Cover Crop Demonstration on a Prevented-Plant Field

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Situation

Above normal snowfall in the winter of 2010-2011 followed by well above normal precipitation, April 169%; May 197%; and June 179%, kept many producers from planting their entire acreage to annual crops during the critical spring seeding season in southwest North Dakota. Several producers chem-fallowed prevented-plant acres but some producers took the opportunity to sow cover crops on these acres. The use of cover crops in southwest North Dakota is relatively new with producers asking questions such as 1) Will cover crops use more water than can be replaced with seasonal precipitation? 2) Do cover crops require more nutrients than are available in the soil? 3) What is the cost of establishing cover crops? 4) Will cover crops improve the bottom line?

Response

Cover crop demonstrations were established in Bowman, Golden Valley and Slope Counties during the growing season in 2011 to acquaint producers with cover crop concepts and to develop local information about cover crop use.

Events and materials were planned and delivered during the "Triple C's" (Cover Crop, Coffee, and Caramel Rolls) meetings held at the Paul White farm near Bowman and the Ernie Holzemer farm near Amidon in August and during summer tours held in Golden Valley County. Producers attending these events learned about soil quality from Jon Stika, NRCS soil scientist, and cover crop seeding information from Extension agents and specialists. Samples of some of the materials developed for these programs are shown on the following pages. Performance of cash crop grown in 2012 in the fields where cover crop was grown in 2011 will be tracked.

Cooperating Organizations

Bowman County: Bowman County Extension Service, Bowman-Slope Conservation District, Natural Resource Conservation Service, and several Bowman County producers.

Golden Valley County: Cooperating organizations included Golden Valley Extension Service, Golden Valley County Conservation District, Natural Resource Conservation Service.

Slope County: Cooperating organizations included Slope County Extension Service, Bowman-Slope Conservation District, Natural Resource Conservation Service, Dickinson Research Extension Center, North Dakota Sustainable Agriculture Research and Education and several Slope County producers.

Bowman/Slope County Cover Crop Demonstration

NDSU Extension Service
North Dakota State University

Cover crops have many uses. Though Bowman/Slope Counties are normally dry this time of the year, growing conditions have been excessively wet early in the season resulting in many producers declaring a prevented planting situation. Some growers are planning to seed winter wheat this fall while others are planning to seed next spring. Evaporation of water will occur from the surface and water in saturated soils will eventually drain away allowing the producer to seed but if nothing is growing in the field over the year the soil will enter next spring at a higher moisture level than normal. Even with just normal precipitation seeding delays due to excessively wet field conditions may be expected this fall and next year. Growing a cover crop will utilize some of the excess water this year. An actively growing well canopied cover crop may use up to 0.33 inches of water per day. In addition to water use a cover crop will add organic matter to the soil, improve biological activity in the soil, improve nutrient cycling and protect the soil from wind and water erosion.

The Cover Crop Demonstration on the Ernie Holzemer Farm was initiated in cooperation with the Bowman-Slope Soil Conservation District, Natural Resource Conservation Service (NRCS), Slope County Extension Service, Sustainable Agriculture Research and Education (SARE), Dickinson Research Extension Center and Hettinger Research Extension Center. Producer's Choice and PGG Seeds provided improved cultivars of radish, forage brassicas, teff, and annual alfalfa. The remaining seed was purchased from Bowman Grain Inc, Bowman, ND. Follow the progress of this demonstration on line on the SW ND Extension Agronomy Notes (ag.ndsu.edu/swagronomynotes).

Why demonstrate various cover crop species? Plants have different characteristics that affect soils and soil health. These characteristics can be used as a "tool" to accomplish a desired result. However like other tools cover crops do have their limitations that need to be recognized and managed. Some species can provide a green bridge for various diseases and insects if the grower doesn't manage the cover crop correctly. An example is cover crop species such as wheat, barley, triticale, and rye are hosts for WSMV and wheat curl mites which transmit the disease. Cover crops containing these species should be terminated at least two weeks prior to seeding a cash crop of wheat, barley, triticale, and rye.

