**Report #1 Final report- June 30 2017**

**Project Title:**

**Broadcast Seeding of Cover Crops into Standing Soybean to Improve Soil Health**

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1. **RESEARCH GOALS**

The main research goal is to find a method to establish cover crops in a standing soybean [*Glycine max* (L.) Merr.] crop to protect the soil during the winter and early spring and reduce soil moisture in wet years. The soybean crop leaves soil unprotected to the elements after harvest, causing erosion and losing nutrients.

1. **RESEARCH OBJECTIVE**

Determine the effect of seeding cover crops into soybean at two late stages of development, on soybean yield, cover crop establishment, potential negatives effects to soybean quality, and soil cover.

1. **METHODOLOGY**

*Field establishment and experimental design*

The research were conducted at two North Dakota State University experimental stations, Fargo, ND (46°89’6’’′N, -96°81’7’’ W) and Prosper, ND, (47°003′N, -97.116 W). Soil samples were taken at both locations the spring before soybean were planted, in the fall after soybean harvest and before cover crops biomass sampling.

The experimental design was a randomized complete block design (RCBD) with a split-plot arrangement with four replicates. The main plot was the soybean growth stage at which the cover crops were sown and the sub-plot was the cover crop treatment. Experimental units were 7.6 m long and 1.7 m. Soybean cultivar 16R008N, a glyphosate resistant, with a bush type architecture and a relative maturity group 00 was used. Soybean sowing dates were 16 and 18 May in Prosper and Fargo, respectively at a row spacing of 0.56 m. The target plant population of soybean was 432,100 plants ha-1. Cover crops were interseeded at the R4 and R6 reproductive stages of soybean on 25 and 26 July for R4 in Fargo and Prosper, respectively and on 16 August for R6.

Four cover crop treatments were seeded between the soybean rows: Austrian winter pea (*Pisum sativum* L.), forage radish cv. Daikon (*Raphanus sativus* L.), winter camelina cv. Joelle (*Camelina sativa* L.), winter rye (*Secale cereale* L.) cv. Rymin , a mixture of all four cover crops, and a check treatment with no cover crops. Cover crops were interseeded in two twin rows centered within the 0.56-m soybean rows. The furrow was hand dug using a hand-hoe. Cover crop seeds were placed within the furrow by hand at a depth of approximately 1.3-cm for all cover crops, and then covered with soil. The seeding rates for Austrian winter pea and forage radish were 89 kg ha-1 and 5.6 kg ha-1, respectively. Seeding rates for winter camelina and winter rye were 6.7 kg ha-1 and 67.2 kg ha-1, respectively. Treatment with cover crop mix had 1/4 the rate of each individual planting rate.

Glyphosate [(N-phosphonomethyl) glycine] (1.4 kg a.i. ha-1) was sprayed on 20 June and 22 July in Fargo and only 21 July in prosper. No insecticide or fertilizer applications were applied. Soil test indicated no P or K application was needed.

*Sampling and Analysis*

Soybean plant stand counts were recorded prior to harvest for final stand counts. Two linear meters were counted within the 2-center rows of each experimental unit. One linear meter was harvested by hand, from each (two linear meter) counts, and collected for biomass and harvest index calculations. Soybean plant stand heights were recorded at physiological maturity or R8 before harvest. Soybean grain yield were harvested with a plot combine, on 29 and 30 September in Prosper and Fargo, respectively. Cover crop biomass were collected after soybean harvest on 28 October at both locations. Biomass samples were collected by hand clipping 0.09-m2 from each cover crop twin row growing between the 2-center soybean rows. All above ground biomass were collected. Biomass samples were dried at 70°C until a constant weight.

*Statistical Analysis*

Statistical analysis were conducted using standard procedure for a RCBD with a split-plot arrangement. Each location per year combination were defined as an environment and were considered a random effect. Different growth stages and cover crops were considered fixed effects. Analysis of variance and mean comparison were conducted using SAS procedures GLM and MIXED; mean separation were performed using LSD at *P* < 0.05.

1. **RESULTS**

Soybean grain moisture, test weight and yield was not affected by interseeding cover crops at any of the cover crops seeding dates or locations (Table 1). This indicates cover crops interseeded into soybean at R4 or R6 did not compete with soybean.

