-5 Cal. State Dept. Agric., Oct. 1, 1948.

(28) Seymour, K. G. and B. C. Byrd. "Wind tunnel evaluation of spray drift potential." Paper No. 64-609C presented at the ASAE meeting, Winter, 1964, New Orleans, La.

(29) Staten, G. "Contamination of cotton fields by 2,4-D or hormone-type weed sprays." Jour. of Amer. Soc. Agronomy, 536-44, Jan., 1946.

(30) Yates, W. E., N. B. Akesson and K. Cheng. "Criteria for minimizing the hazard of drift from aerial applications." Transcript No. 67-155 presented at ASAE/CSAE meeting, June, 1967, Saskatoon, Saskatchewan.

(31) Yates, W. E. and N. B. Akesson. "Equipment and application techniques in relation to pesticide drift and residue." Prod. Tenth Ann. Texas Aviation Conf. and Short Course on Pest Control, Feb., 1961.

III. HERBICIDE PERSISTENCE IN SOILS

(32) Allard, R. W., H. R. Rose and C. P. Swanson. "Some effects of plant growth regulators on seed germination and seedling development." Bot. Gaz., 107:575-583, 1946.

(33) Behrens, R. "Soil residue from herbicides." Agr. Chem., 17(7):34, 78-79, 1962.

(34) Bondarenko, D. D. "Decomposition of amitrol in soil." North Central Weed Control Conf., Proc., 15:5-6, 1958.

(35) Crafts, A. S. and H. Drever. "Experiments with herbicides in solids." Weeds, 8(1):12-18, 1960.

(36) DeRose, H. R. "Persistence of some plant growth-regulators when applied to the soil in herbicidal treatments." Botan. Gaz., 107:583-589, 1946.

(37) DeRose, H.R. and A. S. Newman. "The comparison of the persistence of certain plant growth regulators when applied to soil." Soil Science Society of America, Proc., 12:222-225, 1947.

(38) Ehman, P. J. "The effect of arsenical buildup in the soil on subsequent growth and residue content of crops." Southern Weed Conf., Proc., 18, 1965.

(39) Ehman, P. J. and J. J. Birdsall. "Fate of cacodylic acid in soils and plants." Ansul Chemical Company for U. S. Army Biological Laboratories, Fort Detrick, Frederick, Maryland, Cont. DA-18-064-CML-2826(A), 1963.

(40) Funderburk, H. H., Jr. and G. A. Bozarth. "Review of metabolism and decomposition of diquat and paraquat." Agr. Food Chem., 15(4):563-567, 1967.

(41) Goring, C. A. I., C. R. Youngson and J. W. Hamaker. "Tordon herbicide. . . disappearance from soils." Down to Earth, 20(4):3-5, 1965.

(41a) Grover R., "Influence of soil properties in phytotoxicity for 4-amino-3,5,6-trichloropicolinic acid." Weed Research, 8:226-232, 1968.

(42) Hamaker, J. W., C. A. I. Goring and C. R. Youngson. "Sorption and leaching of 4-amino-3,4,6-trichloropiclinic acid in soils." Adv. Chem., Series No. 60, 1966.

(43) Hamaker, J. W., C. R. Youngson and C. A. I. Goring. "Prediction of the persistence and activity of Tordon herbicide in soils under field conditions." Down to Earth, 23(2):30-36, 1967.

(44) Hernandez, T. P. and G. F. Warren. "Some factors affecting the rate of inactivation and leaching of 2,4,-D in different soils." Amer. Soc. Hort. Sci., Proc., 56:287-293, 1950.

(45) Hemphill, D. D. "Performance of vegetable crops on an area treated with Tordon herbicide." Down to Earth, 24(1), 1968.

(46) Herr, D. E., E. W. Stroube and D. A. Ray. "Effect of Tordon residues on agronomic crops." Down to Earth 21(4):17-18, 1966.

(47) Hill, G. D., et al. "The fate of substituted urea herbicides in agricultural soils." Agron. J. 47:93, 1955.

(48) Loustalot, A. J. and R. Ferrer. "Studies on the persistence and movement of sodium trichloroacetate in the soil." Agron. J. 42:323-7, 1950.

(49) Magee, L. A. and A. R. Colmer. "Decomposition of 2,2-dichloropropionic acid by soil bacteria." Can. J. Microbiol. Vol. 5:255-60, 1959.

(50) Merkle, M. G., R. W. Bovey and R. Hall. "The determination of picloram residues in soil using gas chromatography." Weeds 14(2):161-4, 1966.

(50a) Merkle, M. G., R. W. Bovey and F. S. Davis. "Factors affecting the persistence of picloram in soil." Agron. J. 59:413-415, 1967.

(51) Newman, A. S., J. R. Thomas and R. L. Walker. "Disappearance of 2,4-dichlorophenoxyacetic acid and 2,4,5-trichlorophenoxyacetic acid from soil." Soil Sci. Proc. 16(1):21-4, 1952.

(52) Newman A. S. and J. R. Thomas. "Decomposition of 2,4-dichlorophenoxyacetic acid in soil and liquid media." Soil Sci. Soc. of Amer. Proc. 14:160-4, 1949.

(53) Norris, L. A. "Degradation of 2,4,-D and 2,4,5-T in forest litter." J. Fores. 64(7):475-76, 1966.

(54) Norris, L. A. and D. Greiner. "The degradation of 2,4,-D in forest litter." Bull. of Environ. Cont. & Toxicology, 2(2):65-74, 1967.

(55) Rai, G. S. and C. L. Hamner. "Persistence of sodium trichloroacetate in different soil types." Weeds, 3(1):271-9, 1954.

(56) Sheets, T. J. "Review of disappearance of substituted urea herbicides from soil." Agr. Food Chemistry, 12(1):30-33, 1964.

(57) Sheets, T. J. and C. I. Harris. "Herbicide residues in soils and their phytotoxicities to crops grown in rotations." Residue Reviews, 11:119-140, 1965.

(58) Sheets, T. J. and W. C. Shaw. "Herbicidal properties and persistence in soils of s-triazines." 11(1):15-20, 1963.

(59) Sheets, T. J., A. S. Crafts and H. R. Drever. "Influence of soil properties on the phytotoxicities of the s-triazine herbicides." Agr. Food Chem. 10(6):458-62, 1962.

(60) Shipman, R. D. and J. P. Eichert. "Forest site conversion with soil applied herbicides." J. Forestry, 65:328-34, 1967.

(61) Sund, K. A. "Residual activity of 3-amino-1,2,4-triazole in soils." Agr. Food Chem. 4(1):57-60, 1956.

(62) Thiegs, B. J. "Microbial decomposition of herbicides." Down to Earth, 4 pp, Fall, 1962.

(63) Thiegs, B. J. "The stability of dalapon in soils." Down to Earth, 3 pp, Fall, 1955.

(64) Weldon, L. W. and F. L. Timmons. "Renetration and persistence of diuron in soil." Weeds 9(2):195-203, 1961.

IV. DEGRADATION AND METABOLISM

(65) Goring, C. A. I., et al. "The effect of Tordon on microorganisms and soil biological processes." Down to Earth, 22(4):14-17, Spring, 1967.

(66) Hall, R. C., C. S. Giam and M. G. Merkle. "The photolytic degradation of picloram." Weed Res. 8(4): 292-7, 1968.

(67) Kutschinski, A. H. "Residues in milk from cows fed 4-amino-3,5,6-trichloropicolinic acid." Agr. Food Chem. 17(2):288, Mar/Apr 1969.

(68) Kutschinski, A. H. and Van Riley. "Residues in various tissues of steers fed 4-amino,3,5,6-trichloropicolinic acid." Agr. Food Chem. 17(2):283, Mar/Apr 1969.

(69) Leng, M. L. "Review on the metabolism of phenoxy compounds in plants and animals." The Dow Chemical Company, to be published.

(70) Lynn, G. E. "A review of toxicological information on Tordon herbicides." Down to Earth, 11:6-8, Spring, 1965.

(71) Reid, J. J. "Bacterial decomposition of herbicides." Northeastern Weed Control Conf. Proc. 19-30, 1960.

(72) Redemann, C. T., et al. "The fate of 4-amino-3,5,6-trichloropicolinic acid in spring wheat and soil." Bulletin of Environmental Contamination and Toxicology Vol. 3: 80-96, 1968.

(73) Towers, G. H. N. "Metabolism of phenolics in higher plants and microorganisms." Chapter 7 in Biochemistry of phenolic compounds, ed. by J. B. Harborne, Academic Press, London and New York, 1964.

(74) Warren, L. E. "The fate of DNBP in the soil." Presented at Washington State Weed Conf. Yakima, Wash. Nov 2-3, 1964.

(75) Williams, R. T. "Metabolism of phenolics in animals." Chapter 6 in Biochemistry of Phenolic Compounds, ed. by J. B. Harborne, Academic Press, London and New York, 1964.

V. WATER, FISH AND PLANKTON

(76) Alabaster, J. S. "Survival of fish in 164 herbicides, insecticides, fungicides, wetting agents and miscellaneous substances." Int'l Pest Control, 29-35, March/April, 1969.

(77) Aldhous, J.R. "2,4-D residues in water following aerial spraying in a Scottish forest." Weed Research 7(3):239-41, Eng., 1967.

(78) Aly, O.M. and S.D. Faust. "Studies on the fate of 2,4-D and ester derivatives in natural surface waters." Jour. Agr. & Food Chem. 12(6):541-6, 1964.

(79) Averitt, W. K. "An evaluation of the persistence of 2,4-D amine in surface waters in the state of Louisiana." Southern Weed Conf. Proc., 20:342-7, 1967.

(80) Avraman, F. V. "Maximum permissible concentration of "prometrin" in bodies of water." Gigiena i Sanit.--Hyg. Sanit. (Trans), 33(2):163-7, 1968.

(81) Beasley, P. G. and J. M. Lawrence and H. H. Funderburk. "The absorption and distribution of C^{14}-labeled diquat in the goldfish, carossius airratus (Linnaeus)." Southern Weed Conf. Proc. 18:581, 1965.

(82) Blackburn, R. D. and L. D. Weldon. "Results of three years testing diquat as an aquatic herbicide in Florida." Southern Weed Conf. Proc. 16:365 (Abstr.) 1963.

(83) Brown, E. and Y. A. Nishioka. "Pesticides in selected western streams--A contribution to the National program." Pest. Moni. Jour. 1(2):38-41, Sept., 1967.

*(83a) Butler, P. A. "Commercial fishery investigations." U. S. Fish and Wildlife Circ. 226:65-77, 1965.

(84) Cochrane, D. R., J. D. Pope, Jr., H. P. Nicholson, G. W. Bailey. "The persistence of silvex in water and hydrosoil." Water Resour. Res. 3(2):517-23, 1967.

(85) Cowell, B. C. "The effects of silvex on aquatic vegetation and plankton in central New York farm ponds." Down to Earth 21(1-2):19-20, Summer/Fall, 1965.

(86) Cowell, B. C. "The effects of sodium arsenite and silvex on the plankton populations in farm ponds." Trans. Amer. Fish. Soc., 94(4):371-77, 1965.

(87) Faust, S. D. and O. M. Aly. "Some effects of 2,4,-D and 2,4-DCP on drinking water quality." Northeastern Weed Control Conf., Proc., 17:460-70, 1963.

(88) Faust, S. D., R. J. Tucker and O. M. Aly. "A preliminary report on the effect of some aquatic herbicides on water quality." Northeastern Weed Control Conf. Proc., 15:546-48, 1961.

(89) Frank, P. A. "Persistence and distribution of monuron and neburon in an aquatic environment." Weeds 14(3):219-22, 1966.

(90) Frank, P. A., R. H. Hodgson and R. D. Comes. "Residues of two herbicides in water in irrigation canals." Weeds 15(4):353-55, 1967.

(91) Frank, P. A. and R. D. Comes. "Herbicidal residues in pond water and hydrosoil." Weeds, 15(3):210-13, 1967.

(92) Gaylor, J. and A. Houser. "Three years' results with silvex for aquatic plant control in Oklahoma." Down to Earth. Vol. 18, No. 3, 2-4, 1962.

(93) Gilderhus, P. A. "Effects of diquat on bluegills and their food organisms." Prog. Fish-Cult. 29(2): 67-74, 1967.

(94) Grzenda, A. R. "Public health aspects of weed control in potable water supplies." Presented at Southern Weed Control Conf., Jan. 1963.

(95) Hardy, J. L. "Effect of Tordon herbicides on aquatic chain organisms." Down to Earth 22(2):11-13, 1966.

(96) Johnson, R. E., T. C. Carver and E. H. Dustman. "Indicator species near top of food chain chosen for assessment of pesticide base levels in fish and wildlife--clams, oysters, and sediment in estuarine environment." Pest. Moni. Jour. 1(1): 7-13, 1967.

(97) Kenaga, E. E. "Tordon herbicides--Evaluation of safety to fish and birds." Down to Earth 25(1):5-9, 1969.

(98) Krammes, J. S. and D. B. Wellets. "Effects of 2,4-D and 2,4,5-T on water quality after spraying treatment." U. S. Forest Service Res. Note PSW-52, 1-4, 1964.

(99) Lawrence, J. M. "Aquatic herbicide data Agriculture Handbook No. 231, Agricultural Research Serv., U. S. Dept. of Agr. 1962.

(100) Linden, G. and A. Muller. "Further investigations on the effect of diesel oil on the soil." (In German). Allg. Forstzeitschr 18(50):791-93, 1963.

(101) Marston, R. B., et al. "Amitrole concentrations in creek waters downstream from an aerially sprayed watershed sub-basin." Pest. Moni. Jour. 2(3): 123-8, December, 1968.

(102) Martynyuk, V. Z. and M. I. Gzhegotskii. "Toxic chemical level in water and soil treated with chloroganic herbicides." Gig. Sanit. 32(2):96-8, 1967.

(103) Mullison, W. R. "Some toxicological aspects of silvex." Southern Weed Conf. Proc., 19:420-435, 1966.

(104) Nishiuchi, Y. and Y. Hashimoto. "Toxicity of pesticide ingredients to some fresh water organisms." Bull. Inst. Insect Contr. 32(1):5-11, 1967.

(105) Norris, L. A. and M. Newton and J. Zavitkovski. "Stream contamination with amitrole from forest spray operations." Western Weed Contr. Conf., Res. Comm.-Res. Prog. Report, 33-35, March, 1967.

(106) Petruk, G. F. "Effect of herbicides on heterotrophic microorganisms in ponds." Weed Abstr. 14(6)1837, 1965.

(107) Pierce, M. E. "The effect of the weedicide kuron upon the flora and fauna of two experimental areas of Long Pond, Dutchess County, New York." Proceedings of Northeast Weed Control Conf. 12:338-43, 1958.

(108) Pierce, M. E. "Further study of the effect of the weedicide kuron upon the flora and fauna of Long Pond, Dutchess County, New York." Presented at Northeast Weed Control Conf., Jan., 1958, New York, 13:310-14, 1959.

(109) Resigner, I. C., W. E. Supper and R. R. Johnson. "Will the use of 2,4,5-T to control streamside vegetation contaminate public water supplies?" Jour. of Forestry 66:914-18, 1968.

(110) Reinhart, K. G. "Herbicidal treatment of watersheds to increase water yield." N. E. Weed Control Conf. Proc. 19:546-51, 1965.

(111) Smith, G. E. and B. G. Isom. "Investigation of effects of large-scale applications of 2,4-D on aquatic fauna and water quality." Pest. Moni. Jour. 1(3): 16-21, 1967.

(112) Stubs, J. "The herbicidal properties of 1:1'-ethylene-2:2'-dephydridylium dibromide." Fourth Brit. Weed Cont. Conf. Proc., 251, 1960.

(113) Tarrant, R. F. and L. A. Norris. "Residues of herbicides and diesel oil carriers in forest water." The Herbicide in Vegetation Management Symposium Proc. (Oregon State Univ.) 81-88, Sept, 1967.

(114) U. S. Dept. of the Interior. "Report of the Committee on Water Quality Criteria." x + 234, Washington, D. C., 1968.

(115) Walker, C. R. "Diuron, fenuron, monuron, neburon and TCA mixtures as aquatic herbicides in fish habitats." Weeds 13(4):297-301, 1965.

(116) Winston, A. W., Jr. and P. M. Ritty. "What happens to phenoxy herbicides when applied to a watershed area?" Paper presented at Northeastern Weed Control Conf., Jan., 1961.

(117) Yeo, R. R. "Dissipation of diquat and paraquat, and effects on aquatic weeds and fish." Weeds 15(1): 52-6, Eng., 1967.

VI. ECOLOGICAL RELATIONSHIPS

(118) Barrons, K. C. "Some ecological benefits of woody plant control with herbicides." Science 165:465-68, 1 August, 1969.

(119) Coulter, L. L. "The role of herbicides in wildlife production through creation and stabilization of habitats." Down to Earth, 3 pp, Spring, 1958.

(120) Pfeiffer, E. W. and G. H. Orians. "Mission to Vietnam, Part 1." Sci. Res., 22, 23, 27, 28 and 30 pp, June 9, 1969.

(121) Pfeiffer, E. W. and G. H. Orians. "Mission to Vietnam, Part 2." Sci. Res., 26, 27, 29 and 30 pp, June 23, 1969.

(122) Tschirley, F. H. "Defoliation in Vietnam. The ecological consequences of the defoliation program in Vietnam are assessed." Science, 163:779-86 Feb. 21, 1969.

(123) Way, J. M. "Toxicity and hazards to man, domestic animals, and wildlife from some commonly used auxin herbicides. Residue Reviews 26:37-62, 1969.

LOSS OF PICLORAM AND 2,4,5-T FROM THE ROOTS OF ASH AND MAPLE SEEDLINGS

W. A. Wells, W. Hurtt, and C. P. P. Reid[1]

ABSTRACT

Sublethal concentrations of C^{14}-picloram (4-amino-3,5,6-trichloropicolinic acid) and C^{14}-2,4,5-T (2,4,5-trichlorophenoxyacetic acid) were foliarly applied to red maple (<u>Acer rubrum</u> L.) and green ash (<u>Fraxinus pennsylvanica</u> Marsh.) seedlings grown in nutrient solution under controlled environmental conditions. Similarly, C^{14}-picloram was also applied to the leaves of white ash (<u>Fraxinus americana</u> L.).

Samples were taken from the nutrient solutions of the red maple and green ash at preselected times over a 3-week period and daily from the white ash nutrient solution over a 9-day period. The total amount of C^{14} in each sample was determined by liquid scintillation spectrometry.

Radioactivity was detected in nutrient solution samples from all C^{14}-picloram treated plants within 24 hours. The amount of C^{14}-picloram lost by the roots of the red maple and green ash was increasingly greater over the 3-week period with the exception of a slight decrease in the amount lost on the sixth and sixteenth day from the green ash. The total radioactivity from C^{14}-picloram in the white ash nutrient solution increased over the entire 9-day period.

The nutrient solution samples of the C^{14}-2,4,5-T treated red maple yielded radioactivity within 24 hours and this amount increased over the 3-week sampling period with the exception of a decrease on the sixteenth day. The green ash nutrient solution showed C^{14}-2,4,5-T activity at 48 hours and continued to increase throughout the 3-week period. A greater loss of both labeled herbicides occurred from red maple than from green ash.

The fact that C^{14}-activity in the exudates was associated with unaltered herbicide molecules was substantiated by bioassays of the maple and green ash nutrient solution in conjunction with paper chromatography and liquid scintillation counting.

[1]Plant Physiologists, Plant Sciences Laboratories, Fort Detrick, Frederick, Maryland 21701

THE EFFECT OF FIVE HERBICIDES ON GIBBERELLIC ACID INDUCTION OF α-AMYLASE IN BARLEY ENDOSPERM

Robert M. Devlin and Richard P. Cunningham 1/

INTRODUCTION

Within the last ten years a great deal of knowledge has been accumulated concerning the physiology of the initial stages of grass seed germination. It appears that growth of the embryo during germination depends upon the synthesis and translocation of gibberellic acid (GA) from the embryo to the aleurone tissue where it induces the formation of several hydrolytic enzymes. The mobilization of stored starch and protein in the endosperm and aleurone tissues, as a result of the activities of these enzymes, supports growth in the embryo.

Haberlandt (9) in 1890 was the first to note that aleurone cells secrete starch-digesting enzymes in response to a substance emitted by the embryo. This observation was confirmed eight years later by Brown and Escombe (3). In 1958 work by Yomo (23) demonstrated that the substance responsible for the induction of enzyme formation in the aleurone cells of grass seeds was a gibberellin-like compound. Finally, in 1960 Yomo (24) and Paleg (17), working independently, demonstrated that exogenously applied GA could stimulate amylolytic activity in isolated barley endosperm-aleurone tissue.

To date it has been shown that embryo-free barley seed halves respond to the presence of exogenously applied GA with enhanced formation of α-amylase (21), protease (2), ribonuclease (4), pentosanase, and β-glucanase (14). Of significance is the fact that the *de novo* synthesis of at least two of these enzymes, α-amylase (6) and protease (10), occurs as a result of the activity of GA in this respect. As might be expected, GA-induced synthesis of α-amylase is retarded by the presence of protein synthesis (20) and RNA synthesis (4) inhibitors.

In the present study five herbicides, in practical or experimental use on cranberry bogs, were tested for their effect on GA induction of amylolytic activity in barley endosperm. The herbicides tested were 2,6-dichlorobenzonitrile (Dichlobenil), isopropyl-N-(3-chlorophenyl) carbamate (CIPC), 2-chloro-2,6-diethyl-N-(Methoxymethyl) acetanilide (Alachlor), 2-chloro-N-isopropylacetanilide (Propachlor), and the sodium salt of N-1-naphthyl phthalamic acid (Alanap). Two of these herbicides, Dichlobenil and CIPC, are proven inhibitors of protein synthesis (1).

1/ Associate professor of plant physiology and research assistant, respectively, Laboratory of Experimental Biology, Cranberry Experiment Station, University of Massachusetts, East Wareham, Massachusetts

MATERIALS AND METHODS

The procedures followed in this study in the barley endosperm test were essentially those of Jones and Varner (11) and Varner and Chandra (21). Seeds of barley (Hordeum vulgare var. Himalaya) were transversely cut and the embryo-free halves used as test material. After surface sterilization with 1% sodium hypochlorite (Chlorox) for 20 min followed by a sterile distilled water wash, the seed halves were transferred aseptically to petri dishes containing 100 g sterile standard sand and 20 ml sterile H_2O. The seed halves were allowed to imbibe water for 3 days at 22°C. Ten seeds were transferred aseptically to a 25 ml Erlenmeyer flask (incubation flask) containing 2 micromoles of acetate buffer (pH 4.8), 20 micromoles of calcium chloride, 20 ug of chloramphenicol, 2 ug of GA, and varying amounts of herbicide or water in a total volume of 8 ml. The seed halves were incubated in a water bath-shaker (Eberbach) for 24 hours at 40 oscillations per minute and 25°C.

The incubation medium was then decanted into a centrifuge tube and a 3 ml wash also added. After centrifugation at 2500 x g and 10°C the supernatant was decanted and saved for enzyme analysis. The reaction mixture consisted of 0.2 ml of the supernatant fraction, 0.8 ml H_2O, and 1 ml of starch substrate. The reaction was allowed to progress for 5 min in a water bath-shaker at 40 oscillations per minute and 25°C. Termination of the reaction was accomplished by adding 1 ml of iodine reagent. The reaction mixture containing the iodine reagent was then diluted with 5 ml of water and its optical density read at 620 mu in a Beckman DU spectrophotometer. Direct effect of the herbicides on the amylase-starch reaction was tested by substituting solutions of herbicides for H_2O in the reaction mixture.

The starch solution was prepared from 150 mg native potato starch, 600 mg KH_2PO_4, and 2 mg $CaCl_2$ in a total volume of 100 ml H_2O. The starch solution was boiled for one minute, cooled, and centrifuged at 5000 x g for 10 minutes and the supernatant used in the assay. The iodine stock solution was prepared from 6 g potassium iodide and 600 mg of iodine in a total volume of 100 ml water. One ml of this stock solution was added to 0.05 N HCl to give a total volume of 100 ml. This final solution was called the iodine reagent.

RESULTS

Preliminary tests established that 2 ug/ml GA added to the incubation flask induced sufficient enough amylolytic activity for the purposes of this study. All concentrations of Dichlobenil, from 3.5×10^{-5} to 1.4×10^{-4}M, inhibited GA induction of amylolytic activity in embryo-free barley seed halves (Table 1). The inhibitory influence of Dichlobenil in this respect increased with increase in concentration. With the lowest concentration employed (3.5×10^{-5}M) a 13.3% inhibition was observed. Amylolytic activity was retarded more than 50% by the highest concentration (1.4×10^{-4}M) of Dichlobenil used. Very little, if any, direct inhibition of the amylase-starch reaction by Dichlobenil was observed. That is, the addition of the herbicide directly to the reaction mixture did not affect the reaction (Table 1).

Table 1. The effect of Dichlobenil, CIPC, Alachlor, Propachlor, and Alanap on GA induction of amylolytic activity in barley endosperm. Amylolytic activity induced by GA (2ug/ml) alone was used as a control and is represented as 100% activity. The center column represents the effect of the herbicide when added with GA to the incubation flask. The right-hand column indicates the effect of the herbicide when added directly to the reaction mixture. Each experiment was replicated at least twice.

Treatment (molar conc.)	% Amylase activity	% Inhibition of amylase-starch reaction
Dichlobenil		
3.5×10^{-5}	86.7	3.5
6.9×10^{-5}	77.3	1.1
1.0×10^{-4}	54.3	0.3
1.4×10^{-4}	49.7	-
Alachlor		
3.7×10^{-6}	96.8	0.2
3.7×10^{-5}	94.0	2.4
1.9×10^{-4}	78.7	1.5
2.8×10^{-4}	71.8	2.4
3.7×10^{-4}	62.6	-
Propachlor		
4.7×10^{-6}	100.0	0
4.7×10^{-5}	100.0	0
2.4×10^{-4}	48.2	0
4.7×10^{-4}	18.3	0
CIPC		
4.7×10^{-6}	66.5	0
4.7×10^{-5}	63.4	0
1.9×10^{-4}	48.3	0
Alanap		
3.2×10^{-6}	100.0	0
3.2×10^{-5}	80.6	3.0
3.2×10^{-4}	65.4	25.9

Like Dichlobenil, all concentrations of CIPC, from 4.7×10^{-6} to 1.9×10^{-4}M, inhibited the induction of amylolytic activity by GA (Table 1). Also, with increasing concentrations the inhibitory influence of CIPC increased from a low of 33.5% to a high of 51.7%. Again, as with Dichlobenil, CIPC had no direct affect on the amylase-starch reaction (Table 1).

Although the addition of either of the acetanilides Propachlor and Alachlor to the incubation flask inhibited GA induction of amylolytic activity, at the lower concentrations used they were much less effective in this respect than Dichlobenil and CIPC (Table 1). For example, no inhibition was observed when 4.7×10^{-6} and 4.7×10^{-5} M Propachlor was used and the addition of 3.7×10^{-6} or 3.7×10^{-5} M Alachlor to the incubation flask caused only 3.2 and 6% inhibition, respectively. In a similar concentration range, CIPC caused more than a 33% inhibition of GA induction of amylolytic activity. However, at higher concentrations the acetanilides severely inhibited enzyme activity. Propachlor at 4.7×10^{-4} M caused an 81.7% reduction in activity and Alachlor at 3.7×10^{-4} M, a 37.4% reduction. Neither Propachlor nor Alachlor had any influence on the amylase-starch reaction when added directly to the reaction mixture (Table 1).

No inhibition of amylolytic activity was observed when 3.2×10^{-6} M Alanap was added to the incubation flask. However, GA induction of amylolytic activity was inhibited 19.4 and 34.6% by 3.2×10^{-5} and 3.2×10^{-4} M Alanap, respectively (Table 1). Part of the inhibitory influence of Alanap may have been due to a direct effect of the herbicide on the amylase-starch reaction. The addition of 3.2×10^{-4} M Alanap directly to the reaction mixture caused a 25.9% reduction in amylolytic activity (Table 1).

DISCUSSION

The de novo synthesis of α-amylase in the germinating barley seed occurs as a result of the presence of GA in the aleurone cells (22). Thus, any compound that inhibits protein synthesis or interferes with the production of compounds necessary for protein synthesis, could inhibit GA enhancement of enzyme production in the germinating barley seed. Both Dichlobenil and CIPC have been shown to uncouple phosphorylation from electron transport (7,13), an activity that deprives growing plant tissue of a readily available supply of ATP. In isolated cabbage mitochondria, for example, 10^{-3} M CIPC caused over a 90% inhibition of oxidative phosphorylation (13). In isolated cucumber mitochondria ATP formation was retarded by about 59% by 1.45×10^{-4} M Dichlobenil (7). Since ATP is an essential component in amino acid incorporation and RNA synthesis, it is not surprising that Dichlobenil and CIPC inhibit enzyme production in germinating barley seeds.

Pertinent also is the fact that both of these herbicides were found to inhibit proteolytic activity in the cotyledons of squash seedlings; that is, the formation of enzymes necessary for protein digestion was retarded (1). It is significant to note that the de novo synthesis of proteolytic enzymes in squash cotyledons has been reported (18).

A paucity of information exists on the mode of action of the acetanilides, Propachlor and Alachlor, possibly due to the relatively recent appearance of these herbicides on the commercial market. However, there is some evidence that the acetanilides may also affect protein synthesis in an adverse way. This can be assumed from the work of Duke et al. (5) who found that Propachlor inhibited the incorporation of leucine-C^{14} into protein.

Like the acetanilides, very little positive information exists on the mode of action of Alanap. Alanap influences the growth of plants by reducing their ability to respond to geotropic stimuli (8,19), inhibiting terminal bud growth, and increasing lateral bud growth (15). It is believed that the above effects of Alanap are due to its inhibitory influence on auxin transport (12,16). How this activity of Alanap relates to the adverse effect of the herbicide on GA induction of amylolytic activity is not as yet known.

LITERATURE CITED

1. Ashton, F.M., Penner, D., and Hoffman, S. 1968. Effect of several herbicides on proteolytic activity of squash seedlings. Weed Science 16: 169-171.

2. Briggs, D.E. 1963. Biochemistry of barley germination. Action of gibberellic acid on barley endosperm. J. Inst. Brewing 69:13-19.

3. Brown, H.T. and Escombe, F. 1898. On the depletion of the endosperm of *Hordeum vulgare* during germination. Proc. Roy. Soc. 63:3-25.

4. Chrispeels, M.J. and Varner, J.E. 1967. Gibberellic acid-enhanced synthesis and release of α-amylase and ribonuclease by isolated barley aleurone layers. Plant Physiol. 42:398-406.

5. Duke, W.B., Slife, F.W., and Hanson, J.B. 1967. Studies on the mode of action of 2-chloro-N-isopropylacetanilide. Abstracts, 1967 Meeting Weed Society of Amer., Wash., D.C.

6. Filner, P.F. and Varner, J.E. 1967. A simple and unequivocal test for *de novo* synthesis of enzymes: density labelling of barley α-amylase with $H_2{}^{18}O$. Proc. Natl. Acad. Sci. 58:1520-1526.

7. Foy, C.L. and Penner, D. 1965. Effects of inhibitors and herbicides on tricarboxylic acid cycle substrate oxidation by isolated cucumber mitochondria. Weeds 13:226-231.

8. Grigsby, B.H., Tsou, T.M., and Wilson, G.B. 1954. Some effects of Alanap (NP) and amizole on germinating peas. Proc. 11th North Central Weed Control Conf.

9. Haberlandt, G. 1890. Die Kleberschicht des Gras-Endosperms als Diastase ausscheidendes Drusengewbe. Ber. Deut. Botan. Ges. 8:40-48.

10. Jacobsen, J.V. and Varner, J.E. 1967. The gibberellic acid induced synthesis of protease by isolated aleurone layers of barley. Plant Physiol. 42:1596-1600.

11. Jones, R.L. and Varner, J.E. 1967. The bioassay of gibberellins. Planta 72:155-161.

12. Keitt, G.W. Jr. and Baker, R.A. 1966. Auxin activity of substituted benzoic acids and their effect on polar auxin transport. Plant Physiol. 41:1561-1569.

13. Lotlikar, P.D., Remmert, L.F. and Freed, V.H. 1968. Effects of 2,4-D and other herbicides on oxidative phosphorylation in mitochondria from cabbage. Weed Science 16:161-165.

14. MacLeod, A.M. and Millar, A.S. 1962. Effect of gibberellic acid on barley endosperm. J. Inst. Brewing 68:322-332.

15. Mitchell, J.W., Marth, P.C., and Freeman, G.D. 1965. Apical dominance in bean plants controlled with phthalamic acids. Agricultural Food Chem. 13:326-329.

16. Morgan, D.G. 1964. Influence of α-naphthylphthalamic acid on the movement of indole-3-acetic acid in plants. Nature 201:476-477.

17. Paleg, L.G. 1960. Physiological effects of gibberellic acid: I. On carbohydrate metabolism and amylase activity of barley endosperm. Plant Physiol. 35:293-299.

18. Penner, D. and Ashton, F.M. 1966. Proteolytic enzyme control in squash cotyledons. Nature 212:935-936.

19. Tsou, T.M., Hamilton, R.H., and Bandurski, R.S. 1956. Selective inhibition of the geotropic response by n-1-naphthylphthalamic acid. Physiol. Plant. 9:546-558.

20. Varner, J.E. 1964. Gibberellic controlled synthesis of α-amylase in barley endosperm. Plant Physiol. 39:413-415.

21. Varner, J.E. and Chandra, G.R. 1964. Hormonal control of enzyme synthesis in barley endosperm. Pro. Natl. Acad. Sci. 52:100-106.

22. Varner, J.E. and Johri, M.M. 1968. Hormonal control of enzyme synthesis. In F. Wightman and G. Setterfield (eds.), Biochemistry and Physiology of Plant Growth Substances. Runge Press Ltd., Ottawa, Canada.

23. Yomo, H. 1958. Studies on the barley malt. The sterilization of barley seeds and the amylase formation of separated embryos and endosperms. Hakko Kyokai Shi 16:444-448.

24. Yomo, H. 1960. Studies on the α-amylase activating substance. IV. On the amylase activating action of gibberellin. Hakko Kyokai Shi 18: 600-602.

CHEMICAL WEEDING OF ONIONS GROWN FROM TRANSPLANTS

Charles J. Noll [1/]

Limited acreages of onions are grown in Pennsylvania from transplants. Much of the acreage is on institutional farms and in special projects for 4-H members. Weed control is a major problem. This report is a summary of work completed during the 1969 growing season. Treatments are in part based on the most successful treatments in trials from 1965 to 1968.

Procedure

The onion weed control trials were conducted at the Horticulture farm located 10 miles west of University Park. The soil, a Hagerstown silt loam, was plowed in the Fall of 1968 and the seedbed prepared April 30, 1969. The field was planted to the variety Sweet Spanish, May 6.

Single row plots, 18 feet long and 2 feet wide, were randomized in each of 6 blocks. All chemicals were applied over the total area of the plot. Plots received from 1 to 3 applications of herbicides. Cultivation was practiced. Weed records were taken on July 17 on a basis of 1 to 9, 1 being least desirable, with full weed growth and 9 most desirable with perfect weed control. The onions were harvested October 6.

Results

The results of the trial are presented in Table 1. All herbicide treated plots had better control than the poorly weeded hand weeded plot. Taking into consideration weed control, stand of plants and weight of bulbs the best treatments were propachlor applied in 3 applications of 5 pounds per acre 1, 30 and 60 days after transplanting and in two applications at 10 lbs. per acre 1 day after planting followed by 5 pounds per acre 30 days after planting or in 1 application a combination of propachlor and DCPA at 5 lbs. of each per acre, the day after planting. CP 50144 in a split application, Nitrofen wp at 6 lbs. per acre applied 8 days after transplanting and RP 17623 applied 30 days after transplanting looks promising for the weeding of transplanted onions.

[1/] Associate Professor of Olericulture, Department of Horticulture, College of Agriculture Experiment Station, The Pennsylvania State University, University Park, Penna.

Table 1. Effect of herbicides on weed control, number of onion plants and weight of bulbs grown from transplants.

Treatment	Active Rate lbs/A	Application Days from Planting	AVERAGE PER PLOT Weed Control 1-9	Harvest Record No. Plants	Harvest Record Wt. Bulbs Lbs.
1 Hand Weed	--	---	4.0	35	5.4
2 DCPA	10	Pre +1	8.0	34	5.3
3 Amiben	4	"	9.0	15	2.2
4 CIPC	6	"	8.7	7	1.3
5 Propachlor (Ramrod) wp	5+5+5	Pre +1 Post +30 +60	9.0	43	6.0
6 Propachlor	10+5	" "	9.0	39	6.3
7 RP 17623	4	"	9.0	29	6.7
8 "	6	"	9.0	19	3.8
9 CP 50144 (Lasso)	2	"	8.8	32	5.6
10 "	2+2	Pre +1 Post +30	9.0	45	6.9
11 "	4	"	9.0	30	4.2
12 Propachlor wp + CIPC	5+3	"	8.8	28	4.8
13 CP 50144 + CIPC	2+3	"	9.0	21	3.0
14 Propachlor + DCPA	5+5	"	9.0	45	8.8
15 Propachlor + CP 50144	5+2	"	8.8	32	6.0
16 Chloroxuron (Tenoran)	3	Post +30	8.2	38	6.7
17 "	6	"	6.5	37	5.1
18 "	2+2+2	Pre +1 Post +30 +60	7.8	33	5.0
19 RP 17623	2	Post +30	6.8	23	4.1
20 "	4	"	7.8	29	4.0
21 "	6	"	8.7	35	6.5
22 Nitrofen (TOK ec)	4	Post +8	6.8	30	4.4
23 "	6	"	7.2	27	4.6
24 " (TOK wp)	4	"	6.5	31	4.8
25 "	6	"	8.7	36	7.3
Least Significant Difference	5%		1.4	15	3.2
" " "	1%		1.9	20	4.3

STUDIES ON THE USE OF CHLOROXURON AND OTHER HERBICIDES FOR WEED CONTROL IN ONIONS

J. C. Cialone, D. A. Braden and N. J. Smith[1/]

Introduction

Onion (Allium cepa) is an important vegetable crop in New Jersey. The majority of the current crop acreage on mineral soils is grown from sets. The seed acreage, however, has increased significantly over the past several years and further increases seem likely.

DCPA is the most widely used chemical for weed control in onions grown on mineral soils. Satisfactory control of annual grasses and several broadleaf weeds, including lambsquarter (Chenopodium album) and redroot pigweed (Amaranthus retroflexus), has resulted when irrigation or rainfall have followed chemical application. DCPA, however, is ineffective against common ragweed (Ambrosia artemisiifolia), galinsoga (Galinsoga spp.), sheperdspurse (Capsella bursa-pastoris), pepperweed (Lepidium virginicum) and Anthemis spp. These weeds are commonly found in most onion fields in South Jersey and present a serious problem in the culture of this crop.

The objective of the work reported here was to evaluate herbicides for the control of the above-mentioned problem weed species, in both set and seed grown onions.

Procedure

Experiments were conducted at three grower locations in South Jersey and at the Adelphia Research Center. Both pre and postemergence applications were made to set and seed grown onions. The experiments and locations are summarized in Table 1.

In all cases where grower locations were used, DCPA was applied at 10.0 lbs/A as a preemergence treatment. This includes experiments for both set and seed grown onions.

All experiments were conducted on sandy loam soils. In all cases where sets are reported, the variety Ebenezer was used. In tests conducted with onions grown from seed, the variety Pronto was used. The only exception is that in the Adelphia seed onion experiment, one replicate was planted to the variety Sweet Spanish. A randomized complete block design, with three replicates was used in each test. Where weed or crop responses are reported the following rating system was used; 0 = No crop injury or weed control and 9 = Crop eliminated or 100% weed control.

1/ Associate Research Professor and Graduate Assistant in Weed Control, Soils and Crops Department, and Cumberland County Agricultural Agent, respectively. Rutgers University, New Brunswick, New Jersey.

Table 1. Summary of experiments conducted for weed control in onions during 1969.

Location	I. Set Grown Onions How Chemicals Applied	II. Seed Grown Onions How Chemicals Applied
Sporacio Farm	Pre and Postemergence	Early Postemergence
Taylor Farm	Pre and Postemergence	-
Sorrentino Farm	-	Postemergence
Adelphia Res. Cntr.	Postemergence	Pre and Postemergence

Table 2. The response of onions, grown from sets, and weeds to herbicides applied preemergence - 1969.

		Sporacio Farm		Taylor Farm		
		Onion Response	Ragweed Response	Onion Response	Pepperweed Response	Onion yield* lb/Plot
Chemical	lb/A	5/7	5/7	5/7	5/7	7/11
chlorpropham	.25	0.3	4.6	0.0	1.6	16.2 a
chlorpropham+ chloroxuron	.25+ .75	1.0	4.6	0.3	9.0	25.3 abc
chlorpropham+ chloroxuron	.25+ 1.5	0.6	4.6	0.0	9.0	33.2 bc
chlorpropham+ linuron	.25+ .50	0.0	5.0	0.0	8.6	25.5 abc
chlorpropham+ linuron	.25+ 1.0	1.3	6.3	1.0	9.0	30.3 bc
chloroxuron	.75	0.0	2.0	0.0	8.6	27.8 abc
	1.5	2.3	5.0	0.3	8.6	37.4 c
linuron	.50	0.0	5.6	0.3	9.0	23.6 ab
	1.0	0.3	5.6	0.3	9.0	34.3 bc
control	-	0.3	2.3	0.0	2.0	31.5 bc

*Means having a letter in common are not significantly different at the 5% level (Duncan's Multiple Range Test).

I. Set Grown Onions - Preemergence Applications

Sporacio and Taylor Farms

Chemicals were applied on 3/27/69 at both locations. The onions had roots about 0.5 in. long and the shoots had just begun to emerge from the bulb at the time the chemicals were applied. Various treatments and the results obtained are presented in Table 2.

Discussion

Onion Response

Crop injury was not serious with any of the chemicals or combinations of chemicals applied at either location.

Weed Response

Ragweed - None of the chemicals or combinations of chemicals gave satisfactory control of ragweed at the Sporacio Farm location. Linuron, however, was considerably more active on ragweed than chloroxuron.

Pepperweed - Both linuron and chloroxuron were highly active on pepperweed. Excellent control resulted at all dosages of both chemicals. Chloropropham gave no control of pepperweed when used alone and had little influence when used in combination with either linuron or chloroxuron.

Set Grown Onions - Postemergence Applications

Sporacio and Taylor Farms

Chemicals were applied on 4/18/69 at both locations. The onions had 4 leaves and were about 8 in. tall. The pepperweed was 0.5 in. tall and had 3-4 true leaves. The ragweed had 2 true leaves and was 0.5-1.0 in. tall. Various treatments and results are presented in Table 3.

Discussion

Onion Response

At both locations slight onion injury was observed where chloroxuron was applied at 3.0 or 4.0 lbs/A. Linuron, however, was affected by location. Little injury was observed at the Sporacio Farm location, while serious injury, especially at the 1.0 lb/A dosage, occurred at the Taylor Farm. The injury became progressively more evident as the season progressed. Nitrofen caused severe chlorosis and necrosis of onion leaves early in the season, slight permanent stunting occurred, but onion regrowth was good. KOCN caused slight chlorosis early in the season, but onion recovery was rapid. Cypromid was extremely toxic to onions at both locations.

Weed Response

Ragweed - Both linuron and cypromid gave satisfactory control of ragweed. Chloroxuron, KOCN and nitrofen gave fair control. Nitrofen caused initial burning of ragweed, but many plants recovered.

Pepperweed - Chloroxuron, linuron and cypromid were highly effective against pepperweed at all dosages tested. KOCN and nitrofen gave fair to good control of this weed.

Set Grown Onions - Postemergence Applications
Adelphia Research Center

Chemicals were applied on 5/5/69. The onions were 4-6 in. tall and had 5 leaves. *Anthemis* spp., lambsquarter, chickweed (*Stellaria media*) and crabgrass (*Digitaria sanguinalis*) were 0.5-1.5 in. tall. Various treatments and the results obtained are presented in Table 4.

Discussion
Onion Response

All chemicals caused some crop injury. Chloroxuron caused early chlorosis and nitrofen, cypromid and RP-17623 caused both chlorosis and necrosis.

Weed Response

Anthemis spp., lambsquarter and chickweed were satisfactorily controlled by chloroxuron, but crabgrass was only fair with this chemical. Nitrofen effectively controlled lambsquarter and crabgrass, but gave poor control of *Anthemis* spp. and chickweed. Cypromid effectively controlled all weed species which were present. RP-17623 was effective on all species except chickweed.

II. Seed Grown Onions - Postemergence Applications
Sporacio Farm

Chemicals were applied on 4/18/69. About 25% of the onions were in the flag stage and the rest were in the crook stage. Ragweed plants had 2 true leaves. Various treatments and the results obtained are presented in Table 5.

Discussion
Onion Response

Onion stand and vigor reductions were observed with all compounds

Table 3. The response of onions, grown from sets, and weeds to herbicides applied postemergence - 1969.

		Sporacio Farm		Taylor Farm		
		Onion Response	Ragweed Response	Onion Response	Pepperweed Response	Onion Yields* lbs/Plot
Chemical	lbs/A	5/7	5/7	5/7	5/7	7/11
chloroxuron	3.0	0.3	6.3	0.6	9.0	31.2 e
"	4.0	0.6	6.3	0.6	9.0	23.9 bcde
linuron	0.5	0.0	8.0	3.0	9.0	21.2 bc
"	0.75	0.6	8.6	6.0	9.0	8.7 a
KOCN	4.0	0.3	5.0	0.0	6.6	31.7 e
"	8.0	0.0	4.0	1.0	6.3	30.6 de
nitrofen	4.0	4.0	5.3	3.6	6.6	26.8 bcde
"	6.0	5.0	6.0	3.3	7.3	29.8 cde
cypromid	2.0	6.6	9.0	6.3	9.0	21.7 bcd
"	4.0	7.6	9.0	7.6	9.0	10.4 a
control	-	0.0	3.0	0.6	2.3	20.1 b

*Means having a letter in common are not significantly different at the 5% level. (Duncans Multiple Range Test).

Table 4. The response of onions, grown from sets, and weeds to herbicides applied postemergence. (Ratings made on 6/4/69).

Chemical	lbs/A	Onion Response	Anthemis spp.	Lambsquarter	Chick-weed	Crabgrass
chloroxuron	2.0	1.6	8.6	9.0	9.0	6.3
nitrofen	2.0	2.0	4.3	9.0	3.6	9.0
cypromid	2.0	3.0	7.0	9.0	9.0	9.0
RP-17623	1.5	2.6	9.0	9.0	4.0	9.0
RP-17623	3.0	4.6	9.0	9.0	4.6	9.0
control	-	0.6	5.0	5.6	3.6	6.3

tested. Linuron, nitrofen, cypromid and the 4.0 lb/A dosage of chloroxuron eliminated the crop almost completely.

Weed Response

Ragweed - Linuron and cypromid were highly effective against ragweed, while chloroxuron, KOCN and nitrofen gave only fair control.

Seed Grown Onions - Postemergence Applications
Sorrentino Farm

Chemicals were applied on 5/16/69. The onions had 3 true leaves and were about 4 in. tall. Galisoga was the predominant weed species and plants were 2-4 in. tall at the time of chemical application. Various

Table 5. The response of onions grown from seed to herbicides applied early postemergence - 1969.

		Sporacio Farm				
		Onion Response		Ragweed Response		Onion yields* lb/Plot
Chemical	lb/A	4/22	5/16	4/22	5/16	7/25
chloroxuron	2.0	0.0	2.6	3.6	6.6	24.7 c
	4.0	0.6	6.0	3.6	7.0	8.2 ab
linuron	0.5	2.0	7.6	3.6	8.0	0.0 a
	.75	1.6	8.6	5.0	8.3	0.0 a
KOCN	4.0	1.5	0.6	3.6	5.3	37.8 d
	8.0	1.5	1.3	4.3	6.0	20.5 bc
nitrofen	4.0	5.6	7.6	7.6	7.0	7.1 ab
	6.0	6.6	7.0	7.0	5.3	3.1
cypromid	2.0	5.3	9.0	7.6	9.0	0.0 a
	4.0	8.0	9.0	8.6	9.0	0.0 a
control	-	0.0	0.3	2.0	3.0	44.3 d

*Means having a letter in common are not significant at the 5% level (Duncan's Multiple Range Test).

treatments and the results obtained are presented in Table 6.

Discussion

Onion Response

Application of chloroxuron alone gave only slight injury at dosages up to 3.0 lbs/A. At 4.0 lbs/A more serious injury resulted. Where adjuvant (Adjuvan-T) or adjuvant + oil (Booster-plus) was added to chloroxuron, early season injury resulted even at 1.0 lbs/A. At both 1.0 or 2.0 lbs/A, however, onion recovery was rapid. Linuron and chlorbromuron were extremely phytotoxic to onions at dosages of 0.5 lbs/A or greater.

Weed Response

Galinsoga - Control of galinsoga was only fair when chloroxuron was used alone. When adjuvant or adjuvant + oil were added to chloroxuron at dosages of 2.0 lbs/A or greater, good to excellent galinsoga control resulted. Linuron and chlorbromuron gave excellent control of galinsoga.

Seed Grown Onions - Pre and Postemergence Applications
Adelphia Research Center

Preemergence applications were made immediately after planting

Table 6. The response of onions, grown from seed, and galinsoga to herbicides applied early postemergence - 1969.

Chemical	lb/A	Onion Response 5/26	Galinsoga Response 5/26	Onion yields* lb/Plot 7/18
chloroxuron	1.0	0.6	3.6	32.2 d-g
	2.0	1.0	5.3	46.5 g
	3.0	1.0	5.3	46.8 g
	4.0	2.6	7.3	33.7 d-g
chloroxuron+ Adjuvan-T[1/]	1.0	2.6	6.0	29.2 c-g
	2.0	3.6	7.0	30.8 d-g
	3.0	3.6	7.3	15.5 a-d
	4.0	4.0	8.3	16.7 a-e
chloroxuron+ Booster-Plus[2/]	1.0	2.3	5.6	42.7 fg
	2.0	3.0	8.0	20.9 a-e
	3.0	3.6	8.3	22.6 b-f
	4.0	5.0	9.0	15.0 a-d
linuron	0.5	4.6	9.0	8.2 a-c
	.75	6.6	9.0	4.1 ab
	1.0	8.0	9.0	0.6 a
chlorbromuron	.25	0.3	5.3	37.7 e-g
	.50	3.0	9.0	0.0 a
	.75	3.6	9.0	0.0 a
	1.0	4.0	9.0	0.0 a
control	-	0.0	1.3	21.0 a-e

*Means having a letter in common are not significantly different at the 5% level (Duncan's Multiple Range Test).

1/ Adjuvan-T - product of CIBA Agrochemical Company, Vero Beach, Florida.

2/ Booster-Plus - product of Agway Inc., Syracuse, New York.

on 5/9/69. Postemergence applications were made on 5/23/69. The onions had 2 leaves and were about 2 in. tall at this time. Crabgrass was 0.5-1.0 in. tall and pigweed was about 1.0 in. tall. In some treatments chemicals were applied preemergence as tank-mix combinations. In other treatments preemergence applications were followed by postemergence applications. Various treatments and the results obtained are presented in Table 7.

Discussion

Onion Response

Chloroxuron was consistently more toxic to onions when applied preemergence than when applied postemergence. The same was true for linuron when it was used alone. When linuron applications followed DCPA applications, the reverse was true. No injury resulted from applications of nitrofen either alone or following DCPA applications. KOCN alone or KOCN following DCPA application gave little or no onion injury.

Weed Response

Pigweed - All compounds tested gave satisfactory control of pigweed with the exception of the 4.0 lbs/A dosage of KOCN. When this chemical was combined with 8.0 lbs/A of DCPA, satisfactory pigweed control resulted.

Crabgrass - Postemergence applications of chloroxuron alone and pre and postemergence applications of linuron generally resulted in poor to fair crabgrass control. The 4.0 lbs/A dosage of KOCN gave poor crabgrass control. Cypromid gave satisfactory crabgrass control.

Summary

A number of herbicides were studied for possible use in set and seed grown onions. Chloroxuron and linuron show some promise for the preemergence control of pepperweed in set grown onions. Chloroxuron and nitrofen show promise for postemergence weed control in both set and seed grown onions. Stage of growth with seed onions appears to be a critical factor for the safe use of chloroxuron.

Table 7. The response of onions, grown from seed, and weeds to herbicides alone and in combination, applied pre and early postemergence - 6/27/69

Chemical	lbs/A	How App.	Onion Count No./plot	Onion Response	Weed Response Pigweed	Weed Response Crabgrass
chloroxuron	2.0	PRE	35.3	3.0	9.0	7.0
chloroxuron	2.0	POST	58.6	2.6	9.0	5.6
chloroxuron	4.0	PRE	11.6	5.6	9.0	8.0
chloroxuron	4.0	POST	38.3	2.3	9.0	6.3
DCPA	8.0	PRE	59.3	0.6	7.0	8.3
DCPA	10.0	PRE	50.0	0.3	6.3	8.3
DCPA+ chloroxuron	8.0+ 2.0	PRE PRE	44.6	3.0	8.6	6.6
DCPA+ chloroxuron	8.0+ 2.0	PRE POST	39.3	3.3	9.0	8.0
DCPA+ chloroxuron	8.0+ 4.0	PRE PRE	22.6	3.6	8.6	8.6
DCPA+ chloroxuron	8.0+ 4.0	PRE POST	37.0	4.6	9.0	8.3
linuron	0.5	PRE	24.3	4.0	8.6	4.3
linuron	0.5	POST	42.0	6.0	9.0	6.0
linuron	1.0	PRE	15.6	5.6	9.0	5.0
linuron	1.0	POST	25.3	7.0	9.0	7.6
DCPA+ linuron	8.0+ 0.5	PRE PRE	51.3	2.0	8.3	7.6
DCPA+ linuron	8.0+ 0.5	PRE POST	17.5	7.0	9.0	8.0
DCPA+ linuron	8.0+ 1.0	PRE PRE	12.0	6.3	9.0	8.0

(Continued)

Table 7 (continued).

Chemical	lbs/A	How App.	Onion Count No./plot	Response	Weed Response Pigweed	Crabgrass
DCPA+	8.0+	PRE	1.5	8.0	9.0	8.0
linuron	1.0	POST				
nitrofen(EC)	2.0	POST	81.6	0	8.6	6.3
nitrofen (WP)	2.0	POST	67.0	0	9.0	8.6
nitrofen (EC)	3.0	POST	71.3	0	9.0	7.0
nitrofen (WP)	3.0	POST	65.3	0	9.0	8.3
DCPA+	8+2	PRE	70.6	0.6	9.0	8.6
nitrofen (EC)		POST				
DCPA+	8+3	PRE	76.3	0	9.0	8.6
nitrofen (EC)		POST				
cypromid	.75	POST	35.3	4.3	9.0	7.0
cypromid	1.5	POST	17.0	6.0	9.0	7.3
DCPA+	8.0+	PRE	23.3	6.3	9.0	7.3
cypromid	.75	POST				
DCPA+	8.0+	PRE	5.3	8.0	9.0	8.0
cypromid	1.5	POST				
KOCN	4.0	POST	48.0	0	5.0	3.6
KOCN	8.0	POST	50.3	1.3	7.0	4.3
DCPA+	8.0+	PRE	48.0	1.0	7.3	7.6
KOCN	4.0	POST				
DCPA+	8.0+	PRE	62.0	0.3	8.0	8.0
KOCN	8.0	POST				
weeded control			59.0	0	9.0	8.6
control			51.3	0	2.0	1.3

WEED CONTROL IN TRANSPLANT ONIONS GROWN ON MINERAL SOILS[1]

William J. Sanok[2] and Stewart L. Dallyn[3]

Introduction

The commercial practice on Long Island has been to use CIPC or Dacthal to control purslane or annual grasses. In rotation with onions the growers raise cabbage, cauliflower, beans, cucumbers, and stawberries. As a result of using the popular herbicides on all of these crops, weeds such as galinsoga (Galinsoga ciliata) and pineapple weed (Matricaria matricarioides) have flourished and become severe problems.

MATERIALS AND METHODS

The chemicals used at the Research Farm and on a commercial farm were Dacthal, CIPC, Ramrod and Tenoran. In both cases, Texas-grown Early Harvest onion transplants were used. The soils in these locations are sandy loams.

A. Trial at the L.I. Vegetable Research Farm

Plants were set 4" apart in 34" rows on April 27th. One half of the experimental area was treated with 12 lbs. AIA Dacthal on April 29th. The other half received no treatment until May 12th.

There were four replications of single row plots 30-feet long. In both experiments, weeds were removed by hand before the second and third applications of herbicides.

Weed control ratings were made on June 19, July 2 and July 17. The crop was pulled on August 4 and topped one week later. The bulbs were graded, weighed and samples were placed in common storage until October 15. These samples were checked for amount of rot and a number of bulbs were split open to determine if any treatment affected quality.

The wet weather in late July and the first half of August was very detrimental to overall quality especially storability.

B. Trial on a commercial farm

This trial was conducted on plants set on April 17th 3" apart with 3 rows to a bed. The beds were 6 feet across. One half of the trial was sprayed with 10 lbs. AIA Dacthal by the grower immediately after planting.

---

[1] Paper No. 569, Dept. of Vegetable Crops, Cornell University
[2] Cooperative Extension Agent, Suffolk County, Riverhead, N.Y.
[3] Professor, Cornell University, L.I. Vegetable Research Station.

The plots were one bed wide and 25 feet long with four replications. Two reps were on the Dacthal treated beds and two on the untreated area.

On April 18th the first application of 2 lbs. AIA Tenoran was applied on treatment # 3. This was followed by repeat applications on May 5th and May 21st. The main herbicide application was made on May 5th. At that time there was a flush of pineapple weed in the cotyledon stage.

Ratings were made on May 21st and June 5th. It was necessary to hand weed and hoe treatments 8, 9 and 10 on June 5th and treatments 6 through 10 during the last week of June.

RESULTS AND DISCUSSION

Data from the two experiments on the Research Farm are summarized in Tables 1 and 2 and on the commercial field in Table 3.

On the Research Farm

1) Early treatment with Dacthal appeared to be as effective as CIPC applied two weeks after setting.

2) From Table 1 treatments 2, 6 and 7 which all received Tenoran on June 18 were down in yield. There is some indication that a 4-day hot spell immediately after application may have resulted in some damage.

3) Ramrod and Tenoran were relatively short lived, approximately 3 to 4 weeks. Single applications were not sufficient for season-long control.

4) Pineapple weed was the most difficult to control and was found to some extent in nearly all treatments.

On the commercial farm

1) Tenoran at 4 lbs., the split application of 2 lbs. at 3 times, and Ramrod at 8 lbs. gave excellent control of pineapple weed and galinsoga for the season.

2) Despite some injury from the May 21 application of Tenoran, there were no significant differences in yield. This application was followed by a record hot spell around May 30.

3) There was no advantage in applying Dacthal immediately after planting in this location.

4) In areas where either the Tenoran or Ramrod treated soil was disturbed, weeds readily germinated.

5) Ramrod applications below 6 lbs. AIA were not as effective and require hand weeding.

GENERAL COMMENTS

1) All four chemicals involved in these experiments Dacthal, CIPC, Ramrod and Tenoran were excellent herbicides and used in the proper combinations will provide very satisfactory weed control.

2) Soil treated with Tenoran or Ramrod should not be disturbed by cultivation.

3) There is strong evidence that a hot, humid period following applications of Tenoran can lead to crop injury.

4) Rotation and combinations of herbicides to prevent the build-up of hard to kill weeds is becoming more important.

Table 1. Results of Dacthal at planting plus later applications of various herbicides on yield of onions and control of weeds[1/] on the Research Farm.

Treatment	Lbs. AIA	Application Days From Planting	Yield - Bu/A Total	3"Min.	Weed Control Ratings[2/] 6/20	7/17	% Rot 10/15
1. CIPC	6+6	29+52	626	557	3.2	3.8	11.1
2. " + Tenoran*	6+4	29+52	465	292	4.4	5.0	17.4
3. " + Ramrod*	6+6	29+52	622	572	4.2	4.5	26.3
4. Tenoran	4	29	584	503	4.5	3.0	21.4
5. "	6	29	572	465	4.4	3.6	10.3
6. "	2+2	29+52	499	361	4.0	4.3	12.1
7. "	3+3	29+52	492	349	4.1	4.6	18.0
8. Ramrod	6	29	584	499	4.5	4.6	10.9
9. "	8	29	614	518	4.0	4.0	12.5
10. "	4+4	29+52	618	545	3.6	4.2	7.5
11. Check			538	415	1.0	1.0	11.7
12. "			588	499	1.0	1.0	9.1
		LSD 5%	86	141			

1/ Primary weeds present: annual grasses, pineapple, purslane, mustard, smartweed, lambsquarter, galinsoga. Population of none of them was very severe.
2/ 1 - no weed control, 5 - complete.

* CIPC at 6 lbs. was applied 29 days after planting then Tenoran 4 lbs. or Ramrod 6 lbs. applied 52 days after planting.

Table 2. Results of several herbicides on yield of onions and control of weeds on the Research Farm.

Treatment	Lbs. AIA	Application	Yield - Bu/A		Weed Control Ratings[1/]			% Rot
			Total	3" Min.	6/19	7/2	7/17	10/15
1. CIPC	6+6+6	15+37+60	626	538	3.5	4.0	3.8	4.1
2. " + Tenoran*	6+4	15+37	549	407	4.3	4.8	4.2	12.8
3. " + " *	6+6	15+37	521	380	4.3	4.5	4.2	3.2
4. " + " *	6+3+3	15+37+60	532	392	3.0	4.0	4.2	4.3
5. " + Ramrod*	6+6	15+37	488	331	2.5	3.5	4.0	9.2
6. " + " *	6+8	15+37	663	586	4.5	5.0	4.2	2.0
7. " + " *	6+4+4	15+37+60	623	551	4.3	4.8	4.7	16.1
8. Tenoran	4	15	614	547	3.0	2.0	2.0	15.7
9. "	6	15	561	446	3.0	2.8	2.2	3.6
10. "	4+4	15+37	582	465	4.3	4.0	4.0	1.7
11. "	2+2+2	15+37+60	478	300	3.8	4.3	4.8	2.5
12. "	3+3+3	15+37+60	472	286	4.3	4.8	4.5	11.8
13. Ramrod	6	15	644	566	3.0	3.0	2.5	16.1
14. "	4+4	15+37	660	589	4.3	4.3	3.5	3.5
15. Check			616	485	1.0	1.0	1.0	15.7
16. "			661	588	1.0	1.0	1.0	15.6

1/ 1 - no control, 5 - complete control.

* CIPC at 6 lbs. was applied 15 days after planting then Tenoran or Ramrod 37 and 60 days after planting as indicated.

Table 3. Results of several herbicides on yield of onions and weed control[1] on the Terry Farm.

Treatment	Lbs. AIA.	Weed Control Ratings[2] May 21	June 5	Yield Bu/A
1. Tenoran	3	4.4	3.6	855.2
2. "	4	4.5	4.1	895.8
3. " [3]	2+2+2	5.0	5.0	843.6
4. Ramrod	6	4.6	4.7	893.0
5. "	8	4.7	5.0	904.6
6. " + Dacthal	5+10	4.2	3.9	948.2
7. " + CIPC	5+3	3.5	2.9	904.6
8. Dacthal	10	1.5	1.0	839.2
9. CIPC	3	2.9	2.0	864.0
10. Check		1.1	1.0	833.4
		LSD		NS

1/ Major weeds were pineapple weed, galinsoga and a low population of annual grasses.

2/ 1 = none, 5 = complete

3/ Three applications of 2 lbs. AIA each on April 18, May 5 and May 21.

PRE-EMERGENCE WEEDING OF ASPARAGUS GROWN FROM SEED

Charles J. Noll [1/]

Asparagus crowns are grown from seed for one growing season before being planted in permanent beds. The possibility of direct seeding of asparagus in permanent beds renewed our interest in chemical weeding of this crop.

Procedure

The weeding trials were conducted at the Horticultural farm located 10 miles west of University Park. The soil, a Hagerstown silt loam, was plowed in the Fall of 1967. The seedbed was prepared April 16, 1968 and seeded the next day to the variety Mary Washington. All herbicides were applied the day of seeding or one day after seeding in a pre-emergence application covering the width of the plot. Plots were two feet wide and eighteen feet long and replicated six times.

Major weeds present were lambsquarters, yellow foxtail and redroot pigweed. Plots were cultivated. Where no chemicals were applied at the end of the growing season the asparagus seedlings were completely hidden by the weeds. Weed control records were taken on June 6 and July 8 on a rating scale of 1 to 9, 1 being least desirable, full weed growth and 9 most desirable, no weeds present.

A ten foot section of each plot in the six replications was harvested April 15, 1969.

Results and Conclusion

The results are presented in Table 1. Taking into consideration weed control and weight of roots, the best treatments were Monuron or Linuron at two pounds per acre and Amiben at eight pounds per acre applied as pre-emergence applications. Although the Terbacil treatments at 1 pound per acre gave equally good results at two pounds per acre asparagus yield of roots was greatly reduced.

[1/] Associate Professor of Olericulture, Department of Horticulture, College of Agriculture Experiment Station, The Pennsylvania State University, University Park, Pa.

Table 1. Weed control and weight of asparagus roots grown from seed with varying chemical treatments.

Treatment	Active Rate lbs/A	Application Days from Planting	AVERAGE PER PLOT Weed Control (1-9) June 6	July 8	Wt. Roots 10' of Row Lbs.
1 Nothing	--	--	1.0	1.0	0.2
2 Hand Weed	--	--	9.0	9.0	4.1
3 Monuron	1	Pre +0	8.1	8.7	5.5
4 "	2	"	9.0	9.0	7.4
5 Lenacil (Venzar)	3	"	9.0	9.0	3.9
6 Lenacil (Venzar)	6	Pre +0	9.0	9.0	2.1
7 Linuron	1	"	8.7	7.7	4.2
8 "	2	"	7.8	9.0	7.9
9 Terbacil (Sinbar)	1	"	8.1	9.0	6.3
10 "	2	"	8.8	9.0	1.8
11 Dicamba (Banval D)	1/2	Pre +0	7.8	3.1	1.5
12 "	1	"	6.8	2.8	0.6
13 C3126 (Patoran)	2	"	7.8	8.1	4.9
14 "	4	"	7.9	7.7	4.4
15 Amiben G	4	Pre +1	8.7	6.5	2.5
16 Amiben G	8	Pre +1	8.8	8.1	3.7
17 Amiben	4	Pre +0	8.9	7.7	3.1
18 "	8	"	8.9	9.0	6.5
Least Significant Difference	5%		0.8	1.0	1.7
" " "	1%		1.0	1.3	2.1

EVALUATION OF HERBICIDES FOR ANNUAL WEED CONTROL IN WHITE POTATOES (1969) 1/

Daniel H. Fricke and Stewart L. Dallyn 2/

Introduction

The following paper represents a progress report in evaluation of herbicides for control of annual broadleaf and grassy weeds in white potatoes on Long Island. Two experiments conducted during 1969 are reported.

Procedure

The experiments were conducted on a commercial farm which had a history of high populations of annual broadleaf and grassy weeds. The Katahdin potato variety was planted in 34 inch rows on April 11. At that date the Sassafrass sandy loam soil was fairly moist. Fertilization included a plow down application of 150 lbs. Urea (45%N) and 2700 lbs. of 6-12-6 banded in the planter. As is the standard practice in the area, a plow-plant program was followed. During the growing season the potatoes were irrigated three times and a preventative spray program for insect and disease control was followed.

Plot size in both experiments was 2 rows wide by 30 feet long. Experimental design of the tests was a randomized block with each treatment replicated four times. The preplant applications in Experiment 1 were applied with a small hand sprayer using the rate of 55 gallons of water per acre at 25 psi. Spray formulations applied at drag off or pre-emergence were applied with a tractor mounted 2 row boom sprayer with a pressure of 35 psi. and a volume of 38 gallons of water per acre. Granular materials were applied with a hand held gravity flow funnel type applicator.

