"Planting Green – Extending the Growing Season to Get More Payback from Cover Crops"

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In the spring of 2021, we began evaluating the impacts of the cover crops planted in the fall of 2020 on both corn and soybean. The biomass of the cover crops allowed to grow until soybean and corn seeds were planted in early May was far greater than for the covers terminated in early or mid-April, with about 100 kg/ha of dry matter (about 40 kg of carbon/ha) added for each extra day of growth. For the rye, crimson clover, and winter weeds present on the spring 2021 cover crops, the time of termination influenced the N content and C/N ratio of their tissues (Figure 1). The more mature plants having higher C/N ratios. However, only the rye (and weeds) reached C/N ratios > 20 which would be expected to immobilize nitrogen as they decompose. For corn planted green into cover crops in early May, we evaluated the effect on early corn growth at the V5 stage. There was a large difference between corn growth on the slowly drained silty soil compared to the well-drained sandy soil. Conditions were cold and wet just after planting for several weeks and the much wetter conditions on the silty field were probably responsible for the reduced corn growth. These conditions were aggravated by the presence of cover crop residue, especially the rye residue. The effect was much less for the three-way mixture. The no-cover V5 corn was significantly larger than the corn growing in the rye residue in both fields, but the three-way mix had the largest corn in the Sandy field and was only slightly smaller than the no-cover corn in the wet silky field. We also evaluated nitrogen uptake by the early corn growth. There was little difference in the nitrogen concentration of the corn tissue except for a small decrease due to the rye cover crop in the wet field. Multiplying these two parameters to give nitrogen uptake showed that the rye cover crop reduced nitrogen uptake as well as growth in the corn seedlings especially on the wet field. The data suggest that the growth inhibition was due to both weather conditions under the rye mulch as well as lower nitrogen availability. Stands we're not affected by the cover crop except in the silty field which had a large slug infestation that caused considerable damage to both the corn and soybean crops.

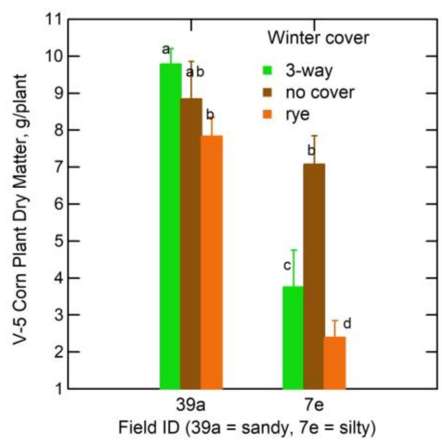

Figure 1 Influence of cover crop on corn seedling growth. Corn was planted green into standing cover crops on 05 May 2021.

Slug damage study

The presence of slugs in the silty soil field (7e) gave us an opportunity to study the impact of cover crop type and termination date on slug damage. We took advantage of this and conducted a study on both the corn and soybean residue plots.

Methods for Slug Study

This study focused on the impact of cover crops on the slug damage sustained by soybean seedlings during the critical early seedling growth stage. Data was collected in a field with 2 to 5% slopes and dominated by Christiana-Russett soils which are slowly drained with a silt loam topsoil over a silty clay loam subsoil. The field had large plots, from which corn or soybean had been harvested in fall 2020.

Figure 3 Soybean damage was scored from 1-5 as illustrated here

These plots were split into three subplots (9.1 m x 54.9 m) with either No cover, 3-way (a radish-rye-crimson clover mixed-species cover crop), or Rye (cereal rye cover crop). In the plots that had grown corn in 2020, these cover crop treatment plots were further subdivided into sub-sub-plots (9.1m x 18.2 ft) in which the cover crop (or weed growth in the No cover) was terminated with glyphosate herbicide either Early (April 7th), Mid (April 26th) or Late (May 13th). The whole experiment was replicated four times. On May 6th soybean was no-till planted in plots that had corn stubble from the previous year and corn was planted on plots that had grown soybean the previous year. Ten days before the soybean and corn were planted, 40 asphalt shingles (28 cm x 30 cm) were pinned to the ground, one per plot, in all three termination-date sub-sub-plots in the rye and 3-way cover crop treatments and in the mid termination date in the no-cover plots (28 sub-sub-plots) as well as in all three cover crop treatments in the corn plots (an

