Cover crop root traits and associated benefits

Cover crops provide a multitude of benefits to growers, including weed suppression, nitrogen retention and fixation, and increased profitability of consecutive cash crops[1,2]. Cover crop adoption is highest in the northeast, partly driven by incentive programs and strict regulations in the Chesapeake Bay watershed[3,4]. After soil health, weed management is the primary reason farmers cite for using cover crops[5]. Cover crops suppress weeds though competition for space and resources between cash crops. This is crucial to reduce the weed seed bank over time.

In recent years cover crop mixtures have increased in popularity. Functionally distinct cover crop species vary in which benefits they provide, and when planted in mixtures we can diversify the suite of functions the cover crops perform[2,6]. Generally, cover crop research focuses on the aboveground portion of the plant as it is difficult and time-intensive to identify root fragments to species. However, understanding cover crop interactions belowground is essential to attaining a full picture of how cover crops aid in weed suppression and nutrient retention, particularly in complex mixtures. The following is a summary of common root traits of three plant types (cereal grasses, mustards, and legumes), and how they relate to weed suppression and nutrient balance.

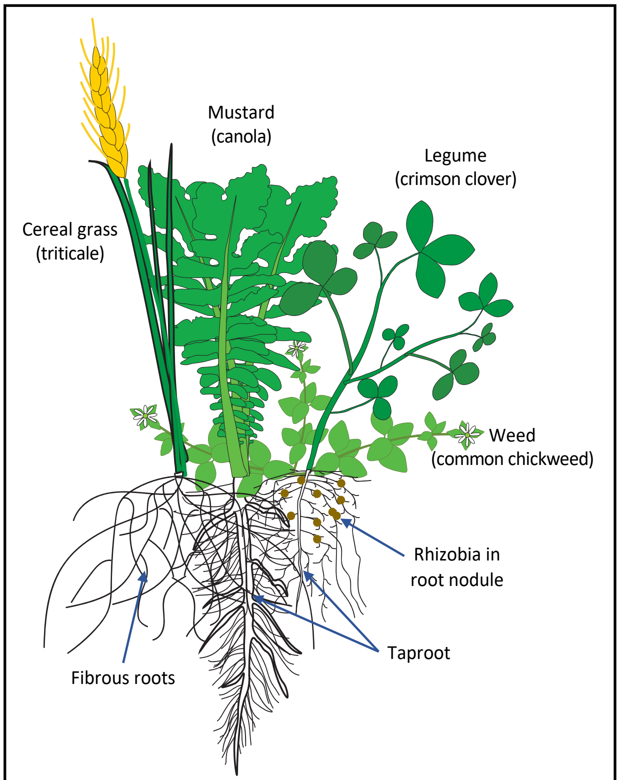

Figure 1. Cereal grass, mustard, and legume above and belowground plant structures.

Cover crop cereal grasses such as cereal rye and triticale establish quickly and their roots form a dense, fibrous mat in soil within and between planting rows[6] (Figure 1). Cereal grass roots scavenge the soil, allowing for increased uptake of phosphorus and inorganic nitrogen, leading to a reduction of runoff into neighboring waterways. The resulting reduction in available nutrient pools inhibits growth of weed seedlings. High density rooting between planting rows may account for grasses exhibiting greater weed suppression compared to other plant types[6,7]. In mixtures, cereal grasses provide the highest weed suppression benefit[7].

Mustards, such as canola, are popular due to their taproots' ability to break up soil compaction (Figure 1). Canola roots are primarily located in the planting rows and do not explore laterally[6]. Mustard roots generally do not form symbiotic relationships with beneficial mycorrhizal fungi and can actively suppress one beneficial fungal group, arbuscular mycorrhizal fungi (AMF)[8,9]. This is unique, as many other plant species rely on relationships with AMF for nutrient acquisition, and growth is reduced in their absence[10]. Overall mustards reduce weed density through the suppression of most AMF and increased competition for resources, but not at the level of suppression as cereal grasses.

Out of the three cover crop types, legumes, such as crimson clover, are the least effective at suppressing weeds[2]. This is due to their slower root growth and reduced root length during establishment. While legumes do scavenge for nutrients, they also form symbiotic relationships with nitrogen fixing rhizobia (soil bacteria; Figure1). This relationship is energetically costly and drives slow root production[6,11]. Alone, legumes do provide weed suppression, but leave an opening for weed establishment during their initial slow growth period in the fall[7]. Depending on what benefits are desired from the cover crop, legumes are a great addition to a mixture with cereal grass and/or mustard to suppress weeds and retain and fix nitrogen.

New experimental tools are making it feasible to understand the composition and functioning of roots in cover crop mixtures, which will further inform our design and optimization of cover crop mixtures. My research integrates molecular techniques to quantify the relative species abundance in root biomass. Specifically, I am developing techniques to determine the proportion of cover crop species roots in mixtures based on the amount of plant DNA present[12,13,14,15]. These techniques will shed light on belowground interactions, not only to cover crops, but also between crops and weeds, crops and other crop species (e.g., diverse forage mixes), or crops and cover crops (e.g., interseeded cover crops).

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