Annual Report for Maryland Soybean Board

Reporting on Activities between April 01, 2023 and March 31, 2024

"Spring management of cover crops - how termination timing affects soybean growth and yield"

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Many farmers who use cover crops terminate them as early as possible in spring to get this task out of the way well before planting to ensure that the cover crop residue will be completely dead and dry and easy to cut through without causing hair pinning. They also may seek to avoid having to plant through thick residues. In the Mid-Atlantic, this often means terminating cover crops in late March or early April, some two to four weeks before cash crop planting. But for cool-season species like those used for winter cover crops, April represents ideal growing conditions during which they may be able to double or even quadruple their biomass. Many of the benefits derived from cover crops are directly related to the amount of biomass produced. This may include water-conserving mulch, nutrient cycling, carbon sequestration, weed suppression, and soil structure improvement. On the other hand, many farmers fear that allowing cover crops to grow large will make the planting process difficult and may provide conditions favorable to pests such as slugs.

This research project compares three cover crop termination timings: Early (several weeks before cash crop planting), Mid (termination simultaneous with planting green into the living cover crop at the normal crop planting time), and Late (one to two weeks after planting green when the cash crop has already emerged). The field experiments applied these three termination dates to three cover crop treatments: 1) NC - no cover crop control containing only winter weeds; 2) Rye - a pure stand of rye established in the fall, and 3) 3-way - a mixed species cover crop established in the fall with radish + rye + crimson clover. The latter cover crop normally would have only two species in the spring (plus any weeds that might be present) since the radish normally freeze-kills during the winter. We studied a factorial combination of three termination times and these three cover crops against the background of either corn residue or soybean residue from the previous cropping season.

The main objective of this research is to determine how to best manage cover crop termination to optimize the benefits derived from the cover crops with regard to slug damage, water conservation, soil health enhancement, and yields of soybeans and corn grown in rotation. The work was conducted on two contrasting soils, one a very sandy well-to-excessively drained soil and the other a silt loam over silty clay subsoil with somewhat poor drainage. Cover crop main treatments were NC, Rye, and 3-way. Where soybeans were planted cover crop management options included early termination, mid-termination timing which was simultaneous with planting green, and late

Figure 1. View of a 3-way cover crop plot subdivided (from back to foreground) into early, mid, and late termination date treatments shortly before the late termination.

termination which was targeting a week to 10 days after planting green (Figure 1). All cover crops planted before corn were given the Mid termination at planting green.

In the spring of 2023, the late cover crop termination was delayed by wet weather and didn't occur until May 20th, almost 3 weeks after the Mid termination date and planting green. This later-than-planned determination resulted in effects that were not seen in previous years when termination was only 7 to 10 days after planting green. These effects included cooler soils during the soybean seedling stage, late emergence of the soybeans, and slightly reduced stands (Figure 2).

This progress report will focus on the cover crop management effects on the yields of soybeans and corn. Soybean yields and fall of 2023 were nearly identical to the yield levels of 2022 and averaged between 65 and 75 bushels per acre. Soybean yields were not affected by cover crop or by cover crop termination timing in either year. This means that cover crops can be allowed to grow late so that soybeans are planted green into living cover crops without sacrificing soybean yield. Late termination allows cover crops to grow much larger biomass and therefore provide a thicker, longer-lasting mulch that conserves water during the summer. In years with severe moisture stress in the summer soybeans have been shown to yield better following a cover crop that left a thick water-conserving mulch on the surface.

Cover Crop Aboveground Biomass Measured in April - May 2023

In spring 2023 there was a significant interaction between the cover crop species or treatment and the timing of determination. Termination time had little effect on clover biomass or weeds, but later termination significantly increased the dry matter of the cereal Rye in the mixture (Figure 2, right). This three-species mixture when planted early enough by interseeding into the cash crop in late summer, is usually dominated by radish in the fall and by clover in the early spring.