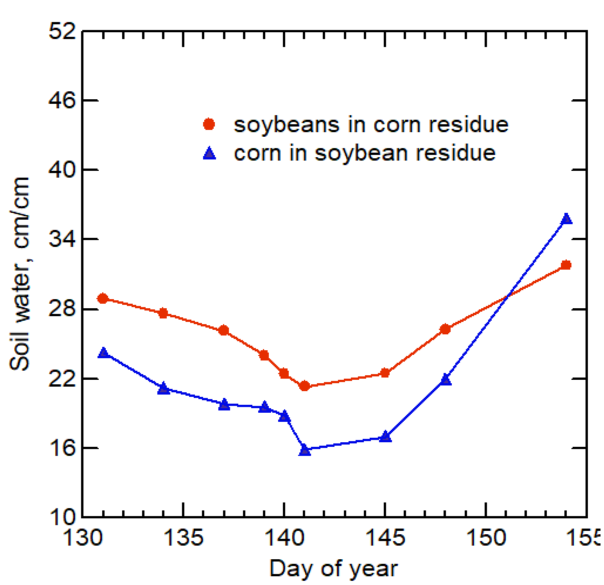

Figure 2 Soil water content under soybean or corn residue from 14 May to 13 June 2021.

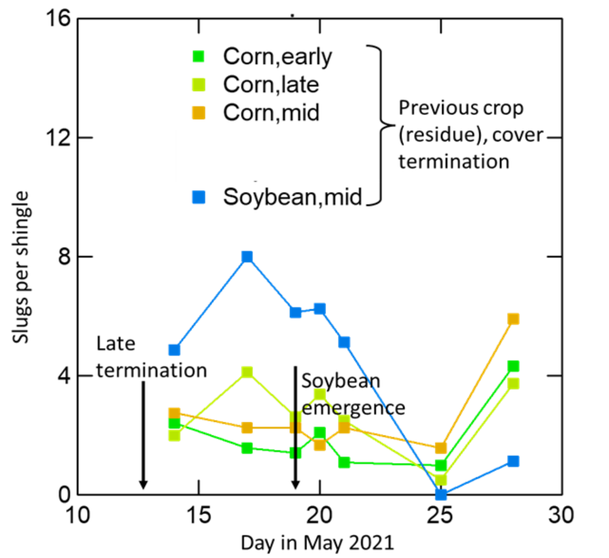

Figure 4 Slug activity dropped in young corn (coming up in soy residue) after corn emergence but increased more in soybeans (in corn residue) once soybean was growing.

additional 12 sub-sub-plots). The shingles served as devices for counting slugs: all slugs present under the shingle were counted in mid-morning every few days from 10 days before to 21 days after soybean and corn planting. Emerging soybean and corn seedlings in two 1-m sections of the row adjacent to each shingle were scored for slug damage on 5 dates and soybean stands were counted on June 3rd. In addition, each time slug data were collected, the soil temperature at the surface adjacent to the shingle was recorded using an infrared non-contact thermometer and the volumetric water content of the upper 5 cm of soil was measured using a capacitance probe (Meter Group ECHO5).

Once seedlings had emerged, slug damage was scored for all visible and counted seedlings on a scale of 1 to 5 (see Figure 2). The scoring was defined as: 1 (none), 2 (1 or 2 small bites, still healthy) 3 (cotyledons or hypocotyl damaged), 4 (severe damage, almost killed), 5 (stem or cotyledon eaten or broken off, the plant will die).