Brassicas- Prevent erosion, suppress weeds and soil-borne pests, alleviate soil compaction and scavenge nutrients. Brassicas in this demonstration includes radish, turnip, winter forage rape, Ethiopian cabbage.

Legumes- Fix atmospheric nitrogen for use by subsequent crops, reduce erosion, add organic matter to the soil, attract beneficial insects. Legumes in this demonstration include field pea, cowpea, soybean, black lentil and alfalfa.

Warm Season Broadleaves–Sunflower for example deep roots scavenge deep nutrients, alleviate soil compaction. Cowpea, black lentil, and soybean are also warm season broadleaves but aren't as deep rooted as sunflower.

Warm Season Grasses- Relieve soil compaction, provide cover, use water, add organic matter, suppress soil-borne pests. Warm season grasses used in this demonstration includes millet, teff, and sorghum-Sudan grass.

Cool Season Grasses-Scavenge nutrients, reduce erosion, add organic matter, suppress weeds. Cool season grass used in this demonstration is oat.

About the Site:

Cropping History – Spring Wheat 2007; Spring Wheat 2008; Flax 2009; Spring Wheat 2010; Prevented Plant with 20 acres seeded to cover crops 2011.

Next Cash Crop - Spring Wheat 2012.

Soil Test October 21, 2010 – N at 0-24" = 68 lbs/acre; Phosphorous = 11 ppm; Potassium = 181 ppm; Chloride 0-24" = 36 lbs/acre; Sulfur 0-24" = 480 lbs/acre; OM = 1.5%; Soil Salts 0-6"= 1.24 mmho/cm, 6-24" = 1.72 mmho/cm.

Herbicide Burndown – June – RT3 @ 24 fl oz/acre + Flame (AMS) @ 1 qt/100 gallons of solution. July 18, 2011 – RT3 @ 43 fl oz/acre + Flame (AMS) @ 1 qt/100 gallons + Aim @ ½ fl oz/acre. No herbicide was used in the cover crop.

Seeding Date – July 21 and 22, 2011

Drill Used –NDSU's Cross-slot opener equipped drill. This drill has a true ultra-low disturbance opener with a STIR factor of 1.95. STIR factor for a single disc opener is 2.43. West Plains Implement Case IH provided the tractor to seed the plot.

First Rainfall Event after Seeding - July 22, 2011 @ 0.8 inches.

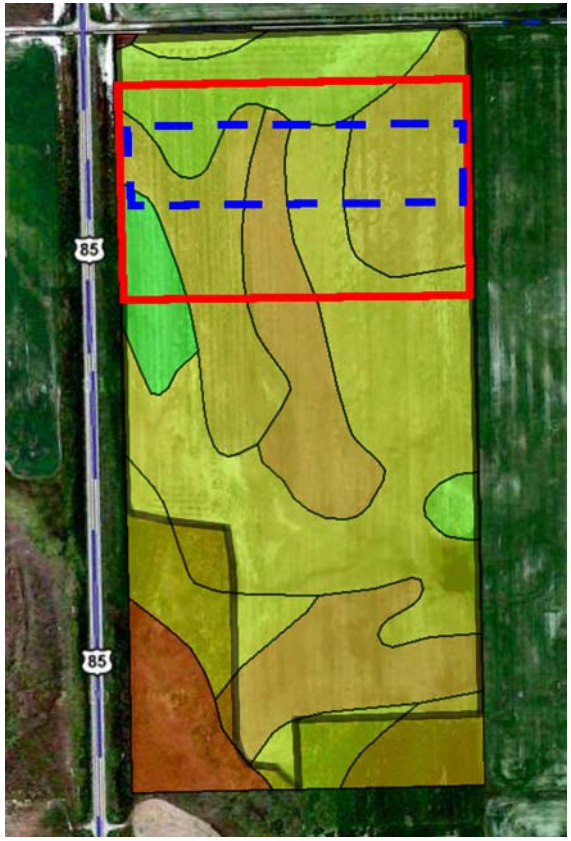
Precipitation events: 7/22 = 0.80, 7/28 = 0.40; 8/3 = 0.50; 8/5 = 1.50; 8/11 = 0.25; 8/15 = 1.30;

First Emergence Noted –Brassicas, alfalfa, and oats on July 25, 2011.

