INCORPORATING COVER CROPS INTO NO-TILL PRODUCTION SYSTEMS

S.L. Osborne[1], T.E. Schumacher[2] and D.S. Humburg[2]
[1]USDA-ARS North Central Agricultural Research Lab
2923 Medary Ave, Brookings, SD 57006
Tel: (605)693-5234, e-mail: shannon.osborne@ars.usda.gov
[2]Dept of Plant Science and Agricultural and Biosystems Engineering
SDSU, Brookings, SD 57007

Abstract

Although no-till soil management has many benefits, including protecting the soil from erosion, improving soil organic matter, and improving soil moisture storage, depending on environmental conditions there could be a number of potential problems. Implementation of no-till soil management in eastern South Dakota can lead to wet and cold soils at the time of planting. Cover crops have the potential to utilize excess soil moisture and improve soil conditions at planting. A field experiment was established to evaluate the impact of different cover crop species as well as no cover crop and conventional tillage on soil conditions prior to corn planting and the impact on corn yield, and quality. The experimental design was a randomized complete block design with four replications. Cover crops evaluated include a mixture of grass, legumes, cool and warm season crops. All cover crops were planted in early August (following spring wheat harvest) at recommended seeding rates. The following spring all plots were planted to corn (*Zea mays* L.). The experiment was conducted in a three year crop rotation (soybean [*Glycine max* (L.) Merrill] /spring wheat (*Triticum aestivum* L.)-cover crop/corn). Corn grown following hairy vetch was the only treatment that exhibited a significant reduction in plant population. Corn yield for plots grown under clover, winter ryegrass and no cover crop had yield significantly higher than corn grown after conventional tillage, hairy vetch and slender wheatgrass. This experiment illustrated the ability of cover crops to utilize excess soil moisture and increase soil strength compared to conventional tillage or no cover crop.

Introduction

A sustainable agricultural system is one that, over the long term: enhances environmental quality and the resource base on which agriculture depends; provides for basic human food and fiber needs; is economically viable; and enhances the quality of life for farmers and society as a whole (White et al., 1994). Increased diversity of crops grown in rotation and no-till farming practices are important components of sustainable agriculture systems. Improved yield under rotation is related to both soil and crop parameters. Crop rotations that included legumes increased soil nitrogen levels (Peterson and Varvel, 1989; Raimbault and Vyn, 1991). Crop rotation also improved soil structural stability (Raimbault and Vyn, 1991), increased crop water use efficiency (Varvel, 1994), improved crop mineral nutrient uptake (Riedell et al., 1998), and increased soil organic matter levels (Campbell and Zentner, 1993).

Many of the advantages of no-till crop production are derived from the residue mulch that remains on the soil surface after grain harvest. The residue mulch protects the soil from wind and water erosion but also delays soil warming in the spring (Swan et al., 1996). Cooler soil temperatures translate into slower seed germination, reduced uptake of non-mobile soil nutrients, and less vigorous early crop growth (Barber, 1984; Griffith and Wollenhaupt, 1994). Under no-till conditions, Drury et al. 1999 found that fall-seeded cover crops (red clover) planted after wheat harvest allowed the following corn crop to have emergence and yield equal to that of a corn crop following wheat under tilled conditions. Meisinger et al., 1991 outlined the importance of cover crops in improving environmental quality. Cover crops scavenge nitrogen from the soil profile and prevent it from moving below the root zone during periods of time when the soil water is being recharged. Under tilled conditions, cover crops also help protect the soil from water and wind erosion. Hatfield and Keeney, 1994 outlined some of the knowledge gaps in cover crop use that need to be addressed through research including; cover crop systems for climates with short growing seasons and/or low water availability, and the benefits of fixed nitrogen from legume cover crops. As different cover crop species have differing characteristics, the hypothesis is that certain cover crop species will be more suited for inclusion in complex crop rotations under no-till soil management in the northern Great Plains than other species