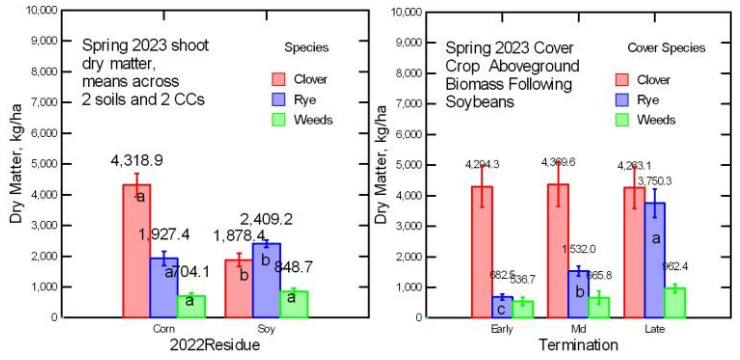

Figure 2 (Left) Cover crop above ground dry matter accumulation for three termination times and three cover crop components. Only the rye gained significant dry matter with late termination. (Right) Shoot biomass averaged across two cover crops (3-way and Rye) and two soils for Mid termination timing in either corn residue or soybean residue.

The spring biomass for the mid-kill date (simultaneous with planting green) is shown in Figure 2 (left), which indicates that the same cover crop will behave differently depending on which cash crop it is following. A corn crop and its residues tend to create a low nitrogen environment which gives the nitrogen-fixing crimson clover an advantage over the nitrogen-requiring rye and radish. The weed biomass produced was similar whether in corn or soybean residue. However, the clover biomass was more than twice as great in corn residue as in soybean residue, while the rye biomass was about 25% greater when following soybean. This pattern has been observed in previous site-years and highlights the fact that various management factors can affect the cover crop performance just as much as the seeding rate.

Preliminary results on cover crop root growth measurements and root-to-shoot ratio

One of the objectives of this research was to determine how termination timing affects the below-ground contribution of carbon to the soil to better understand how cover crops affect soil health and carbon sequestration. Most models that describe the amount of carbon added to the soil by crops and cover crops are based almost entirely on above-ground growth patterns and make oversimplified assumptions about root growth by using a simple shoot-to-root ratio for a given species. Since there's very little research on the shoot-to-root ratio of different cover crop species, let alone different stages of maturity, the carbon models have to rely on very limited data to estimate below-ground carbon inputs.

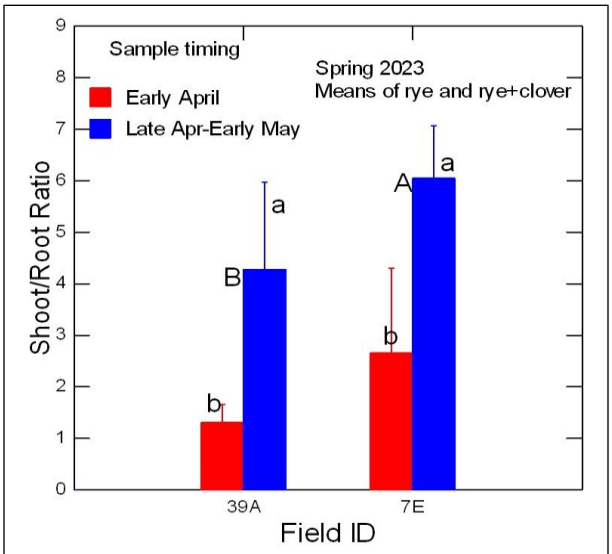

Figure 3 The shoot-to-root dry matter ratios for rye and rye + clover cover crops were significantly higher in a clayey field (7E) than in a sandy field (39A) and increased significantly during the 4 weeks between early April and around the 1st of May.

We, therefore, hope to contribute more detailed data on how different cover crop species may have changing shoot-to-root ratios over time. Figure 3 shows the shoot-to-root ratio averaged across the rye and the 3-way cover crop (which in spring consisted of only rye + crimson clover) as grown on two contrasting soils (field 39a has very sandy soils and field 7e has silt loam over silty clay). The two cover crops were averaged together because there was no significant difference between them in the shoot-to-root ratio. On the other hand, the fine-textured soil consistently produced cover crops with a significantly higher shoot-to-root ratio than the cover crops grown on the sandy soil. As a general principle, when plant growth is restricted by conditions in the root zone the plant will send more energy to the roots to try to alleviate the compaction, water shortage, or low access to nutrients that may be present, and this will create greater root biomass at the expense of shoot growth and thus a lower shoot to root ratio. Therefore, it's not surprising that the lower fertility, lower water-holding capacity sandy soil would produce plants with lower shoot-to-root ratios.