Photo July 29, 2011

Photo by Ernie Holzemer

Soils Information



AgA	Amor loam, 0 – 3% slope
BhA	Belfield-Rhodes silty clay loam 0-2% slope
DaB	Daglum-Rhodes silty clay loam 0-6% slope
MeA	Moreau silty clay 0-2% slope
MeB	Moreau silty clay 3-6% slope
MpB	Morton complex 3-6% slope
MrB	Morton-Dogtooth silt loam 3-6% slope
RhA	Regent-Dogtooth silty clay loam 0-3% slope
RsA	Rhoades-Belfield complex 0-2% slope
VrB	Vebar-Talley fine sandy loam 3-6% slope
WaE	

Soils information provided by NRCS,.

Dotted blue line indicates border of single and mixed species plots.

Red solid line indicates border of bulk seeding of soybean + millet + Sunflower + Turnip

Photos August 11, 2011

Treatment 1 is found at north end of plots. Each plot is 12 feet wide and 1320 feet long.

Treat No	Crop Species	Crop Variety Name	Planting rate pounds per acre (percent in mix by weight)	Seed Costs per acre	Seed Source
1	Radish	Tillage	8.2 (100)	$26.24	Producer's Choice
2	Radish	Graza	5 (100)	$16.00	PPG Seed
3	Winter Brassica	Winfred	10 (100) coated*	$30.00	PPG Seed
4	Winter Brassica	Winfred	10 (100)	$30.00	PPG Seed
5	Ethiopian Cabbage	PG584	2 (100)	$10.00	PPG Seed
6	Alfalfa	Not stated – Big "N" Brand	3.5 (100)	$11.38	Producer's Choice
7	Soybean	Not stated	60 (100)	$51.00	Agassiz Seed
8	Cowpea	Iron & Clay	70 (100)	$98.00	Agassiz Seed
9	Field Pea	4010 Forage Pea	86 (100)	$29.41	Agassiz Seed
10	Sunflower	Viper	17 (100)	$13.06	Agassiz Seed
11	Oat	Morton	75 (100)	$24.61	Agassiz Seed
12	Millet	Siberian Foxtail	20 (100)	$9.20	Agassiz Seed
13	Black Lentil	Indianhead	26 (100)	$26.00	Agassiz Seed
14	Teff Grass	Tiffany	8 (100) coated*	$14.40	Producer's Choice
15	Soybean + Sorghum Sudangrass	Not stated + Sweet Thing	60 (63 + 37)	$56.85	Agassiz Seed
16	Soybean + Millet	Not stated + Siberian Fox-tail	45 (80 + 20)	$34.74	
17	Cowpea + Soybean + Millet + Winter Bras-sica + Radish + Sun-flower	Iron & Clay + not stated + Siberian Foxtail + Winfred + Tillage + Viper	45 (27 + 41 + 20 + 3 + 3 + 6)	$47.36	
18	Field pea + Lentil + Oat + Winter Brassica + Radish + Sunflower	4010 Forage pea + Indian-head Black + Morton + Winfred + Tillage + Viper	75 (52 + 17 + 24 + 2 + 2 + 3)	$43.02	
19	Soybean + Millet + Sunflower + Turnip	Not stated + Manta Siberian + Black Oil + Purple Top	28 (55 + 30 + 11 + 4)	$21.45	

*The coating is an enhancement, to improve identification, ballistics, germination and plant survival.The latter two aspects apply to the ZEBA component which is a moisture absorbing material. It is corn based ,not petroleum (polyacrylimide). Simply ,you get more plants with less seed. Brassicas are nonmy-corrhizal but with grasses and forbs we include a mycorrhizal component.This is especially crucial in dryland seedings.

All legumes were inoculated with proper rhizobium but the cost of the inoculum was not included in seed costs.

