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CERES ORGANIC GRANT

Development of Cultural Practices to use a Roller/Crimper in Organic Cropping Systems for Eastern Nebraska

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Significance of Project to Organic Agriculture

To be certified, organic farmers must follow the National Organic Program (NOP) regulations which state that famers manage their soil fertility and pests by diversifying their crop rotation, using cover crops (CCs) and developing other strategies to improve soil fertility. The USDA NOP standards are-written broadly as to allow implementation across a wide range of ecosystems throughout the United States. Farmers are left to their own devices to develop farming practices that work with their bioregion and that are consistent with the standards. NOP Standard 205.203 Soil Fertility and Crop Nutrient Management Practice states: (a) The producer must select and implement tillage and cultivation practices that maintain or improve the physical, chemical, and biological condition of soil and minimize soil erosion and (b) The producer must manage crop nutrients and soil fertility through rotations, CCs, and the application of plant and animal materials. However, the standard does not dictate what tillage and cultivation practices are used and what rotations and CCs work best.

The NOP standards are intended to be general. Certification of organic farming operations takes place within many diverse bioregions, and development of farming practices is dependent on available labor and equipment. Therefore, the NOP standards cannot dictate one set of practices that will improve soil fertility and manage pests (weeds, disease and insects) for organic growers nation-wide. Practices that are successful in one area may not be successful in other areas. This is particularly true when trying to create a cropping system that includes CCs.

Organic farmers understand that the more multi-crop/ multi-year rotations, strip cropping, habitat for natural predators and cover/green manure crops they have in their rotations, the more resilient their systems become to weeds, insects, pathogens, other biotic pests. Extension Educators working with farmers to increase CC usage realize that farmers do not have the time or means to test all these different systems. Often organic farmers look at CCs and technologies that have been used within a different bioregion than theirs and try to adapt it to their operation.

For example, the Rodale Crimper was developed in Pennsylvania, and when used according to their management guides allows for a reduced tillage/CC system. However, eastern Pennsylvania receives an average of 44 inches of rain/year. Farmers in Nebraska cannot take these recommendations directly since eastern Nebraska receives an average rainfall of 25 inches. Organic farmers in Nebraska are interested in reducing tillage to prevent erosion, provide more mulch for weed control and improve soil organic matter. The University of Nebraska has worked with no-till and organic farmers to increase the use of cover crops and increase the choice of cash grains to farmers in the western Corn Belt. This research project was designed to help producers contemplating using a roller/crimper to terminate a CC.

We had the following objectives in this grant.

Objectives

1. Determine the effect of triticale planting rate, crimping date and crimping frequency on triticale CC survival and subsequent soybean yield.

   (Revised to oats since triticale could not be planted in the fall 2013)

2. Determine the effect of Austrian winter pea (AWP) planting rate, crimping date and crimping frequency on AWP CC survival and subsequent corn yield.

   (*Revised to spring forage peas)*

3. Determine the effect of soil moisture status on triticale kill at boot stage.

   (Experiment conducted in 2014 and 2015 due to poor soil conditions in 2014)

4. Facilitate on-farm experimentation with roller/crimper CC termination.

This report is focused on our field work for 2014-2015 and supplements the interim report that contains the response to the 2013 field work and the on-farm trials.

Materials and Methods

Table 1 contains a listing of the treatments conducted in the two roller/crimper management (RC) studies and the soil water management (SW) studies. The RC study had a change in treatments for 2014. Instead of a factorial of two termination timings and either one or two crimper operations conducted either in the same direction or perpendicular, more controls were included. We decided that the two timings were not feasible and that perpendicular crimping created experimental design problems we could not overcome with the space available. In 2014, crimping was conducted on 7/3 for the oats and 7/10 for the peas. Figure 1 shows the conceptual plan for the crimping experiments as envisioned in the original proposal. Due to unfavorable fall planting conditions, the 2013 fall triticale plots were planted to oats in the spring of 2014, as was the forage peas. Tables 2 gives the complete listing of cultural practices for these experiments.