Figure 3 also shows the difference between cover crop shoot/root ratios measured in early April (red bars) and ratios measured about four weeks later just before planting corn and soybeans in early May (blue bars). On both soils, the shoot-to-root ratio increased significantly. This was largely due to increased shoot biomass with little change or even a decrease in the root biomass (data not shown). It can be seen from Figure 3 that the shoot-to-root ratio under the same weather conditions varied fourfold (between 6.1 and 1.4). It is therefore obvious that any plant growth or carbon sequestration model that assumes a particular shoot-to-root ratio is likely to be highly inaccurate in predicting dry matter and carbon fixation for any particular circumstance.

Cover crop and termination timing effects on soil properties in spring.

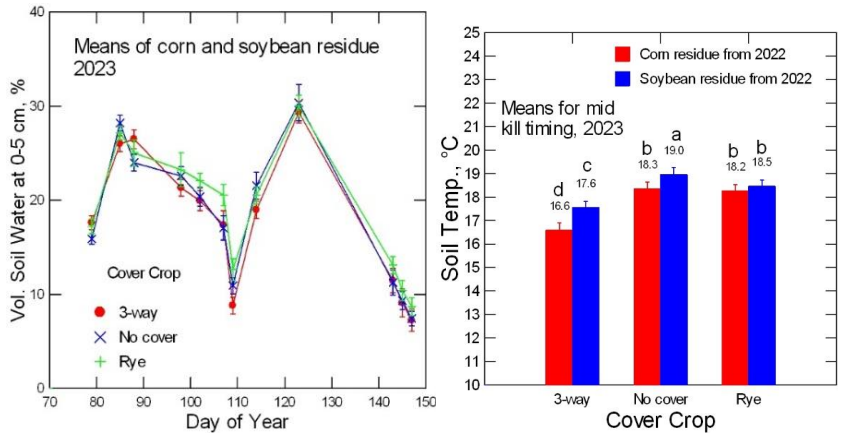

Figure 4. Soil moisture and temperature measurements made in the slug study on the silt loam soil. (Left) Soil water as affected by cover crop type from late March through late May 2023. Cover crop treatment did not significantly affect the volumetric water content of the upper 5 cm (2 inches) of soil. (Right) Crop residue type (corn or soybean) and cover crop treatment affected the temperature of the upper 5 cm of soil. The soil was slightly cooler on average in plots with corn residue from 2022, and with the 3-way multi-species cover crop present.

Although like any growing plants, cover crops take up and transpire water from the soil, they tend to use water mainly from the subsoil rather than from the surface layer. Thus, the surface soil where seeds are placed in spring remains moist under most cover cropping conditions. The shading effect of cover crops may even keep the surface soil a bit moister than with no cover crop.

Soil water in the upper 5 cm (2 inches) was not affected by the cover crop treatments from late March through late May 2023 (Figure 4, left). Crop residue type (corn or soybean) and cover crop treatment did affect the temperature of the upper 5 cm of soil. In spring 2023, the surface soil was slightly cooler, on average, in plots with corn residue than in plots with soybean residue from 2022 (Figure 4, right). Also, the 3-way multi-species cover crop with its thick clover canopy kept the soil significantly cooler by 1.5 °C in early spring.

Cover crop and termination timing effects on slugs and slug damage to crop seedlings.

The results in spring 2023 regarding slug populations and damage to corn and soybean seedlings were similar to what we observed in previous years. Figure 5 (Left) shows that there was increasing slug