Cover Crop Management Tips

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Cover crop is a crop used to cover the soil surface; to decrease erosion and leaching, shade the ground, and offer protection to the ground from excessive freezing and heaving. When a cover crop is grown to reduce nutrient leaching or retrieve nutrients deep in the soil profile, it is referred to as a "catch crop." A **green manure crop**, sometimes called green fallow, is a crop that is grown primarily to improve soil fertility and is terminated shortly after planting while it is still green or soon after flowering. An annual crop that is grown primarily for grazing or haying is called an **annual forage crop**. Cover crops, catch crops, green manure crops, and annual forage crops can provide an opportunity for growers to increase diversity in crop rotations. Excessive moisture for spring seeding in 2011 provided producers an opportunity to add diversity in their crop rotations as well as use this water to grow cover crops. Excess water lost to percolation below the root zone, runoff to creeks and rivers, and evaporation is of little value to production agriculture. Cover crops provide the opportunity to capture carbon and add it to soils in the form of organic matter. Problems associated with mid-summer planting in highly variable conditions are a challenge.

"Too Wet to Seed – Too Dry to Germinate."

This seemingly contradictory statement has actually been uttered by individuals expressing frustration with their inability to seed into wet soils and then when they do seed failing to get a plant stand because soils were dry in the seed zone. Bare soils as found in tilled systems will often dry in the planting zone to a point where seed will not germinate or germinate sporadically while just an inch or two below the seed soils are at field capacity or more. Water at or near the surface can evaporate, percolate into the soil or run off. Most of the water below the surface must percolate to deeper depths in the soil, move laterally to someplace else (saline seep) while very little evaporates. Producers have tried tillage to dry soils but in the process compacts wet soils and makes it more difficult to get a vigorous growing crop stand. Producers who till are more dependent upon timely precipitation. Maintaining upright residue at the surface in long term no-till develops more structure to support equipment operation as well as improved plant rooting and growing conditions.

Mid-summer Seeding

Mid-summer can be one of the most challenging times to seed a crop no matter what the purpose. Precipitation isn't as dependable as during May or June, soil temperatures are hot, and the soil surface dries faster. Soils where little or no residue is present are more hostile for mid-summer seeding. Crop residue that is not connected to the soil can be washed off during intense summer rainfall events or blown away by the wind essentially creating a hostile environment for germinating seed, young plants and soil. Crop residue left standing modifies the temperature and moisture conditions available for germination and crop establishment. Maintaining and using residue to improve germination and establishment of the crop is essential for consistent, successful summer time seeding. Research indicates that even when soils are close to wilt point, residue cover maintains soil humidity levels between 90 to 100%, sufficient to germinate seed.

Seeding into Wet Soils

"*Seeding into wet soils is an engineering problem*." If seeding could be done without compacting soil we can seed. Some producers have sown seed using an airplane to spread the seed across the field but high humidity/moisture conditions are needed to germinate seed on the exposed soil surface. In the Great Plains wet conditions are not very dependable so a harrow is required to incorporate seed into the soil.

Avoid using high disturbance seeding equipment. The further soil is moved from the seed slot the more difficult it is to move the soil back over the seed. Also high disturbance seeders tend to leave large chunks of soil on the surface that turn into rock hard clods unless a tillage implement follows immediately behind the opener to break up the clods. Wet soils often cling to disc openers. Mud thrown off the disc can be picked up by gauge wheels and

packer wheels changing the depth of seeding –raising the opener to the extent where seed is placed on the surface of the ground. Also mud that is brought up with the opener also contains weed seed. Weed seed brought to the surface may break dormancy creating additional weed control problems. Growers can minimize mud problems by adjusting gauge wheels and seeding boots to rub up against the disc to scape mud off. Some opener designs provide subsurface scrapers to keep mud below the surface rather than allowing it to come to the surface where it becomes a problem.

Some soils swell with the addition of water and then shrink as it dries. These soils contain clay. These soils are particularly difficult to plant into as seed slots are very difficult to close and when the slots are closed in the seeding operation can be pulled apart as soil dries under the hot drying sun. Check slot closure often during seeding and post seeding to emergence. If the slot isn't closing properly adjust the drill. If the slot opens after seeding is complete light tillage with a harrow or other tillage implement may help move soil over exposed seed. Ultra low disturbance openers (STIR < 2.0) reduce slot closure problems as well as post-seeding soil drying.