For the SW study, where we intended to irrigate sufficiently to create a gradient of soil moisture levels, but precipitation in June 2014 precluded this plan. We ended up waiting for the soil to dry out as we applied our treatments. Because we were not satisfied with the 2014 grain crop after the SW treatments, we repeated the study in 2015. Table 1 lists the dates we crimped for the SW study in both years, Table 2 lists the cultural practices for 2014 and Table 3 lists cultural practices for 2015. Tables 4 and 5 provide the daily rainfall, which was recorded at 8:00 AM indicating precipitation over the previous 24 hours.

RC Management

The RC studies have the same treatment set; one is a grass (oats) CC, terminated with RC and followed by a legume cash crop (soybeans); the other is a legume (peas), terminated with RC and followed by a grass cash crop (corn). The treatment set contains the following treatments: crimping 1 time (Trt 4), crimping 2 times in the same direction (Trt 5), and crimping 2 times in opposite directions (Trt 6). These treatments are compared to several alternatives:

Trt 1, plant cash crop into the standing CC, mow one week later

Trt 2, mow CC before planting cash crop

Trt 3, crimp CC, plant cash crop, then mow

Trt 7, disk oat CC, then plant cash crop

Trt 8, no CC planted; disk and then plant cash crop

These treatments were designed to differentiate the crimping from traditional organic practices. We created the following contrasts to quantify these comparisons:

1. No CC versus the average of all the CCs (Trt 8 versus all others)

2. Average of all the crimping (Trts 3-6) versus the average of other termination methods (Trts 1,2,7).

In Tables 6 and 7 the difference in the means between the two groups with each comparison is given and compared to the LSD for that variable.

In addition to the RC treatments, the CCs were planted at three initial populations. In 2014, the oats were planted at 36, 54, and 72 lbs/ac and the forage peas at 60, 90, and 120 lbs/ac. Our intent was to determine if more biomass would be produced with greater seeding rates and if that extra mass would affect weed suppression, termination success, and the subsequent cash crop production.

For the 2014 oats study, biomass samples were taken at seed set (7/3/2014) from 0.25 m^2, weighed wet and dry; percent DM was calculated and mass at 100% DM is reported. Soybean vigor was measured by assessing the combined visual appearance of plant stand and plant height. This is a subjective assessment, but is based on experience. Oat and weed ratings were conducted on August 8, 2014, and were visual assessments of percent oats terminated, grass weeds reduced and broadleaf weeds reduced.

Statistical analysis

We used SAS to conduct all statistical analyses. Analysis of variance (ANOVA) was performed PROC GLM. The study was a split plot with the RC treatments as the main plots and the CC planting rates as the sub-plots. Error A (Rep x RC treatment) was used to test the main effects of the RC treatments. Tables 6 through 9 are in the same format. For each variable, the ANOVA is presented for the main effects and interactions, the CV is next, then the main effect LSDs, using 0.05 as the probability level. Next, the main plot means are listed, with the effect mean below. The 'Comparisons (a vs. b)' section shows the contrasts that were created above and the difference is displayed; those means greater than the LSD are highlighted in yellow. Highlighting the significant comparisons allows the reader to spot important relationships easily. For the first comparison, negative numbers signify that using CCs produced a greater result than no CC. For the second comparison, a negative number signifies the non-crimping alternative had a greater value. For all variables, a greater number is considered the positive outcome. The LSD statistic is used to compare these two means and can be used to compare any two treatments. We caution the use of the LSD when the F test is not significant.

For the seeding rate comparisons, we calculated the difference between the maximum and the minimum values to compare to the LSD. It is not possible to calculate an LSD for the interaction means, so where appropriate, we comment on the trends shown by the data.

Results

Oats➔Soybeans (2014)

Table 6 contains the ANOVA for each important variable and the associated main effect LSDs, the means and the interaction means. There was no significant differences in oats percent dry matter (DM) at sampling. For the oats biomass weight, the CC treatments produced 254 lbs acre^{-1} more biomass than the non-oats treatment. This is expected since the biomass in the disk treatment was of weeds and not oats. The crimping vs other comparison was not significant which is what we expect since at the point in time of sampling no treatments were imposed, and the oats values give us an indication of the material to be crimped. Soil moisture was measured at the time of oat sampling, and the field was 23.8% gravimetric moisture in the top six inches, but there were no definitive differences between the treatments.

