Confirmation of a five-way herbicide-resistant waterhemp (*Amaranthus tuberculatus*) population in North Carolina

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Non-native weeds have been introduced to crop fields by migrating wildlife, planting of contaminated native plant seed for pollinator/wildlife habitats and purchasing machinery contaminated with weed seeds from outside of the region, among others. Recently, waterhemp has encroached crop fields of North Carolina where the plant is not native. Waterhemp has been documented in the Coastal Plain, Piedmont, and Tidewater regions of North Carolina. Through communication with the farmers of the infested fields, the consensus is the waterhemp seed came from machinery purchased in the Midwest United States where the plant is native. Waterhemp has likely been in North Carolina for a longer duration but mistaken for other weed species.

Waterhemp shares common vegetative characteristics between other Amaranth species (i.e. Palmer amaranth and redroot pigweed) common in North Carolina and the Northeast United States (Figure 1). The most practical way to distinguish Palmer amaranth from waterhemp is the length of the petiole (Figure 1). Redroot pigweed can be distinguished from Palmer amaranth and waterhemp by the pubescent covering of its stems (Figure 1). Palmer amaranth and waterhemp are dioecious (separate male and female plants), thus the different flowers can be useful for identification. The bracts on female Palmer amaranth flowers are long and sharp while the bracts on female waterhemp are small and smooth. While identification of the two species is easiest when flowers are present, plants should not be allowed to mature to this point as crop yield loss has been realized and seeds are likely already produced. Careful identification must be made early so waterhemp can be eradicated from isolated fields and cease the spread to other fields/regions.

Controlling waterhemp emigrating from the Midwest United States will be complex. There are confirmed waterhemp populations that have evolved resistance to seven unique herbicide groups and multiple herbicide-resistant populations are the norm. Waterhemp populations that have been introduced to North Carolina have been reported as multiple herbicide-resistant, but no investigations have been conducted. A waterhemp population was collected from Surry County, North Carolina and treated with 1, 2, and 4x of the maximum labeled rate of imazethapyr (Pursuit, herbicide group [HG] 2), 2,4-D (Weedar, HG 4), dicamba (Clarity, HG 4), atrazine (Aatrex, HG 5) glyphosate (Roundup, HG 9), glufosinate (Liberty, HG 10), fomesafen (Reflex, HG 14), and mesotrione (Callisto, HG 27) applied postemergence (4 inch weeds). At least one plant from the Surry County waterhemp population survived the 4x rate of imazethapyr, atrazine, glyphosate, fomesafen, and mesotrione (Figure 1). No plants survived any rate of 2,4-D, dicamba, and glufosinate. Plants surviving lethal herbicide rates provides evidence that North Carolina (and the Northeast United States) has inherited a five-way herbicide-resistant waterhemp population from the Midwest United States.

The five-way herbicide resistance profile of the Surry County waterhemp population is novel to the Northeast United States. If these multiple herbicide-resistant waterhemp populations are allowed to spread throughout the region and hybridize with other Amaranth weed species, the increased complexity of weed control in all crops is inevitable. While 2,4-D, dicamba, and glufosinate controlled the Surry County waterhemp population, these herbicides should not be relied on exclusively or the selection for herbicide-resistant weed populations will be expedited. Biological, cultural, and mechanical control options need to be implemented to complement chemical control options for waterhemp and reduce the selection pressure for the evolution of herbicide resistance. The Surry County farmer has been hand weeding and mowing along with

applying effective herbicides the waterhemp-infested field with great success on reducing the population. Additionally, newly purchased machinery should be meticulously cleaned before use; machinery should be cleaned regularly to stop the movement of weed seeds from field to field as well.

Figures

Figure 1. Vegetative characteristics of waterhemp (A), Palmer amaranth (B), and redroot pigweed (C). The petiole difference can be a guideline for identifying young waterhemp (half of the leaf) and Palmer amaranth (longer than the leaf) plants. Redroot pigweed and waterhemp share similar petiole lengths. Redroot pigweed plants are pubescent whereas Palmer amaranth and waterhemp plants are glabrous.

Figure 2. Plants from the Surry County waterhemp population surviving imazethapyr (4x; A), glyphosate (2x, B), mesotrione (4x, C), atrazine (4x, D), and fomesafen (4x, E). The plants on far left of each inset were not treated with herbicide. At least one plant survived the 4x rate of the aforementioned herbicides, showing the waterhemp population in Surry County had evolved five-way herbicide resistance before being transported into state via machinery.