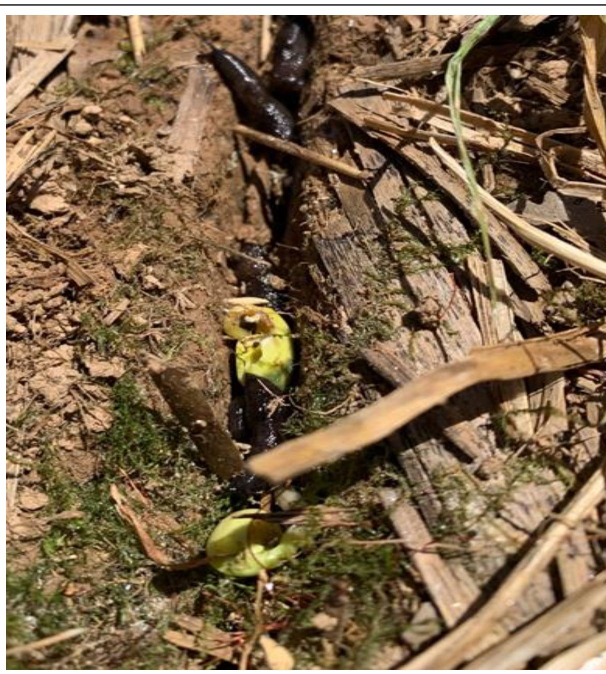

Figure 5 Failure of no-till planter to properly close the seed slot can provide an easy path for slugs to feed on soybeans even before germination.

Once the soybeans had put out two true trifoliate leaves and were likely to outgrow further slug damage, stand counts were done by counting soybean plants in two 3-meter sections of the row near each shingle.

Results

Slug Presence Before Crops Emerged

Prior to crop emergence, slug counts were higher in soybean residue than in corn residue even though during this period the soil under corn residue was wetter than soil under soybean residue (Figure 3.). Prior to soy or corn crop emergence, the presence of the cover crops did not affect slug numbers (Figure 4). Due to clayey soil texture and wet conditions during planting, some seed furrows were not properly closed, providing easy access for slugs to feed on germinating soybean seeds (Figure 5).

Cover Crop Termination Date's Impact on Slug Damage to Emerging Crop

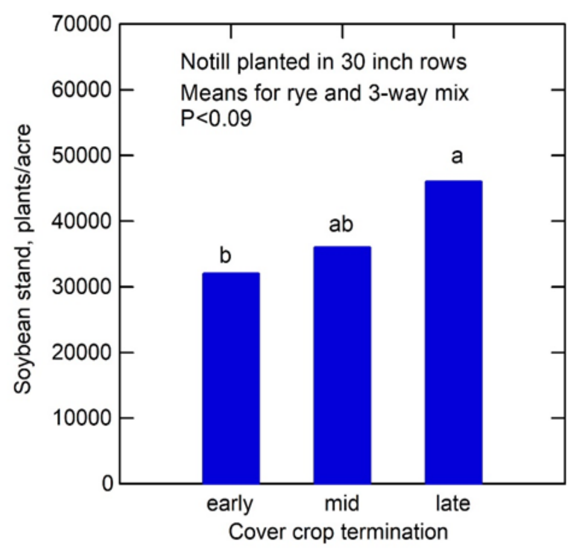

Figure 6 Soybean stand density based on counting two 10-ft sections of row on 03 June were significantly better in the plots where the soybeans were "planted green" and the cover crops were killed on the latest date (13 May) than in the earliest killed cover crop plots.

Soybean damage scores averaged across rye and 3-species mix cover crops were lower in the latest killed cover crop (planted green) plots than in the early and mid-killed plots, see Figure 5. Damage was similar in the mid killed and early killed plots. By the time trifoliate leaves developed, soybean stand counts were somewhat higher in late-kill "planted green'' plots (Figure 6). The cool spring conditions delayed soybean emergence until after the late-kill cover had mostly desiccated. The benefit of planting green may be greater under conditions better for rapid soybean germination and seedling growth.

Cover Crop Species' Impact on Slug Damage to Emerging Crop

Studying the cover crop species impact on slugs showed interesting results. When comparing slug presence in no cover, rye, or the 3-way mix plots, the number of slugs were highest in the 3-way and lower in the no cover and rye plots. However, this pattern was not reflected in the damage inflicted by the slugs on the young soybeans. The most slug damage was sustained in the rye cover crop plots and lower in the no-cover and 3-way (Figure 7). This suggests that the 3-way mix cover crop supported more slugs but tended to keep them off the soybeans while the rye was not able to do this.

