TECHNICAL NOTE

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Cover Crop Technology in South Dakota (SD)

Conservation Agronomist and Soil Quality Specialist

Introduction

In the spring of 2000, the United States Department of Agriculture (USDA) Agricultural Research Station (ARS), the Natural Resources Conservation Service (NRCS), and SD State University (SDSU) met to form a working group with the objective to discuss, study, and review the use of cover crops in rotations in SD. Since that time, research has been conducted, in SD, and the adoption of cover crop technology has begun to accelerate in the last several years. The major benefits of cover crops originally identified fit within a number of resource concerns. These original resource concerns where cover crops could benefit were issues such as soil erosion, compaction, moisture management, soil salinity, rotational diversity, cycling nutrients and residue, as well as, fixing nitrogen (N). In addition to these initial concerns, the additional benefits of cover crops that have since been identified, in SD, are improved soil structure, increased soil organic matter, increase trafficability, weed control or suppression, increasing or maintaining soil biological activity (fallow syndrome), high quality fall grazing, and additional wildlife habitat benefits.

The objective of this technical note is to highlight areas of knowledge and understanding that have been gained in the period since the spring of 2000.

Biomass Production

Cover crops planted after small grain harvest provide an ideal opportunity for producers to grow additional forage, extend the grazing season, and even grow or cycle residual N in the rotation. To account for these additions of biomass or nutrient in the rotation, it is necessary to accurately account for the additional biomass within the rotation provided by the cover crop. The SDSU data collected in 2007 indicated that various cover crop mixes were producing an average of 1.7 tons of dry above ground biomass whereas USDA ARS data at Brookings during the same time period indicated that biomass production was half of this value. In 2008 and 2009, the NRCS collected a random sample of cover crop fields after wheat harvest. The 2008 survey found a high degree of variability in the cover crop dry matter production throughout east central SD averaged 1.2 tons as the values ranged between ¾ and 3.5 tons per acre dry matter produced. The dry matter variability of the survey information in 2008 (Figure 1) was reviewed by the NRCS and the ARS with no identified individual cause for the observed variability. Soils, precipitation preceding or after planting, initial soil moisture, soil fertility, residual N, and cover crop species diversity were all identified as potential sources of variability. However, the review of the 2009 biomass data (Figure 2) indicated that less than half of the variability in biomass production can be explained by the delay planting.