Materials and Methods

A field experiment was conducted in which different species of grasses and legumes (planted into spring wheat stubble) were evaluated as cover crops in a three year rotation (soybean/spring wheat-cover crop/corn) under no-tillage soil management. The experiment is located near Brookings, South Dakota on a silty clay loam at the USDA, ARS, North Central Agricultural Research Laboratory on two separate experimental sites. Cover crop, a fallow (no cover crop) and conventional tillage treatments were replicated four times within the experimental area. Cover crops evaluated include: Crimson clover (*Trifolium incarnatum* L.), alsike clover (*Trifolium hybridum* L.), red cover (*Trifolium pratense* L.), sweet clover (*Melitous alba* Desr.), annual and winter rye (*Secale cereale* L.), hairy vetch (*Vicia villosa* Roth.), Carneval field pea (*Pisum sativum* L.), Austrian winter pea, slender wheat grass (*Agropyron* sp.), non-dormant alfalfa (*Medicago sativa* L.), sudangrass (*Sorghum bicolor* L.), buckwheat (*Fagopyrum esculentum* Moench.) and barley (*Hordeum vulgare* L.). All cover crops were planted in early August (following spring wheat harvest) at recommended seeding rates. The following spring all plots were planted to corn.

During the course of the experiment, data collection included growing environment (soil temperature, soil moisture, rainfall, air temperature etc. using standard techniques), soil physical properties (using methods to infer soil bearing strength such as a regular cone penetrometer, bulk density, water content after planting, and vane shear strength), total cover crop growth (biomass measurement), cash crop emergence and growth and corn grain yield (combine harvest with determination of yield, yield components and seed moisture).

Results and Discussion

There are numerous species of grasses and legumes that can be utilized as cover crop. The species that best fit each individual situation is dependant on a number of factors. This research project evaluated 14 different species, as well as a no cover crop (fallow), and conventional tillage treatments.

Stand counts were performed to evaluate the effect of soil temperature on stand establishment. Initial stand counts performed eight days after planting revealed that emergence for the hairy vetch and no cover crop was significantly lower compared to the other treatments, while the conventional tillage and slender wheatgrass had the highest initial emergence (Figure 1). Count performed on later dates (11 to 13 days after planting) found that stand establishment evened out for all treatments except for the hairy vetch which remained significantly lower.

Another concern with no-till production in an area with limited growing degree days is the ability to plant crops in a timely manner to utilize as much of the growing season as possible. No-till production in this area can delay crop planting due to moist soil conditions in the spring. Cover crops that survive the winter have the ability to utilize excess moisture and increase soil strength to ensure an earlier planting date.

Soil strength is defined as a measure of the soils capacity to withstand stresses without giving way to those stresses by collapsing or becoming deformed. Soil bearing strength and the depth of soil failure were measured to evaluate the effect of cover crop on soil trafficability. Measurements collected prior to corn planting found that plots with a hairy vetch cover had a significantly higher bearing strength compared to all other treatments, with conventional tillage and no cover crop treatments having the lowest bearing strength (Figure 2). Improved trafficability may be related to the above ground biomass growth characteristics and the root system. While the hairy vetch did not have the highest spring or fall biomass production, the manner in which the hairy vetch grows should assist in increasing the soil strength (Figure 3). Winter rye had a significantly higher biomass production in the fall and spring compared to the hairy vetch, but the structure of the winter rye is dramatically different. The hairy vetch grows in a manner that it is inter-twined making a thick mat that covers the ground, while the winter rye exhibits a vertical growth. While the bearing strength was not significantly different for the conventional tillage compared the no cover crops and the other cover crop treatments the depth of soil failure was significantly deeper, indicating that once force is applied to the soil such as tractor wheels that exceed the bearing strength the soil will fail or sink to a depth of eight inches compared to the hairy vetch that would only sink to a depth of five inches after considerably more pressure is applied (Figure 2). In general terms this indicates that plots with a hairy vetch cover crop would be able to handle heavier wheel traffic without causing significant compaction.

Corn grain yield was significantly affected by cover crop treatment for the 2001 growing season. Grain yield was greatest under no cover crop, red clover and winter rye compared to conventional tillage and slender wheatgrass. The lowest corn yield was under the hairy vetch. For the 2002 growing grain yield was not different for the no cover crop, hairy vetch, slender wheatgrass and red clover which had a higher yield compared to the conventional tillage and winter rye. This experiment illustrated the ability of cover crops to utilize excess soil moisture and increase soil strength compared to conventional tillage or no cover crop, without adversely affecting yield.