To examine the effect of cover crop termination date on slug damage to soybeans we averaged the data across rye and 3-way mix cover crops. As shown in Figure 8, on all three dates when damage was scored, there was significantly less soybean damage in the late-killed cover crop plots compared to the early and mid-killed. We speculate that the slugs may have been distracted by feeding on the cover crop plants in the late-kill plots.

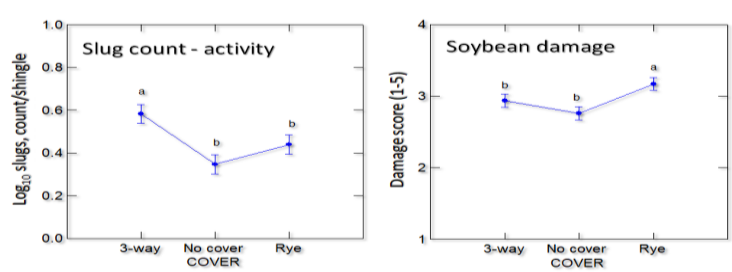

Figure 7 For the cover crop plots termination on the mid date, more slugs were counted in the 3-way mix, but more damage was observed in the rye.

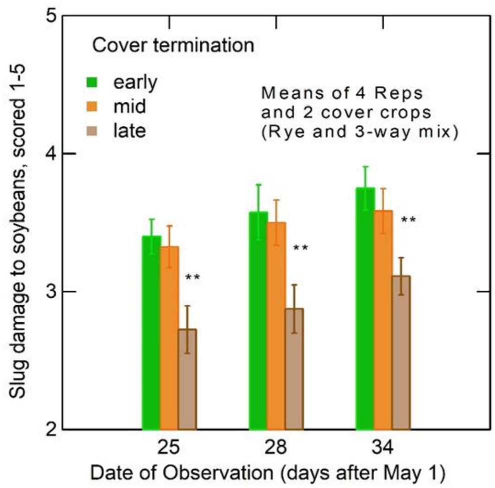

Figure 8 The plots where the cover crops had been killed the latest (sprayed on 13 May, a week after soybean planting) had lower damage to soybeans than the plot with early and mid-killed cover crops.

Once the soybeans outgrew the slug-susceptible seedling stage the stands varied by treatment from 30,000 to 50,000 plants/acre. This was low enough that we had to replant soybean to get a decent crop. Therefore, we are not able to report any effect of slug damage and cover crops on the soybean yield for 2021. We replanted soybeans as close to the original rows as possible when the first planting was in the 2nd trifoliate stage. This actually worked quite well (see Figure 9) and both the original and second planting soybeans grew well where weed pressure or waterlogging was not an issue.

Soybean Harvest

By harvest time, soybean yields were much lower than normal (2500 kg/ha or 37 bu/acre) in the experimental field (7e, right side of Figure 10.), whether no cover crop, rye or the 3-way mix had preceded the crop (no cover crop effect). We ascribe the low yields to the extremely wet spring and summer conditions resulting in poor seed furrow closure, standing water for extensive periods, and high amounts of grassy weeds. A nearby sandy field (39A, left side of Figure 10.) planted at the same time with the same cover crop and soybean seeds yielded more than normal (3900 kg/ha or 58 bu/acre). On the normally droughty sandy field, the unusually wet conditions were favorable to soybean growth and neither weeds nor slugs were a problem.

Figure 9 Replanted soybeans after slug damage. Larger plants were seeded on 06 May and survived the slug infestation. The smaller plants were seeded on 26 June. Photo was taken on 08 July.

Conclusions from First Year Slug Study:

1. When terminated two weeks before soybean planting, the rye cover crop, but not the 3-way mix, seemed to make the slug damage worse than with no cover crop.

2. When averaged across both cover crop types, planting green with termination a week after planting resulted in a significant, though small, reduction in slug damage, but not numbers.

3. The number of slugs counted was not closely related to the amount of damage they caused to soybean seedlings.

4. The extremely cool and wet conditions after soybean planting were great for slugs and very poor for rapid soybean emergence and early growth.

5. Within the context of no-till soybeans, our data from a single site and year suggest that cover crops probably do not make slug damage worse, and termination after planting may be worth considering, especially if planting can be timed for weather warm enough to stimulate soybean emergence.