Figure 1

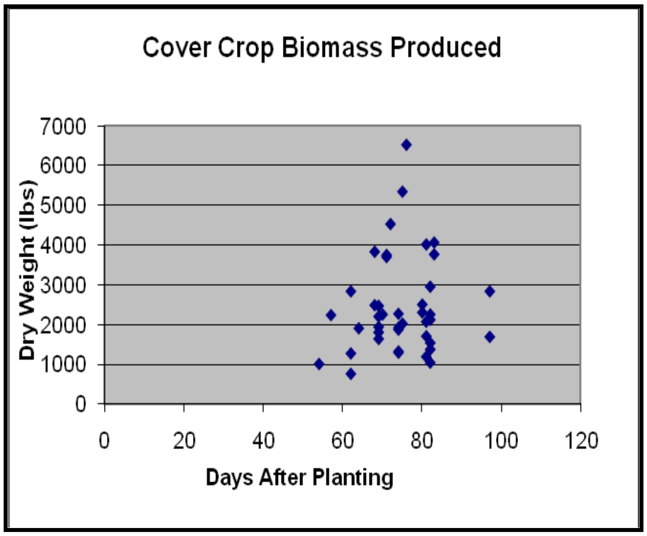


Figure 2

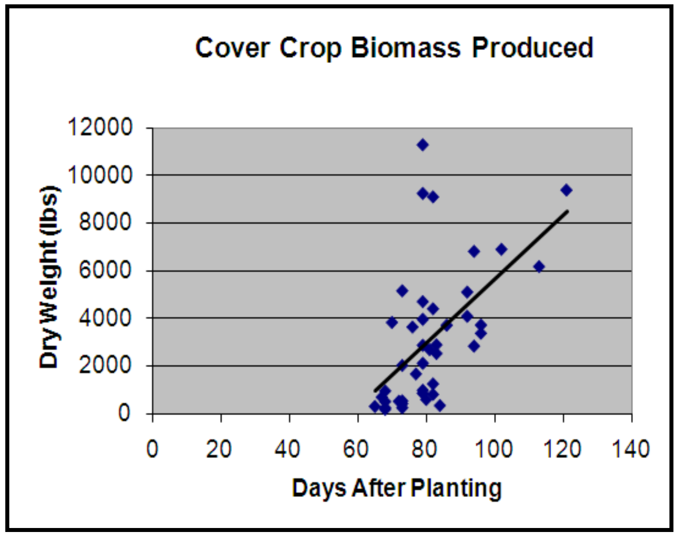


Figure 1. In the fall of 2008, the NRCS randomly sampled fields resulting in the above ground biomass values ranging from ¾ to 3½ tons/acre dry matter.
Figure 2. Fall of 2009 survey data indicates less than that half of the variability in biomass production can be explained by planting date.

Mixtures versus Monocultures

Field observations and current ARS research have shown that mixtures typically out produce monocultures. Dry matter production of a cover crop mixture has been twice that of a single species cover crop. This phenomenon is not well understood and there could be a number of reasons for this result such as plant competition, nutrient availability, increased soil biology, or a symbiotic relationship. Research will continue to determine the reasons for this increase in production; however, until further findings come out, the normal guidance to producers should be to plant mixtures of species and not any one single species.

Grazing Potential

Cover crop mixtures planted after small grain harvest can provide high quality forage late into the fall and provide a rest period for other cool-season pasture or rangeland. The brassicas (such as turnip, radish, and canola) will typically stay green into November and have been sampled with a range in crude protein of 14-19 percent. In addition to late season quality forage, the brassicas are also known for their early canopy and residue cycling characteristics. Other cover crop mixtures can not only provide quality forage but also provide a substantial amount of dry matter production. Typically, mixtures that contain warm-season grasses such as sorghum, sudan grass, or millet produce some of the highest dry matter results. Figure 3 provides an example of the increases in biomass as warm-season grasses are added into the cover crop mix.

Field observations indicate that the amount of forage produced by nonlegume species (specifically the brassicas: canola, radishes, and turnips) is directly tied to the amount of residual N in the field. Producers that plan to plant cover crops for grazing should consider soil testing and monitoring the amount of residual N in the profile after small grain production. When residual N is not available in the profile, producers may wish to either increase the mix of legumes (such as field peas, lentils, clover, or vetch) and grasses in these fields or apply additional N fertilizer to maximize production. If, however, there is residual N in the profile, producers could maximize production by using the residual N with a mix of nonlegume (brassicas, turnip, radish, canola, and rape) and grass species (such sorghum, millet, oats, wheat, rye, and triticale).

Additional Grazing Concerns - Bloating

Bloating has been a consistent producer concern when turning cattle out into any lush cover crop field. Producers need to keep in mind that some ways to reduce the risk of bloat are: 1) not to introduce hungry animals in to a field; 2) introduce animals slowly either through put and take or by restricted access over a 7-to-10-day period; 3) provide dry matter (hay, millet hulls, dry pasture, or crop stalks) to the cattle when they are grazing in the cover crop field; 4) the cover crop species should be 25 percent grasses and not be more than 70 to 80 percent brassicas; 5) strip graze whenever possible to get the best utilization of the cover crop plants; and 6) use bloat blocks where ever practical.