Seeding to moisture is a mistake. Seed planted deep will have poor emergence and weak growth. In bare soil conditions, soils will often dry to seeding depth/tillage depth leaving seed high and dry. Seed should be planted to the recommended depth in wet or dry conditions. Small seeded crop species should be seeded no deeper than ¼ inch while large seeded species need not be seeded deeper than an inch. Mixed species that contain both large and small seeded species should be seeded at the shallowest depth recommended. If the seed is placed in dry soils the next rainfall will germinate the seed and the seed will emerge rapidly. Under no-till conditions with adequate crop residue, properly placed residue over the seed slot will maintain humidity levels between 90 to 100%.

Wet residue can hair pin with disc openers. Growers can reduce this problem by setting grain tables to cut as high as possible while gleaning grain from the field. Better yet, stripper headers leave the majority of the straw attached (90% of the mature plant height) to the soil leaving only chaff to spread and cover the surface. Soils under upright attached residue warms and dries faster than soils where residue is half standing and half lying flat on the soil surface. Also residue dries faster standing than lying flat on the soil surface. If most residue is left standing hair pinning becomes less of an issue. Also hair pinning can be minimized by offsetting seeding direction by about 3^{o} or more from the previous direction of seeding. GPS and auto steer makes this part easier.

Designing Cover Crop Mixtures ("Cocktails")

Several factors need to be considered when designing cover crop mixtures. Some of these considerations are:

1) Residual herbicides used in previous crop(s)
2) Next cash crop in the following year(s)
3) Crop insurance
4) Timing of cover crop planting operation
5) Water-use of cover crop
6) Termination
7) Volunteering in following crops
8) Seeding rate and costs

Residual Herbicides What herbicides were used in the previous crop or crops that may injure or kill specific species in the proposed cover crop. Depending on the particular herbicide, herbicide residues can last from a few hours to a few years. Include species unlikely to be damaged by these herbicides. Cover crops also provide a means to do a bioassay in fields where long term residual herbicides have been used. Include some seed of sensitive species to gain insight into how much residue remains in the field. Information on crop rotation restrictions can be found in the NDSU Extension Seed Science publication, 2011 North Dakota Weed Control Guide, pages 108-111 and herbicide product labels.

Next Cash Crop. Cover crop species should be selected that add to diversity of the crop rotation and limit the potential to provide a green bridge for disease and insects to the next cash crop. Broadleaf crops such as sunflower and canola (brassicas) where diseases such as sclerotina is a problem should be limited to planting once every second or third year. Including these species in a cover crop when sunflower or canola will be grown within the next two or three years may not be such a good idea. Growing grass species such as millet, oat, wheat, barley and rye probably isn't a good idea if winter wheat and possibly spring wheat is your next cash crop unless termination eliminates these species **at least two weeks prior to seeding**. With the diversity of the species available to use in cover crop mixtures or cocktails producers should be able to tailor these mixtures to their needs.

Crop insurance is used by producers to manage risks in production and income. Cash crops are the main income source and cover crops should be used as a tool to improve long term productivity of their soils. Poor planning in cover crop design can limit producers on their seeding options the following year(s). A table summarizing crop insurance rotation restrictions is provided below.

Seeding Time. Adjust species selected for cover crops to match your seeding schedule. Seeding a cool season grass in the middle of summer and expecting it to produce large quantities of residue is unrealistic. Select species that will grow well in the conditions in which they will be seeded and grow. The diversity of species available can provide you a chance to seed at the right time almost every month of the year.

Water-use. Cover crops do use water and depending on the species and time of year they can use as little as 0.01 to 0.33 inches a day. Producers can decide when and where to plant cover crops and when to terminate their growth. In dry conditions producers may decide they will not plant any cover crops as the cash crop will use all the available water to produce straw and grain. Producers may decide that they have sufficient moisture to grow a cover crop for a portion of the year and then terminate with herbicide. The residue from the cover crop may contribute more to the next crop growth than the water it uses. Crop species generally use about half of the total moisture the crop will use for germination to the beginning of reproductive stages compared to allowing the plant to go to maturity. Termination at flowering will provide crop residue to protect the soil as well as catch snow during the winter.