While this is just one site-year, the data do lend some support to the idea that having a living cover crop for some time after soybean planting may divert slugs and dilute their damage to the soybean crop. Clearly, this needs to be studied further.

Soil and Crop Responses in 2021

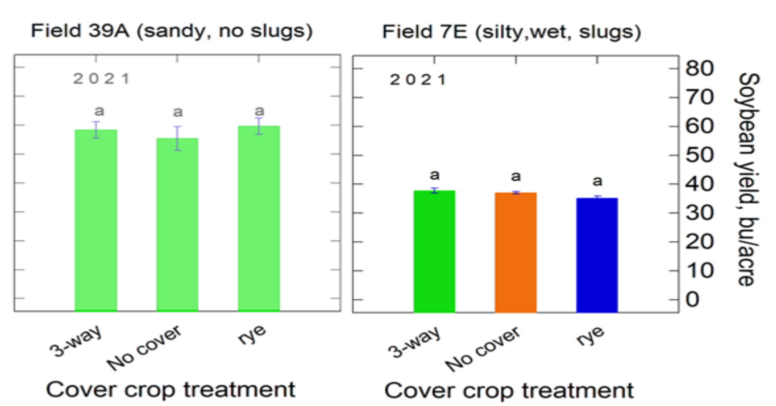

Figure 10 Final soybean yields in Fall 2021 were not affected by cover crop treatments. However, yields were much lower on the wet, silty field than on its paired sandy field that did not have slug issues. Means within a field having the same lowercase letter are not significantly different.

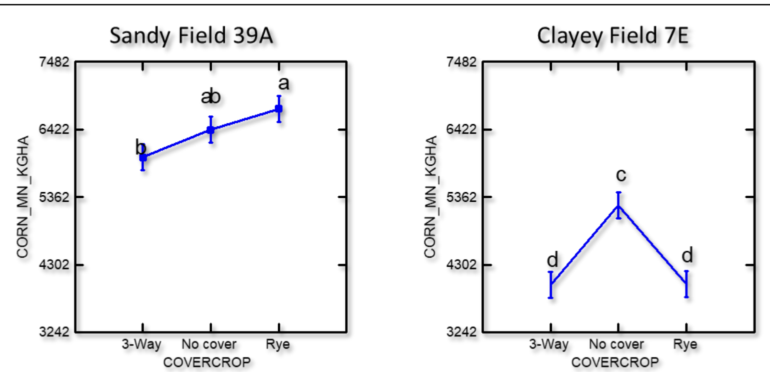

Figure 11 Effect of cover crop treatment on corn yields as measured by combine yield monitor on two fields of contrasting soi texture at CMREC. The lower yield in the rye and 3-way cover crop plots in the clayey field (Right) was mainly due to damage caused by the interseeder drill operation performed when the soil was excessively wet in June.

During the summer soil moisture and temperature sensors were installed into replications at each site for each of the treatments. Shallow trenches were dug to bury the wire so that the installation could be permanent and the data loggers that received the signals were installed just outside the field where they would be out of the way of field operations. Therefore, we anticipate being able to monitor soil conditions continuously even during harvest and planting without having to remove and reinstall the sensors. Data logged between July and October 2021 was downloaded and is summarized for the field with sandy soil in Figure 12. The figure presents two kinds of data collected by two different kinds of soil water sensors placed in the no cover, three-way mixture, and rye cover crop treatment plots during the corn growing season. These cover crops were inter-seated into soybeans in the fall of 2020. The upper part of the figure shows the data from watermark granular matrix resistance sensors that indicate soil water tension with greater tension indicating dryer soil and lower tension indicating water soil with saturated soils near zero. This type of sensor becomes more sensitive in the moisture stress range and less sensitive in the very wet soils so is ideal for monitoring drought stress on crops but not great for monitoring saturated conditions that might induce denitrification losses of into gas or conditions too wet for good root growth. The lower graph presents data from a completely different type of sensor installed in a different replication block of the field but the same cover crop treatments. These data are collected by capacitance probes which determine the volumetric water content of the soil. With this data, the higher water content is wetter soil and low water contents are dry soil. In the data from both types of sensors in both parts of the experiment, the patterns were similar even though the graph is the mirror image. The brown lines represent the no-cover control plots with the darker brown being the water measurements at 30 cm deep and the lighter brown being the water measurements at 15 cm. With both types of sensors and in both parts of the field these no cover control plots became significantly drier than the cover crop plots and both depths. Having very similar results from two completely independent types of measurements in different parts of the field heads to the confidence was which we can say that cover crops conserved moisture drink the dry. Of the summer. In both graphs we can especially see that the shallow soil in the no cover plot that had minimal residue on the surface dried out more rapidly than the other soils after each rainfall. This cover crop effect on soil moisture produced visible differences in corn growth and leaf morphology during dry periods in the summer but we're not reflected in the final corn yields. Similar data (not shown) was collected in the soybean plots where the cover crop residues originated from cover crops interseeded into corn in fall 2020.