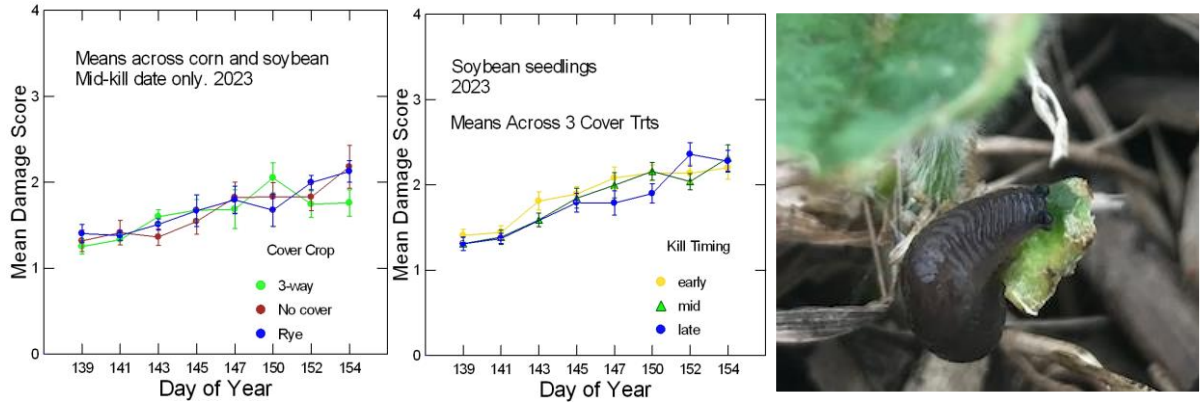

Figure 5 Neither cover crop treatment (Left) nor termination timing (Center) affected the amount of slug damage to the crops. (Right) A Black Meadow slug shown severely damaging a soybean seedling.

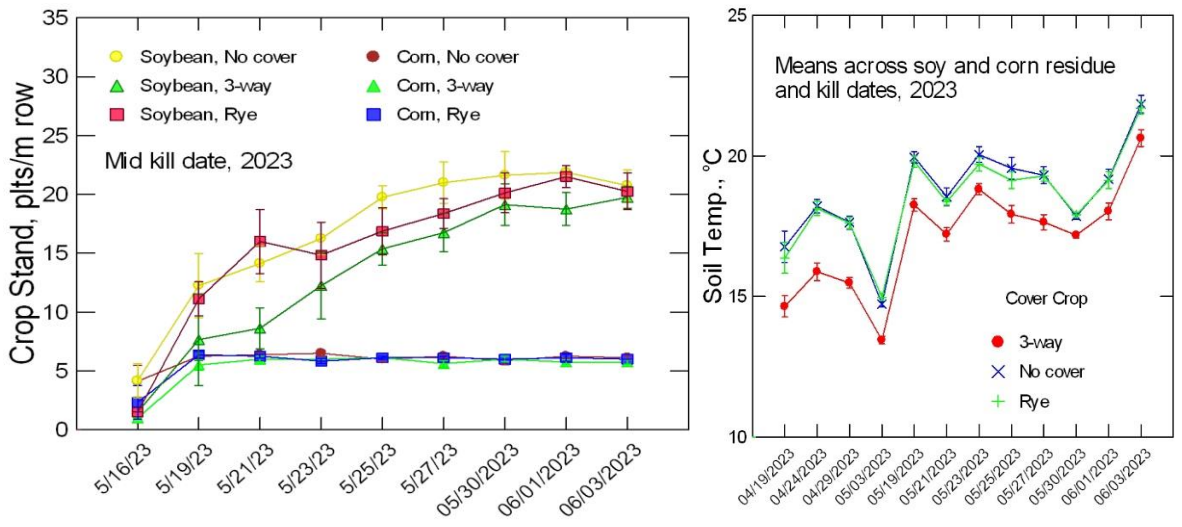

Figure 6 Although cooler soil (right) under the clover-heavy 3-way mix slowed soybean emergence, final plant populations (left) were not affected by the cover crop treatments in a slug-infested silt loam field in 2023.

damage observable on crop seedlings during the first two weeks after emergence, but that the extent of the damage was the same for Rye, 3-way or No cover crop. The center panel in Figure 5 shows that the timing of cover crop termination also had no effect on the degree of damage to soybean seedlings during the first two weeks after emergence. The number of slugs counted per shingle trap in the plots did occasionally vary with cover crop treatment (data not shown), but this was not reflected in the damage done. In the treatments where the soybeans were planted green and the cover crops terminated nearly two weeks afterward, we observed slugs feeding on the still living cover crop clover and rye. On the other hand, in the early terminated cover crop the soil was covered by a thin layer of dead brown residue and the young soybean plants emerging were the only green living tissue available for the slugs to feed on. Figure 6 (left) shows that there were no cover crop type or termination timing effects on the final stands of either corn or soybean. Shading by the heavy crimson clover growth did reduce soil temperature near the surface somewhat, and this delayed and slowed soybean emergence in early growth (Figure 7). But even in the clover-heavy 3-way mix within 2 weeks after emergence, the soybeans plant density had caught up with the other treatments.