References

Barber, S.A. 1984. Soil Nutrient Bioavailability: A Mechanistic Approach. John Wiley and Sons, Inc., New York, NY.

Campbell, C.A., and R.P. Zentner. 1993. Soil organic matter as influenced by crop rotations and fertilization. Soil Science Society of America Journal 57:1034-1040.

Drury, C.F., C.-S. Tan, T.W. Welacky, T.O. Oloya, A.S. Hamill, and S.E. Weaver. 1999. Red clover and tillage influence on soil temperature, water content, and corn emergence. Agronomy Journal 91:101-108.

Griffith, D.R., and N.C. Wollenhaupt. 1994. Crop residue management strategies for the midwest. p. 15-37. *In*: J.L. Hatfield and B.A. Stewart (eds.) Crop Residue Management. Lewis Publishers, Boca Raton, FL.

Hatfield, J.L., and D.R. Keeney. 1994. Challenges for the 21st century. p. 287-307. *In*: J.L. Hatfield and B.A. Stewart (eds.) Crop Residue Management. Lewis Publishers, Boca Raton, FL.

Meisinger, J.J., W.L. Hargrove, R.L. Mikkelsen, J.R. Williams, and V.W. Benson. 1991. Effects of cover crops on groundwater quality. p. 57-68. *In*: W.L. Hargrove (ed.) Cover Crops for Clean Water. Soil and Water Conservation Society, Ankeny, IA.

Peterson, T.A., and G.E. Varvel. 1989. Crop yield as affected by rotation and nitrogen rate. I. Soybean. Agronomy Journal 81:727-731.

Raimbault, B.A., and T.J. Vyn. 1991. Crop rotation and tillage effects on corn growth and soil structural stability. Agronomy Journal 83:979-985.

Riedell, W.E., T.E. Schumacher, S.A. Clay, M.M. Ellsbury, M. Pravecek, and P.D. Evenson. 1998. Corn and soil fertility responses to crop rotation with low, medium, or high inputs. Crop Science 38:427-433.

Swan, J.B., T.C. Kaspar, and D.C. Erbach. 1996. Seed-row residue management for corn establishment in the northern US corn belt. Soil Tillage Research 40:55-72.

Varvel, G.E. 1994. Monoculture and rotation system effects on precipitation use efficiency of corn. Agronomy Journal 86:204-208.

White, D.C., J.B. Braden, and R.H. Hornbaker. 1994. Economics of sustainable agriculture. p. 229-260. *In*: J.L. Hatfield and D.L. Karlen (eds) Sustainable Agricultural Systems, CRC Press, Boca Raton, FL.

Figure 1: Stand establishment counts, number of plants emerged in three meter of row, by treatment.