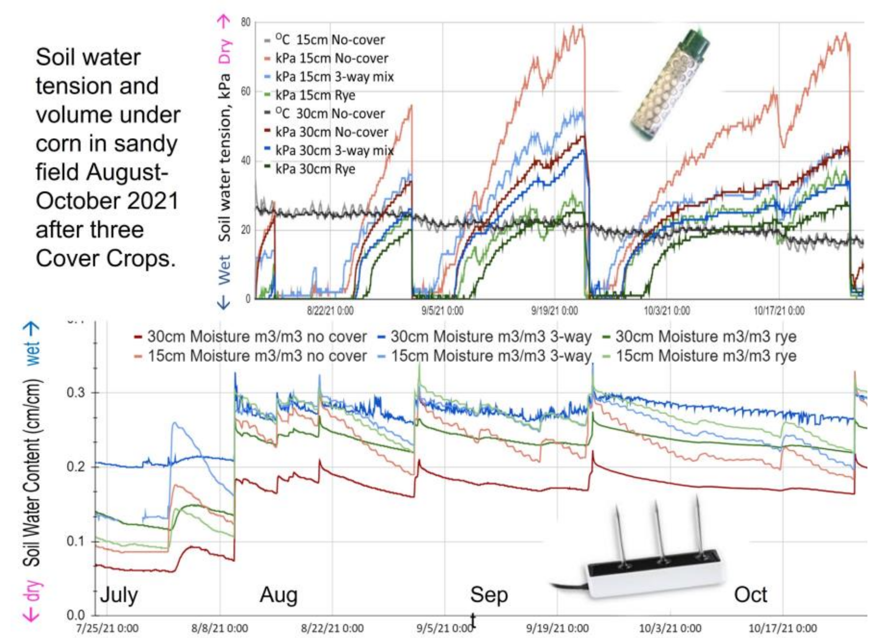

Figure 12 Soil water in the sandy field at CMREC from July-October. (Upper) Soil water tension as measured by Watermark granular matric resistance sensors indicating drier soil with greater tension readings. (Lower) Water content of the soil measured by Meter Group capacitance sensors expressed as a fraction of the soil volume.

The spring of 2021 was much cooler and wetter than normal, and these conditions resulted in significantly lower yields on the clay field compared to the Sandy field (Figure 10). The clay field had long periods with standing water in places and was excessively wet at the time of cover crop interseeding by the high clearance drill method at corn lay by. These wet conditions led to some damage to the corn seedlings during the cover crop inter seating drill pass and also led to very high weed pressure. The combination of weeds and damage were probably responsible for the lower yields and the lack of damage from the inter-seater drill in the no-cover plots probably accounts for the somewhat higher yields under that treatment in the clay field. Yields were significantly higher in the Sandy field across the board and there the rye cover crop plots yielded more corn than the three species cover crop plots did with the no cover crop but in between and not significantly different from either (figure 10, left side). The three cover crop treatments were split into three rates of nitrogen applied to corn its high dressing and these nitrogen effects will be discussed later.