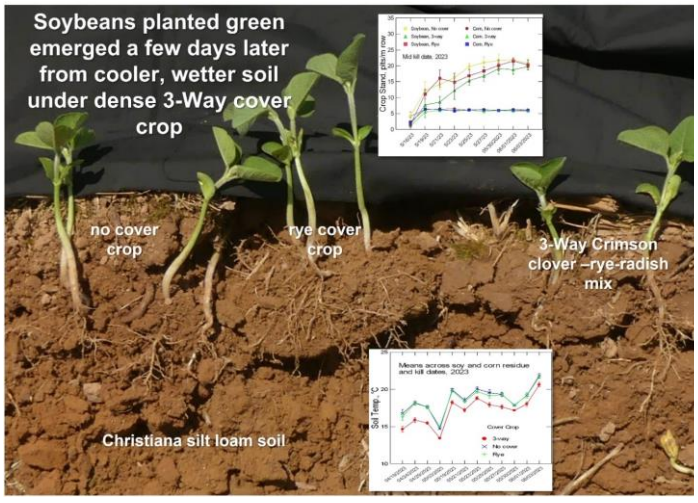

Figure 7. The appearance of soybean seedlings growing after seed was planted green inter No Cover, Rye and 3-way plots. The 3-way cover crop included a dense stand of crimson clover which keep the soil cooler and delayed soybean emergence by a few days. No cover crop effect on emergence or stands was observed for corn.

These results should help alleviate fears farmers have that by planting green and allowing cover crops to produce high biomass they may be increasing the risk of severe crop damage by slugs. As a side

observation, it should be mentioned that from late April through mid-May in the late termination plots the Crimson clover was in bloom and the plots were humming with pollinating insects. Thus, the provision of pollinator resources is a secondary benefit of late cover crop termination.

Cover crop and termination timing effects on crop yields in fall 2023.

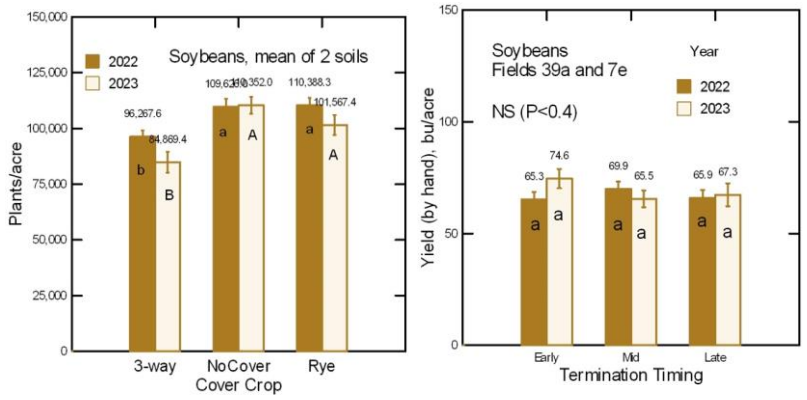

Figure 8 (Left) Soybean stand counts as affected by cover crop treatments (averaged across termination timings). (Right) Soybean yields were unaffected by cover crop termination timing.

A major objective of this research is to determine how to best manage cover crop termination to optimize the benefits derived from the cover crops while maintaining or increasing yields of soybeans and corn grown in rotation. In the spring of 2023, the late cover crop termination was delayed by wet weather and didn't occur until May 20th, almost 3 weeks after the mid-termination date and planting green. This later-than-planned termination resulted in effects that were not seen in earlier years when termination was only 7 to 10 days after planting green. These effects included cooler soils during the soybean seedling stage (Figure 6, right and Figure 7, lower inset), late emergence of the soybeans (Figure 7, Figure 6, left).