Austrian winter pea establishment and biomass yield was the highest across sowing dates and locations but not significantly different than radish and the cover crop mix. Austrian winter peas average soil cover was 68.9%.

A significant interaction of cover crop by sowing date was observed for cover crop biomass yield (Table 2). Biomass yield of Austrian winter pea, cereal rye, and the cover crop mix was numerically higher, but non-significant when established in R4 growth stage compared with establishment on R6. Oppositely, radish had significantly better establishment and biomass yield when established on R6. Winter camelina establishment was very low on both sowing dates and was not different from the check with no cover crop. Winter camelina and radish sown on R4 emerged well, but the lack of soil water in the surface for three weeks after establishment killed many of the plants. The lack of soil water did not affect winter peas and rye as much probably because these crops root system was deeper at the time of the limited soil water. The earlier growth on winter peas and rye sown in R4 allowed these crops to accumulate slightly more dry matter.

Nitrogen and P accumulation in cover crops biomass is shown in Fig. 1. Nitrogen accumulation was greater in Austrian winter pea and radish and lower in cereal rye. The soil before planting soybean had on average 122 lbs/acre of NO3-N. Most of the N in the cover crops biomass probably came from the soil. Pea is a good N scavenger. Legumes in general use the N available first before N2 fixation.

Soil NO3-N in the fall was significantly greater for check plots without a cover crop. This indicates cover crops scavenged the N between the rows of soybean shown in Fig. 2. This difference was no longer seen in the soil samples taken in the spring.

The photosynthetically active radiation (PAR) was measured from August 9 to September 29, this included growth stages R4 to R8. The PAR intercepted by soybean canopy decreased as plants start shedding leaves and the leaf area index (LAI) decreased (Fig. 3). Incident PAR reaching the soil under the canopy increased as soybean plant matured and thus was available for the cover crop. At soybean R6 stage, pea and rye started to intercept PAR, by harvest pea and rye intercepted 31 and 14% of the incident PAR. Interseeding a cover crop after R4 in soybean is feasible because soon after the cover crop is planted soybean starts to drop the leaves allowing light into the canopy.

Table 1. Soybean grain moisture, test weight and grain yield and cover crops dry matter biomass yield and fall soil cover averaged across two cover crops seeding dates and two locations, Fargo and Prosper, ND

|  |  |  |
| --- | --- | --- |
|  | Soybean | Cover crop |
| Cover crop | Grain moisture | Test weight |  Grain yield | Biomass yield | Soil cover |
|  | % | lbs |  lbs/acre | lbs/acre | % |
| Winter camelina | 12.85 | 55.8 | 3999 |  34 |  3.7 |
| Austrian winter pea | 12.79 | 55.6 | 4171 | 1610 | 68.9 |
| Radish | 12.89 | 55.6 | 3919 | 1190 | 17.8 |
| Cereal rye | 12.92 | 55.7 | 4034 |  884 | 34.1 |
| Mix | 12.90 | 55.7 | 3962 | 1183 | 17.8 |
| No cover crop | 12.88 | 55.7 | 4051 |  0 |  0.0 |
| LSD (0.05) | NS | NS | NS |  788 | 17.5 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |

Table 2. Biomass yield for sowing date by cover crop interaction averaged across locations, Fargo and Prosper, ND.

|  |  |  |
| --- | --- | --- |
| Cover crop | Sowing date at R4 | Sowing date at R6 |
|  | Dry matter yield (lbs/acre) |
| Winter camelina |  0 |  68 |
| Austrian winter pea | 1829 | 1390 |
| Radish |  451 | 1928 |
| Cereal rye | 1088 |  680 |
| Mix | 1286 | 1082 |
|  LSD1 (0.05) |  975 |  |
|  LSD2 (0.05) | 1085 |  |
|  LSD3 (0.05) |  901 |  |

LSD1 to compare means of cover crops within same sowing date

LSD2 to compare means of sowing dates within a same cover crop

LSD3 to compare means between a different sowing date and cover crop

Fig. 1. N and P accumulation by cover crops biomass in fall (biomass harvested on 11 October) from two location Prosper and Fargo, ND. Austrian winter pea and radish accumulated 69 and 70 lb/ac of N respectively, whereas cereal rye accumulated only 39 lb/ac N in above ground biomass. Austrian winter pea and radish accumulation of N was significantly different than cereal rye. P accumulation was not significantly different in any of the treatments.