Termination. Some species may be more difficult to terminate with herbicide or tillage than other species. Many of the species used for cover crops are killed when freezing conditions occur in late fall or early winter while other species may survive into the next growing season. For example adapted alfalfa varieties and hairy vetch can be a challenge to terminate with glyphosate. See the ND Weed Control Guide, page for suggested herbicides used to terminate volunteer crop species. Timing of termination to various plant stages can also be a challenge.

Volunteer Cover. Cover crops may go to seed before termination providing a source of competing plants during the cash crop phase of the rotation. Herbicides and crop competition will often control volunteers but some hard seeded crops may have several "flushes" to control. See the 2011 ND Weed Control Guide, page 115 for suggested herbicide used to control volunteer cover crop species in the cash crop.

Seeding Rates and Costs. Growers can purchase premixed cover crop cocktails or they can mix their own. A "ball park" estimate for the amount of seed to include of each species in a mix is to divide the full rate of each species if it were to be seeded as a pure stand by the number of species to be included in cocktail mix. Use clean, disease free high quality seed. Poor quality seed can lead to poor germination, introduction of some diseases, and poor performance. Growers can develop inexpensive mixes by adjusting both amounts of specific species going into the mix as well as total rate per acre seeded. Depending on specific field situation and management abilities "half seeding rates" may be used and still obtain desirable results.

Rotation restriction summary for crop insurance in North Dakota, Risk Management Agency, Actuarial Information, http://www.rma.usda.gov, August 29, 2011.

Crop[1]	County Coverage Listing[2]	Rotation Restrictions[3]
Barley	All Counties	None
Buckwheat	Burleigh, Dickey, Dunn, Hettinger, Kidder, La Moure, McIntosh, McLean, Mountrail, Sheridan, Stark, Stutsman	Canola, crambe, chickpeas, dry beans, mustard, rapeseed, soybeans, sunflowers, **buckwheat**
Canola	All Counties	**Canola, chickpeas, dry beans, mustard, rapeseed, or sunflowers**.
Corn	All Counties	None
Dry Bean	Barnes, Benson, Burleigh, Cass, Cavalier, Dickey, Eddy, Emmons, Foster, Grand Forks, Grant, Griggs, Hettinger, Kidder, La Moure, McHenry, McKenzie, McLean, Nelson, Oliver, Pembina, Pierce, Ramsey, Ransom, Richland, Rolette, Sargent, Sheridan, Steel, Stutsman, Towner, Traill, Ward, Wells, Williams	Dry bean, canola, crambe, mustard, rapeseed, soybeans, or sunflowers.
Dry Peas	All Counties	**Field peas (Austrian, Forage/Feed, Smooth, Green or Yellow)** or sunflowers.
Flax	All Counties	None
Garbanzo beans (Chickpeas)	Divide, Dunn, Golden Valley, Grant, Hettinger, McKenzie, McLean, Mountrail, Oliver, Stark, Ward.	**Garbanzo beans (chickpeas)**
Lentils	All Counties	**Lentils** or any other broadleaf crop
Mustard	Adams, Billings, Burke, Cavalier, Divide, Dunn, Golden Valley, Hettinger, McLean, Mountrail, Nelson, Ramsey, Renville, Slope, Stark, Towner, Ward, Williams	Crambe, mustard, canola, chickpeas, dry beans, rapeseed, or sunflowers
Oats	All Counties	None

[1]Crop to be insured.
[2]North Dakota counties where crop is insured. Insurance available in other counties by special arrangement.
[3]Crops grown in year previous to insured crop. Crops listed in **bold print**; have been planted in **either of the preceding two crop years**. Crops listed in **bold and underlined**; crop has been planted in **any of the three preceding years**.