Figure 3

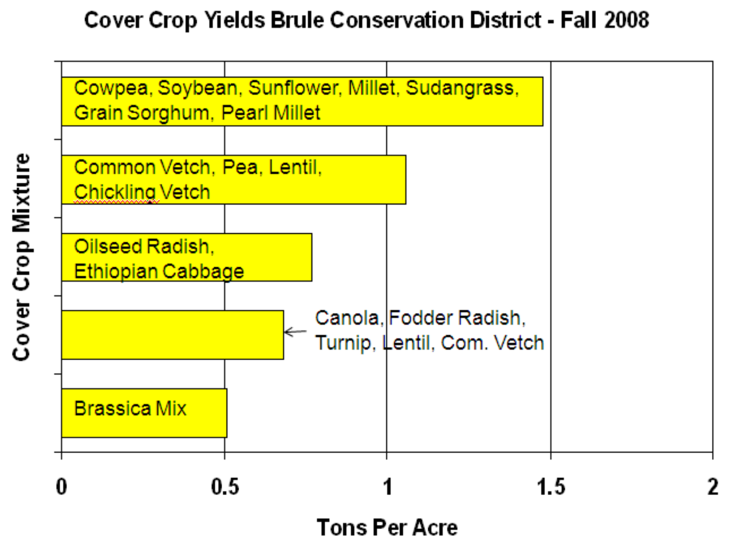
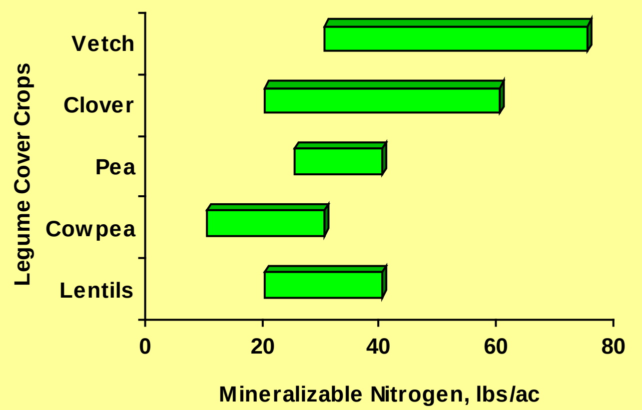


Figure 3. Cover crop production values from the Brule County Conservation District as sampled in 2008.

Nutrient Management – Residual N, Sulfur (S), and Fixed N

A major monetary incentive for planting a cover crop by many producers may be N management. Species selection for recovering residual N may include species that have a fibrous root system to recover N in the upper-most regions of the soil profile, as well as, species with deep tap root systems to recover N below two to three feet. Warm-season grasses such as sorghum or millet; or cool-season grasses such as rye, wheat, barley, or oats, may very effectively tie up shallow nitrate in the soil profile. Other species that recover N deeper in the profile may include sunflower or cool-season broadleaves such as rape, canola, or sugar beet. Field observations have shown that rape or canola appear to remain greener into the fall when other brassicas are clearly showing N deficiency symptoms. This phenomenon may be due to a deeper recovery of N by canola in the soil profile or possibly other plant characteristics. A more extensive recovery of residual N in the profile may also explain the increases in productivity of crops grown after canola as compared to other cover crops including the legumes, as well as, the observed increased rate of residue break down of crop residue on the soil surface after canola or other brassicas. Sulfur deficiency symptoms have been documented after some cover crops in the subsequent corn crop. This fertility concern has not been a problem in the cover crop; however, this short-term tie up of S has led to the S deficiency symptoms in subsequent corn crops. It appears in most cases that these fields test low or very low in S prior to the planting of the cover crop and the small additional tie up of S manifests S deficiency symptoms in corn. Producers in highly productive cropping systems need to select the row crop soil test that includes testing for S and zinc, as well as, N, P, and K. Producer fields that test low or very low in S will need to incorporate this nutrient in their fertilizer programs.

The amount of N fixed by cover crops planted for a short portion of the growing season has been a very relevant question for some time. The most recent results by ARS and SDSU, in SD, suggest that legume cover crops planted after wheat may uptake or fix 0 to 75 pounds of N per acre. Annual legumes such as lentils or field peas would be on the lower end of this range while perennial or biennial species such as the clovers and vetches would be on the higher end. The amount of N fixed will not only depend upon the species grown but the climatic growing conditions. A range of mineralizable N (N recovery by corn) among some legume species is found in Figure 4. A number of studies have been done to estimate the N credit or N fertilizer replacement value of the legume cover crop for the following crop (Table 1). The best method to determine N credit is to measure the biomass produced, analyze the N content of the biomass, and estimate the amount of N that would be recycled to the next crop. Current estimates of the legume cover crop N that is recycled is approximately 50 percent. An example would be as follows: A field with dry matter production of 2,000 pounds (1 ton) and a crude protein value of 19 percent would calculate out to a 30 lb. N credit. (19 percent crude protein divided by 6.25 equals 3.04 percent N) (2,000 lbs. x 3 percent N x 50 percent recycled to the crop). In lieu of measured crude protein value, a conservative estimate of 3.0 percent N could be used in producer calculations.



Range of Mineralizable Nitrogen from Legume Cover Crops
Figure 4

Table 1. Legume[1] cover crop nitrogen credits for the following crop.