Soybean population densities at harvest time were slightly but significantly reduced following the 3-wyay cover crop, regardless of termination timing, in both 2022 and 2023 (Figure 8, left). Soybean yields in fall of 2023 were nearly identical to the yield levels of 2022 and averaged between 65 and 75 bushels per

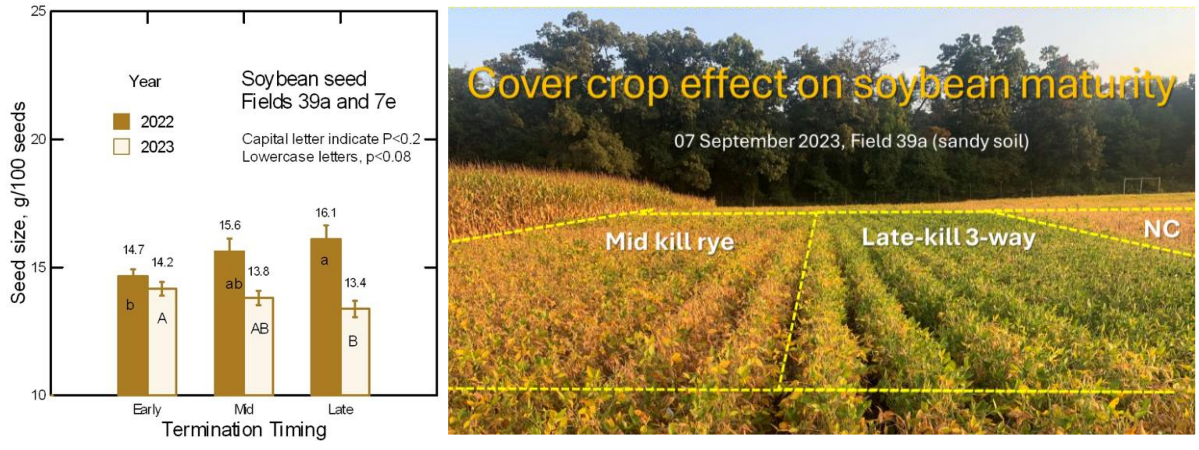

Figure 9. Cover crop termination timing affected soybean seed size and maturity. (Left) Late termination of cover crops reduced soybean seed size (g/100 seeds) in 2023, but increased seed size in 2022. (Right) The later-than-planned late termination, especially of the 3-way cover crop, in 2023 slightly delayed soybean senescence. Soybean yield, however, was not affected.

acre. Despite the effects on population densities, soybean yields were not affected by cover crop type or by cover crop termination timing in either year. This suggests that cover crops can be allowed to grow late so that soybeans are planted green into living cover crops without sacrificing soybean yield. Late termination allows cover crops to grow much larger biomass and therefore provide a thicker, longer-lasting mulch that conserves water during the summer. In years with severe moisture stress in the summer soybeans have been shown to yield better following a cover crop that left a thick water-conserving mulch on the surface.

Even though soybean yields were not affected, the cover crop termination timing did affect the harvest time stand counts (as already mentioned), the timing of senescence-induced leaf drop (Figure 9, right), and the seed size of the soybeans (Figure 9, left). The most dramatic effect observed was that the three-way cover crop mixture, especially when terminated late some 3 weeks after planting green, reduced the soybean stand somewhat (Figure 8, left) and also the seed size (g/100 seeds), see Figure 9, left. Termination timing had contrasting effects on seed size in 2022 compared to 2023. Later termination of cover crops decreased the soybean seed size in 2023 but increased it in 2022.

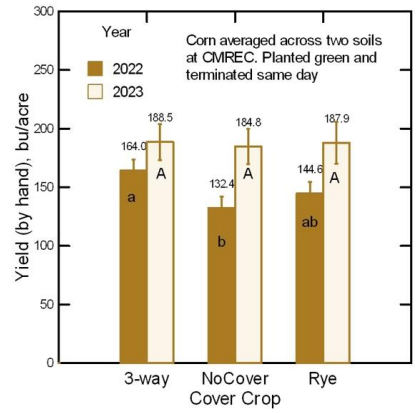

Figure 10 Corn yields were increased by cover cropping in 2022 but not in 2023.

For corn, the effect of cover crops was different in 2022 than 2023. Ignoring the zero- nitrogen corn and considering only the corn that received realistic nitrogen rates between of 100 and 180 lb N per acre, yields in 2023 averaged about 186 bushels per acre and were unaffected by the cover crop treatments. This is in contrast to the corn yields in 2022 when both rye and three-way cover crops produced higher corn yields than the no-cover treatment. In 2022 the 3-way cover crop corn produced 32 bushels more corn per acre than the no cover treatment and the nitrogen response (Figure 11) indicated that only part of this yield increase was due to increased nitrogen availability.