Potatoes were lightly tilled with a spike tooth harrow on May 1. On May 5th, 3 groups of treatments were applied - incorporated, with 2 passes of a tractor mounted cultivator and weeded; pre-emergence, to freshly tilled soil; and delayed pre-emergence, on untilled soil with emerged weeds. A total of 1½ inches of rain fell during the following three days. The potatoes showed about 25% emergence on May 12. Granular treatments to be

---

1/ Paper No. 570, Dept. of Vegetable Crops, Cornell University

2/ Cooperative Extension Agent, Suffolk County, Riverhead, N.Y. and Professor, Cornell University, L.I. Vegetable Research Station, respectively.

incorporated at the first cultivation were applied May 29 and a final hilling was done on June 5 when plants were 9-12 inches tall. Lay-by granular treatments were applied following the final hilling. Herbicide information is listed in Table 3.

Observations for phytotoxic effects were made throughout the season and weed control was rated on September 2. Vines were killed on September 12 and plots were harvested October 2.

Principal weed species were: barnyard grass (*Echinochloa crusgallia* (L.) Beauv), smartweed (*Polygonum* spp.) and wild mustard (*Brassica* spp.). Present in smaller amounts were fall panicum (*Panicum dichotomiflorum* Michx.), crabgrass (*Digitaria* spp.), lambsquarters (*Chenopodium album* L.) and ragweed (*Ambrosia* spp.).

Results

Experiment 1

The treatments compared in Experiment 1 are listed in Table 1. The plots were examined on May 15, when about 30-40% of the potato plants had emerged. All of the delayed pre-emerge treatments (post emergence to weeds) completely killed broadleaf weeds present at the time of application, May 5. Some necrosis of leaf tips and margins of potatoes was noticed in all plots where alachlor had been applied. Some chlorosis was present in the SD15418 treatments.

A number of the treatments gave effective season long commercial control of broadleaf weeds, but, did not adequately control barnyard grass. The treatments which gave commercial or near commercial control of both broadleaf and annual grasses included alachlor 4 lbs.-linuron 2 lbs. emulsifiable combination at pre-emergence; alachlor 2 lbs.-linuron 1 lb. emulsifiable combination at pre-emergence and linuron 1 lb. w.p. at pre-emergence plus alachlor 2 lbs. granular at lay-by. Approaching commercial control of both broadleaf and grassy weeds were dinoseb 3 lbs. pre-emergence plus EPTC 5 lbs. at first cultivation; Nîtralin at both .75 and 1.5 lbs. pre-emergence; and EPTC 4 lbs. plus R11913 1 lb. combination at drag off. The performance of alachlor seemed to be improved by the addition of linuron.

There were no statistically significant effects on yield in this experiment, in spite of the fact that heavy weed populations were present in some treatments.

An evaluation on November 8th of the rye cover crop planted after harvest indicated that all of the diphenamid treatments except diphenamid 2 lb. pre-plant followed by dinoseb 3 lbs. pre-emergence, had some retarding effect on the rye cover. None of the other treatments had any noticeable effect at that time.

Experiment II

Due to an error at planting time, two of the replicates in this experiment were planted to the Kennebec variety, rather than all four with the Katahdin variety. The more prolific vine growth of the Kennebec variety resulted in fewer weeds and differences too small to evaluate. Therefore, this experiment should be considered an observational trial, since only the two Katahdin replicates are included in the data.

No phytotoxic effects on potato plants were observed in any of the treatments. A list of the treatments, yields and weed control is given in Table 2. Probably because of the high weed seed population, only a few of the treatments appeared to give adequate control of both broadleaf and annual grassy weeds. The only treatment giving commercial control of both was linuron 1 lb. pre-emergence followed by EPTC 4 lbs. granular at the first cultivation. Treatments which gave close to commercial control included metobromuron 3 lbs. in a wettable powder formulation at pre-emergence; Maloran in a wettable powder formulation pre-emergence; linuron 1 lb. pre-emergence plus 1 lb. granular at lay-by; norea at 2.4 or 3.2 lbs. pre-emergence; and EPTC at 5 lbs. incorporated at drag off as either 6E, 10G or 25G formulations. There was no significant effect on yield.

No effect on the rye cover crop was noticed from any of the treatments when rated on November 8.

Conclusions

Under the conditions of these experiments with very heavy weed seed populations, most herbicides, including the standard commercially used treatments, provided only marginal weed control.

1. The following herbicides gave commercial or nearly adequate control of both the broadleaf and annual grassy weeds present: alachlor-linuron combinations; nitralin; dinoseb-EPTC, and linuron-EPTC split treatments; norea; linuron split treatments; EPTC; Maloran; and metobromuron.

2. Diphenamid used at 2 lbs. pre-emergence reduced stands of fall seeded rye cover crops. Two pounds applied pre-plant did not result in a stand reduction.

Table 1. Experiment 1 - Potato Herbicides

Treatments, Material Formulation	Lbs. AIA	Timing	Yield Cwt./A Field Run	Sept. 2 Weed Control[1/] B.L.	Grass
1. diphenamid 50W plus diphenamid-dinoseb 2-1.5 lbs. per gal.	2 2 + 1.5	Preplant Delayed PE	349	7.8	5.5
2. diphenamid 50W plus dinoseb 3 lbs./gal.	2 3	Preplant Delayed PE	365	7.5	4.0
3. diphenamid 50W	2	PE	355	7.2	3.8
4. diphenamid-dinoseb 2-1.5 lbs./gal.	2 + 1.5	Delayed PE	370	6.2	4.8
5. dinoseb 3 lbs.gal. plus EPTC 10G	3 5	Delayed PE Inc. 1st Cult.	352	6.2	7.0
6. SD15418 80W	1	PE	333	7.2	3.2
7. SD15418 80W	2	PE	281	7.0	3.0
8. nitralin 4 lbs. WDL	.75	PE	350	6.8	6.0
9. nitralin 4 lbs. WDL	1.5	PE	360	5.8	7.0
10. alachlor 4 lbs. EC	2	PE	358	6.5	4.5
11. alachlor 4 lbs. EC	4	PE	306	5.8	5.8
12. alachlor 15G	2	PE	306	5.4	4.2
13. alachlor-linuron 2.67-1.33 lbs/gal.	2+1	PE	339	7.2	6.5
14. alachlor-linuron 2.67-1.33 lbs/gal.	4+2	PE	306	8.0	7.0
15. alachlor-linuron 10G-5G	2+1	PE	336	7.2	5.0
16. linuron 50W+surfactant+alachlor 15G	1 2	Delayed PE Layby	337	7.8	7.2
17. EPTC 6E plus R11913 80W	4 1	Inc. at D.O.	313	6.8	6.2
18. Check			330	5.2	5.0
		LSD @ 5% level	N.S.	1.8	2.1

1/ Weed control; 1-no control, 7-commercial control, 9-perfect control.

Table 2. Formulation, Rate and Timing - Potato Herbicides 1969

Treatments, Material, Formulation		Lbs. AIA	Timing	Yield Cwt./A Field Run	Sept. 2 Weed Control[1/] B.L.	Grass
1. metobromuron	50W	2	PE	378	7.5	4.5
+metobromuron	10G	1	layby			
2. metobromuron	50W	1.5	PE	388	7.0	4.0
3. metobromuron	50W	2	PE	412	6.0	4.5
4. metobromuron	50W	3	PE	338	7.0	5.5
5. metobromuron	10G	3	PE	396	5.5	4.5
6. Maloran	50W	1.5	PE	396	6.5	5.5
7. Maloran	50W	3	PE	372	6.5	5.5
8. Maloran	10G	3	PE	358	6.0	4.0
9. Maloran	50W	2	PE	334	7.5	4.5
plus Maloran	10G	1	layby			
10. linuron	50W	1.5	Delayed PE	390	6.5	4.0
11. linuron	50W	1	Delayed PE	323	7.0	5.0
+linuron	10G	1				
12. linuron	10G	1.5	PE	388	6.0	4.0
13. norea	80W	1.6	PE	372	3.5	4.5
14. norea	80W	2.4	PE	358	6.5	6.0
15. norea	80W	3.2	PE	358	6.5	6.0
16. EPTC	6E	5	Inc. D.O.	394	6.5	6.0
17. EPTC	7E	5	Inc. D.O.	412	4.5	5.5
18. EPTC	10G	5	Inc. D.O.	358	6.0	7.0
19. EPTC	25G	5	Inc. D.O.	403	7.0	6.5
20. linuron	50W	1	Delayed PE	402	7.5	7.5
plus EPTC	10G	4	Inc. 1st Cult.			
21. linuron	50W	1	Delayed PE	366	7.5	4.0
+metobromuron	50W	2				
22. Check				369	5.0	3.7
				N.S.		

1/ Weed control rating; 1-no control, 7-commercial control, 9-perfect control.

Table 3. Herbicides Used in 1969 Potato Herbicide Evaluations

Common Name	Trade Name	Chemical Name
linuron	Lorox	3(3,4-dichlorophenyl-1-methoxy-1-methylurea
alachlor	Lasso	2-chloro-2',6'-diethyl-N-(methoxymethyl) acetanilide
metobromuron	Patoran	3-(p-bromophenyl)-1-methyl-1-methoxyurea
	SD15418 (Shell)	2-(chloro-6-ethylamino-S-triazine-2-ylamino) 2-methylpropionitrile
dinoseb	Premerge	2 <u>sec</u>-butyl-4,6-dinitrophenol
nitralin	Planavin	4-methylsulfonyl-2, 6-dinitro-N, N dipropylaniline
diphenamid	Enide	N,N-dimethyl-2,2-diphenylacetamide
	Maloran	3-(4-bromo-3-chlorophenyl) -1-methoxy-1-methylurea
norea	Herban	3-(hexahydro-4,7-methanoindan-5-yl)-1,1-dimethylurea
EPTC	Eptam	S-ethyl dipropylthiocarbamate
	R11913 (Stauffer)	Unknown

Proprietory Mixtures

diphenamid-dinoseb	Enide-Dinitro
alachlor-linuron	Lasso-Linuron

COMPARISONS OF NITROFEN (TOK) E.C. AND W.P. FORMULATIONS ON CRUCIFERS [1,2]

J. A. Ivany and R. D. Sweet[3]

Previously we reported (1) that although TOK E-25 (2,4-dichlorophenyl-4-nitrophenyl ether) caused injury to cabbage (Brassica oleracea var. capitata) when applied post-emergence, there was no reduction in final total yield. Recently a 50 per cent wettable powder formulation of TOK was made available and early reports as well as preliminary tests by the authors indicated it might be somewhat less toxic than the E-25 formulation, when applied post-emergence to cabbage foliage.

In several field experiments with TOK over the past several seasons there were instances where it appeared that spraying when the cabbage had only 1 true leaf was more toxic than spraying when 3 true leaves were present. Furthermore, it seemed that recovery from early sprays was slower than from late sprays.

The purpose of the experiments reported here was, 1) to compare emulsifiable and wettable formulations as to their toxicity to cabbage and closely related crucifers and 2) to determine the influence of time application on crop response.

EXPERIMENTAL

Comparison of TOK E-25 and W.P. in the Field

An experiment was conducted in 1969 on a Howard gravelly loam soil at Freeville, New York, to compare the effect of TOK E-25 and 50 W.P. formulations applied pre- and post-emergence on several crucifer species. Plots were 6 feet by 20 feet and were seeded on May 14 with one row each of Waltham 29 broccoli (Brassica oleracea var. italica); Scarlet Globe radish (Raphanus sativus) and two cabbage varieties Golden Acre and King Cole hybrid. There were three replications.

Treatments were applied using a hand-held small plot sprayer at 40 psi pressure applying 45 gallons of water per acre. Rates of application were 2,4 and 6 pounds active ingredient per acre applied pre-emergence May 14 and post-emergence June 16 when the crops all had 2-4 leaves and were 3-5 inches tall. Visual ratings of treatment effects on the crops were made on July 2.

1/ Paper No. 596 of the Department of Vegetable Crops, Cornell University, Ithaca, New York.

2/ This research was partially supported by a grant-in-aid from the Rohm and Haas company.

3/ Research Assistant and Professor, respectively.

The results are presented in Table 1. As can be seen, there were no differences between the crucifer species in their responses to formulation, rate or time of application of TOK. The greatest differences observed were between pre- and post-emergence applications and between formulations. Increasing the rate of application had no effect on broccoli or radish. However, the two cabbage varieties were injured slightly by the 6 pound rate of both formulations. At a given rate, post-emergence treatments were more toxic than pre-emergence treatments. Note, however, that at the 4 and 6 pound rates post-emergence, the 50 w.p. formulation was less toxic than the E-25 formulation.

Time of Application

As a follow-up to the marked differences between pre- and post-emergence applications in the field test, an experiment was conducted in the greenhouse during the fall of 1969 to compare the response of cabbage to two rates of the two TOK formulations at four times of application. Small fiber flats were filled with a greenhouse potting soil and seeded with one row of Golden Acre cabbage. The dates and the stage of plant growth at the time of treatment are presented in Table 2. All treatments were applied using a specially designed moving belt sprayer with a fixed nozzle at 35 psi pressure delivering 45 gallons of spray per acre. There were four replications. Ratings of crop response were made on November 5.

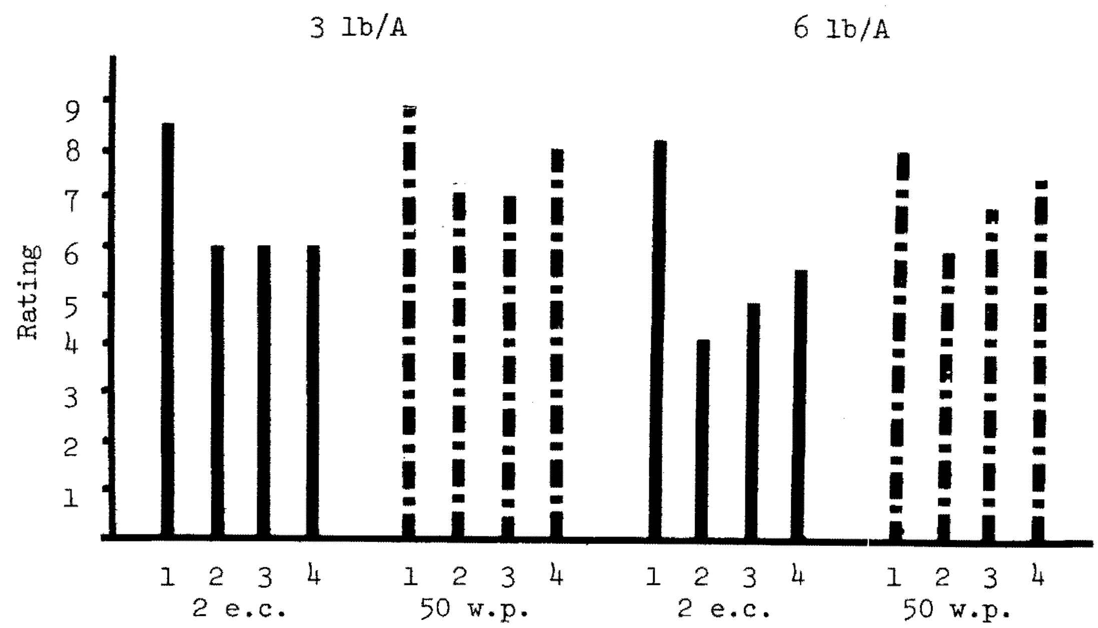
The responses of cabbage are presented in Figure 1. The pre-emergence treatment gave the best selectivity with no crop injury. Once again the lower toxicity of the 50 w.p. formulation in post-emergence applications is readily apparent. At the low rate, 3 lbs. per acre, little difference in timing was noted. At the 6 lb. per acre rate, however, early post-emergence applications resulted in severe injury. This injury was somewhat less when the plants were larger. Symptoms consisted primarily of foliage burn with resultant substantial areas of necrosis. The injury was so severe the younger plants were much more retarded in their speed of recovery. This problem is compounded, however, by the fact that in the very early stage the cabbage growing point is exposed and therefore, is likely to have greater direct contact by the herbicide than is the case later because then the point is much better shielded from direct spray contact.

At the time of making the ratings, the plants treated in the two true leaf stage were below the acceptable rating level of 7. However, they were vigorous and seemed to be on their way to recovery. It has been observed under field conditions that plants in this condition do in fact recover and produce normal yields.

Varietal Response

Late in the summer of 1968 an experiment was conducted to compare the response of three cabbage varieties to several rates of the two formulations of TOK both pre- and post-emergence. One row each of the varieties King Cole,

Figure 1. Ratings[1/] of cabbage when treated with TOK E-25 and 50 w.p. at two rates and four times of application[2/].



1/ 9=perfect crop; 7=slight injury but acceptable crop; 1=complete kill.
2/ Time of application : 1=pre; 2=cotyledon; 3=1st true leaf; 4=2nd true leaf.

Chieftain Savoy, and Danish Ballhead were seeded on July 31 on Eel silt loam soil in plots measuring 6 feet by 15 feet. The treatments were applied as previously described. Pre-emergence treatments were made August 1 and post-emergence September 21, when the crop had 4-6 leaves and were 6-8 inches tall. Visual ratings of crop responses were made on October 2.

The results are presented in Table 3. No marked differences were apparent between varieties with the possible exception that the King Cole may be more tolerant of both formulations at 6 pounds per acre post-emergence. The greatest difference observed was the lower injury with the 50 w.p. formulation at 4 and 6 pounds per acre post-emergence as compared to the E-25 formulation. Hopen (2) working with many cabbage varieties both transplanted and field seeded found highly significant differences between varieties. These ranged from a high degree of tolerance to marked susceptibility and many intermediates.

CONCLUSIONS

The data presented showed clearly the 50 w.p. formulation of TOK to be less toxic to crucifer foliage than the E-25 formulation.

The cabbage varieties compared showed no marked difference in response to TOK. This test, however, involved only a very limited number of varieties and further work is necessary on this aspect of the problem.

Table 1. Ratings[1/] of crucifer species responses to TOK E-25 and 50 w.p. formulations.

				Crop			
No.	Formulation	Timing	lbs.	Waltham 29 broccoli	Golden Acre cabbage	King Cole cabbage	Scarlet Globe radish
1	TOK 2 e.c.	pre	2	8.6	8.6	8.6	8.6
2	" 2 e.c.	"	4	7.6	8.0	8.0	8.0
3	" 2 e.c.	"	6	8.0	7.0	7.6	8.0
4	" 2 e.c.	post	2	7.0	6.6	6.6	6.6
5	" 2 e.c.	"	4	6.6	6.0	6.0	7.0
6	" 2 e.c.	"	6	5.6	5.6	5.6	5.6
7	TOK 50 w.p.	pre	2	8.6	8.6	8.6	8.6
8	" 50 w.p.	"	4	8.6	8.6	8.6	8.6
9	" 50 w.p.	"	6	8.6	7.0	7.0	8.3
10	" 50 w.p.	post	2	7.3	7.0	7.0	7.3
11	" 50 w.p.	"	4	8.0	7.0	7.6	8.3
12	" 50 w.p.	"	6	7.3	7.0	7.0	7.0
13	Check			7.7	8.0	8.0	8.0

1/ 9=perfect crop; 7=slightly injured but acceptable crop; 1=complete kill.

Table 2. Stage of growth and time of treatment of cabbage with TOK formulations.

Date	Timing	Plant Appearance
9/18/69	seeded crop	-----
9/19/69	pre-emergence	-----
9/26/69	cotyledon	cotyledon fully expanded
10/ 6/69	first true leaf	first true leaf size of a penny
10/14/69	second true leaf	first true leaf fully expanded, second true leaf size of a half dollar

Very early post-emergence application of TOK to cabbage resulted in severe injury from which the plants are slow to recover. Application at the two leaf stage gave less injury and visually the plants recovered much more rapidly. Treatment at the two true leaf stage or later was best for crop safety. Work needs to be done, however, to see how weeds respond at different times of application.

Table 3. Ratings[1/] of three cabbage varieties exposed to TOK E-25 and 50 w.p. formulations.

No.	Formulation	lbs.	timing	King Cole	Chieftain Savoy	Danish Baldhead
1	TOK 2 e.c.	2	pre	8.0	8.0	8.0
2	" 2 e.c.	4	"	8.0	8.5	8.5
3	" 2 e.c.	6	"	7.5	7.5	7.5
4	" 50 w.p.	2	"	7.5	8.0	8.0
5	" 50 w.p.	4	"	8.5	8.5	8.5
6	" 50 w.p.	6	"	6.5	7.5	7.0
7	" 2 e.c.	2	post	8.5	8.5	7.5
8	" 2 e.c.	4	"	6.0	6.0	6.0
9	" 2 e.c.	6	"	6.5	6.0	5.5
10	" 50 w.p.	2	"	9.0	9.0	8.5
11	" 50 w.p.	4	"	8.5	7.5	7.5
12	" 50 w.p.	6	"	9.0	9.0	9.0
13	Check			9.0	9.0	9.0

1/ 9=perfect crop; 7=slightly injured but acceptable crop; 1=complete kill.

REFERENCES CITED

1. Ivany, J. A. and R. D. Sweet. 1969. Effect of Herbicides on Direct-Seeded Crucifers. Proc. NEWCC 23: 44-49.

2. Hopen, H. University of Southern Illinois. Personal Communication.

WEED CONTROL IN WHITE POTATOES IN MAINE - 1969

H. J. Murphy and M. J. Goven[1/]

Several herbicides were tested in Maine during the 1969 season for control of broadleaved weeds and annual grasses growing in white potatoes. In Maine we are looking for herbicides which have broad-spectrum weed control, are flexible as to time of application, more economical than our present standard herbicides now in use, and they must not have any adverse effects on vines to mask disease symptoms or quality of tubers for seed use.

Rainfall in 1969 as presented in Table 1, was above normal particularly during the treatment period of late May and early June. Soil conditions were favorable for growth of annual grasses during the entire growing season. Growth of all weeds was very vigorous during the early part of the growing season.

Table 1. 1969 Rainfall - Presque Isle, Maine

May	3	0.03	June	2	T	July	1	0.63	August	3	0.97
	4	T		3	T		5	0.35		5	0.54
	7	T		4	0.03		6	0.21		6	1.41
	9	0.28		6	0.03		10	T		8	0.05
	10	0.14		7	0.54		11	0.11		9	0.67
	12	0.41		14	1.05		12	0.67		10	0.33
	13	0.07		15	0.56		13	0.30		11	0.40
	14	T		16	0.77		14	0.04		14	0.21
	17	0.03		20	0.40		21	0.09		15	0.02
	18	0.32		24	0.32		22	0.04		17	0.32
	19	0.23		25	0.06		27	0.08		19	0.22
	20	0.66		26	T		28	0.19		21	0.01
	21	0.01		28	0.10		29	0.16		25	0.07
	24	0.03		29	0.01		30	0.65		29	0.14
	25	0.16		30	T		31	0.07			5.36
	26	0.01			3.87			3.59			
	28	0.02									
	29	0.22									
	31	0.05									
		2.64									

1/Associate Professor of Agronomy and Technician II Department of Plant and Soil Sciences, University of Maine, Orono, Maine 04473.

Procedure

Katahdin potatoes were planted on May 26, 1969 and fertilized with 1300 pounds of a 10-10-10 fertilizer placed in conventional row sidebands. Seedpieces were spaced 9 inches apart and covered with not more than 1½ inches of soil. Soil type at both locations was Caribou gravelly sandy loam with organic matter content of 4.71 percent. Plot areas had been fall plowed in 1968 and harrowed twice before planting in 1969. Previous crop was Japanese millet without any chemical weed control. Weeds growing in millet were allowed to go to seed before plowing under.

Experimental designs for both tests reported in this paper were randomized blocks with each treatment replicated six times. Plot size was single 25 foot rows with untreated buffer rows between treated plots. Herbicides were applied with one pass of a small plot sprayer using a pressure of 40 pounds and a volume of 80 gallons of water per acre. Herbicides were applied at the following dates: Planting (PL), May 27; Pre-planting (PP), May 23; Pre-emergence (PE), June 15; Emergence (EM), June 18; Early post-emergence (EPE), June 26; Layby (L), July 23. Soil conditions on June 15 and June 18 were moist. Layby treatments were not incorporated into the soil.

Weed control ratings were made on dates indicated in Tables 3 and 4. Vines were mechanically rotobeated before harvest and single box samples of 25 pounds were saved from each plot for storage studies and residue analysis.

Source and designation of herbicides included in trials are presented in Table 2.

Results

Weed Control: Data presented in Table 3 indicate that with the exception of 1.0 pounds of Nitralin (Planavin 4WDL), all herbicides and combinations of herbicides gave satisfactory broadleaved weed control (4.0 rating or better). Chlorobromuron (Maloran) at 2 and 3 pounds per acre provided full season broadleaved weed control as did VC438 at 3 pounds, and VC437 at 2 pounds per acre. Only DNBP plus Dalapon applied at emergence of potatoes provided satisfactory grass control (4.0 rating or better). Chlorobromuron, at all rates, 3.0 pounds of VC438, 4.0 pounds of VC437, and SD15418 incorporated plus 1.0 pound of Nitralin provides good commercial control (3.5 or better) of annual grasses.

All herbicides presented in Table 4 indicate satisfactory full season broadleaved weed control. Only Paraquat, however, applied as an early

Table 2. Herbicides used on white potatoes in Maine - 1969

Trade Name	Common Name	Chemical Name
Dachthal W75	DCPA	Dimethyl ester of tetrachloroterephthalate.
Dowpon	Dalapon	2, 2-dichloropropionic acid.
Premerge	DNBP	4, 6-dinitro-o-sec-butylphenol.
Dyfonate-Eptam	Dyfonate-EPTC	O-ethyl-s-phenylethylphosphonodithioate and S-ethyl dipropylthiocarbamate (4:3E).
Enide 50W	Diphenamid	N, N-dimethyl-2, 2-diphenylacetamide.
Enide-Dinitro	Diphenamid-DNBP	N, N-dimethyl-2, 2-diphenylacetamide plus triethola-mine salt of 2-sec-butyl-4, 6-dinitrophenol.
Eptam 6E	EPTC	S-ethyl dipropylthiocarbamate.
Lasso EC	Alachlor	2-chloro-2, 6-diethyl-N (methoxy-methyl) acetanilide.
Lasso 15G	Alachlor	2-chloro-2, 6-diethyl-N (methoxy-methyl) acetanilide.
Lasso-linuron EC		(ratio of 2 to 1)
Lorox 50W	Linuron	3-(3, 4-dichlorophenyl)-1-methoxy-1-methylurea.
Maloran 50W	Chlorobromuron	3-(4-bromo-3 chlorophenyl)-1-methoxy-1-methylurea.
Paraquat CL		1, 1'-dimethyl-4, 4'-bipyridinium dichloride.
Patoran 50W	Metobromuron	3-(P-bromophenyl)-1-methyl-methoxy-urea.
Planavin 4WDL	Nitralin	4-(methylsulfonyl)-2, 6-dinitro-N, N-dipropylaniline.

Table 2. (cont.)

Trade Name	Common Name	Chemical Name
Bay 86791 70W		4-amino-6-cyclohexyl-3-(methyltho-as-triazin-5-(4H)-one.
RP 17623		2-tertiobutyl-4-(2, 4-dichloro-5-isopropyloxyphenyl) -5-oxo-1, 3, 4-oxadiazoline.
R 11913 80W		restricted - temporarily.
SD 15418 80W		2-(4-chloro-6-ethylamino-s-triazin-2-ylamino)-2-methylpropionitrile.
VC 437		restricted - temporarily.
VC 438		restricted - temporarily.

Table 3. Yield and annual weed control in white potatoes following application of various herbicides. Maine - 1969

Treatments Pounds of Active Material Per Acre	Yield Cwt./acre	Weed Control Ratings[1] Broadleaf[2] 6/27	 Broadleaf[2] 9/18	 Annual grass[3] 6/27	 Annual grass[3] 9/18
Check - no treatment	324	1.0	1.0	1.0	1.0
4.5# DNBP + 5# Dalapon, EM.[4]	368	5.0	4.8	3.8	4.2
1.0# Linuron, EM.	344	5.0	4.2	2.2	2.5
1.0# Linuron, PL.	343	4.3	4.2	1.2	1.3
1.0# Linuron, 1½ pts. surfactant WK at PL.	371	4.2	4.6	2.5	2.8
4.5# DNBP, EM. + Metobromuron 2.0# layby[5]	364	5.0	4.8	2.7	2.3
2.0# Metobromuron, PE.	365	5.0	4.8	2.8	3.2
3.0# Metobromuron, PE.	377	5.0	4.6	3.0	3.3
2.0# Chlorobromuron, PE.	369	5.0	4.6	3.5	3.8
3.0# Chlorobromuron, PE.	355	5.0	5.0	3.2	3.5
4.0# Chlorobromuron, PE.	366	5.0	5.0	3.2	3.7
1.5# VC. 438, PE.	352	5.0	4.6	3.3	2.3
3.0# VC. 438, PE.	371	5.0	5.0	3.2	3.5
2.0# VC. 437, PE.	354	5.0	5.0	3.3	3.3
4.0# VC. 437, PE.	283	5.0	4.8	3.2	3.5
4.5# DNBP, EM. + 1.5# Lasso layby	361	5.0	5.0	3.0	2.2
1.0# Nitralin, EM.	324	2.0	2.3	1.0	1.7
1.0# Nitralin, EM. + 1.5# DNBP, EM.	346	5.0	4.0	2.7	2.3
1.6# SD15418, PE. (Incorporated) + 1.0# Nitralin, PE.	360	5.0	4.0	3.2	3.7
8.0# Diphenamid - DNBP, EM.	357	5.0	4.6	3.7	3.0
2.0# Diphenamid - DNBP, EM. + 2.0# Diphenamid layby	358	4.7	3.8	1.7	1.7
4.0# Diphenamid - DNBP, EM. + 2.0# Diphenamid layby	364	5.0	4.8	2.8	2.8
L.S.D. (0.05)	N.S.	0.7	0.5	0.8	0.6

[1] Weed control ratings: 1 = no control; 5 = excellent control.
[2] Broadleaf weed species: Chenopodium album, Brassica campestris, Brassica rapa, Amaranthus retroflexus, and Polygonum persicaria.
[3] Annual grass species: Echinochloa crusgalli and Setaria viridis.
[4] EM = applied at emergence; PL = applied at planting; PE = applied at pre-emergence.
[5] Layby treatments were applied after last hilling and were not incorporated.

Table 4. Yield and annual weed control in white potatoes following application of various herbicides. Maine - 1969

Treatments Pounds of Active Material Per Acre	Yield Cwt./acre	Weed Control Ratings[1/] Broadleaf[2/] 6/27	7/3	9/18	Annual Grass[3/] 6/27	7/3	9/18
Check - no treatment	333	1.0	1.0	1.0	1.0	1.0	1.0
4.5# DNBP + 5# Dalapon, EM.[4/]	371	5.0	5.0	5.0	4.2	4.2	2.4
1.0# Linuron, EM.	358	5.0	5.0	5.0	1.8	3.7	2.8
Lasso-Linuron, PE. (1.33# to 0.67#)	352	5.0	5.0	5.0	3.5	4.0	3.4
Lasso-Linuron, PE. (2.67# to 1.33#)	354	5.0	5.0	5.0	4.0	4.5	3.6
2.0# Lasso, PE.	353	4.5	4.7	4.6	2.2	3.2	2.0
4.0# Lasso, PE.	341	4.8	4.7	5.0	3.0	4.3	3.4
1.5# Lasso + 3.0# DNBP (tank mix), PE.	353	5.0	5.0	5.0	2.3	3.7	2.4
0.5# Paraquat, EPE.	343		5.0	5.0		5.0	4.8
1.6# R11913 + 3.0# EPTC (tank mix), PP. (Incorporated)	374	4.7	4.3	5.0	1.0	3.2	4.2
Dyfonate - EPTC (4.0# to 3.0#), PP. (Incorporated)	366	5.0	4.8	5.0	1.2	3.2	3.6
6.0# DCPA, PL.	371	5.0	4.8	5.0	1.0	3.2	1.8
2.0# Bay 86791, PE.	365	5.0	5.0	5.0	3.4	4.4	3.8
1.0# Bay 86791, PE.	379	5.0	5.0	5.0	2.8	4.4	3.8
0.5# Bay 86791, PE.	366	5.0	5.0	5.0	1.8	3.6	2.6
2.0# Bay 86791, EPE.	340		5.0	5.0		4.6	3.8
1.0# Bay 86791, EPE.	348		5.0	5.0		3.6	2.2
0.5# Bay 86791, EPE.	372		5.0	5.0		2.6	1.8
1.5# RP17623, PE.	318	5.0	5.0	5.0	4.4	4.6	1.7
3.0# RP17623, PE.	245	5.0	5.0	5.0	4.6	4.8	1.4
L.S.D. (0.05)	29	0.5	0.6	0.5	0.9	1.0	0.8
(0.01)	39	0.7	0.7	N.S.	1.2	1.3	0.9

[1/] Weed control ratings: 1 = no control; 5 = excellent control.
[2/] Broadleaf weed species: Chenopodium album, Brassica campestris, Brassica rapa, Amaranthus retroflexus, and Polygonum persicaria.
[3/] Annual grass species: Echinochloa crusgalli and Setaria viridis.
[4/] EM = applied at emergence; PE = applied pre-emergence; PP = applied preplanting; EPE = applied early post emergence; PL = applied at planting.

post emergence treatment gave excellent full season control of both broadleaved weeds and annual grasses. Herbicides such as Lasso-Linuron combination of (2.67 to 1.33), R11913, EPTC, Bay 86791 applied pre-emergence at rate of 1 and 2 pounds and at the 2 pound rate as an early post emergence treatment gave satisfactory commercial control of grasses as indicated by ratings made on September 18. Some materials such as Dalapon, Linuron, Lasso at the 4.0 pound rate, RP17623, and others did a good job on annual grasses early in the season as indicated by the July 3 ratings but apparently did not provide control for the full season.

Potato Yields: Yield of tubers from herbicide treated plots are presented in Tables 3 and 4. Only one compound, RP17623 at the 3 pound rate reduced yield significantly when compared to no treatment. In both Tables 3 and 4, however, data indicate that several compounds had a tendency to reduce yields as compared to the old standard combination of DNBP and Dalapon. Had the potato plants in these plots been subjected to moisture stress during the 1969 growing season, probably many of the herbicides listed in Tables 3 and 4 would have reduced yields. Only RP17623 at 3 pounds per acre and Linuron applied as an emergence treatment showed any symptoms of phytotoxicity on vine growth.

Conclusions

In Maine during 1969 several herbicides and combinations of herbicides were tested for broadleaved weed and annual grass control in white potatoes. In general, all materials tested with the exception of Nitralin alone gave satisfactory broadleaved weed control. Satisfactory annual grass control was obtained with DNBP plus Dalapon, Paraquat, and R11913 plus EPTC. Several other compounds such as Chlorobromuron, VC 438, VC437, SD15418, and Bay 86791 looked promising for grass control but need further study under Maine's climatic conditions.

Only one compound RP17623 reduced yield of tubers significantly, but several others affected yield as compared to standard mixture of DNBP and Dalapon. Layby treatments used in 1969 were not particularly effective for control of annual grasses late in the season.

Of all materials tested in 1969 under Maine climatic conditions, it appears that Nitralin, DCPA, and RP17623 did not demonstrate enough ability to be worthy of further testing.

POTATO VINE KILLING IN MAINE - 1968

H. J. Murphy and M. J. Goven[1]

The following paper reports the results of potato vine killing studies conducted in Maine during the 1968 growing season. Evaluation of harvested tubers was made during the 1968-69 storage period and emergence trials were conducted during the 1969 growing season.

Materials and Methods:

All chemicals unless otherwise indicated were applied in 80 gallons of water per acre at 40 pounds pressure to actively growing Katahdin potato vines on the dates indicated in each table. A compressed air sprayer equipped with a two-nozzle brush type boom was used for foliar application of chemicals. Plots consisted of single rows, 25 feet long, with single buffer rows between treatments. Plots were arranged in randomized blocks with treatments replicated six times.

Using a five-step rating system as listed in Table 1, vine kill ratings were made at weekly time intervals after application of vine desiccants.

Table 1. Potato vine-kill rating code. Maine - 1968

1. Poor or no kill of leaves or stems.
2. 90% of leaves killed but poor stem kill.
3. 100% of leaves and 40% of stems killed.
4. 100% of leaves killed and 70% of stems killed.
5. 100% of leaves and stems killed.

Approximately 25 pounds of tubers were collected from each plot at harvest time and stored at 50°F for examination during the winter months. Storage studies consisted of observing tubers

[1] Associate Professor of Agronomy and Technician, Grade II, Department of Plant and Soil Sciences, University of Maine, Orono, Maine.

from each treatment for storage disorders and examination of individual tubers for internal and possible external discolorations which might be caused by use of chemical desiccants. From these storage samples, tubers were also made available upon request to each chemical supplier for residue analysis.

Tubers snipped and examined for internal vascular discoloration were bulked by treatment and stored at 38°F. In the spring of 1969 tubers from each treatment were planted in replicated emergence and yield trials to determine possible side effects of desiccants on sprouting, emergence, vigor, and yield of tubers.

Results and Discussion:

Data presented in Table 2 compare the effect of several desiccants on vines, tubers, and plant emergence. Essentially, standard treatments in these studies were sodium arsenite at the 8 pound rate without an additive and Premerge (DNBP) at the 1 gallon rate (3# AI). For new compounds to be acceptable for potato vine killing in Maine, they must be equal to or exceed the performance of the above standards.

Data in Table 2 indicate that sodium arsenite in combination with nitrogen at either the 4 or 8 pound of active AS_2O_3 per acre provided good vine desiccation. Dow General plus oil and Paraquat plus X114 spreader-sticker also gave good vine desiccation. Of the numbered candidate compounds, only RP 2929 killed potato vines satisfactorily. During the 1968 period, the use of X114 spreader-sticker and nitrogen from Uran improved or stepped up the kill of potato vines when used with Paraquat and sodium arsenite.

Sodium arsenite at both 4 and 8 pound rates plus nitrogen and Dow General caused an excessive amount of internal vascular discoloration of tubers. In the case of Dow General, however, had it been used at the recommended rate, vascular discoloration might not have been greater than discoloration caused by use of Premerge or sodium arsenite alone. Some discoloration, however, is always evident from either chemical or mechanical vine killing when soil conditions are dry and air temperatures are high at time of vine killing.

Table 2. Effect of several chemicals on potato vine desiccation, vascular discoloration of tubers, and emergence of plants from tubers used for seed. Katahdin variety. Maine - 1968.

Treatments 1/			Vine kill ratings 2/		Percent vascular discoloration 3/			Percent emergence
Material	Rate/Acre	Additive	Aug. 28	Sept. 5	Slight	Medium	Severe	1969
No treatment	-		1.0	1.0				100.0
Sodium Arsenite	8 lbs. AS_2O_3		4.2	3.9*	6.6	0.7		100.0
Sodium Arsenite	4 lbs. AS_2O_3	10 lbs. N (Uran)	4.8	4.8*	41.7	15.0	2.8	100.0
Sodium Arsenite	8 lbs. AS_2O_3	10 lbs. N (Uran)	4.8	4.5*	36.4	20.5	4.5	100.0
Premerge	1 gal.	5 gals. #2 oil + 1 pt. emulsifier	3.2	2.7*	3.9	0.2		100.0
Dow General	1 gal.	5 gals. #2 oil	5.0	4.8*	52.0	16.4	4.9	100.0
Paraquat	1 pt.		3.9	3.3*				99.0
Paraquat	1 pt.	8 oz. X114	4.0	4.3*				99.2
RH 2300	2 gals.		2.5	2.5				100.0
RH 2300	1½ gals.		1.9	2.0				100.0
RH 2300	1 gal.		1.2	1.0				100.0
RH 2300	1 gal.	8 oz. X114	1.2	1.2				98.3
WD-1	1 pt.		1.0	1.0				100.0
WD-1	1 qt.		1.0	1.0				100.0
WD-1	1 pt.	1 lb. AS_2O_3	1.3	1.3				100.0
WD-1	1 qt.	1 lb. AS_2O_3	1.0	1.0				100.0
RP 2929	4 lbs.	5 gals. #2 oil	4.7	4.3*	7.4	1.9		100.0
		L.S.D. (0.05)	0.5	0.6				
		(0.01)	0.7	0.9				

* Some vine regrowth on September 5.

1/ Materials applied August 21, 1968. Weather cloudy. Temperature 70°F. Soil conditions very dry and vines very green. Precipitation from kill date through rating period 1.10 inches.

2/ Kill rating code presented in Table 1.

3/ Examinations made on 15 pound samples from each of 6 replications on December 27, 1968.

None of the chemicals listed in Table 2 had any effect on emergence of plants grown from seed harvested from plants treated in 1968. In the few cases where less than 100 percent emergence is indicated in Table 2, seed pieces were either rotted, had no eyes, or were missing.

Data presented in Table 3 indicate that Des-I-Cate at rates of 8 quarts per acre, and at rates of 6 and 8 quarts plus oil gave good to excellent vine desiccation. Numbered compounds and standard treatments of sodium arsenite and Premerge were unsatisfactory in this test. From these data in Table 3 it was very evident that oil improves the performance of Des-I-Cate considerably.

The small amount of discoloration caused by 8 quarts of Des-I-Cate may not be a real factor since occasionally untreated tubers have shown discoloration also. Plant emergence was not affected by any of the treatments listed in Table 3.

Table 4 presents source and chemical names of compounds used in the 1968 potato vine killing tests in Maine.

Summary:

Potato vine killing studies conducted in Maine during 1968 indicated sodium arsenite plus nitrogen, Dow General, Paraquat plus X114, Des-I-Cate plus oil, and RP-2929 were all satisfactory for potato vine desiccation. In 1968 Dow General, and sodium arsenite plus nitrogen caused excessive vascular discoloration of tubers. None of the desiccants affected emergence or stand of plants in emergence tests in 1969.

Table 3. Effect of Des-I-Cate combinations on potato vine desiccation, vascular discoloration of tubers, and emergence of plants from tubers used for seed. Katahdin variety. Maine - 1968.

Treatments 1/			Vine kill ratings 2/		Percent vascular discoloration 3/			Percent emergence
Material	Rate/Acre	Additive	Aug. 28	Sept. 5	Slight	Medium	Severe	1969
No treatment			1.0	1.0				100.0
Sodium Arsenite	8 lbs. AS_2O_3		2.7	3.0				100.0
Premerge	4 qts.	5 gals. #2 oil + 1 pt. emulsifier	3.0	2.7*				100.0
Des-I-Cate	6 qts.		3.2	3.5*				100.0
Des-I-Cate	8 qts.		4.2	4.5*		0.7	0.2	100.0
Des-I-Cate	6 qts.	5 gals. #2 oil	4.8	5.0*				100.0
Des-I-Cate	8 qts.	5 gals. #2 oil	5.0	5.0				100.0
TD 6251	2 qts.		2.7	2.7				100.0
TD 1492	3 gals.		1.8	2.0				100.0
TD 6263	3 gals. 3/	(10% solution in F.S. oil)	1.3	1.5				100.0
		L.S.D. (0.05)	0.5	0.4				
		(0.01)	0.7	0.6				

* Some vine regrowth on September 5.

1/ Materials applied August 22, 1968. Cloudy weather. Temperature 70°F. Vines very heavy and green.

2/ Kill rating code presented in Table 1.

3/ Examinations made on 15 pound samples from each of six replicates on December 27, 1968.

Table 4. Chemicals used for Maine potato vine killing studies - 1968.

Compound	Active Ingredient	Source
Sodium Arsenite	Arsenic trioxide	C. W. Staples Co., Inc.
Premerge	4, 6-dinitro-O-sec-butylphenol	Dow Chemical Co.
Dow General	4, 6-dinitro-O-sec-butylphenol	Dow Chemical Co.
Des-I-Cate	Mono-(N, N-dimethylathylanion salt of endothal	Pennsalt Chemical Co.
TD 6251		Pennsalt Chemical Co.
TD 1492		Pennsalt Chemical Co.
TD 6263		Pennsalt Chemical Co.
Paraquat	1, 1-dimethyl-4, 4-bipyridinium dichloride	Chevron Chemical Co.
RH-2300		Rohm and Haas Co.
WD-1		Chemical Insecticide Corp.
RP-2929	4-dimethylaminothocyanobenzene	Rhodia (Chipman Div.)
Uran	Ammonium Nitrate - Urea Solution	Allied Chemical Corp.
FS oil		Sunoco Oil Co.

Influence of Four Experimental Herbicides on Cranberry Vine Growth and Crop

Robert M. Devlin and I.E. Demoranville[1/]

INTRODUCTION

Although a number of herbicides are available for the control of weeds on cranberry bogs, there are still many weed species that escape control. One of the weed species that continues to be a major problem is Cyperus dentatus Torr. (nutgrass). Previous to this study nutgrass on cranberry bogs was controlled almost exclusively through the use of the herbicide 2,6-dichlorobenzonitrile (dichlobenil). However, dichlobenil does not eradicate nutgrass, but only inhibits its growth. Also, it has become increasingly apparent that the continuous use of dichlobenil may be damaging cranberry vines and reducing yield.

In our 1967 and 1968 herbicide tests we found four experimental herbicides that gave control of nutgrass comparable to that achieved by dichlobenil. The herbicides tested were a formulated mixture of sodium N-1-naphtyl phthalamate and isopropyl N-(3-chlorophenyl) carbamate (alanap-CIPC), a formulated mixture of potassium azide and isopropyl N-(3-chlorophenyl) carbamate (KN_3-CIPC), 2- (4-chloro-o-tolyl)oxy -N-methoxyacetamide (OCS-21799), and the potassium salt of OCS-21799 (OCS-21799-K).

The purpose of this study was to determine the feasibility of using these herbicides on a commercial scale for the control of nutgrass on cranberry bogs. The influence of the herbicides on vine growth, yield, berry size, and anthocyanin development was observed.

MATERIALS AND METHODS

Field design and harvest procedure. A latin square consisting of 25 ten-ft square test plots was established in a section of weed-free cranberry bog containing a relatively consistent stand of vines. Each test plot was divided into 4 subplots which were lettered A-D. Thus, the latin square contained 100 subplots, designated 1A-D, 2A-D, etc. In this arrangement each individual treatment was replicated 5 times. Alanap-CIPC (8.1%G-5%G) was applied at concentrations of 6.48, 8.1, and 9.72 lbs Alanap a.i./A; KN_3-CIPC (10%G-10%G) at 20, 25, and 30 lbs a.i./A; OCS-21799 (6%G) at 4, 6, and 8 lbs a.i./A and OCS-21799-K (85% WP) at 4, 6, and 8 lbs a.i./A. OCS-21799-K was applied at a rate equivalent to 300 gal/A.

1/ Associate professor of plant physiology and assistant professor of horticulture, respectively, Laboratory of Experimental Biology, Cranberry Experiment Station, University of Massachusetts, East Wareham, Massachusetts.

All A, B, and C subplots were treated in April 1968. Subplots designated with the letter D received no treatment. The plots were harvested with a scoop and the berries immediately weighed. Berry size was determined by the number of berries required to fill a standard 8-oz cranberry measuring cup. Subsamples were taken from each sample at harvest and immediately frozen to stop further color development. Pigment concentration was determined after all subsamples had been collected.

Color analysis. The techniques used in the analysis for anthocyanin content were primarily those of Francis and Atwood (1) and Servadio and Francis (3). Fifty gram aliquots of berries from each subsample were blended for 4 min with a 400 ml mixture of 0.1N HCl and 95% ethanol (15:85). The homogenate was decanted and allowed to stand for 30 min, during which time most of the solid materials settled. A 2 ml aliquot of the clear supernatant was removed and diluted 10-fold with the aforementioned acid-ethanol solvent. After standing for 30 min, a small sample of the diluted juice was read at 535 mμ in a Beckman DU spectrophotometer. Beckman DU readings were converted to mg of anthocyanin per gram of fresh fruit. The factors involved in the conversion of DU readings to mg of anthocyanin were determined by Fuleki and Francis (2) who have isolated, identified, and established the absorption coefficients for the anthocyanins present in the cranberry.

RESULTS

Alanap-CIPC. Yields from plots treated with alanap-CIPC were similar to that of the control (Table 1). Plots that received applications of 6.48 and 9.72 lbs a.i./A showed increases of 1.9 and 3.9 barrels per acre and those plots that received an application of 8.1 lbs a.i./A showed an average decrease of 1.7 barrels/A. Berry size was also not affected by alanap-CIPC, average cup counts from treated plots being almost identical to that of the control (Table 1). However, alanap-CIPC did cause a small but noticeable increase in pigment production. Compared to the amount of anthocyanin per gram of fresh fruit found in the control plots (0.387mg), plots treated with 6.48, 8.10, and 9.72 lbs a.i./A alanap-CIPC yielded berries containing 0.419, 0.394, and 0.433 mg of pigment per gram of fresh fruit, respectively (Table 1). This represents increases of about 9, 2, and 12% over the control.

KN_3-CIPC. A significant increase in yield was found in plots treated with KN_3-CIPC (Table 1). The highest yields were taken from plots treated with 25 lbs a.i./A, the average yield exceeding the control by approximately 24%. One of the reasons yields were higher in plots treated with KN_3-CIPC was that berries harvested from these plots were larger than the control berries (Table 1). Color was not appreciably changed by KN_3-CIPC treatment (Table 1). Slight increases in pigment development were observed for the lowest (20 lbs a.i./A) and highest (30 lbs a.i./A) herbicide treatments. However, color development in berries treated with 25 lbs a.i./A KN_3-CIPC was similar to that of the control.

OCS-21799. Application of OCS-21799 at 4, 6 and 8 lbs a.i./A resulted in yield reductions of 31.1, 38.1, and 51.6%, respectively (Table 1). In addition, all concentrations of the herbicide caused vine injury. Vine injury ranged from slight with the lowest concentration (4 lbs a.i./A) to severe with the highest concentration (8 lbs a.i./A) applied. Berry size was reduced considerably by OCS-21799, influence on size apparently being a function of the concentration of herbicide applied (Table 1). It is also apparent from Table 1 that OCS-21799 causes a slight increase in color development.

Table 1. The effect of alanap-CIPC, KN_3-CIPC, OCS-21799, and OCS-21799-K on yield, size, and color of 'Early Black' cranberries. Each figure in the table represents an average of 5 replicates except for the control which represents an average of 25 replicates.

Treatment (lbs a.i./A)	Yield (barrels/A)	Size (cup count)	Color mg pig/g berry
Control	54.7	122	0.387
Alanap-CIPC			
6.48	56.6	121	0.419
8.10	53.0	122	0.394
9.72	58.6	120	0.433
KN_3-CIPC			
20.0	56.5	117	0.405
25.0	68.0	118	0.382
30.0	63.3	118	0.409
OCS-21799			
4.0	37.7	135	0.392
6.0	33.8	137	0.415
8.0	26.5	144	0.414
OCS-21799-K			
4.0	25.3	123	0.424
6.0	17.4	127	0.460
8.0	13.8	130	0.480

OCS-21799-K. All applications of the potassium salt of OCS-21799 caused severe vine injury and considerable crop reduction. Yields from plots receiving 4, 6, and 8 lbs a.i./A of OCS-21799-K were down 53.7, 68.2, and 74.8%, respectively (Table 1). A slight decrease in berry size was also observed. Treatment of cranberry vines with OCS-21799-K unquestionably raised the pigment content of the berries, pigmentation increasing as concentration of herbicide increased. Increases in anthocyanin production of 10, 19, and 24% were observed in berries treated with 4, 6, and 8 lbs a.i./A OCS-21799-K, respectively (Table 1).

DISCUSSION

Of the four herbicides tested two appeared to be tolerated by cranberry vines. With the exception of a slight increase in color, alanap-CIPC was innocuous to cranberry vine and crop. Favorable results were also obtained with the use of KN_3-CIPC. No vine injury was observed and yields and berry size were actually increased.

On the other hand, OCS-21799 and its potassium salt (OCS-21799-K) were not tolerated by the vines. Severe vine injury and crop reduction were observed even on plots receiving the lower applications of these compounds. The simplest explanation for the stimulatory influence of OCS-21799-K on pigmentation is that the compound is phytotoxic when applied to cranberries. Cranberries typically respond to injury with an accelerated synthesis of anthocyanins. This occurs when the berries are punctured, bruised, infected or otherwise damaged.

LITERATURE CITED

1. Francis, F.J. and Atwood, W.M. 1961. The effect of fertilizer treatments on the pigment content of cranberries. Proc. Amer. Soc. Hort. Sci. 77: 351-358.

2. Fuleki, T. and Francis, F.J. 1968. Quantitative methods for anthocyanins. I. Extraction and determination of total anthocyanin in cranberries. J. Food Sci. 33:72-77.

3. Servadio, G.J. and Francis, F.J. 1963. Relation between color of cranberries and color and stability of sauce. Food Tech. 17:124-128.

SWEETPOTATO AND WEED RESPONSES TO SEVERAL HERBICIDES 1/

H. P. Wilson, R. L. Waterfield, Jr. and H. J. Davis 2/

Four herbicides are currently being used for controlling weeds in sweetpotatoes in Virginia. The two most widely used are diphenamid (N,N-dimethyl-2,2-diphenylacetamide) and DCPA (dimethyl 2,3,5,6-tetrachloroterephthalate). Both of these chemicals will effect control of most annual grasses and often control certain broadleaved weeds. However, the spectrum of broadleaved weeds controlled is frequently narrow with such species as lambsquarters, morning-glories, ragweed, jimsonweed and cocklebur escaping control. Furthermore, since diphenamid and DCPA are applied preemergence, their activity is dependent upon an adequate amount of soil moisture at or within a few days following application. Failure to get these herbicides into the area of germinating seeds results in poor control.

Vernolate (S-propyl dipropylthiocarbamate) is also used by sweetpotato growers and has the advantage of being less dependent on moisture to carry it into the soil since it must be incorporated. Several reports, however, indicate that sweetpotatoes may be injured by this compound (1,2,3). The fourth compound which has been used is amiben (3-amino-2,5-dichlorobenzoic acid). Grower experience with amiben has generally indicated that results are inconsistent on the light soils of eastern Virginia.

The studies reported herein were conducted to further research herbicides currently being used in sweetpotatoes as well as to determine if several other chemicals had potential for use in this crop.

Materials and Methods

Herbicides were researched at the Eastern Shore Branch, Virginia Truck Experiment Station, Painter, on a Sassafras sandy loam soil with approximately 1% organic matter. Two experiments (preplant incorporated and preemergence) were conducted each in 1968 and 1969. Experiments were designed as randomized complete blocks with three replications in 1968 and four replications in 1969. Sweetpotato sprouts (var. Nemagold) were planted on the flat on June 6, 1968, and June 24, 1969 in plots measuring 5 ft x 20 ft and containing one row in 1968 and two rows in 1969. Herbicides listed in the Appendix were applied on the dates of planting with the exception of preemergence applications in 1969 which were made the day following planting. Applications were made with a plot sprayer at a delivery rate of 55 gpa using water as the diluent. Propane was the pressure source. Incorporation, where utilized, was with a power

---

1/ Contribution from the Plant Physiology Department, Virginia Truck Experiment Station. Paper No. 146, Journal Series. Approved for publication November 25, 1969.

2/ Plant Physiologist, Research Assistant and Research Technician, respectively, Virginia Truck Experiment Station, Eastern Shore Branch, Painter, Va.

driven rototiller. In 1968 tines on the rototiller were adjusted to cut to a depth of 3 in. In 1969 incorporating was done twice in opposite directions of travel with tines cutting to a depth of 2 to 2½ in.

The time elapsed from herbicide application until the first precipitation was 11 days in 1968, when 1 in of rainfall was received. In 1969 all treatments received 1 in irrigation within 1 to 2 days following herbicide application.

Individual species were rated using the scale 0 to 10 where 0 represents no weed control or crop injury and 10 represents complete reduction in plant stand or vigor. Predominant weeds differed in 1968 and 1969 but included pigweed (Amaranthus retroflexus L.), lambsquarters (Chenopodium album L.), purslane (Portulaca oleracea L.), carpetweed (Mollugo verticillata L.), crabgrass (Digitaria spp.), bullgrass (Paspalum Boscianum Fluegge.) and lovegrass (Eragrostis cilianensis (All.) Link.).

Sweetpotatoes were not cultivated in 1968 with the exception of check plots; in 1969 all plots were cultivated on July 23 after weed control and crop injury evaluations were made. One check treatment was also hand-weeded on this date in each study in 1969. Plots were harvested both years to permit determination of weed and herbicide effects on yields. Yield data were analyzed statistically and treatment means compared using the L.S.D. values computed.

Results and Discussion

Weed control, sweetpotato tolerances and yields are presented in Tables 1 and 2. Preplant incorporated herbicides will be discussed first.

Notwithstanding that excellent control of broadleaved weeds and grass was obtained with vernolate and EPTC, considerable reduction in vigor of sweetpotatoes resulted. The addition of the insecticide N-2790 to EPTC did not result in any lasting increase in crop injury. Molinate provided good broad-spectrum control and seemed to possess a satisfactory margin of crop safety. Rates of 3 to 4 lb/A with cultivation were needed to control weeds until sweetpotato vines offered enough ground cover to prevent weed growth. Incorporation of diphenamid and DCPA resulted in good control of weeds but sweetpotatoes were injured by DCPA to the extent that yields were lower than those of the cultivated check; no injury resulted from diphenamid. The combination of vernolate with diphenamid provided outstanding control of weeds and resulted in less initial crop injury than did vernolate alone; however, yields did not differ from those produced by sweetpotatoes treated singly with vernolate. Both nitralin and trifluralin caused extensive sweetpotato injury.

With reference to preemergence treatments, both diphenamid and DCPA effected good weed control and possessed a satisfactory margin of crop safety when applied in this manner. Little differences in crop tolerance or weed control were observed between the two formulations of amiben. The good performance of amiben both years was attributed to an adequate amount of soil moisture either at the time of application or shortly thereafter. Combinations of DCPA with metobromuron caused increasing amounts of crop injury as rates of either herbicide increased.

However, the low rates of 4 + 3/4 lb/A of DCPA + metobromuron respectively provided excellent control of weeds.

In 1968 no treatments yielded lower than the checks. However, since cultivation was not performed until late in the season, many weeds were not controlled and continued to compete with the crop. Although sweetpotatoes were cultivated earlier in 1969 and checks were hand weeded as well, it is believed that weeds had competed sufficiently long to cause yields to be lower than they otherwise might have been. In general, though, yields of sweet-potatoes can be related to weed control and crop tolerance to individual treatments.

Summary

Herbicides were researched for their capacity to provide control of several broadleaved weeds and grasses in sweetpotatoes. Vernolate and EPTC provided good weed control and sweetpotato yields although initial crop injury was extensive. Molinate effected broad-spectrum control at rates of 3 to 6 lb/A while possessing a satisfactory margin of safety to the crop. Diphenamid and DCPA controlled weeds when applied preplant incorporated or preemergence but considerable crop injury resulted from incorporation of DCPA. The combination of vernolate with diphenamid caused less initial injury to sweetpotatoes than the higher rates of vernolate alone. Both trifluralin and nitralin caused crop injury. Differences between the ammonium salt and methyl ester formulations of amiben were small. Combinations of DCPA with metobromuron caused increasing crop injury as rates increased but low rates were sufficient to control weeds. In general, sweetpotato yields were related to weed control and crop injury.

Appendix

Chemistry of compounds researched in sweetpotatoes in 1968 and 1969.

Herbicide	Chemical description
amiben	3-amino-2,5-dichlorobenzoic acid
chlorbromuron	3-(4-bromo-3-chlorophenyl)-1-methoxy-1-methylurea
DCPA	dimethyl 2,3,5,6-tetrachloroterephthalate
diphenamid	N,N-dimethyl-2,2-diphenylacetamide
EPTC	ethyl N,N-dipropylthiocarbamate
metobromuron	N-(p-bromophenyl)-N'-methyl-N'-methoxyurea
molinate	S-ethyl hexahydro-1 H-azepine-1-carbothioate
N-2790	O-Ethyl-S-phenyl-ethylphosphonodithioate
nitralin	4-(2-methylsulfonyl)-2,6-dinitro-N,N-dipropylaniline
trifluralin	a,a,a-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine
vernolate	S-propyl dipropylthiocarbamate

Literature Cited

1. Altman, C. D. and J. D. Long. 1969. Weed control in sweet potatoes. Proc. NEWCC 23:12-16.

2. Cialone, J. C. 1966. Herbicide evaluation in sweet potatoes. Proc. NEWCC 20:122-125.

3. Long, J. D. and W. A. Matthews. 1965. Chemical weed control in sweet potatoes. Proc. NEWCC 19:61-64.

Table 1. Weed Control and Crop Responses to Herbicides Applied Preplant Incorporated and Preemergence to Sweetpotatoes in 1968

Herbicide	Rate, lb/A ai	Crop 1/ Response	Weed Control 1/ Lambs-quarters	Carpet-weed	Purs-lane	Crab-grass	Yield Bu/A
Preplant, Inc.							
vernolate	1 1/2	1.7	10.0	10.0	9.9	10.0	303.4
	2	1.9	9.9	9.9	10.0	10.0	236.7
	3	3.8	10.0	10.0	10.0	10.0	274.4
molinate	2	0.4	7.2	8.4	6.5	8.3	249.7
	4	1.3	9.5	9.2	9.2	10.0	287.5
	6	0.9	10.0	10.0	9.7	10.0	344.1
EPTC	2	2.5	9.8	9.8	9.6	10.0	288.9
EPTC + N-2790	2 + 2	3.2	9.8	9.7	9.9	10.0	341.2
trifluralin	3/4	3.6	10.0	9.6	9.7	9.8	334.0
	1 1/2	6.7	10.0	10.0	10.0	10.0	165.5
Check		0.0	0.0	0.0	0.0	0.0	220.7
Check		0.0	0.0	0.0	0.0	0.0	271.5
Check		0.2	0.0	0.0	0.0	0.0	203.3
LSD 0.05							50.1
Preemergence							
diphenamid	2	0.4	9.9	10.0	9.4	9.0	380.4
	4	0.6	9.8	9.6	9.0	9.9	339.8
DCPA	9	1.2	10.0	10.0	10.0	9.5	367.4
amiben (ammonium salt)	3	1.2	9.3	9.6	10.0	9.0	316.5
	4	1.2	9.7	9.5	10.0	9.1	201.8
amiben (methyl ester)	3	0.8	9.2	8.8	10.0	9.8	299.1
	4	1.4	9.9	9.5	10.0	9.7	342.7
DCPA + metobromuron	4 1/2 + 3/4	0.8	10.0	10.0	10.0	9.8	326.7
	4 1/2 + 1	1.5	10.0	10.0	10.0	9.8	422.5
chlorbromuron	1 1/2	2.1	10.0	10.0	10.0	9.7	304.9
	3	4.8	10.0	10.0	10.0	10.0	364.5
Check							213.4
LSD 0.05							N.S.

1/ Scale: 0 to 10; 0=no effect and 10=complete reduction in crop vigor or weed stand.

Table 2. Weed Control and Crop Responses to Herbicides Applied Preplant Incorporated and Preemergence to Sweetpotatoes in 1969.

Herbicide	Rate, lb/A ai	Crop[1/] Response	Weed Control [1/] Pig-weed	Crab-grass	Bull-grass	Love-grass	Yield, Bu/A
Preplant, Inc.							
vernolate	2	2.5	10.0	10.0	10.0	10.0	328.2
	3	4.5	10.0	10.0	10.0	10.0	296.2
molinate	3	0.0	8.6	9.9	10.0	10.0	323.1
	6	0.5	9.7	10.0	10.0	10.0	336.9
diphenamid	3	0.5	9.9	9.7	9.7	9.7	355.0
	4	0.7	9.8	9.9	9.9	10.0	435.6
DCPA	6	3.0	9.6	9.5	9.7	9.9	228.0
	8	5.4	9.4	10.0	9.7	9.3	202.6
vernolate + diphenamid	1 + 2	1.9	10.0	10.0	10.0	10.0	338.3
nitralin	3/4	5.0	10.0	10.0	10.0	10.0	200.4
	1 1/2	6.9	10.0	10.0	10.0	10.0	137.9
Check (Cult.)		1.6	10.0	10.0	10.0	10.0	319.4
Check		1.5	0.0	0.0	0.0	0.0	63.2
LSD 0.05							85.7
0.01							114.7
Preemergence							
diphenamid	3	0.5	9.8	9.8	9.8	9.8	388.4
	4	0.6	10.0	10.0	10.0	10.0	410.9
DCPA	6	1.5	8.1	10.0	9.5	10.0	375.3
	8	0.4	9.5	10.0	9.0	9.1	376.1
amiben (methyl ester)	3	1.3	9.9	10.0	10.0	10.0	392.8
	4	1.2	10.0	10.0	10.0	10.0	378.2
DCPA + metobromuron	4 + 3/4	1.3	10.0	10.0	9.8	9.9	364.5
	4 + 1	1.8	10.0	10.0	10.0	10.0	402.2
	6 + 3/4	2.5	10.0	10.0	10.0	10.0	360.1
	6 + 1	2.2	10.0	10.0	9.9	10.0	377.5
Check (Cult.)		1.6	10.0	10.0	10.0	10.0	286.0
Check		2.0	0.0	0.0	0.0	0.0	63.9
LSD 0.05							47.2
0.01							63.9

1/ Scale: 0 to 10; 0=no effect and 10=complete reduction in crop vigor or weed stand.

WEED CONTROL IN NEWLY PLANTED STRAWBERRIES[1/]

C. D. Altman and G. J. Stadelbacher[2/]

The importance of dependable weed control in the season a new strawberry planting is made has been emphasied by Long et al. (1). Combining herbicides to provide broad-spectrum weed control has been investigated and reported for greenhouse and field conditions (1,2). However,chemical treatments to control weeds in newly planted strawberries are not numerous and only a few compounds have obtained wide acceptance in Maryland (3). DCPA is the only chemical suggested for use in Maryland immediately following planting. Diphenamid or chloroxuron is suggested for use after plants have become well established. A second application of DCPA, diphenamid or chloroxuron may be administered during the summer.

New compounds that show promise in strawberry weed control warrant additional research in an effort to increase the efficacy of the chemical weed control program. The objective of this field experiment was to evaluate herbicide combinations and new herbicides for a complete broad-spectrum weed control program in newly planted strawberries.

Materials and Methods

Herbicide studies were conducted on newly planted Surecrop strawberries at the Vegetable Research Farm, Salisbury, Maryland on a sandy soil containing less than 1% organic matter. The experimental design was randomized complete blocks with four replications. Plots consisted of four rows 28 feet long and three feet wide. Dormant, certified Surecrop strawberry plants were planted two feet apart (14 plants per row) on April 14. All herbicides were applied as water dilutions with a tractor-mounted sprayer at the rate of 50 gallons per acre. Entire plots were treated but only the two center rows were used for records. Herbicides evaluated in this study are listed in the appendix.

Immediately following herbicidal applications on April 14, all plots received 0.5 inch irrigation. Additional significant precipitation in the amount of 3.69 inches was recorded during the period April 16 to April 22. Rainfall for the period April 23 to July 1 (70 days) was only 2.56 inches.

The predominant weeds of natural infestation were *Oenothera laciniata* (primrose), *Geranium carolinianum* (cranesbill) and *Trifolium arvesnse* (rabbit-foot clover). Weed ratings by species and crop response ratings were made using the scale 0 to 10. Ten respresents nearly perfect weed control and/or no apparent crop phytotoxicity whereas 0 represents no weed control and/or death of all berry plants. Daughter plant counts were made on July 21

1/ Misc. Publ. No. 747 ,Contribution No. 4276 , of the Maryland Agricultural Experiment Station, Department of Horticulture.

2/ Research Assistant and Associate Professor respectfully, University of Maryland.

Results and Discussion

Weed control and crop response ratings are recorded in Table 1. Ratings were made June 20 and naturally do not include influences of herbicidal treatments applied August 29. However, no apparent crop phytotoxicity symptoms were observed from the August 29 sprays.

Treatment five (DCPA, 7.5 lb. ai/A) was considered to be the standard method used for weed control. Acceptable control of primrose, cranesbill and rabbit-foot clover was obtained with all treatments. However, absence of grass species in the experimental area is noted and their presence may have affected the weed control of some herbicides. The combination of 1.5 lb. CP-50144 plus 4.0 lb. chloroxuron provided nearly perfect control of all three weed species with no crop phytotoxicity.

Four of the 11 herbicide treatments resulted in crop injury. RH-315 when applied immediately following transplanting severely stunted plant growth and killed some plants. However, when 30 days elasped between planting and RH-315 application no apparent injury was noted. Treatments involving nitralin also stunted strawberry growth. DCPA only at the highest rate (9.0 lb. ai/A) reduced plant vigor and early plant production.