The soybean populations measured August 8, 2014 were less than the recommended populations (120,000 plants acre^{-1}), but reasonable. However, the soybeans were late in emerging, and there was a significant developmental delay with a fairly dry July. The CC treatments had slightly greater populations than the no CC treatments, but not agronomically significant. The crimped treatments were similarly increased in population by about 3600 plants acre^{-1} which was not agronomically significant.

As expected, the measurement of oat termination should be 100% and was 100% Oats killed for the non-oats treatment. The disk treatment controlled almost 90% of the oats, and the non-crimping treatments significantly had about 30% greater oats termination than the crimped treatments. It was expected that disking would be more effective. When it came to weed control, the generalized grass and broadleaf ratings did not show any differences.

It is almost not worth discussing the soybean yields since they averaged 2.5 bu acre^{-1} and would not be worth harvesting on a commercial basis. The reason for this was the late season for the CC growth, and late soybean planting date (7/4), modest rainfall (5.1 in poorly distributed precipitation for the 30 days after planting, and poor growth with weed competition during the season. Statistically, the disked treatments (4.8 bu acre^{-1}) did better than all the other treatments (1.7 bu ac^{-1}). Under other environmental conditions, the soybean yields would be greater, we do need to document and be able to calculate the risk of these treatments, and the probability of zero or very low yields due to precipitation distribution, early frost, and late CC maturity.

Peas ➔ Corn (2014)

The peas were drier (16%) at sampling than the oats (25%), but the no CC weed samples were similar at 23% DM (Table 7). There were no agronomically significant differences within the peas, which as with the oats is how it should be since the treatments were applied after the biomass sampling. Due to missing values, we did not calculate an LSD for corn population, but the non-crimping treatments had greater populations with the no CC, mow and plant, and disking having an average of 1,370 more plants per acre. The disk treatments might have had a greater population, but the soil was wet at the time of disking and there were large weeds that made the seedbed less than ideal. The major difference was that the one time crimping without any other management had only 10,600 plants acre^{-1} compared to either crimping twice or crimping with mowing which averaged 14,440 plants acre^{-1}. If the season had appropriate weather, this population difference would have been agronomically significant. This difference continued onto corn DM harvest which was taken in place of grain yield due to the poor seed set. The two-time crimping yielded 2704 lbs acre^{-1} of stover, almost 900 lbs more than the one time crimping (1822 lbs acre^{-1}; averaged with one time with mowing.) This difference was not statistically significant, but does indicate the second crimping might have helped reduce competition.

Weed pressure during the season as indicated by the assessment of grass and broadleaf competition showed a significant effect of RC treatment and seeding rate. However, with broadleaf control none of the differences followed the trends we have been discussing, there is no clear advantage to the disking nor disadvantage with the crimping. With grasses, the trends do show that one-time crimping averaged 55% control compared to 68% for the two-time crimping. These treatments compare unfavorably to the disk treatments which had 84% control. The mowing only averaged 73% control.

The increased seeding rate for the forage peas did seem to improve grass control, broadleaf control, corn population and corn stover DM. Inexplicably, increased seeding rate decreased pea biomass. There was an interaction between the RC treatments and pea seeding rate, but it was one of magnitude since within each RC treatment, greater pea seeding rate improved broadleaf weed control.

Soil moisture effects on RC efficacy

2014

As mentioned above, we were not able to complete the soil water part of the project as intended since spring precipitation did not allow us to control soil moisture during the crimping period. We were able to create a surface moisture gradient with significant treatment differences in 0-3” and 0-6” depths (Table 8). The trend with soil moisture was increasing from the driest (16.9% to the wettest 21.9%). Combining the 0-3 and 3-6” samples had the same trend, but the 3-6” samples alone while significant, most of the difference was between the dry and the others.