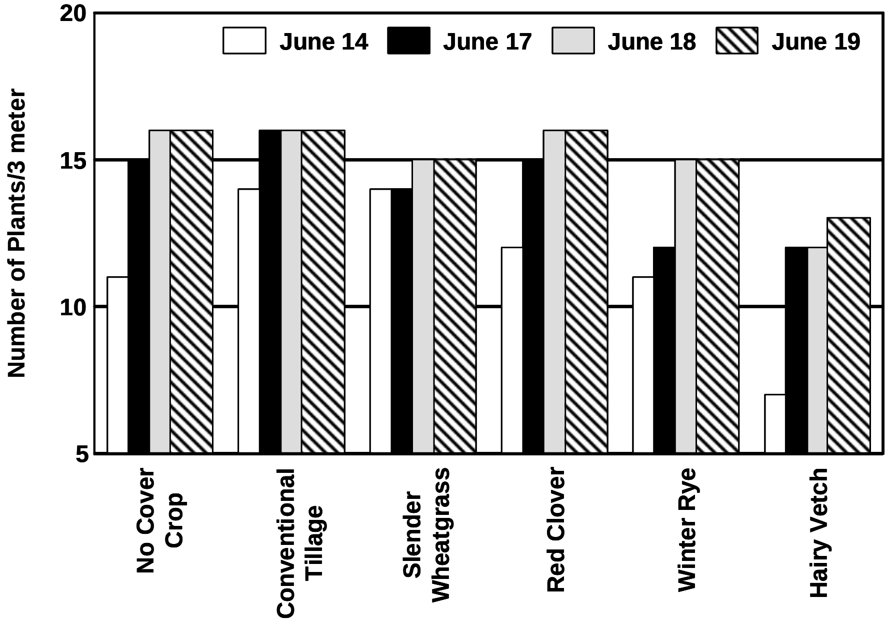


Figure 2: Soil bearing strength pressure and the depth of soil failure, by treatment.

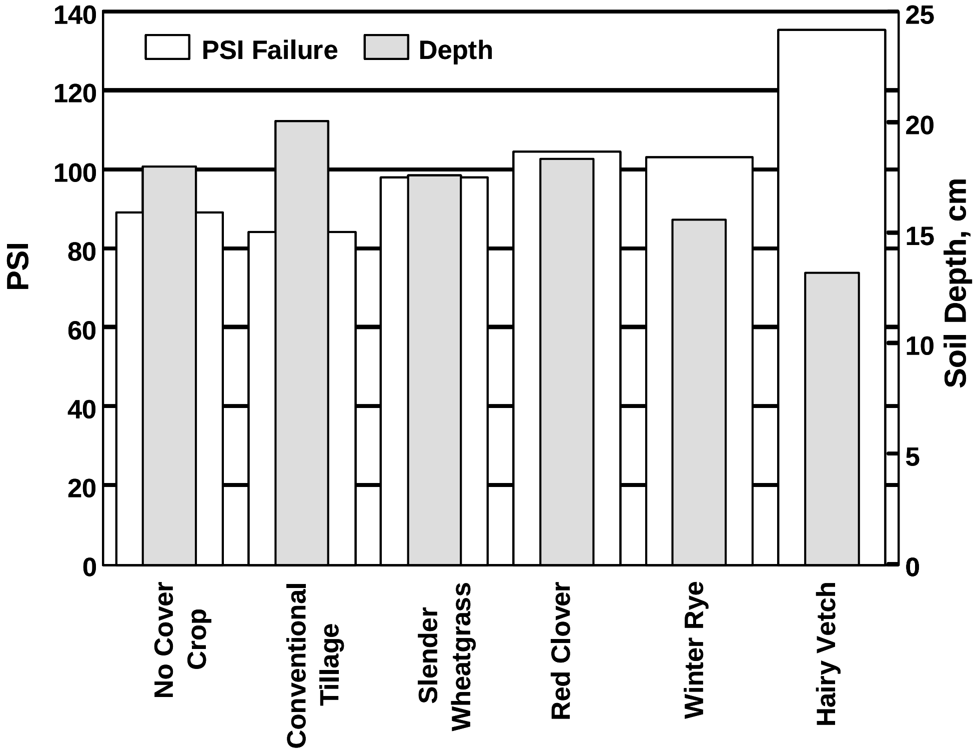


Figure 3: Individual cover crop biomass production; fall biomass growth from planting until killing frost; spring biomass growth from early spring until herbicide burndown approximately two weeks before planting.