The number of daughter plants produced per plot by July 21 followed the same order as crop response ratings noted June 20. Only three treatments produced significantly less daughter plants than the standard treatment of DCPA 7.5 lb. ai/A.

Summary

Herbicidal treatments including new compounds and combinations of two chemicals were evaluated for weed control and crop injury in newly planted Surecrop strawberries. All treatments effected acceptable control of primrose, cranesbill and rabbit-foot clover. Daughter plant production was significantly reduced when nitralin or RH-315 was applied immediately following strawberry transplanting. CP-50144 plus chloroxuron, DCPA plus sesone, RH-315, chloroxuron and C-6989 show promise for controlling weeds in first year strawberry plantings.

Table 1. Effect of various herbicidal treatments on weed control, crop phytotoxicity and number of daughter plants in newly planted strawberries.

Treatment1/	Rate lb ai/A	Method and Date of Application	Weed Control 6/20 Primrose	Crane	Clover	Crop Response3/ 6/20	Number Daughter Plants/Plot4/ 7/21
1.DCPA +	9.0	Pre 4/14	9.8	8.5	9.5	10.0	200 a
sesone 73WP	2.7						
2.RH-315 75WP	1.0	Pre 4/14	9.5	8.2	9.0	7.2	65 b
3.RH-315 75WP	1.0	Pre 5/16	9.0	7.8	10.0	10.0	166 a
4.RH-315 75WP	2.0	Pre 5/11	9.5	8.8	9.5	10.0	190 a
5.DCPA 75WP +	7.5	Pre 4/14	7.5	7.8	8.2	10.0	174 a
diphen-amid 4WD	4.0	Pre 8/29					
6.DCPA 75WP +	9.0	Pre 4/14	8.0	8.0	9.8	9.2	157 a
DCPA 75WP	9.0	Pre 8/29					
7.CP-50144 4E	1.5	Post 5/16	10.0	10.0	10.0	10.0	218 a
+ chloroxuron 50WP	4.0	Post 5/16					
8.chloroxuron 50WP +	2.0	Pre 4/14	9.2	8.5	9.8	10.0	193 a
chloroxuron 50WP	2.0	Pre 8/29					
9.C-6989 50WP +	3.0	Pre 4/14	8.8	8.8	9.2	10.0	178 a
C-6989 50WP	3.0	Pre 8/29					
10.nitralin 4WDL	1.0	Pre 4/14	8.8	9.5	9.5	9.0	52 b
+ DCPA 75WP	7.5	Pre 4/14					
11.nitralin 4WDL	1.0	Pre 4/14	8.8	9.0	9.0	9.5	93 b

1/ Plants were set 4/14. Pre-emergence (pre) sprays were applied immediately to a dry soil surface with a temperature of 70°F. Air temperature was 63-65°F. All plots received 1/2" irrigation 4/14 following herbicidal sprays. Pre-emergence 5/16 treatments were sprayed following a clean cultivation of those plots only. Pre-emergence 8/29 treatments were sprayed following a clean cultivation. All plots were topdressed 6/19, cultivated and sidedressed 7/14 and 8/26 and hand-weeded 7/24. Irrigation of 1" was applied 7/2.

2/ Rated on basis of 0 to 10 with 10 representing nearly perfect weed control. Primrose = Oenothera laciniata, crane = Geranium carolinianum and clover = Trifolium arvense.

3/ Rated on basis of 0 to 10 with 10 representing no apparent phytotoxicity and 0 death of all plants.

4/ Means are average of 4 replications of 28 mother plants spaced 2' x 3'. Means followed by the same letter are not significantly different at the 5% level.

Appendix

Chemical descriptions of herbicides used in the strawberry study.

Common Name or Number	Chemical Designation
C-6989	2,4'-dinitro-4-trifluoromethyl-diphenylether
chloroxuron	N'-4-(4-chlorophenoxy)phenyl-N,N-dimethylurea
CP-50144	2-chloro-2',6'diethyl-N-(methoxymethyl acetanilide
DCPA	dimethyl 2,3,5,6-tetrachloroterephthalate
diphenamid	N,N-dimethyl-2,2-diphenylacetamide
nitralin	4-(methylsulfonyl)-2,6-dinitro-N,N-dipropylaniline
RH-315	-----
sesone	Sodium 2,4-dichlorophenoxyethyl sulfate

Literature Cited

1. Long, J. D. and G. J. Stadelbacher. 1968. Herbicide studies on new strawberry plantings. Proc. Northeastern Weed Control Conf. 22:245-248.

2. Schubert, Oscar E. 1969. Effect of several combinations of herbicides on the weight and development of Midway strawberry plants in the greenhouse.

3. Stadelbacher, G. J., C. D. Altman and B. L. Rogers. 1969. Chemical weed control in strawberry, raspberry, blueberry and grape plantings. Hort. Mimeo HE26-69, University of Maryland.

Comparative Effects of EPTC, Butylate and VCS 438 on Annual Weeds and Alfalfa [1/]

William B. Duke, Barry J. Brecke and Paul F. Boldt [2/]

Introduction

Several herbicides including S-ethyl dipropylthiocarbamate (EPTC), 2-sec-butyl-4,6-dinitrophenol (dinoseb) and 4-(2,4-dichlorophenoxy) butyric acid (2,4-DB) are currently being used to control annual and perennial weeds in seedling alfalfa. EPTC used preplant and incorporated will control most seedling weed grasses but is not entirely effective for controlling broadleaf weeds (2) while on the other hand most broadleaf weeds can be controlled with dinoseb or 2,4-DB but neither material is particularly effective for grass control (3). Several have reported excellent broad spectrum weed control from combination of EPTC and DNBP or 2,4-DB (1, 2, 3). Notwithstanding that weed control with these combinations is excellent, the requirements of incorporation plus the possible need for an extra post-emergence application have made growers reluctant to use these materials.

Preliminary studies in the greenhouse in 1967 indicated that VCS 438 (structure undisclosed) and S-ethyl diisobutylthiocarbamate (butylate) were effective for weed control in seedling alfalfa (1). The margin of crop safety with VCS 438 was slightly less than with butylate. VCS 438 severely injured birdsfoot trefoil.

The studies reported herein were conducted to compare the effectiveness of EPTC to that of butylate and VCS 438 for broad spectrum weed control in seedling alfalfa at several locations in New York.

Materials and Methods

During 1968 and 1969, studies were conducted at several locations in New York. The 1968 study was conducted at the Aurora Research Farm near Aurora, New York, on a Honeoye silt loam (OM = 3.4%). Studies in 1969 were conducted at the Miller Farm (private farm near Auburn, New York) on a Lima silt loam (OM = 2.5%) and the Leonard Farm (private farm near Sidney, New York) on a Tioga silt loam (OM = 1.9%) and the Aurora Research Farm. Each experiment was randomized complete block. Six replications used in 1968 while four replications were used at each location in 1969. Plot size was

---

1/ Contribution from the Department of Agronomy, New York State College of Agriculture, Cornell University, Ithaca, New York. Agronomy Journal Series No. 873.

2/ Assistant Professor, Research Assistant and Experimentalist, respectively, Department of Agronomy, Cornell University, Ithaca, New York.

6 x 25 ft. All herbicides were applied in water at a delivery rate of 30 gpa. Air was used as the source of pressure. Herbicides applied preplant were incorporated by discing twice at right angles with a tandem disc immediately after spraying. Depth of discing was 2 to 3 in. All plots were disced to eliminate tillage as a variable.

At all locations, plots were seeded with Saranac alfalfa at 16 lb/A. Seeding was done with a grain drill equipped with press wheels and with attachments for placement of fertilizer and crop seed in bands. Fertilizer (0-20-20) at 300 lb/A was applied in bands approximately 2 in. beneath the legume seed. The press wheels were set to provide compaction of soil between the seeded 7 in. rows.

1968 Study: On April 29, EPTC at 0, 2 and 3 lb/A and butylate at 0, 3, and 4 lb/A were applied and incorporated. Alfalfa was planted the same day. VCS 438 at 0, 1, 2 and 4 lb/A was applied at planting. On June 3, dinoseb at 1 lb/A was applied to emerged alfalfa and weeds on plots previously treated with 0 and 3 lb/A EPTC. Alfalfa was in the 6-true-leaf stage, grass weeds average 3 in. tall and broadleaf weeds were in the four-to six-true-leaf stage. Annual weed species predominant in this study were: wild mustard (*Brassica kaber* (D.C.) L. C. Wheeler), yellow foxtail (*Setaria glauca* (L.) Beauv.) and ladysthumb (*Polygonum persicaria* L.).

1969 Studies: On the Miller Farm and the Leonard Farm, EPTC and butylate at 0 and 3 lb/A were applied and incorporated on May 2. Alfalfa was planted the same day. VCS 438 at 0, 2, 3 and 4 lb/A was applied at planting. After alfalfa and weed emergence, DNBP at 1 lb/A was applied to plots previously treated with 0 and 3 lb/A EPTC or butylate. Alfalfa was in the four to six-true-leaf stage, grass weeds averaged two in. tall and broadleaves were in the four-eight-true-leaf stage at the time of spraying. Predominant weed species in these trials were witchgrass (*Panicium capillare* L.), yellow foxtail, wild radish (*Raphanus raphanistrum* L.) and common lambsquarters (*Chenopodium album* L.).

In 1969, a separate study was conducted at the Aurora Research Farm to examine effects of preemergence VCS 438, applied alone and in combination with postemergence DNBP. Alfalfa was seeded on May 28. VCS 438 at 0, 2 and 4 lb/A was applied at planting. Five weeks after seeding, dinoseb at 0, 1/4 and 1/2 lb/A was applied to weeds and alfalfa. Alfalfa was in the four to six-true-leaf stage and weeds averaged 4 in. tall. Annual weed species predominant in this trial were barnyardgrass (*Echinochloa crusgalli* (L.) Beauv.), green foxtail (*Setaria viridis* (L.) Beauv) and redroot pigweed (*Amaranthus retroflexus* L.).

In all studies, weed control ratings on individual species and crop injury ratings were made using the scale 0 to 10 where 0 represents no control or crop injury and 10 represents a complete reduction in plant stand and vigor. An area 3.25 x 20 ft. through the center of each plot was taken at each harvest date for total yield determinations. In 1968, one cutting for total yield was taken on July 29. In 1969, one cutting was taken for total yield on July 27 at the Miller Farm and July 28 at the Leonard Farm. In the study at the Aurora Farm in 1969, cuttings were taken for total yield on July 26 and

and October 12. All yield data are expressed on an oven-dry basis (75°C to a constant weight).

Significance of treatments or treatment means at the 0.05 level was determined by the Duncan Multiple Range Test.

Results and Discussion

Individually, EPTC and butylate treatments in 1968 gave excellent annual grass control, but neither herbicide was effective in controlling wild mustard (Table 1). Therefore, forage yield was significantly reduced (Table 1). Control of yellow foxtail and wild mustard by VCS 438 was very impressive, however, ladysthumb appeared to be tolerant of this chemical. Significant yield increases were noted in response to VCS 438 treatments. A combination of EPTC with dinoseb effected excellent control of all weeds and also caused a significant yield increase. Similar results have been reported by others (2).

Table 1. Weed control ratings and forage yield as affected by preplant incorporated applications of EPTC and butylate and preemergence applications of VCS 438 in 1968.

Herbicide Treatment	Rate lb/A	Alfalfa Response 1/	Weed Control Ratings 1/ Yellow Foxtail	Wild mustard	Ladys-thumb	Yield Dry Matter lbs/A 3/
EPTC	2	1.2	8.6	2.2	3.2	3314 cd
	3	0.6	9.4	6.6	5.8	3478 cd
butylate	3	1.3	6.8	0.6	3.1	2651 d
	4	1.0	9.1	3.2	3.0	2750 d
VCS 438	1	2.0	4.2	3.1	1.1	3200 cd
	2	0.1	8.6	8.8	3.1	4522 ab
	4	0.2	9.9	10.0	4.1	4020 ab
EPTC + dinoseb 2/	3 + 1	0.1	9.9	9.8	8.8	4900 a
Control	-	2.0	0.0	0.1	0.1	3018 d

1/ Scale: 0 to 10; 0 = No effect and 10 = a complete reduction of plant stand and vigor.

2/ Dinoseb applied postemergence when the alfalfa was in 4 to 6 leaf stage.

3/ Yield values with identical letters are not significant at the 0.05 level.

Data from two locations in 1969 have been summarized and are presented in Table 2. Butylate was not as effective as EPTC for the control of annual grasses or broadleaves. In combination with postemergence applications of dinoseb, control was not equal to that obtained with EPTC plus dinoseb. At each location, VCS 438 was markedly more active on broadleaf weeds than either EPTC or butylate, however, it was slightly less active on annual grasses. This did not create a significant reduction in yield (Table 2). Control yields were higher than treated plots because of the added weight of weeds. At the 4 lb/A rate, VCS 438 caused a reduction in crop stand and a significant reduction in forage yield. This reduction was most evident at the Leonard Farm in Chenango County. At this location, the OM was only 1.9%. Selectivity of alfalfa to VCS 438 may be dependent on amounts of OM in the soil.

Table 2. Weed control ratings and yield of forage as affected by preplant incorporated applications of EPTC and butylate and preemergence applications of VCS 438 in 1969. Figures are averages of two locations.

Herbicide Treatment	Rate lb/A	Alfalfa Response 1/	Weed Control Ratings 1/ Witch-grass	Yellow Foxtail 2/	Wild Radish	Common Lambs-quarters	Yield 4/ Dry Matter lb/A
EPTC	3	0.1	9.2	10.0	5.6	3.7	2656 b
butylate	3	0.1	8.8	9.8	2.6	1.7	2964 ab
VCS 438	2	0.2	7.3	10.0	9.1	9.9	2792 ab
	3	0.6	8.9	10.0	9.6	9.9	2863 ab
	4	2.5	9.9	10.0	10.0	10.0	2135 c
EPTC + dinoseb 3/	3+1	0.6	9.8	10.0	10.0	10.0	2529 bc
butylate + dinoseb 3/	3+1	1.0	8.8	10.0	8.6	6.8	3002 ab
Control	-	0.0	0.0	0.3	0.1	0.3	3106 a

1/ Scale: 0 to 10; 0 = no effect and 10 = complete reduction of plant stand and vigor.

2/ Data from one location only - Leonard Farm, Chenango County.

3/ Dinoseb applied postemergence when alfalfa was in the 4-6 leaf stage.

4/ Yield figures with identical letters are not significant at the 0.05 level.

Table 3. Weed control ratings and yield of forage as affected by preemergence applications of VCS 438 and postemergence applications of dinoseb in 1969.

			First Cutting, June, 1969					Second Cutting, Oct., 1969			
				Weed Control Ratings 1/				Botanical Composition (%) 4/			
VCS438 2/ Rate lbs/A	dinoseb Rate lbs/A		Alfalfa 1/ Response	Barn-yard-grass	Green Fox-tail	Red-root Pig-weed	Yield Dry Mat. lbs/A	Alfalfa	BLW	Grass	Yield Dry Mat. lbs/A
2 +	0		0.0	8.5	8.8	8.0	2259	83	7	10	1172
4 +	0		0.3	9.5	9.5	7.8	2277	84	9	7	1245
		mean	0.2b	9.0a	9.1a	7.9a	2268b	83a	8	8	1208b
2 +	1/4		0.3	8.8	8.5	5.8	2428	76	19	5	1558
4 +	1/4		0.0	9.0	9.3	8.3	2238	89	9	2	1490
		mean	0.2b	8.9a	8.9a	7.0a	2333b	82a	14	4	1524ab
2 +	1/2		2.1	8.5	9.1	6.7	1978	89	6	5	1475
4 +	1/2		2.8	9.5	9.5	9.0	1729	84	4	13	1054
		mean	2.4a	9.0a	9.3a	7.8a	1853c	86a	5	9	1264b
0 +	1/4		0.8	2.8	2.3	0.8	2529	50	29	21	1720
0 +	1/2		0.5	2.5	2.3	2.3	3049	50	19	31	1824
		mean	0.6b	2.6b	2.3b	1.5b	2789a	50b	24	26	1772a
0 +	0		1.3	1.0	2.0	1.5	2971	65	20	15	1560
0 +	0		0.1	2.0	1.2	2.0	3033	55	30	15	2016
		mean	0.7b	1.5b	1.6b	1.7b	3002a	60b	25	15	1788a

1/ Scale: 0 to 10; 0 = no effect and 10 = complete reduction of plant stand and vigor.

2/ VCS 438 applied at planting; dinoseb applied after alfalfa and weeds had emerged.

3/ Means followed by identical letters do not differ significantly at the 0.05 level.

4/ Botanical Composition is a percentage based on a visual estimate of total weight.

Since the results of the 1968 experiment indicated a weakness of VCS 438 for ladysthumb control (Table 1), a separate study was initiated in 1969 to determine if combining this herbicide with a postemergence treatment of dinoseb would broaden the spectrum of weeds controlled and yet not affect crop tolerance. Results of this study are presented in Table 3. Individually, VCS 438 was effective in reducing broadleaf and grass weed competition while the low rates of DNBP were completely ineffective. Combining dinoseb with VCS 438 did not significantly increase overall weed control, however, it did cause a significant reduction in alfalfa stand and forage yield. Forage yield from plots treated with VCS 438 alone were significantly lower than untreated plots. This was not due to an effect of the chemical on the crop but rather a result of elimination of weeds as a contributor to plot weight.

Visual estimates of botanical composition by weight at second cutting revealed that there was significantly more alfalfa as a result of VCS 438 treatments (Table 3). Total forage yield was significantly reduced by VCS 438. It is felt that this reduction is primarily a result of elimination of competition, however, it is also possible that the reduction was due to a delayed effect of the herbicide on alfalfa vigor. Preliminary experiments in the greenhouse have indicated that this may occur.

The significant degree of annual weed control obtained with VCS 438 alone indicates that this herbicide may provide a very valuable cultural tool for forage crop growers. As mentioned above, a serious drawback to the use of EPTC has been the need for incorporation coupled with its weakness on several broadleaf weeds thereby necessitating the use of another herbicide such as dinoseb or 2,4-DB. VCS 438 should only be considered as an alternative for those growers who have annual weed problems since this material has no activity on perennial weeds such as yellow nutsedge (*Cyperus esculentus* L.) or quackgrass (*Apropyron repens* (L.) Beauv).

Summary

Comparisons of EPTC with butylate and VCS 438 for broad spectrum weed control in alfalfa were conducted in 1968 and 1969. Individually, both EPTC and butylate gave excellent grass and poor broadleaf control. In both cases, butylate was less effective than EPTC. VCS 438 effected greater broadleaf control and almost equal grass control as the thiocarbamates. (Table 1). In combination with dinoseb, EPTC gave excellent overall weed control and high forage yields. The combination of butylate and dinoseb was not as effective as EPTC plus dinoseb (Table 2).

Broadleaf and grass weed control with no crop injury was obtained with VCS 438 alone (Table 3). The addition of dinoseb as a postemergence treatment to increase overall weed control resulted in crop injury and no increase in spectrum of weeds controlled. Second cutting yields were lowered as a result of VCS 438 treatment but this was felt to be due to elimination of weeds as a yield component.

Applying VCS 438 immediately after planting alfalfa should provide a practical method for controlling a broad spectrum of annual weeds with minimal damage to the legume. The use of this chemical will eliminate the need for incorporation and the need for an extra treatment with a postemergence herbicide for broadleaf control.

Literature Cited

1. Duke, William B. 1969. Herbicides for controlling weeds in seedling alfalfa. Supple. Proc. NEWCC 23:26.

2. Linscott, D. L. and R. D. Hagin. 1968. Interaction of EPTC and DNBP on seedlings of alfalfa and birdsfoot trefoil. Weed Science 16:182-184.

3. Peters, Elroy J. 1964. Pre-emergence, preplanting and postemergence herbicides for alfalfa and birdsfoot trefoil. Agron. Jour. 56:415-419.

EFFECTS OF RH 315 ON QUACKGRASS AND ESTABLISHED ALFALFA [1]

William B. Duke [2]

Introduction

The herbicide N-(1,1-dimethylpropynyl)-3,5-dichlorobenzamide (RH 315) has been implicated as a potential chemical for the control of both annual and perennial grasses in several crops. [3] Parochetti (4) reported that applications of RH 315 in the spring to established alfalfa (*Medicago sativa* L.) virtually eliminated orchardgrass (*Dactylis glomerata* L.) and effected a significant increase in crop yield. Duke [4] observed a significant reduction in quackgrass (*Agropyron repens* (L.) Beauv) and no effect on alfalfa following applications of this herbicide to dormant alfalfa in the spring or in the fall. Significant reductions of quackgrass and other weeds in established alfalfa following RH 315 applications have been observed by others. [5] The studies reported herein were designed to determine the proper time of application of RH 315 for maximum quackgrass control in established alfalfa and to ascertain the effects of the herbicide on crop yield and quality.

Materials and Methods

During the period 1967 to 1969, experiments were conducted near Canton, New York, on Wallington silt loam (OM = 4.5%) and near Aurora, New York, on Lima silt loam (OM = 2.6%). In all experiments, plots 6 x 25 ft. were established in an alfalfa stand infested with quackgrass and other perennial weeds including dandelion (*Taraxacum officinale* Weber), white cockle (*Lychnis alba* Mill.) and yellow rocket (*Barbarea vulgaris* R. Br.). All herbicide applications were made with a Mater plot sprayer calibrated to deliver 30 gpa.

In Experiment I, RH 315 at 0, 3/4, 1 1/2 and 3 lb/A was applied to a two-year old stand of Naragansett alfalfa at each of two different times, October 20, 1967, and April 11, 1968. Applications in October were made immediately after the forage had been harvested for the third time. April treatments were applied prior to visable initiation of spring growth of alfalfa or weeds. Experiment I was designed and analyzed as a randomized complete block with four replications.

Total forage yields were taken at two different cutting times during

---

[1] Contribution from the Department of Agronomy, New York State College of Agriculture, Cornell University, Ithaca, New York. Agronomy Journal Series No. 874.

[2] Assistant Professor, Department of Agronomy, Cornell University, Ithaca, New York.

[3] Anon. 1969. Announcing Kerb. Mimeo. Rohm and Haas Company.

[4] Duke, W. B. 1969. RH 315 for quackgrass control is established alfalfa. Proc. NEWCC (Supple) 23:26.

[5] Unger, V. H. 1968. Personal Communication.

the 1968 growing season and one cutting date in 1969. At each time, a swath 3.25 x 20 ft. was taken through the center of each plot for yield determinations. All yield data are expressed as lb/A on an oven-dry basis (75°C to a constant weight). Botanical composition estimates were made on the standing forage by the visual weight estimation procedure described by Hunt (2).

Observations in 1968 indicated that timing of applications of RH 315 was important in relation to its herbicidal activity on perennial grasses. Consequently, in 1969, Experiment II was initiated in two-year old Narragansett alfalfa to determine the effects of RH 315 at 0, 3/4, 1 1/2 and 3 lb/A applied at several dates on the regrowth of both alfalfa and quackgrass. These dates of application were: October 14, November 26, March 28 and May 6. In October, RH 315 was applied to the alfalfa immediately after harvest while applications in November were made after the alfalfa had ceased to actively grow. Plots in March were treated prior to visible spring growth of alfalfa or quackgrass. Applications in May were made when the alfalfa and quackgrass averaged four to six in. in height. Experiment II was a split plot with four replications with main plots being times of application and subplots rates of RH 315.

Yield and botanical composition data for Experiment II were obtained as described earlier for Experiment I. In Experiment II, samples were taken at each harvest for protein determinations. Total protein was determined by micro-Kjeldhal procedures (1).

Results and Discussion

In Experiment I, quackgrass control by RH 315 treatments was very outstanding at the time of first forage harvest (CT I) in 1968 (Table 1). The most significant reduction in quackgrass growth was caused by 3 lb/A applied in the fall or spring. Differences between dates of application were not significant, however, there was a trend towards greater activity following applications in the fall. The removal of quackgrass with RH 315 tended to increase the percentage alfalfa contributing to overall plot weight although the differences were not significant. None of the treatments effected a significant reduction in crop yield, although in early May, 1968, a slight degree of alfalfa discoloration was noticed in plots which had been treated with 3 lb/A RH 315 in April of the same year. No rate of this herbicide affected broadleaf weed growth.

An obvious question at the time visual observations were being taken was whether quackgrass was present but could not be seen because of the excellent stand of alfalfa. To answer this, close examinations were made of the plant growth in the RH 315-treated plots. These close-quarter notes revealed that relatively little quackgrass could be found under the alfalfa or even at the soil surface. The small percentage which was found was considered moribund. Typically, those quackgrass plants found in areas treated with 1 1/2 to 3 lbs/A were somewhat blue-green and exhibited typical "onion-leafing" symptoms. Plants in plots receiving 3/4 lb/A did not exhibit "onion-leafing" but had narrower leaves than untreated plants and also exhibited necrosis at the leaf tips. Examination of unearthed rhizome sections revealed no bud activity at any node. No noticeable bud damage was evident although several appeared watery.

Table 1. Yield of forage dry matter and botanical composition of first and second cuttings of forage as affected by RH 315 applied in the spring and fall to established alfalfa, Canton, New York, 1967-1968.

Time of Application	RH 315 Rate lb/A	Botanical Composition (%) 1/ Quackgrass 2/ CT I	CT II	Alfalfa CT I	CT II	Yield Dry Matter lbs/A CT I	CT II
Oct. 20, 1967	3/4	14ab	19b	81	75	3918	3438
	1½	3d	10c	89	80	3878	3554
	3	0d	8c	91	80	4404	3404
April 11, 1968	3/4	10bc	18b	84	75	4392	3532
	1½	6c	10c	86	70	4364	3660
	3	3d	6c	88	69	4142	3760
Control	0	22a	28a	80	82	4468	3452
Control	0	16a	24ab	81	70	4516	3499

1/ Botanical composition figures obtained by the visual weight estimation method.

2/ CT I and CT II refer to forage harvests taken in early June and early August of 1968, respectively.

3/ Figures followed by identical letters are not significant at the 0.05 level.

Quackgrass control by RH 315 was still evident in the latter part of July (CT II) although the degree of exclusion of the grass was not as good as had been observed in early June (Table 1). Quackgrass re-intestation was beginning to occur but even so, crop yields at CT II were not significantly affected.

As had been done in CT I, notes were taken at CT II within the forage canopy and at the soil level. The growth of quackgrass at that time appeared very vigorous with no visible symptoms of the type described above. New shoots from rhizomes were obvious in all treated areas. Rhizomes were dug and examined and no bud damage or decrease in normal bud activity could be found.

The results of Experiment II showed that all rates of RH 315 significantly reduced quackgrass levels in the first cutting (CT I), 1969 (Table 2). Differences between times of application were not significant although it appeared

Table 2. Yield of forage dry matter, protein percentage and botanical composition as affected by RH 315 applied in the fall and spring to established alfalfa, Aurora, New York, 1968-1969.

Time of Application in 1969	RH 315 Rate lb/A	Botanical Composition %[1/2/] Quackgrass CT I	CT II	Alfalfa CT I	CT II	Yield [2/] Dry Matter lb/A CT I	CT II	Kjeldahl [2/] Protein mg/g CT I	CT II
Oct. 14	3/4	48	60	41	30	2890	1897	143	173
	1½	28	40	58	48	2261	2037	156	173
	3	1	21	88	60	2320	2155	169	179
Nov. 26	3/4	31	56	48	35	2654	2043	157	175
	1½	18	48	68	41	2383	2474	169	172
	3	5	26	80	48	1885	1854	173	166
March 28	3/4	31	61	61	29	3117	1827	162	176
	1½	13	50	77	29	2631	2093	163	181
	3	7	29	83	36	2432	2150	164	187
May 6	3/4	30	56	53	32	2610	2191	151	175
	1½	11	52	81	31	2231	2210	141	184
	3	10	28	85	40	2366	2113	172	200
Control	0	63	60	27	21	3080	1843	131	176
Control	0	65	56	26	26	2935	2045	131	175
Control	0	52	62	41	24	3456	1945	150	176
	0	60a	59b	31a	23	3157b	1944a	137a	176a
RH 315	3/4	35b	58ab	51ab	32	2182ab	1989a	153ab	175a
Mean	1½	18ab	48ab	74b	37	2377a	2203a	157b	177a
	3	8a	42a	84bc	44	2223a	2068a	170bc	183a

1/ Botanical composition values were obtained by the visual weight estimation method.

2/ Treatment means followed by identical letters are not significant at the 0.05 level.

3/ CT I and CT II refer to forage harvests taken in early June and late July, respectively.

as though the November or March treatments were slightly better. Total forage yield was significantly reduced by the 3 lb/A rate of RH 315, but this was probably due to the elimination of quackgrass as a component of yield rather than an effect of the chemical on the crop. Alfalfa percentage and hence yield was increased at this first cutting.

As was observed in Experiment I, quackgrass levels began to increase at second cutting (CT II), 1969 (Table 2). Even though total yield was not significantly affected by any of the treatments, the percentage alfalfa contributing to overall forage weight was significantly reduced to a level approaching that of the control. This decline in amount of alfalfa was apparently due to the severe quackgrass competition which was occurring by the end of July.

Percent protein in the forage at CT I in 1969 was significantly increased by 1 1/2 and 3 lb/A RH 315 (Table 2). This increase is probably due to the significant increase in alfalfa growth and to the decrease in quantity of quackgrass contributing to forage yield. A direct effect of the chemical on nitrogen metabolism and hence protein metabolism is not suspected at this time. At CT II, no significant differences in quantity of protein were found.

Quackgrass infestations the second cropping year following treatment with RH 315 were almost the same in all plots regardless of previous time of application or rate (Table 3). This information would seem to bear out the fact that RH 315 activity diminishes in late July the same year of treatment.

Table 3. Botanical composition and first cutting yield of forage as affected by RH 315 applied to an established alfalfa-quackgrass stand the previous year. Canton, New York, 1967-1969.

		Botanical Composition % 1/ First Cutting, 1969			Yield 2/
Time of Application	RH 315 Rate/A	Quackgrass	Alfalfa	Broadleaf weed	Dry Matter lbs/A
October, 1967	3/4	9a	24a	67	1788.3
	1½	11	42	46	1888.3
	3	16	36	48	1880.9
March 1, 1968	3/4	28	33	38	2032.7
	1½	7a	53	39	2077.4
	3	15	48	37	2166.0
Control	0	22	18a	60	2158.6
	0	17	27a	56	1529.8

1/ Botanical Composition values were obtained by the visual weight estimation method.

2/ Treatments followed by identical letters are not significant at the 0.05 level.

The observed loss of RH 315 activity would seem to indicate first that the herbicide is inducing a "secondary dormancy" from which the quackgrass recovers or second that the herbicide kills all actively growing quackgrass through the first of June but does not have enough residual life to be completely effective after that time. Discussing the latter alternative first seems to be appropriate since, to the author, it seems more logical. According to Johnson and Buchholtz (3), quackgrass rhizomes produced in the fall become very active during early April of the following spring. Bud activity along the rhizome continues at a declining rate until a period defined as "late-spring dormancy" occurs. This type dormancy appears different than secondary dormancy along the rhizome which is associated with apical dominance. During "late-spring dormancy", rhizome buds are completely inactive (3). Relating this to RH 315 activity, it appears that this herbicide effectively stops meristematic activity of those rhizome buds growing during April to early June. During the June "late spring dormancy" or inactive period, the soil temperature is increasing and conditions become unfavorable for maximum RH 315 activity. This would seem to be due to a loss of the herbicide as a result of chemical or microbial decomposition, volatilization, or leaching. When "late-spring dormancy" ends, insufficient RH 315 is present to control the now active rhizome buds.

A second explanation for the observed loss in herbicidal activity would be that during April and May, RH 315 is translocated into the quackgrass rhizomes and accumulated in active buds thereby inducing a dormant condition. Similar results have been reported with 1,2-dihydro-3,6-pyridazinedeone (MH) (5). This dormant condition is not dissimilar to the "late-spring dormancy" described earlier. Dormancy would appear to last until the level of herbicide within or surrounding the rhizome is insufficient to maintain this induced dormancy. Loss of the herbicide within the plant could be by detoxification and loss from the soil could be by one of several ways previously mentioned.

Regardless of which theory is true, the most important fact is that RH 315 apparently does not have enough residual activity to provide season-long control. Means need to be devised to 1) increase the residual life of RH 315 or 2) stimulate quackgrass rhizome activity such that all buds begin to actively grow during April or May or during that time when phytotoxic levels of the herbicide are still present.

Summary

Quackgrass control obtained with treatments of RH 315 in the fall or spring was excellent through early June. Control of the quackgrass caused an increase in alfalfa and quantity of protein in the forage. By the end of July, quackgrass regrowth was sufficient to reduce alfalfa stands. Quackgrass competition became severe enough following re-intestation of treated plots to virtually eliminate alfalfa in the second cropping year following treatment.

These studies attempted to provide a recipe for eliminating quackgrass from alfalfa but rather provided a framework for future research for eradication of this perennial pest.

Literature Cited

1. Association of Official Agricultural Chemists. 1960. Micro-Kjeldahl: in Official Methods of Analysis. (9th Ed.) The Association, Washington, D. C. 832 p.

2. Hunt, O. J. 1964. An evaluation of the visual weight estimation method of determining botanical composition of forage plots. Agron. Jour. 56:73-76.

3. Johnson, B. G., and K. P. Buchholtz. 1962. The natural dormancy of vegetative buds on the rhizomes of quackgrass. Weeds 10:53-57.

4. Parochetti, J. V. 1969. Chickweed control in dormant alfalfa with paraquat, diquat and experimental herbicides. Proc. NEWCC 23:206-212.

5. Zick, Warren H. 1956. Factors influencing the effectiveness of maleic hydrazide in controlling quackgrass. Ph.D. Thesis. University of Wisconsin, Madison, Wisconsin.

CONTROL OF QUACKGRASS (AGROPYRON REPENS) IN ALFALFA BY KERB (RH-315)

K. L. Viste and J. M. Sanborn[1]

INTRODUCTION

Quackgrass (Agropyron repens) is a major grass in forage legumes. It is a strong competitor and is instrumental in shortening the productive life of an alfalfa stand. While it contributes weight in hay, it reduces protein content, an important consideration in quality of alfalfa hay and alfalfa meal.

Kerb [N-(1,1-dimethylpropynyl)-3,5-dichlorobenzamide], formerly RH-315, applied to established legume stands at any time from early fall to mid-spring provides control of quackgrass and certain other weeds without injury to the crop.

METHODS

The test site was a commercial alfalfa field near Nazareth, Pennsylvania, that was planted in 1966. The field was uniformly and heavily infested with quackgrass. Applications of 75 percent wettable powder of Kerb were made with a bicycle sprayer with flat fan nozzles in a volume of 25 gpa. Weed control was measured by visual estimate. Yields were taken on a 75-sq-ft sample in 4 harvests per season.

RESULTS

Quackgrass control in June 1968 resulted from application at any time from September 1967 to May 1968 (Table I). The October application was optimum. While there was a dosage response, the increase in control at 3 lb/A over 1.5 lb/A was not great.

The control persisted throughout the season though quackgrass was relatively less important in midsummer. Control was still evident in the spring of 1969, 18 months after application (Table II). This residual control was caused by the slow reinvasion of quackgrass rather than the continued presence of Kerb which is known to break down in the warm soil of the summer months.

---

[1] Rohm and Haas Research Laboratories, Spring House, Pennsylvania 19477

TABLE I. Percent quackgrass control on June 17, 1968, from applications of Kerb made at different times.

Application Date	Kerb Rate (lb/A) 0.75	1.5	3.0
Sept. 19, 1967	62	88	94
Oct. 23, 1967	82	93	99
Dec. 8, 1967	60	89	92
Feb. 6, 1968	55	82	94
Feb. 28, 1968	75	90	95
March 25, 1968	65	90	96
April 15, 1968	70	90	98
May 16, 1968	85	94	100

TABLE II. Residual weed control on April 25, 1969, in plots treated in 1967 compared with 1968 treatments.

Year of Treatment	Kerb Rate (lb/A) 0.75	1.5	3.0
1967	35	78	94
1968	99	100	100

Another series of plots established in October 1968 showed that rates as low as 0.5 lb/A provided excellent control of quackgrass through the spring growth of quackgrass (Table III).

TABLE III. Percent quackgrass control evaluated at different times from application of Kerb on October 17, 1968.

Evaluation Date	Kerb Rate (lb/A) 0.5	1.0	2.0
March 28, 1969	100	100	100
April 25, 1969	97	99	99
May 12, 1969	91	96	96
June 3, 1969	78	90	95
July 10, 1969	62	68	79

The value of controlling grasses in alfalfa includes yield and quality considerations. In the applications made in October 1967, removal of quackgrass, which was 65 percent of the hay in untreated plots, reduced hay yield in the first cutting by 25 percent (Table IV). However, yield of pure alfalfa was increased by 140 percent (Table V). Moreover, in later harvests, yield of hay in the treated plots was greater than the checks so that total yields for the season did not differ greatly between treated and untreated. In plots treated with Kerb, most of the total weight was alfalfa while in the checks, nearly half was quackgrass.

TABLE IV. Tons per acre alfalfa hay in four 1968 harvests after Kerb application made on October 23, 1967.

Harvest Date	Kerb Rate (lb/A) 0	0.75	1.5	3.0
May 30, 1968	1.6	1.2	1.1	1.0
July 2, 1968	1.2	1.4	1.3	1.2
Aug. 15, 1968	1.0	1.0	1.0	1.2
Sept. 15, 1968	.6	.7	.7	.8
TOTAL HAY YIELD	4.4	4.3	4.1	4.2

TABLE V. Tons per acre of pure alfalfa in four 1968 harvests after Kerb application on October 23, 1967.

Harvest Date	Kerb Rate (lb/A) 0	0.75	1.5	3.0
May 30, 1968	.5	1.2	1.0	1.0
July 2, 1968	.6	.9	1.1	1.2
Aug. 15, 1968	.6	.8	.9	1.0
Sept. 15, 1968	.6	.7	.7	.8
TOTAL ALFALFA YIELD	2.3	3.6	3.7	4.0

That the reduction of competition had a long-range beneficial influence on alfalfa is shown by the higher yields in 1969 resulting from a single application of Kerb at 3 lb in 1967 or repeated application of Kerb at 0.75 or 1.5 lb in 1967 and 1968 (Table VI).

TABLE VI. Tons alfalfa hay per acre in 1969 from areas treated in fall of 1967 and in both 1967 and 1968.

Year of Treatment	Kerb Rate (lb/A) 0	0.75	1.5	3.0
1967	3.4	3.4	3.6	4.0
1967 and 1968	3.4	3.6	3.8	3.6

The elimination of quackgrass from the first cutting resulted in a marked increase in protein content of the hay (Table VII). In later cuttings, protein levels in hay from treated and untreated plots were about equal.

TABLE VII. Percent protein in alfalfa hay from three 1968 harvests on plots treated with Kerb.

Harvest Date	Kerb Rate (lb/A) 0	0.75	1.5	3.0
May 30, 1968	15.6	21.5	21.2	20.7
July 2, 1968	18.1	20.0	18.7	20.0
Aug. 8, 1968	22.5	20.5	21.5	20.8

There are two explanations for the occurrence of increased protein content in first cutting hay but not in hay of later harvests resulting from removal of quackgrass. First, quackgrass grows more vigorously early in the season and, therefore, makes up a larger portion of the first cutting hay. Second, since quackgrass starts to grow in March, it is in an advanced stage of growth with lower protein in late May when the first harvest is taken. The reduction in protein content of quackgrass with age is shown in Table VIII.

TABLE VIII. Protein content of quackgrass at different age.

Weeks Since Cutting	Percent Protein
2	28.2
3.5	24.9
4	23.4
5	21.3
6	13.2
8	11.3

SUMMARY

Kerb provides a high degree of control of quackgrass in established alfalfa when applications are made in fall or spring. The reduction or elimination of quackgrass will frequently reduce yield in first cutting hay, but this is offset by increased yields in later cuttings and higher quality hay in the first cutting.

WEED CONTROL IN CROWNVETCH (CORONILLA VARIA L.) [1/]

D. L. Linscott, R. R. Seaney and R. D. Hagin [2/]

Crownvetch (Coronilla varia L.) is a perennial legume which has had considerable success as an erosion control plant. It is especially desirable for protecting road banks, pond slopes, mine strips and other easily erodible sites. The perennial nature and dense growth makes this legume valuable as game cover in conservation sites. Crownvetch compares favorably with other legumes in feed value and thus can be used for forage. The legume recovers slowly after cutting or grazing and therefore does not produce the tonnage per season as does alfalfa.

From an agronomic viewpoint crownvetch is difficult to establish. It is sensitive to all types of weed or companion crop competition early in the development stages. Seedling vigor is poor. If weeds are not controlled during establishment, two to three years of development after seeding may be required before a stand is sufficient for good cover, forage or seed production. In some cases the competition will be severe enough to prevent satisfactory stands. Therefore, weed control practices are desirable that eliminate competition during early stages of development of crownvetch with sufficient numbers of vigorous early developing plants as the result. This paper gives a progress report on chemical methods for controlling weeds during the establishment of crownvetch.

In 1968, 24 different chemical treatments were evaluated for weed control potential and the most promising selected for further study in 1969. The 1968 studies indicated that crownvetch was tolerant of preemergence applications of S-ethyl-dipropylthiocarbamate (EPTC) or N-butyl-N-ethyl-a,a,a,-trifluoro-2,6-dinitro-p-toluidine (benefin) followed by a postemergence application of 2-sec-butyl-4,6-dinitrophenol (dinoseb). Postemergence treatments were necessary to control broadleaf weeds sufficiently. In 1969 two seedling establishment studies were conducted.

Study A: EPTC at 0, 2, and 4 lb/A or benefin at 0, 1, and 2 lbs/A in 30 gpa water were applied to a dry Honeoye silt loam near Aurora, New York on May 15, 1969. The herbicides were incorporated by 2 tandem diskings, the second disking at right angles to the first. Plot size was 7 by 24 feet. A single row of Chemung crownvetch was seeded in a band with a drill equipped with band seeder and band fertilizer attachments and with packing wheels. On June 17, dinoseb was applied at 0, 1/2, and 1 lb/A to previously treated plots to

---

[1/] Contribution from the Crops Research Division, Agr. Res. Serv., U. S. Dept. of Agric. in cooperation with Cornell University Agr. Exp. Sta.

[2/] Research Agronomist, Associate Professor and Biological Technician, Agr. Res. Serv., U. S. Dept. of Agric. and the Department of Agronomy, Cornell University, Ithaca, New York.

give all possible plot combinations of EPTC or benefin alone or with dinoseb.

The following treatments were determined to be most satisfactory for overall weed control and for tolerance by crownvetch during 1969: EPTC 4 lb/A preplanting + dinoseb 0.5 lb/A postemergence > EPTC 2 lb/A + dinoseb 0.5 lb/A > EPTC 2 lb/A + DNBP 1 lb/A > benefin 2 lb/A + dinoseb 0.5 lb/A > benefin 2 lb/A + dinoseb 1 lb/A. Best season long weed control was obtained with EPTC at 4 lb/A + dinoseb at 1 lb/A, however, vetch plant numbers were reduced considerably. Weed control in plots receiving preplanting and postemergence treatments was excellent until about mid-July, after which time a considerable population of annual broadleaf weeds developed. Vetch in treated plots made good growth in spite of late weed encroachment and probably will produce well in 1970.

Study B: EPTC at 2 lb/A or benefin at 1 lb/A was applied and incorporated and crownvetch was seeded as in Study A. At drilling, simazine or bromacil at 1 or 2 lb/A in 30 gpa of water was applied between the seeded row. In other words, a 14 inch band directly over the seeded row received benefin or EPTC and the remaining area between the rows (= 58 inches) received a simazine or bromacil application as well. Simazine and bromacil were applied in two ways, namely on the surface and incorporated. The spray boom was attached to either the front of the drill for incorporated treatments (incorporation accomplished by revolving disks of the drill) or to the rear of the drill behind the packing wheels for the surface treatments.

Experimental design in both studies A and B was randomized complete block with 5 replications. Annual weeds typical of the region were the primary problems in studies A and B. Only limited quantities of quackgrass (_Apropyron repens_ L.) or yellow nutsedge (_Cyperous esculentus_ L.) infested the plot area. Lambsquarter (_Chenopodium album_ L.), redroot pigweed, (_Amaranthus retroflexus_ L.), wild mustard (_Brassica kaber_ D.C.), L. C. Wheeler, (var. _pinnatifida_ Stokes), annual ragweed (_Ambrosia artemisiifolia_ L.), annual foxtails (_Setaria_ sp.) were the primary species.

In 1969, crownvetch in all plots receiving overall treatments of 2 lb/A EPTC or 1 lb/A benefin plus bromacil or simazine at 1 lb/A between the rows, established successfully. By September 15, the vetch was in blossom and covered from 24 to 36 inches of row. Crownvetch receiving 2 lb/A bromacil or simazine between rows was damaged in the early stages by simazine or bromacil which washed into the seeded row by heavy rain. At the 1 lb/A rate damage was minimal and annual grass and broadleaf weed control was excellent throughout the season. This technique of applying preemergence herbicides overall, and banding persistent herbicides between the row seems to be very promising for commercial crownvetch seed production.

In 1969, one experiment was conducted involving weed control measures on crownvetch seeded the previous year.

Study C: In 1968, EPTC was applied at 4 lb/A in 30 gpa of water in May to a Hudson silt loam soil and incorporated by cross tandem disking. Crownvetch was seeded at the rate of 4 lb/A with a grain drill equipped with band seeding attachments. The resulting crownvetch stand was marginal. By spring of 1969, a considerable population of yellow rocket (*Barbarea vulgaris* L.) had developed. On April 30, 1969 the following treatments were applied: Paraquat, dinoseb, 2,4-DB, bromacil, at 0, 1/2, 1, or 1 1/2 lb/A and simazine at 0, 1, 2 or 4 lb/A, all in 30 gpa water. At the time of spray application, yellow rocket was about 6 inches tall.

Of the chemicals used, paraquat was most successful in containing yellow rocket while damaging crownvetch but little. As a result of paraquat action in removing early competition, crownvetch was released and within 4 weeks had covered the plots. Few grasses or broadleaf weeds appeared in these paraquat treated plots until mid-summer.

Excellent general weed control was obtained from simazine or bromacil but vetch growth was severely retarded by both chemicals. However, at rates of 1 lb/A and lower, vetch made rapid recovery after July 15th and remained essentially weed free during the season. These simazine or bromacil treated plots should produce seed in quantity during 1970.

Dinoseb and 2,4-DB treatments were completely unsatisfactory for controlling weeds. Further, of all the chemicals used 2,4-DB was most damaging to crownvetch. Over 85% of the vetch plants were killed with 1 1/2 lb/A of 2,4-DB. Of the others, paraquat was the only one which resulted in significant increases in plant numbers over the check as determined by mid-season count. Plant numbers in paraquat treated plots were 70% greater than controls in this particular experiment.

In summary, these experiments for weed control in crownvetch are promising. We intend to continue the research until the potential has been more fully delineated.

WEED CONTROL IN FLAX WITH PREPLANT INCORPORATED, PREEMERGENCE, AND POSTEMERGENCE HERBICIDES

R. D. Ilnicki and L. F. Hist[1/]

Abstract

As of late, there has developed in the Northeast an interest in flax as a source of fiber. Whether or not this crop can be successfully and economically produced will depend on several factors, weed control being one of the most important ones. Weed control experiments were undertaken this past year in order to ascertain the importance of weeds in flax production and to determine susceptibilities and tolerances of flax to a number of herbicides and herbicide treatments. Herbicide treatments were applied prior to planting, immediately after planting, and after emergence.

Of the preplant incorporated treatments only one herbicide, isopropyl carbanilate (propham), had a serious effect on stand and vigor of flax. Stand was reduced approximately 50% by 6 and 8 lb/A and control of lambsquarters, pigweed, hedge mustard, and ragweed was poor. The outstanding treatment was a,a,a-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine (trifluralin) at 3/4 lb/A. Almost equally effective were S-ethyl dipropylthiocarbamate (EPTC) and S-propyl dipropylthiocarbamate (vernolate) at 4 lb/A, vernolate performing slightly better than EPTC. 4-(Methylsulfonyl)-2,6-dinitro-N,N-dipropylaniline (nitralin) was ineffective in the experiment at ½ to 1 lb/A.

Of the preemergence treatments only 1-(2-methylcyclohexyl)-3-phenyl=urea (siduron), dimethyl tetrachloroterephthalate (DCPA), and 2-(4-chloro-o-tolyl)oxy-N-methoxy acetamide (OCS-21799) had no effect on vigor or stand of flax. Propham and 3-(p-bromophenyl)-1-methoxy-1-methylurea (metobromuron) reduced stand and vigor of flax with no weed control from propham but reasonably good control from metobromuron at rates of 2 to 3 lb/A. Outstanding preemergence treatments included metobromuron at 2-3 lb/A, DCPA at 8 lb/A, and N-(4-bromo-3-chlorophenyl)-N'-methoxy-N'-methylurea (chlorbromuron) at 1½ and 2 lb/A. 2-Chloro-N-isopropylacetanilide (propachlor) at rates of 2-4 lb/A was very effective on annual grasses but ineffective on broadleaves. Nitralin as a preemergence herbicide was not effective on any weeds in the experimental area.

[1/] Research Professor in Weed Science and Senior Laboratory Technician, respectively, Department of Soils and Crops, Rutgers University, New Brunswick, New Jersey.

A large number of postemergence treatments were evaluated. None had any serious effect on flax stand or vigor. Outstanding treatments included various combinations of 3,6-dichloro-o-anisic acid (dicamba) with [(4-chloro-o-tolyl)oxy] acetic acid (MCPA), dicamba with (2,4-dichlorophenoxy)acetic acid (2,4-D), 4-amino-3,5,6-trichloropicolinic acid (picloram) with MCPA, and 2,2-dichloropropionic acid (dalapon) in combination with 3,5-dibromo-4-hydroxybenzonitrile (bromoxynil). Rates of the above herbicides alone or in combination ranged from 1/16 to 1/8 lb/A for dicamba, 1/8 to 1/4 for MCPA and 2,4-D, 3/4 to 1 lb/A for dalapon, 1/2 to 3/4 lb/A for bromoxynil, and 1/16 to 1/8 lb/A for picloram. Picloram alone at 1/8 and 1/4 lb and bromo=xynil at 1/2 to 3/4 lb/A were the two most effective single herbicide treatments used.

EFFECTS OF ETHREL ON THE GROWTH OF WINTER WHEAT[1/]

William B. Duke and J. N. Rutger[2/]

ABSTRACT

Two winter wheat (Triticum aestivum L.) varieties were treated with 4 rates of 2-chloroethanephosphonic acid (Ethrel) at 2 fall and 2 spring growth stages. The 2 varieties responded similarly to the different chemical treatments. The spring stages of application of Ethrel reduced plant height and lodging, and increased number of kernels per head. Yield, heads per plot and kernel weight were not affected by stage of treatment. Rate of application affected only plant height. A significant stage x rate interaction was observed for plant height, with the greatest height reduction (25 cm) resulting from the combination of the highest rate (3 lb/A) applied at the latest stage (June 4). Although Ethrel might be used on an emergency basis to shorten a wheat crop, concentration on reduction of plant height by genetic means might be a more suitable long-term approach.

INTRODUCTION

For many years, plant breeders have been trying to reduce the height of the high yielding wheat varieties because most are susceptible to lodging, particularly under high nitrogen and moisture conditions. Two lines of research have been followed to obtain high-quality, high-yielding lodging-resistant wheats: 1) using growth regulators to reduce height of existing varieties, and 2) developing new dwarf, high yielding varieties through breeding programs. Using growth regulators to reduce the height of cereal crops would be a temporary measure until dwarf varieties were developed.

An experimental growth regulator, 2-chloroethanephosphonic acid (here after referred to as Ethrel), has been reported to be effective for reducing wheat height[3/]. The effects noted were similar to those obtained from wheat treated with 2-chloroethyltrimethylammonium chloride (CCC) as reported by Tolbert (2) and Appleby et al. (1).

The objectives of the research reported herein were to evaluate the effects of rate and stage of applications of Ethrel on the height, lodging and yield of two varieties of winter wheat grown in New York.

1/ Contribution from the Departments of Agronomy and Plant Breeding, New York State College of Agriculture, Cornell University, Ithaca, New York. Journal Series No. 872.

2/ Assistant Professor of Agronomy and Assistant Professor of Plant Breeding, Cornell University, Ithaca, New York.

3/ Stewart, Vern R. and Glen P. Hartman. 1969. Effects of Ethrel chemical growth regulator on the agronomic characteristics of spring wheat and barley. West Soc. Crop Sci. Abstr. p4.

MATERIALS AND METHODS

A factorial experiment with 4 replications was planted on September 24, 1968, near Ithaca, New York. Plot size was 6 x 20 ft. The factors and their levels were wheat varieties (Avon and Yorkstar); 4 stages of application (1 = 2 leaf stage (fall), 2 = 3-4 leaves on main culm and 1-2 leaves on tillers (fall), 3 = fully tillered (spring), and 4 = early boot (spring); and 4 rates (0 lb/A, 3/4 lb/A of active material, 1 1/2 lb/A, and 3 lb/A). The wheat was sprayed with water dilutions of Ethrel which contained 2-chloroethanephosphnic acid (45-48%), mono-2-chloroethy ester (34-38%) and 2-chloroethanephosphonic anhydride (11-14%). Total spray volume at all times was 30 gpa.

The experimental area received 400 lb/A of 10-20-20 fertilizer broadcast and incorporated before planting. A topdress application of 30 lb/A of nitrogen was made on April 14, 1969. The central portion of each plot, 4-1/12 by 20 ft., was combined on July 29, 1969. Data were subjected to standard analysis of variance techniques.

RESULTS AND DISCUSSION

Varieties differed significantly for all traits except lodging (Tables 1 and 2). The absence of significant interaction terms involving varieties (Table 1) indicates that both varieties responded similarly to the different Ethrel treatments. Therefore the data shown in subsequent tables are averaged over the two varieties.

Table 1. Significance of variety (V), stage (S), and rate (R) terms and their interactions in the test on effect of Ethrel on wheat.

Character	Term						
	V	S	R	SR	SV	RV	SRV
Height	**	**	**	**			
Lodging		*					
Yield	**						
Heads/plot	*						
Kernels/head	*	**					
Kernel weight	**						

*, ** Significant at 5% and 1% levels respectively. Blanks indicate non-significance.

Table 2. Performance of the two winter wheat varieties used in the study.

	Avon	Yorkstar	LSD 5%	LSD 1%
Height, cm	124	109	2	3
Lodging, %	11	10	-	-
Yield, bu/A	51.3	65.1	2.3	3.1
Heads/plot	1968	2455	119	157
Kernels/head	30	31	1	-
Kernel weight, mg	45.4	43.8	0.9	1.2

The later stages of application significantly reduced plant height and lodging, and slightly increased number of kernels per head (Table 3). Yield, heads per plot, and kernel weight were not affected by stage of treatment. Rate of application affected only plant height (Table 1). An examination of the stage x rate interaction for height (Table 1) shows a significant dwarfing effect resulted from the application of the highest rate at the latest stage (Table 4). Compared to the control (mean of the 0 rate) this particular treatment combination reduced height 25 cm. Such a reduction in height is desirable in that it was accompanied by a decrease in lodging. Thus Ethrel could be used to reduce plant height conditions where excessive growth and subsequent lodging are expected. Since the greatest dwarfing benefit is obtained from the latest stage of application (June 4 in this experiment), a farmer would have some opportunity to observe his fields to see how the wheat overwintered and thus to speculate on whether lodging might be likely, before deciding to use Ethrel. If growth conditions are such that lodging is not expected to be a problem, there would be no advantage to using Ethrel, inasmuch as it does not increase grain yield (Table 1).

Table 3. Effect of stage of application of Ethrel on winter wheat.

Character	Stage 1	Stage 2	Stage 3	Stage 4	LSD 5%	LSD 1%
Height, cm	122	120	118	107	3	4
Lodging, %	15	13	10	3	7	-
Yield, bu/A	57.2	58.6	58.7	58.6	-	-
Heads/plot	2234	2247	2114	2219	-	-
Kernels/head	29	30	32	31	1	2
Kernel weight, mg	45.4	44.4	44.5	44.1	-	-

Table 4. Stage x rate interaction for height in centimeters of winter wheat treated with Ethrel.

Stage	Rate, lb/A 0	3/4	1 1/2	3	Mean
1	122	124	122	120	122
2	119	120	120	121	120
3	122	120	118	113	118
4	121	108	102	96	107
Mean	121	118	116	112	

LSD .01 for comparing 2 stage-rate combinations = 7; for 2 stages = 4; for 2 rates = 4.

Therefore, the present study indicates that Ethrel might be used on an emergency basis to reduce plant height where excessive growth and subsequent lodging are expected. However, concentration on reduction of plant height by genetic means might be a more suitable long-term approach to this problem. Height reductions have already been accomplished in varieties such as Yorkstar (Table 2) and even shorter varieties will become available in the future.

LITERATURE CITED

1. Appleby, A. P., W. E. Kronstead, and C. R. Rodhe. 1966. Influence of 2-chloroethyltrimethylammonium chloride (CCC) on wheat (Triticum aestivum L.) when applied as a seed treatment. Agron. Jour. 58:435-437.

2. Tolbert, N. E. 1960. (2-chloroethyl) trimethylammonium chloride and related compounds as plant growth substances. II. Effect on growth of wheat. Plant Physiol. 35:380-385.

WEED CONTROL IN BARLEY AND WHEAT WITH SEVERAL HERBICIDE TREATMENTS IN COMBINATION WITH LIQUID NITROGEN

W. J. McAvoy, L. F. Hist, and R. D. Ilnicki[1]

Abstract

Weed control studies in fall-sown barley (var. Wong) and wheat (var. Redcoat) were conducted in the spring of 1969. Dicamba (2-methoxy-3,6-dichlorobenzoic acid), 2,4-D (2,4-dichlorophenoxyacetic acid), bromoxynil (3,5-dibromo-4-hydroxybenzonitrile), 2,4-D + dicamba, and 2,4-D + bromoxynil were applied to the small grains alone and in combination on April 3 and April 25 with and without liquid nitrogen. The herbicide treatments were applied in water alone and with the liquid nitrogen at 30 and 60 lb/A. Common chickweed (Stellaria media) and corn chamomile (Anthemis arvensis) were the weeds occupying the experimental area.

Chickweed control was greater at the higher rates of the herbicides, alone and in combination. It was noted that the earlier applications produced better chickweed control than the later applications.

Slight reductions in barley vigor were produced by 2,4-D, dicamba, bromoxynil, 2,4-D + bromoxynil, and 2,4-D + dicamba. Similarly, wheat vigor was reduced by the same treatments; however, the extent of this reduction was far less than in barley. These reductions in vigor were short-lived and were later outgrown. Reductions in vigor from herbicide treatments were less as the level of nitrogen increased. Reductions in small grain vigor were less from herbicide applications made at the later date.

Control of the weeds was less from treatment applications made at the later date and was greater where no nitrogen was used. Yields were not significantly reduced by any herbicide treatment and were generally greater where nitrogen was used.

---

[1] Research Assistant, Senior Laboratory Technician, and Research Professor in Weed Science, respectively, Department of Soils and Crops, Rutgers University, New Brunswick, New Jersey.

WEED CONTROL PERFORMANCE OF THREE SOIL INCORPORATED HERBICIDES AS AFFECTED BY DIFFERENT PERIODS OF DELAY BETWEEN APPLICATION AND INCORPORATION

O. E. Rud[1/]

The labels of most herbicides, in which soil incorporation has been considered a criterion for their effective use, has indicated that incorporation should be done very soon after application. Under field conditions, the immediate incorporation is often impractical to implement. With the increased use of soil incorporated herbicide, and the advances made in technology of application of herbicides, information of what effect increased time periods between application and incorporation is of interest. In practical field use, the coordination of application and incorporation has become more of a problem.

Because of certain physical characteristics, several of the preemergence herbicides have generally been enhanced in their performance by incorporation but have exhibited much variability in performance in observations reported. Knake et al. (1) found that trifluralin gave significantly better control of annual grass weeds when incorporated into the soil to one inch depth than when surface-applied. This was evident at a wide range of soil moisture levels. In contrast, Sweet et al. (2) found no consistant benefit from incorporation of trifluralin compared to surface application as long as soil moisture was adequate. Similar responses have been observed for other herbicides. This experiment was designed to observe the field performance of several herbicides as affected by the length of time they remained on the soil surface before being mixed into the soil.

Procedure

The experiment was conducted at the Tidewater Research Station, Holland, Virginia. Soil was a complex of Woodston and Dragston loamy fine sand. Surface soil characteristics of the two are very similar. Organic matter content in the surface soil is about two percent. The predominant weed species were crabgrass (*Digitaria sanguinalis* L.) goosegrass, (*Eleusine indica* L.) carpetweed (*Mullugo verticillata* L.) with a scattered infestation of morningglory (*Ipomoea purpurea* L.), fall panicum (*Panicum dichotomiflorum*) and pigweed (*Amaranthus retroflexus*). Experimental design was a split plot with herbicide treatments as main plots and incorporation timing as subplots. Each treatment was replicated three times. Main plots were six feet wide and 150 feet long. Each main plot was divided into five subplots on which the various incorporation regimes were applied.

Main plots consisted of the following herbicide treatments: (a) vernolate 3 lb./A. (b) benefin 1.12 lb./A. (c) benefin 1.12 plus vernolate 3 lb./A. (d) nitralin 0.75 lb./A. (c) no chemical (check). The herbicides were applied with a custom designed tractor mounted sprayer in a volume of 18 gpa of spray material.

[1/] Assistant Professor Plant Physiology, Tidewater Research Station, Holland, Va., 23391

The incorporation was done with a power take-off tractor-mounted rotary tiller[2/] with the rotors penetrating to a average depth of four inches in the preplant operations and two and one-half inches in the postplant operations. Incorporation treatments were, for herbicide treatments a, b, and c: 1- preplant immediately after application (prpl + 0 hrs), 2- two hours after application (prpl + 2 hrs), 3- four hours after application (prpl + 4 hrs) 4- nine hours after application (prpl + 9 hrs), and 5- no incorporation (no inc.). For herbicide treatment d, the schedule was as follows: 1- prpl 0 hrs, 2- postplant immediately after herbicide application after planting (popl + 0 hrs), 3- post plant 7 days after application just after planting. (Popl + 7 da), 4- postplant 14 days after application just after planting (popl + da), 5- no incorporation. For treatment e, the following schedule applied: 1- just prior to planting (prpl + 0 hrs), 2- just after planting (popl + 0 hrs), 3- 7 days after planting (popl + da), 4- 14 days after planting (popl + 14 da), 5- no incorporation (no inc.).

Soil conditions at the initiation of the experiment on June 5 were good. A total of 2.6 inches of rainfall was recorded in the 15 days before the experiment was established. Of the total, 0.03 inches occurred in the 7 day period before establishing the test. 0.02 inches was recorded on the fourth day after establishment and no additional rainfall was recorded until the ninth day after initiation when 2.85 inches occurred.

No cultivation of the plots, except the respective incorporation, was imposed on the treatments for the season which extended from June to October.

Virginia type runner peanuts were planted on the day of preplant treatments to introduce a crop canopy effect that would cover the ground by August 1.

Treatment effects were recorded by making visual ratings (0 - very heavy weed infestation, 10 - excellent control) of annual grass and annual broadleaf control on July 16 and annual grass control ratings on September 12.

Results & Discussion

Average weed control ratings for the treatments are shown in tables 1 and 2. All treatments that were not treated with a herbicide had a lower rating for weed control at both the July 16 and September 9 ratings. The differences on the earlier date were of greater magnitude than the September 9 evaluations and show a greater differential in the ratings. Of the herbicides and under the conditions of this experiment, benefin appeared to be the most susceptible to loss of activity when left on the surface. The loss in activity increased with time at which incorporation was done. There was, however, some activity with all herbicides when not incorporated, some as good as immediate incorporation.

The physical effect of the incorporation process was evident for a short time after it was done, as is indicated in table 1. The check treatment,

2/ Ferguson tilrovator furnished by Ferguson Mfg. Company, Suffolk, Va.

rotary tilled at the days corresponding to the incorporations for nitralin, had been done 15 days and 22 days, respectively, before the July 16 evaluation. The effect of the 14 day incorporation was yet evident, while the weeds had reinfested the plots tilled 7 days before. Vernolate gave very good control of weeds for the entire season with and without incorporation. Nitralin performed well. A mixture of vernolate and benefin performed well early in the season, but for some unexplained reason was not as effective in control of grasses as was vernolate alone.

Summary

The effect of delay of incorporation from 2 hours to 14 days on the activity of 5 herbicidal treatments was compared in weed control activity to no incorporation and to no herbicide. Benefin lost effectiveness most when incorporation was delayed, vernolate and nitralin performed well even when not incorporated into the soil. Weed infestations in the checks were reduced only temporarily for a short time after the cultural operation involved in incorporation.

Literature Cited

1. Knake, Ellery L., Arnold P. Appleby, and William R. Furtick. 1967. Soil incorporation and site of uptake of preemergence herbicides. Weeds 15: 228-232.

2. Sweet, R. D., D. W. Davis, C. T. Dickerson, Jr., and G. H. Bayer. 1966. Effectiveness of trifluralin in vegetable crops. WSA Abstr. p. 17.

Table 1. Weed Control[1/] as Affected by Elapsed Periods of Time Between Application and Soil Incorporation. Applied June 5, Evaluated July 16. Tidewater Research Station, Holland, Virginia, 1969.

	Treatment	Lbs.	prpl+[2/] 0 hr	prpl+ 2 hr	prpl+ 4 hr	prpl+ 9 hr	popl+ 0 hr	popl+ 7 da	popl+ 14 da	No inc
ANNUAL	vernolate	3	10.0	10.0	10.0	10.0	-	-	-	9.0
GRASSES	benefin	1.12	9.7	8.3	7.0	6.0	-	-	-	4.3
	vernolate +	3								
	benefin	1.12	10.0	9.7	9.3	9.7	-	-	-	7.0
	nitralin	0.75	9.0	-	-	-	8.3	6.3	10.0	7.3
	no chemical	-	0.3	-	-	-	0.7	0.0	6.0	0.7
ANNUAL	vernolate	3	8.0	8.7	8.7	8.3	-	-	-	8.0
B'LEAF	benefin	1.12	7.7	8.0	7.7	6.3	-	-	-	6.0
	vernolate +	3								
	benefin	1.12	6.7	8.3	6.7	7.0	-	-	-	6.3
	nitralin	0.75	8.0	-	-	-	7.7	7.0	8.7	6.7
	no chemical	-	3.7	-	-	-	3.3	3.7	7.7	2.3

1/ Weed control - 0 none, 10 best

2/ Type of application and elapsed time between application and incorporation. Prpl.-preplant (before planting) & Popl.-postplant (after planting)

Table 2. Weed Control[1] as Affected by Elapsed Periods of Time Between Application and Soil Incorporation. Applied June 5, Evaluated September 9. No conventional cultivation. Tidewater Research Station, Holland, Virginia, 1969.

	Treatment	Lbs.	prpl+[2] 0 hr	prpl+ 2 hr	prpl+ 4 hr	prpl+ 9 hr	popl+ 0 hr	popl+ 7 da	popl+ 14 da	No inc
ANNUAL	vernolate	3	9.8	9.3	10.0	9.5	-	-	-	8.7
GRASSES	benefin	1.12	9.5	8.0	7.2	7.2	-	-	-	5.8
	vernolate +	3								
	benefin	1.12	9.7	9.0	9.2	8.7	-	-	-	5.3
	nitralin	0.75	8.5	-	-	-	8.0	8.0	8.7	7.8
	no chemical	-	3.0	-	-	-	3.0	3.2	2.7	4.0

1/ Weed control, visual rating - 0 poor, 10 best

2/ Type of application and elapsed time between application and incorporation. Prpl - preplant (before planting) & Popl - postplant (after planting).

PROGRAMMING AND EVALUATING RIGHT OF WAY BRUSH CONTROL BY AERIAL PHOTOGRAPHY

J. Baribeau, B.Sc.F.E. [1/]
J. Rivest, B.Sc.F.E. [2/]

The maintenance of a transmission line network involves among other things, the control of the vegetation growing under those lines.

This can be properly assured by careful planning of sylvicides applications.

A new approach based on the use of aerial photography, combined with ground control, has been tried over some sections of Hydro-Quebec network.