Fig. 2 Soil NO3-N (0-24 inches depth) in fall and spring.

Fig. 3. Photosynthetically active radiation (PAR) intercepted by soybean canopy, PAR incident at soil level below the canopy, PAR intercepted by pea and rye and soybean leaf area index (LAI)

***Deliverables***

 This project will result in a peer-reviewed publication once season 2017 is finished. Funds for this project were requested for only 1 Year, the second year of the study is being funded by a NIFA –AFRI project.

***Findings***

From this experiment, farmers will be able to better understand how interseed cover crops at later reproductive stages without affecting soybean quality. The data present shows that interseeding cover crops such as Austrian winter pea, radish, cereal rye, and winter camelina do not show a reduction on soybean yield or quality.

Understanding how the cover crops affect soybean, and in this case showed no yield reduction, this opens the door for more research to be done. Researchers can now find which cover crops will perform the best under low light conditions, like that of a soybean canopy. This experiment also demonstrated so far that Austrian winter pea was able to establish under low light conditions and scavenge soil N keeping it from leaching.

***Presentations, publications and meeting lists***

1. **Berti, M.T**., and D. Samarappuli. 2017. Nutrient cycling potential of *Camelina sativa* as a cover crop in the northern Great Plains, USA. European Geosciences Union Conference, Vienna, Austria, 22-27 April, 2017.
2. **Berti, M**.T., O. Teuber, D. Samarappuli, A. Aponte, J. Lukaschewsky, A. Peterson, S. Cabello, S. Podder, B. Andersen, B.L. Johnson, K. Aasand, J. Ransom, M. Geizler, D. Ripplinger, A. Wick, D. Franzen, G. Yan, K. Acharya, M. Ostlie, S. Zwinger, C. Engel, E. Aberle, J. Teboh, J. Nielsen, D. Burr, T. Schroeder, S. Schaubert, E. Eriksmoen, C. Augustin, J. Nowatzki, R. Gesch, H. Dose, and J. Oberlander. 2017. Midwest Cover Crop council Annual Report 2016. Grand Rapids, Michigan, 12-14 March, 2017.
3. **Berti, M.T.** 2017**.** Interseeding cover crops into standing corn and soybean: what, when, and how. Production Agriculture Symposium Univ. of Minnesota. Minneapolis, MN. 22 February 2017 Keynote speaker
4. **Berti, M.T.,** 2017. What, when, and how to plant cover crops in the northern Great Plains. Annual Symposium Seed sales representatives. Agassiz Seed, Mapleton, ND. 9 February 2017 Invited speaker.
5. **Berti, M.T.** 2017. Cover crops use in the Upper Midwest: What, when, and how. National Crop Insurance Services Annual Meeting. Fargo, ND, 5 January 2017. Invited speaker.

***Field days experiments/results were shown at these two field days)***

1. Cover crop field day at CSSP farm 7 October 2016, Forman, ND, (30 participants)
2. Cover crop field day NDSU-NC SARE and CAP project 4 October, 2016 Fargo, ND, (72 participants)

***Key benefits to farmers and other researchers***

Planting a cover crop after soybean is harvested is generally too late for any cover crop to grow in the fall and provide soil cover in the fall or early spring. Also, the only crop that survives the winter to provide cover in the spring is cereal rye, but if the crop after soybean is corn, cereal rye can cause toxicity to corn if not terminated early.

The results of this experiment demonstrated that interseeding cover crops into soybean after R4 is feasible and does not reduce soybean yield and quality. This is very important when it comes to the economic value of investing in cover crops. With this knowledge famers will be able to adapt this practice and apply it to their own farming systems. Soybean does not leaves much residue on top of the soil to protect it from erosion. Reducing soil erosion will improve farm profitability and long-term sustainability.