Oat production as measured by lbs DM acre^{-1} was affected by both water regime (Prob. > F, 0.03) and seeding rate (Prob. > F, 0.08). The harvest times were different since the oats were sampled on the day of crimping which spanned a 17-day period. The dry weights do not follow the sampling dates closely since the DM plateaued with the 7/10 sampling (2W, 1110 lbs acre^{-1}) which was greater than the 7/4 sampling (3W, 816 lbs acre^{-1}). Soybean populations were also affected by the crimping dates with the driest treatments having the lowest soybean population (24790 vs 95398 plants acre^{-1}). Oats seeding rate did not make much difference.

The in-season ratings of oat termination and the weed growth did not show differences due to the water regime/termination date. However, the seeding rate of oats did affect all three parameters with the greater oat seeding rate having the most weed suppression. After the 8/14 assessments the experiment was cultivated. A late season reassessment showed that there were differences in late season volunteer oat growth, with the earlier terminated oats in the wettest environment having the least competition. There were no differences for broadleaf weeds. Average suppression was fairly high for broadleaf (92%) but not grass (65%). Due to late planting and dry weather, there was no soybean harvest in 2014.

2015

The soil moisture study was repeated in 2015 to try and get a complete year's data from crimping through soybean harvest. In 2014 we crimped as the soil dried out, but in 2015 the driest soil moisture treatment was first. We decided to crimp after a dry May. Three days after the first crimping there was about 3 inches of precipitation (Table 5), so the next crimping was the wettest and the soil dried out for the 2W and 3W crimps, but precipitation after the 2W crimping led to wetter conditions for the 1W crimping. We did not want to wait longer to apply the last crimping since more precipitation was predicted, so the 1W treatment is not the second driest treatment. Soil moisture conditions show the percent moisture in the top 6" (Table 9.) Triticale biomass was taken the day of crimping and increased as the season progressed. Except for the very dry conditions, the triticale was killed at 92% or greater. Weed suppression was also less for the early crimping compared to the 3W crimping time. Resulting soybean stands planted 6/19 and counted before harvest were similar and averaged 74,000 plants acre^{-1}, which was similar to other years but lower than recommended plant populations. Both soybean height and yield tended to be less for the drier crimping time. Because of the late planting, the soybean yields were less than half what would be an acceptable soybean yield.

Several of the parameters were statistically significant for the triticale planting rate, and in all cases there was a trend for increased positive outcomes with the greater triticale rate.

Discussion

This report presents data collected from the 2014 and 2015 season; it supplements the 2013 progress report. The main findings are in the order of our objectives:

1. Determine the effect of a spring small grain planting rate and crimping program on small grain termination and subsequent soybean yield.

Increased planting rate of the small grains had marginal improvements in some parameters and is probably a good practice to ensure sufficient biomass production. Crimping date was not fully explored, but earlier within the suggested time allows for the following crop to establish and reach maturity. Crimping twice in the same direction gave some improved results, although not all these practices were consistent in their effects. The main problem with using the crimper is the need to wait too long into the season to get adequate small grain termination. This makes for a very late planting of soybeans, limiting yields. The delayed soybean planting makes it difficult for the roots to explore the sub-surface moisture.

2. Determine the effect of a spring forage pea planting rate and crimping management program on forage pea termination and subsequent corn yield.

Crimping the forage peas had comparable results to the crimping the small grains for similar reasons.

3. Determine the effect of soil moisture status on triticale kill at boot stage.

Because of the poor weather conditions in both 2014 and 2015 we cannot draw any major conclusions, except that it was a risky strategy to design a field experiment which relied on soil being dry at a certain period. There is some evidence that the moister soils make crimping easier and more effective, but since the crimping was spread out over 2 weeks, other factors confound the conclusions.

We believe the following are general concepts that organic producers can use if they want to use RC. Our experience has shown that the immediate benefit of disking earlier in the season allows for increased yields of the cash crop.

Plant greater amount of CC seed

Crimp when soils are moist

Crimp more than once

Crimp earlier than later

Plan on supplemental weed control

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