Why this new approach ? To achieve the control of vegetation, knowledge of the rate of growth of the different species, in relation with the ecological environment, constitutes a definite necessity. Also, the fact that more line miles are added each year to the total length of the transmission network calls for the review of the method used previously. Since aerial photos and more specially infra red aerial photos were used in forestry to detect alterations in the foliage activity, we thoughtthe same principle would apply when alterations were caused by chemical interference.

The consulting forestry firm of Couillard, Lessard and Rivest collaborated closely with Hydro-Quebec to perfect the aerial photo technique in relation with the present problem.

For inventory purpose, black and white infrared was preferred to panchromatic because of a better haze penetration during summer months and a better differentiation between evergreens and deciduous.

The interpretation process involves features such as: relative humidity related to water retention capacity of the soil: these features are better rendered on infrared than on panchromatic films.

Many authors, like G. Ross Cochrane (1968), stated that the complex physical and physiological properties of plants and their influences on reflection, absorption and transmission of spectral wavelengths are not well known. Much experimentation is still required if we want to predict accurately the effect of the reflected light by plants on infrared films or on any imagery system. Nevertheless, there is ample documentation which we used as guide line.

It is of prime importance to choose a scale large enough to facilitate the photo-interpretation and small enough to cover as much territory as possible for economic reasons.

1/ Hydro-Quebec, Montreal, Canada
2/ Couillard, Lessard, Rivest, & Ass., Québec, Canada

Some sampling has to be done in the field in conjunction with the photo interpretation to minimize errors. The intensity of sampling varies according to the scale and the quality of the pictures, but depends largely upon the skill and experience of the photo interpreter.

The stereoscopic comparison with other objects of known dimensions allows the classification of small growing trees by classes of height.

By ecologic inherence, it is possible to determine the categories of species.

The information obtained is then recorded on a data sheet bearing the photo, line and structure numbers, and all other pertinent details.

The photos bear identification number corresponding to the data sheet for quick reference. The data sheet is then used for the preparation of the chemical spraying specifications.

At the planning stage, the Kodak Ektachrome infrared aero (false colour) was also tried. It should be noted that anyone accustomed to grey tones is happy to see such coloured pictures.

The false colour 9 inches wide film was found to be too expensive due to the fact that only two inches out of nine were useful. Using a 9" x 9" survey camera, an inch in width is added at no additional cost because the lateral perforations on the film are useless.

The picture format then is of 2 3/4" x 9" in the line direction and covers approximately 4,500 feet instead of 1,400 feet on ideal format 2 1/4" x 2 3/4" with a 70 mm. camera.

There is no need to emphasize the quality and reliability of the optical mechanical system of today's survey cameras.

Under the stereoscope, a striking difference was noted between different species growing at the edges of rights of way. That difference was less obvious between young healthy ligneous vegetation within the rights of way.

Photography taken during the summer and early fall showed a good and reliable difference between herbaceous and ligneous vegetation. Little was gained in using false colour at the planning stage because the difference between ligneous and non-ligneous vegetation can be easily detected on black and white infrared as soon as it reaches a certain height over the surrounding vegetation.

Another experiment was carried in two successive flights with two different infrared films, namely black and white infrared and false colour, over the same area during and after spraying.

On the first mission, the black and white infrared showed no evidence of the effect of sylvicides whereas the colour film produced traces of discoloration only ten days after treatment.

On the second mission, three weeks after treatment, both films showed strong evidence that vegetation activity was hampered by the sylvicides but an extensive ground sampling would have to be carried out to assess the extent of defoliation with the black and white film. By contrast, the colour film brought out strikingly every cluster which was sprayed in a familiar straw colour of chlorophyl deficient tissues, against the reddish colour of living plants, making it possible to count the stems and determine the percentage spraying.

It was also noted that dead evergreens bearing dead leaves showed greenish blue, or whitish when there is a minimum of physiological activity.

The experiment was extended over an area that had been sprayed from a helicopter. The false colour showed clearly a serious drift problem within the right of way and where the sylvicide had touched the surrounding vegetation.

On the black and white infrared photography, the rate of efficiency of spraying can be assessed only by comparison between two series of photographs, one before and one after spraying. The reason is that the lack of reflectance of the leaves caused it to react as to disappear on the photography.

The interpreter confuses dying or dead vegetation with high layers of the soil. This confusion is impossible on colour infrared photography.

The infrared colour film was therefore adopted to assess the results of spraying.

Aerial photography offers a wide variety of other uses, such as identification of access roads, encroachments, erosion and landslide areas to name a few, and as more experience is gained, we expect to use this system extensively.

SOME VARIABLES AFFECTING THE RESPONSE OF UNWANTED HARDWOODS WITH TREE-INJECTED 2,4,5-T

R. D. Shipman [1/]

The tree injector, a tool employed for the rapid injection of metered dosages of diluted and undiluted herbicides into unwanted woody plant species, has been widely used by practicing foresters and land managers during the past ten years. Even though advances have been made through mechanical improvements in injector design, the user today is still confronted with the wide variation that exists between geographical locations, season of application and species differences, including unexplained variations due to concentration, basal placement and operator inconsistencies.

Data reported from the past application and current use of injectors suggest that somewhere in the tree injection method there are optimum combinations of herbicide, carrier, dilution and volume; of blade widths, depth of cut and spacings; of size, vigor and site; of species and season; and, of chemical and labor costs, where desired results could be predicted with a reasonable degree of accuracy and consistency in practice.

If tree injection, as an accepted method for low-cost control of undesirable woody plants, is to achieve its rightful place on a "prescription" basis useful in land resource programs, these variables must be more precisely defined by the researcher and quantified for the user.

In an effort to explore some of the relationships between and among measurable elements of the tree injection technique, a study was initiated in the spring (May) of 1964 on three upland oak-hickory sites located in central Pennsylvania. The major objective of this investigation was to determine the effects of combination treatments of injector blade width, number of injections, tree diameter, dosage per injection and basal placement on the response of 812 individual trees representing eight northeastern broadleaf species, arbitrarily selected throughout a range of easy-to-kill, intermediate, and difficult-to-kill sample trees. These were: white oak (_Quercus alba_ L.), scarlet oak (_Quercus coccinea_ Muenchh.), red oak (_Quercus rubra_ L.), chestnut oak (_Quercus prinus_ L.), hickory (_Carya_ spp.), red maple (_Acer rubrum_ L.), ironwood (_Ostrya virginiana_ (Mill.) K. Koch), and shadbush (_Amelanchier canadensis_ L.).

1/ Associate Professor of Forest Ecology, School of Forest Resources, The Pennsylvania State University, University Park, Pennsylvania.

Materials and Methods

Four one-tenth-acre plots were randomly selected on each of three upland oak-hickory sites approximately fifteen miles apart. The four treatment combinations applied at each of the three locations were as follows:

Treatment Combination

Plot Designation	Dosage per hack (mls.)	Hack Method	Injector blade width (inches)
A	2	Connected	3
B	2	Spaced (1 per 2" d.b.h.)	3
C	1	Connected	2
D	1	Spaced (1 per 2" d.b.h.)	2

The above four injector treatment combinations were applied to each plot according to the assigned treatment and species designation. However, all eight species were not equally represented on every plot. A total of 812 trees, which ranged in d.b.h. from 1 to 12 inches, were treated in May, 1964 with a 5% by volume mixture of 2,4,5-T iso-octyl ester in fuel oil, or 20 lbs. of acid equivalent per 100 gallons of solution (containing 4 pounds of 2,4,5-T acid per gallon). Trees two inches in diameter or smaller received only one injection. Since one of the objectives of the study was to determine the influence of incision height above the ground, no effort was made to place the incisions at predetermined heights, and, therefore, this factor was varied according to the operator's convenience in applying the chemical. The treated trees were checked for mortality two years after treatment; only the percent of crown kill with no sprouting is given in this report according to the following susceptibility rating system, or degree of crown reduction: (1) readily susceptible (100% crown reduction); (2) susceptible (75% crown reduction); (3) moderately susceptible (50% crown reduction); and, (4) resistant (no crown reduction).

Statistical Evaluation

A modified computer program employing the principle of parsimony in a stepdown multiple linear regression analysis was written for use in the System/360 computer. Essentially, the principle of parsimony eliminates one variable at a time until there are no variables remaining in the resulting equation which are not significant. The three principal independent variables tested per tree species for regression analysis in this study were: x_1 (d.b.h.), x_2 (number of hacks per tree) and x_3 (hack height above ground).

The degree of crown reduction (Y) for each of four treatment combinations was the dependent variable. A total of 24 separate equations (6 species x 4 treatments) were thus developed initially. The basic mean values for the number of trees sampled, including the dependent and independent variables by species and treatment, are given in Table 1 and Figure 1.

Results

An analysis of variance of the data shown in Table 1 after two growing seasons showed that all the major variables investigated (treatment combination, species, diameter class, and hack height class) to be highly significant in terms of their effects upon crown reduction. Accordingly, to determine the amount of variation that each of the three independent variables contributed to the individual species, multiple regression equations were developed. The fraction of explained variance (R^2) and its significance to the final regression for each species by treatment is presented in Table 2. As the data in Table 2 indicate, only one species (White oak) is highly significantly correlated with all four treatments.

One is justified in assuming that any general prediction equation expressing the degree of crown reduction for all four treatments can be developed for White oak only, with a minimum level of confidence.

Herbicide Prescription

The following equations were developed from the foregoing data for estimating the level of crown kill of White oak (Quercus alba L.) in central Pennsylvania:

$$\text{Treatment A} = 107.693 - 1.411\ (x_2) - 1.127\ (x_3)$$

$$\text{Treatment B} = 87.494 - 11.90\ (x_1) - 7.14\ (x_2) - .382\ (x_3)$$

$$\text{Treatment C} = 134.299 + 1.93\ (x_1) - 2.29\ (x_2) - 6.75\ (x_3)$$

$$\text{Treatment D} = 65.625 - 10.09\ (x_1) + 6.45\ (x_2) + .939\ (x_3)$$

Where:

Crown reduction (Treatment A) = 3" blade, 2 ml per hack - 2,4,5-T
Crown reduction (Treatment B) = 3" blade, 2 ml per hack - 2,4,5-T
Crown reduction (Treatment C) = 2" blade, 1 ml per hack - 2,4,5-T
Crown reduction (Treatment D) = 2" blade, 1 ml per hack - 2,4,5-T

Table 1. Mean values of dependent and independent variables by species and treatment.

Variable	White Oak				Chestnut Oak				Scarlet-Red Oaks				Hickory				Red Maple				Ironwood-Shadbush			
	Treatment																							
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
No. trees 1/	87	142	58	72	11	11	24	48	25	18	30	29	7	20	31	6	25	11	16	21	26	47	40	7
Crown reduction (percent)	90	56	83	40	84	45	68	36	95	47	83	45	68	30	69	50	82	7	12	32	83	48	82	18
d.b.h. 2/ (inches)	5.1	3.8	5.1	5.1	4.8	4.8	4.3	5.1	6.6	5.7	7.0	5.1	2.9	4.1	3.1	2.7	2.7	4.0	3.3	3.0	1.8	1.5	1.6	1.6
No. of hacks	7	2	8	3	6	2	8	3	9	3	12	3	5	2	5	2	3	2	5	2	3	1	3	1
Hack ht. (inches)	6.1	6.7	6.2	7.7	8.0	9.7	7.8	11.1	7.4	8.0	6.7	8.0	7.1	10.0	6.7	9.4	8.4	6.8	6.5	6.3	6.5	8.3	5.2	9.4

1/ Total for experiment 812 trees.
2/ Diameter of tree 4.5 feet above ground.

Figure 1. Species response by treatment.

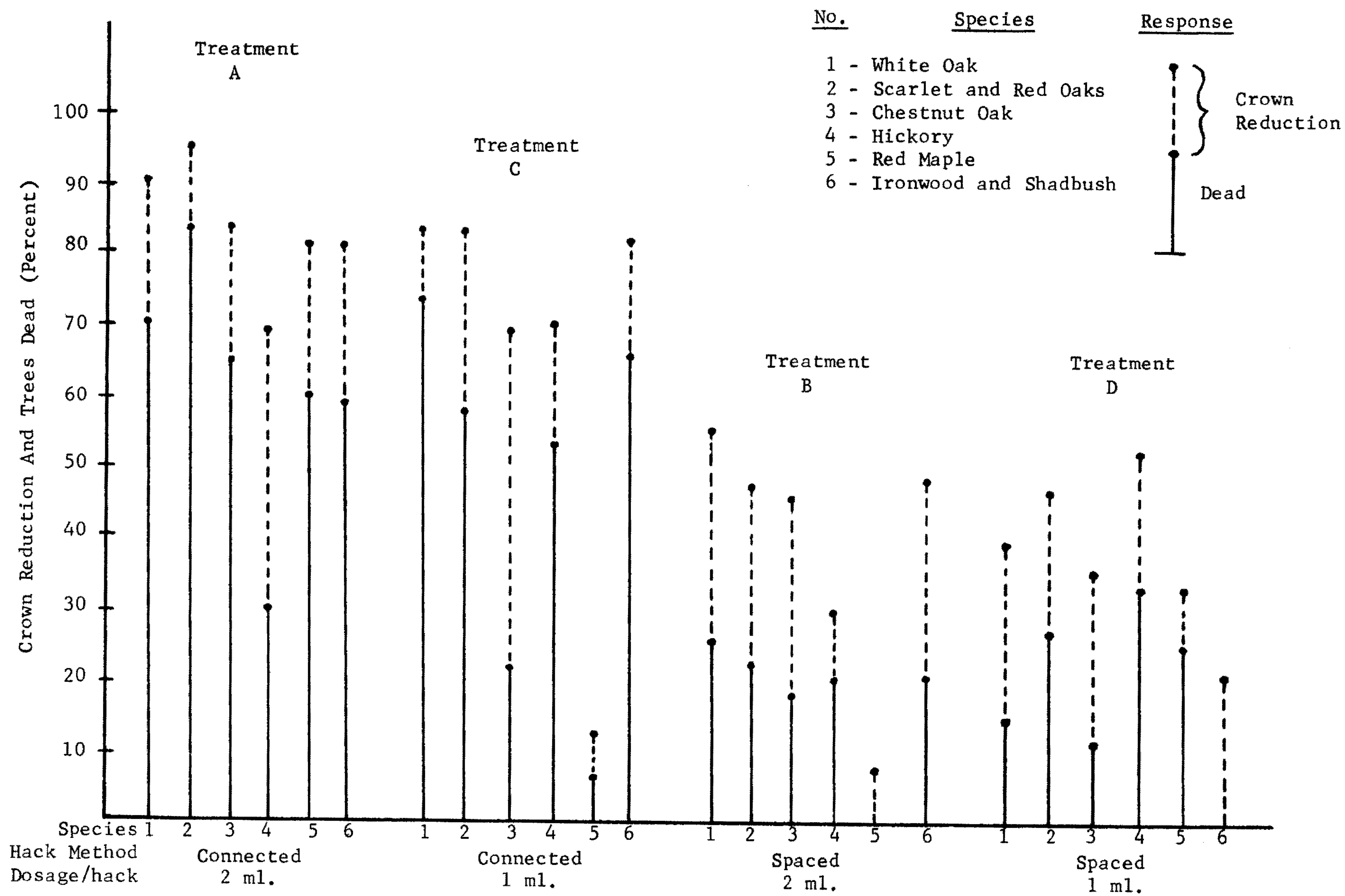


Table 2. Squared multiple correlation coefficients (R^2) for six tree species by treatment.

Species	Fraction of explained variance (R^2) Treatment A	B	C	D	Independent variables in "best" regression [2/] Treatment A	B	C	D
White oak	.227** [1/]	.260**	.467**	.168**	x_2x_3	$x_1x_2x_3$	$x_1x_2x_3$	$x_1x_2x_3$
Chestnut oak	.567*	.374	.076	.272**	x_1x_2	NS	NS	$x_1x_2x_3$
Scarlet-Red oaks	.335*	.700**	.362**	.096	$x_1x_2x_3$	$x_1x_2x_3$	$x_1x_2x_3$	NS
Hickory	.730	.328*	.421**	-	NS	x_2x_3	x_1x_3	-
Red maple	.531**	.201	.228	.361*	x_1x_3	NS	NS	$x_1x_2x_3$
Ironwood-Shadbush	.355**	.098	.091	.168	x_1x_3	NS	NS	NS

1/ ** - significant at 1 percent probability level.
    * - significant at 5 percent probability level.

2/ Where x_1 = d.b.h.
x_2 = No. of hacks
x_3 = Hack height

<u>And</u>:

x_1 = d.b.h.

x_2 = number of hacks

x_3 = height of hack from ground

<u>Using</u>:

A 5% volume mixture of 2,4,5-T iso-octyl ester in fuel oil, or 20 lbs. of acid equivalent per 100 gallons of solution (containing 4 pounds of 2,4,5-T acid per gallon).

EFFECT OF SOIL TYPES ON THE PERFORMANCE OF SOME TOTAL GROWTH CONTROL CHEMICALS

W. R. Effer 1/

The main object of these trials was to study how three different soils in Southern Ontario affected the relative and absolute performance of several total growth chemicals. A secondary object was to compare the performance of mixtures of chemicals with the performance of each of their components.

Materials and Methods

The three sites were on Ontario Hydro property at Schomberg (silty clay loam), London (medium loam) and Orangeville (sandy loam). The soils were analyzed for particle size distribution, pH, organic content and soil moisture at the time of treatment. These data and the total precipitation occurring between the times of treatment and evaluation are given in Table 1.

Herbicides used and application rates are given in Table 2. Mixtures of herbicides were tested only at the London site. Rates in the mixtures were half those used in the single herbicide application. The herbicides were mixed in half a gallon of water and applied with a knapsack sprayer on 10-ft x 10-ft plots. Untreated strips, 3 ft wide, surrounded each plot except at Schomberg where the distance was increased to 6 ft because of a slope on the site. Each treatment was replicated.

The species of weeds and grasses at each site are listed in Table 3. Both weed and grass control ratings were determined after two growing seasons. The species resistant to the treatment were noted in order of their frequency.

Results and Discussion

Results of single and mixed herbicide treatments at the three sites are summarized in Table 4.

Soil Characteristics

The main difference between the three soils was in the particle size distribution. The pH increased slightly as the clay content increased but the organic content was low in each case. Precipitation was slightly higher on the medium soil.

Effect of Soil Type on Weed and Grass Control

For total vegetation control bromacil, NIA 11092, atrazine, prometone and Geigy 14254 were all clearly more effective on the heavier soil. Diuron and Daxtron, however, were more effective on the lighter soil. The performance of some herbicides was reduced by the escape of one weed species, eg bromacil - common mullein, prometone and Geigy 14254 - wood sorrel and diuron - wild carrot. Other herbicides such as NIA 11092 and Daxtron allowed a more even

1/ Ontario Hydro Research Division, Toronto, Ontario, Canada.

distribution of escapes. The effect of soil type on the performance of picloram could not be determined because weed control was highly effective in each case and the grass density increased over the controls.

To compare the performance of the herbicides on each soil type is of little value because only one level has been used. However, among the triazines atrazine was slightly more effective for total growth control than either prometone or Geigy 14254 but if one weed escape, wood sorrel, is ignored, both prometone and Geigy 14254 are much superior to atrazine on each soil type. Comparing bromacil and NIA 11092, the effectiveness of bromacil was affected much more by soil type than NIA 11092, but again, if the escape of one weed species, common mullein, is ignored, bromacil is more effective on each soil type and allows fewer weed escapes.

With the exception of picloram, grass control was so high that differences between soils could not be detected. Among the triazines, atrazine was inferior to prometone and Geigy 14254 due mainly to the escape of annual grasses. Bromacil was slightly more effective than NIA 11092 in each of the three soils.

Results with single herbicide applications demonstrate that soil type should be a prime factor in deciding on the choice of herbicide. In addition, specific vegetation control situations, eg sterilized soil placed under a depth of crushed stone, may be able to effectively control smaller weed escapes and therefore make one herbicide more attractive over another.

Mixed Herbicides

For total growth control mixed herbicide treatments do not appear to be generally much different from the average of their components. This may be due to the fact that tests were carried out only on the medium loam soil which produced a smaller spread between the effectiveness of the herbicides than either the clay or sandy soils (Table 4). NIA 11092 was generally superior to bromacil in combination. Atrazine and diuron had similar effectiveness when each was combined with bromacil, but when combined with NIA 11092, atrazine was clearly superior in weed control but inferior than diuron in grass control.

Picloram by itself was the most active herbicide for weed control and yet in mixtures was less effective or only equal to that of the other component (NIA 11092, bromacil or Daxtron), when used by itself. When picloram is used alone its effectiveness may be reinforced by the increased density of grass growth. In mixtures, the other component reduces grass density and allows more active weed growth. In addition to the picloram mixtures, bromacil-diuron also exerted less weed control than either of its two components, the main escapes being Canada and bull thistle. Atrazine-Daxtron and atrazine-bromacil both exerted better control than either of their components but atrazine-NIA 11092 was intermediate between the effectiveness of its two components.

Grass control was low in two of the three picloram mixtures, the escapes being perennial grasses. In the atrazine mixtures control was poor due to annual grass escapes.

The value of combinations of herbicides may be more apparent where recommendations are required for a wide range of soil types. From the behaviour of the herbicides by themselves, diuron in combination with bromacil, NIA 11092 or the triazines may provide a broader and more even spectrum of control.

Summary
Bromacil, NIA 11092, atrazine, prometone and Geigy 14254 were found to be more effective on a heavier soil whereas diuron and Daxtron were more effective on a lighter soil. On a medium loam soil, mixtures of herbicides generally had control ratings between the ratings of the two component herbicides used singly. Exceptions were mixtures containing picloram which tended to have lower control ratings than either of the two components. The value of some mixtures of herbicides may be their effectiveness in the control of a broader spectrum of weeds and grasses over a wider range of soil types and growing conditions.

Table 1. Soil analysis and rainfall at three sites.

	Schomberg (silty clay loam)	London (medium loam)	Orangeville (sandy loam)
Particle size distribution (%)			
less than 0.002 mm (clay)	31	23	7
0.002 - 0.005 mm (silt)	53	45	38
greater than 0.005 mm (sand)	16	32	55
pH	8.4	8.2	7.2
Organic matter (%)	2.8	5.3	3.8
Moisture at time of treatment (%)	10.1	4.5	2.8
Precipitation (in)			
May 1968 - Sept 1968	12.9	16.7	13.7
Sept 1968 - Sept 1969	29.5	39.0	34.0

Table 2. Herbicides and application rates.

Herbicide	Application Rates (lb ai/A)
Bromacil	16
NIA 11092	16
Diuron	32
Atrazine	32
Prometone	32
Geigy 14254 2/	32
Picloram	4
Daxtron	24
Daxtron + atrazine	12 + 16
Daxtron + picloram	12 + 2
Daxtron + diuron	12 + 16
NIA 11092 + atrazine	8 + 16
NIA 11092 + picloram	8 + 2
NIA 11092 + diuron	8 + 16
Bromacil + atrazine	8 + 16
Bromacil + picloram	8 + 2
Bromacil + diuron	8 + 16

2/ 2-sec butylamino-4-ethylamino-6-methoxy-5-triazine.

Table 3. Species of grasses and weeds at three sites

		Schomberg	London	Orangeville
1.	Kentucky bluegrass Poa pratensis	X	X	X
2.	Timothy Phleum pratense	X	X	X
3.	Redtop Agrostis alba	X	X	X
4.	Old witchgrass Panicum capillare		X	
5.	Hairy crabgrass Digitaria ischaemum		X	
6.	Yellow foxtail Setaria glauca	X	X	
7.	Wild strawberry Fragaria virginiana	X	X	X
8.	Dandelion Taraxacum officinale	X	X	X
9.	Wild carrot Daucus carota	X	X	X
10.	Goldenrod Solidago canadensis	X	X	X
11.	Canada thistle Cirsium arvense	X	X	X
12.	Bull thistle Cirsium vulgare	X	X	
13.	Red clover Trifolium pratense	X	X	X
14.	Common plantain Plantago major	X	X	X
15.	Ribgrass Plantago lanceolata	X	X	X
16.	Bladder campion Silene cucubalus	X	X	
17.	Wood sorrel Oxalis stricta	X	X	X
18.	Yarrow Achillea millefolium	X	X	
19.	Milkweed Asclepias syriaca		X	X
20.	Saint Johns Wort Hypericum perforatum		X	X
21.	Prostrate knotweed Polygonum aviculare		X	X
22.	Goatsbeard Tragopogon pratensis	X		
23.	Black medic Medicago lupulina	X		
24.	Yellow sweet clover Melilotus officinalis	X	X	X
25.	Tall buttercup Ranunculus acris	X	X	
26.	Creeping buttercup Ranunculus repens	X		
27.	Hawkweed Hieracium Sp	X		
28.	Field bindweed Convolvulus arvensis		X	
29.	Toadflax Linaria vulgaris		X	
30.	Chickweed Stellaria media		X	
31.	Canada fleabane Conyza canadensis		X	X
32.	Vetch Vicia cracca			X
33.	Common mullein Verbascum thapsus	X		X
34.	Catmint Nepeta cataria			X
35.	Bird's-foot trefoil Lotus corniculatus	X		
36.	Ragweed Ambrosia artemisiifolia	X	X	
37.	Daisy fleabane Erigeron annuus	X	X	X
38.	Rough fruited cinquefoil Potentilla recta		X	
39.	Houndstongue Cynoglossum officinale	X		
40.	Horsetail Equisetum arvense	X	X	X

Table 4. Weed and grass control ratings after two growing seasons.

Herbicides	Weeds						Grasses					
	Control Rating4/			Escapes3/			Control Rating4/			Escapes3/		
	Heavy	Med	Light	Heavy	Med	Light	Heavy	Med	Light	Heavy	Med	Light
Bromacil	0.4	2.7	8.7	33,10,15	37,10,31,36, 9	33,10,20,34, 7,17	0.9	0.0	0.0	(1,2,3) 6		
NIA-11092	1.8	4.7	6.2	24,15,35,9, 11,8,40,36	9,11,12,31, 24,15	20,34,10,9, 33,17,24	1.6	1.2	0.1	(1,2,3)	(1,2,3) 4	(1,2,3)
Diuron	1.2	2.5	0.1	15,9,24	9,11,12,10, 40	14	0.2	0.2	0.1	(1,2,3)	4,(1,2,3)	(1,2,3)
Atrazine	0.0	1.8	2.7		9,11,12,40	20,34,17,9, 10	0.0	1.3	0.3		4,6,5	(1,2,3)
Prometone	0.1	4.2	7.5	17	17	17,20,10,9, 34	0.0	0.0	0.0			
Geigy 14254	0.6	2.5	5.7	17,40	17,9,40,	17,20	0.2	0.0	0.0	(1,2,3)		
Picloram	0.0	0.1	0.0		40		7.4	9.9	10.0	(1,2,3)	(1,2,3)	(1,2,3)
Daxtron	6.0	5.0	4.5	15,24,17,37, 8,36,10,9	7,40,11,12, 31,8,36,17	17,10,34,33, 24,20,11,14	0.6	0.0	0.7	(1,2,3)		(1,2,3)
Daxt-atr		1.1			7,11,12,40, 10,9,17			0.3			6,4,(1,2,3)	
Daxt-pic		6.0			9,10,7,11, 31,17,12,40			0.1			(1,2,3)	
Daxt-diur		3.5			11,12,9,17, 31,7,36,14			0.5			(1,2,3)	
Ni-atr		3.5			9,40,7,8, 37			0.7			4,5	
Ni-pic		4.5			9,7,11			1.7			(1,2,3)	
Ni-diur		2.8			9,10,31,15, 7			0.6			4,(1,2,3)	
Brom-atr		1.0			9,40			3.0			4,5,(1,2,3)	
Brom-pic		4.2			31,10,7,9, 36,12			3.5			(1,2,3)	
Brom-diur		5.0			11,12,10,31, 9,7,37			0.1			4,5,(1,2,3)	
Control	2.8	3.0	3.3	- - - - - - - As Table 3 - - - - -			5.5	7.0	6.7	- - - - - - As Table 3 - - - - -		

3/ In order of frequency. Numbers refer to weeds and grass listed in Table 3
4/ Control Rating. 10 - 100% coverage, 0 - bare.

THE USE OF ETHYL HYDROGEN PROPYLPHOSPHONATE AND RELATED COMPOUNDS AS WOODY PLANT GROWTH RETARDANTS

Arthur A. Nethery[1]

Introduction

In a broad range of greenhouse and field trials conducted during a period of five years, ethyl hydrogen propylphosphonate (hereinafter referred to as NIA 10637) has been found effective in retarding the growth of a number of herbaceous and woody plant species. Several related compounds, including propylphosphonic acid (NIA 10656) and various salts of these compounds also are effective in promoting these retardant responses.

Chemical and Physical Properties

NIA 10637 is a liquid miscible with water and with most organic solvents. It is available as a water miscible formulation containing 8 lb/gal of active chemical.

NIA 10637 appears to move readily through the soil. When applied to the surface of a 10-inch soil column (a mixture of sandy loam and silt loam soil) which was then watered just sufficiently to wet the soil at the bottom of the column, a bioassay procedure detected the presence of NIA 10637 distributed from the 3- to the 7-inch layers.

Materials and Methods

Greenhouse testing. Applications were made to Regal, California and Ibolium privet (*Ligustrum* sp.), silver maple (*Acer saccharinum*), mock orange (*Philadelphus virginalis*) and *Euonymus patens* in greenhouse tests. Foliar and dormant treatments were aqueous sprays applied to the point of run-off; soil drench and lanolin paste applications also were made.

Field trials. Field trials designed for the study of NIA 10637 as an inhibitor of woody growth were initiated in 1966. These tests included five tree species: wild cherry (*Prunus* sp.),

- - - - -

[1] Research Biologist, Research and Development, Niagara Chemical Division, FMC Corporation, Middleport, N.Y.

quaking aspen (*Populus tremuloides*), white ash (*Fraxinus americana*), hophornbeam (*Ostrya virginiana*) and beech (*Fagus grandifolia*). Applications were made to foliage shortly after the initiation of spring growth but before extensive shoot growth had taken place. Aqueous foliar sprays containing 4050, 6750 and 9450 ppm were applied to the point of run-off. Similar tests were performed on quaking aspen and ash trees in 1967, using concentrations of 2025 and 4050 ppm. A description of the trees at the time of the growth retardant applications is given in Table 1.

Table 1

Pre-treatment Conditions of Trees in Growth Retardant Trials

Species	Tree Height	Trunk Diameter at Ground Level	Extent New Growth	Date of Application
Wild cherry	5-7 ft	3/4-1 inch	1-2 inch shoots	May 6, 1966
Hophornbeam	5-8 ft	3/4-1 inch	4-5 leaves, very little shoot extension	May 19, 1966
Beech	4-7 ft	1/2-3/4 inch	3-4 leaves, 2-4 inch shoots	May 20, 1966
Aspen	4-9 ft	3/4-1-1/2 inches	5-6 leaves, 1-2 inch shoots	May 26, 1966
Ash	5-8 ft	1-1-1/2 inches	4-6 leaves, 2-4inch shoots	June 1, 1966
Aspen	5-8 ft	1-1-1/2 inches	2-4 inch shoots	May 26, 1967
Ash	5-8 ft	1-2 inches	4-6 inch shoots	June 12, 1967

The treatments in all the tests described were based on solution concentrations rather than rates per unit area. All concentrations are reported as ppm active ingredient; approximately 1100 ppm of NIA 10637 equals 1 lb active ingredient/100 gal.

Results and Discussion

Foliar applications of NIA 10637 to greenhouse-grown woody plants resulted in positive growth retardant responses on a large number of test species. At 8100 ppm retardation was induced in *Euonymus patens*, silver maple, mock orange and Regal privet (Table 2). A comparison of a dormant spray application and a foliar spray application was made on Ibolium privet in the greenhouse utilizing NIA 10637 and several of its metal salts.

Table 2

Responses of Woody Plants to NIA 10637 Foliar Treatments

Species	Treatment Concentration - 8100 ppm Responses Observed at 107 Days After Treatment
Euonymus patens	No new growth
Silver maple	Shoot growth inhibited; slight leaf chlorosis
Mock orange	Shoot growth inhibited; slight leaf chlorosis
Regal privet	No new shoot growth; new leaves small and chlorotic

While retardant activity was promoted by the dormant applications (Table 3), the foliar applications of all compounds tested were more effective at equivalent rates (Table 4). The salts in

Table 3

Effects of Dormant Applications of NIA 10637 in Ibolium Privet

Treatment	Maximum Shoot Growth (inches) - 160 Days
Untreated control	64
NIA 10637	
2200 ppm	50
4400 ppm	35
8800 ppm	30
NIA 10637-sodium salt	
2200 ppm	46
4400 ppm	40
8800 ppm	30
NIA 10637-zinc salt	
2200 ppm	50
4400 ppm	40
8800 ppm	35
NIA 10637-calcium salt	
2200 ppm	45
4400 ppm	37
8800 ppm	17

Table 4

Effects of Foliar Applications of NIA 10637 on Ibolium Privet

Treatment	Maximum Shoot Growth (inches) - 133 Days
Untreated control	64
NIA 10637	
2200 ppm	4
4400 ppm	5
8800 ppm	3
NIA 10637-sodium salt	
2200 ppm	6
4400 ppm	5
8800 ppm	4
NIA 10637-calcium salt	
2200 ppm	25
4400 ppm	7
8800 ppm	7

general caused responses very similar to those induced by NIA 10637. The calcium salt was slightly less active than NIA 10637 in the foliar treatment but slightly more active in the dormant application. A period of four to six weeks of normal growth occurred before the appearance of growth inhibition. Once the effect could be observed, very little new growth occurred. The terminal buds were inhibited and development of lateral buds was stimulated, providing a characteristically branched effect not seen in the untreated plants. These lateral buds did not develop long shoots but were retarded after a brief period of growth. The newer leaves formed were smaller than normal, and in some cases, slightly chlorotic. The dormant applications minimize foliar injury.

NIA 10656 (propylphosphonic acid) has induced retardation of herbaceous species at 1/2 to 1/4 the rates of NIA 10637 required for similar effects. In preliminary tests NIA 10656 retarded growth of woody plant species. Extensive comparison of NIA 10656 and NIA 10637 as growth retardants of woody plant species will be made during the 1970 season.

Field testing. Although early season growth had been initiated by the trees at the time of treatment, reductions in growth from that in untreated trees was observed by midseason in all species tested. Final measurements of the year's growth were taken in October. The initial tests of 1966 were followed through three seasons of growth without further chemical applications to the trees. Retardation of growth was observed in the second season after treatment; the higher treatment levels resulted in residual retardant effects during the third season following application (Table 5). An average of nine to fifteen individual measurements was used to compute the reported percentage reduction in growth due to the chemical treatments. The

Table 5

Responses of Four Tree Species to NIA 10637 Foliar Treatments

Spray Concentrations	Percentage Growth Reduction 1966	1967	1968	Total
Wild cherry-1966 Application				
4050 ppm	70.7	65.0	42.0	62.7
6750 ppm	62.0	58.2	30.0	54.0
9450 ppm	84.7	79.1	60.0	77.5
Hophornbeam-1966 Application				
4050 ppm	35.5	60.0	12.5	35.2
6750 ppm	48.6	9.8	8.4	19.7
9450 ppm	70.6	74.3	68.8	71.2
Beech-1966 Application				
4050 ppm	47.3	90.5	59.3	65.9
6750 ppm	42.0	89.5	67.0	66.3
9450 ppm	52.0	76.8	69.3	65.9
White ash-1966 Application				
4050 ppm	59.6	35.5	2.0	40.0
6750 ppm	52.0	58.0	-5.2	32.6
9450 ppm	54.7	76.4	22.5	49.5

total growth reduction, i.e., reduction in total shoot length from that of the untreated control, was calculated for the three year period. In all cases the 4050 ppm concentration provided retardation during the first season, with satisfactory residual control during the second season. Although the higher treatment levels resulted in slightly greater percentage retardation or longer residual activity, there was a tendency for the trees to acquire a dense, bushy appearance due to the extremely shortened internodes. In addition, an initial foliar injury consisting of chlorotic mottling and strap-shaped leaf formation occurred at the higher rates of application. Leaf injury did not appear serious at the concentration of 4050 ppm.

Retesting of quaking aspen and white ash in 1967 at 2025 and 4050 ppm demonstrated that approximately 2000 ppm or less is sufficient to achieve significant retardance of growth of these fast-growing trees (Table 6).

Table 6

Responses of Two Tree Species to NIA 10637 Foliar Treatments

	Percentage Growth Reduction		
Spray Concentration	1967	1968	Total
Aspen-1967 Application			
2025 ppm	86.5	42.8	68.8
4050 ppm	81.3	30.4	60.5
Ash-1967 Application			
2025 ppm	46.8	70.3	58.9
4050 ppm	60.2	61.0	60.6

All of the trees which have been in these tests for more than three years have resumed normal growth. The trees which were originally treated at concentrations of 4050 ppm or less have returned to normal growth patterns after the second growing season following the application.

It should be noted that the carry-over of the retardant activity into the second growing season has not occurred in all tests. This may be due to climatic factors, susceptibility of the plant species, or the manner of application. Where partial tree sprays are used, the branches sprayed are retarded first; if a major part of the tree is covered by the spray, translocation occurs and the growth of the remainder of the tree is eventually retarded. A relatively small portion of a tree may also be affected by a direct application; little retardant activity is noted in other parts of the tree after translocation because of dilution effects. Little residual activity in succeeding seasons would be expected after sufficient dilution.

Additional woody species whose growth has been retarded successfully by applications of NIA 10637 in greenhouse or field trials include willow, black walnut, maple, sycamore, eucalyptus, black oak, apple, crabapple, pear, peach, apricot, mulberry, plum, sweet cherry, English ivy, boxwood, *Pinus* sp., *Cupressus sempervirens* Glauca, *Forsythia* sp., *Juniperus* sp., *Ribes alpinum*, *Olea europaea* Mission and *Cotoneaster parneyi*. Table 7 indicates the dosages at which growth retardant responses have been noted for 15 species. In many cases, lower rates are sufficient for inducing retardation.

Various modes of application have been tested, including aqueous foliar sprays, dormant sprays in aqueous or oil solutions, aqueous soil drench sprays, granular soil applications and frill or injection treatments. Successful woody growth retardation has been obtained with each of these types of treatments on selected species.

Table 7

NIA 10637 Dosages Providing Retardant Responses

Species	Dosage (in ppm) at Which a Decided Effect is Noted
Willow	1100
Sycamore	3300
Eucalyptus	2200
Black oak	3300
Apple	2000
Peach	2000
Apricot	2000
Plum	4000
Sweet cherry	6000
Boxwood	6600
Pinus sp.	5000
Forsythia sp.	3000
Juniperus sp.	3000
Ribes alpinum	6600
Olea europaea Mission	3000

Foliar spray applications of NIA 10637 are recommended for experimental woody growth retardation at concentrations of 1 to 4 lb/100 gal (1100-4400 ppm), depending on the species. The minimum effective dosages should be used because excessive dosages may cause undesirable foliar injury. Dormant, frill or soil applications may be used where they are preferable to foliar spray applications.

Whole tree sprays at optimum concentrations should retard current growth and would be expected to provide residual retardation in the succeeding season. Partial tree sprays should control the branches treated but may not effectively retard the whole tree. Retardation in the second season is not likely after a partial tree spray.

PROGRESS REPORT ON 1 PERCENT NAA GROWTH INHIBITOR TREE PAINT

Herbert J. Cran, Jr. 1/

As one of the five original Cooperating Utilities to first make field tests of the EEI-Battelle Institute fortified wound dressings (April 26, 1963), we have become a most enthusiastic advocate of this method of retarding the regrowth of pruned trees without impairing their health or appearance.

Even though some of the earliest formulations, particularly with the lanolin base, were disappointing, we could see the advantage of the active ingredient Alpha Napthaleneacetic Acid with the Ethyl Ester.

After the use of the lanolin base was discontinued, we had no further adverse side effects such as one to two-inch cambium die-back below the wound. One thing that we did experience was the excessive running of the wound dressing on all of the vertical cuts. Despite the run-down, all of the cuts apparently had an appreciable layer of dressing on the wound to inhibit the normal growth by 50 percent. Our applicators brushed in the material thoroughly to insure good adhesion and made certain that they had an additional layer on the outer 1/2-inch of the cut surface.

The run-off problem was cleared up in 1965 when an abestos fiber was incorporated (5% by weight) to the asphalt cutback (94%) and to the Napthaleneacetic acid, ethyl ester (1% by weight). We now no longer need to build up the dressing at the edge of the wound.

In 1965, our trimming experiments were made in the Spring and Summer. The trees treated and the results were as follows:

Period	Tree Species	Percent Reduction in Amount New Wood to be Removed Next Trimming
Spring Experiment		
	Ash	100%
	White Birch	100%
	Cherry	75%
	Elm	100%
	Hickory	86%
	Linden	100%
	Norway Maple	96%
	Red Maple	78%
	Sugar Maple	80%
	Black Oak	95%

1/ Arborist and Landscape Architect
The Connecticut Light and Power Company, Hartford, Connecticut

These experiments included roundovers, side trim and overhangs. A general comparison between the Spring and Summer treatments was as follows:

Comparative Study	Spring 1965	Summer 1965
1. Usual trim interval:	36 mos.	36 mos.
2. Fortified trim interval:	36 mos.	36 mos.
3. Reduction of wood next trim:	80%	80%
4. Reduction of sprouts:	80%	80%
5. Reduction in length of sprouts:	60%	0%
6. Origin of sprouts downward:	12"	0-3"
7. Most affected:________________	(Norway Maple)	Ash
	(Ash)	Oak
8. Most unaffected:______________	(Black Birch)	Black Birch
	(Red Maple)	

#1 Problem - Secondary spur sprouting

#2 Problem - Sustained release

Concentration vs. toxicity has been no problem except with the earlier lanolin-based material. We did find that we have equal or better inhibition with the 1% rather than with the 2% concentration.

Our greatest concern with regard to trimming frequency has been with the Norway Maple planted in the urban city areas under our overhead distribution system during the W.P.A. days. We were going in and trimming these trees on a yearly basis. This specie along with the Sugar Maple and Red Maple were selected for special study by our Company in the Spring and early Summer of 1966.

There was, this time, a difference in the inhibiting effect between the 1% and 2% concentrations of the growth retardant chemical alpha napthalene acetic acid in Sugar Maple, with no cuts sprouting at 1% concentration to 16% of the cuts sprouting at the 2% and 68% of the cuts sprouting with the regular commercial dressing. The Norway Maple, in Norwalk, 45% of the cuts for both 1% and 2% concentration sprouted while 100% of the cuts sprouted with the regular commercial dressing. In Greenwich, 11% of the cuts sprouted at 1% concentration and 0% at the 2% concentration.

This difference in the degree of inhibition found in the two cities can be explained by the reduction in vigor observed in the Norwalk trees where the trees were growing under more adverse, restricted conditions.

The Red Maples showed greater inhibition with the 2% inhibition in Greenwich and the percent of cuts sprouted averaged as follows:

1% concentration - 41%
2% concentration - 6%
Commercial paint - 81%

The ratio of the number of sprouts per cut, using the commercial dressing versus the fortified wound dressing, was better than 5 to 1.

The results of the 1% concentration then were as follows, observed six months after treatment:

Tree Specie	% Reduction of Sprouts	% Loss in Clearance
Sugar Maple	100%	0%
Norway Maple	55%	10%
Red Maple	59%	0%

Pole pruner activity in some sections did not help to improve our sprout reduction. The pole pruner should not be used in future drop-crotch pruning practices where trees under our conductors are involved. This practice simply negates the effectiveness of the growth inhibitor.

Eight to ten drop-crotch saw cuts should be used to lower the entire crown under our distribution lines without disturbing the remaining branches. This permits the growth inhibiting hormones, present in the terminal buds, to function undisturbed and so serve to assist the inhibitor in preventing the development of water sprouts.

In 1967, we concentrated on our No. 1 urban problem, the Norway Maple. Two studies were undertaken.

1. 84 Norway Maples under a seasonal study, comparing two concentrations with a standard commercial dressing during the four seasons.

2. 80 Norway Maples treated during the four seasons using a liquid, asphalt and commercial dressing.

Results of those cuts in Norway Maples received the fortified wound dressing in 1967 at bud break, full leaf and at leaf fall:

Inhibitor Concentration	% of Cuts Sprout Free	% Reduction of Sprout Number	% Reduction of Length of Tallest Shoot
1%	50% *	47%	50%

* All suckers found near cut were removed at pruning time.

The effectiveness of the liquid formulations compared favorably with the semi-solid paint formulations. However, the most effective inhibition can be obtained with the aerosol application when good pruning practices are followed.

Concentration	% Sprout Reduction	% Reduction in Length of Tallest Shoot
Sugar Maple		
1%	37%	14%
Red Maple		
1%	63%	6.2%
Black Maple		
1%	57%	1.5%
Willow		
1%	0%	6.8%

(Loss of clearance in Willows only 30% in one season)

In January of 1968, permission was secured from management to permit several of our contractors to use the Amchem product (1% N.A.A.) "Tre-Hold" in predetermined areas to provide for close appraisal of the product that spring.

It proved to be equally as effective as the material we used under the EEI-Battelle Institute Growth Control Studies. The initial success we had using the commercial product was due to two factors. First, the Amchem product "Tre-Hold" uses the active ingredient Alpha Naphthaleneacetic acid with the Ethyl Ester, using their own solvents to obtain the right viscosity so that the applicators will experience no difficulty in brushing on the material, particularly in the colder months. Mr. John H. Kirch, Marketing Manager of Industrial Chemicals for the Amchem Company, is now recommending that the winter grade be used all year round, so that the applicator will experience no problem with the material flowing from the brush to the wound. For the most part, the applicators now experience no difficulty in applying the fortified wound dressing. However, if some applicators experience greater viscosity and is consuming more time than necessary in applying the material, Mr. Kirch recommends that the "Tre-Hold" be cut with solvisol or naptha. A small amount of the material can be stirred in thoroughly with the fortified wound dressing, the amount of the cutting agent will depend of course on the temperature. The amount of solvisol or naptha will not reduce the effectiveness of the inhibiting agent. Mr. Kirch informs me that a new batch is being produced at the Amchem Company and will be reformulated as an all-year-round wound dressing which should eliminate any of these high viscosity brush-on problems.

We are avoiding severe trimming that would remove most of the terminal buds containing growth-inhibiting hormones and avoiding all pole clipping that would leave a stub condition; for these methods would only produce water sprouts and defeat the purpose of the inhibitor paint. In many cases, a handsaw is a must where we have to remove one of several laterals that are growing in a tight V crotch.

By using the handsaw, we can make larger cuts at least an inch or two inches in diameter, and by the careful drop-crotch method of going down to a live lateral can reduce the crown of the tree, leaving it in an attractive natural form which is most acceptable to the public.

As of June 1968, all tree contractors with one exception working for CL&P have been required to use Amchem's "Tre-Hold" on all their pruning cuts in distribution line clearance work. One of our contractors was granted permission to use an aerosol growth inhibitor wound dressing using the same active ingredient proven so effective in the EEI-Battelle study.

The following is a recapitulation of the observations made on May 5 through May 15 and June 27, 1969 of the commercial growth inhibitor wound dressings applied to cuts during the Summer and Fall of 1968:

Tree Specie	Total # Trees Observed	Total # Cuts With Shoots	Total # Cuts Without Shoots
Sugar Maple	22	11	179
Red Maple	5	13	67
Norway Maple	27	37	143
Silver Maple	3	2	32
Ash	3	18	40
White Birch	2	1	8
Horse Chestnut	1	-	30

Thus out of a total of 581 cuts made, 86% of them were without shoots and 14% had shoots.

In order of effectiveness of the fortified wound dressing, I have listed below the tree species and the percentage of inhibition of new shoots or water sprouts:

Horse Chestnut 100% - Sugar Maple 94% - Silver Maple 94% - White Birch 88% - Red Maple 84% - Norway Maple 79% and Ash 69% inhibition.

In my observations made on these same trees on June 27, 1969, I saw no appreciable change in the number of shoot free cuts with one notable exception. Where pole pruning pencil cuts were made and an aerosol dressing applied some of the observations made in early May were reversed in late June.

One 16" Sugar Maple, with 50 cuts showing no sprouts, averaged at least one sprout per cut one-inch below cut. The tallest sprout averaged 16 inches in length along the top of the crown.

A 15 and an 18-inch diameter Sugar Maple which had 50 cuts each showing no shoot growth in May, all had at least one sprout per cut, all 16 inches in length.

Another 16-inch diameter Sugar Maple showing 50 shoot-free cuts in early May, now show 25 cuts with at least one shoot and 25 cuts shoot-free. The tallest shoot was 16 inches.

Two 7-inch Schwedler Maples showing 30 shoot-free cuts in early May, now show

#1 - 5 cuts with sprouts
25 cuts without sprouts

#2 - 16 cuts with sprouts
9 cuts without sprouts

One 8-inch Locust, 5-inch Sugar Maple and 10-inch Linden all had 50 cuts without sprouts both in early May and in late June, 1969.

All these trees receiving an aerosol dressing were growing on spacious lawns but were under our distribution lines. The entire crown in each case, despite the diameter of these trees, were lowered and the result has not been unattractive. However, the sudden lack of growth inhibition in June when tree growth is at its peak was due primarily to one factor. The cuts for the most part were stub pencil cuts made with a pole pruner. By not going down to a live lateral and not permitting any terminal buds to remain in the top of the crown, the inhibitor could not do the job for which it was designed.

Savings in Pruning Costs Through The Use of The Fortified Wound Dressing

In developing a cost-savings picture resulting from inhibitor tree paints, I have selected the nine uniform Norway Maples on Route 7 in Wilton as they represent the optimum in growing conditons and have a complete wound-by-wound history on each tree since it first received an inhibitor wound dressing on April 21, 1964.

Pruning Date	# Trees	# Pruning Cuts	$/Man Hr. Incl. Equip.	Pruning Time	Total Cost
1. Oct., 1963	9	(Regular wound dressing used) All round overs	$5.07		
2. Apr. 21 - Jun. 25, 1964	4) 5)	203 50% of control (check) cuts 50% cuts treated with inhibitor dressing	$5.01	12 hrs. 15 min. (1 hr. 22 min./ tree) (6.80 per tree)	$61.20
3. June, 1967	9	A few water sprouts from control cuts made in 1964 that grew into primaries	$6.20	20 min.	$ 2.05

Pruning Date	# Trees	# Pruning Cuts	\$/Man Hr. Incl. Equip.	Pruning Time	Total Cost
4. Sept., 1968	9	80* All cuts received a fortified wound dressing	$5.91	7.2 hrs. (48 min. per tree) ($4.73 per tree)	$42.55

* Observed May 15, 1969, 57 cuts without sprouts and 23 with sprouts 4 to 8 inches long.

The following savings were thus realized since the pruning cuts were made in the Spring and mid-summer of 1964 on the nine Norway Maples in front of the Holson Company and Bob Sharp property at 117 Danbury Road, (Route 7) in Wilton, Connecticut.

1. Trimming cycle has increased from six months to 4 years and 3 months.

2. Number of cuts required to clear primaries and to insure service continuity has decreased by 39%.

3. Although cost per-man-hour, including equipment has gone up 15% since 1963 in this area, the <u>cost</u> of trimming these trees has been <u>reduced</u> by <u>30%</u>.

4. The time required to prune the nine Maple trees has been reduced since the fortified wound dressing was applied four years ago by 41% which means that the combination of effective drop-crotch pruning and the use of the growth inhibitor wound dressing has paid off.

Since the fortified wound dressing was used on only 50% of the pruning cuts in 1964, and we now apply a similar dressing on all wounds, it is safe to assume that we can further reduce the time to prune and the cost to prune in the next trimming cycle.

Effect of Normal Precipitation In Any One Year On Inhibiting Effect of 1 Percent N.A.A. On Norway Maple

These are observations made on a sampling of 4 out of 23 uniform Norway Maples on Windmill Hill Road in Branford, Connecticut, and averaging 18 inches in caliper and growing under our primary services.

Site Conditions: Country asphalt road, no curb, no walk, spacious lawns, lovely suburban homes.
Treatment: 1 Percent N.A.A. on all pruning cuts.
Treatment Date: November 27, 1967.
Observations Date: November 13, 1969.
Precipitation 12 months ending October 31, 1968: 44.40 inches.
Precipitation 12 months ending October 31, 1969: 45.92 inches.
Average normal rainfall, Mount Carmel, Connecticut: 47.73 inches.

Tree #	Cuts Observed: With Sprouts	Cuts Observed: No. Sprouts	Strength of Sprouts	Sprts. Per Cut	Tallest Sprout Feet	Est. Clearance Feet	Eval. 0 to 4	Months After Trtmt.	Prec. % Below Normal	New Grwth. Nr. Trtd. Cuts Feet	Avg. Normal Growth Feet
37	10	10	Vigorous	1	6	1/2	2	24	1968 7%	2-3	2/3
35	4	12	Average	1	2-1/2	1-2	4	24	1969 4%	4-6	1
31	5	13	Weak	1	1	3-1/2	4	24			
26	8	18	Average	1	1	3	4	24			

The performance of the inhibitor on pruning cuts on last three were superior to the first tree studied (#37) because of superior drop crotch pruning in those three with a greater percentage of terminal buds permitted to remain throughout the upper crown of the tree. This excellent performance was made despite the close-to-normal precipitation in 1968 and 1969.

Although the amount of precipitation was almost the same in 1968 and 1969, the dry periods in 1968 occurred during the spring and summer growing seasons, while in 1969, there was ample rainfall during both growing seasons which accounts for the increase in terminal shoot growth this past year.

COMPARATIVE INHIBITION OF GRASSES AND TREES WITH MALEIC HYDRAZIDE (SLO-GRO) AND MALEIC HYDRAZIDE PLUS ADJUVANT (ROYAL SLO-GRO)

Otto E. Wenger [1]

"Slo-Gro,"* containing three pounds of the diethanolamine salt of maleic hydrazide per gallon as the active ingredient, is well known as a growth inhibitor of grasses, woody shrubs and trees. A dosage rate of four pounds of active ingredient per acre on grasses and four pounds of active ingredient per 100 gallons of water applied to runoff on trees has been found to be effective in inhibiting growth through most of the growing season without carryover into the next season.

A new product, "Royal Slo-Gro,"* has recently been developed. It contains one and a half pounds of the diethanolamine salt of maleic hydrazide per gallon as the active ingredient and is formulated with an adjuvant. It was developed to improve the growth regulating activity per pound of active ingredient in the formulation.

The two compounds were evaluated in a cooperative effort with the Illinois Highway Department. Slo-Gro at four pounds active ingredient, and Royal Slo-Gro at four, three and two pounds active ingredient were applied in sixty gallons of water per acre to bluegrass (Poa pratensis), quackgrass (Agropyron repens) and orchardgrass (Dactylis glomerata). Three replications were made of each treatment.

Royal Slo-Gro at three pounds active ingredient per acre gave inhibition of all three grasses equal to that obtained with Slo-Gro at the four pound rate. The Royal Slo-Gro at the four pound rate was definitely more effective than Slo-Gro at the four pound rate.

An evaluation was made on trees in California using Sycamore (Plantanus occidentalis) and American Elm (Ulmus americana). The trees had been heavily pruned in the winter of 1967 and exhibited vigorous growth the following spring. Slo-Gro at four pounds of active ingredient per 100 gallons of water was compared with Royal Slo-Gro at three pounds of active ingredient per 100 gallons of water. The trees were sprayed to runoff when they were in full leaf and new growth was about 16 to 18 inches in length. A check treatment was also included.

[1] UniRoyal Chemical, Division of UniRoyal, Inc.
*Trademarks UniRoyal, Inc.

Fifteen trees in each treatment were visually rated six months after treatment. They were rated on a scale of zero to ten with zero representing new growth of eight to ten feet and ten representing new growth of less than one foot. The Slo-Gro treated trees had an average rating of 7.1, the Royal Slo-Gro treated trees had an average rating of 9.2 and the check trees had an average rating of 2.2.

In summary, these evaluations show that Royal Slo-Gro at three pounds of active ingredient per acre is equal to Slo-Gro at four pounds of active ingredient for inhibition of growth of grasses and trees of the species tested.

DIQUAT RESIDUES IN TWO NEW YORK LAKES

W. D. Sewell[1/]

Replicated one quart water samples were taken at 6 in., 24 in., and 42 in. depths in two Diquat treated lakes in Western New York in June and July 1969. Samples were taken at 0, 2, 4, 8 and 10 days after treatment. Samples were acidified with 5 ml. of conc. sulfuric acid per quart, which stabilized the Diquat present in the sample. Samples were analyzed by Chevron Chemical Company Laboratory, Richmond, California.

The following results were obtained. The analytical procedure is sensitive down to .005 ppm.

Findley Lake, New York - Plot size 10 acres (Cove) 2 gallons Diquat (4 lb. cation) per surface acre applied 6-26-69

ppm. Diquat
Days after Application

Depth	Rep.	0	1	2	4	8	10
6 inch	I	0.012	0.076	0.040	0.024	0.000	0.000
	II	0.016	0.086	0.052	0.024	0.000	0.000
	$\bar{X}$	0.014	0.080	0.046	0.024	0.000	0.000
24 inch	I	0.012	0.079	0.055	0.024	0.000	0.000
	II	0.010	0.077	0.052	0.017	0.000	0.000
	$\bar{X}$	0.011	0.078	0.053	0.021	0.000	0.000
42 inch	I	0.000	0.081	0.044	0.024	0.000	0.000
	II	0.000	0.076	0.049	0.024	0.000	0.000
	$\bar{X}$	0.000	0.079	0.047	0.024	0.000	0.000

Weed Control - Heavy stand of Water Milfoil (Myriophyllum species) was present and controlled within the 10 day period.

SUMMARY: Weed control (Water Milfoil) was complete within the 10 day sampling period.

Diquat residues fell below detectable levels between 4 and 8 days after treatment in Findley Lake. Diquat residues fell below detectable levels in Chautauqua Lake between the 0 and 1 day sample interval. Findley Lake was a cove treatment with heavy weed growth, which restricted water flow. Chautauqua Lake was a typical perimeter treatment of a large lake.

1/ Field Technical Specialist, Chevron Chemical Company, Cherry Hill, New Jersey 08034.

Chautauqua Lake, New York
2 gallons Diquat (4 lb. cation) per surface acre (Perimeter)
applied 7-21-69

		ppm. Diquat found Days after Application					
Depth	Rep.	0	1	2	4	8	10
6 inch	I	0.265	0.000	0.000	0.000	0.000	0.000
	II	0.389	0.000	0.000	0.000	0.000	0.000
	$\bar{X}$	0.327	0.000	0.000	0.000	0.000	0.000
24 inch	I	0.549	0.000	0.000	0.000	0.000	0.000
	II	0.289	0.000	0.000	0.000	0.000	0.000
	$\bar{X}$	0.419	0.000	0.000	0.000	0.000	0.000
42 inch	I	0.663	0.000	0.000	0.000	0.000	0.000
	II	-	0.000	0.000	0.000	0.000	0.000
	$\bar{X}$	0.663	0.000	0.000	0.000	0.000	0.000

1½ gal. (3 lb. cation) per surface acae (Perimeter)

		ppm. Diquat found Days after Application					
Depth	Rep.	0	1	2	4	8	10
6 inch	I	0.881	0.000	0.000	0.000	0.000	0.000
	II	-	0.000	0.000	0.000	0.000	0.000
	$\bar{X}$	0.881	0.000	0.000	0.000	0.000	0.000
24 inch	I	0.166	0.000	0.000	0.000	0.000	0.000
	II	-	0.000	0.000	0.000	0.000	0.000
	$\bar{X}$	0.166	0.000	0.000	0.000	0.000	0.000
42 inch	I	0.145	0.000	0.000	0.000	0.000	0.000
	II	-	0.000	0.000	0.000	0.000	0.000
	$\bar{X}$	0.145	0.000	0.000	0.000	0.000	0.000

ATRAZINE, TRIFLURALIN, AND BROMACIL IN SURFACE WATER FROM SELECTED AGRICULTURAL AND INDUSTRIAL SITES

W. A. Davis and E. M. Rahn[1/]

ABSTRACT

With increased use of herbicides in recent years, questions about contamination of surface and ground water with herbicides have increased. To answer these questions, surface run-offs from several fields receiving either atrazine or trifluralin were collected and analyzed. In some cases water in a stream or drainage ditch adjacent to the fields was analyzed. Surface run-offs from an industrial site treated with bromacil were also collected and analyzed. Surface water and ground water collected from an irrigated experimental area receiving all three herbicides were analyzed. An F & M Model 810 gas chromatograph was used for the determinations.

No trifluralin was found in surface water from a 500-acre lima bean field containing a loamy sand receiving 0.75 lb/A, nor in a drainage ditch adjacent to a 20-acre soybean field containing a sandy loam soil. In addition, no trifluralin was found in the run-off from an irrigated area containing a sandy loam soil, or in the water taken from a 15-ft. deep well in the center of this area.

With atrazine or bromacil, insignificant amounts were sometimes found in surface water when a heavy rain or irrigation followed within 2 to 4 weeks after application. These amounts were far below levels that would injure animal or plant life, however.

[1/]Plant Science Department, University of Delaware.

NUTRIENT BUDGETS IN RESERVOIRS

C.R. Frink[1/]

In eutrophic Bantam Lake in Connecticut (1), the nutrient input from a largely forested watershed was found adequate to support abundant weeds and algae. Moreover, this modest nutrient input resulted in the storage of considerable quantities of nutrients in the bottom sediments (2). Thus, we concluded weeds and algae in Bantam Lake were the result of natural eutrophication, which man would be hard pressed to alter.

Less is known of the accumulation and storage of nutrients in recent man-made impoundments or reservoirs. It seems possible, for example, that fewer nutrients have been stored and that efforts to reduce nutrient input would be more rewarding. Consequently, a study of a section of the Housatonic River basin in western Connecticut was begun in 1968. Some preliminary findings of this study are reported here.

In an approximately 30-mile section of the Housatonic River, there are two large impoundments: Lake Lillinonah, constructed in 1955 and covering about 1,900 acres, and Lake Zoar, located downstream from Lillinonah, constructed in 1919 and covering about 975 acres. Both lakes are used to store water for the generation of power and for recreation. For the latter purpose, they are virtually unusable at certain times of the year due to extremely dense algal blooms.

Automatic water samplers (3) collected weekly composite samples at 9 different stations along the river for a period of 52 weeks. The samples were analyzed according to Standard Methods (4) for NO_3-N, Kjeldahl-N, Cl, Total P, volatile, fixed, and total solids.[2/] Flow in the river was obtained from U.S. Geological Survey gaging stations and Connecticut Light and Power Co. records. Samples of the bottom sediments were collected with an Ekman dredge and their chemical and mineralogical properties determined as described elsewhere (2).

The concentration of phosphorus in the input to the two lakes was found to be about twice that observed in the Bantam Lake watershed, or about 0.065 ppm P. The concentrations of NO_3-N and NH_4-N totaled 0.4 - 0.6 ppm N, or about the same as that observed at Bantam. Subjective estimates indicate that algal blooms in these two lakes are heavier than those in Bantam: thus, phosphorus seems to be the growth-limiting element.

Contrary to expectations, considerable nitrogen and phosphorus has accumulated in the sediments of both lakes. The organic matter content of the sediments is somewhat less than that observed in Bantam Lake, reaching a maximum of about 25%. However, the C/N ratios are identical, indicating that the material has similar composition. Phosphorus concentrations, on the other hand, are much higher in these sediments than in Bantam. At the same organic matter and clay content, for example, total phosphorus in the Zoar and Lillinonah sediments is about twice that observed in

1/ Soil Chemist, The Conn. Agr. Exp. Station, New Haven, Conn.

2/ These analyses were performed by Continental Testing Laboratories, Hartford, Connecticut.

Bantam. This appears to confirm the hypothesis that the sediments act as a nutrient sink, since concentrations in the sediments appear to increase with increasing concentrations in the incoming water.

There are some differences between the two lakes, however, and at present these are not well understood. When Lake Lillinonah was constructed in 1955, it was anticipated that this reservoir would intercept some of the phosphorus load previously entering Lake Zoar and thus lessen the severity of algal blooms in the downstream reservoir. Lillinonah certainly acts as a sink, as evidenced by the accumulation in the sediments. Unfortunately, algae now grow profusely in both lakes. Moreover, this interception of phosphorus by Lake Lillinonah is not detectable in our measurements of the total nutrient load into and out of the lake.

Lake Zoar, however, appears to be functioning as a very effective nutrient sink; about 40% of the measured annual phosphorus load and 30% of the nitrogen load is retained in the lake. As a measure of the precision of our nutrient budget for this lake, 93% of the total chloride load leaving the lake is accounted for by our measurements of chloride entering the lake. This balance for chloride, a non-conservative element, enhances the credibility of the observed retention of nitrogen and phosphorus. Our budget for Lillinonah is less precise and perhaps explains the failure to observe nutrient retention there.

One feature of the nutrient accumulation in Lake Zoar is of special interest. If phosphorus and nitrogen are retained by algae which die and sink to the bottom, the greatest accumulation might be expected during the summer months. The phosphorus retention calculated for the weekly sampling periods, however, is greatest during the winter months from November through March. The reasons for this are not yet known.

The implications of these findings for recent impoundments are not encouraging. Even though Lake Lillinonah was created only 13 years ago, the bottom sediments are richer in phosphorus than those of Bantam Lake impounded 10,000 years ago. Although the depth of sediment in Lillinonah is unknown, it is clearly greater than a superficial scum of organic debris. Perhaps the greatest hope lies in discovering the mechanism which reduces the phosphorus load leaving Lake Zoar by 40%, since a series of such impoundments would obviously produce clean water in a hurry.

ACKNOWLEDGEMENTS

This work was supported in part by funds from the Connecticut Water Resources Commission. Many people generously cooperated in this study, including members of the Water Resources Commission, the US Geological Survey Water Resources Division, The Connecticut Light and Power Company, and Continental Testing Laboratories. In addition, my colleagues at the Station have provided invaluable assistance in water and sediment sampling and analysis, as well as in statistical analysis of the data.

LITERATURE CITED

(1) Frink, C.R. 1967. Nutrient budget: rational analysis of eutrophication in a Connecticut lake. Environ. Sci.Tech. 1:425-428.

(2) Frink, C.R. 1969. Chemical and mineralogical characteristics of eutrophic lake sediments. Soil Sci. Soc. Amer. Proc. 33:369-372.

(3) Brailsford, H.D. 1965. New developments in proportional sampling instruments. Water Sewage Works 112: 350-352

(4) Standard Methods for Examination of Water and Waste Water, 1965. Amer. Public Health Assoc, 12th Ed.

CHEMICAL CONTROL OF POTAMOGETON ROBBINSII UTILIZING THE SUBMERSED APPLICATION TECHNIQUE

C.E. GILBERT[1/] and J.M. CORTELL[2/]

INTRODUCTION

Greenwood Lake was originally a natural lake. A dam built in 1765, to supply water power and another in 1836 brought the lake up to its present level and area of 1,920 acres. The shoreline is highly developed, and the area is a popular year-round recreational site.

The New York - New Jersey boundary line divides the lake approximately in half, the New Jersey portion of the lake being 983 acres with a maximum depth of 35 feet and an average depth of 7 feet.

Eighty percent of the New Jersey portion has been heavily infested with a variety of submersed aquatic vegetation. Most notable was the heavy infestation of *Potamogeton robbinsii* found growing in water up to 16 feet in depth. Secondary species included *P. amplifolius*, *P. crispus*, *Ceratophyllum demersum* and *Cabomba caroliniana*.

During May 1969, the New Jersey Department of Conservation and Economic Development requested proposals for the chemical treatment of 775 acres of Greenwood Lake to control *P. robbinsii*, *P. crispus*, *P. amplifolius* and *Najas flexilis*.

Since Greenwood Lake is in the Wanaque Reservoir watershed and lake water is drawn directly from the lake by a number of communities in New York State as well, the North Jersey District Water Supply Commission restricted the use of herbicides in Greenwood Lake to diquat dibromide or dipotassium endothall.

A limited number of references on the control of *P. robbinsii* can be found in the literature. Essbach(1) reports control with a combination of endothall and silvex (7.2 lbs. + 10 lbs. a.i./A). Contact with others involved in aquatic weed control resulted in limited information on the activity of the two approved herbicides on *P. robbinsii*.