In 2022 corn yields were greatest after the three-way cover crop, next highest after the rye cover crop, and lowest after no cover crop, regardless of nitrogen application rate (Figure 11). By contrast, in 2023 on the silty soil, corn yields averaged considerably higher but were unaffected by cover crop treatments. Corn yields at the 110 pound/acre nitrogen rate were no different from those at the 180 pound/acre nitrogen rate in either year (see Figure 11).

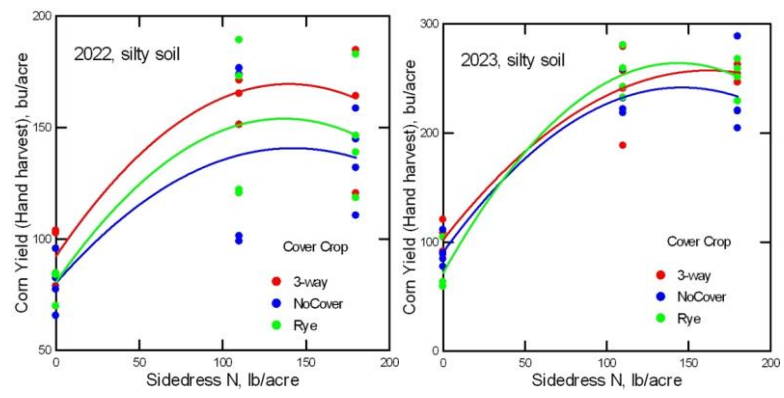

Figure 11. Corn yields in 2022 and 2023 on the silty clay soil as affected by N application rate and cover crop.

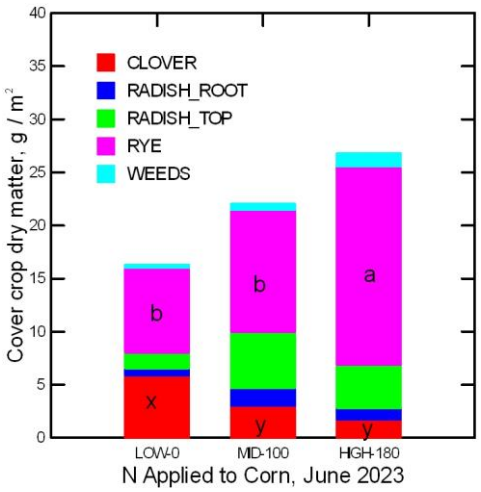

Figure 12. Fall 2023 cover crop biomass by species in the 3-way mixture as affected by N applied to corn in June 2023. Note: g/m² x 10 = kg/ha.

Fall 2023 growth of cover crops interseeded into corn and soybeans.

Finally, cover crops intersown into standing corn before harvest produced more biomass by early December in plots where the corn had had 180 lb of nitrogen per acre than in plots where corn had received lower amounts of nitrogen (Figure 12). This suggests that nitrogen fertilizer applied at side-dressing time was not efficiently used by the corn such that significant amounts of N were left over in late fall and still available for cover crops to take up. The effect on the cover crop productivity was more dramatic considering that during the cover crop establishment and early growth the corn that had received low rates of nitrogen provided less competition for light and water compared with the more heavily fertilized corn. As would be expected, the biomass of the nitrogen-fixing crimson clover component of the cover crops was reduced with higher N rates on the corn, while the nitrogen-responsive rye component biomass was increased.

Conclusions.

1. Letting cover crops grow longer in spring increases the biomass and carbon returned to the soil, but the increase varies by species.
2. The above-ground biomass of cover crops is not well correlated with below-ground biomass, hence the shoot/root ratio varies greatly by growth stage and species, making most carbon models poorly suited to predict below-ground carbon.
3. Planting into living cover crops and terminating the cover crop at the same time does not appear to increase the risk of damage from slugs or poor crop stands as compared to the traditional termination of cover crops several weeks before planting. However, letting a lush cover crop with legumes grow several weeks after cash crop planting may have reduced stands or delayed crop emergence in some cases.
4. In 2023 with little moisture stress during summer, neither rye or multispecies cover crops reduced corn or soybean yields as compared to no cover crop in a long-term no-till system. In the previous year with drought at critical periods, cover crops increased corn yield significantly at all nitrogen levels.