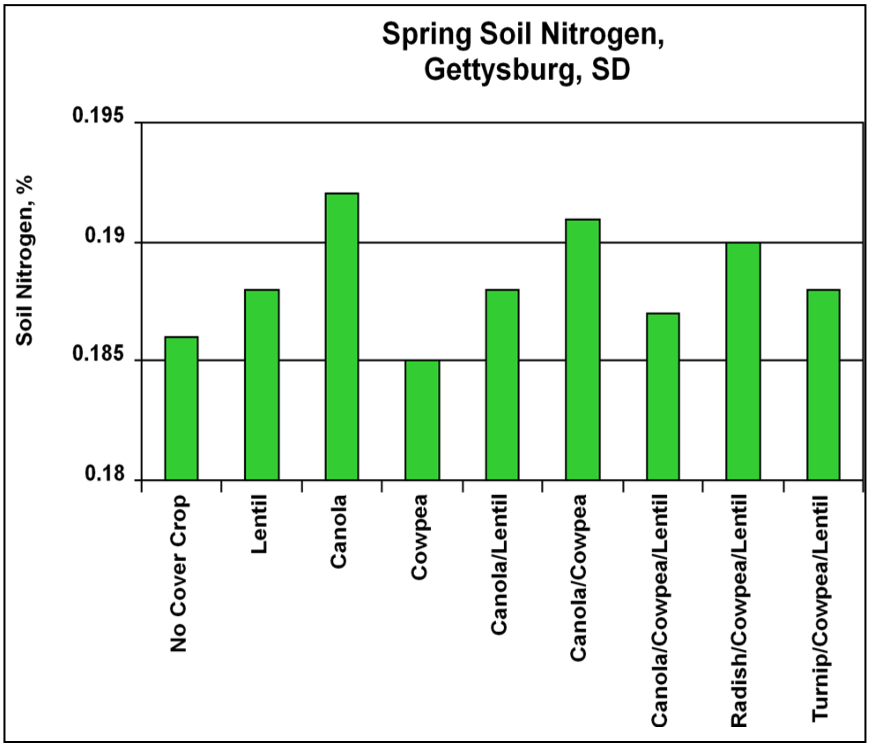
Cover Crop	Province or State	Credit[2] (lb/a)
Chickling Vetch	Manitoba	28 – 53
Chickling Vetch	Saskatchewan	40 – 60
Red Clover	Ontario	0 – 14
Red Clover	Michigan	40 -50
Red Clover	Ohio	0
Red Clover	Wisconsin	26 – 182
Hairy Vetch	Saskatchewan	30 - 60
Hairy Vetch	Ontario	100
Hairy Vetch	Wisconsin	66 - 200
Lentils	Ontario	15 - 35
Peas	Ontario	15 - 35
Lentils	Wisconsin	36 -200

[1] 100% Legume stands.
[2] Either measured or estimated as N fertilizer replacement value.

Legumes incorporated into cover crop mix must be inoculated with the rhizobium specific to that species to assure nodulation and maximize N fixation. The following rhizobium species are indicated for the appropriate cover crops common to SD. They are: pea, lentil, vetches - Rhizobium leguminosarum; soybean - Bradyrhizobium japonicum; alfalfa, sweet clover - Rhizobium meliloti; and the clovers - Rhizobium trifolii.

Soil testing and monitoring the amount of residual N within the soil profile should be accomplished to verify the amount of N fixed. This testing should include deep nitrate testing not only before and after the cover crop in the rotation, but should also include testing after the next subsequent crop to ascertain whether or not there is additional residual N in the profile. Utilizing subsequent crop residual N information should help fine tune the legume credit assigned within the nutrient budget. Total soil N levels under cover crop studies, in SD, appear to be increasing three to five percent as compared to noncover crop areas of the field (Figure 5).

Figure 5



Cover Crop Establishment

Drilling cover crops is the preferred method of cover crop establishment. Broadcasting seed into standing wheat stubble has been successful depending on weather conditions; however, broadcast application seeding rates should be increased at a minimum by twice the listed pure live seed seeding rate for drilled applications. Cover crop species or mixes that consist of large seeded species (with the exception of cereal rye) should be drilled and not broadcast. Broadcasting applications should not be made prior to crop harvest and not made after harvest of a low residue crop.