PROGRAM DEVELOPMENT

Biological surveys were made of the lake to provide additional information required to formulate an effective control program. Target weed species, an average depth of 7 feet and chemical cost per acre were determining factors in selecting the herbicide and application technique. Diquat dibromide

---

1/ Regional Manager, Allied Biological Control Corp., Chester, N. J.
2/ Consultant Biologist, Allied Biological Control Corp., Wellesley Hills, Mass.

at 4 pounds cation per acre was chosen for the biological, economic and operational advantages it offered in this situation.

It was also felt that the depth of water in the treatment area required a special approach to the technique in which the herbicide was applied. The normal surface application of a liquid herbicide would, in this case, result in a minimum herbicidal concentration in the weed-infested zone. In addition, the presence of a thermocline would substantially reduce the possible mixing of the treated surface water with the denser water of the weed-infested hypolimnion. Conversely, a submersed application would result, at least temporarily, in a maximum concentration of herbicide in the weed zone.

A submersed chemical delivery system capable of applying the herbicide solution at a depth of 6 to 12 feet was designed and fabricated. The system consisted of a high-volume pump which draws water from the lake at approximately 100 gallons per minute. The herbicide is introduced into the water intake line by means of a chemical proportioning system, dissolved and mixed in the pump. The herbicide solution is then pumped to the submersed nozzles consisting of 10-foot lengths of 1-inch galvanized pipe located on both sides of the boat. The discharge end of each submersed nozzle contains thirty 1/4-inch holes which facilitate good lateral dispersion of the herbicide solution. Two lengths of 1-inch rubber hose mounted at the pump end of the nozzles provided the required flexibility which allowed the nozzles to be lowered to the desired depth.

TREATMENT

On June 17, 1969, a submersed application of diquat dibromide at 4 pounds cation per acre commenced at the southern end of Greenwood Lake. An 18-foot Boston Whaler equipped with a McCulloch OX-14 outboard motor was used as the spraycraft. Chemicals were stored on board in a 275-gallon tank enabling the spraycraft to treat nearly 140 acres without refilling. Treatment swaths were applied at 50-foot intervals at a boat speed of approximately 3 m.p.h. Water depths determined by means of an on-board fathometer aided the operator in maintaining the submersed nozzles at 18 to 24 inches from the lake bottom.

Unfortunately, the treatment was suspended the second day when New York State officials became concerned over a potable water intake approximately one mile north of the treatment area. As a result of this suspension of operations, 400 acres of the proposed 775 acres were treated.

RESULTS OF TREATMENT

Post-treatment surveys were made every 2 weeks to evaluate control. Two weeks after application *P. robbinsii* plants examined appeared essentially unaffected. At 4 weeks, the plants examined exhibited obvious changes. Most notable was the large increase in the number of dead leaves and portions of the stems which had started decaying. At 6 to 8 weeks, the plants had collapsed, stems had decayed and were without leaves. Five months after treatment no regrowth was observed. Biological surveys also disclosed that *P. robbinsii* was controlled in a 70-acre area adjacent the 400 acres treated.

Effective control of P. amplifolius, P. crispus, Ceratophyllum demersum and Najas flexilis was noted; however, Cabomba caroliniana remained unaffected.

RESIDUE ANALYSES

Water samples were collected at two locations at three depths; 6, 24 and 42 inches, on 0, 1, 2, 4, 8 and 10 days after application for chemical residue analysis.

Plot No. 1 was in the center of the treated area. Plot No. II was located at the outlet some 300 feet from the treatment area and may account for the lower concentration of diquat recovered. Highest concentrations in both plots were found in samples collected 2 days after application, and residues were recovered within detectable limits 10 days after application.

SUMMARY

As a result of the treatment conducted at Greenwood Lake this past year, it appears that a submersed application of diquat at 4 lbs. cation per acre is an effective means of controlling P. robbinsii. Equally effective control may have resulted from a surface application or from lesser quantities of herbicide per acre.

The submersed application technique appears to be a useful means of applying liquid herbicides in certain situations such as treatments made in deep water or the presence of a thermocline.

Analysis of water samples taken from two different locations in the lake and 3 depths produced detectable residues of diquat up to 10 days after application with a maximum concentration at 2 days.

ACKNOWLEDGMENTS

We wish to thank Bruce Pyle, Assistant Bureau Chief and Frank Bolton, Fisheries Biologist, Division of Fish and Game, Lebanon, N.J., and James Rankin, Chief, N.J. Bureau of Navigation, for their support and cooperation in this project.

We also wish to acknowledge the assistance of William Sewall, Field Technical Specialist, Chevron Chemical Company, for providing the residue analysis.

LITERATURE CITED

1. Essbach, A.R. 1965. Supplement to Proc. NWCC 19:164.

Table I - Analyses for presence of diquat dibromide residues expressed in p.p.m.

	days after application					
location	0 **	1	2	4	8	10
Plot I	0.036	0.083	0.138	0.062	0.039	0.012
Plot II	0.008	0.000*	0.025	0.009	0.011	0.003

* 0.6 p.p.m paraquat ion found, reason unknown.

** 0 days, 4 hours after application.

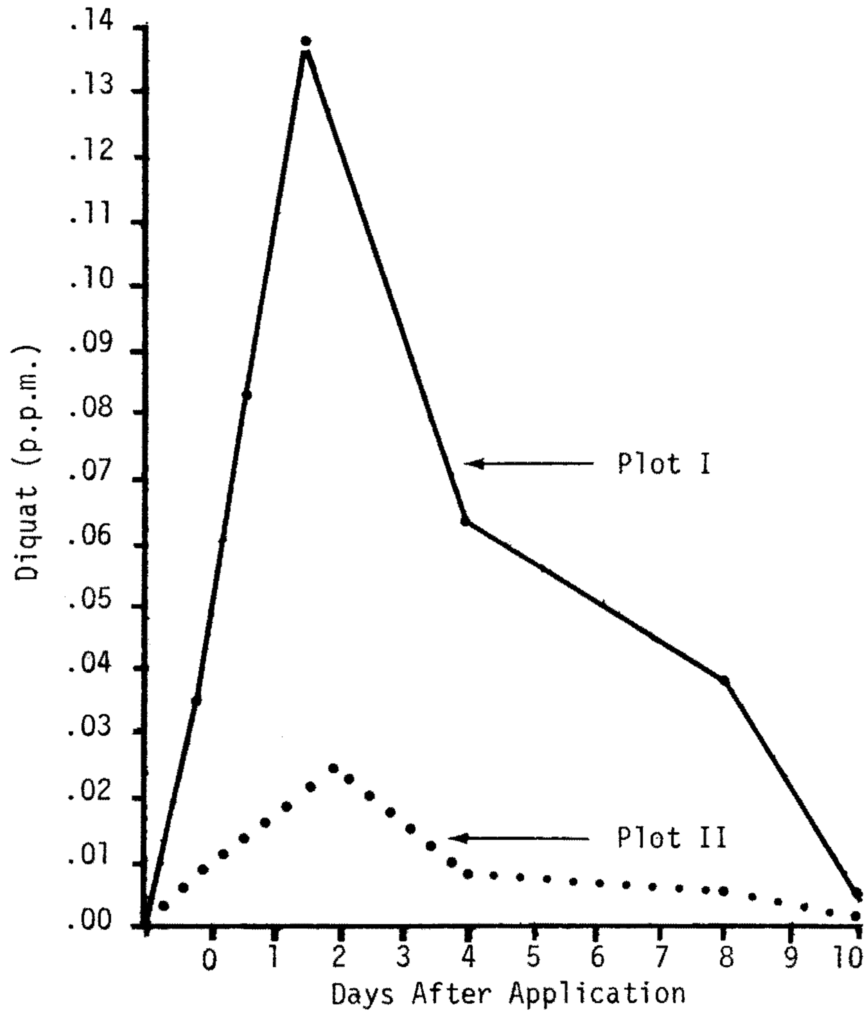


Figure 1. Degradation of diquat dibromide applied at 4 lbs. cation per acre.

A TOTAL APPROACH TO THE CONTROL OF NUISANCE ALGAE

C.L. Noyes[1/] and J.M. Cortell[2/]

INTRODUCTION

This paper is presented in two sections, the first of which presents and discusses the procedures and criteria established to determine the need for, and the frequency of, chemical treatment for the control of algae in conjunction with several considerations to be taken prior to treatment. Secondly, what appears to be a possible cycle of the dominant blue-green algae when exposed to repeated treatments of copper sulfate will be discussed herein.

METHODS AND MATERIALS

Chemical analysis was made utilizing colorimetric techniques, conducted on freshly collected unpreserved samples. Dissolved oxygen content was determined by a modified azide-Winkler method. Iron determinations were made by the 1,10 phenanthroline method, and the stannous chloride procedure was used in conducting orthophosphate tests. Qualitative and quantitative studies of the phytoplankton and zooplankton were conducted in accordance with procedures established by the American Public Health Association using the Sedgwick-Rafter Counting Chamber at 100 magnifications. Additionally, on site light penetration readings using the Secchi Disc, and temperature profiles using the Bright Radio Laboratories' electronic thermometer were conducted.

Locations of the study were pre-determined due to the nature and origin of nutrients, morphology and depths of the lakes involved and similar algae populations. These included Lake Annabessacook, a 1420 acre lake in Winthrop and Monmouth, Maine; Lake Cochituate, a 614 acre lake located in Natick, Cochituate and Wayland, Massachusetts, and South Watuppa Pond, a 1283 acre lake situated between Fall River and Westport, Massachusetts.

Diamond copper sulfate (Cu-25.5% minimum) crystals are used at a rate of 0.3 parts per million, calculated to a depth of 6 feet. To effect chemical control of the algae population in all three lakes, the chemical was applied as a liquid surface spray utilizing the Chemical-Injection-System using conventional aquatic spraycraft, as well as, an AB-125 Aircat Airboat. The use of the airboat contributed to the accuracy of the treatment in that it was capable of negotiating the shallow shorelines and back coves without difficulty.

An algae surveillance sampling program was established on each of the three lakes. Water was collected from designated sampling stations. These included "grab samples" from the surface in close proximity to the shoreline

---

1/ Aquatic Biologist, Allied Biological Control Corporation, Wellesley Hills, Massachusetts 02181

2/ Consultant Biologist, Wellesley Hills, Massachusetts 02181

and composite samples obtained from open water. Secchi Disc readings were obtained to determine visual light penetration. Also, temperatures were recorded at the sampling points and at various depths throughout the lakes. The samples were analyzed and the findings plotted. Population comparisons were made between the Cyanophyceae and Chlorophyceae. Light penetration readings, as determined by the Secchi Disc were plotted against the total algae count.

Algae treatments in Lake Annabessacook and Lake Cochituate were scheduled when the total count exceeded 1000 total areal standard units. Treatment of South Watuppa Pond was not scheduled until the total count exceeded 3500 units.

RESULTS

Findings of algae counts, Secchi Disc readings and surface water temperatures are reported in Tables I, II and III. Using a cut-off point of 1000 organisms per cubic centimeter on Lakes Annabessacook and Cochituate, the algae bloom condition in both lakes was maintained at a minimum. Light penetration readings were held above the 4 feet recommended by the Federal Water Pollution Control Administration for recreational waters(6). Generally, throughout the season, there is a continual exchange of dominance in the types of algae. While treatment directed against a specific target species resulted in its control, a previously subordinate species would then develop and obtain dominance. For example, during the month of July on Lake Cochituate, there occurred not only a shift in species, but a green algae succeeded the blue-green. On July 11th, a treatment was performed on Lake Annabessacook to control *Anabaena*. This treatment resulted in over a 95% reduction of this blue-green algae. However, within two weeks, the algae *Gloeobotrys* had developed from a previously minor significance to dominate the algae population.

South Watuppa Pond was treated two times in the season. Prior to the first treatment, the total algae count was 400,000 per cubic centimeter. At this time, the target algae were *Micro cystis*, *Anabaena* and *Aphanizomenon*. The *Micro cystis* proved to be more resistant to the treatment, while the *Anabaena* and *Aphanizomenon* responded with a sharp and rapid decline in population. The second treatment on this lake resulted in complete control of all three algae. Due to the infrequency of treatments on this lake, no shift in algae populations were noticed.

DISCUSSION

Criteria for Treatment

To establish procedures and criteria, several methods were considered, singly and in combination, and concluded in what can be called a "total approach".

As Riemer reported(7), the most favorable method of applying the algicide is through a liquid surface spray. This method ensures good distribution and minimizes the chance of "hot spots". Hale(2) provides good data on the susceptibility of various organisms to copper sulfate, as well as, certain species of fish.

Secchi disc readings provide, to a certain degree of accuracy, an indication of algae conditions. Since light penetration is inversely proportionate to the amount of turbidity present, one would expect that with a decrease in light penetration, an increase in turbidity (and more than likely algae population) was occurring.

This, however, is not always the case. Frost(1) reported Aphanizonenon as being susceptible to copper sulfate, yet dead or alive, the organism does not readily disappear from surface waters and only results in a dirty blue-gray color with apparently little, if any, increase in light penetration. In some cases, for about seven to twelve days following treatment of Anabaena, a dense dark-brown coloration of the water had taken over. This is due to large amounts of lysed and broken algae still remaining in the surface waters. A natural factor also to be considered is the true color index of the body of water.

Some lakes and ponds receive large influxes of ferric or ferrous ions either constantly or periodically, thereby affecting the color of the water. The degree of visible light penetration here is inversely proportionate to the true color reading. In Lake Cochituate, which is formed by a chain of three inter-connected lakes, the iron content ranges from .42 parts per million at the source of inflowing water in the first lake to .04 parts per million at the outflow in the third lake. The best, after-treatment light penetration readings for these particular lakes have been 6'8" and 14'6", respectively. Obviously, the Secchi Disc criteria for the first lake cannot be applied to the latter, or any other. Hence, optimum light penetration readings must be determined on an individual basis before the Secchi Disc can be used to any degree of reliability, as indicative of algae population.

Visual inspection is not entirely satisfactory. An impending algae bloom is not realized until the bloom condition is near and does not provide enough time for scheduling treatment. Silt-laden water may also give a false impression, yet many knowledgeable people use visual inspection as the sole indicator.

The scheduling of treatment is often made difficult, since algae blooms develop at a very fast pace once they get started. The best manner in handling the situation is to "head off" the bloom. Lackey(3) defines a bloom quantitatively as 500 organisms per cubic milliliter. However, there is a distinct difference between 500 Anabaena, 500 Gloeobotrys, or an equal distribution of perhaps 10 genera of green algae as far as a treatment is concerned. Nickerson and Chute(4) have rightfully pointed out that the maximum suppression of growth seems to occur when treatment is applied just as the water appears green to the naked eye, a situation comparable to approximately 3000 organisms per cubic centimeter. Few people though, will tolerate the building up of the green color.

In gaining initial control of an algae condition, the inter-relationship of water temperature, available oxygen and the possibility of toxic effects must be considered. Water temperature has a distinct effect on dissolved oxygen, in that, the higher the water temperature, the lower the amount of dissolved oxygen is available to the fish and other aquatic organisms. One should carefully consider such a situation where a high water temperature (higher than 75°F) is encountered in shallow lakes. This could also be coupled with an already lowered dissolved oxygen content in some eutrophic lakes and ponds, particularly where uniform shallow depths are encountered. Also, not be be forgotten, is the lowering effect of dying algae on the available oxygen once the chemical is applied.

Various blue-green algae have been known to produce certain amounts of endotoxins. Palmer(5) reports that Anabaena, Anacystis, Chlorella and Lyngbya are responsible for toxic by-products to one degree or another. Frost(1), in 1966, reported his unfortunate encounter with Aphanizomenon and its apparent responsibility for a large fishkill on New Hampshire's Lake Winnisquam.

The combination of released toxic substances, high water temperatures, and low amounts of available oxygen to already weakened fish could have extremely deleterious effects on the fauna. Therefore, once control is achieved, the population of blue-green algae should not be allowed to go beyond 1000 organisms per cubic centimeter.

Cycling of Algae Population

Natural fluctuations in algae population occur either in conjunction with seasonal changes or shortly after a bloom when the available nutrients have been utilized and not replenished.

Such fluctuations may also be caused artificially by repeated exposure to certain chemicals (copper sulfate for instance). Many instances have been reported where populations of blue-green algae have been replaced by other Cyanophyceae either within the same season or in successive seasons, and all in conjunction with the use of copper sulfate. In Lake Winnisquam in 1964, Aphanizomenon was dominant while in 1965, Endorina and some Anabaena appeared. At the present, the dominant species is Gloeotrichia, one of the Chlorophyceae.

On Lake Annabessacook, the 1967 population was dominated by Anabaena and Aphanizomenon. In 1968, Anabaena was still present, but Anacystis replaced Aphanizomenon. Recent plankton studies indicate Anabaena was dominant until mid-summer when Gomphosphaeria started to accelerate. At the present time, Anabaena can be located only in minute quantities and one can only speculate as to which will be present next season.

Another in-season change occurred in Lake Cochituate, however, this time to a green algae. Anabaena had been for years, the dominant algae, until mid-summer of 1969. With a sudden decline in the Anabaena population, a sharp rise in population of Mougeotia occurred. This green algae suddenly appeared in a bloom, reaching proportions of 4300 organisms per cubic centimeter. Soon thereafter, a copper sulfate treatment was directed against this algae producing a two-fold result; a reduction in the population (but not erradication) of Mougeotia, and afforded the Anabaena (present in amounts of only 10 per cubic centimeter) the opportunity to gain dominance once again and bloom.

Of significance is the decline of a dominant population after repeated treatment with copper sulfate and its replacement by another algae. Some of these changes have occurred in mid-season, with no apparent relationship to temperature or nutrient level.

A possible explanation may be offered in that after receiving certain repetative amounts of copper sulfate, the reproductive capacity of the dominant or susceptable algae is impeded and ultimately may lead to its demise. It may also be pointed out that while one population was declining in these situations, another was taking advantage of the decline to increase its own numbers. Thus, an interaction of these two probable causes may well account for the sudden changes.

A high green algae population has a less objectionable effect than a corresponding blue-green population. Therefore, whenever possible, it is more desirable to eliminate the blue-green population and allow the less offensive green algae to grow.

CONCLUSIONS

The safe and successful algae control and maintenance program involves a total approach to the problem. The following factors must be considered:

1. Water temperature and lake depths.
2. Amounts of dissolved oxygen.
3. Nutrient levels.
4. Light penetration, true and apparent color.
5. Algae to be controlled and the possibility of endotoxins.

In addition to a reduction of population, a shift in dominance and algae type may be experienced.

LITERATURE CITED

1. Frost, T.P. 1966. The Winnisquam Story. Proc. NWCC 20: pp. 458-463.
2. Hale, F.E. 1950. The Use of Copper Sulphate in Control of Microscopic Organisms. Phelps Dodge Refining Corp., New York.
3. Lackey, J.B. 1949. Plankton As Related to Nuisance Conditions in Surface Water. A.A.A.S. Bull., Wash. pp. 55-63.
4. Nickerson, G.W. and Chute, R.M. 1968. A Study of The Growth Factors Relating to The Overabundance of Algae in Lake Annabessacook, Monmouth and Winthrop, Maine, during 1968. Biology Department, Bates College.
5. Palmer, C.M. 1962. Algae in Water Supplies. U.S. Department of Health, Education and Welfare. Public Health Service.
6. Report of The Committee on Water Quality Criteria. 1968. Federal Water Pollution Control Administration., Wash., D.C.
7. Riemer, D.N. and Toth, S.J. 1967. Behavior of Copper Sulfate in Small Ponds. Proc. NWCC 26: pp. 534-540.

Table I - Lake Annabessacook, 1969

Sample Dates	Algae Count Chlorophyceae	Cyanophyceae	Total	Secchi Disc	Surface Temperature
6-21	32	2920	2952	4'4"	71°F
6-30	First Treatment (4000 lbs. $CuSO_4 \cdot 5H_2O$)				
7-6	203	126	329	7'6"	72°F
7-13	395	170	565	6'1"	70°F
7-20	1524	336	1860	4'9"	75°F
7-22	Second Treatment (4000 lbs. $CuSO_4 \cdot 5H_2O$)				
7-27	560	16	576	5'4"	74°F
8-3	752	136	888	5'2"	77°F
8-11	Third Treatment (4000 lbs. $CuSO_4 \cdot 5H_2O$)				
8-17	600	3600	4200	4'7"	74°F
8-28	Fourth Treatment (4000 lbs. $CuSO_4 \cdot 5H_2O$)				
9-14	400	40	440	9'4"	68°F
9-27	154	36	190	8'0"	62°F

Table II - Lake Cochituate (South Lake), 1969

Sample Dates	Algae Count: Chlorophyceae	Algae Count: Cyanophyceae	Algae Count: Total	Secchi Disc	Surface Temperature
6-17	12	280	292	-	73°F
6-27	212	1072	1284	3'0"	73°F
6-27	First Treatment (2000 lbs. $CuSO_4.5H_2O$)				
6-29	208	340	548	-	78°F
7-8	393	372	765	4'6"	74°F
7-25	4800	200	5000	3'8"	71°F
8-7	536	88	624	6'8"	81°F
8-8	Second Treatment (2200 lbs. $CuSO_4.5H_2O$)				
8-22	441	560	1001	5'6"	73°F
9-3	800	16,400	17,200	2'1"	75°F
9-10	600	4,900	5,500	-	69°F
9-30	150	12	162	3'0"	64°F
9-30	Third Treatment (2300 lbs. $CuSO_4.5H_2O$)				
9-30	696	32	728	4'6"	51°F

Table III - Lake Cochituate (Middle Lake), 1969

Sample Dates	Algae Count Chlorophyceae	Cyanophyceae	Total	Secchi Disc	Surface Temperature
6-27	32	144	176	7'0"	72°F
6-27	First Treatment (2000 lbs. $CuSO_4.5H_2O$)				
6-29	84	48	132	-	78°F
7-8	104	280	384	8'0"	73°F
7-25	1276	12	1288	5'11"	72°F
8-7	576	48	624	8'0"	80°F
8-8	Second Treatment (2000 lbs. $CuSO_4.5H_2O$)				
8-11	877	60	937	9'0"	76°F
8-22	344	136	480	8'0"	74°F
9-3	264	520	784	7'3"	75°F
9-30	200	80	280	5'4"	64°F
9-30	Third Treatment (2000 lbs. $CuSO_4.5H_2O$)				

CONTROL OF CORDGRASS IN TIDAL MARSHES

John H. Steenis[1] and Robert A. Beck[2]

Abstract

The cordgrasses, principally Spartina cynosuroides, S. patens, and S. alterniflora, are the major turf species of the estuarine marshes along the Atlantic and Gulf coast. These estuaries are the incubator and nursery grounds for perpetuation of commercial and sport fisheries resources. They also furnish essential habitat for waterfowl and furbears, mainly muskrat. Productivity of these marshes, particularly for waterfowl, can be improved by causing an interspersion of marsh and water areas.

The preliminary objective of these Delaware studies was to determine how to control these cordgrass species. Previous tests had revealed that smooth cordgrass (Spartina alterniflora) was the most difficult to control, so emphasis was placed on determining how to control that species. Graded dosages of following herbicides were tested, dalapon, amitrole-T, fenac, dicamba, dichlobenil, cacodylic acid, bromacil and 1-[5-(3a,4,5,6,7, 7a-hexahdro-4,7-methanoindanyl)]-3,3-dimethylureae. Only dalapon, at rates of 40 lb. ae/A, yielded effective results. Successful treatments were obtained during exposure of the marsh turf by an ebbing tide to the period of half rise. Treatments at weekly intervals revealed that smooth cordgrass could be controlled effectively during stages of mature growth through flowering and early fruiting period. In Delaware this period is from the last week of July through the first week of September.

Investigations are now underway for determining how to use this control procedure to improve marsh habitat.

1/ U.S. Fish and Wildlife Service, Laurel, Maryland
2/ Delaware Board of Game and Fish Commissioners, Dover, Delaware

COMMON PURSLANE COMPETITION IN VEGETABLE CROPS[1/]

Jonas Vengris[2/]

Abstract

Field competition trials between common purslane (Portulaca oleracea) and table beets (Beta vulgaris) and snap beans (Phaseolus vulgaris) were conducted in 1967, 1968 and 1969. The main objective of our investigations was to obtain specific information on common purslane competition in relation to the time of weed emergence and length of competition affecting the yields of cultural plants.

Beet and beans were kept purslane-free for various periods during the growing season. Also, in a set of treatments, purslane was allowed to grow with beets or beans for various periods before being removed. The first two weeks after beet or bean emergence, purslane control was most important. Purslane control longer than two weeks did not increase beet or bean yields. It is important to eradicate the first crop of purslane seedlings within two weeks after emergence. The longer purslane was allowed to compete after beet or bean emergence, the more yields were decreased. Purslane was a stronger competitor in beets than in beans. This could be explained by faster and taller growing bean plants as compared with beets. During the entire growing season purslane did not surpass snap beans in height of growth. Conversely, purslane emerging at the same time as the beet variety, was taller and the dominant plant.

Cultivation until lay-by between rows increased beet as well as bean yields significantly. By far this measure was more effective in beans than in beets.

1/ Contribution of the Massachusetts Agricultural Experiment Station, College of Agriculture, University of Massachusetts, Amherst.

2/ Associate Professor, Department of Plant and Soil Sciences, University of Massachusetts, Amherst.

A STUDY OF NUTRIENT DEFICIENCY SYMPTOMS IN COMMON CHICKWEED (STELLARIA MEDIA)

William J. McAvoy, Jr. and Berril Gold[1/]

Abstract

A study was undertaken to investigate the deficiency symptoms in common chickweed (Stellaria media). Chickweed seedlings were established in sand cultures and supplied with nutrient solutions. Nitrogen, phosphorus, potassium, calcium, and magnesium deficiency symptoms were studied for approximately six weeks.

Several of the deficiency symptoms which were observed and recorded were similar to major symptoms exhibited by many dicotyledons. Low nitrogen produced chlorosis of older leaves. Low potassium exhibited slight chlorosis and a definite dark green color in young leaf growth. The symptom of large, thick, leathery leaves was observed in the low calcium plants.

In addition to fresh and dry weight records, plant tissue analyses were conducted for nitrogen, phosphorus, potassium, calcium, magnesium, sodium, copper, iron, manganese, and zinc. Some nutrient deficiencies appeared to enhance the uptake or increase the level of certain other elements. The low potassium treatment slightly doubled the calcium content as compared to the control. Low calcium and magnesium treatments also increased the potassium content. A reciprocal relationship is indicated between the calcium and potassium.

[1/] Research Assistants, Department of Soils and Crops, Rutgers University, New Brunswick, New Jersey.

GROWING NUTSEDGE (CYPERUS ESCULENTUS) IN THE GREENHOUSE FOR RESEARCH PURPOSES[1,2]

C. H. Doty and R. D. Sweet[3]

Growing various weed species in the greenhouse allows research during the winter months and, to a limited extent, control over environmental factors. Often growth of a given species can be enhanced or the life cycle shortened by controlling certain factors in the environment. One of the important weeds in the world, yellow nutsedge (*Cyperus esculentus* L.), has received relatively little attention under controlled conditions. In a large measure this is because information has not been available to the potential research worker on how to manage the weed so that it would be in the condition, or stage of growth, desired by the worker whenever he wanted it. This report discusses methods found successful in growing yellow nutsedge in the greenhouse.

Containers

A 4' x 4' box constructed of 2' x 6" framing lumber and homasote, and lined with a sheet of plastic, is used for growing supplies of tubers. It can be moved fairly easy and provides a large, bottom-surface area, relative to soil volume, for tubers to form. Drainage is not required, but care must be used not to overwater. One hundred fifty to 200 plants can be grown in this box, and will yield 2000 to 2500 tubers.

Commercial fiber or styrofoam containers commonly used for bedding plants which require 40 to 60 square inches of bench space are used for experimental work. Three to four plants yield 75 to 100 tubers per container. Both the large 4' x 4' and the small containers take 10 to 12 weeks from planting before new tubers are ready to harvest.

Growing Media

An artificial soil media is used for all work other than pre-emergence chemical application (2). The media (Cornell peat-lite Mix A) is composed of one half vermiculite (No. 2, 3, or 4) and one half sphagum peat moss. To one cubic yard is added 5 lbs. ground limestone, 2 lbs. 20% superphosphate, 6 lbs. 5-10-5 fertilizer, 10 grams 11% Borax, and 25 grams chelated iron. The advantage of using this media include: reproducible uniformity, easier handling, more rapid establishment and growth, less frequent and more uniform watering and easier harvesting of tubers.

1/ Paper No. 597 of the Department of Vegetable Crops, Cornell University, Ithaca, New York.
2/ Some of this research has been supported by NE-42 regional funds.
3/ Research Assistant and Professor, respectively.

Planting

Three to four inches of media is used in the growing containers. Artificial mixes containing peat should be watered well at least one day in advance of planting to allow thorough wetting. Pre-germinated tubers are planted when the sprouts are 1/2 to 3/4 of an inch long. Pre-germination gives a more uniform stand and a faster start.

Planting depth is 1 to 1-1/4 inches. If sprouts become elongated the crowns (basal bulbs) will often form above the soil surface. An extra 1/2 to 3/4 inch of media can be added to provide better support for the plants.

Watering

When growing in peat-lite mix, watering often introduces variability in growth. It is nearly impossible to obtain uniform watering of the small containers by overhead sprinkling, unless a measured amount is applied uniformly to each individual pack. Media which is constantly saturated prevents proper root, rhizome and tuber formation. Likewise, dryness limits tuber production.

Subirrigation largely eliminates this problem. Any level bench with sides can readily be converted to subirrigation. When no sides are present a 2" x 2" frame can be bolted around the edges of the bench. A sheet of plastic is then thumbtacked to the bench sides or the 2" x 2" frame, forming a shallow pool into which flats are placed. Water is run into the pool as necessary to provide uniform subirrigation.

Lighting

In Ithaca, New York (latitude 45° N) supplemental lighting is necessary from September through March, otherwise tubers are initiated when plants are very young and the yield is small. In more southerly latitudes extra light probably would be needed for a shorter part of the year. Which specific type and intensity of light is best has not been determined. For our purposes, two 8 foot, VHO, cool white, fluorescent lamps give satisfactory growth for an 8 x 4 foot area. Lights are suspended 20 inches from the greenhouse bench surface.

Photoperiod

Detailed investigations with photoperiod have not been made. Plants are grown under a 20 hour photoperiod from time of planting until placed under short days. In Ithaca, the lights are left on the full 20 hour period from October through March due to low light intensity during these months. The rest of the year the natural daylength is just extended with the lights. Plants are usually 10 to 14 inches tall in 4 to 5 weeks under these conditions. At this stage they are placed under short days.

The same supplemental lighting is also given plants under short days. The daylength is set at 12 hours. This is short enough to induce tuber initiation, yet provides a long enough photosynthetic period to give high tuber production. Black shade cloth is used to provide the short day length. Plants are uncovered at 8:00 a.m. and covered at 4:30 p.m., with supplemental light making up the remainder of the 12 hour photoperiod. Under a 12 hour photoperiod plants form tubers and senesce in 4 to 5 weeks. Tubers are harvested when the foliage is 95% or more dead, at which time tubers are dark tan, hard and covered with many scale-like projections. A majority of the tubers are formed against the bottom surface of the growing media and are easily harvested.

Temperature

Garg et al., (4) reported that high temperature and short photoperiod increased differentiation of rhizomes into tubers. Therefore, the greenhouse was set to maintain 85° F days and 70° F nights. Rapid vegetative growth under long days as well as good tuber initiation and development under short days were obtained with these temperatures.

Tuber Germination

Several workers have reported results of vernalization treatments on tubers to break dormancy, (1, 3, 6). It appears that ecotypes respond differently to the length of vernalization necessary to break dormancy. Tubers grown in northern sections of the Eastern United States appear to have a greater cold requirement than those grown further south. However, in the field a high proportion of the plants in a given location originate from tubers formed the previous year.

To have a continuous research program with nutsedge it is often desirable to induce a high per cent germination in the shortest time possible. Preliminary vernalization experiments showed both 3 and 5 weeks at 32° F gave better germination than higher temperatures,for storage periods up to two months. However, 5 weeks at 32° F gave, at best, only 40 to 50% germination.

It was felt this could be improved, possibly, by modifying the storage environment. Rinsing in cold water has been reported to enhance tuber germination (6, 7). Thornton (5) describes the use of peat moss or other absorbent media to improve germination. It is known that alternating temperatures will sometimes enhance seed germination of certain species (8). A vernalization experiment to test the effect of these factors on germination was initiated. Specific treatments were: storage in moist peat moss vs. storage in moist paper towel; rinsing in cold water following storage vs. non-rinsed; germination at constant temperature vs. alternating temperatures. All treatments were for five weeks. Tubers were germinated in petri dishes containing 1/4 inch vermiculite, filter paper and 25 ml water. An electric heated, metal-box type germinator was used. Germination temperatures were 80, 100, and 80-100 alternated every 48 hours. The results of this experiment are given in Figure 1.

It appears that moist peat moss and alternating germination temperatures may enhance tuber germination. Rinsing with cold water improved germination in some treatments but not in others. Alternating germination temperature seems to have the greatest influence on tuber germination.

Summary

Work reported here shows that with a modest investment in equipment and facilities yellow nutsedge (*Cyperus esculentus*) plants can be grown readily any time of the year. Also tuber formation can be initiated at almost any period. Although plants only a few inches tall can be induced to form tubers, in order to obtain large yields, plants should be at least 5 weeks of age before short days are given. At least 150 mature tubers per square foot of

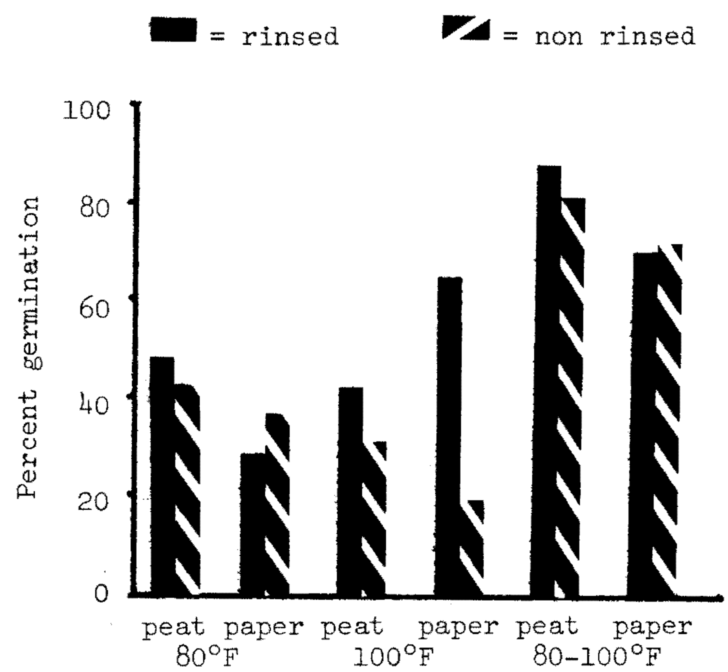


Figure 1. Germination of nutsedge tubers after 5 weeks storage at 32° F and 2 weeks at the indicated germination temperatures.

greenhouse bench can be produced in about three months. Germination of tubers greater than 75% can be obtained with an alternating temperature of 80°-100° F provided the tubers have been pre-treated by storing at 32° F for 5 weeks.

Literature Cited

1. Bell, R. S., W. H. Lachman, E. M. Rahn and R. D. Sweet. 1962. Life history studies as related to weed control in the northeast. 1-Nutgrass. Rhode Island Agric. Expt. Bull. No. 364.

2. Boodley, J. W. and R. Sheldrake, Jr. 1967. Cornell peat-lite mixes for commercial plant growing. Cornell Extension Bull. No. 1104.

3. Bundy, O. m., W. F. Donnalley and E. M. Rhan. 1960. Growth and development of northern nutgrass as affected by certain environmental conditions. Proc. NEWCC 14: 44.

4. Garg, D. K., L. E. Bendixen and S. R. Anderson. 1967. Rhizome differentiation in yellow nutsedge. Weeds 15: 124-128.

5. Thornton, N. C. 1949. Dormancy. In: Growth and differentiation of plants. Iowa State College Press, Ames, Iowa. pp. 137-148.

6. Tumbleson, M. E. and T. Kommedahl. 1962. Factors effecting dormancy in tubers of *Cyperus esculentus*. Bot. Gazette. 123: 186-190.

7. Tumbleson, M. E. and T. Kommedahl. 1961. Reproductive potential of *Cyperus esculentus* by tubers. Weeds 9: 646-653.

8. Yearbook of Agriculture. 1961. Seeds. The United States Department of Agriculture. p. 103.

PROPAGATION OF ASH AND MAPLE FOR LABORATORY INVESTIGATIONS

J. W. Akerman, C. A. Vile, and W. Hurtt[1/]

ABSTRACT

One of many problems associated with using seedling trees in studies involving herbicides and plant growth regulators is the lack of uniform plants, especially during normal dormancy. Investigations were initiated to evaluate methods and to establish procedures for growing seedling trees to a predetermined uniform size.

White ash (*Fraxinus americana* L.) seed was gathered in the fall from indigenous sources and placed in a cool-moist environment for 90 days at 4 C to break embryonic dormancy. Red maple (*Acer rubrum* L.) and silver maple (*Acer saccharium* L.) were similarly obtained in the spring but did not require a cold treatment. Seed were germinated in vermiculite, a 1:1 peat-perlite mixture, and washed silica sand in the greenhouse at 23-28 C and in a growth chamber at 24-26 C. Following emergence the seedlings were grown for varying periods in a growth chamber in nutrient culture as well as in the above media in the greenhouse under supplementary light.

In contrast to the above procedure, dormant ash and maple seedlings were obtained from commercial sources and exposed to varying photoperiods. Day lengths of 16 and 20 hrs were used in the growth chamber studies. Greenhouse photoperiods of 16, 20, and 24 hrs were achieved by supplementing the natural day of 10-11 hrs with increments of fluorescent or incandescent light.

Since our use of plant material frequently involves root-applied compounds, both labeled and nonlabeled, as well as foliar applications in which subsequent effects upon roots may be as important as foliar effects, the solution culture system is the only practical method which provides the opportunity for analyses or autoradiography of both foliage and roots. The optimum procedure evolved from these studies was to germinate ash and maple seed in vermiculite and transplant into individual pots of vermiculite, initially saturated with Hoagland's nutrient solution, when the seedlings were ca. 4 cm tall. After attaining a height of 20-25 cm the seedlings were transferred to aerated solution culture and were considered ready for experimental use after 2-3 days of acclimatization. The environmental parameters were 25 $\pm$ 3 C, 60 $\pm$ 15% RH, and a 16-hr photoperiod of 1000 $\pm$ 300 ft-c.

When grown from seed, ash and silver maple required 5 weeks to reach 20-25 cm; whereas red maple required 8-9 weeks. Plants of this size were optimum for these studies because of the limitation imposed by the size of our lyophilization equipment. We have successfully grown trees in solution culture in 1-qt pots for 2 months with no special requirements other than periodic replenishment of the solution. The only limitation to growth of larger trees would be the need for physical support.

[1/] Plant Physiologists, Plant Sciences Laboratories, Fort Detrick, Frederick, Maryland 21701

EFFECT OF SOLVENT COMPOSITION ON INACTIVATION OF SEVERAL PHENYL AND THIO CARBAMATE HERBICIDES IN SOIL

L. L. Danielson and W. A. Gentner[1]

Abstract. Inactivation of S-ethyl dibutylthiocarbamate in soil was hastened by application in 40 gpa of kerosene or No. 2 fuel oil. Rate of inactivation of S-ethyl dipropylthiocarbamate [EPTC] from soil was accelerated when volume of kerosene used in application was increased from 10 to 40 gpa. Inactivation of subsurface band placements of EPTC in soil was hastened when kerosene was used in applying the herbicide.

- 0 -

Kerosene and No. 2 fuel oil used to apply S-ethyl dipropylthiocarbamate [EPTC] to soil hastened rate of inactivation of the herbicide in previous studies (1). Acetone, benzene, or xylene did not affect rate of inactivation. The studies reported herein determine the effects of all of the above-named solvents on rate of inactivation in soil of S-ethyl dibutyl= thiocarbamate, hereafter referred to as R-1870; isopropyl m-chlorocarbanilate [chlorpropham]; isopropyl carbanilate [propham]; and 2-chloroallyl diethyl= dithiocarbamate [CDEC]. Effect of volume of kerosene used and effect on upward movement of subsurface band placements of EPTC and inactivation in soil were also studied.

Materials and Methods

Effect of solvents on inactivation of technical chlorpropham, propham, CDEC, and R-1870 in soil was studied using the methods previously described (3). The herbicides were applied at 1/8, 1/4, 1/2, 1, 2, and 4 lb/A. Treatments were applied in 40 gpa of acetone, benzene, xylene, No. 2 fuel oil, and kerosene, and were incorporated to a depth of 1 inch in the soil. Commercial formulations were applied at the same rates in water at 40 gpa. Composition of petroleum based solvents is given in Table 1. Oats [*Avena sativa* (L.) var. Clinton] were planted immediately after treatment and at 7-day intervals thereafter to assay for phytotoxic quantities of herbicides remaining in the soil. The oats were cut at the soil level after 4 weeks of growth and the following data recorded: (a) injury score - 0 to 100, where 0 equals no effect and 100 equals death of all plants; (b) fresh weight reduction percentage; and (c) height reduction percentage. Growth inhibition index was calculated by combining the (a), (b), and (c) records and dividing by 3.

The methods and conditions described above were used in a continuation of these studies to determine the effects of 10 to 120 gpa of kerosene on rate of inactivation of EPTC in soil. EPTC was studied because it was a commercial herbicide and was similar to R-1870 in responses in the preceding

1/ Plant Physiologists, Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland.

experiments. The commercially formulated, emulsifiable EPTC concentrate applied in 40 gpa water was used for comparison in these studies.

The effects of kerosene on upward movement and inactivation of subsurface band placements of EPTC in soil were determined by the following method. A 3-inch layer of potting soil in one set of flats was sprayed with 2 lb/A of commercially formulated EPTC in 40 gpa of water, and a second set was sprayed with equivalent amounts of pure EPTC in 40 gpa of kerosene. The soil was thoroughly mixed after treatment. A volume equal to a 1/2-inch layer of the treated soil was placed in small plastic containers and covered with 3 inches of untreated soil. The containers were placed in controlled climate chambers at 70 F night and 80 F day temperatures, and 12 hr day length. Subirrigation was used. The surface soil was bioassayed immediately after treatment and at intervals of a week using surface plantings of annual ryegrass [Lolium multiflorum Lam.] to detect the herbicide.

Results and Discussion

A. Herbicide inactivation vs. solvent composition. The rate of inactivation of chlorpropham, propham, and CDEC in soil was not affected by use of any of the solvents. Technical R-1870 applied in 40 gpa of kerosene or No. 2 fuel oil was inactivated in about 2 weeks, Figure 1. The commercial formulation applied in water and the technical form applied in acetone, benzene, and xylene were active for more than 5 weeks.

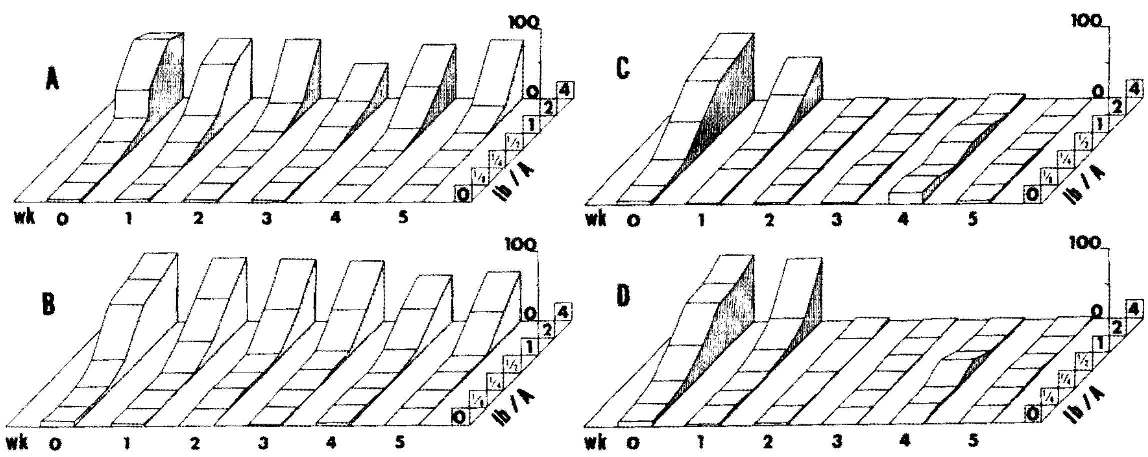


Figure 1. Inactivation of R-1870 in soil as percentage growth inhibition of ryegrass. (A) Commercial formulation in 40 gpa water and pure R-1870 in 40 gpa of (B) benzene, (C) kerosene, and (D) No. 2 fuel oil.

B. EPTC inactivation vs. volume of solvent. Increasing the volume of kerosene stepwise from 10 to 40 gpa reduced the active period of EPTC from more than 5 weeks to 2 weeks, Figure 2. Use of 80 and 120 gpa did not cause further increases in the rate of inactivation.

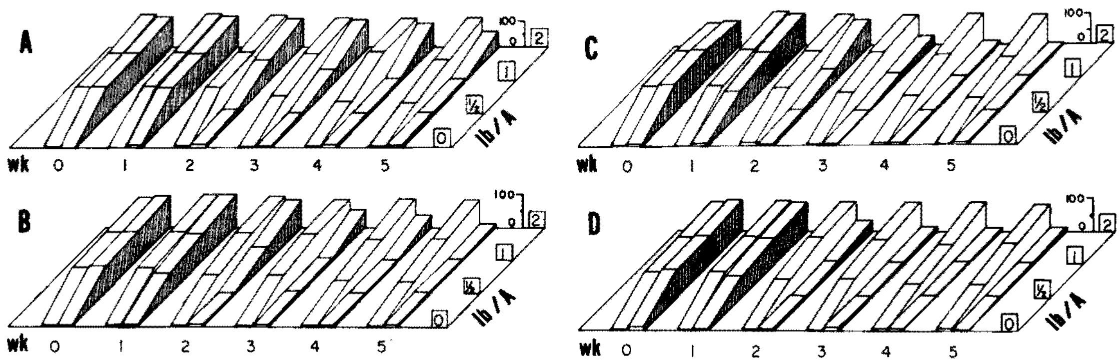


Figure 2. Inactivation in soil of EPTC applied in different volumes of kerosene as percentage growth inhibition of ryegrass. The left-hand curve of each pair is the commercial formulation applied in 40 gpa water. Pure EPTC was applied in kerosene at (A) 10 gpa, (B) 20 gpa, (C) 40 gpa, and (D) 80 gpa.

C. <u>Solvent vs. inactivation of subsurface band placements of EPTC</u>. EPTC in a subsurface band treated with the commercial formulation in water moved upward to the soil surface in 3 weeks and remained active in the surface soil layer for 6 weeks, Figure 3. Pure EPTC applied in the same way in kerosene moved upward to the soil surface in 3 weeks and was inactivated in 2 additional weeks.

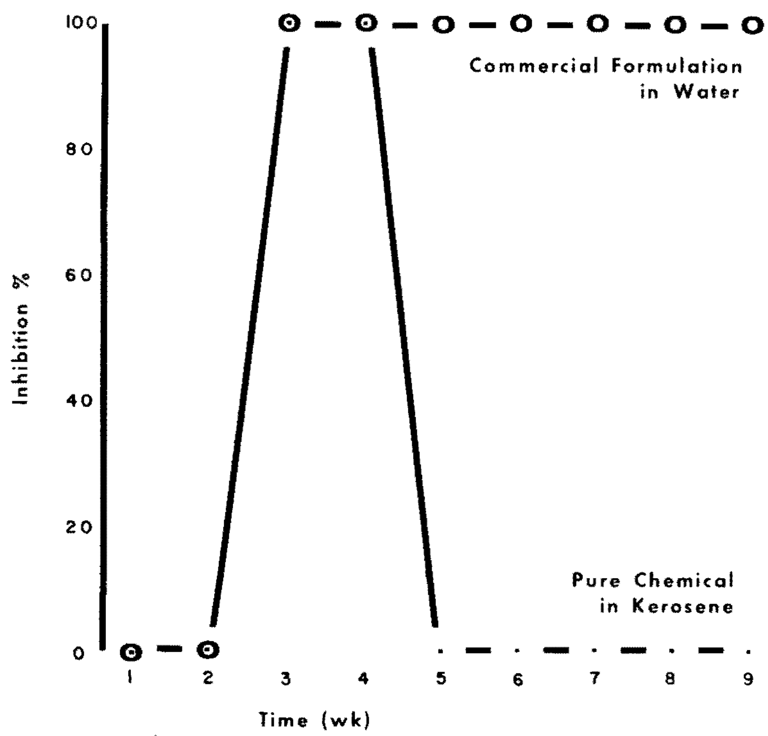


Figure 3. Inactivation of subsurface band placements of EPTC in soil as percentage growth inhibition of ryegrass seeded on the soil surface at weekly intervals.

Regulation of the rate of inactivation of EPTC and R-1870 in soil by the use of a specific solvent such as kerosene at a specific volume could facilitate the use of the rapid rotations required for efficient vegetable and nursery crop production.

The effects observed in these experiments may be explained as follows. EPTC is inactivated slowly in dry soil and rapidly in moist soil (1, 2). Increasing the rate of air movement over moist, treated soil, accelerates the rate of inactivation of EPTC (4). Earlier studies on incorporated treatments (3) and the present results showing the rapid inactivation of EPTC applied in kerosene as subsurface band placements in soil may be explained on the basis of a change in surface tension that facilitates movement of the herbicides to the soil surface where they enter the atmosphere. Increase in rate of inactivation with increase in volume of kerosene up to 40 gpa appears to support this explanation.

Acknowledgments

We gratefully acknowledge the cooperative assistance of the following companies in supplying chemicals and solvents for this research: Stauffer Chemical Company; PPG Industries, Inc.; Monsanto Company; and the Sun Oil Company.

Literature Cited

1. Antognini, Joseph. 1958. Activity of EPTC as affected by soil moisture at time of application. Proc. NEWCC 12:398.

2. Ashton, F. M. and T. J. Sheets. 1959. The relationship of soil adsorption of EPTC to oats injury in various soil types. Weeds 7:88-90.

3. Danielson, L. L., W. A. Gentner, and L. L. Jansen. 1961. Persistence of soil-incorporated EPTC and other carbamates. Weeds 9:463-476.

4. Danielson, L. L. and W. A. Gentner. 1964. Influence of air movement on persistence of EPTC in soil. Weeds 12:92-94.

Table 1. Physical and chemical properties of petroleum fractions used as solvents.

Test	ASTM method	Kerosene	Fuel oil	Xylene
Viscosity SUS/100	D-446	32	34.1	-
Flash, TCC, °F	D-56	129	-	82
Flash, TOC, °F	D-1310	-	-	92
Flash PMCC, °F	D-93	-	163	-
Color	D-1500	-	0.75	-
Gravity, °API	D-287	43.3	33.5	32.2
Gravity, specific	D-1250	0.8090	0.8576	0.8642
Aniline Pt.	D-611	146	135	57.6 (a)
Aromatics %		15	32	94.6 (b)
Distillation	D-86			
Initial °F		374	370	-
10% °F		393	432	-
50% °F		427	490	-
90% °F		464	577	-
E.P. °F		491	633	-
Recovery %		98	98	-
Total Sulfur	D-1266	0.033	0.33	0.0005
Lb per gal.	D-1250	6.736	7.141	7.198
K.B. value				95.4
Color, Saybolt	D-156	26		Pass (c)
Distillation	D-850			
Initial °C				138.4
Dry Point °C				141.3
Recovery, %				98

(a) Mixed Aniline Pt.
(b) By D-1019 acid absorption
(c) Lighter than 0.003 g $K_2Cr_2O_7$/L

ANALYSIS OF KATAHDIN POTATO FOR RESIDUE OF MALORAN 1/

T. W. Kerr, C. E. Olney and R. S. Bell 2/

The herbicide Maloran, 3-(4-bromo-3-chlorophenyl)-1-methoxy-1-methylurea has been shown by Bell and Hillebrecht (1) to be effective for control of wild radish and other broadleaved annual weeds in Katahdin potato. The investigation reported here was undertaken to determine whether measurable amounts of the compound accumulated in the tubers obtained from the same experiment conducted by the above-mentioned authors.

PROCEDURE

The herbicide was applied in 1968 as a pre-emergent treatment at 2 and 3 pounds of active ingredient per acre. At harvest, in early September, from each of 4 replicates 10 to 12 pounds of #1 potatoes were obtained at random from the grader. They were maintained in cold storage until early May, 1969, when 8 tubers from each replicate were washed in tap water, halved lengthwise and finely chopped. After mixing, a subsample was taken for residue analysis. During the latter part of the month, the same procedure was used for a similar number of unwashed tubers. In both instances untreated potatoes were provided.

The potatoes were analyzed by a modification of the Ciba procedure (2). A 150 g. subsample was refluxed in 0.3 N HCl for 3 hours. After cooling, the urea was hydrolyzed to 4-bromo-3-chloroaniline by sodium hydroxide and the hydrolysis product steam distilled and extracted into iso-octane on a Bleidner apparatus (3). The 4-bromo-3-chloroanaline was extracted from the iso-octane with 0.25 N HCl diazotized and coupled with N-1-naphthylethylenediamine to produce a purple dye. The solution was transferred to a cellulose column and contaminating dyes from plant material were eluted with 150 ml of 1 N HCl-acetic acid (9 + 1). The azo dye of the 4-bromo-3-chloroanaline was eluted then with 1 N HCl-acetic acid (1 + 2), diluted to 25 ml and its absorbance at 550 nm measured on a spectrophotometer.

RESULTS

None of the samples, treated or untreated, washed or unwashed, contained Maloran residue exceeding 0.03 ppm, the limit of sensitivity of the analytical method.

1/ Contribution #1334, Rhode Island Agricultural Experiment Station, a contribution from Regional Research Project NE-36.

2/ Entomologist, chemist and agronomist, respectively.

LITERATURE CITED

1. Bell, R. S. and W. R. Hillebrecht. 1969. The control of wild radish and other annual weeds in Katahdin potatoes. Proc. NEWCC 23:104-107.

2. Anonymous. May 1968. Methods of analysis for residues of 3-(4-bromo-3-chlorophenyl)-1-methoxy-1-methylurea (C-6313) by spectrophotometry. Ciba Research Bulletin No. 45.

3. Pease, M. L. 1962. Separation and colorimetic determination of monuron and diuron residues. Jour. Agr. Food Chem. 10:279-81.

TRIPHENYL TETRAZOLIUM CHLORIDE ASSAY FOR HERBICIDAL ACTIVITY

G. W. Burt, J. V. Parochetti, and I. M. Wedderspoon[1/]

Abstract

The ability of plant tissue to reduce triphenyl tetrazolium chloride (TTC) was used as a quantitative estimate of plant tissue viability. Briefly, this technique consists of placing approximately 100 mg of tissue into 3 ml of a buffered (pH 7.4) 0.6% solution of TTC. This tissue was incubated in the solution for 16 hours at 30C after which it was extracted with boiling 95% ethanol. The amount of reduced TTC was used as a quantitative estimate of viability and was measured as an increase in optical density at 520 mu.

Experiments with Johnsongrass (*Sorghum halepense* L.) rhizomes not treated with herbicide showed that the nodes reduced more TTC than the internodes. TTC reaction within the first 3 nodes from a growing point were often higher than the remainder of the rhizome with the exception of internode 2 or 3 which reduced less TTC than other internodes.

TTC was used to assay for metabolic activity of rhizomes previously soaked in dalapon solutions, (0, 10^{-5}, 10^{-4}, 10^{-3} M). These rhizomes were obtained from both a dalapon resistant and a dalapon susceptible selection of Johnsongrass. They were soaked in dalapon solutions for 24 hours, placed in moist vermiculite for different time intervals, and subsequently harvested and assayed for metabolic activity. TTC activity of the dalapon susceptible selection was initially reduced by dalapon treatment, but was increased one week after the initiation of the experiment. The resistant selection responded less and more slowly than the susceptible selection. Freezing these dalapon treated rhizome pieces with subsequent TTC assay indicated that dalapon increased the frost hardiness of the rhizomes at high concentrations of dalapon but reduced hardiness at concentrations where TTC assay indicated an increase in metabolic activity. This technique has been found to be useful in studying the interactions of many metabolites and environmental conditions on herbicidal activity.

1/ Assistant Professors and Graduate Assistant, respectively, Department of Agronomy, University of Maryland, College Park, Maryland 20742

QUANTITATIVE SEPARATION AND DETECTION OF INORGANIC ARSENICALS AND CACODYLIC ACID IN PLANT TISSUE

Roy M. Sachs,[1,2] Frank B. Anastasia,[1] and William A. Wells[1]

ABSTRACT

Cacodylic acid is readily separated from the inorganic arsenicals III and V by paper and thin layer chromatography. The former method is most useful in the fractionation of plant extracts. Among several solvent systems tested, n-propanol:ammonium hydroxide (7:3) gave the widest separation. When pure samples of the three arsenicals were chromatogrammed the arsenic was detected using a silver spray. Confirmation of Rf values was accomplished by a wet-ash digestion of the chromatograms and subsequent detection of arsenic using the silver diethyldithiocarbamate method.

In the detection of arsenic fractions from plant extracts, a wet-ash digestion of the resulting chromatogram was necessary, because of interfering silver nitrate positive fractions. Aqueous extracts of fresh tissue gave higher arsenic recovery than similar extracts using dried tissue. Alkaline extracts of dried tissue gave better recovery rates than either neutral or acidic extracts.

[1] Plant Physiologists, Plant Sciences Laboratories, Fort Detrick, Frederick, Maryland 21701

[2] On leave from the University of California, Davis, California 95616

WEED CONTROL AND CROP RESPONSE OF BEANS, CORN AND CUCUMBERS TREATED WITH DIPHENAMID-DINOSEB, UC22463 OR NITROFEN (TOK) E-25 ALONE AND IN COMBINATION WITH DIMETHYL-SULFOXIDE (DMSO)

George J. Gebe, Jr.1/ and C. A. Langer2/

Introduction

Superior herbicides with wide spectrum weed control must be developed and tested to reduce cost of production and to increase quality of produce. Three experimental herbicides, UC22463 (Sirmate), Diphenamid and DNBP (Enide-Dinitro), and Tok E-25 (Nitrofen or FW925), have shown promise in controlling weeds in several types of crops.

Additives that increase herbicidal activity without being phytotoxic by themselves are also of interest. One material, Dimethyl Sulfoxide (DMSO), increases the semi-permeability of the plant membrane. In this study DMSO was used as a pretreatment as an attempt to increase transport of herbicidal molecules across the cell membranes and thus into the water transport system of the plant.

Materials and Methods

Experimental plots were established in 1968 at the University of New Hampshire Horticulture Farm at Durham. Approximately 15 tons of manure per acre was plowed and disked in prior to planting. On June 18, the test area was marked into plots. Each of the plots was hand-planted with one of 3 crops; corn, beans or cucumbers. The corn and beans were spaced 6 inches apart (20 seeds per row). The cucumbers were planted in hills, 8 seeds per hill and the hills spaced 24 inches apart. Specific seed numbers allowed use of emergence data as one check on the toxicity of the herbicide to the crop.

The design was a randomized block consisting of 2 replications. Each replicate included a total of 30 treatments on each crop. The herbicides were applied on June 19, immediately after planting. Where DMSO was part of the treatment, it was applied separately and followed immediately by the herbicide. This procedure was used to decrease the danger resulting from accidental spillage. Each treatment was applied using a Co_2 small-plot sprayer equipped with non-drip nozzles on a 6 foot boom.

1/ Graduate Assistant, Plant Science Department, University of New Hampshire, Durham, New Hampshire.

2/ Professor of Horticulture, Plant Science Department, University of New Hampshire, Durham, New Hampshire.

Emergence counts were taken in each plot on July 1, one week after all plants had emerged in control plots. On the first emergence count, certain seedlings showed toxicity symptoms; therefore, on July 9 a second observation was made to ascertain if the affected plants had recovered.

Observations were made throughout the growing season to evaluate weed control and crop plant injury within the specific plots.

The snap beans were harvested from each plot and weighed on a spring scale immediately following picking. Cucumber yield data included the total number of specimens plus their weight. Sweet corn production was measured by the number of saleable ears.

The data were analyzed by standard variance analysis.

Results and Discussion

Good to excellent weed control was obtained from UC22463 at 6 and 8 lbs./acre in beans, corn and cucumbers. Other researchers reported acceptable weed control in beans and corn at the 4, 6 and 8 lbs./acre rate (1, 2, 3, 4).

Applications of UC22463 made directly to the soil do not inhibit seed germination. Upon emergence, however, seedlings can be killed by absorption of the chemical at the soil surface. Cucumbers were damaged severely after emergence at 8 lbs./acre resulting in low production. Sensitive plants become chlorotic since chlorophyll synthesis apparently is inhibited by UC22463 (1). Acceptable yields were obtained at the 6 lbs./acre rate with less injury evident to the crop plants. Although some decrease in mean emergence was observed at higher rttes of UC22463, good production of beans and corn was obtained at the 6 and 8 lbs./acre rate.

Emergence, compared to the cultivated controls, was markedly reduced when Tok E-25 was applied at 4 and 6 lbs./acre rate in beans and cucumbers. Corn emergence was not affected by the application rate of Tok E-25. Injury to corn did appear at the 4 and 6 lbs./acre rate after crop emergence. The leaves of the corn seedlings were curled or rolled toward the main axis of the plant and the margins and tips were either burned or slightly chlorotic in appearance. However, after two weeks, the plants outgrew these toxicity symptoms and normal plants developed. Tok E-25, however, attained only fair occasionally poor weed control. As a result, production levels of all three crops were low because of competition from weeds.

Enide-Dinitro E. C., at the 7 and 5 lbs./acre rate, caused excess injury to cucumber seedlings reflected in poor yields. Decreasing rates resulted in improved emergence of this crop. Bean and corn emergence was not affected by the several rates of Enide-Dinitro. While slight chlorotic and stunting condition was observed, it disappeared in two weeks.

As the rate of Enide-Dinitro application was increased, weed control became more effective, particularly at the 7 and 5 lbs./acre rates in beans and corn. Poor weed control and crop production was experienced at the 1 and

3 lbs./acre rate of Enide-Dinitro. Similar results were reported by Langer and Gebe (2).

DMSO applied as a two percent solution did not enhance herbicidal activity of any of the chemicals tested. Possibly it lost some effectiveness applied as a pre-treatment. Different results might have been obtained if it had been directly mixed into the herbicidal solution.

The unusually heavy precipitation in June, 1968 may account for the results of this trial. It is believed that this heavy precipitation leached the active herbicide chemical and reduced the length of weed control.

Literature Cited

1. Anonymous. 1967. Sirmate - Technical Information Bulletin, Union Carbide Corporation, New York, New York.

2. Langer, C. A. and G. Gebe. 1969. The effects of UC22463, metobromuron and diphenamid - DNBP on weed control in beans, peas and sweet corn. Proc. N.E.W.C.C. 23:17-20.

3. Noll, C. J. 1968. Chemical weeding of lima beans. Proc. N.E.W.C.C. 22:13.

4. Wilson, H. P., J. B. Regan, E. J. Visinski, and R. D. Ilnicki. 1967. Preplant incorporated and Pre-emergenced applications of herbicides in snap beans and lima beans. Proc. N.E.W.C.C. 21:1-8.

Table 1. Mean emergence in Beans, Corn and Cucumbers untreated and treated with UC22463, Enide-Dinitro or Tok E-25 with and without Dimethyl Sulfoxide.

Treatment Material	Herbicide Rate[1]	Treatment Means: No. of plants emerged per plot — Beans	Corn	Cucumbers
UC22463 (Sirmate)	8	15.5[e]	18.0	23.5
	6	18.0	19.0	33.5
	4	17.0	18.5	18.5
	2	18.5	19.0	25.0
UC22463 + DMSO[2]	8	17.0	19.5	18.0
	6	16.5	19.0	31.5
	4	17.5	18.5	29.0
	2	18.5	19.5	28.0
Diphenamid and DNBP (Enide-Dinitro E. C.)	7	18.5	19.5	10.0[e]
	5	16.0	19.5	7.5
	3	17.0	17.5	15.5
	1	18.5	19.5	25.5
Diphenamid and DNBP + DMSO[2]	7	17.0	18.0	3.5
	5	18.5	17.5	10.5
	3	17.0	19.0	19.0
	1	18.0	20.5	24.5
Tok E-25	6	13.5[eq]	15.5	13.0[e]
	4	13.5	17.5	21.0
	2	18.5	15.5	33.0
Tok E-25 + DMSO[2]	6	14.5	14.5	19.0
	4	14.5	17.0	22.5
	2	17.5	18.5	20.5
Cultivated Control	-	18.0	19.5	33.5

1 - Active ingredients lbs./acre
2 - Dimethyl Sulfoxide at 2% of total solution
e - Significant linear effect of rate
q - Significant quadratic effect of rate

Table 2. Mean weed control in Beans, Corn and Cucumbers untreated and treated with UC22463, Enide-Dinitro or Tok E-25 with and without Dimethyl Sulfoxide.

Treatment Material	Herbicide Rate[1]	Treatment Means[3]		
		Beans	Corn	Cucumbers
UC22463 (Sirmate)	8	9.0[e]	9 [e]	8.5
	6	8.5	7	8.0
	4	7.0	6.5	5.5
	2	6.0	4.0	2.5
UC22463 + DMSO[2]	8	8.5	9.0	8.0
	6	8.0	8.0	7.5
	4	7.0	4.0	7.0
	2	5.0	3.5	5.0
Diphenamid and DNBP (Enide-Dinitro E. C.)	7	9.5[e]	9.5[e]	9.0
	5	9.0	9.0	9.0
	3	3.0	8.5	9.0
	1	5.5	6.5	5.0
Diphenamid and DNBP + DMSO[2]	7	9.5	10.0	9.0
	5	9.0	9.5	8.5
	3	7.5	7.5	7.0
	1	5.0	4.5	3.0
Tok E-25	6	6.0[e]	7.0	4.5
	4	4.5	5.5	6.0
	2	2.5	5.0	4.5
Tok E-25 + DMSO[2]	6	5.5	7.0	7.0
	4	4.5	6.5	5.5
	2	4.0	3.5	1.5
Cultivated Control	-	10.0	10.0	10.0

1 - Active ingredients lbs./acre
2 - Dimethyl Sulfoxide at 2% of total solution
d - 0 = No weed control; 10 = complete weed control
e - Significant linear effect of rate
q - Significant quadratic effect of rate

Table 3. Production in Beans, Corn and Cucumbers, untreated and treated with UC22463, Enide-Dinitro or Tok E-25 with and without Dimethyl Sulfoxide.

Treatment Material	Herbicide Rate[1]	Treatment Means		
		Beans Lbs./plot	Corn No. Ears/plot	Cucumbers Lbs./plot
UC22463 (Sirmate)	8	2.70[eq]	18.5[deq]	13.75
	6	3.22	18.0	42.37
	4	2.69	11.5	25.00
	2	1.35	12.0	20.00
UC22463 + DMSO[2]	8	2.72	16.5	23.00
	6	3.07	12.5	23.00
	4	2.09	7.0	13.75
	2	1.78	10.0	33.50
Diphenamid and DNBP (Enide-Dinitro E. C.)	7	3.40[e]	16.5[eq]	13.00
	5	2.77	13.0	6.25
	3	2.30	15.0	25.12
	1	2.40	4.5	7.25
Diphenamid and DNBP + DMSO[2]	7	2.60	17.5	5.00
	5	3.22	13.5	11.75
	3	1.54	13.0	8.12
	1	2.51	8.5	16.00
Tok E-25	6	1.59	12.0[e]	3.75
	4	.87	5.0	12.25
	2	1.42	1.1	6.75
Tok E-25 + DMSO[2]	6	.79	9.5	.75
	4	1.15	7.0	3.00
	2	1.41	1.0	.50
Cultivated Control		3.15	16.0	32.37

1 - Active ingredients lbs./acre
2 - Dimethyl Sulfoxide at 2% of total solution
d - Significant effect of DMSO
e - Significant linear effect of rate
q - Significant quadratic effect of rate

CHEMICAL WEEDING OF LIMA BEANS

Charles J. Noll [1/]

Lima beans respond well to good weed control practices by producing larger yields of beans. Earlier weeding trials indicated that Lima beans was tolerant of a number of herbicides. This experiment was designed to evaluate the most promising of these chemical weed killers.