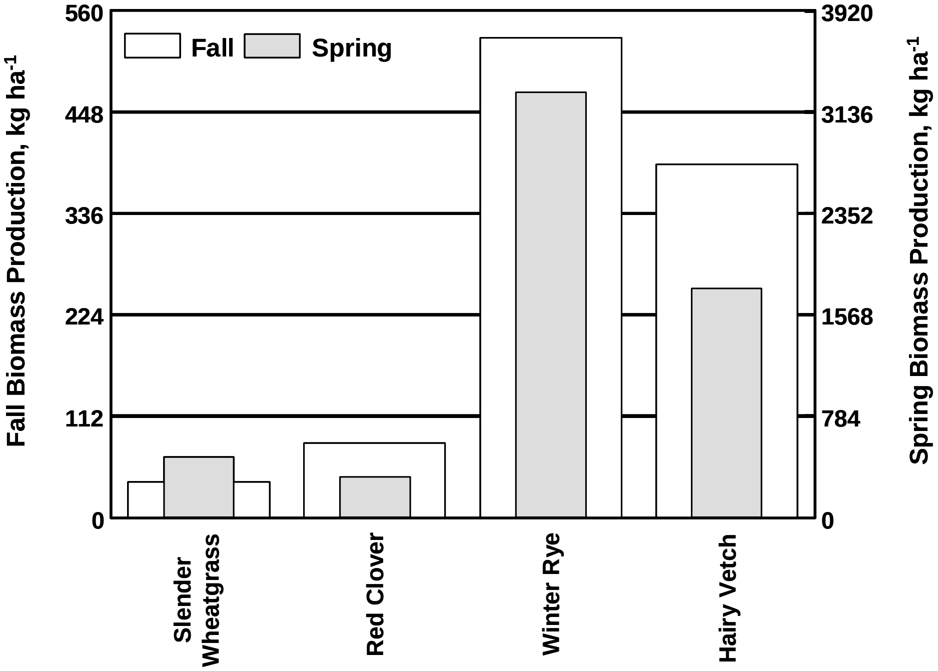
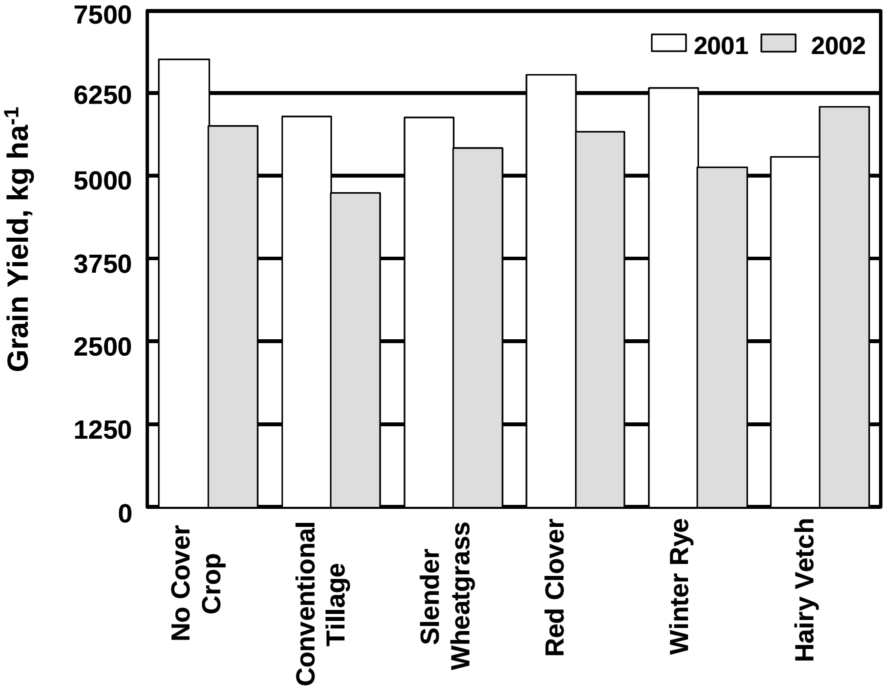


Figure 4: Corn yield following cover crop growth for each treatment for the 2001 and 2002 growing seasons.



PROCEEDINGS OF THE

THIRTY-EIGHTH NORTH CENTRAL EXTENSION-INDUSTRY SOIL FERTILITY CONFERENCE

Volume 24

November 12-13, 2008
Holiday Inn Airport
Des Moines, IA

Program Chair:
Darryl Warncke
Michigan State University
East Lansing, MI 48824-1325
(517) 355-0270
warncke@msu.edu

Published by:
International Plant Nutrition Institute
2301 Research Park Way, Suite 126
Brookings, SD 57006
(605) 692-6280
Web page: www.IPNI.net

Cover photo provided by Peggy Greb, USDA-ARS.