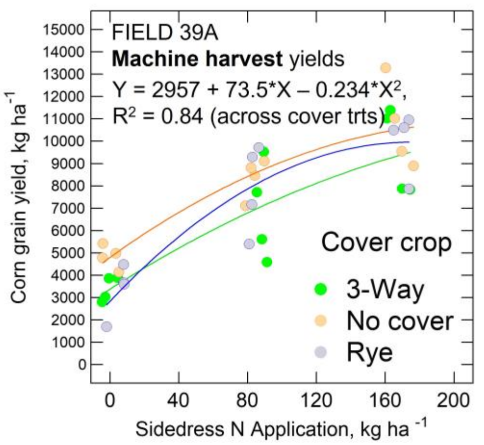

Figure 13 Fall 2021 corn yields at three N rates following three cover crop treatment inter-sown into 2020 soybeans. Cover crop treatment did not affect the corn response to nitrogen fertilizer.

Soybean yields were significantly higher in the sandy field than in the clayey field. In the case of soybeans, the lower normal yields in the clay soil field were due to a combination of the above-mentioned cool and excessively wet conditions as well as damaging slug infestation. The effect of cover crops and termination date on slug damage was discussed in a previous progress report. Neither the wetness nor the slug problem was present in the Sandy field and yields averaged near 60 bushels per acre for all cover crop treatments.

Figure 13 shows the corn yield response to side-dress nitrogen rates as affected by the cover crop treatment. There was a good response to applied nitrogen on both fields. Only the data for the Sandy field is shown in figure 13. Nitrogen nearly tripled the yield with the highest rate of nitrogen being 168 kg nitrogen per hectare (150 lb per acre). There was no significant effect of cover crop on the response curves, even though the three-way cover crop had large amounts of clover in it and termination in May.

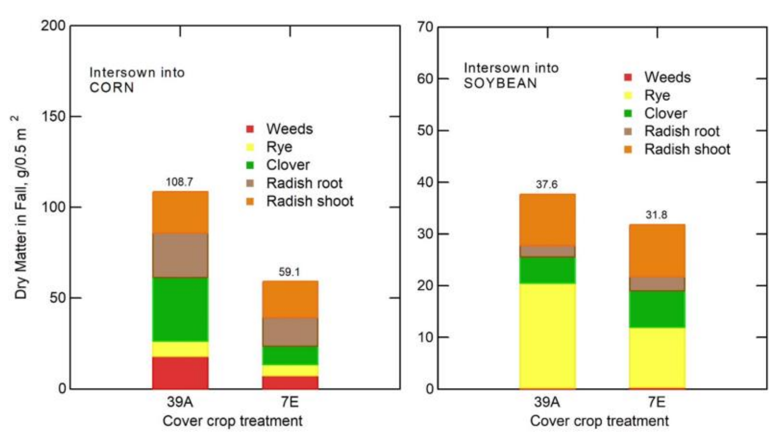

Figure 14 Fall 2021 cover crop dry matter (gram per 0.5 m²) by species for sandy and clayey fields in corn (left) and soybean (right). Note the different scales.

At the first leaf drop in the soybean plots, the 2021 - 2022 cover crop was planted using the highboy air seeder. In the corn plots, the cover crops were interseeded with the highboy air seeder in August. Cover crop biomass accumulated in Fall was measured in late November and early December and the dry matter values are presented in figure 14 (note the different y-axis scales for corn versus soybean). Cover crop dry matter was less than half as large in the soybean as compared to cover crops sown into corn. This is largely due to the later planting date since we had to wait until leaf drop in the soybean crop which occurred in early to mid-September. The earlier interseeding in the corn allowed more Growing Degree Days for the cover crop as the sunlight began to penetrate the senescing corn canopy in late August and early September. There was also a marked difference in the species composition even though the same seeding mixtures were used in the two crops. For the cover crop interseeded into the soybean canopy, the dominant species was rye with radish second and then clover. In the corn, the dominant species was radish and in the sandy field, clover was nearly as large. In both fields, very little rye was present in the cover crop. There were more weeds in the corn than in the soybean plots.

The hundreds of dry matter samples that have been collected, dried, and ground from the cover crops are still being analyzed for their nitrogen content. We intend to rotate between corn and soybean crops in the spring and apply the differing termination date treatments. We also will study slugs in the clay field again in the spring as we have preliminary slug counts showing that that field is again infested with slugs.

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