Procedure

The weeding trials were conducted at the Horticultural farm located 10 miles west of University Park. The soil, a Murrill loam, was plowed in the Fall of 1968 and the seedbed prepared June 16, 1969. Pre-planting treatments were applied and incorporated into the soil June 17 and seeded immediately to the Lima bean variety Fordhook 242. Pre-emergence treatments were applied the day of seeding or 7 days after seeding, just prior to bean emergence. An estimate of weed control was made August 7 on a basis of 1 to 9: 1 being least desirable, no weed control and 9 most desirable, complete weed control.

Single row plots were 29 feet long and 3 feet wide. Treatments were randomized in each of 8 blocks. All chemicals were applied in a 2 foot band over the row. Cultivation controlled the weeds between the rows. The beans were harvested September 25.

Results

The results are presented in Table 1. All herbicides in the trials significantly reduced the weed population without reducing the stand of plants as compared to the unweeded plot. Taking into consideration weed control, stand of plants and yield of beans, the following are the most promising treatments. In the incorporated treatments trifluralin at 1 lb. per acre. In the pre-emergence treatments Amiben ME at 4 lbs. per acre, propachlor at 4 lbs. per acre, TH 469 at 3 and 6 lbs. per acre, H 16993 at 4 and 6 lbs. per acre or CP 50144 at 3 lbs. per acre. In the delayed pre-emergence treatment DNBP at 4 lbs. per acre gave excellent weed control with good yield. A number of combinations of these chemicals also resulted in excellent weed control with good yields.

[1/] Associate Professor of Olericulture, Department of Horticulture, College of Agriculture Experiment Station, The Pennsylvania State University, University Park, Pa.

Table 1. Weed control, number of plants and weight of Lima beans under chemical herbicide treatments.

Treatment	Active Rate lbs/A	Application Days from Planting	AVERAGE PER PLOT Weed Control 1-9	Number of Plants	Wt. Beans Lbs.
1 Nothing	--	---	1.0	40.4	9.6
2 Trifluralin	1	Inc -0	9.0	49.2	16.9
3 Nitralin (Planavin)	2	"	8.6	32.0	13.7
4 Trifluralin + Nitralin	1/2 + 1	"	8.8	42.6	17.6
5 H 16993	4	"	8.9	40.2	13.7
6 Trifluralin & Amiben	1/2 & 2	" & Pre +0	8.9	48.4	16.9
7 " "	1 & 4	" "	9.0	47.4	18.1
8 Amiben ME	4	Pre +0	8.9	52.0	19.3
9 VCS 437	2	"	9.0	40.8	16.8
10 "	3	"	9.0	40.2	14.6
11 VCS 438	2	"	7.5	40.6	15.6
12 "	3	"	8.8	35.6	15.1
13 TH 469	3	"	9.0	44.2	16.4
14 "	6	"	9.0	43.0	18.2
15 AC 72986	3/4	"	9.0	42.6	18.5
16 "	1-1/2	"	8.9	39.2	14.5
17 AC 78126	3/4	"	8.9	48.8	17.6
18 "	1-1/2	"	9.0	35.2	14.6
19 H 16993	4	"	9.0	43.0	15.4
20 "	6	"	8.8	48.0	15.3
21 C 6989 (Preforan ec)	4	"	9.0	38.0	15.8
22 "	6	"	9.0	29.0	12.7
23 C 6989 (Preforan wp)	4	"	9.0	34.8	15.1
24 "	6	"	9.0	31.2	14.9
25 RP 17623	4	"	9.0	31.0	6.2
26 "	6	"	9.0	29.2	5.0
27 CP 50144	3	"	9.0	45.6	17.9
28 Propachlor (Ramrod)	4	"	8.9	52.4	17.5
29 Amiben + Propachlor	2+2	"	8.9	52.0	18.1
30 DNBP	4	Pre +7	9.0	39.0	16.9
Least Significant Difference	5%		0.6	12.8	3.4
" " "	1%		0.8	17.0	4.5

WEED CONTROL IN TRANSPLANTED CUCUMBERS

Richard A. Ashley[1]

Experiments were conducted on the University of Connecticut Vegetable Research Farm, North Coventry, Connecticut to evaluate several herbicides and herbicide combinations for weed control and crop injury in transplanted cucumbers.

Materials and Methods

Cucumber (Cucumis sativus L.) cv. Marketmore were seeded in 2¼ inch peat pots in the greenhouse May 21, 1969. Plants were transplanted into the field June 24, 1969, set 18 inches apart in 5 foot rows. Experimental plots consisted of an area 4 feet wide over the row and 15 feet long with a 1 foot wide untreated area between plots. Treatments were arranged in a randomized block design with treatments replicated 3 times. The soil was a Merrimac fine sandy loam.

Pre-plant incorporated applications of DCPA at 12 lb/A, bensulide at 6 lb/A, and nitralin at 1 lb/A were made June 23, 1969. Herbicides were incorporated immediately after application to a depth of 1-1½ inches by raking.

Bensulide at 6 lb/A was also applied pre-plant incorporated as described above, then pre-transplant applications of CDEC at 2 lb/A, naptalam sodium salt at 2 lb/A, and dinoseb at 2 lb/A applied over the top to form combination treatments. Naptalam at 4 lb/A was also applied alone. Pre-transplant applications were made on June 24, 1969.

Post-transplant treatments of DCPA at 10 lb/A and trifluralin at 1 lb/A were applied to clean cultivated plots on July 14, 1969. Trifluralin treated plots were then again lightly cultivated to incorporate the herbicide.

All treatments were applied using a 3 gallon knap sack sprayer and 1 gallon of spray per plot. All rates are given in pounds of active ingredient per acre.

Predominant weed species in the experimental area were: large crabgrass (Digitaria sanguinalis (L.) Scop.), witch grass (Panicum capillare L.), purslane (Portulaca oleracea L.), lamb's quarters (Chenopodium album L.) and redroot pigweed (Amaranthus retroflexus L.). Purslane was by far the dominant species.

Weed ratings were taken based on the above species to determine control of broadleaf weeds and annual grasses. A 0 to 10 scale was used with 0 indicating no effect and 10 representing complete kill. Similar ratings were taken for crop stand and vigor.

Yield data were taken on August 6, August 18, and September 11, 1969 to determine the effect, if any, on early and total yield.

---

[1] Assistant Professor of Horticulture, University of Connecticut, Storrs, Conn.

Results and Discussion

Excellent full season weed control was obtained with DCPA at 12 lb/A pre-plant incorporated or 10 lb/A post-transplant, trifluralin at 1 lb/A, nitralin at 1 lb/A and bensulide + CDEC at 6 + 2 lb/A (Table 1). Excellent early control of both broadleaf weeds and annual grasses was obtained with bensulide + naptalam at 6 + 2 lb/A and bensulide + dinoseb at 6 + 2 lb/A but control of broadleaf weeds, particularly purslane, decreased late in the season. Bensulide alone, provided season long control of annual grasses but purslane, pigweed and lamb's quarters were present in fair numbers in the plots by the September 3, 1969 rating. Even though significant differences in weed control were observed neither early nor total yields were affected.

Significant crop injury was observed with the bensulide + CDEC combination in the form of reduced vigor. However, this injury did not depress yields.

TABLE 1. COMPARISON OF SEVERAL HERBICIDES AND HERBICIDE COMBINATIONS FOR WEED CONTROL IN TRANSPLANTED CUCUMBERS.

Treatment	Applied	Weed Control Rating, 7/14/69 ABLW[2]	Weed Control Rating, 7/14/69 AGW[2]	Weed Control Rating, 9/3/69 ABLW[2]	Weed Control Rating, 9/3/69 AGW[2]	Crop Vigor[1] 9/3/69	Total Yield[6] Lb.
DCPA, 12 lb/A[3]	PPI	9	10	8	9	0	150.4
DCPA, 10 lb/A[4]	Post-trans.	–	–	9	8	1	111.8
Bensulide, 6 lb/A[3]	PPI	8	9	7	9	0	192.9
Trifluralin, 1 lb/A[4]	Post-trans.	–	–	9	7	0	154.8
Nitralin, 1 lb/A[3]	PPI	9	10	8	8	0	173.4
Bensulide, 6 lb/A+[3]	PPI	9	10	8	9	3	139.1
CDEC, 2 lb/A[5]	Pre-trans.						
Bensulide, 6 lb/A+[3]	PPI	9	10	7	9	0	179.1
Naptalam, 2 lb/A[5]	Pre-trans.						
Naptalam, 4 lb/A[5]	Pre-trans.	5	7	6	7	0	132.6
Bensulide, 6 lb/A+[3]	PPI	9	9	7	9	0	150.5
dinoseb, 2 lb/A[5]	Pre-trans.						
Cultivated check		–	–	–	–	–	140.8
L.S.D. 5%		2	2	2	3	2	N.S.

1/ Average of 3 replications. 10 = complete kill, 0 = no effect.
2/ ABLW = annual broadleaf weeds. AGW = annual grassy weeds.
3/ Applied 6/23/69.
4/ Applied 7/14/69.
5/ Applied 6/24/69.
6/ Average yield of 3 plots 4x15 feet. Represents total of 4 harvests.

WEED CONTROL IN TRANSPLANTED CUCUMBERS UNDER CLEAR PLASTIC

Richard A. Ashley[1]

Experiments were conducted on the University of Connecticut Vegetable Research Farm, North Coventry, Connecticut to evaluate several herbicides and herbicide combinations with regard to weed control and crop injury in transplanted cucumbers under clear plastic mulch.

Materials and Methods

Cucumbers (Cucumis sativus L.) cv. Marketmore were seeded in 2¼ inch peat pots in the greenhouse May 8, 1969 and transplanted into treated field plots on June 13, 1969. Plants were spaced 18 inches apart in 5 foot rows. Treatments were arranged in a randomized block design with treated plots consisting of one row 4 feet wide and 15 feet long with a 1 foot wide untreated area between each plot. Treatments were replicated 3 times. Soil type was a Merrimac fine sandy loam.

Early pre-plant applications of bensulide + dinoseb at 6 + 2 lbs/A, DCPA + dinoseb at 12 + 2 lbs/A and dinoseb alone at 6 lbs/A were made May 22, 1969. Bensulide was incorporated to a depth of 1-1½ inches by raking immediately after treatment. All rates are in pounds active ingredient.

Applications of bensulide at 6 lbs/A and DCPA at 12 lbs/A pre-plant incorporated, CDEC at 2 lbs/A pre-plant, and bensulide at 6 lbs/A pre-plant incorporated + CDEC at 2 lbs/A pre-plant were made June 13, 1969. Pre-plant incorporated treatments were incorporated immediately after application to a depth of 1-1½ inches by raking.

Within 10 minutes of treatment, plots were covered with a 1.5 mil clear polyethylene film. Additional untreated plots were covered with clear and black polyethylene film to serve as controls.

The predominant weed species present in the experimental area were: large crabgrass (Digitaria sanguinalis (L.) Scop.), witch grass (Panicum capillare L.), purslane (Portulaca oleracea L.), lamb's quarters (Chenopodium album L.), and redroot pigweed (Amaranthus retroflexus L.). Purslane was by far the dominant species.

Weed ratings were taken to determine the control of the above broadleaf weeds and annual grasses using a 0 to 10 scale with 0 indicating no effect and 10 representing complete kill. Similar ratings were taken for crop stand and vigor.

Yield data was taken on July 25, August 8, August 18 and September 11, 1969 to determine the effect, if any, on early and total yield.

1/ Assistant professor of Horticulture, University of Connecticut, Storrs, Conn.

Results and Discussion

Excellent full season weed control was obtained with all materials tested except bensulide at 6 lbs/A which gave poor control of the broadleaf species present (Table 1).

Significant decreases in crop vigor were noted with all treatments containing dinoseb. The result of this decreased crop vigor was evident in the total yield where plants treated with dinoseb at 6 lbs/A or bensulide + dinoseb at 6 + 2 lbs/A yielded no more than the weedy check despite excellent weed control. Yields for the weedy check were 24.3 lbs. as compared to 23.3 for plots treated with dinoseb and 25.6 for the bensulide + dinoseb combination. Yields from these two treatments were also significantly below the weed-free check (black plastic) which yielded 45.2 lbs. per plot. Early yields did not differ significantly.

TABLE 1. COMPARISON OF SEVERAL HERBICIDES AND HERBICIDE COMBINATIONS FOR WEED CONTROL IN TRANSPLANTED CUCUMBERS UNDER CLEAR PLASTIC.

Treatment	Applied	Weed Control Rating, 7/14/69 1/ ABLW 2/	AGW 2/	Weed Control Rating, 9/3/69 1/ ABLW 2/	AGW 2/	Crop Vigor 1/ 7/14/69	9/3/69	Total Yield 5/ Lb.
Untreated	——	0	0	0	0	0	0	24.3
Black Plastic	——	7	10	9	9	0	0	45.2
Bensulide, 6 lb/A 3/	inc.	5	8	6	7	0	0	56.4
Bensulide, 6 lb/A+ dinoseb, 2 lb/A 4/	inc. surface	10	10	9	7	1	3	25.6
DCPA, 12 lb/A 3/	inc.	9	10	9	9	0	0	66.3
Dinoseb, 6 lb/A 4/	surface	10	10	8	10	0	3	23.3
CDEC, 2 lb/A 3/	surface	8	7	9	9	0	0	45.5
DCPA, 12 lb/A+ 4/ dinoseb, 2 lb/A	surface surface	8	7	9	7	1	2	30.3
Bensulide, 6 lb/A+ 3/ CDEC, 2 lb/A	inc. surface	9	9	8	10	1	1	46.4
L.S.D. 5%		3	3	2	2	N.S.	2	19.2

1/ Average of 3 replications. 10 = complete kill, 0 = no effect.
2/ ABLW = annual broadleaf weeds. AGW = annual grassy weeds.
3/ Applied June 13, 1969.
4/ Applied May 22, 1969.
5/ Average yield of 3 plots 4x15 feet. Represents total of 4 harvests.

PRETRANSPLANT INCORPORATED AND POSTTRANSPLANT HERBICIDE TREATMENTS FOR WEED CONTROL IN TOMATOES[1/]

Oscar E. Schubert and C. E. Hickman[2/]

Abstract. The following herbicides were applied as pretransplant, incorporated treatments for tomatoes: diphenamid, 6 lb/A ai; nitralin, 0.75 lb/A ai; pebulate 6 lb/A ai; trifluralin, 0.5 lb/A ai; bensulide + trifluralin, 4 + 0.5 lb/A ai; diphenamid + pebulate, 6 + 6 lb/A ai; and pebulate + trifluralin, 6 + 0.5 lb/A ai. The herbicides were incorporated by cross-disking to a depth of about three inches and irrigated the same day following the setting of Heinz 1370 tomato plants. All treatments, except pebulate, gave satisfactory weed control from June 26 until October 20, 1969. Total yields were not significantly different from each other or check for the harvest period from September 11 to October 4.

The following herbicides were applied as posttransplant, broadcast treatments for Heinz 1370 tomatoes set the day before (June 25): methyl ester of amiben, 4 lb/A ai; diphenamid, 6 lb/A ai; methyl ester of amiben + diphenamid, 2 + 4 and 4 + 6 lb/A ai; and bensulide + diphenamid, 4 + 6 lb/A ai. All treatments, except the methyl ester of amiben, gave satisfactory weed control from June 26 to October 20. Plants from the bensulide + diphenamid-treated plots had higher total yields than check for the period of September 10 to 17. All other treated plots did not differ significantly from the check in yields.

INTRODUCTION

The posttransplant application of N,N-dimethyl-2,2-diphenylacetamide (diphenamid) has been one of the most reliable treatments for weed control in previous herbicide experiments with tomatoes (1,2,3,4,5); however, weeds like common ragweed (*Ambrosia artemisiifolia* L.), black nightshade (*Solanum nigrum* L.), and ladysthumb (*Polygonum persicaria* L.) have been problems. Since it may be more convenient for some growers to make pretransplant applications these were evaluated and were compared with posttransplant treatments in an adjoining block. The primary objective was to evaluate the following herbicides either alone or in certain combinations as pretransplant, incorporated treatments: diphenamid; 4-(methylsulfonyl)-2,6-dinitro-N,N-dipropylaniline (nitralin); S-propyl butylethylthiocarbamate (pebulate); a,a,a,-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine (trifluralin) and O,O-diisopropyl phosphorodithioate with N-(2-mercaptoethyl) benzenesulfonamide (bensulide). The secondary objective was to evaluate the following herbicides as posttransplant treatments: 3-acetamido-2,5-dichlorobenzoic acid (the methyl ester of amiben), diphenamid, bensulide plus diphenamid, and two combinations of the methyl ester of amiben plus diphenamid.

MATERIALS AND METHODS

Pretransplant, incorporated treatments: The field (Monongahela sandy loam) for all pretransplant, incorporated treatments was marked into plots 12 feet wide and 20 feet long. The herbicide treatments (Table 1) were

[1/]Published with the approval of the Director of the West Virginia University Agricultural Experiment Station as Scientific Paper No. 1098.

[2/]Horticulturist and Assistant Horticulturist, West Virginia University, Morgantown, West Virginia.

applied in two passes with a 6-foot boom mounted on the rear of a 4-wheel Bolens garden tractor. Four TeeJet 8004 nozzles on the boom were used to apply the herbicides in 50 gpa. Tank mixes were used where two herbicides were included in a treatment. A carbon dioxide cylinder with regulator was used to supply a constant pressure of 33 psi. The CO_2 for spraying was introduced into the bottom of the stainless steel tank with a jet agitator to provide agitation and to prevent settling of herbicides. A small amount of CO_2 was bled-off continuously to provide agitation between spraying of individual plots. The sequence of treatment applications (Table 1) was arranged to provide the practical minimum of time between application of herbicides requiring incorporation and subsequent incorporation by cross-disking. Treatments of diphenamid and nitralin were applied on the 26th of June since incorporation within three and two days, respectively, is acceptable. Trifluralin and bensulide plus trifluralin were applied first on the following morning since a leeway of perhaps four hours would be permissible. Treatments involving pebulate were applied between 8:00 and 8:55 AM EDT on June 27. Stakes were removed, and the entire field was cross-disked (second pass perpendicular to the first) to a depth of about three inches between 9:00 and 9:20 AM EDT. More time elapsed between application of pebulate and incorporation than is recommended. The individual plots were re-marked from permanent corner stakes and the rows were laid-off with a 2-row furrowing shovel. Heinz 1370 tomato plants were set between 10:00 and 12:00 AM EDT the same day (June 27). Twelve plants per plot were set three feet apart in rows four feet apart. The planting was irrigated with about one and one-half inches of water starting at 3:00 PM EDT the same day.

Table 1. Pretransplant, incorporated herbicide treatments[1/]

Herbicides and Formulation	Rate lb/A ai	Time	Day
Check--no herbicides applied		Hoed three times	
Diphenamid, 50 wp	6	7:25-7:50 PM	June 26
Nitralin, 75 wp	0.75	8:20-8:40 PM	June 26
Pebulate, 6 ec	6	8:45-8:55 AM	June 27
Trifluralin, 4 ec	0.5	7:20-7:35 AM	June 27
Bensulide + trifluralin, 4 ec + 4 ec	4 + 0.5	7:40-7:55 AM	June 27
Diphenamid + pebulate, 50 wp + 6 ec	6 + 6	8:30-8:40 AM	June 27
Pebulate + trifluralin, 6 ec + 4 ec	6 + 0.5	8:00-8:15 AM	June 27

[1/]All herbicides were incorporated to a depth of about three inches by cross-disking. Disking was done between 9:00 and 9:20 AM EDT on June 27. Irrigation of about one and one-half inch started at 3:00 PM EDT on June 27. Temperature reached 92°F on June 26 and 93°F on June 27.

<u>Posttransplant treatments</u>: The field (Monongahela sandy loam) for post-transplant treatments was marked into 12 x 20 foot plots. Heinz 1370 plants were set on June 25 and treatments were applied on June 26, 1969 with equipment described previously.

Table 2. Posttransplant herbicide treatments.[1/]

Herbicides and Formulation	Rate lb/A ai	Time	Day
Check	0	Hoed three times	
Amiben, methyl ester, 2 ec	4	4:55-5:10 PM	June 26
Diphenamid, 50 wp	6	5:20-5:35 PM	June 26
Amiben, methyl ester + diphenamid, 2 ec + 50 wp	2 + 4	5:50-6:10 PM	June 26
Amiben, methyl ester + diphenamid, 2 ec + 50 wp	4 + 6	6:20-6:40 PM	June 26
Bensulide + diphenamid	4 + 6	6:50-7:05 PM	June 26

[1/]Treatments were applied the day after setting. Maximum temperature was 92°F.

Data: Per cent weed control was recorded on July 17, August 21 and October 20, 1969. Tomato plant vigor was noted for the July 17 period. Tomatoes were harvested and graded into No. 1's and culls from September 11 to October 4 for the pretransplant experiment and from September 10 to 17 for the posttransplant experiment. Weed species and their relative size and intensities were recorded for all plots on August 21. Both experiments were set up as randomized complete blocks with eight replications. The data were analyzed by Duncan's Multiple Range Test at the 5 per cent level of significance.

RESULTS AND DISCUSSION

Pretransplant, incorporated treatments: Weed control on July 17, three weeks after treatment, was excellent (Table 3). Eight weeks after treatment (August 21) weed control in the nitralin- and trifluralin-treated plots was inadequate. At the end of the season, 16 weeks after treatment, all herbicide treatments except pebulate alone gave satisfactory weed control. This 'apparent' increase in weed control may have resulted from vigorous tomato plant growth which helped suppress weeds and many of the weeds severely injured by herbicides died or were suppressed greatly.

Nineteen weed species were found in the check plots. Black nightshade, redroot pigweed, common purslane, barnyardgrass, large crabgrass, johnsongrass (some from rhizomes) and fall panicum were the most prevalent and troublesome (Table 4). Of these weeds only redroot pigweed, barnyardgrass, large crabgrass and johnsongrass from seed were controlled by herbicide treatments. Common ragweed, ladysthumb, and prickly sida, which have often been serious problems, were not present in sufficient numbers to be problems even in the check plots. Black nightshade was a serious problem in all treatments and check except the treatment of diphenamid plus pebulate.

Tomato plant vigor was not appreciably affected by the herbicides used (Table 5).

Table 3. Pretransplant, incorporated tomato herbicide treatments and weed control.

Treatment[1/]	Rate lb/A ai	Weed control (100 = complete; 0 = none) July 17	August 21	October 20
Check--hoed three times	0	44c[2/]	68cd	72bc
Diphenamid	6	95ab	90ab	93a
Nitralin	0.75	89b	65d	75abc
Pebulate	6	95ab	82abc	66c
Trifluralin	0.5	88b	59d	76abc
Bensulide + trifluralin	4 + 0.5	94ab	84abc	81abc
Diphenamid + pebulate	6 + 6	96a	94a	90ab
Pebulate + trifluralin	6 + 0.5	96a	74bcd	76abc

1/Treatments of diphenamid and nitralin alone were applied June 26. All others were applied June 27. Plots were cross-disked within one-half hour after last treatment was applied. Plants were set and irrigated the same day.

2/Averages in the same column followed by a common letter are not significantly different from each other according to Duncan's Multiple Range Test at the 5 per cent level.

Yields of No. 1 fruit from plots treated with nitralin and pebulate were lower than from check and trifluralin treated plots but not different from other treatments for the harvest period from September 11 to October 4 (Table 5). Total yields from the various treatments were not different from the check for this interval.

Posttransplant, broadcast treatments: Weed control on July 17 and August 21, three and eight weeks after treatment, was excellent for all herbicide treatments (Table 6). Sixteen weeks after application (October 20) all herbicide treatments gave excellent weed control except the methyl ester of amiben treatment. Under the conditions of this experiment where the field was irrigated the day after treatment there were no advantages of using a second herbicide with the diphenamid. Furthermore, the lower rates of the methyl ester of amiben plus diphenamid (2 + 4 lb/A ai) were just as effective as the higher rates (4 + 6 lb/A ai).

Nineteen weed species were found in check plots of posttransplant treatments (Table 4). The weeds generally were slightly smaller and fewer in number in the treated-plots. Redroot pigweed, carpetweed and barnyardgrass were controlled by all treatments except the methyl ester of amiben. Large crabgrass and goosegrass were controlled by all posttransplant treatments. Only black nightshade and purslane were present in appreciable numbers.

Tomato plant size and vigor was reduced by applications of the methyl ester of amiben either alone or in combination with diphenamid (Table 7). Tomato plants were more severely wilted the day after treatment in treatments containing amiben than in the other treatments. They also showed a moderate amount of epinasty during the first week after treatment. Although plants recovered well, they always remained slightly smaller in size than plants from other treatments and check.

Table 4. Weed species and intensities in pretransplant and posttransplant treatments in tomatoes.

Weed Species	Intensity of Weeds[1/] Pretransplant								Posttransplant					
	Check	Diphenamid	Nitralin	Pebulate	Trifluralin	Bensulide + trifluralin	Diphenamid + pebulate	Pebulate + trifluralin	Check	Amiben, methyl ester	Diphenamid	Amiben,me + diphenamid 2 + 4	Amiben,me + diphenamid 4 + 6	Bensulide + diphenamid
BROADLEAF WEEDS:														
Bindweed, hedge (<u>Convolvulus sepium</u> L.)	1	1	1	0	0	0	0	1	1	0	1	1	0	1
Carpetweed, (<u>Mollugo verticillata</u> L.)	3	1	0	0	0	0	1	1	5	5	0	0	0	0
Copperleaf, Virginia (<u>Acalypha virginica</u> L.)	2	0	0	0	0	0	0	0	2	0	0	0	0	0
Galinsoga, smallflower (<u>Galinsoga parviflora</u> Cav.)	3	0	1	3	0	0	0	1	2	0	0	0	0	0
Horsenettle (<u>Solanum carolinense</u> L.)	1	1	2	1	1	1	1	1	2	1	1	1	1	1
Ladysthumb (<u>Polygonum persicaria</u> L.)	1	0	0	0	0	1	0	0	0	0	0	0	0	0
Lambsquarters, common (<u>Chenopodium album</u> L.)	3	0	0	0	0	0	0	0	3	0	0	0	0	0
Morningglory, ivyleaf (<u>Ipomea hederacea</u> (L.) Jacq.)	1	0	0	1	0	0	1	0	1	0	1	1	0	1
Nightshade, black (<u>Solanum nigrum</u> L.)	4	4	5	5	5	5	2	5	4	2	4	3	2	4
Pigweed, redroot (<u>Amaranthus retroflexus</u> L.)	6	0	1	2	2	1	1	2	5	2	0	0	0	0
Purslane, common (<u>Portulaca oleracea</u> L.)	6	3	5	5	5	5	3	5	6	4	3	2	2	3
Ragweed, common (<u>Ambrosia artemisiifolia</u> L.)	1	0	0	0	0	0	0	0	1	0	0	0	1	0
Sida, prickly (<u>Sida spinosa</u> L.)	1	0	0	0	0	0	0	0	1	0	0	0	0	1
Spurge, spotted (<u>Euphorbia maculata</u> L.)	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Woodsorrel, yellow (<u>Oxalis stricta</u> L.)	0	0	0	0	0	0	0	0	1	2	1	1	1	1
GRASSY WEEDS:														
Barnyardgrass (<u>Echinochloa crusgalli</u> (L.) Beauv.)	6	1	2	2	1	1	1	1	6	3	0	0	0	0
Crabgrass, large (<u>Digitaria sanguinalis</u> (L.) Scop.)	4	2	0	0	2	1	0	1	4	0	0	0	0	0
Goosegrass (<u>Eleusine indica</u> (L.) Gaertn.)	2	0	0	0	0	1	0	0	2	0	0	0	0	0
Johnsongrass (<u>Sorghum halepense</u> (L.) Pers.)	4	2	3	3	3	3	2	3	4	3	2	2	2	2
Panicum, fall (<u>Panicum dichotomiflorum</u> Michx.)	4	1	2	2	2	2	1	2	3	1	1	1	1	1
SEDGES:														
Nutsedge, yellow (<u>Cyperus esculentus</u> L.)	1	1	3	2	3	0	1	1	0	0	0	0	0	0

1/ Intensity of weeds was recorded for each plot with 0 = none observed; 1 = few weeds or small weeds; 2 = several weeds or medium size weeds; 3 = many weeds or several medium size weeds; 4 = very many small to medium weeds; 5 = very many medium to large weeds; and 6 = very many large weeds.

Table 5. Pretransplant, incorporated tomato herbicide treatments, tomato plant vigor and yields.

Treatment[1/]	Rate lb/A ai	Tomato plant Vigor[2/] (July 17)	Yield from 9/11 to 10/4/69 tons/A[3/] No. 1	Culls	Total
Check--hoed three times	0	96a[4/]	12.7a	4.3ab	17.0a
Diphenamid	6	96a	11.8ab	5.6ab	17.4a
Nitralin	0.75	93a	9.6b	5.8a	15.4a
Pebulate	6	93a	9.3b	5.6ab	14.9a
Trifluralin	0.5	96a	13.1a	3.7ab	16.8a
Bensulide + trifluralin	4 + 0.5	93a	11.1ab	5.4ab	16.5a
Diphenamid + pebulate	6 + 6	92a	11.2ab	5.5ab	16.7a
Pebulate + trifluralin	6 + 0.5	90a	10.6ab	3.6b	14.2a

1/Treatments of diphenamid and nitralin alone were applied June 26. All other herbicide treatments were applied June 27. Plots were cross-disked to a depth of about three inches within one-half hour after last treatment was applied. Plants were set and irrigated the same day.

2/Plants were rated on the basis of vigor with the largest plants scoring 100.

3/Yield per plot converted to yield per acre.

4/Averages in the same column followed by a common letter are not significantly different from each other according to Duncan's Multiple Range Test at the 5 per cent level.

Table 6. Posttransplant tomato herbicide treatments and weed control.

Treatment[1/]	Rate lb/A ai	Weed control (100 = complete; 0 = none) July 17	August 21	October 20
Check--hoed three times	0	44b[2/]	76b	61b
Amiben, methyl ester	4	97a	83ab	54b
Diphenamid	6	95a	92a	93a
Amiben, methyl ester + diphenamid	2 + 4	96a	89a	90a
Amiben, methyl ester + diphenamid	4 + 6	96a	92a	91a
Bensulide + diphenamid	4 + 6	96a	93a	94a

1/All treatments were applied on June 26, 1969 the day after setting. The planting was irrigated with about one and one-half inches of water on June 27 the day after treatment

2/Averages in the same column followed by a common letter are not significantly different from each other according to Duncan's Multiple Range Test at the 5 per cent level.

Table 7. Posttransplant tomato herbicide treatments, tomato plant vigor, and yields.

Treatment[1/]	Rate lb/A ai	Tomato plant Vigor[2/] (July 17)	Yield from 9/10 to 9/17/69 tons/A[3/] No. 1	Culls	Total
Check--hoed 3 times	0	92a[4/]	6.3bc	1.6bc	7.9bc
Amiben, methyl ester	4	80b	4.4d	1.0c	5.4c
Diphenamid	6	96a	7.1ab	1.7abc	8.8ab
Amiben, methyl ester + diphenamid	2 + 4	81b	5.3bcd	1.4bc	6.7bc
Amiben, methyl ester + diphenamid	4 + 6	74b	5.2bcd	1.8ab	7.0bc
Bensulide + diphenamid	4 + 6	91a	8.3a	2.3a	10.6a

[1/]All treatments were applied on June 26, 1969 the day after setting. The planting was irrigated with about one and one-half inches of water on June 27 the day after treatment.

[2/]Plants were rated on the basis of vigor with the largest plants scoring 100.

[3/]Yield per plot converted to yield per acre.

[4/]Averages in the same column followed by a common letter are not significantly different from each other according to Duncan's Multiple Range Test at the 5 per cent level.

Yields of No. 1 and total yields of fruit for the harvest period from September 10 through the 17th was less for the amiben-treated plots than for the highest yielding plot (bensulide plus diphenamid). Yields of fruit from plots treated with the methyl ester of amiben were not significantly lower than the check except for No. 1 fruit from the amiben alone plots. It is assumed that the use of a granular formulation of the methyl ester would have avoided the injury and possibly reduced yield since the granular formulation caused no injury in a previous experiment (2).

ACKNOWLEDGEMENTS

The author gratefully acknowleges the cooperation of Amchem Products, Inc., Eli Lilly and Company, Shell Chemical Company, Stauffer Chemical Company, and The Upjohn Company in supplying the herbicides used in these experiments. The assistance of Dr. W. H. Childs in reviewing the manuscript is gratefully acknowledged and deeply appreciated.

LITERATURE CITED

1. Schubert, Oscar E. 1963. A comparison of several herbicides used in a field of transplanted Rutgers tomatoes. Proc. NEWCC 17:116-120.

2. Schubert, Oscar E. and C. E. Hickman. 1968. Chemical weed control in transplanted tomatoes. Proc. NEWCC 22:102-106.

3. Schubert, Oscar E., C. E. Hickman and C. B. Sperow. 1967. Herbicide investigations in transplanted tomatoes. Proc. NEWCC 21:83-88

4. Schubert, O. E., C. E. Hickman, C. B. Sperow and R. F. Sweitzer. 1966. Evaluation of herbicide treatments on weed control and yield of tomatoes. Proc. NEWCC 20:59-66.

5. Schubert, O. E., R. F. Sweitzer, C. E. Hickman and C. B. Sperow. 1965. Chemical weed control in transplanted tomatoes. Proc. NEWCC 19:42-46.

RESPONSE OF CUCUMBER VARIETIES TO CP49814 HERBICIDE[1,2]

Austin Maitland[3]

The differential response of vegetable varieties to herbicides can be of practical significance in the selection of a variety to plant, in the choice of a herbicide, and in the breeding of new varieties. Studies have been reported on the responses of various cucurbits to herbicides, Fuelner et al., (1) and Ivany (3). Carrot varieties have been studied in some detail by Ivany and Dickerson (4). Lynch (6) reported differential response of tomato varieties to diphenamid.

Results from 1968 field tests by Ivany (3) and Lynch (6) were variable as to cucumber response to CP49814.* Since no particular soil type, weather, dosage or timing pattern emerged as the reason for this variability, it was decided to investigate the possibility of cucumber varietal differences as a cause.

EXPERIMENTAL

In selecting varieties for investigation, consideration was given to genetic origin and to type. Broadly speaking, there are two basic types of cucumbers as far as fruits are concerned: "slicers" and "picklers". Varieties representative of these types have been originated by plant breeders in South Carolina and Cornell as well as at many other locations. Generally, those varieties developed in the South carry mildew resistance and those from the North are resistant to mosaic and scab. The specific varieties chosen and their source was as follows:

Slicer		Pickler	
Name	Source	Name	Source
Gemini	So. Carolina	Pioneer	So. Carolina
Ashley	So. Carolina	[4]Wisc. SMR-18	Wisconsin
Tablegreen-65	Cornell	[4]Heinz 2395	Heinz (closed pedigree)
[4]Marketmore	Cornell		
[4]Highmark II	Asgrow (closed pedigree		

In the greenhouse experiments temperatures were maintained at 80-85°F days, and 70-75°F nights. Cucumbers were seeded fairly thick in 5" x 8" styrofoam flats and thinned to 10 seedlings per flat. The potting mix used had the following composition: equal parts sand, peatmoss, and Eel silt loam soil. To each cubic yard of mix was added 5 lbs. of 20% superphosphate, 2 lbs. 5-10-10 fertilizer and 3.75 lbs. ground limestone.

1/ Much of this work was supported by a grant-in-aid from the Monsanto Company.
2/ Paper No. 594 of the Department of Vegetable Crops, Cornell University, Ithaca, New York; part of a thesis for the M.S. degree.
3/ Acknowledgments for assistance in these investigations go to Dr. R. D. Sweet and Dr. P. A. Minges, Vegetable Crops Department, Cornell University.
4/ These varieties were included only in the field experiments.

Sprays were applied by means of a conveyor belt laboratory or greenhouse sprayer. Compressed air at 35 psi was the pressure source. Flats passed under the nozzle on the movable belt at a speed of 43 feet per minute (0.5 mph).

Unless otherwise indicated, a randomized complete block design was used. When visual ratings were utilized to measure results the following scale was utilized: 1 = complete kill; 7 = moderate injury with ultimate visual recovery; 9 = no visible injury.

Experiment 1.

Six varieties of cucumbers were seeded March 7, 1969, and on March 17, 1969 CP49814 was applied at rates of 0, 2, and 4 lb./acre. Cotyledons were fully expanded and seedlings had reached an average height of about 4 cm.

In this first test no injury was evident at 2 lb./acre. At 4 lb./acre, all varieties were injured, manifested mainly in varying degrees of yellowing of the first true leaf, reduction in leaf expansion and growth retardation. Some varietal differences were noticeable, but not clear cut in terms of overall appearance.

Experiment 2.

This experiment was initiated at the same time as experiment 1. In order to determine if stage of plant development influenced response of cucumbers to CP49814, the herbicide was not applied until the first true leaf was expanded. Rates were the same as for the previous experiment. Ratings for injury and fresh weights were taken 7 days after treatment.

Results of this test showed that treatment at the first true leaf stage elicited a more positive toxic response than treatment at the cotyledon stage. Varietal responses were more prominent and could be associated with differences in type and genetic origin. Pioneer and Wisc. SMR-18 were least injured, whereas Tablegreen-65 and Marketmore were most injured at 4 lb./acre. Gemini and Ashley were intermediate. Table 1 summarizes injury ratings and fresh weight data. A definite correlation did not usually exist for overall appearance and actual fresh weight. For example, low rating, severe injury, could be accompanied by a relatively high fresh weight.

Experiments 3, 4, 5, 6.

Having established that treatments after true leaf expansion could be more toxic than earlier treatments, this series of experiments was conducted for further verification, and also to study responses at higher rates and *in vivo* persistence of CP49814.

Cucumbers were seeded April 2, 1969 and treated at 0, 2, 4 and 8 pounds per acre in the following order: experiments 3 and 5 - at cotyledon stage; experiments 4 and 6 - at first true leaf. There were three replications of each experiment. Results of experiments 3 and 4 are summarized in tables 2 and 3, respectively.

At 8 lb./acre all varieties were injured. However, injury was only slightly and at times not visually apparent at the actual site of herbicide contact, irrespective of the time of treatment. Symptoms such as yellowing, dwarfing, reduced expansion and tip and marginal necrosis of true leaves, longitudinal stem cracking and sloughing off of epidermal tissue varied in severity among varieties. Pioneer showed the least injury, and Tablegreen-65 and Marketmore were the most seriously injured (see table 3). Terminal growing points of some plants treated at first true leaf suffered complete necrosis. This was especially evident for Tablegreen-65. Wisc. SMR-18 suffered severe tip burn, yellowing and dwarfing at 8 lb./acre but was only slightly injured at 4 lb./acre (table 3). At 4 lb./acre Tablegreen-65 suffered tip burning and yellowing almost comparable to that of Wisc. SMR-18 at 8 lb./acre. Gemini and Ashley were slightly injured at 4 lb./acre, and Pioneer appeared to have suffered only a slight reduction in growth at this rate.

Rate of Recovery.

Plants from experiments 5 and 6 were kept to determine if, and within what period of time plants recovered from initial injury. Previous tests showed that injury was quite evident within 6-7 days after treatment. Twelve to fifteen days after treatment, plants of all varieties were recovering from injury, especially at 4 lb./acre rate. The extent of recovery have some relationship to the severity of the initial injury, which varied among varieties. Recovery was faster for plants treated at cotyledon stage, with the third true leaf showing only slight injury after two weeks. Injury was more presistent for treatments at first true leaf, and in some cases it completely stopped terminal growth even at 4 lb./acre. Due to relatively rapid recovery it appears that CP49814 does not persist as a toxic entity in cucumber plants.

Field Tests.

In order to determine if cucumber variety responses to CP49814 under field conditions was similar to that obtained in the greenhouse, and to get more evidence on yields, two tests were conducted at the Freeville experimental farm in the summer of 1969.

Experiment 7.

The purpose of this experiment was threefold:

1. To evaluate variety response to CP49814 under field conditions.
2. To evaluate the activity of the herbicide on weeds.
3. To determine the capacity of the several varieties to recover from initial injury when treated at different stages of development.

Eight varieties of cucumbers were seeded in rows six feet apart on Howard gravelly loam soil. Each plot consisted of a single row of a given variety thirty feet in length. There were three 96' subblocks in each replicate. Each subblock, with all eight varieties replicated twice, received the same rate of herbicide at different timing, i.e. a 48' section of each subblock received, for example, 3 lb./ acre at time t1, the adjacent 48' replicate received the same rate, but at time t2.

Three rates of CP49814, 0, 3, and 6 lbs./acre were applied at three different timings as follows:

time 1, early post - first true leaf starting to expand,
time 2, post - second true leaf partially expanded,
time 3, late post - fourth true leaf partially expanded.

'No chemical' check plots, both clean weeded and weedy were included. Due to a shortage of chemical, there were two replications of time 1, three of time 2, and one of time 3. Plants of slicers were thinned to 12 inches apart and those of picklers to 6 inches apart. After the plots were evaluated for weed control, the area, between the rows was cultivated once mechanically, and later, weeds within the rows were pulled by hand. Hand pulling was timed for each treatment, to give some measure of the weed stand at that time. Variety response, weed control, and yield data were taken. Yields are presented in table 4. The middle 15' of each row was harvested over a period of 4 weeks.

Results of this experiment showed that cucumbers have the capacity to recover from the toxic effects of CP49814 and to produce crops comparable to those of untreated plants. Differences in yields existed among varieties, notably between Pioneer and Wisc. SMR-18 at 6 lb./acre t_1, and between Gemini and Tablegreen-65 at 3 lb./acre t_1 (table 5). How much the herbicide influenced these differences is difficult to say, bearing in mind that varieties of different genetic origin do differ in yield potential. In nearly all cases also, yields from weeded check plots were lower than for treated plots. Yields from early post application were not always better than for late post, and at higher rates of herbicide, yields were usually higher than at lower rates. For pickle types, yields were usually higher for the early post treatments, (table 5).

At high rates of CP49814 a striking apical effect was noted. All varieties, but notably Tablegreen-65, Marketmore and Wisc. SMR-18, stopped terminal growth and proliferated numerous laterals which flowered profusely. One could perhaps speculate that this increase in flowering increased the overall yields for those plants receiving higher rates of chemical.

Experiment 8.

Since yellowing was one noticeable symptom of injury, it was considered desirable to have a more objective measure of the extent of injury than is possible with a simple visual rating. An additional test was therefore, conducted to provide material for chlorophyll analysis.

Cucumbers were seeded on Eel silt loam soil and treated with CP49814 at 0, 3, and 6 lb./acre when the first true leaf was first appearing. Fourteen days after treatment, the first true leaf of ten plants of each variety were collected. Taking discs from each of the 10 leaves, 0.5 grams of leaf tissue was put in 10 ml. of 85% acetone and extracted for 40 hours at 40°F. 1.0 ml aliquots from each sample were diluted to 10 ml. with distilled water. Optical density of the diluted total chlorophyll extracts was determined at wavelengths of 429 and 453 u, respectively, using a Beckman DU Spectrophotometer. These wavelengths were chosen to represent absorption peaks in the spectrum for chlorophyll a and b, respectively. Optical density measurements were used as the basis for determining chlorophyll content.

Table 1. Visual rating and fresh weight of 6 cucumber varieties treated in the first true leaf stage with CP49814 herbicide.[1,2]

	0 lbs.		2 lbs.		4 lbs.	
Variety	Rating	Wt.	Rating	Wt.	Rating	Wt.
Gemini	7.2	30.3	6.8	30;0	6.2	28.0
Ashley	6.5	26.3	6.3	25.8	5.7	18.4
Wisc. SMR-18	7.5	31.9	7.7	33.4	6.8	27.9
Tablegreen-65	7.0	32.8	5.3	23.9	5.7	24.9
Marketmore	7.3	30.5	6.0	26.4	5.2	24.1
Pioneer	7.0	36.3	6.5	31.0	6.0	27.0

1/ Scale: 1 = complete kill
7 = moderate injury with ultimate visual recovery or somewhat less than perfect growth
9 = no apparent injury

2/ Weight in grams, of tops of 10 plants cut at soil level.

Table 2. Visual ratings and fresh weight of 6 cucumber varieties treated in the cotyledon stage with CP49814 herbicide.[1]

	0 lbs.		2 lbs.		4 lbs.		8 lbs.	
Variety	Rating	Wt.	Rating	Wt.	Rating	Wt.	Rating	Wt.
Gemini	9.0	23.6	8.3	23.5	6.3	18.8	5.0	18.3
Ashley	8.6	23.6	8.3	21.8	6.3	17.6	5.0	15.3
Wisc. SMR-18	9.0	28.4	8.0	23.2	7.0	22.3	4.3	18.3
Tablegreen-65	9.0	25.2	8.0	22.1	5.0	17.1	4.0	13.8
Marketmore	8.3	23.9	8.0	23.2	6.0	17.5	5.0	17.5
Pioneer	9.0	28.7	8.6	24.3	7.0	23.3	6.0	20.0

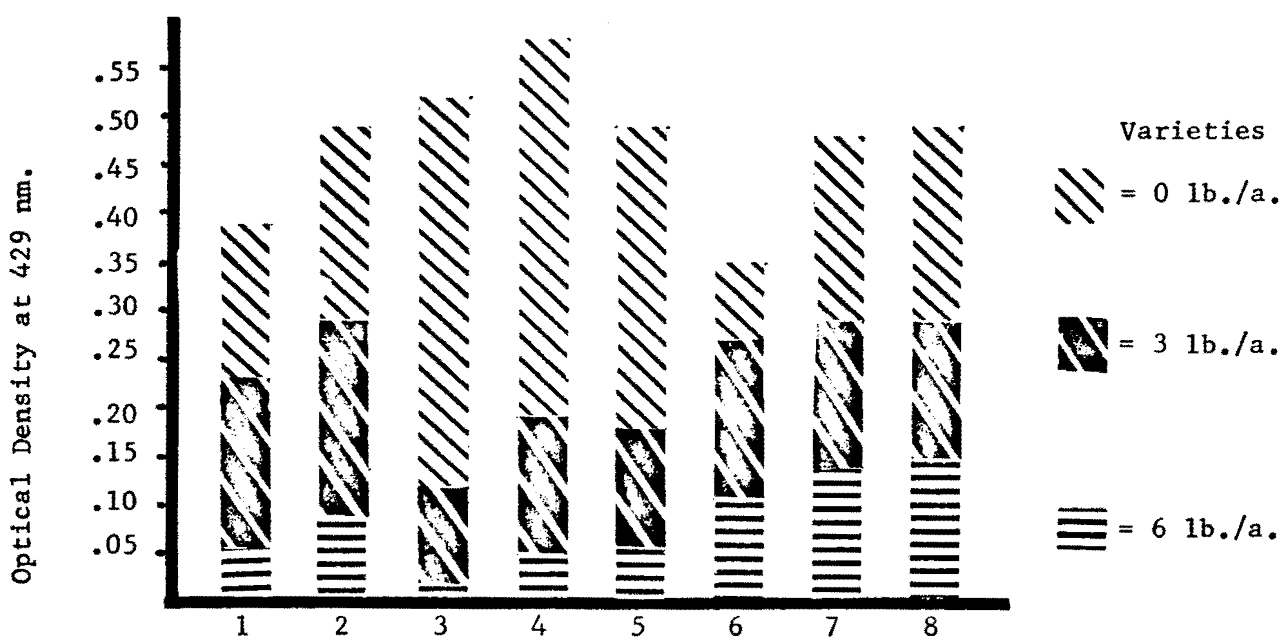
1/ Weight in grams of tops of 6 plants cut at soil level.
Ratings: 1 = complete kill
7 = slight to moderate injury
9 = perfect growth

Table 3. Visual ratings and fresh weights of 6 cucumber varieties treated with CP49814 herbicide at first true leaf stage.[1/]

Variety	0 lbs. Rating	0 lbs. Wt.	2 lbs. Rating	2 lbs. Wt.	4 lbs. Rating	4 lbs. Wt.	8 lbs. Rating	8 lbs. Wt.
Gemini	9.0	25.3	8.3	22.6	6.6	17.2	4.3	15.4
Ashley	8.6	21.9	8.3	19.8	7.0	17.3	4.6	13.2
Wisc. SMR-18	9.0	20.8	7.6	21.9	6.3	20.5	4.3	17.6
Tablegreen-65	8.6	21.9	8.3	19.6	5.3	17.2	3.6	15.8
Marketmore	8.6	22.6	6.6	16.6	5.3	14.9	3.6	16.0
Pioneer	9.0	23.2	8.6	23.4	6.6	23.8	4.6	21.2

1/ Weights in grams of tops of 6 plants. See tables 1 and 2 for explanation of ratings.

Figure 1. Optical Density of Total Chlorophyll extracts of 8 cucumber varieties treated with CP49814 Herbicide.



1 = Gemini
2 = Ashley
3 = Tablegreen-65
4 = Marketmore
5 = Highmark II
6 = Pioneer
7 = Wisc. SMR-18
8 = Heinz 2395

Table 4. Total yields of cucumber treated with CP49814 at three stages of growth.[1/]

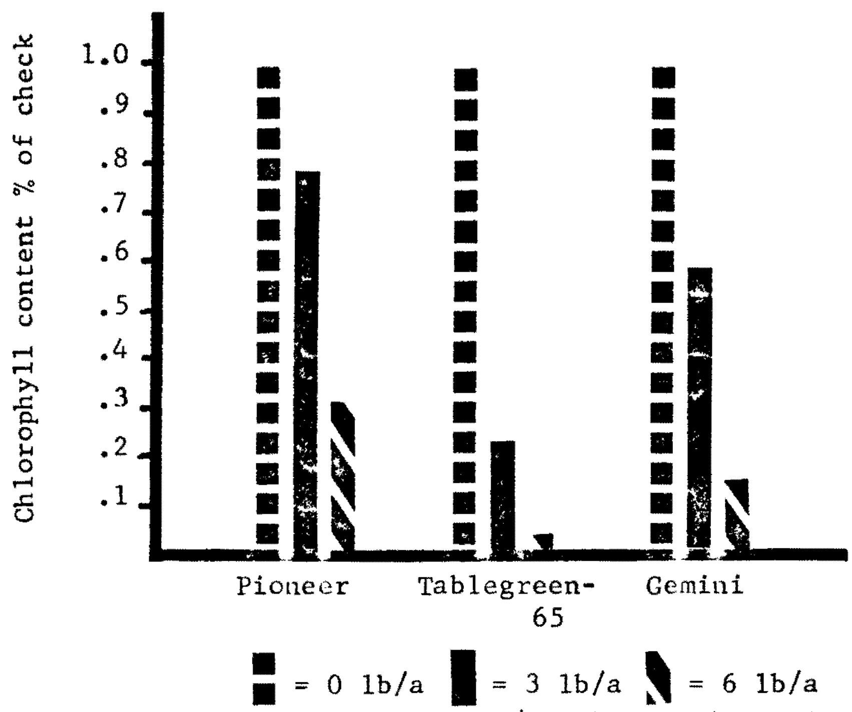
	None				3 lb./a.						6 lb./a.					
	Weeded		Weedy		t_1		t_2		t_3		t_1		t_2		t_3	
Variety	No.	lb.	No.	lb.	No.	lb.	No.	lb.	No.	lb.	No.	lb.	No.	lb.	No.	lb.
Pickling:																
Pioneer	452	47.5	322	46.9	585	57.9	535	53.6	430	46.6	723	66.2	628	58.8	495	62.3
W. SMR-18	451	53.9	275	41.4	526	58.1	445	46.8	457	45.9	542	56.3	550	49.5	532	50.9
H-2395	506	54.9	345	46.8	683	64.3	607	58.4	408	44.6	729	58.9	621	50.3	529	53.5
Slicing:																
Gemini	137	77.3	100	58.4	209	113	193	100.5	177	90.3	179	96.5	177	99.4	183	92.2
Ashley	116	49.6	74	33.5	122	51.3	176	69.7	153	60.8	157	66.5	159	68.7	147	56.3
T'-green-65	140	75.5	121	62.9	133	71.5	173	88.4	147	75.2	167	87.3	159	79.6	131	63.3
M'-more	118	61.8	106	55.8	158	80.5	204	101.5	193	85.2	206	98.3	201	97.3	196	98.6
High MII	136	75.6	58	31.6	154	81.8	181	98.0	170	90.3	147	79.6	182	96.3	226	115.8

1/ t_1 = early post application - ave. of 2 reps.

t_2 = post - ave. of 3 reps.

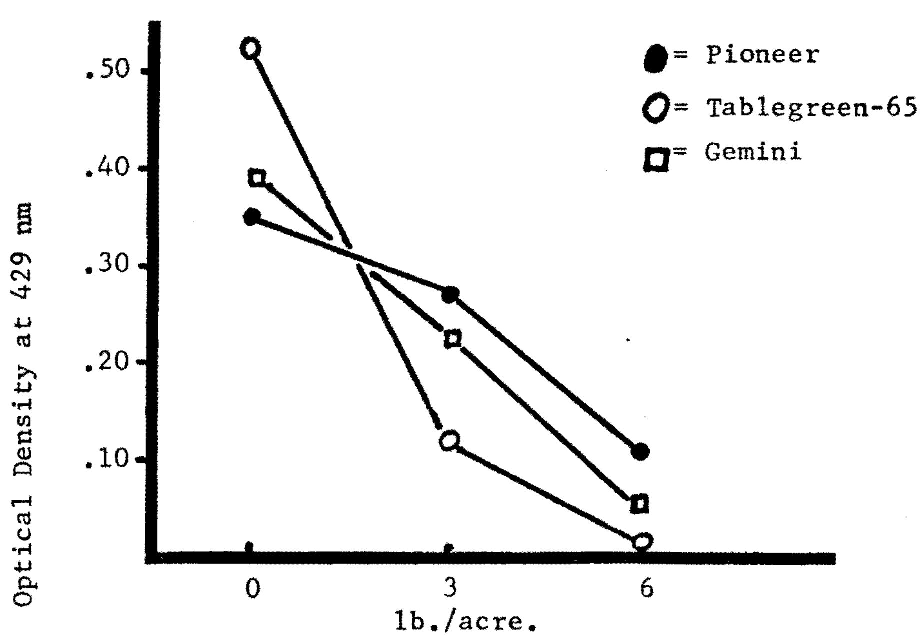
t_3 = late post application - 1 rep.

Figure 2. Total chlorophyll content of representative cucumber varieties treated with CP49814 herbicide. 1/



1/ Optical density values at 0 lb/a arbitrarily assigned a value of 100% total chlorophyll. O. D. values at 3 and 6 lb/a, as percentages of values at 0 lb/a used to represent reduction in total chlorophyll content.

Figure 3. Optical density of total chlorophyll extracts from cucumber varieties treated with CP49814.



The results are summarized in figures 1, 2, and 3. It is possible from these results, to compare chlorophyll content of untreated and treated plants for a given variety, and to see the extent of chlorophyll reduction in treated plants. Differences in chlorophyll content among varieties is clearly evident (figure 1) and the extent of reduction at 3 and 6 pounds per acre varies significantly among some varieties, (figures 1 and 2). Pioneer at 3 lb/acre shows about a 22% reduction in chlorophyll content, Tablegreen-65 about a 77% reduction (figure 2). Of the slicers, Gemini and Ashley showed the least reduction, about 41% each. Tablegreen and Marketmore were the most seriously affected (figure 1). The pickle types were the least affected, with small variation among the three at 3 lb/acre. There is some correlation between visual injury and chlorophyll analysis. Tablegreen-65, for example, which had high injury ratings (table 3) showed low chlorophyll content even at 3 lb./acre (figure 2).

SUMMARY

From the results of greenhouse and field tests, it was evident that cucumber varieties differed in the extent to which they were injured by CP49814 herbicide. The varieties tested exhibited the capacity to recover from the toxic effects of the herbicide even at high rates of treatment. Timing of treatment applications with respect to stage of development of the plants influenced the extent of injury.

Differences in response were also associated with differences in genetic origin of the varieties, and with types. Tablegreen-65 and Marketmore, both of Cornell lines were more susceptible to injury by CP49814 than were Gemini and Ashley of South Carolina lines. Pioneer, of South Carolina lines, and Heinz 2395, from Heinz, both pickle types, showed little susceptibility to CP49814 injury. Variation among pickle types with respect to injury was small and much less than that of the slicing types. Chlorophyll content measurements seemed to be a positive method for determination of CP49814 injury on cucumbers.

REFERENCES

1. Fuelner, R. L., Kuratle, H., Rahn, E. M. Weed control in cucurbits. Proceedings of the N.E. Weed Control Conference, Vol. 22: 219-223. 1968.

2. Holm, Rake L., Groskopf, M. Preplanting, preemergence, and post-emergence weed control in cucumbers. Eighteenth Annual Research Report North Central Weed Control Conference p. 91-92. 1961.

3. Ivany, J. A. Response of cucurbit species to certain analogs of amiben. M.S. Thesis, Cornell University. 1969.

4. Ivany, J. A., Dickerson, C. T., Jr., Sweet, R. D. Carrot response to post-emergence applications of Linuron and Stoddard Solvent. Proceedings of the N.E. Weed Control Conference, Vol. 23: 21-25. 1969.

5. Long, J. D. Weed control in cantaloupes and cucumbers. Proceedings of the N.E. Weed Control Conference, Vol. 22: 216-218.

6. Lynch, Mark R., Sweet, R. D. Environmental effects on Diphenamid activity - a progress report. Proc. NEWCC, Vol. 23: 34-43. 1969.

WEED CONTROL IN LETTUCE AND ENDIVE

D. A. Braden and J. C. Cialone[1/]

INTRODUCTION

Lettuce (Lactuca sativa) and endive, although limited in total acreage in New Jersey, usually provide growers with a high per acre cash value.

Spring and fall crops of lettuce (head and leaf) and endive are grown from transplants and by direct seeding. Lettuce is generally transplanted in the spring and seeded for the fall crop, while escarole (Cichorum endivia) and chicory (Cichorum intybus) are usually transplanted.

These different crop cultures provide a great array of weed problems. With spring transplantings, consideration must be made for methods of herbicide application (preplant incorporation vs. posttransplanting) and the pressure of early broadleaf weeds.

The problem of herbicide residues must also be carefully considered since the spring crop is often followed by another crop. With summer plantings for the fall crop, different weed species will predominate. Grasses constitute the major problem at this time of year.

The objective of the studies reported here was to evaluate herbicides alone and in combination for weed control in lettuce and endive.

MATERIALS AND METHODS

Experiments were initiated to evaluate the following herbicides alone and in combination:

Bensulide - [N-(2-mercaptoethyl) benzene-sulfonamide s-(o,o,-diisopropyl phosphorodithioate]

Benefin - (N-butyl-N-ethyl-a,a,a,-trifluoro-2,6-dinitro-p-toluidine)

CDEC - (2-chloroallyl diethyldithiocarbamate)

RH-315 - [N-(1,1-dimethyl(propynyl)-3,5-dichlorobenzamide]

[1/]Graduate Assistant and Associate Research Professor, Soils and Crops Department, Rutgers University, The State University of New Jersey, New Brunswick, N. J. 08903.

Four experiments were conducted in 1969 to evaluate herbicides in lettuce (direct-seeded and transplanted) and endive (chicory and escarole transplants). The experiments are summarized in Table 1.

A randomized complete block design was used in all tests. Experiments I, III and IV had 3 replicates and Experiment II had 4 replicates.

Table 1. Summary of Experiments on Lettuce and Endive, 1969.

Experiment		Date	Location	Crop	Culture	Soil	Weeds
I.	A	4/29	Adelphia, N.J.	Lettuce (Var. Fulton)	Seed Beds	Freehold sandy loam	Pigweed Carpetweed *Anthemis spp.*
	B	5/8	Adelphia, N.J.	Lettuce (Var. #659)	Transplants Beds	Freehold sandy loam	Lambsquarter Crabgrass
II.		5/8	Adelphia, N.J.	Escarole (Var. Full Heart Batavian) Chicory (Var. Green Curled)	Transplants Beds	Freehold sandy loam	Pigweed *Anthemis spp.* Carpetweed Crabgrass
III.		8/12	Wayne, N.J.	Escarole (Var. Full Heart Batavian)	Transplants Flat	Loam	Smartweed Galinsoga Crabgrass
IV.		8/18	Centerton, N.J.	Lettuce (Var. White Boston)	Seed Flat	Sassafras sandy loam	Morning glory Crabgrass Lovegrass Lambsquarter

Where weed or crop responses are reported, the following rating system was used:

Scale: 0-9

0 = No crop injury or weed control.

9 = Crop eliminated or 100% weed control.

DISCUSSION

Experiment I.

Direct seeded and transplanted lettuce shared the same bed. Various treatments and results are presented in Table 2. Weed control data for redroot pigweed (Amaranthus retroflexus) and crabgrass (Digitaria sanguinalis) indicated that preemergence applications of RH-315 are slightly better than preplant incorporation applications and that control is increased with increased dosages up to 4 lb/A. Weed control, relative to the check, was acceptable although weaker on pigweed. Combinations of benefin and bensulide with RH-315 did not improve weed control significantly. Data from direct seeded lettuce indicate that the yields from all treatments were significantly increased over the control.

Table 2. The Response of Lettuce and Weeds in Experiment I.

Chemical[1/]	lbs/ A	Pigweed Response Rating 5/20/69	Pigweed Response Counts[2/] 6/20/69	Crabgrass Response 5/20/69	Average Weight of 16 Heads[2/] 7/1/69	Crop Response 5/20/69
RH-315 (PRE.)	1.0	5.0	8.3bc	7.6	9.6b	0.0
" "	2.0	6.3	5.0ab	9.0	9.5b	0.3
" "	3.0	6.6	4.3ab	8.3	10.1c	1.3
" "	4.0	7.6	1.7a	8.7	9.0b	1.0
RH-315	1.0	4.3	15.0d	7.0	9.0b	0.7
"	2.0	5.6	5.7ab	8.0	9.8c	0.7
"	3.0	5.6	6.0ab	8.0	9.7b	0.3
"	4.0	6.6	3.3ab	8.6	10.8e	2.0
Bensulide	2.0	3.6	11.7cd	7.3	9.6b	0.3
"	6.0	5.3	7.0abc	9.0	9.5b	0.7
Benefin	0.5	5.6	6.0ab	8.3	8.3b	0.7
"	1.5	6.6	1.3a	9.0	7.9b	1.7
RH-315 + Bensulide	2.0+ 2.0	5.3	5.7ab	7.6	8.7b	1.0
RH-315 + Benefin	2.0+ 0.5	6.6	3.3ab	8.7	10.2d	1.3
Control	---	2.0	21.3e	3.6	5.3a	0.7

[1/] Application of RH-315 preemergence and preplant incorporated. All others applied preplant and incorporated to a 3-inch depth with a TILROVATOR.

[2/] Means having a letter in common are not significantly different at the 5% level. (Duncan's Multiple Range Test.)

Experiment II.

The treatment list is presented in Table 3. RH-315 was applied preplant and incorporated to a depth of approximately four inches. Weed control, as in Experiment I, appeared satisfactory with grasses while control of pigweed was weaker in this respect. Benefin, bensulide and RH-315 produced similar effects. With RH-315 there is an indication of slight injury to escarole and essentially no injury to chicory.

Experiment III.

All chemicals were applied preemergence and CDEC was considered for additional summer grass control. All afforded excellent control of grass. Control of smartweed (Polygonum pensylvanicum) was satisfactory, but where galinsoga (Galinsoga spp.) predominated, broadleaf control was not effected. Broadleaf control was better in combinations as shown in Table 4.

Experiment IV.

The data supports previous findings. RH-315 in combination with CDEC provided little more weed control than RH-315 alone. Generally, all compounds performed satisfactorily on lambsquarter (Chenopodium album). Injury to lettuce by RH-315 is indicated.

CONCLUSIONS

1. Preemergence application of RH-315 appears to provide better weed control than preplant incorporation. This supports 1968 data.

2. Slight injury to crops from RH-315.

3. All herbicides utilized performed better on grasses than broadleaf weeds.

Table 3. Summary of Chemicals and Treatments on Lettuce and Endive Experiments in 1969.

Treatment Number	Chemical	Dosage (lb/A)	Application
		Experiment I	
1	RH-315	1.0	Preemergence
2	"	2.0	"
3	"	3.0	"
4	"	4.0	"
5	"	1.0	Preplant Incorporation
6	"	2.0	with TILROVATOR
7	"	3.0	" "
8	"	4.0	
9	Bensulide	2.0	
10	"	4.0	
11	"	6.0	
12	Benefin	0.5	
13	"	0.75	
14	"	1.5	
15	Control		
16	RH-315 + Bensulide	1.0 + 2.0	
17	" "	1.0 + 4.0	
18	" "	2.0 + 2.0	
19	" "	2.0 + 4.0	
20	Control		
21	RH-315 + Benefin	1.0 + 0.5	
22	" "	2.0 + 0.5	
23	" "	1.0 + 0.75	
24	" "	2.0 + 0.75	
		Experiment II	
1	Benefin	0.75	Preplant Incorporation
2	"	1.0	with TILROVATOR
3	"	1.5	
4	Bensulide	4.0	
5	"	6.0	
6	"	8.0	
7	RH-315	2.0	Preemergence
8	"	3.0	"
9	"	4.0	"
10	Control		

Table 3 continued.

Treatment Number	Chemical	Dosage (lb/A)	Application
		Experiment III	
1	Benefin	1.0	Preemergence
2	"	2.0	
3	RH-315	2.0	
4	"	4.0	
5	CDEC	4.0	
6	"	6.0	
7	Benefin + CDEC	1.0 + 4.0	
8	RH-315 + CDEC	2.0 + 2.0	
9	RH-315 + CDEC	3.0 + 2.0	
10	Control		
		Experiment IV	
1	Benefin	1.0	Preplant Incorporation with disc
2	"	2.0	
3	Bensulide	4.0	Preemergence
4	"	6.0	"
5	"	4.0	Preplant Incorporation with disc
6	"	6.0	
7	RH-315	1.0	Preemergence
8	"	2.0	
9	"	3.0	
10	CDEC	2.0	
11	"	4.0	
12	"	6.0	
13	RH-315 + CDEC	1.0 + 2.0	
14	" "	2.0 + 2.0	
15	" "	3.0 + 2.0	
16	Control		

Table 4. Summary of Responses of Leaf Crops and Weeds in Experiments III and IV, 1969.

Chemical	Exp. III lbs/A	Exp. III Crop Chicory 9/20	Exp. III Crop Escarole 9/20	Exp. III Crab-grass 9/20	Exp. III Broad-leaves[1/] 9/20	Exp. IV lbs/A	Exp. IV Crop Lettuce 9/5	Exp. IV Crab-grass 9/5	Exp. IV Broad-leaves[2/] 9/5
Benefin	1	9.0	4.0	0.0	0.0	1	1.0	5.0	3.0
"	2	9.0	6.0	0.0	0.0	2	1.0	5.0	2.3
RH-315	2	9.0	5.3	0.3	0.3	2	2.0	8.3	8.3
"	4	9.0	5.3	0.0	0.0	(3)	(1.7)	(8.7)	(8.0)
CDEC	4	8.0	7.1	0.0	0.0	4	1.0	4.0	3.7
"	6	9.0	7.1	0.0	0.0	6	1.7	5.3	4.0
Benefin + CDEC	1+ 4	8.3	9.0	0.0	0.0	-	---	---	---
RH-315 + CDEC	2+ 2	9.0	9.0	0.0	0.0	2+ 2	0.7	6.7	6.7
RH-315 + CDEC	3+ 2	9.0	9.0	0.3	0.7	3+ 2	1.7	8.0	8.0
Control	--	4.3	3.0	0.0	0.0	--	1.0	2.7	0.3

[1/] Smartweed and galinsoga.

[2/] Lambsquarter.

HERBICIDE APPLICATIONS FOR WEED CONTROL IN SUGAR BEETS

T. W. Scott and T. W. Bateman [1/]

In recent years commercial sugar beet growers have been obtaining favorable results controlling weeds with herbicides. This increased use of herbicides has aided, in many cases, in reducing hand labor required to remove weeds from sugar beet fields. Since weed competition can drastically reduce the root yields of sugar beets, effective control measures must be employed. These include various chemicals as well as timely cultivations.

The objective of this study was to determine the best method or methods of chemical weed control in sugar beets by investigating different chemicals, rates and methods of application.