The selected plant species should have a minimal potential to act as a host in pest cycles for adjacent crops, as well as, for the next crop in the rotation. Therefore, the cover crop species or majority of the cover crop species in the mixture should be the opposite crop type of the following year's cash crop. For example, a broadleaf cover crop is planted prior to a corn crop (warm-season grass). Also, Roundup ready spring canola could head out and produce seed resulting in a weed problem in the spring.

Table 2 contains a list of resource concerns and suggested primary species for cover crop mixes in SD.

Table 2

Resource Concern	Primary Species
Grazing	turnips, lentils, rape, radish, rye, oat, triticale, sorghum-sudan, millet
Compaction	radish, canola, sugarbeet, sunflower, sorghum-sudan, turnip, and turnip hybrids
Moisture	rape, clovers, winter wheat, rye ,triticale
N-fixation	clovers, vetches, lentils, cowpeas, soybean, field pea
Residue Cycling	rape, canola, turnip, radish, mustards
Nutrient Cycling	sunflower, rape, canola, turnip, radish, sugarbeet, small grains
Salinity	rye, barley, winter canola, rape, sugarbeet

Herbicides used on crops prior to cover crops establishment need to be compatible with the cover crop species to be planted. Carefully evaluate labels of those herbicides that will be used in the cash crop prior to seeding the cover crop for potential herbicide carryover. Most brassicas, legumes, and/or broadleaf cover crops are sensitive to herbicides used for broadleaf weed control. In SD, a number of the sulfonureas used in wheat production prior to cover crop establishment have been the primary concern for herbicide carryover.

Soil Moisture Management Concerns

The major crop production concern in eastern SD may be moisture management. Planting corn in a timely manner into last year's wheat stubble, due to excessively wet soil conditions, has been a major issue in eastern SD. Cover crop mixes that canopy early in the fall to improve residue decay along with species that will utilize fall moisture, as well as, use spring moisture, are the answer to this rotational concern. Species that fit this criteria for fall canopy are cool-season broadleaves like the brassicas, (i.e., winter canola, Dwarf Essex (DE) Rape, turnips, radishes, and sugar beets.) Species that use early spring moisture will over winter and increase trafficability through a living root system. These species are the winter small grains (winter wheat, winter rye, triticale) and the clovers/vetch (sweet clover, red clover, hairy vetch). Species with early spring growth characteristics will utilize spring moisture and have been shown in ARS studies to increase trafficability by 40-60 percent. Some of the driest spring planting conditions in the Brookings ARS studies have been the hairy vetch, clover, and rye treatments. In areas where the lack of moisture is a concern, the canopy from cover crops will shade the bare soil surface to reduce evaporation and help maintain soil biology.

Salinity Concerns

In SD, soil salinity can be a resource concern for a few acres or a major concern across an entire field. Species selection for salt tolerance in a cover crop mix might include species of small grains such as rye, barley, and wheat. The threshold electrical conductivity (EC) values in mmhos/cm are listed in Table 3. The threshold value represents the maximum salinity level at which a yield reduction should not occur. The slope percent represents the percent yield reduction for each whole unit of salinity measured in EC (millimole (mmhos)/centimeter (cm)). For example, barley yields decline approximately five percent per unity salinity increase above eight mmhos/cm. Therefore, a soil salinity level of 10 mmhos/cm would result in a 10 percent yield reduction as compared to a soil at 8 mmhos/cm. Also, broadleaf plants with good salt tolerance would be species such as canola, DE rape, or sugar beets. In SD, salt affected fields or portions of fields with ECs greater than five or six are those fields where more intensive long-term solutions need to be employed. Some of these areas may be devoid of typical salt tolerance vegetation such as foxtail barley and kochia. In such areas, long-term salt tolerant perennial cover should be planted including species such as western or tall wheatgrass.

Table 3. Salt Tolerance of Selected Crops			
Crop	**Threshold EC, mmhos/ cm**	**Slope Percent**	**Salt Tolerance Rating**
Rye	11.4	10.8	T
Barley	8	5	T
Wheat	8.6	3	T
Canola (Rape)	10	11.2	T
Sugarbeet	7	5.9	T
Western Wheatgrass	6	5.6	MT
Tall Wheatgrass	7.5	4.2	T

References

South Dakota State University, Personal Correspondence, Dr. Ronald Gelderman and Dr. Peter Sexton.

USDA-ARS. Personal Correspondence, Dr. Shannon Osborne and Dr Walter Reidell.