Materials and Methods

This field study was conducted at the Aurora Research Farm in Central New York on a Honeoye-Lima silt loam soil. This silt loam soil is representative of soils recommended and used for commercial sugar beet production in New York.

After broadcasting 800 lbs/A of 10-20-20 fertilizer, the experimental site was plowed on May 2. The only fitting of the seedbed was accomplished with a clodbuster pulled behind the plow. This minimum tillage provided a seedbed that was loose but firm enough to plant small seeded crops such as sugar beets. The sugar beet seed used was Kleinwanzleben IS-93. This same variety was used commercially in New York.

After seedbed preparation and prior to planting, weed seeds were broadcast over the experimental area with a wheel-barrow type seeder. Weeds that were broadcast included the following: black mustard (*Brassica niger* L. KOCH); ragweed (*Ambrosia artimisiifolia* L.); lambsquarters (*Chenopodium album* L.); foxtail (*Setaria glauca* L.); and pigweed (*Amaranthus retroflexus* L.).

This field study consisted of 36 different treatments. Each treatment was replicated 4 times. The individual plots consisted of 4, 30 inch rows which were 30 feet in length. The treatments receiving preplanting incorporated herbicides were done on May 6. Incorporation was accomplished by discing in the chemical immediately after application to the soil with a two way tandem disc. Sugar beets were planted on the same date with a commercial 4 row drill. Preemergence herbicides were also applied on May 6. Postemergence treatments were applied on June 6 while sugar beets were in the 2 to 4 true leaf stage of growth. Chemicals were applied with a back-pack sprayer.

Since the beet seed was planted at a 2 inch spacing to insure an adequate

1/ Associate Professor and Research Associate, Department of Agronomy, Cornell University, Ithaca, New York. Dept. of Agronomy Journal Series No. 871.

final stand, stand reduction or thinning was required to leave one plant per foot of row. Thinning was done by hand on June 18 when the beet plants were in the 4 to 6 true leaf stage of growth. Care was taken so that weeds would not be disturbed.

Stand evaluations by visual inspection were made for sugar beet seedling injury and for herbicide effectiveness on weed control. Ratings were made on incorporated and preemergence treatments on June 6. All treatments were rated visually on June 16 and July 11. Only the July 11 ratings are reported here (Table 1.)

Starting in mid-September, sugar beet blades and petioles were removed and beet roots were lifted for harvest. This was accomplished by harvesting the two center rows of each plot with a mechanical one-row harvester adapted for research plots. It should be mentioned that after defoliation and prior to harvest, plots with very small roots not of marketable size were abandoned and not harvested. In these situations roots were less than 2" in diameter and are reported in the results as < 5 tons/A.

Results and Discussion

Sugar beet yields were considered good in the better treatments. The top yields were not as high as those reported for the 1968 growing season. Although moisture received on the plots was good in June and July, below average rainfall was reported for August and September (Figures 1 and 2). The earlier harvest in September may also have resulted in producing somewhat lower yields than was possible for the growing season. It should be noted that light precipitation occurred following planting and the application of preplanting incorporated and preemergence herbicides (Figure 2).

Two check treatments were used in the study. One in which no herbicides were applied or cultivation used. The other in which chemicals were not used but weed competition eliminated through hand weeding and cultivation as needed. This resulted in yields ranging from < 5 tons/A on the complete check (Treatment 1) to 20.4 tons/A on the hand weeded check. Considering treatments receiving various types, combinations and rates of chemicals, yields ranged from < 5 tons/A to 17.5 tons per acre.

Broadleaf weed species were the dominant weeds in the various plots. Although actual weed species counts were not made, estimates on control of the various species were made by visual ratings. These are reported in Table 1.

Preplanting incorporated treatments

Cycloate preplant incorporated used in combination with pyrazon preemergence resulted in yields of about 14 tons/A (treatments 33 and 34.) The application of both chemicals preplant incorporated at the 4 lb level was less effective and yields of 12.8 tons resulted. At the 3 lb rate for each incorporated, yields were reduced to 6.4 tons/A. Cycloate plus R-11913 gave yields of only 9.7 tons/A. Nitralin did not control weeds and caused serious injury to sugar beets.

Preemergence and postemergence treatments

The highest yielding treatment involving chemicals was pyrazon 4 lbs and TCA 6 lbs plus 3 cultivations. This resulted in excellent weed control and no observable injury to the sugar beets. The yield was 17.5 tons/A. This treatment and the hand weeded check were the only treatments receiving cultivation. Pyrazon plus TCA without cultivation resulted in yields of only 9 tons/A. Herbicides that were applied preemergence, postemergence or in combination and resulting in good weed control and yields in excess of 11 tons were treatments 32, 19, 25, 15, 24 and 23. Treatments including Schering 4075 alone or in combination with other chemicals were outstanding although this chemical did not control pigweed. (Amaranthus retroflexus L.). BASF 2430, which had resulted in good overall weed control in 1968, was equally effective but resulted in more injury to sugar beets. Serious injury to sugar beet plants was noted. Complete results are shown in Table 1.

Summary

Sugar beet yields among the various treatments ranged from a high of 20.4 to $<$ 5 tons/A. Most of the treatments reflecting the higher yields involved using a combination of chemicals. This is to be expected since a rather broad spectrum of weeds were present prior to treatment.

The hand weeded check treatment yielded 20.4 tons/A. Pyrazon plus TCA plus cultivation was the best treatment involving chemicals. Without cultivation and using the same chemicals, this resulted in a yield of 9 tons/A. Scherring 4075 again looked very good as a postemergence treatment for sugar beets. Since Scherring 4075 is weak on grasses and pigweed (*Amaranthus retroflexus* L.) it is most effective when used in combination with other chemicals.

Cycloate incorporated plus pyrazon preemergence gave effective control of most weeds. BAS 2430 was not as effective in 1969 as in 1968. This was primarily because more injury occurred after treatment to the young beet seedlings and the final yields were reduced.

Chemical treatments affected the total sugar content of the beets only as the treatments affected the yield.

Table 1. Injury Ratings, Yields, Sugar Percentage and Dominant Weed Species as Influenced by Treatment

Treat No.	Chemical	Rate/A lbs a.i.	Method of Application: Inc	Pre	Post	Injury Ratings[1/]: Beets	BLW	Grass	Net Yield[2/] Roots T/A	Sucrose[3/] %	Predominant Weeds Present: Mus-tard	Rag-weed	Pig weed	Ladies Thumb	Buck wheat
4	Hand Weeded Check	-	-	-	-	0.0	10.0	10.0	20.4	13.2					
9	Pyrazon & TCA & Cult.	4+6		X		0.0	10.0	10.0	17.5	14.2					
32	Schering 4075 & Dalapon	3+2			X	1.0	8.5	8.5	16.7	14.7			X	X	
19	BAS 2430 + TCA + Schering 4075	4+6+2		X	X	4.0	9.5	9.5	14.5	15.6					
34	Cycloate + Pyrazon	3+3	X	X		2.0	9.0	9.0	14.2	15.7					
33	Cycloate + Pyrazon	4+4	X	X		1.0	9.0	9.0	13.9	15.1					
25	Schering 4075	3			X	1.0	8.0	7.5	13.4	15.8			X	X	
15	Pyrazon + TCA + Schering 4075	4+6+2		X	X	1.0	9.0	9.0	13.4	15.2					
35	Cycloate + Pyrazon	4+4	X			1.0	9.0	9.0	12.8	15.6					
24	Schering 4075	4			X	2.5	8.0	8.5	11.3	15.2			X		
23	TCA + Schering 4075	6+3		X	X	2.0	7.5	7.5	11.1	15.2			X		
17	BAS 2430	4		X		3.5	8.5	8.0	10.7	15.3		X			
10	Pyrazon + TCA + Pyr. Plus	1+4+9 lbs		X	X	2.0	6.5	8.5	10.5	15.3	X	X	X		
18	BAS 2430	3			X	3.0	8.5	6.0	10.2	14.9	X		X		
22	BAS 2430 + TCA + Schering 4075	2+4+2		X	X	2.0	8.0	9.0	9.8	14.9			X		
11	Pyrazon Plus + oil	12 lbs prod			X	2.5	6.5	8.0	9.7	14.9	X	X			
7	Cycloate + R-11913	2+1	X			3.0	8.0	8.0	9.7	14.6		X	X	X	X

Table 1. (Cont'd) Injury Ratings, Yields, Sugar Percentage and Dominant Weed Species as Influenced by Treatment

Treat No.	Chemical	Rate/A lbs a.i.	Method of Application Inc	Pre	Post	Injury Ratings[1/] Beets	BLW	Grass	Net Yield[2/] Roots T/A	Sucrose[3/] %	Predominant Weeds Present Mus-tard	Rag-weed	Pig weed	Ladies Thumb	Buck wheat
31	Schering 4075 + oil	3+2			X	1.5	6.0	6.5	9.6	14.8		X	X	X	
3	Pyrazon	4		X		1.5	6.5	1.0	9.6	15.5	X	X	X	X	
8	Pyrazon + TCA	4+6		X		2.5	7.5	7.5	9.1	14.8	X	X	X		
36	BAS 2430	3		X		3.5	8.5	7.5	9.1	16.2			X	X	
21	Pyrazon Plus + Schering 4075	9+2			X	2.0	7.5	9.0	9.0	14.8			X		
14	BAS 2430 + W.A.	4 + 3/4%			X	4.5	9.0	6.5	8.9	14.0		X	X		
28	BAS 54105	4		X		2.0	8.5	7.5	8.8	15.1		X	X	X	
5	Pyrazon + CP5223	3 + 1½		X		2.0	7.5	9.0	8.1	14.7		X	X		X
20	BAS 2430 + Dalapon	3+2			X	4.0	8.0	7.5	7.9	15.0		X	X		
13	Pyrazon Plus	12 lbs prod			X	3.0	5.0	8.5	7.5	14.1	X	X	X	X	
16	BAS 2430	4			X	5.0	8.5	5.5	6.8	14.8	X				
30	Schering 4075 + W.A.	3 + 3/4%			X	3.0	5.5	7.5	6.7	14.1		X	X	X	
6	Cycloate + Pyrazon	3+3	X			3.0	7.0	8.0	6.4	15.1		X	X	X	X
4	Pyrazon + oil	4+1			X	5.0	4.0	0.0	6.3	15.6	X	X	X	X	X
12	Pyrazon Plus + oil	9 lbs prod			X	3.0	4.5	8.0	5.4	14.6	X	X	X	X	X
29	HOE 2934	4		X		5.0	2.5	2.0	< 5.0	--		X		X	X
26	Planavin (Liquid)	1.3	X			9.0	0.0	0.0	< 5.0	--	X	X		X	X
27	Planavin (Liquid)	1.3		X		9.5	0.0	0.0	< 5.0	--	X	X		X	X
1	No chem. or Mech. Control					8.0	0.0	0.0	< 5.0	--	X	X	X	X	X

1/ Rated July 11th 0 = No injury 10 = 100% Kill or Suppression

2/ L.S.D. .05 for any Treatment Mean = 4.66 Tons/Acre

3/ L.S.D. .05 for any Treatment Mean = 1.53% Sucrose

Table 2. Herbicides Used in 1969 Sugar Beet Investigation

Compound	Trade Name	Chemical Name
pyrazon	Pyramin	5-amino-4-chloro-2 phenyl-3 (2H) pyridazinone
TCA	TCA	tichloro acetic acid
cycloate (phenmedipham)	RoNeet	S-ethyl-N-ethelthiocyclohexane-carbamate
Schering 4075	Betanal	3-methoxycarbonylaminophenyl-N-(3'-methyl-phenyl) carbamate
BAS 2430	-	1 phenyl-4-amino-5-bromo-pyridazone
BAS 54105	-	------
dalapon	Dowpon	2,2 dichloropropionic acid
tropachlor	Ramrod	2 chloro-N-isopropylacetanilide
CP 5223	-	2-chloro-N-(isobutoxymethyl)-2', 6'-acetoxylidide
nitralin	Planavin	4-(methylsulfonyl)-2,6 dinitro-N, N-diproplyaniline
R 11913	-	------

Fig. 1. A Comparison of 1969 Growing Season Rainfall with the Long Term Average

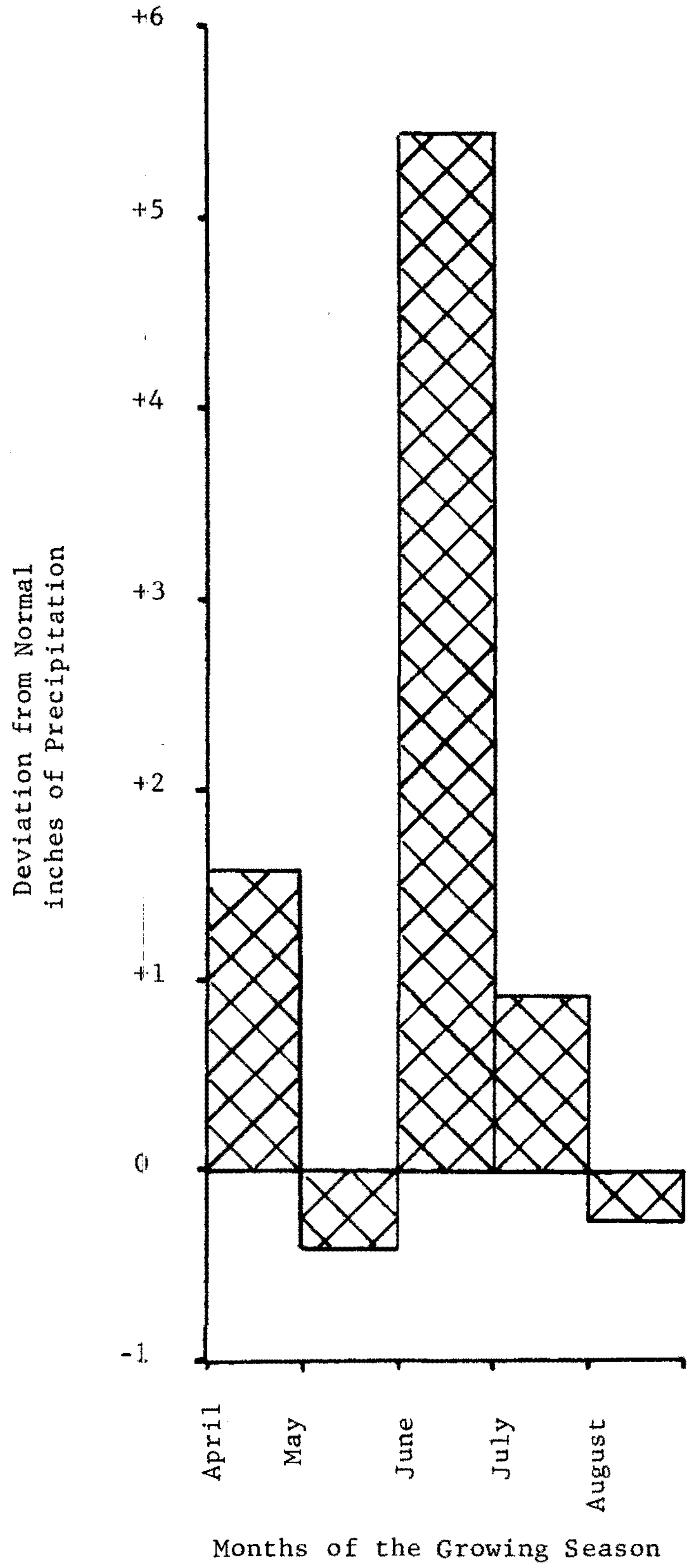
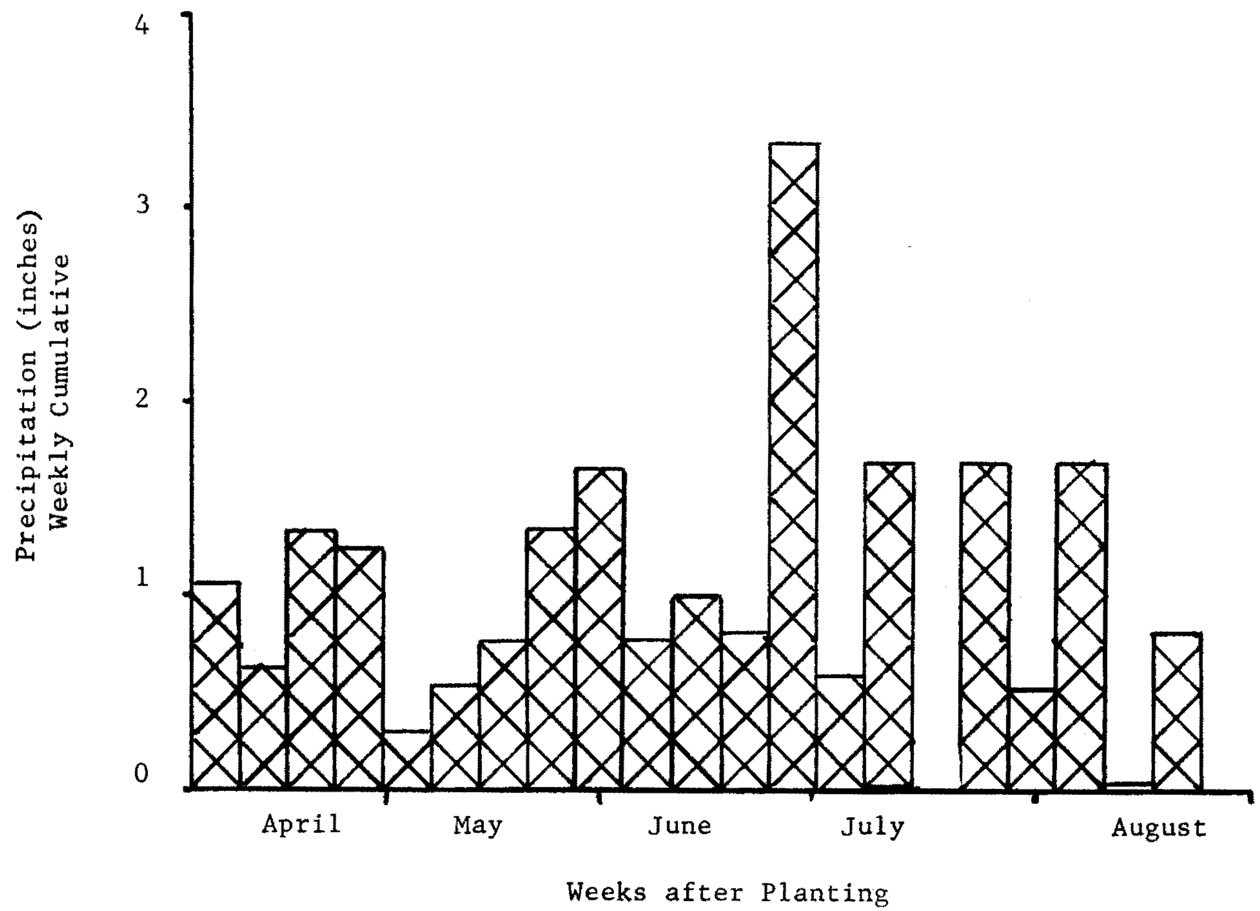


Fig. 2. Weekly Precipitation at the Aurora Research Farm 1969



FIELD PLOT EVALUATION OF RED BEET HERBICIDES

D. H. Young[1/] and R. Becker[2/]

Herbicides presently being used for weed control in red beets do not provide consistent, satisfactory weed control. In the past the major cash expense in red beet production has been for hand weeding. With the labor supply shrinking and a rising minimum wage, it is essential for growers to reduce or eliminate the field labor requirements.

The purpose of this trial was to evaluate a pre-plant incorporated (cycloate) and three pre-emergence herbicides (pyrazon, solubor and TCA) used individually and in combination to determine the most effective herbicide program for grower use in 1970. This trial was performed under field conditions using standard cultural practices performed by the grower, except the direct application of the treatments.

Literature Review

Weed control experiments performed by Wisconsin researchers in 1948-50 proved Borax to have herbicidal properties when used on red beets and sugar beets.(8) Research in New York has shown Solubor to be a convenient form of boron and relatively effective if adequate soil moisture were present. When used at a rate of 150 lbs/A. there was no effect on plant stand but growth was initially stunted. Yield reductions were sometimes noted. (1,2,4)

Pyrazon was found to have selective herbicidal properties in sugar beets (5,6) but sufficient precipitation is necessary to move the chemical into the soil root zone for plant absorption (6). Pyrazon has also proven to be a good herbicide for use on red beets in New York provided sufficient rainfall occurs immediately after application (2).

New York and Maine sugar beet researchers have reported cycloate, pre-plant incorporated, to be unsatisfactory for weed control unless used in combination with pyrazon (9,10,11). Red Beet researchers have varied experiences. Data from 1967 work shows cycloate giving very satisfactory weed control (2). However, in a trial conducted in 1968, cycloate did not perform well. Satisfactory weed control was not obtained (3).

Experimental Methods

This trial was conducted on a Honeoye fine, sandy loam field in Orleans, N. Y. All treatments were applied over-all to the 6" x 30' plots with a hand pump plot sprayer. The chemicals were applied to the 180 sq. ft. area in 1 quart of water, equivalent to 60.5 gal./A., at approximately 40 PSI. Three replicates were used.

1/ Research Agronomist, Comstock-Greenwood Foods, Borden Inc., Foods Division, Newark, N.Y.
2/ Cooperative Extension Specialist, Vegetable Industry, Cornell University, Ithaca, N. Y.

The treatments, rates, and methods of application are incorporated into Table I.

All treatments were applied May 28, the day of planting, except Solubor which was applied one day later.

The cycloate was applied to a rolled, fine textured seedbed. The soil surface was dry and soil moisture optimum for planting. The material was immediately incorporated into the soil to a depth of 2-3 inches with a garden roto-tiller. After incorporation, the entire trial area was retilled with a spring-tooth drag and roller.

The trial was planted with 6 Planet Jr. seeder units mounted on a tool bar. Twenty pounds of Ruby Queen seed were planted per acre in 24" rows. The weather conditions were clear and dry. The air temperature was 75°F. A breeze of approximately 10 MPH was blowing directly down the row. On June 1 and 2, 2.04 inches of precipitation were measured.

Weed control and crop injury ratings were made on June 25 and 30 by three horticulturists. A 0-10 rating scale was used, with 0 indicating no weed control or no crop injury, and 10 indicated complete weed control or crop kill. Any value above 7 was considered satisfactory weed control, while a crop injury rating of 3 or above was considered excessive crop damage.

On July 11, the trial was cleared of all weeds and kept clean for the remainder of the season.

Twenty-one feet of row from the center of each plot was hand harvested on August 20. The roots were graded into 5 sizes and weighed.

Results And Discussion

The major weed species in the field were lambsquarters (Chenopodium album L.), red root pigweed (Amaranthus retroflexum L.), and yellow foxtail (Seteria glauca L.). These were used as indicator plants for evaluating the effectiveness of the treatments.

Table I represents the weed control and crop injury ratings. The figures given represent the average of the 3 ratings made at two dates. Crop injury ratings made on June 30 are reported by replicate due to the injury noted in the third replicate of the check plot. This was possibly the result of the competition from the extremely high weed population. The damage to this check plot resulted in a yield reduction so that the average yield of the check was lower than some chemically treated plots.

The combination of pre-plant incorporated and pre-emergence herbicides gave superior weed control:

Cycloate + Solubor gave the best weed control (see Table I) with no observable injury to the crop. Crop yield is lower than the check plot. The yield suppression probably was the result of the grade yield distribution (see Table II). Note the similarity to the Solubor plot. Solubor is suspected of delaying maturity and/or yield reduction.

Cycloate + pyrazon compared very favorably with the above treatment in terms of weed control. Crop injury comparisons in late June showed stunting of growth but these effects were not evidenced in comparing yield data. This treatment gave the best over-all (weed control + crop injury + field yield) performance.

Where annual grasses are a consideration, the cycloate + TCA treatment gave a better weed control rating than pyrazon + TCA but had a slightly greater adverse effect on yield.

Generally, treatments with individual chemicals did not give as satisfactory weed control as did the combinations. Effectiveness of individual chemicals to control the specific weed species present were rated as follows:

cycloate - good on foxtail, good on red root, and fair to good on lambsquarters.
pyrazon - poor on foxtail, good on red root, and fair to good on lambsquarters.
Solubor - poor on foxtail, good on red root, and fair to good on lambsquarters.

The addition of T.C.A. to pyrazon gave complete kill of foxtail. For weed control, pyrazon + TCA ranks above the other pre-emergence treatments and compared favorably with the pre-plant incorporated cycloate. At comparable grades, the field yield of the pyrazon + TCA treatment was superior to all other treatments.

Conclusion

Weed response to all chemicals was consistent in all replicates. Cycloate (Ro-Neet)(1) was comparable in weed control to the pyrazon + TCA treatment. However, cycloate, when used in combination with pyrazon, Solubor, or TCA, gave superior weed control, to all other treatments.

The pyrazon + TCA treatment was superior to other pre-emergence treatments and produced the highest field yield in this trial.

For general field use, it appears that cycloate in combination with pyrazon or Solubor will be a practical commercial treatment.

Acknowledgments

The cooperation of the following people is gratefully appreciated:
The Jensen Brothers Farm, Orleans, New York
S. A. Anderson, Director, Raw Product Research, Comstock-Greenwood Foods, Borden Inc., Foods Div., Newark, N.Y.
Dr. R. Sweet, Professor of Vegetable Crops, Cornell University, Ithaca, N.Y.

(1) F.D.A. approval for use on red beets is pending.

Table I Weed Control And Crop Injury Ratings[1]
(Arranged in order from best to poorest weed control)

Treatment	Rate[2] Lbs./A.	Weed Control Ratings: June 25 Ave-3 reps.	Weed Control Ratings: June 30 Ave-3 reps.	Weed Control Ratings: Ave. 2 dates	Crop Injury Ratings: June 25 Ave.	Crop Injury Ratings: June 30 Rep. 1	Crop Injury Ratings: June 30 Rep. 2	Crop Injury Ratings: June 30 Rep. 3
Cycloate[4] + Solubor[3]	4 + 150	9.7	9.3	9.5	1.0	1	1	1
Cycloate[4] + Pyrazon[3]	4 + 4	9.3	9.3	9.3	2.0	3	4	4
Cycloate[4] + TCA[3]	4 + 6	9.0	8.3	8.7	1.0	3	2	3
Pyrazon[3] + TCA[3]	4 + 6	8.7	7.7	8.2	1.0	2	1	3
Cycloate (RoNeet)[4]	4	8.0	7.3	7.7	1.0	2	2	2
Solubor[3]	150	6.7	6.0	6.3	1.0	1	1	1
Pyrazon (Pyramin)[3]	4	6.7	5.3	6.0	1.0	2	1	4
Check Plot	--	1.00	1.0	1.0	1.0	1	1	4

(1) Average ratings by three horticulturists on two separate dates
Rating scale 0 - 10 0 equals no weed control, 10 equals complete weed control
0 equals no crop injury, 10 equals complete crop kill
(2) All rates are in pounds of active chemical except Solubor (20%B) which is given in pounds of formulation (150 lbs. applied over-all is equivalent to the standard commercial treatment of 25 lbs/A applied in a 4-6" band over the row.)
(3) Pre-emergence treatment
(4) Pre-plant incorporated treatment.

Table II Root Yield And Grade Data[1]

Treatment	Rates[2] (Lbs/A)	Yield/A (Tons)	Grade Yield -- % Under 7/8"	7/8-1 3/4"	1 3/4-2 1/2"	2 1/2"-3"	Over 3"
Cycloate[3] + Solubor[4]	4+150	30.0	2.8	55.9	38.6	2.7	0.0
Cycloate[3] + Pyrazon[4]	4+4	34.1	1.6	34.6	51.9	11.0	0.9
Cycloate[3] + TCA[4]	4+6	34.8	1.8	42.8	48.4	6.3	0.7
Pyrazon[4] + TCA[4]	4+6	36.8	1.9	41.7	49.0	7.4	0.0
Cycloate(Ro-Neet)[3]	4	35.3	1.3	40.6	49.3	8.0	0.8
Solubor[4]	150	28.6	3.1	57.7	36.6	2.6	0.0
Pyrazon(Pyramin)[4]	4	32.5	1.4	43.7	44.5	9.6	0.8
Check	-	31.9	2.0	44.5	47.3	6.2	0.0

(1) Average of three replicates. Growing season-84 days (5/28/69-8/20/69)
(2) All rates are in pounds of active chemical except Solubor (20%B) which is given in pounds of formulation (150 lbs. applied over-all is equivalent to the standard commercial treatment of 25 lbs/A applied in a 4-6" band over the row.)
(3) Pre-plant incorporated treatment.
(4) Pre-emergence treatment.

Literature Cited

1) Anderson, S. A., Curtis, L.E., Zaharchuk, A. Pre-emergence Weed Control Test In Red Beets N.E.W.C.C. Proceedings Vol. 15 1961

2) Becker, R.F., Jeffers, C.V., Curtis, L.E. Field Plot Evaluation of Herbicides For Control of Weeds In Red Beets-1967 N.E.W.C.C. Proceedings Vol. 22 1968

3) ________Curtis, L.E., Jeffers, C.V. Red Beet Herbicide Trial-1968 Unpublished Data

4) ________Effect On Yield of Boron Weed Control-Unpublished Data, 1961

5) Frank, R., Switzer, C.M. Effects of Pyrazon On Growth, Photosynthesis, And Respiration Weed Science Vol. 17, July 1969 No. 3

6) ________,________ Absorption And Translocation of Pyrazon By Plants Weed Science Vol. 17, July 1969 No. 3

7) ________,________Behavior of Pyrazon In Soil Weed Science Vol. 17, July 1969 No. 3

8) Kaudy, J.C., Gerger, K.C., Troug, E. Borax Applications To Canning And Sugar Beets For The Control Of Weeds Agronomy Journal Vol. 44, No. 8 August, 1952.

9) Scott, T. W., Bateman, T.W. Methods of Weed Control In Sugar Beets N.E.W.C.C. Proceedings Vol. 22 1968

10) ________, ________, The Use of Chemicals To Control Weeds In Sugar Beets N.E.W.C.C. Proceedings Vol. 23 1969

11) Travett, M.F., Gardner, W. Weed Control in Sugar Beets With Pre-planting, Pre-emergence, and Post-emergence Herbicides N.E.W.C.C. Vol. 23 1969

SELECTIVE CONTROL OF QUACKGRASS IN CORN WITH SEVERAL HERBICIDES [1/]

William B. Duke, Paul F. Boldt and C. S. Smith [2/]

Introduction

Quackgrass (Agropyron repens (L.) Beauv.) can be controlled in field corn (Zea mays L.) with several herbicides including 2-chloro-4-(ethylamino)-6-(isopropylamino)-s-trazine (atrazine), 3-amino-s-triazole (amitrole), and 2,2-dichloroproprionic acid (dalapon). The combination of plow-down (preplow application followed by plowing in a short period of time), plus pre- or early postemergence treatments with these herbicides has proven effective for year-to-year quackgrass control (3). A split application of atrazine is the most effective for yearly control (3). Duke et. al. (2) have found that complete control or eradication is not obtained unless at least 4 lb/A of atrazine are used one year followed by a 2 lb/A atrazine treatment the following year. This may create herbicide residual problems for sensitive succeeding crops unless non-residual chemicals are used in the final year of corn (2). Amitrol and dalapon have never performed in New York as has been reported in other areas (3). It would be desirable to eliminate the need for the preplow application since this is a prime drawback to grower acceptance of the use of herbicides for quackgrass control.

The objective of the studies reported herein was to evaluate the effect of several herbicides on quackgrass and annual weeds in corn and to determine their effect on crop yield.

Materials and Methods

In 1968 studies were conducted on the Saltonstall Farm (a private farm near King Ferry, New York) on Lima silt loam (OM = 2.1%) while in 1969, a similar trial was established on the Leonard Farm (a private farm near Sidney, New York) on Lima silt loam (OM = 1.9%). Each experiment was a randomized complete block with four replications. All herbicide applications were made with a Mater plot sprayer calibrated to deliver 30 gpa.

For the 1968 study, plots 10 x 40 ft. were established in a heavy quackgrass sod that had not been cultivated for at least three years. Preplow herbicides were applied on April 18 to quackgrass with an average height of 5 in. Herbicides and rates applied at this time were atrazine 2 lb/A; 2,3,5-

---

1/ Contribution from the Department of Agronomy, New York State College of Agriculture, Cornell University, Ithaca, New York. Agronomy Journal Series No. 875.

2/ Assistant Professor of Agronomy, Experimentalist and Experimentalist, respectively, Department of Agronomy, Cornell University, Ithaca, New York.

trichloro-4-pyridinol (pyrichlor) 1 lb/A; 2-(4-chloro-6-ethylamino-s-trazine-2-ylamino)-2-methylpropronitrile (SD 15418) at 2 and 4 lb/A; 1,1 dimethyl-4,4-bipyridinium salts (paraquat) 1 lb/A; 3-amino-s-triazole + ammonium thiocyanate mixture (amitrol-T) 2 lb/A; and 2-chloroethanephosphonic acid (Ethrel) 1 1/2 lb/A.

The area was plowed April 25 and planted with Funk G-11A on May 27th in 30 in. rows at a rate to give a population of 25,000 plants/A. A 13-13-13 analysis fertilizer was placed in a 2 x 2 in. band beside the row at planting time at a rate of 300 lb/A.

Most plots which had received the preplow applications were retreated immediately after planting with preemergence treatments of 1 or 2 lb/A atrazine. Exceptions to this were SD 15418 plots which were retreated with SD 15418 at 2 lb/A and one-half of amitrol-T + Ethrel plots which were not retreated. Several postemergence herbicides were applied when the corn was 8-10 in. tall. At this time quackgrass averaged 4 in. in height. These materials and rates were atrazine 2 lb/A plus an 80% paraffin base oil plus 16% polyoxyethlene sorbitan fatty acid ester (AL-411A) at 1/3 gpa; atrazine 2 lb/A plus 2,4-dichlorophenoxyacetic acid 1/8 and 1/4 lb/A plus AL-411-A 1/3 gpa.

The studies in 1969 were conducted in the same manner as in 1968. Plots 16 x 50 feet were established in a heavy quackgrass sod that had not been plowed for several years. Preplow applications of the following herbicides were made on April 28: atrazine 2 lb/A; amitrol-T 2 lb/A; amitrol-T + Ethrel 2 + 1 1/2 lb/A and SD 15418 2 and 3 lb/A. The area was plowed on April 29 and planted with Minn 4400 hybrid on May 18. Row width was 34 in. and final plant population was 24,000 plants. Most plots which had received pre-plow applications were retreated at planting with 2 lb/A atrazine preemergence. Exceptions were SD 15418 plots which were retreated preemergence with SD 15418 2 and 4 lb/A. One-half of the Amitrol-T + Ethrel plots were retreated with 1/2 lb/A 2,4-D postemergence. Other postemergence treatments were the same as described for the 1968 study except for applications of S-6115 (structure undisclosed).

Weed control ratings on individual species and crop injury ratings were taken using the scale 0 to 10 where 0 represents no control or crop injury and 10 represents complete reduction in plant stand. In 1968 and 1969, corn ears were harvested when mature, weighed and yields of grain calculated at 15% moisture.

Results and Discussion

Weed control and crop injury ratings and yield data for the 1968 experiment are presented in Table 1. Applications of 2 lb/A atrazine preplow followed by 2 lb/A atrazine preemergence gave the most outstanding control followed closely in overall activity by pyrichlor preplow plus atrazine pre-emergence. Both treatments gave residual quackgrass activity which according to Duke *et al*. (2) is a major requirement for quackgrass eradication. The herbicide SD 15418 gave moderate control through July but did not provide adequate control later. Similar results were noted for Paraquat plus atrazine.

Preliminary greenhouse experiments had indicated that Ethrel might break "secondary dormancy" of quackgrass rhizomes and hence increase activity of a relatively non-residual herbicide such as amitrol-T. Treating with quackgrass with amitrol-T followed by Ethrel was not particularly effective (Table 1). Even combing this treatment with atrazine did not increase its effectiveness beyond October.

Table 1. Quackgrass control and crop yield, as affected by herbicides applied preplow and preemergence to corn in 1968.

Preplow 2/ Herbicide	Rate lbs/A		Pre-emergence Herbicide	Rate lbs/A	Crop 1/ Response	Quackgrass control 1/ July'68	Oct.'68	May'69	Yield Bu/A
Atrazine	2	+	Atrazine	2	0.1	9.8	8.5	8.8	132.4
Pyrichlor	1	+	Atrazine	1	0.4	10.0	8.9	7.6	130.3
SD 15418	2	+	SD 15418	2	0.2	6.2	4.2	2.3	120.6
	4	+		2	0.1	6.9	5.6	2.0	125.4
Paraquat	½	+	Atrazine	2	0.1	8.9	4.3	2.3	123.2
Amitrol-T	2 & 1½	+	None	-	0.2	8.3	4.6	4.6	101.6
Ethrel 3/	2 & 1½	+	Atrazine	2	0.2	8.9	8.6	8.6	118.3
None	-		Atrazine	2	0.2	8.4	6.1	6.0	110.1
				4	0.1	9.1	7.2	6.1	124.6
None	-		None	-	0.3	1.3	0.6	2.1	61.3
				LSD 0.05					21.6

1/ Scale: 0 to 10; 0 = no effect and 10 = complete reduction in plant stand.
2/ Chemicals were applied 25 days before plowing and planting.
3/ Ethrel was applied 7 days after the amitrol-T.

With the notable exception of the "split-applications" of atrazine or pyrichlor plus atrazine, no herbicide or combination in 1968 was useful for lasting quackgrass control. However, since both Ethrel + amitrol-T and SD 15418 had given early control, it was felt that another experiment should be established in 1969 to reexamine their effectiveness.

In 1969, 4 lbs/A atrazine split equally between preplow and preemergence gave the best overall control (Table 2). Particularly impressive was the combination of amitrol plus Ethrel preplow followed by atrazine preemergence. Their effects were notably additive. SD 15418 effected early season control but re-infestation occurred by October. Atrazine 4 lbs/A preemergence was slightly less active than the "split application".

Table II. Weed control and crop response as affected by herbicides applied preplow and preemergence to corn in 1969.

Preplow Herbicide [2/]	Rate lbs/A		Pre-emergence Herbicide	Rate lbs/A	Crop Response [1/]	Weed Control Ratings [1/] Quackgrass July	Quackgrass October	Yellow Foxtail July	Yellow Foxtail October
Atrazine	2	+	Atrazine	2	0.0	9.6	8.0	8.8	9.9
Amitrol-T	2	+	Atrazine	2	0.1	8.1	4.3	7.9	9.8
Amitrol-T	2 & 1½	+	2,4-D [3/]	½	0.3	4.2	1.0	1.9	2.0
Ethrel	2 & 1½	+	Atrazine	2	0.1	8.9	7.0	8.0	10.0
SD 15418	2	+	SD 15418	2	0.6	7.6	3.5	8.2	8.6
	3	+		2	1.2	8.4	3.3	8.4	9.3
None	-		Atrazine	2	0.1	6.1	2.5	6.0	6.3
None	-			4	0.1	7.4	6.3	8.3	9.8
None	-		None	-	0.4	1.1	0.0	0.2	0.7

1/ Scale: 0 to 10; 0 = no effect and 10 = a complete reduction in stand and vigor.

2/ Chemicals were applied 19 days before plowing and planting.

3/ 2,4-D was applied postemergence when corn was eight in. tall.

Postemergence treatments of atrazine and oil gave excellent control through July (Table 3). These treatments have proven extremely useful as an emergency method for growers unable to use the preplow plus preemergence treatments. Under the proper conditions, addition of 2,4-D to the mixture increased activity and effected longer kill than did atrazine and oil alone. S-6115 provided moderate control of quackgrass in 1969. Some burning of corn leaves was noticeable for 2 weeks after application.

Summary

The combination of 2 lbs/A atrazine preplow plus 2 lbs/A atrazine preemergence was the best treatment for quackgrass control. Amitrol-T plus Ethrel followed by atrazine may provide adequate quackgrass control for those growers who need a herbicide treatment which will not affect sensitive succeeding

crops. SD 15418 gave good initial quackgrass control but the effects were not lasting. Atrazine and oil and atrazine plus 2,4-D and oil provided excellent emergency control of emerged quackgrass.

Table III. Quackgrass control and crop response as affected by herbicides applied postemergence to corn in 1968 and 1969.

Herbicide	Rate lb/A	Crop Response 1/	Quackgrass Control 1/ July	Quackgrass Control 1/ October
Atrazine + AL-411A 2/	2 + 1/3 gpa	0.1	7.9	6.8
Atrazine + 2,4-D(A) + AL-411A	2 + 1/8 + 1/3 gpa 3/	0.3	8.2	4.2
AL-411A	2 + 1/4 + 1/3 gpa	0.2	9.2	7.0
S-6115	1-1/2 4/	0.4	7.1	7.5
Control	-	0.1	0.2	0.3

1/ Scale: 0 to 10; 0 = no effect and 10 = complete reduction in plant stand.

2/ AL-411A is an 80% paraffin base oil plus 16% polyoxyethylene sorbitan fatty acid ester.

3/ Data taken in 1968 only.

4/ Data taken in 1969 only.

Literature Cited

1. Buchholtz, K. P. 1968. Control of quackgrass with pyrichlor. Weed Science 16:439-441.

2. Duke, William B., Robert Burt, and Robert Lucey. 1970. Repeated treatments for quackgrass eradication in crops. I. Treatments in corn. Proc. NEWCC 24: (In press).

3. Fertig, Stanford N. 1962. A summary of quackgrass control studies for 1961. Proc. NEWCC 16:286-290.

4. Putnam, A. R., and S. K. Ries. 1968. Factors influencing the phytotoxicity and movement of paraquat in quackgrass. Weed Science 16:80-83.

Repeated Herbicide Treatments for Quackgrass Eradication in Crops. I. [1/]
Treatments in Corn.

William B. Duke, Robert Burt, and Robert Lucey [2/]

ABSTRACT

The influence of repeated herbicide treatments for quackgrass (Apropyron repens (L.) Beauv.) control in a three year corn - four year alfalfa rotation is being investigated. Complete removal of quackgrass from the corn in the rotation required the following sequel of treatments: Year 1 - 2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine (atrazine) 2 lb/A preplow in combination with 2 lb/A atrazine preemergence; Year 2 - atrazine 2 lb/A preemergence, and Year 3 - a combination of atrazine plus 3-(3,4-dichlorophenyl) -1-methoxy-1-methylurea (linuron) 1 lb/A each. Any deviation from this sequence allowed reinfestation with quackgrass. Atrazine 4 lb/A preplant incorporated in Year 1 followed in turn by treatments for Year 2 and 3 listed above gave almost equal control. Atrazine 2 lb/A plus a non-phytotoxic oil treatment during Year 1 gave excellent quackgrass control but reinfestations were so great that 2 lb/A atrazine in Year 2 were not sufficient for control.

In Year 4, standard herbicides will be used to establish alfalfa and measurements will be taken to evaluate herbicide residual effects and to determine the length of time required for quackgrass to re-infest land which has received the herbicide treatment schedule listed above.

1/ Contribution for the Department of Agronomy, New York State College of Agriculture, Cornell University, Ithaca, New York. Agronomy Journal Series.

2/ Assistant Professor, Research Associate and Associate Professor, respectively, Department of Agronomy, Cornell University, Ithaca, New York.

PREEMERGENCE CRABGRASS CONTROL IN MERION KENTUCKY BLUEGRASS TURF WITH RP 17623 AND OTHER HERBICIDES

R. E. Engel and R. D. Ilnicki[1/]

The experimental herbicide RP 17623 [2-tert.butyl-4-(2,4-dichloro-5-isopropyloxyphenyl)-5-oxo-1,3,4-oxadiazoline] was applied to mixed lawn turf in 1968 and 1969 with several of the current preemergence herbicides to determine its comparative efficiency for crabgrass control. The 1968 test was applied on a turf of Merion Kentucky bluegrass. Three tests were conducted in 1969. Test 1 was applied on mixed turf that contained largely Kentucky bluegrass with some red fescue and bentgrass. Both of these test sites had some crabgrass previously and for insurance of stand the sites had been overseeded with crabgrass seed. Mowing below $1\frac{1}{2}$ in was used intermittently to encourage development of crabgrass.

In 1968, treatments were applied on June 3; in 1969 they were applied on April 4, April 28, and May 13. Plots were 3 x 20 ft and all treatments were replicated three times in a randomized block design. All dry materials were applied with a 3 ft drop-spreader and spray treatments were applied with a two-nozzle boom at 40 psi and 40 GPA. Ratings of crabgrass control were made by three independent estimates in August and September for each of the primary tests.

Tests 2 and 3 of 1969 were on sparse cool-season turf. Rp 17623 was applied alone and with 2-(4-chloro-o-tolyl)oxy propionic acid (mecoprop) and 3,6-dichloro-o-anisic acid (dicamba) in these respective 1969 tests. The former test had no visible germination of knotweed and the latter had considerable knotweed germinating at the time of herbicide application. These were rated for crabgrass and knotweed control on August 14, 1969.

Results

Applications of 2 and 4 lb/A of RP 17623 (ec formulation) to lawn grass turf in 1968 gave better crabgrass control than the standard treatments of 0,0-diisopropyl phosphorodithioate S-ester with N-(2-mercaptoethyl) benzenesulfonamide (bensulide), dimethyl tetrachloroterephthalate (DCPA), and 1-(2-methylcyclohexyl)-3-phenylurea (siduron) (Table 1). In 1969, the 3 and 4 lb rates of granular preparation produced as good or better control than the four standard herbicides (Table 2). The $1\frac{1}{2}$ and 2 lb/A rates of the granular preparations gave 44 and 56% control, respectively. The latter,

---

[1/] Research Professor in Turfgrass Management and Research Professor in Weed Science, respectively, Department of Soils and Crops, Rutgers University, New Brunswick, New Jersey.

an early April treatment at 2 lb/A, was superior to the 49 and 27% control, respectively, with the late April and early May treatments. Wettable powder and emulsifiable concentrate preparations applied in water spray performed less efficiently than the granular preparations. Under sparse turf conditions in the two additional 1969 tests (Tables 3 and 4), RP 17623 granular at 3 lb/A gave 80 and 55% crabgrass control. Knotweed control of 53% was obtained with a 3 lb/A granular preemergence application. This latter result compared favorably with those obtained with such standards as dicamba, mecoprop, and 2-(2,4,5-trichlorophenoxy) propionic acid (silvex).

Conclusion

The herbicide, RP 17623, has inherent ability to give major reductions in crabgrass and knotweed.

Table 1. Crabgrass control in 1968 on Merion Kentucky bluegrass turf with RP 17623 applied June 3, 1968.

Treatment	a.i./A	Crabgrass Control (%)*
RP 17623 ec	$\frac{1}{2}$	39
"	1	52
"	2	77
"	4	93
bensulide gr	12	37
DCPA gr	12	64
siduron gr	12	56

*Average of August and September ratings.

Table 2. Crabgrass control with preemergence applications of RP 17623 to lawn turf. Test 1 - 1969.

Chemical	a.i./A	Date of Application	Crabgrass Control (%)*
RP 17623 gr	1½	E. April	44
"	2	"	56
"	3	"	72
"	4	"	84
"	2	L. April	49
"	2	May	27
"	1	E. April	44
" wp	2	"	28
" ec	2	"	34
bensulide gr	10	"	48
DCPA gr	12	E. April	59
"	12	L. April	75
siduron gr	18	M. April	73
benefin gr	2	L. April	60

*Average of August and September ratings.

Table 3. Crabgrass and knotweed control with RP 17623 on sparse cool-season turf. Test 2 - 1969.

Treatment	Application Date	a.i./A	Crabgrass Control (%)	Knotweed Control (%)
RP 17623 wp	L. March	2	48	27
" gr	"	1	42	17
"	"	1½	63	27
"	"	2	70	23
"	"	3	80	53
"	L. April	2	18	0
RP 17623+mecoprop	"	1 + 1½	5	20
dicamba	L. March	¼	0	7
mecoprop	L. April	1½	5	25

Table 4. Crabgrass and knotweed control on a sparse stand of cool-season grasses with RP 17623. Test 3 - 1969.

Treatment	Application Date	a.i./A	Crabgrass Control (%)	Knotweed* Control (%)
RP 17623 gr	L. March*	1½	40	0
"	"	2	33	0
"	"	3	55	40
" wp	"	1½	7	17
"	"	2	8	40
"	"	3	22	37
RP 17623+dicamba	April	1½ + ¼	7	43
dicamba	"	¼	0	33
mecoprop	"	1½	0	42
silvex	"	1	0	23

*Knotweed germination started.

PRE AND POSTEMERGENCE CHEMICAL CRABGRASS CONTROL STUDIES IN TURFGRASS 1968-69 1/

John A. Jagschitz 2/

Preemergence herbicides are used to control crabgrass (*Digitaria ischaemum* (Schreb.) Muhl.) in turfgrass areas (1,3,4). Each year experimental herbicides are released by industry. One of the three tests reported in this paper evaluates some of these new chemicals in an attempt to find less phytotoxic and more effective materials.

The second test reports on the effect of using half the chemical amount for crabgrass control in the second year. If successful, herbicide residues in turfgrass areas could be lessened and costs could be reduced. The third test evaluates certain herbicides for controlling crabgrass when applied before, during and after its emergence. Pilot work at Rhode Island in 1968 and other investigations have shown that certain chemical combinations can be effective for postemergent control (2,4).

Materials and Methods

The tests were conducted at the turfgrass research area at the Rhode Island Agricultural Experiment Station on Bridgehampton silt loam. The turf was mowed at a height of about one inch. It was fertilized during the summer with a 10-6-4 fertilizer at the rate of 15 lbs per 1000 sq ft. Irrigation was used to encourage crabgrass germination and to avert drought conditions.

Granular materials were applied by hand and sprays were applied with a pressure sprayer adjusted to 30 psi. The herbicides in each test were applied to plots measuring 4 ft x 5 ft in three randomized complete blocks. There were three untreated plots in each block.

1/ Contribution No. 1339, Agricultural Experiment Station, Kingston, Rhode Island 02881.

2/ Assistant Professor, Department of Agronomy & Mechanized Agriculture.

Visual estimates of turfgrass injury were made monthly to September. The scale used was 0-10 with 0 being no injury and 10 being brown or dead turf. Crabgrass emergence started about June 20th and reached 98% by July 9. Estimates of crabgrass cover on each plot were made in September. Percent control was obtained by comparing treated plots with untreated plots in each block.

In test No. 1, evaluation of new chemicals, the turf was established in the fall of 1966 with red fescue and Kentucky bluegrass. It was overseeded with crabgrass in 1967 and 1968. The herbicides, formulations and rates used are shown in Table 1. These were applied on April 30 or May 1, 1969 with the exception of RP-17623, which was applied on June 3. A second application of MF 415 + 416 was applied on May 21, and M-3251 was applied again on May 21, June 16, and July 16. Except for MF 415 + 416, which was sprayed at 40 gpa, the other sprays were applied at 272 gpa.

The turfgrass in test No. 2, value of half chemical rates in second year for crabgrass control, was established in the fall of 1964. It contained Kentucky bluegrass, Merion Kentucky bluegrass, Pennlawn red fescue and Exeter colonial bentgrass. The details and results from full rates in the first year (1968) were presented in a previous paper (3). In January of 1969 the area was overseeded with crabgrass. On May 5, 1969 treatments were made to half of the area of certain plots. They received either full-rates, half-rates or no chemical at all. The treatments and a portion of the 1968 results are presented in Table 2.

The treatments in test No. 3, effect of herbicides in relation to time of crabgrass emergence, were initiated to turfgrass similiar to that of test 1. Chemicals were applied as sprays in water at the rate of 218 gpa. The herbicides, formulations, rates and dates of application in relation to crabgrass emergence and stage of growth are shown in Table 3.

Results and Discussion

Test No. 1 -- Evaluation of new herbicides

The results of standard and new herbicides for crabgrass control are presented in Table 1. The standard materials, bandane, benefin, bensulide, DCPA, nitralin, siduron and terbutol, produced good (80-89%) to excellent (90-100%) crabgrass control with only slight turfgrass injury (less than 2.0). However, plots treated with DCPA showed a reduction in fescue and an increase in bluegrass.

Of the new materials, VCS-438 and MF 415 + 416 produced severe turfgrass injury (4.0 or greater) without achieving fair crabgrass control (at least 70%). CP-53619 produced good crabgrass control, but caused objectionable or moderate turf injury (2.0 to 3.9). Although RP-17623 produced poor crabgrass control, higher rates should be investigated since turf injury was only slight. D-292 produced excellent crabgrass control with only slight turf injury, but caused thinning of fescue and an increase in bluegrass. Lower rates should be investigated. Excellent control was obtained from NC-5651 at the 9 lb rate with only slight injury. This appears to be about the safe rate for turfgrass. M-3251 also produced excellent crabgrass control with only slight injury to the turf. It seems justified to investigate using less material and/or fewer applications.

<u>Test No. 2 -- Effect of half rates for control the second year</u>

The results of full, half, and no treatments to plots treated in the second year are presented in Table 2. None of the treatments produced more than slight turfgrass injury although DCPA plots showed a reduction in bentgrass and fescue and an increase in bluegrass. Plots that were not re-treated had poor crabgrass control, indicating insufficient chemical residue. Bensulide showed the greatest comparative control without re-treatment.

All treatments applied at the full rates in the second year produced excellent control with the exception of benefin (68% control). Excellent results from half rates were produced by bandane, bensulide (EC), bensulide (cob) at the 15 lb rate, DCPA and siduron at the 18 lb rate. Good control was produced by the normal rate of siduron (12 lb) and fair to good control from bensulide (cob) at the 10 lb rate. Poor control was obtained from terbutol and nitralin following the fall application in 1967 but control was fair to good following the 1968 spring treatment. The reverse was true for DMPA and no logical reason can be offered.

<u>Test No. 3 -- Pre and postemergent herbicide applications</u>

The results of the treatments applied before (pre), during and after (post) crabgrass emergence are presented in Table 3. Excellent preemergence results were obtained from

DSMA in combination with either DCPA or siduron. When 73% of the crabgrass had emerged and the plants were in the 1-2 leaf stage, excellent control was produced by siduron alone or the combination of DSMA with either bensulide, DCPA or siduron. When emergence was 98% and the plants were in the 3-5 leaf stage, only the DSMA + siduron combination produced excellent control. Of the materials applied alone at this time only siduron produced good results. Turf injury was only slight from the treatments with the exception of DCPA applied on June 26.

Conclusions

During the 1968-69 season three experiments were conducted in lawn-type turf to evaluate chemicals for the control of crabgrass. One test evaluated new herbicides while another determined whether half rates applied the second year would give satisfactory control. The third test determined the effect of herbicides applied before, during and after crabgrass emergence. The following conclusions are drawn based on the results of these studies:

1. Effective crabgrass control with only slight turfgrass injury was obtained from standard materials such as bandane, benefin, bensulide, DCPA, nitralin, siduron and terbutol. Some thinning of fescue was noted from DCPA.

2. New materials that appear promising and/or deserve further study are CP-53619, D-292, NC-5651, M-3251 and RP-17623. Results with MF 415 + 416 and VCS-438 were discouraging.

3. Half rates of bandane, bensulide, DCPA, nitralin and siduron in the second year after previous spring treatment produced good to excellent crabgrass control. Fair control was produced by half rates of DMPA and terbutol while poor control was obtained from benefin.

4. Siduron alone or combinations of DSMA with either bensulide, DCPA or siduron produced good to excellent control of crabgrass when treated in the 1-2 leaf stage. When plants were in the 4-5 leaf stage, siduron produced good control and the combination of DSMA + siduron produced excellent control.

Literature Cited

1. Engel, R. E. and R. D. Ilnicki. 1965. Performance of experimental herbicides applied pre-emergence for crabgrass control in turf. Proc. NEWCC 19: 470-472.

2. Jagschitz, J. A. 1964. Postemergence crabgrass control results for 1962 and 1963. Proc. NEWCC 18: 511-518.

3. Jagschitz, J. A. 1969. Fall and spring use of preemergent crabgrass control chemicals in turfgrass. Proc. NEWCC 23: 398-404.

4. Perkins, A. T., J. M. Duich, and D. V. Waddington. 1969. Pre- and postemergence crabgrass control results for 1967-68. Proc. NEWCC 23: 391-397.

Appendix

Herbicide	Company	Herbicide	Company
bandane	Velsicol	terbutol	Hercules
benefin	Elanco	CP-53619	Monsanto
bensulide	Stauffer	D-292	Amchem
DCPA	Diamond Shamrock	M-3251	Dow
DMPA	Dow	MF 415 + 416	Mallinckrodt
DSMA	Ansul, Amchem	NC-5651	Fisons
nitralin	Shell	RP-17623	Rhodia
siduron	DuPont	VCS-438	Velsicol

Table 1. Evaluation of herbicides applied in the spring of 1969 for the selective control of crabgrass in a bluegrass-fescue turf.

Herbicide and formulation	ai	Rate lb ai/A	Percent crabgrass control Sept	Maximum turfgrass injury *
bandane (verm)	10%	35	94	.4
benefin (gran)	2½%	2	90	1.0
bensulide (cob)	7%	10	96	.2
" " (gran)	12.5%	10	90	.5
DCPA (gran)	5%	10	100	.0 **
nitralin (gran)	2%	2	89	.3
siduron (verm)	5.7%	12	99	1.0
terbutol (verm)	5%	10	100	.3
CP-53619 (liq)	4 lb/gal	4	44	1.5
" " "	"	8	87	3.0
D-292 (verm)	4%	15	100	.3 **
" " "	"	20	100	1.3 **
M-3251 (gran)	5%	4 (4 X)	100	.9
MF-415+416 (liq)	1+1 lb/gal	1+1 (2 X)	22	4.0
NC-5651 (WP)	20%	6	81	.3
" " "	"	9	97	1.3
" " "	"	12	99	2.3
" " "	"	24	100	4.8
RP-17623 (clay)	5%	2	28	.7
" " "	"	4	54	.4
VCS-438 (liq)	4 lb/gal	½	18	.0
" " "	"	1	8	1.3
" " "	"	2	25	5.3 **
" " "	"	4	18	9.6 **
Checks	-	-	-	.8

Ave crabgrass cover in check plots = 72%

* Turf injury scale 0-10 (0=none, 10=complete brown or kill) from May to Sept.

** Reduction in fescue.

Table 2. Percent crabgrass control in turfgrass from herbicides applied at full and half rates during the second season.

Herbicide and formulation	ai	Rate lb ai/A	Percent Crabgrass Control Sept 1968	September 1969 Retreated Spring 1969 Full Rate	Half Rate	None
Fall application 1967						
bandane (verm)	10%	35	92	99	95	-
benefin (gran)	2.5%	2	63	68	44	-
bensulide (cob)	7%	10	99	98	77	-
" " "	"	15	99	99	97	-
bensulide (EC)	4#/gal	10	97	99	91	-
" " "	"	15	99	99	97	-
DCPA (verm)	4.92%	10	98 *	100 *	99 *	-
DMPA (cob)	4.4%	15	90	97	92	-
terbutol (verm)	5%	10	32 **	97	50	-
nitralin (gran)	.46%	2.4	89 **	92	57	-
siduron (gran)	5.7%	12	7	99	84	-
" " "	"	18	24	99	90	-
Spring application 1968						
bandane (verm)	10%	35	95	-	93	36
benefin (gran)	2.5%	2	55	-	23	12
bensulide (cob)	7%	10	99	-	88	47
" " "	"	15	99	-	99	54
bensulide (EC)	4#/gal	10	99	-	98	51
" " "	"	15	100	-	100	58
DCPA (verm)	4.92%	10	99 *	-	96 *	32 *
DMPA (cob)	4.4%	15	97	-	77	4
terbutol (verm)	5%	10	95	-	74	4
nitralin (gran)	.46%	2.4	95	-	89	5
siduron (gran)	5.7%	12	92	-	87	36
" " "	"	18	97	-	94	18
Ave crabgrass cover in check plots			67%	73%	73%	73%

*Reduction in bentgrass and fescue.

**Moderate to severe turf injury.

Table 3. Effect of herbicides for pre and postemergent control of crabgrass in turf during 1969.

Time of Treatment and Herbicide	Rate lb ai/A	Percent crabgrass control Sept	Maximum turfgrass injury *
<u>Preemergence</u> (June 6, 2 wks before emergence of crabgrass).			
DSMA (WSP)	3	15	.4
" " + bensulide (EC)	3+10	68	1.2
" " + DCPA (WP)	3+10	99	.8
" " + siduron (WP)	3+10	96	.6
<u>Pre and postemergence</u> (June 26, 73% emergence, 1-2 leaf and up to ½ inch height).			
DSMA	3	35	.5
bensulide	10	59	.9
DCPA	10	40	2.8
siduron	10	87	.9
DSMA + bensulide	3+10	95	.3
" " + DCPA	3+10	96	.8
" " + siduron	3+10	98	.6
<u>Postemergence</u> (July 9, 98% emergence, 3-5 leaf and up to 1 inch height).			
DSMA	3	41	.7
bensulide	10	55	.9
DCPA	10	15	1.7
siduron	10	84	1.8
DSMA + bensulide	3+10	74	.4
" " + DCPA	3+10	57	1.7
" " + siduron	3+10	99	.8
Checks	-	-	.6

Ave crabgrass cover in check plots = 74%

*Turf injury scale 0-10, June to September

PREEMERGENCE HERBICIDE EFFECTS ON THE GROWTH OF NEWPORT KENTUCKY BLUEGRASS (POA PRATENSIS L.) SEEDLINGS[1/]

F. V. Juska and A. W. Hovin[2/]

Abstract. Ten Newport Kentucky bluegrass seedlings were planted in 1-gallon crocks containing Evesboro loamy sand. Benefin, bensulide, and DCPA significantly lowered the yield of rhizomes at both the recommended and at twice the recommended rate. 'F' values indicated no significant differences between rates for clippings, crowns, and root weights. Root weights were significantly reduced by bensulide and terbutol. None of the crowns weighed less than the check. Only calcium arsenate lowered clipping yield significantly below that of the check.

Introduction

Several herbicides are available for the preemergence control of crabgrass (Digitaria spp.) and annual bluegrass (Poa annua L.). However, other researchers have reported that injury to fine turf may result from the application of some preemergence herbicides.

Under field conditions, root development from bermudagrass nodes was delayed with preemergence herbicidal treatments. DCPA, bensulide, and terbutol gave the greatest inhibitory effect during the first month (1). Terbutol and bensulide reduced root growth from plugs of mature Merion bluegrass turf (2). Of the herbicide materials used in another study, DCPA showed the greatest reduction in both numbers and length of rhizomes and number of tillers from Kentucky bluegrass plants. Polychlorodicyclopentadiene Isomers and chlordane did not show any change, except a suppression of rhizome number and length at the highest rates, 60 and 90 lb/A active material (3).

The objectives of this study were to determine the effect of several preemergence herbicides on clipping weight, crown, root, and rhizome development of Newport Kentucky bluegrass seedlings.

Materials and Methods

Newport Kentucky bluegrass was seeded in two flats in the greenhouse on October 4, 1968. After the plants had reached seedling stage (two leaves), 10 seedlings were transplanted into gallon crocks containing Evesboro loamy sand on October 24, 1968. Evesboro loamy sand had a pH of 4.8 and was extremely low in nitrogen, phosphorus, and potassium. The lime requirement based on exchange capacity for Evesboro loamy sand for pH 7 was calculated to be 2,200 pounds $CaCO_3$ per acre (5). Elemental P as 0-20-0 was added to

---

1/ Contribution from Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Maryland.

2/ Research Agronomists, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Maryland.

the soil at the rate of 220 lb/A, K at 200 lb/A as KCl, and 4 lb N as urea. Lime, P, K, and N were thoroughly incorporated into the soil with a soil-mixing machine. Micro elements were added at the rate of 5 cc in 50 cc of water per culture on the soil surface in November.

The preemergence crabgrass herbicides were applied on January 15, 1969, at two rates--the recommended and twice the recommended rate[3] (Table 1). A randomized block design was used, with five replications. The cultures were clipped weekly at a height of 2 inches. The soil was brought to field capacity at weekly intervals. The cultures were harvested May 7, 1969. The crowns were cut at the soil surface and the soil washed from the roots and rhizomes over a fine mesh screen. After removing the soil, the rhizomes were separated from the roots. The roots were oven dried, weighed, and then ashed to compensate for any soil that was present. Treatments were evaluated in terms of dry weight of clippings, crowns, roots, and rhizomes.

Results and Discussion

Herbicide treatments significantly affected dry weights of clippings, crowns, roots, and rhizomes, and total weight of each plant part (Table 1). Calcium arsenate lowered clipping yield significantly below that of the check (7.2 to 6.5 g). The weight of clippings decreased slightly but not significantly when terbutol and benefin were applied and increased slightly when DCPA and siduron were applied. Benefin treated Kentucky bluegrass plants produced fewer tillers but the culms were thicker than those of plants that received other treatments.

None of the crowns weighed less than the check. There was a significant increase in crown weights for the following herbicides: bensulide, DCPA, terbutol, and lead arsenate.

A significant reduction in root yield was obtained with the bensulide and terbutol treated cultures and a slight but not significant reduction from benefin and siduron. There was no reduction in root yield from the calcium arsenate treated culture. But reduction was noted in other research where 508 lb ai/A of calcium arsenate were applied to Kentucky bluegrass turf (4). However, bluegrass in the latter study was grown in the field and may have been under moisture stress at times.

When the two rates of herbicides were combined, the rhizome yields for benefin, bensulide, and DCPA were significantly lower compared to the check. Differences among rates for herbicides were highly significant for rhizomes only (Table 2). Benefin, bensulide, and DCPA reduced the yield of rhizomes at both rates of herbicide application. The reduction in yield of rhizomes was considerably greater at the higher herbicide rate. The reduction in yield at the double rate for benefin was 163%, for bensulide 157%, and for DCPA 155%. The yield of rhizomes obtained from the terbutol treatment at the 10 lb/A rate was slightly higher than the check.

3/ See Appendix for chemical names.

The results of this study suggest that a yearly application of some of the preemergence herbicides suppresses growth of clippings, roots, and/or rhizomes; however, recovery within the year is very probably. Yearly applications of some preemergence herbicides may be deleterious to turf.

Literature Cited

1. Bingham, S. W. 1967. Influence of herbicides on root development of bermudagrass. Weeds 15:363-365.

2. Engel, R. E., and L. M. Callahan. 1967. Merion Kentucky bluegrass response to soil residue of preemergence herbicides. Weeds 15:128-130.

3. Gaskin, T. A. 1964. Effect of crabgrass herbicides on rhizome development in Kentucky bluegrass. Agron. J. 56:340-342.

4. Singh, R. K. N., and R. W. Campbell. 1965. Herbicides on bluegrass. Weeds 13:170-171.

5. Whittaker, Colin W., W. H. Armiger, P. P. Chichilo, and W. M. Hoffman. 1955. "Brown mud" from the aluminum industry as a soil liming material. Soil Sci. Soc. of Amer. Proc. 19:288-292.

TABLE 1. Effect of herbicides on the dry weight of clippings, crowns, roots, and rhizomes of Newport Kentucky bluegrass.

Herbicide	Rates lb ai/A	Clippings g	Crowns g	Roots g	Rhizomes g	Total weight g
benefin	2 & 4	6.9	7.38	3.7	1.27*	19.25
bensulide	15 & 30	7.1	8.40*	2.9*	1.37*	19.77
DCPA	10 & 20	7.4	7.83*	4.6	1.71*	21.54
terbutol	10 & 20	6.8	8.16*	2.6*	3.00	20.56
siduron	12 & 24	7.4	7.48	3.7	2.80	21.38
lead arsenate 96% ai	308 & 616	7.2	8.43*	4.2	2.80	22.63
calcium arsenate 69% ai	396 & 792	6.5*	7.54	4.1	2.85	20.97
check	0	7.2	6.96	4.1	2.90	21.16
*LSD 5% herbicides		.5	.84	.6	.51	

TABLE 2. Yield of rhizomes from Kentucky bluegrass seedlings treated with two rates of preemergence herbicides.

Herbicide	Rate lb ai/A	Yield g	lb ai/A	Yield g
benefin	2	1.84*	4	0.70*
bensulide	15	1.70*	30	1.04*
DCPA	10	2.12*	20	1.29*
terbutol	10	3.28	20	2.73-
siduron	12	2.54-	24	3.05
lead arsenate	308	2.83-	616	2.87
calcium arsenate	396	3.02	792	2.66-
check	0	3.02	0	2.79
		20.35		17.13

*LSD 5% rhizome yield = .72

APPENDIX

Common name	Chemical name	Trade name	Manufacturer's name
benefin	*N*-butyl-*N*-ethyl-*a*,*a*,*a*-trifluoro-2,6-dinitro-*p*-toluidine	* Balan	* Eli Lilly
bensulide	*O*,*O*-diisopropyl phosphorodithioate *S*-ester with *N*-(2-mercaptoethyl) benzenesulfonamide	* Betasan	* Stauffer
DCPA	dimethyl tetrachloroterephthalate	* Dacthal	* Diamond Shamrock
terbutol	2,6-di-*tert*-butyl-*p*-tolyl methylcarbamate	* Azak	* Hercules
siduron	1-(2-methylcyclohexyl)-3-phenylurea	* Tupersan	* E. I. du Pont
lead arsenate	lead arsenate 96% active	several names	various companies
calcium arsenate	calcium arsenate 69% active	several names	various companies

*Mention of trade names, proprietary products, or company names does not constitute a guarantee or warranty of the product by the U. S. Department of Agriculture, and does not imply its approval to the exclusion of other products that may also be suitable.

CHEMICAL CONTROL OF POA ANNUA L. IN TURFGRASS AND THE EFFECT OF VARIOUS CHEMICALS ON SEED PRODUCTION [1]

John A. Jagschitz [2]

Annual bluegrass (*Poa annua* L.) in turfgrass is usually considered to be a troublesome weed. Its control has been the goal of numerous researchers. Two recent approaches for its control have been (1) to use preemergent herbicides and (2) to chemically inhibit seed production.

To examine further these methods of control two tests were initiated, one on putting-green turf and the other on lawn turf. Both tests evaluated chemicals for preemergent control of annual bluegrass; the test on lawn turf was also designed to study the effect of the chemicals on seed production.

Materials and Methods

Experiments were conducted at the turfgrass research area of the Rhode Island Agricultural Experiment Station. The soil type is a Bridgehampton silt loam.

Test No. 1, on the preemergent chemical control of *Poa annua* in putting-green turf, was initiated in May 1965 on an old stand of *Astoria* colonial bentgrass maintained at ¼ inch height. Herbicides were applied by hand to plots measuring 4 ft x 5 ft in four randomized complete blocks and watered in after application. There were six untreated check plots in the experiment. The chemicals, formulations, rates and dates of application are presented in Table 1.

Estimates of annual bluegrass cover in each plot were made at the time of treatment in 1965 and in May or June of 1966, 1967, and 1969. Percent control was based on the reduction. Observations for turfgrass injury were made periodically during the test period.

Test No. 2 was initiated in April of 1969 on lawn turf to determine the effect of chemicals on control of plants and on seed production. The turf was chiefly annual bluegrass with patches of Kentucky bluegrass, velvet bentgrass, and white clover. The chemicals were applied to plots measuring 5 ft x 8 ft in two randomized complete blocks. There were four untreated plots in each block. The chemicals, formulations, rates and dates of application are presented in Table 2. Granular materials were applied by hand and others as sprays in water at the rate of 272 gpa with the exception of ethrel, MH and MF 415 + 416 which were applied at 40 gpa.

---

[1] Contribution No. 1341, Agricultural Experiment Station, Kingston, R.I. 02881.

[2] Assistant Professor, Department of Agronomy & Mechanized Agriculture.

Estimates of annual bluegrass cover in each plot were made at the time of treatment and on October 17, 1969. Percent control was based on the reduction. Color observations of annual bluegrass were made on June 10. The scale used was 0-10, with 10 being completely yellowed plants. Turf injury estimates were made on May 16 and June 10 and the scale used was 0-10 (0=none, 10=complete brown or kill). As a further indication of injury, estimates of bare area of each plot were made on July 24 and October 17.

Visual estimates of seed head reduction were made on May 16, May 25 and June 10. On June 10 seed head heights were measured by averaging several clumps in each plot. Treatments which showed a considerable reduction in seed heads were selected for seed head counts. The seed head in an area 6 x 6 inches were counted and expressed as number per sq ft. These harvests were cleaned and the seed obtained was expressed in grams per sq ft. On July 12 the presence of a new crop of seed heads in the plots was recorded.

Results and Discussion

Test No. 1 -- Preemergence control in putting-green turf

At no time during this test was there more than slight, temporary discoloration to the turfgrass from any of the herbicide treatments. Annual bluegrass control estimates are presented in Table 1. All treatments produced some control within one-year; however, it was not until after the second year of application that some treatments produced control of 80 percent or better. These were the single, yearly applications of bensulide at the 15 lb rate and the split applications of tri-calcium arsenate and lead arsenate.

Although the results from this test are favorable, it is possible that reseeding problems might occur where the annual bluegrass population is high and it dies all at one time. Since annual bluegrass control is basically achieved by preventing establishment of new plants from seed, the effects the residues will have on overseeding of basic grasses will be extremely important.

Test No. 2 -- Chemical effects on control and seed production

The results from herbicide treatments in 1969 to lawn turf are presented in Tables 3, 4 and 5. Since satisfactory control may take several years to develop and some chemicals were used for the first time, the data might best serve to indicate guides for further testing.

Severe turfgrass injury and a reduction in clover and annual bluegrass was produced by atrazine + simazine. Few seed heads were evident, but this was due to direct plant injury. Treatment with tri-calcium arsenate produced yellowing of annual bluegrass, turfgrass injury, and some reduction in clover. It also resulted in a reduction in annual bluegrass, but had little effect on the seed heads. Lower rates of these two chemicals should be investigated as well as retreatment in succeeding years.

Some control of annual bluegrass was produced by DCPA and nitralin. They had little effect on seed heads or turfgrass. Benefin and CP-53619 gave a similar response although there was some initial bareness in the plots. Bensulide, D-292, M-3447 and neburon had little effect on annual bluegrass or its seed heads, but the latter two chemicals resulted in some initial bareness. Retreatment with these chemicals for several years may produce gradual control.

Ethrel treatments resulted in some yellowing, some control of annual bluegrass, a reduction in clover, slight turfgrass injury, and some bareness. Seed head heights and numbers were reduced, but the seed yield appeared unaffected. Treatment with MH produced a considerable amount of yellowing of annual bluegrass and moderate to severe turf injury although little bareness developed. Control of annual bluegrass was not apparent, but there was a considerable reduction in the height and number of seed heads and yield of seed. The MH treatments were also effective in reducing seed heads which formed later in July.

Treatments of MH 415 + 416 produced some yellowing and reduction of annual bluegrass and a reduction of clover. Turf injury was slight, except with the 1 + 1 lb rate in two applications which caused severe injury, and all treatments caused considerable bareness. Treatments which produced a considerable reduction in height and number of seed heads and seed yield were the $\frac{1}{2}$ + $\frac{1}{2}$ lb rate applied in April + May and the 1 + 1 lb rate applied in either April or April + May.

Results indicate that ethrel, MH and MF 415 + 416 may have considerable value in an annual bluegrass control program by preventing seed production. Although peak seed yields may occur in May or June it was observed that some seed was produced during the summer and fall. Whether all seed must be prevented to have a successful control program is a serious question. It is apparent that various rates and times of application with these chemicals need to be investigated.

Conclusions

Two tests were conducted to evaluate herbicides for the control of annual bluegrass. One test also studied the effect of chemicals on seed production. Based on the results of these tests the following conclusions may be reached:

1. Bensulide, lead arsenate and tri-calcium arsenate treatments for several years in putting-green turf resulted in good control of annual bluegrass.

2. Data on turfgrass injury, yellowing and control of annual bluegrass, seed head reduction and seed yields from the various chemicals, rates and times of application in the tests can be used to indicate guides for further testing.

3. The use of ethrel, MH or MF-415 + 416 appeared promising for preventing seed production of annual bluegrass.

Appendix

Herbicide	Company	Herbicide	Company
atrazine	Geigy	MF - 415 + 416	Mallinckrodt
benefin	Eli Lilly	MH (P-342)	Uniroyal
bensulide	Stauffer	NC - 5651	Fisons
CP - 53619	Monsanto	neburon	DuPont
D - 292 (69-130)	Amchem	nitralin	Shell
DCPA	Diamond Shamrock	simazine	Geigy
ethrel (68-240)	Amchem	tri-calcium arsenate	Rhodia
M - 3447	Dow		

Table 1. Control of annual bluegrass from herbicides applied annually in April or May to putting-green turf. (Astoria colonial bentgrass)

Herbicide	Form	Rate lb ai/A 1965 - 68	% Annual bluegrass control May 1966	June 1967	May 1969
bensulide	7% cob	10 + 5*	33	64	64
bensulide	7% cob	15	28	67	83
lead arsenate	98% dust	534 + 534**	24	29	86
lead arsenate	98% dust	1067	30	29	76
tri-calcium arsenate	48% gran	105 + 105**	22	47	91
tri-calcium arsenate	48% gran	209	17	29	66
Ave annual bluegrass cover in checks			11%	18%	17%

* Applied in August of 1965 & 1966
** Applied in June each year

Table 2. Treatments applied to lawn-type turf in the spring of 1969 for the control of annual bluegrass plants and seeds.

Herbicide	Formulation	Rate lb ai/A	Date of application
benefin	2.5% gran	2	4/21
bensulide	7% gran	10	"
D-292 (69-130)	4% gran	16	"
DCPA	5% gran	10	"
nitralin	2% gran	2	"
tri-calcium arsenate	48% gran	209	"
M-3447	8 lb/gal	4	4/21+5/16+6/17+7/16
neburon	50% WP	2	4/25
atrazine + simazine	80% WP	½+½	"
CP-53619	4 lb/gal	4	4/29
NC-5651	20% WP	12	5/19
ethrel (68-240)	2 lb/gal	2	4/25+5/16
" " " "	" " "	6	4/25
MH (P-342)	1½ lb/gal	3/8	4/25+5/16
" " "	" " "	3/4	" "
MF-415 + MF-416	1 lb/gal	½+½	4/25
" " " "	" " "	"	5/16
" " " "	" " "	"	4/25+5/16
MF-415 + MF-416	1 lb/gal	1+1	4/25
" " " "	" " "	"	5/16
" " " "	" " "	"	4/25+5/16

Table 3. Effect of herbicides applied in the spring of 1969 on annual bluegrass and turfgrass.

Treatment	Annual Bluegrass percent yellow June 10	Annual Bluegrass percent control Oct 17	Turf injury 0-10 May-June	Percent Bare July 24	Percent Bare Oct 17
benefin	0	21	.5	16	2
bensulide	0	0	0	4	0
D-292	0	6	0	5	3
DCPA	0	33	0	8	0
nitralin	0	64	0	4	2
tri-calcium arsenate	20	80 *	4.3	15	14
M-3447 (4 times)	0	0	.5	14	5
neburon	0	7	.5	24	1
atrazine + simazine	0	39 *	8.5	35	11
CP-53619	5	24	.5	12	5
NC-5651	0	0	0	6	5
ethrel 2 lb April+May	15	34 *	1.0	24	10
" " 6 lb April	5	24	0	2	14
MH 3/8 lb April+May	60	0	2.5	5	2
" 3/4 lb " "	85	17	5.5	2	3
MF ½ + ½ lb April	0	44 *	.5	53	24
" " " May	5	26 *	0	35	29
" " " April+May	20	43 *	1.3	47	25
MF 1 + 1 lb April	10	35 *	.8	30	16
" " " May	5	42 *	.5	35	21
" " " April+May	85	57 *	5.5	43	25
Checks	0	-	.1	7	3

Ave annual bluegrass cover in check plots = 41%

*Reduction in clover

Table 4. Effect of herbicides applied in the spring of 1969 on annual bluegrass seed heads.

Treatment	% Seed Head Reduction May 16	May 26	June 10	Seed Head Height (inches) June 10
benefin	0	10	0	8
bensulide	0	10	10	7
D-292	10	10	10	6
DCPA	10	0	10	7
nitralin	10	0	10	8
tri-calcium arsenate	10	20	20	5
M-3447	10	10	10	7
neburon	0	0	10	6
atrazine + simazine	40	90	-	-
CP-53619	0	0	10	6
NC-5651	10	10	10	7
ethrel 2 lb April+May	10	30	60	4
" " 6 lb April	20	70	60	4
MH 3/8 lb April+May	10	70	90	1
" 3/4 lb " "	70	90	90	1
MF ½ + ½ lb April	10	30	0	6
" " " May	0	10	30	6
" " " April+May	20	60	80	3
MF 1 + 1 lb April	30	90	60	4
" " " May	10	20	70	3
" " " April+May	70	90	90	1
Checks	10	0	10	7

Table 5. Effect of herbicides applied early in the spring of 1969 on number of annual bluegrass seed heads and seed yield.

Treatment	Seed Heads (per sq ft) June 2	Seed Yield (g / sq ft) June 2	Seed Heads * July 12
ethrel 2 lb April + May	-	-	4
ethrel 6 lb April	624	1.16	3
MH 3/8 lb April + May	332	trace	2
MH 3/4 lb April + May	108	.00	1
MF $\frac{1}{2}$ + $\frac{1}{2}$ lb April	-	-	4
MF $\frac{1}{2}$ + $\frac{1}{2}$ lb May	952	.46	4
MF $\frac{1}{2}$ + $\frac{1}{2}$ lb April + May	588	.10	4
MF 1 + 1 lb April	252	trace	4
MF 1 + 1 lb May	808	.22	4
MF 1 + 1 lb April + May	272	trace	2

* Scale 0 to 4, 0 = none, 4 = many

RESULTS WITH SEVERAL SURFACTANTS IN COMBINATION WITH TURFGRASS HERBICIDES

K. J. McVeigh, R. E. Engel, and R. D. Ilnicki[1/]

Abstract

Five different spray adjuvants were used in turf herbicide treatments to determine if they increased herbicidal efficiency. A sufficient increase in effectiveness would allow a reduction in the application rate of the chemical. The herbicide (2,4-dichlorophenoxy)acetic acid (2,4-D) was evaluated with the several adjuvants for the control of broadleaf plantain (Plantago major) and dandelion (Taraxacum officinale, while the herbicide disodium methanearsonate (DSMA) was used with the same materials for the control of crabgrass (Digitaria sanguinalis). All evaluations were conducted in the field on a predominantly bluegrass (Poa pratensis) turf. The oils included one paraffin base oil (Sun Oil Co. #11) and two vegetable oils (Sun Oil Co. ESAF and ELIN). The spray adjuvants were Atlas Chemical Co. AL-209 and AL-411A. The rates of herbicide and adjuvant were varied to provide a range of comparisons.

No great differences in degree of control were noted. However, certain combinations appeared to increase herbicide efficiency.

Additional studies with these herbicides and adjuvants are anticipated in the future.

[1/] Research Assistant, Research Professor in Turfgrass Management, and Research Professor in Weed Science, respectively, Department of Soils and Crops, Rutgers University, New Brunswick, New Jersey.

CHICKWEED CONTROL IN DORMANT ALFALFA[1/]

J. V. Parochetti[2/]

Chickweed (Stellaria media L. Cyrillo) is a major winter weed problem in alfalfa (Medicago sativa L.) in Maryland. Chickweed growth can become so dense that proper cutting and field curing are not possible, thus lowering the quality of the resultant hay. This paper reports three experiments conducted in three different years with various chemicals for the control of chickweed.

Materials and Methods

Three locations in Maryland were selected for experimental work in dormant Williamsburg alfalfa and orchardgrass (Dactylis glomerata L.) predominately infested with common chickweed. All locations had been established at least one full year. The spray volume was 30 gpa. Herbicides impregnated on a fertilizer carrier and granular formulation were applied as the dry material.

Chickweed control was recorded as an estimate of the percentage of ground not covered by chickweed. Alfalfa and orchardgrass injury was rated on a scale of 0 to 100 with 0 equalling no effect on the crop and 100 equalling 100% destruction; a rating of 30 or higher was considered unacceptable injury. All yields are expressed on an oven-dry basis.

Location 1. Herbicides studied and applied as a spray formulation were 2-chloro-4,6 bis (ethylamino)-s-triazine (simazine), 3-(3,4-dichlorophenyl)-1,1 dimethylurea (diuron), isopropyl m-chlorocarbanilate (chloropropham), and 2-sec-butyl-4,6-dinitrophenol (dinoseb).

Herbicides tested that were impregnated on fertilizers included simazine, 2-sec-butylamino-4-ethylamino-6-methoxy-2-s-triazine (GS 14254), and diuron. Treatment rates are listed in Table 1, applications were made in the fall, December 15, 1967, and the spring, March 25, 1968, near Ringgold, Maryland. The soil was Duffield silty clay loam with 2.2% organic matter, 54% silt, 18% sand, 28% clay. The experimental design was a randomized block with three replications. All plots were fertilized with 400 lb/A of 0-10-30.

Location 2. Herbicides applied as a spray were simazine, GS 14254, diuron, chloropropham, dinoseb, 2,6-dichlorobenzonitrile (dichlobenil), 3-tert-butyl-5-chloro-6-methyluracil (terbacil), and N-(1,1-dimethylpropynyl)-3,5-dichlorobenzamide (RH 315).

1/ Scientific Article No. A1570 and Contribution No. 4284 of the Maryland Agricultural Experiment Station, Department of Agronomy.

2/ Assistant Professor, Department of Agronomy, University of Maryland, College Park, Maryland 20742.

Herbicides that were impregnated on fertilizer were simazine, GS 14254, diuron, and chloropropham. Treatments were applied February 28, 1969 near Wilson, Maryland. The soil was Hagerstown loam with 2.9% organic matter, 44% silt, 30% sand, and 26% clay. The experimental design was a randomized complete block with three replications. All plots received 724 lb/A of 0-10-30 fertilizer.

Location 3. Herbicides studied were simazine, 2-chloro-4-ethylamino-6-isopropylamino-*s*-triazine (atrazine), and GS 14254. Where a phytobland oil was used, it was Sun Superior spray oil 11# + 1% Rohm-Haas surfactant 9D-207. The experimental design was a randomized complete block with four replications. Time of applications and rates are listed in Table 3. Treatments were applied March 30, 1967, at the Plant Research Farm, Fairland, Maryland. Alfalfa had just broken dormancy and had 1 to 2 leaves developed. The soil was Chillum loam with 2.4% organic matter, 43% silt, 36% sand, and 21% clay.

Results and Discussion

Location 1. Fall application of all herbicides tested resulted in better chickweed control than spring applications (Table 1) when observed on May 17. Poor to fair chickweed control resulted from an early spring application of diuron, dinoseb, and dichlobenil applied as a spray; whereas, excellent chickweed control was recorded from the spring sprayed applications of simazine. Chickweed control resulting from the sprayed applications of chloropropham in the spring showed a marked increase from April 16 to May 17. In contrast to the other herbicides studied which resulted in rapid chickweed kill, chloropropham manifested its herbicidal action slowly taking four to eight weeks to kill chickweed.

Chloropropham and diuron impregnated on fertilizer applied in the fall resulted in chickweed control comparable to the sprayed herbicides. However, spring applications of these two herbicide-fertilizer combinations were inferior to the sprayed formulations.

Grass injury occurred from fall applications of 1.5 lb/A of both diuron and simazine; this injury was reflected in a reduction of total forage harvested for these two treatments. However, there were no significant differences in alfalfa portion of the yields at the first harvest and further yields were not taken.

Location 2. Simazine and GS 14254 applied as a spray at 0.8 lb/A resulted in excellent (90% or better) control of chickweed, whereas, inferior control resulted from 0.8 lb/A of sprayed diuron. At 1.6 lb/A, these three herbicides provided excellent chickweed control. Chickweed control resulting from simazine and GS 14254 impregnated on fertilizer at 0.8 lb/A at the early date of observation April 19 was about 10% less than the 0.8 lb/A spray application. However, at the late date of observation of the chickweed, the impregnated fertilizer applications were comparable to the sprayed applications. At 1.6 lb/A simazine and GS 14254 impregnated fertilizer application provided excellent chickweed control similar to the 1.6 lb/A sprayed application. Diuron on fertilizer provided inferior chickweed control, probably due to the late application date of February 28, (Table 2).

The only significant increase from the check in alfalfa-grass yields was an increase from 0.8 lb/A of simazine impregnated on fertilizer. At the 0.01 level of probability there were no differences from the check and further yields were not taken.

Terbacil at 0.4 lb/A resulted in excellent chickweed control, but completely eliminated the orchardgrass. RH 315 at 2 lb/A and chloropropham at 1 lb/A effected similar chickweed control which increased from fair to excellent control from April 19 to the April 30 observation. At the rates studied, dinoseb and dichlobenil were not effective chickweed herbicides.

Location 3. Chickweed control resulting from the early spring application of several triazine herbicides was quite low when compared to data from Locations 1 and 2. Rates of 2 lb/A of simazine and GS 14254 resulted in 89.2% and 84.5% chickweed control. With 1 lb/A atrazine, the addition of Sun Oil 11E (3% v:v) increased chickweed control from 75.5% without oil to 97.4% with oil, (Table 3).

Alfalfa injury as yellowing of new growth was recorded for atrazine and the two higher rates of GS 14254. Weed free alfalfa yields were not significantly different from the check.

Other workers (1, 2, 3, 4) have also reported that chickweed is controlled satisfactorily with the chemicals used in this study. This study provided further evidence that rates as low as 0.8 lb/A applied in the fall provided excellent chickweed control.

Summary

In general fall application of most herbicides tested gave excellent chickweed control with the exception of dinoseb and dichlobenil. In 1969, late winter applications of the lower rate of sprayed and fertilizer impregnated simazine and GS 14254 were superior to the same rate of diuron. Diuron and chloropropham impregnated fertilizer applied in the fall resulted in excellent chickweed control.

In general none of the treatments significantly affected total alfalfa grass yields; terbacil, although not reducing total forage yields, was the only herbicide to completely eliminate orchardgrass.

Acknowledgement

The author acknowledges the assistance of Dr. John Ellis, Mssr. Kenneth Wisner, Gary Reedy, and Robert Smart in carrying out these investigations. The partial financial support of Geigy Chemical Corporation, Ardsley, New York is appreciated.

Literature Cited

1. Duke, W. B., and E. S. Spear. 1969. Weed control in established legumes. Proc. NEWCC. 23:212-219.

2. Ilnicki, R. D., and L. F. Hist. 1969. Weed control in dormant alfalfa. Proc. NEWCC. 23:222-226.

3. Peters, R. A., and R. M. O'Leary. 1967. Herbicidal response of white cockle (Lycnis alba) and other winter weeds associated with alfalfa. Proc. NEWCC. 23:299-302.

4. Pruss, S. W. 1969. Control of winter annual weeds in established alfalfa with simazine. Proc. NEWCC 23:227-232.

Table 1. Chickweed control in established dormant alfalfa, 1968, Washington County, Maryland.

Herbicide	Time of Year	Rate lb/A	% Chickweed Control[1/] 4/16	% Chickweed Control[1/] 5/17	% Reduction Vigor[2/] Alfalfa 5/17	% Reduction Vigor[2/] Grass 5/17	Tons/A Dry Weight First Harvested Alfalfa+Grass 5/17	Tons/A Dry Weight First Harvested Alfalfa 5/17
1. Check	Fall[3/]	--	0 d[5/]	0 d	0	0	1.18	.41
	Spring[4/]		0 d	0 d	0	0	1.05	.37
2. Diuron	Fall	.75	100 a	100 a	0	0	1.27	.24
	Spring		38 c d	70 b c	0	0	1.20	.36
3. Diuron on Fertilizer	Fall	.75	93 a	100 a	0	0	1.25	.26
	Spring		28 c d	53 c	33	0	1.24	.28
4. Diuron	Fall	1.5	100 a	100 a	7	53	.83	.50
	Spring		60 a b c	100 a	0	0	.98	.40
5. Simazine	Fall	1.0	100 a	100 a	0	0	1.23	.50
	Spring		88 a b	100 a	0	0	1.13	.33
6. Simazine	Fall	1.5	100 a	100 a	10	50	.57	.31
	Spring		93 a	100 a	0	0	1.12	.32
7. Chloropropham	Fall	1.0	100 a	100 a	0	0	1.13	.27
	Spring		60 a b c	100 a	0	0	1.37	.34
8. Chloropropham	Fall	2.0	100 a	100 a	0	0	1.31	.31
	Spring		68 a b c	83 a b	0	0	1.17	.25
9. Chloropropham on Fertilizer	Fall	1.0	100 a	100 a	0		1.24	.37
	Spring		43 b c d	83 a b	0		1.17	.41
10. Dinoseb	Fall	1.0	60 a b c	100 a	0		1.36	.66
	Spring		53 a b c	47 c	0		1.38	.26
							$lsd_{0.05}$ = .36	n.s.

1/ Visual ratings of the percentage of the ground not covered by chickweed; 0=ground covered with chickweed, no control; 100=100% of the ground chickweed free and 100% chickweed control.

2/ Visual ratings, 0=no effect on crop (alfalfa and grass); 100=100% reduction in vigor of crop

3/ Fall application made on December 15, 1967.

4/ Spring application made on March 25, 1968.

5/ Values within a column followed by identical letters are not significant at the 0.05 level of probability.

Table 2. Chickweed control in established dormant alfalfa, 1969, Washington County, Maryland with herbicides applied as spray applications and on impregnated 0-10-30 fertilizer.

Treatment	Carrier	Rate lb/A	% Chickweed Control[1/] 4/19	% Chickweed Control[1/] 4/30	Tons/A Dry Weight Orchardgrass + Alfalfa 5/14
Check	--	--	0.0 e[2/]	0.0 d	.88
Diuron	Spray	0.8	55.0 b c	76.7 a b	1.10
Diuron	Spray	1.6	93.3 a	100.0 a	.98
Diuron	Fertilizer	0.8	13.3 e	20.0 c d	.97
Diuron	Fertilizer	1.6	41.7 c d	56.7 b	.74
Simazine	Spray	0.8	86.7 a	98.3 a	.98
Simazine	Spray	1.6	93.3 a	100.0 a	1.05
Simazine	Fertilizer	0.8	81.7 a b	98.3 a	1.15
Simazine	Fertilizer	1.6	95.0 a	100.0 a	.75
GS 14254	Spray	0.8	90.0 a	98.3 a	1.09
GS 14254	Spray	1.6	98.3 a	100.0 a	1.05
GS 14254	Fertilizer	0.8	78.3 a b	95.0 a	1.05
GS 14254	Fertilizer	1.6	98.3 a	100.0 a	.92
Dichlobenil	Spray	1.0	16.7 d e	6.7 c d	1.05
Terbacil	Spray	0.4	96.7 a	100.0 a	.99
Terbacil	Spray	0.8	100.0 a	100.0 a	.91
RH 315	Spray	1.0	55.0 b c	75.0 a b	.84
RH 315	Spray	2.0	78.3 a b	93.3 a	1.08
Chloropropham	Spray	1.0	75.0 a b	96.7 a	1.06
Dinoseb	Spray	2.0	46.7 c	28.3 c	1.02
					$lsd_{0.05}$ = .26

1/ Visual ratings of the percentage of the ground not covered by chickweed; 0=ground covered with chickweed, no control; 100=100% chickweed free

2/ Values within a column followed by identical letters are not significant at the 0.05 level of probability.

Table 3. Chickweed control in dormant established alfalfa, 1967, Plant Research Farm, Fairland, Maryland.

Treatment	Rate lb/A	% Alfalfa[1/] Yellowing 4/19/67	% Chickweed Control 5/2/67		Yields Tons/A 5/18	7/1	8/9
Simazine	1.0	0	69.5	c[3/]	.70	.88	.78
Simazine	1.5	0	77.0	b c	.72	.78	.64
Simazine	2.0	0	89.0	a b	.73	.80	.62
GS 14254	1.0	0	27.5	d	.70	.86	.77
GS 14254	1.5	5	79.0	b c	.84	.82	.67
GS 14254	2.0	10	84.5	a b c	.76	.89	.78
Atrazine + oil	0.5	15	75.5	b c	.73	.79	.55
Atrazine + oil	1.0	20	97.4	a	.68	.77	.65
Check		0	8.3	e	.72	.91	.72
					n.s.	n.s.	n.s.

1/ Visual ratings, 0=no effect on alfalfa; 100=100% reduction in vigor of crop.

2/ Visual ratings of the percentage of the ground not covered by chickweed; 0=ground covered with chickweed, no control; 100=100% chickweed free

3/ Values within a column followed by identical letters are not significant at the 0.05 level of probability.

GIANT FOXTAIL AND FALL PANICUM CONTROL IN SOYBEANS[1/]

J. V. Parochetti[2/]

Several herbicides are used in Maryland for annual grass control in soybeans. Growers seek information regarding the most effective herbicide available. This experiment was conducted to determine the potential of several herbicides for controlling weeds in soybeans.

Materials and Methods

Two experiments were conducted at the Wye Institute, near Queenstown, Maryland. The plots were 4 rows, spaced 2.5 feet apart, by 20 feet long. A completely randomized block design was used with four replications. All treatments were applied at 30 gpa.

In both experiments Cutler variety soybeans were planted on June 4. Preemergent treatments were applied June 4; preplant incorporated treatments were applied June 3. Experiment A was infested primarily with giant foxtail (Setaria faberii Hermm.) and was located on Mattapex silt loam. Treatments are listed in Table 1. Experiment B was heavily infested with fall panicum (Panicum dichotomiflorum Michx.) and was located on Bertie silt loam. Treatments are listed on Table 2.

Results and Discussions

No soybean injury was recorded for any treatments. Soybean yields were taken only in experiment A; the highest rate of each herbicide except dinoseb resulted in a significant yield increase (Table 1). However, this yield increase cannot be attributed to foxtail control because several lower rates of 2-chloro-2',6'-diethyl-N-(methoxymethyl)acetanilide (alachlor) resulted in excellent foxtail control with no subsequent yield increase. Annual morningglory (Ipomea spp.) infestation was sporatic and may thus have effected yields.

Best foxtail control was obtained with alachlor (Table 1). For comparable foxtail control approximately twice as much 3-(4-bromo-3-chlorophenyl)-1-methoxy-1-methylurea (linuron). At the rates studied, 2-sec-butyl-4,6-dinitrophenol (dinoseb) did not control foxtail; the methyl ester of 3-amino-2,5-dichlorobenzoic acid (amiben) at 3 lb/A resulted in poor foxtail control.

1/ Scientific Article No. A1572 and Contribution No. 4286 of the Maryland Agricultural Experiment Station, Department of Agronomy.

2/ Assistant Professor, Department of Agronomy, University of Maryland, College Park, Maryland 20742.

In Experiment B, excellent full season fall panicum control was effected by 3 lb/A of 2,4'-dinitro-4-trifluromethyl-diphenylether (C-6989), and N,N-dimethyl-2,2-diphenylacetamide (diphenamide) plus dinoseb at 2.0 + 1.5 lb/A provided good full season fall panicum control. The following herbicides or combinations provided good to excellent early season fall panicum control, but failed to provide adequate control at the end of the growing season: α,α,α-trifluro-2,6-dinitro-N,N-dipropyl-p-toluidine (trifluralin), linuron and amiben (methyl ester) + 3-(hexahydro-4,7-methanoindan-5-yl)-1,1-dimethylurea (norea). Fair fall panicum control was experienced with sodium N-1-naphthylphthalamate + dinoseb and amiben (methyl ester).

Summary

Excellent giant foxtail control resulted with all rates of alachlor employed. Twice the amount of C 6313 was needed as linuron for comparable giant foxtail control. Excellent and good full season fall panicum control resulted from C 6989 and a combination of diphenamide + dinoseb.

Table 1. Experiment A: Preemergence foxtail control in soybeans.

Treatment	Rate lb/A	% Control[1/] Foxtail 7/2		Bu/A	
Control	--	0	e[2/]	31.3	a b
Control-cultivated	--	65	b c	34.3	a b c
Alachlor	1.0	93	a b	33.0	a b c
Alachlor	1.5	98	a	30.8	a b
Alachlor	2.0	95	a	44.3	c
Linuron	0.5	70	a b c	35.7	a b c
Linuron	0.75	83	a b	36.0	b c
Dinoseb	3.0	8	d	24.1	a
Amiben (methyl ester)	3.0	48	c	41.5	b c
C 6313	0.75	65	b c	32.7	a b c
C 6313	1.0	73	a b c	34.7	a b c
C 6313	1.5	86	a b	44.0	c

1/ Visual observations based on a scale of 0=no control; 100=100% control.

2/ Values within a column followed by identical letters are not significant at the 0.05 level of probability.

Table 2. Experiment B: Fall panicum control resulting from several preemergent herbicides in soybeans.

Treatment	Rate lb/A	% Control[1/] Fall Panicum 7/2	10/17
Control	--	0 c[2/]	0 c
Cultivated Control	--	98 a	80 a b
Trifluralin	.75	93 a b	65 a b
Linuron	.75	85 a b	35 b c
Naptalam + Dinoseb	2.0 + 1.0	78 b	53 a b
C 6989	3.0	90 a b	95 a
Diphenamide + Dinoseb	2.0 + 1.5	88 a b	88 a
Amiben + Norea	1.0 + 0.8	88 a b	53 a b
Amiben + Norea	1.5 + 1.2	98 a	55 a b
Amiben	3.0	78 b	35 b c

[1/] Visual observations based on a scale of 0=no injury; 100=100% weed control.

[2/] Values within a column followed by identical letters are not significant at the 0.05 level of probability.

POSTEMERGENCE WEED CONTROL IN CORN WITH COMBINATIONS OF ATRAZINE, OIL, AND PHYTOTOXIC HERBICIDES[1]

J. V. Parochetti[2]

Preemergent application of herbicides for weed control in corn, generally results in better grassy weed control and subsequently higher corn yields than postemergent applications. However, growers are sometimes faced with the necessity of treating corn postemergence generally due to unfavorable climatic conditions following corn planting. Considerable research has been conducted on the use of herbicides postemergence in corn with and without adjuvants. However, little emphasis has been given to combinations of herbicides for overall postemergent application. Behrens, Miller and Darwent (1) reported that a combination of 2-chloro-4-ethylamino-6-isopropylamino-*s*-triazine (atrazine), 2,2-dichloroproprونic acid (dalapon), and a phytobland oil applied as an overall early postemergence successfully controlled *Setaria* spp. without causing corn injury.

Field observations in 1968 of Maryland growers indicated that an overall postemergence combination of atrazine (1 lb/A) and 3-(3,4-dichlorophenyl)-1-methylurea (linuron) at approximately 0.25 lb/A resulted in excellent grassy weed control and no corn injury. However, where the spray pattern overlapped, considerable corn injury resulted.

The objective of this study was to test combinations of atrazine, phytobland oil, and phytotoxic herbicides at reduced rates for giant foxtail (*Setaria faberii* Herrm.) control.

Materials and Methods

The experiment was located at the Wye Institute, near Queenstown, Maryland. The soil was Mattapex loam, containing 47% silt, 18% clay, 35% sand, and 1.5% organic matter. Pioneer 3304 corn was planted April 28, 1969, at 21,500 plants per acre. The land was fertilized for maximum production according to the soil test report. The experimental design was a randomized complete block with four replications. Four row plots were 30 feet long and row width was 2.5 feet. The cultivated control was cultivated once on June 1, all other treatments were not cultivated.

All postemergence applications were made overall at 30 gpa with water as the diluent. Treatments are listed on Table 1. Sun oil 11E was used at 3% (v:v). The early postemergent treatment was applied May 22, 24 days after

[1] Scientific Article No. A1571 and Contribution No. 4285 of the Maryland Agricultural Experiment Station, Department of Agronomy.

[2] Assistant Professor, Department of Agronomy, University of Maryland, College Park, Maryland 20742.

planting the corn when the height of foxtail and corn was 1.5 and 4 inches respectively. The late postemergent treatment was applied June 1, 33 days after planting the corn when the height of foxtail and corn was 5 to 12 inches respectively.

Percent weed control was rated visually from 0 to 100, with 0 equalling no control and 100 equalling 100% control. A rating of 70 or higher was equivalent to commercially acceptable control and weeds could be removed by cultivation at this weed population. Percent vigor reduction was rated from 0 to 100 with 0 equalling no injury and 100 equalling 100% crop reduction. A rating of 30 or higher was designated as commercially unacceptable crop injury.

Results and Discussion

Weed control, crop injury and yield data are presented in Table 1. Best foxtail control and highest corn yields were obtained with the early postemergent applications except atrazine and dalapon. No late postemergent treatment resulted in acceptable weed control, and as a result, corn yield was markedly reduced when compared to the early postemergence. The best foxtail control was an early postemergent application of atrazine, dalapon at 1 + 1/2 lb/A plus 3% (v:v) oil. However, this combination without oil resulted in inferior weed control which significantly lowered corn yields.

Corn injury was noted only with an early postemergent application of atrazine + linuron and atrazine + C 6313 (3-(4-bromo-3-chlorophenyl)-1-methoxy-1-methylurea). However, the yields from these two treatments were not reduced.

Summary

The use of atrazine plus dalapon at 1 + 1/2 lb/A applied as a postemergent treatment did not injure the corn when applied early to 4 in. corn and late to 12 in. corn. However, giant foxtail was controlled only when in early growth stage (1.5 in. high). Late postemergent treatment when foxtail was 5 in. tall resulted in poor control. Overall postemergent combinations of atrazine plus C 6313 and atrazine plus linuron were injurious to 4 in. corn but not to 12 in. corn. However, weed control from the early application, although injurious to the corn, did not reduce corn yields. Poor weed control in the late applications reduced corn yields.

Literature Cited

1. Behrens, R., G. R. Miller, and L. A. Darwent. 1968. Postemergence atrazine - dalapon - oil mixtures on corn. Down to earth. 24(4):11-13.

Table 1. The effect of mixtures of atrazine, oil, and phytotoxic herbicides, on corn and giant foxtail, Wye Institute, Queenstown, Maryland.

Treatment	Rate lb/A	Corn Vigor[1/] 5/28	Corn Vigor[1/] 6/17	Giant Foxtail Control[2/] 5/28	Giant Foxtail Control[2/] 6/17	Giant Foxtail Control[2/] 7/2	Yield Bu/A
Control	-	0 b	0 b	0 c	0 c	0 e	8.6 a[5/]
Control, cultivated	-	0 b	0 b	0 c	70 a	88 a	74.3 d e
		Early Postemergence[3/]					
Atrazine+Dalapon+Oil	1+1/2+3% v:v	0 b	0 b	92 a	88 a	88 a	89.5 e
Atrazine+Dalapon	1+1/2	0 b	0 b	55 b	70 a	65 b	69.6 c d e
Atrazine+Linuron	1+1/4	25 a	15 a	92 a	78 a	68 b	99.9 e
Atrazine+C 6313	1+1/2	20 a	13 a	94 a	80 a	60 b c	81.5 e
		Late Postemergence[4/]					
Atrazine+Dalapon+Oil	1+1/2+3% v:v	-	10 a b	0 c	25 b	40 d	39.6 b c
Atrazine+Dalapon	1+1/2	-	10 a b	0 c	23 b	43 c d	29.5 a b
Atrazine+Linuron	1+1/4	-	0 b	0 c	23 b	8 e	43.4 b c d
Atrazine+C 6313	1+1/2	-	0 b	0 c	23 b	10 e	47.7 b c d

1/ Visual observations based on a scale of 0=no injury; 100=100% crop destruction.

2/ Visual observations based on a scale of 0=no control; 100=100% control.

3/ Treated May 22, 1969, 24 days after planting; foxtail 1.5 in. high; corn 4 in. high.

4/ Treated June 1, 1969, 33 days after planting; foxtail 5 in. high; corn 12 in. high.

5/ Yield values within a column followed by identical letters are not significant at the 0.05 level of probability.

RESPONSE OF QUACKGRASS AND CORN TO THREE APPLICATION SCHEDULES OF DALAPON GRASS KILLER

J. B. Regan 1/

Abstract

Quackgrass Agropyron repens (L.) Beauv. is an economically important weed in a number of field crops. Satisfactory control can generally be achieved by spring treatment with DOWPON® grass killer, however, a short waiting period is recommended before a number of field crops can be planted. If quackgrass could be controlled effectively by treatment in late fall or very early spring, farmers could seed crops and not have to be concerned with the waiting period between treatment and planting.

A field test was conducted in the fall and spring of 1967-1968 at Midland, Michigan to determine if applications of DOWPON at rates of 3.7 to 14.8 lb ae/A either in late November or early March would provide the same degree of control as spring treatments.

No injury to corn resulted from any of the treatments. The most effective control of quackgrass was produced when DOWPON was applied in November. No dosage response was evident when rates of from 3.7 to 14.8 lb ae/A had been applied on this date. Treatment in March was more effective than the late spring treatment. A positive dosage response was found when DOWPON was applied on March 7. This response was evident on the two dates that quackgrass injury ratings were recorded (5/3/68 and 7/16/68).

The same information was evident when the amount of regrowth of quackgrass was measured from soil cores which had been placed in the greenhouse.

Higher green weights of corn ears were associated with early treatment (November). Lowest weights were obtained from April treatments. Consistently high green weights of corn ears were produced from plots treated March 7.

Higher rates of DOWPON were necessary in the spring than in the fall to show a degree of control. High temperatures coupled with rainfall would be contributing factors to the loss of DOWPON in the spring. These factors may not be as influential during the winter months, thus persistence would be greater during cooler periods. These same factors contribute to greater soil microbial activity in the spring than during the fall months.

1/ Field Agriculturalist, Agricultural Department, The Dow Chemical Company, Midland, Michigan 48640

THE EFFECT OF RATES OF DIPHENAMID-DNBP, METOBROMURON, AND LINURON APPLIED AT PREEMERGENCE ON WEED CONTROL IN POTATOES

Arthur Hawkins [1/]

Season-long chemical weed control in potatoes has been practiced in Connecticut for several years. First DNBP applied preemergence to potatoes became a common practice in Connecticut about fifteen years ago. More recently control of late germinating weeds with chemicals applied just before or at time of last hilling was found practical and has become a common practice (2, 3, 4, 5, 6). EPTC is used either preplant or at ridge-off for nutgrass control and/or for season-long weed control, or is applied at layby for control of late germinating weeds, especially grasses, following early control of weeds with DNBP.

A combination of 3 lb/A diphenamid and 2½ lb/A DNBP applied late pre-emergence to potatoes gave excellent control of crabgrass in Connecticut in 1968 (1).

Diphenamid-DNBP, metobromuron, and linuron were compared when applied just prior to emergence of Katahdin potatoes on two farms in 1969.

Materials and Methods

Two commercial potato fields in the Connecticut River Valley with a history of crabgrass (*Digitaria* spp.) were selected for test sites. The soil at location 2 was fine sandy loam, and silt loam at location 1. The Katahdin variety had been planted in 34" rows at each location. Plots were 3 rows wide x 12 feet long and were replicated 4 times in randomized blocks. Spray formulations of the chemicals were applied with a 1-gallon sprayer equipped with a T-Jet nozzle, at 100 gallons solution per acre rate.

At Farm 1 the chemicals were applied shortly before emergence of potatoes. The soil had not been disturbed since planting; but the row ridges had been flattened during the planting operation. The weeds were ¼ - ½" high and the soil was moist at the time of herbicide application, on 6/4/69. Rain, 0.1 inch, occurred on 6/7/69 and 6/9/69; potatoes emerged on 6/10.

At location 2, rows were ridged-off on 6/6 under dry hot conditions, which killed the heavy early weed population. Some grass in the 2-leaf stage, and some ragweed 1" were present at the time of treatment on 6/12.

About one inch of rainfall occurred on 6/16, and again about one inch on 6/21. Following final hilling and until the first week of August an unusually high amount of nearly 10" of rainfall occurred including 3" on 7/13; 1½" on 7/29; and 2" on 8/4.

The herbicides used, the amount of active ingredient applied per acre, kind of weeds present, weed control ratings, and yields are given in Tables 1 and 2.

1/ Agronomist and Potato Specialist, University of Connecticut, Storrs, Connecticut.

Results and Discussion

Location 1

a. Control of weeds prior to first cultivation: The combination of diphenamid at 3 lb/A + DNBP at $2\frac{1}{2}$ lb/A, metobromuron at 3 lb/A, and linuron at 1 lb/A gave excellent control of weeds, primarily large crabgrass (*D. sanguinalis*) prior to the first cultivation at location 1. Diphenamid at 2 lb/A + DNBP $1\frac{1}{2}$ lb/A, and metobromuron at 2 lb/A gave adequate weed control until time for cultivation when potatoes were 6 inches high.

b. Control of weeds following the last cultivation and hilling: Under conditions of high rainfall (about ten inches, during the 30 days after the last hilling) diphenamid 3 lb/A + DNBP $2\frac{1}{4}$ lb/A, and metobromuron 3 lb/A gave acceptable control of crabgrass, the only weed which was a problem at location 1 (Table 1). These treatments were superior to linuron applied at the 1 lb/A rate.

The lower rate of diphenamid-DNBP (2 + $1\frac{1}{2}$), and metobromuron at 2 lb/A did not give acceptable control of crabgrass.

Location 2

At location 2, weeds which had emerged prior to ridge-off had been controlled in the process of cultivation under hot dry conditions, prior to application of treatments (Table 2).

Heavy vines as a result of high rainfall shaded emerging weeds preventing vigorous growth of weeds. Weed control ratings are based on a relatively light weed population, primarily large crabgrass, (*D. sanguinalis*), barnyard grass, (*Echinochloa crusgalli*), and ragweed (*Ambrosia artemisifolia*). All treatments resulted in acceptable control of weeds, with better control from the higher rate of diphenamid-DNBP and the higher rate of metobromuron.

Summary

A comparison of rates of diphenamid-DNBP, metobromuron, and linuron applied preemergence to Katahdin potatoes for season-long control of weeds was made on two farms. An unusually heavy rainfall of about 10 inches occurred during the 30 days following final hilling.

At the location with a moderate population of large crabgrass and where rows had been ridged-off while planting (no cultivation prior to treatment), a combination of 2 lb/A diphenamid + $1\frac{1}{2}$ lb/A DNBP, or metobromuron at 2 lb/A gave commercial control of grassy weeds (the only kind present) until time of hilling. The best control was obtained with diphenamid 3 lb/A + DNBP $2\frac{1}{4}$ lb/A, metobromuron at 3 lb/A, and with linuron at 1 lb/A. No apparent injury to potatoes resulted from these rates. The higher rates of either diphenamid-DNBP or metobromuron gave season-long control of crabgrass, but the lower rates of these materials did not provide season-long control. The higher rates of either diphenamid-DNBP or metobromuron were superior to linuron at 1 lb/A.

At a location with a light population of large crabgrass, barnyard grass and ragweed, all treatments resulted in acceptable control of weeds, although better control was obtained with the higher rates of either diphenamid-DNBP or metobromuron.

Table 1. Effect of Diphenamid-DNBP, Metobromuron, and Linuron Applied Preemergence to Potatoes on Weed Control and Yield of Katahdin Potatoes. Location 1 1/, Connecticut 1969

Chemical 2/	Active lbs/A	Weed 3/ Control (Grass) 6/17	Crabgrass 4/ Control 10/1/69	Yield 5/ - cwt/A Total Yield	Above 1 7/8"
0		1.0	1.0 4/	305	281
Diphenamid + DNBP	2 1½	8.0	6.3	295	270
Diphenamid + DNBP	3 2¼	9.5	8.5	329	306
Metobromuron	2	7.5	6.5	320	294
Metobromuron	3	10.0	9.5	302	275
Linuron	1	9.5	7.3	305	279
L.S.D. .05				N.S.	N.S.

1/ Plots 3 rows wide x 12 ft., replicated 4 times. Row-ridges flattened during the planting operation.

2/ Treatments applied preemergence to potatoes on 6/4/69; grass in 2-leaf stage ¼ - ½". Soil had not been disturbed since planting.

3/ Weed rating on two replicates with moderate population of weeds in controls; the controls in other replicates were relatively free of weeds.
Weed ratings: 10 = complete control; 7 = acceptable; 3 = poor control; 1.0 = no control.

4/ Crabgrass control on the two replicates with moderate population of crabgrass in controls. Potatoes had been cultivated 6/21/69, and cultivated and hilled later. Potatoes vinekilled 9/20/69. Notes on crabgrass 10/1/69.

5/ Yield based on 4 replicates. Sampled 2 middle rows x 10 feet. Sampled shorter areas where stand not good.

Table 2. Effect of Diphenamid-DNBP, Metobromuron, and Linuron Applied Preemergence to Potatoes on Weed Control and Yield of Katahdin Potatoes. Location 2 1/, Connecticut 1969

Chemical 2/	Active lbs/A	Weed Control 3/ 9/26/69	Yield 4/ - cwt/A Total	Above 1 7/8"
0		1.0 3/	286	241
Diphenamid + DNBP	2 1½	7.8	274	226
Diphenamid + DNBP	3 2¼	8.5	290	247
Metobromuron	2	8.3	275	224
Metobromuron	3	9.0	280	226
Linuron	1	7.3	279	230
L.S.D. .05			N.S.	N.S.

1/ Plots 3 rows wide x 12 ft. replicated 4 times. Conditions: Planted May 25. Heavy weed population at time row ridges dragged-off, 6/6/69.

2/ Treatments applied 6/12/69; some grass in 2-leaf stage, some ragweed 1".

3/ Light weed population, and most weeds stunted by heavy growth of vines. Weed rating: 10 = complete control; 7.0 = acceptable; 3 = poor control; 1 = light population of large crabgrass, barnyard grass, and ragweed.

4/ Yield based on 4 replicates. Sampled 2 rows x 8 ft. per plot.

References

1. Hawkins, Arthur. 1969. Effect of Rate of DCPA, Diphenamid and EPTC for Weed Control in Potatoes. NEWCC Proceedings 23:99-103.

2. ______________. 1963. Lay-by Chemical Weed Control in Potatoes with Granular and Spray Applications. NEWCC 17:140-144.

3. ______________. 1963. Spraying Chemicals for Soil Incorporation While Cultivating for Lay-by Weed Control in Potatoes. NEWCC 17:129.

4. ______________. 1962. Lay-by Chemical Weed Control in Potatoes with Granular Formulations of CDAA, Dalapon and Other Chemicals. NEWCC 16: 178-180.

5. ______________. 1962. Adapting Equipment for Applying Chemicals for Lay-by Weed Control in Potatoes. American Potato Journal, April 1962 Vol. 39 No. 4 pp. 162-163.

6. ______________. 1961. Post-hill Chemical Weed Control in Potatoes with Granular Formulations. NEWCC 15:180-181.

INFLUENCE OF SOD SPECIES IN NO-TILLAGE CORN PRODUCTION

R. A. Peters and W. L. Currey[1/]

The feasibility of seeding corn without prior plowing and disking of the seedbed is now well established if 1) herbicides are used which effectively kill any existing vegetation and 2) a planter is used which can penetrate the sod, place the corn seed at the proper depth and adequately cover.

While other herbicide combinations have potential for vegetation kill in no-tillage schemes, the most commonly used treatment is a mixture of paraquat and atrazine. This combination varies in effectiveness, however, because of inherent differences in the response of different plant species.

This paper discusses the response of several plant species to paraquat-atrazine mixtures under three management schemes. The treatment response was measured by the degree of plant kill and the growth of silage corn planted in the treated plots.

Procedure

The experimental area was on the Agronomy Research Farm, Storrs (Conn) Agricultural Experiment Station, Storrs, Conn. Seedings of all grass and legume species mentioned were made on August 12, 1968 except for a late seeding of rye made on October 1, 1968. The species used are listed in Table I. Each replication was divided into three strips in the spring of 1969 and each managed differently. The individual plots within the management strips were 10 x 16½ feet in size. All data were subjected to analysis of variance.

All chemical applications are expressed in terms of pounds active ingredient or acid equivalent per acre. All applications were made at a rate of 25 gallons of water per acre.

Management A

In this strip plots were chemically treated on April 25 with atrazine 1 lb plus paraquat ½ lb with X-77 wetting agent 2 oz per 25 gallons of water. Grass and legumes were just beginning active growth. Wisconsin 335A corn was planted on May 13 in 34 inch rows to give a population of 28,000 plants per acre with an Allis Chalmers Series 600 No-til planter. An application of 1000 lb/A of 15-15-15 granular fertilizer was surface broadcast prior to planting. A starter fertilizer of 200 lb/A 10-34-0 was banded beside the

[1/] Professor of Agronomy and Graduate Assistant, respectively. Plant Science Department, University of Connecticut, Storrs, Connecticut.

seed at planting.

Management B

Wisconsin 335A corn was planted as in Management A on May 13 directly into the standing crops. At seeding, the early rye was 30 inches tall and in the boot stage, orchardgrass was 15 inches tall, and alfalfa was 12 inches tall. The chemical treatment was atrazine 1 lb plus paraquat ½ lb with X-77 wetting agent plus alachlor 1 lb ai. Fertilization and seeding was the same as in Management A above.

Management C

On June 2 all plots were sampled for forage yields. Rye was over 4 feet tall and in anthesis, orchardgrass was 3 feet tall and emerging from the boot; and alfalfa was 2 feet tall. On June 4 the plots were chemically treated and planted to corn. The herbicide combination was atrazine 2 lb plus paraquat ½ lb with wetting agent plus alachlor 1 lb ai. A28 corn was planted with the Allis Chalmers planter as in A and B above except no starter fertilizer was applied.

Alachlor was used in the herbicide mixture applied in Management B and C to control annual grassy weeds. Previous work at Storrs (1969) demonstrated that atrazine-paraquat treatments may give adequate control of perennial species but will not prevent proliferation of crabgrass.

Results and Discussion

Vegetation control

In general control of all species by the atrazine-paraquat mixture was excellent when applied as growth was starting in Management A. In Managements B and C control was good except for tall fescue, orchardgrass and alfalfa. To control the alfalfa regrowth ½ lb of 2,4-D amine at ½ lb ae/A was applied on June 10, 1969. In Management B the alfalfa had regrown to 2 feet in height.

Annual grasses did not prove to be a factor on any of the plots including those in Management A where no alachlor was applied.

Stands of Corn

There was no significant difference in stand counts in plots within managements which indicated that the planter used was capable of seeding into sod of all the species involved in this experiment as readily as into the bare soil. There was a difference, however, in the average stand between managements as indicated in Table I.

There was no difference in mean stand between Managements A and B indicating that the no-tillage planter used functioned well even in actively growing sod. The lower stand in Management C may have been due to the later date of seeding when conditions were not as favorable for germination.

Corn growth

There was no obvious difference in the rate of corn growth in Managements A and B except for the earlier emergence in the bare plots. No statistical differences in yields from Managements A or B were found. There was a distinct trend, however, in Management B for greater yields in the seeded plots compared to the non-seeded plot. This can be associated with the greater mulch accumulation in Management B where the sod was not sprayed until the corn was planted.

In both Managements A and B there was indication of yield depression in the timothy plots. No explanation is offered.

In Management C there was no obvious difference in height between plots (Table I) as observed on July 29, 56 days after planting. Corn averaged 6.0, 5.6 and 5.4 feet in the alfalfa, red clover and ladino clover plots, respectively, as opposed to 4.3 feet in the non-seeded check plots. Corn in any of the grass plots was at least one foot shorter than corn in the alfalfa plots. By harvest time the height differential was no longer evident.

Corn was the tallest in 3 plots that contained legume residues. While a total of 170 lb/A of nitrogen had been applied in May the additional nitrogen supplied to the corn by the legume residues was probably a factor in the greater initial growth rate of the corn.

The corn yields in Management C were distinctly lower than in Management A or B. This was expected since an early maturing corn variety was used which was seeded 22 days later. Unlike in Managements A or B, there were yield differences between plots since yields of corn in the legume plots were significantly higher. This was likely due to the increased nitrogen available from the legume residues. In contrast to Managements A and B, the non-seeded check plots had a greater corn silage yield than any of the plots seeded to grass. This was related to the fertility removed by the grass silage harvested just prior to the planting of corn.

The yields of grass silage removed on June 2 are given in Table II. The yields of silage obtained from most of the sod species largely compensated for the lower corn yields (Table II). No Ladino clover was harvested since there was a 75% loss of stand over winter. Yields of ryegrass, early seeded rye and winter wheat were poor because of excessive growth in the fall resulting in smothering of a large part of the stand.

Table I. Corn Stand Counts in Three No-tillage Plantings and Height Measurements in the Last Planting.

Sod Species	Management A Sprayed 4/25-Planted 5/13 Plant Count	Management B Sprayed & Planted 5/13 Plant Count	Management C Sprayed & Planted 6/4 Plant Count	Management C Height in feet
Domestic ryegrasses	32,260	27,650	22,760	4.2
Rye - early	28,800	25,340	23,040	4.7
Rye - late	27,260	27,260	21,890	3.9
Winter wheat	29,570	27,260	24,960	3.9
Timothy	26,110	25,730	24,580	4.3
Orchardgrass	28,030	28,800	22,270	4.4
Tall fescue	27,260	27,650	23,040	4.8
Reed canarygrass	25,340	26,500	22,660	5.0
Alfalfa	25,340	31,870	24,580	6.0
Red clover	27,650	27,260	23,800	5.8
Ladino	30,340	25,340	26,110	5.5
Non-seeded	25,340	26,110	23,420	4.2
Mean	27,650	27,260	23,580	4.7
LSD .05	N.S.	N.S.	N.S.	.68
.01				.88

Table II. Yields of Silage Under Three No-tillage Management Schemes.

Sod Species	Management A Corn Silage T/A[1]	Management B Corn Silage T/A	Management C Grass Silage[1,2] T/A	Management C Corn Silage T/A	Management C Total T/A
Domestic ryegrass	23.6	25.2	1.9	14.9	16.8
Rye - early	23.7	25.0	4.8	14.9	19.7
Rye - late	23.9	21.9	5.3	14.1	19.4
Winter wheat	22.6	22.4	3.3	16.0	19.3
Timothy	18.9	19.7	5.6	14.6	20.2
Orchardgrass	22.7	21.5	5.0	14.7	19.7
Tall fescue	21.9	22.8	7.0	17.0	24.0
Reed canarygrass	22.8	19.6	4.8	15.4	20.2
Alfalfa	21.0	25.0	4.3	19.0	23.3
Red clover	25.6	26.4	5.3	19.0	24.3
Ladino clover	21.9	24.6	-	19.7	-
Non-seeded	21.2	20.0	-	17.1	-
Mean	22.5	22.8	-	16.4	-
LSD .05	N.S.	N.S.	1.2	2.7	
.01			1.6	3.2	

1/ 30% dry matter basis

2/ Yields obtained from sod species June 2 just prior to treatment with atrazine-paraquat-alachlor.

Summary

Atrazine-paraquat mixtures were applied to 11 different sod crops under 3 managements. Applications were made 1) in April prior to direct seeding of corn in May 2) in May at the same time corn was planted in the standing crops and 3) in June after removing a grass silage crop. Good kill was obtained of all species in April when growth was starting. Applications made in May when most sod species were heading out or in June after removing a silage cut gave incomplete control of alfalfa, orchardgrass and tall fescue.

The no-tillage planter with a fluted coulter used in this experiment planted the corn adequately in all of the sod species, as judged by stand counts.

Yields of the corn when planted in May were comparable between sod species. There was no significant difference between yields of corn planted in sod and in the non-plowed, non-seeded plot. When corn was planted in June after a grass silage crop was removed there were differences in yields. Since the significantly greater yields were all associated with legume plots, it was assumed that residual nitrogen was available to the corn. The legume effect was also reflected in the greater height of the corn early in the season.

The yields of the June planted corn were considerably lower than the May planted corn but the grass silage crop obtained compensated for the decrease.

Literature Cited

1969. Peters, R. A. and W. L. Currey. Herbicide usage in no-tillage crop production. Proceedings, NEWCC 22:167-172.

We wish to acknowledge Chevron Chemical for grant funds used in this experiment and the Allis Chalmers Company for supplying an AC series 600 no-til planter.

EFFECT OF RATES OF DIPHENAMID AND LINURON FOR LAYBY WEED CONTROL IN POTATOES

Arthur Hawkins 1/

Control of late germinating weeds in potatoes with chemicals applied either (a) just before or at the time of the last cultivation or hilling and soil incorporated, or (b) applied shortly after the last hilling has been found practical (2, 3, 4, 5, 6). Soil incorporation of EPTC at the time of the last cultivation or last hilling has become a common practice in Connecticut.

Diphenamid applied at late preemergence to potatoes at 2 to 3 lb/A gave season-long control of large crabgrass in Connecticut in 1968 (1). In 1969 herbicides evaluated for control of late-germinating weeds in potatoes were diphenamid soil incorporated at the time of last hilling, and linuron applied after the last hilling.

Materials and Methods

A commercial potato field with a history of crabgrass and barnyard grass in the Connecticut River Valley was selected for the test site. The soil was a fine sandy loam. Plots were 3 rows wide x 12 ft. long, and were replicated four times in randomized blocks.

Diphenamid 50 WP was applied with a 1-gallon sprayer equipped with a T-Jet nozzle, at 100 gallons of solution per acre, just prior to the last hilling. A granular formulation of linuron (10 G) was applied with a Midget Duster just after the last hilling; granules remaining on the plants were brushed off.

The materials were applied on 7/1/69 when the Katahdin potatoes were in the full bud to early bloom stage. The soil was moist at the time of application. Weather conditions were dry and hot during the following week. An unusually high amount of rainfall of about 10 inches occurred during the three-week period 7/13 to 8/4 including 3.0" on 7/13, 1.2" on 7/28, and 2.0" on 8/4.

The herbicides used, the amount of active ingredient applied per acre, kind of weeds present, weed control rating, and yield are given in Table 1.

Results and Discussion

Weed Control: A heavy growth of vines as a result of high rainfall shaded emerging weeds, preventing vigorous growth of weeds. The untreated border around the potato field which had been cultivated up to and including the date of the last hilling was heavily infested with weeds, primarily grasses, later in the season.

The weed control ratings in Table 1 are based on a low population of large crabgrass (*Digitaria sanguinalis*), barnyard grass (*Echinochloa crusgalli*), and pigweed (*Amaranthus retroflexus*).

1/ Agronomist and Potato Specialist, University of Connecticut, Storrs, Connecticut.

Diphenamid at either 1½ or 2 pounds, and linuron at 1 or 1½ pounds per acre gave acceptable to good control of these weeds.

Crop Rating and Yield: There was no apparent injury to the potato vines from application of the chemicals. No damage to foliage was noted from linuron granules that may not have been brushed off the leaves.

Yields were lower on plots treated with linuron at 1 or 1½ lb/A than yields on the untreated plots. However, the differences were not statistically significant.

Table 1. Effect of Spray Formulation of Diphenamid Incorporated While Hilling, and Granular Formulation of Linuron Applied After Hilling, on Control of Late Germinating Weeds and Yield of Katahdin Potatoes. Location H 1/- Connecticut 1969

Chemical Applied 2/	Active lbs/A	Crop Rating 3/ 7/11/69	Weed Control 4/ 9/26/69	Yield 5/ - cwt/A Total	Above 1 7/8"
0		10	1.0 3/	327	277
Diphenamid	1	10	5.3	335	282
Diphenamid	1½	10	8.3	368	319
Diphenamid	2	10	7.4	303 6/	261 6/
Linuron (10 G)	1	10	8.6	269	223
Linuron (10 G)	1½	10	8.8	290	236
L.S.D. .05				N.S.	N.S.

1/ Plots 3 rows wide x 12 ft., replicated 4 times.

2/ Treatments applied 7/1/69; potatoes full bud to early bloom stage.
Diphenamid applied in 100 gals. water per acre, as directed spray between rows just prior to last cultivation and hilling.
Linuron 10 G granular applied with small midget duster after last hilling; granules brushed off plants.

3/ Crop rating: 10 = no effect; 0 = complete kill.

4/ Weed rating: 10 = complete control; 7 = acceptable; 3 = poor control; 1 = low population of crabgrass, barnyard grass and pigweed 9/26/69.

5/ Sampled 4 reps, two rows x 8 ft. Sampled shorter areas where stand not good.

6/ 3 reps only.

Summary

Diphenamid soil-incorporated at the time of last hilling, and linuron in a granular formulation applied after the last hilling were evaluated for control of late-germinating weeds in potatoes. Conditions of unusually high rainfall resulted in a heavy growth of vines and a relatively light population of large crabgrass, barnyard grass, and pigweed.

Diphenamid at $1\frac{1}{2}$ or 2 lbs/A applied in a spray formulation and soil-incorporated at the last hilling, and linuron applied at either 1 or $1\frac{1}{2}$ lbs/A applied in a granular formulation after the last hilling gave acceptable to good control of a relatively light population of weeds.

No injury to potato foliage was noted from any linuron granules which may not have been brushed off the leaves. Yields from plots treated with linuron at 1 or $1\frac{1}{2}$ lb/A were lower than those on the untreated plots, but the differences were not statistically significant.

Acknowledgement

Acknowledgement is made to the following companies which supplied materials: Upjohn, and E. I. DuPont.

Literature Cited

1. Hawkins, Arthur. 1969. Effect of Rate of DCPA, Diphenamid and EPTC for Weed Control in Potatoes. NEWCC Proceedings 23:99-103.

2. ______________. 1963. Lay-by Chemical Weed Control in Potatoes with Granular and Spray Applications. NEWCC 17:140-144.

3. ______________. 1963. Spraying Chemicals for Soil Incorporation While Cultivating for Lay-by Weed Control in Potatoes. NEWCC 17:129.

4. ______________. 1962. Adapting Equipment for Applying Chemicals for Lay-by Weed Control in Potatoes. American Potato Journal, April 1962 Vol. 39 No. 4 pp. 162-163.

5. ______________. 1962. Lay-by Chemical Weed Control in Potatoes with Granular Formulations of CDAA, Dalapon and Other Chemicals. NEWCC 16: 178-180.

6. ______________. 1961. Post-hill Chemical Weed Control in Potatoes with Granular Formulations. NEWCC 15:180-181.

NEW CRITERIA FOR DEVELOPMENT OF HERBICIDES

E. A. Walker

Herbicides have been registered by the U.S. Department of Agriculture since 1947. There have been over 12,000 herbicides submitted for registration since then. Some are used to kill many weeds and others are developed to control only specific weeds. Herbicide usage has risen over 275 percent since 1963 and in 1967 there was over 430 million dollars market value of organic herbicides used at the manufactures level.

Much progress have been made in the past. Major attention has been given to the effective and safe use of herbicides. Chemical residue data has been evaluated on food and feed crops, and tolerances have been established at a safe level for many herbicides. Soils and Waters have been monitored for presence of persistant herbicides. Animal toxicity studies have been made by competent laboratories and herbicides are found to be the least toxic of all the pesticide groups. There has been close cooperation and free exchange of information between the several Federal agencies that review label claims for herbicides, including the Public Health, Food and Drug Administration, and the Fish and Wildlife Service.

Chief Staff Officer, Herbicides & Plant Regulator Review Staff, Pesticides Regulation Division A.R.S. U.S. Dept. of Agriculture Washington, D.C. 20250

There still are many problem areas that need more of our attention. There is an increase in the use of herbicide mixtures, including both prepackaged and tank mixed formulation. We need to know much more about them. Data is needed on the effective and safe use of these mixtures. Compatibility and stability studies are needed and the residue remaining on, or in food and feed crops must be determined for each mixture before registration is completed.

Information is lacking on the effective and safe use of aquatic herbicides. Too little is known about the rate of disappearance from the water, adsorption of the product to weeds and soil, and the effect on fish, water fowl and wildlife using these waters. There must be standards established for herbicides used in water, especially for potable water supplies.

It is essential that tolerance be established for all herbicides used on food and feed crops. Many herbicides will be cancelled this year for lack of further extension of use. Extensions will be granted only if there is a request for the extension and evidence submitted to show there is a petition submitted to establish a tolerance, or there is bonifide research being conducted to obtain animal toxicity and chemical residue data to support a petition.

We can expect a closer cooperation and coordination between the Department of Agriculture, the Department of Health, Education and Welfare, and the Department of The Interior for defects in present labling and for all new products submitted for registration in 1970. This will strengthen the Interagency agreement concept on the effectiveness, safety and residues likely to remain in the environment from proper herbicide usage.

Persistant herbicides must be reexamined and reevaluated to see what can be done with those chemical that remain in the soil beyond the current growing season for each crop. Attention must also be given to water soluble products and their mobility from the target area. More must be known about the degradable products from herbicide uses which might adversely affect the lives of man, useful animals and useful vegetation, and lastly we must not overlook the determination that must be made for the need for herbicides for the future, for which there is no alternative available. There is much yet that must be done before new herbicides will become available to the public.