Crop[1]	County Coverage Listing[2]	Rotation Restrictions[3]
Potatoes	Barnes, Benson, Cass, Cavalier, Dickey, Eddy, Emmons, Foster, Grand Forks, Griggs, Kidder, La Moure, Logan, McHenry, McLean, Mercer, Morton, Pembina, Ramsey, Ransom, Richland, Steel, Stutsman, Traill, Walsh	Potatoes or sunflowers
Rye	Barnes, Bottineau, Burke, Burleigh, Dickey, Foster, Grant, Hettinger, Kidder, La Moure, McHenry, McIntosh, Morton, Pierce, Richland, Rolette, Sargent, Stutsman, Ward, Wells, Williams	None
Safflower	Adams, Benson, Bottineau, Bowman, Burke, Divide, Dunn, Golden Valley, Grant, Hettinger, McHenry, McKenzie, McLean, Morton, Mountrail, Pierce, Renville, Slope, Stark, Ward, Williams	None
Soybean	Barnes, Benson, Bottineau, Burleigh, Cass, Cavalier, Dickey, Eddy, Emmons, Foster, Grand Forks, Griggs, Kidder, La Moure, Logan, McHenry, McIntosh, McLean, Morton, Mountrail, Nelson, Pembina, Pierce, Ramsey, Ransom, Renville, Richland, Rolette, Sargent, Sheridan, Steel, Stutsman, Towner, Traill, Walsh, Ward, Wells	None
Sugar Beets	Cass, Grand Forks, McKenzie, Pembina, Richland, Steele, Traill, Walsh, Williams	Sugar beets
Sunflowers	All Counties	Sunflowers, canola, crambe, dry beans, safflowers, mustard, or rapeseed
Wheat	All Counties	None

[1]Crop to be insured.

[2]North Dakota counties where crop is insured. Insurance available in other counties by special arrangement.

[3]Crops grown in year previous to insured crop. Crops listed in **bold print**; have been planted in **either of the preceding two crop years**. Crops listed in **bold and underlined**; crop has been planted in **any of the three preceding years**.

Ernie Holzemer Farm, Amidon, ND Cover Crop Demonstration Update

Seed costs per pound of dry matter produced and nutrients captured, Ernie Holzemer Farm, Amidon, ND, 2011.

Crop Species	Crop Variey Name	Planting rate (percent in mix by wt)	Seed Costs	Dry Weight	Seed Cost/lb dwt/acre	N+P+K	Seed[1] cost/lb NPK/acre
		lb/acre (%)	$/acre	lb/acre	$/lb/acre	lb/acre	$/lb/acre
Radish	Tillage	8.2 (100)	26.24	518	0.051	24.8	1.058
Radish	Graza	5 (100)	16.00	516	0.031	21.8	0.734
Winter Brassica	Winfred	5 (100)	30.00	452	0.066	21.0	1.429
Winter Brassica	Winfred	10 (100)	30.00	503	0.060	23.4	1.282
Ethiopian Cabbage[2]	PG584	2 (100)	10.00	516	0.019	18.3	0.546
Alfalfa	Not stated	3.5 (100)	11.38	360	0.032	24.3	0.468
Soybean	Not stated	60 (100)	51.00	427	0.119	19.8	2.576
Cowpea	Iron & Clay	70 (100)	98.00	222	0.441	10.4	9.423
Field Pea	4010 Forage Pea	86 (100)	29.41	661	0.044	35.1	0.838
Sunflower	Viper	17 (100)	13.06	628	0.021	34.6	0.377
Oat	Morton	75 (100)	24.61	692	0.036	27.7	0.888
Millet	Siberian Foxtail	20 (100)	9.20	551	0.017	16.6	0.554
Black Lentil	Indianhead	26 (100)	26.00	376	0.069	23.1	1.126
Teff Grass	Tiffany	4 (100)	14.40	554	0.026	17.8	0.809
Soybean + Sorghum Sudangrass	Not stated + Sweet Thing	60 (63 + 37)	56.85	931	0.061	46.4	1.225
Soybean + Millet	Not stated + Siberian Foxtail Millet	45 (80 + 20)	34.74	798	0.044	32.6	1.066
Cowpea + Soybean + Millet + Winter Brassica + Radish + Sunflower	Iron & Clay + not stated + Siberian Foxtail + Tillage + Viper	45 (27 + 41 + 20 +3 + 3 + 6)	47.36	1274	0.037	59.4	0.797
Field pea + Lentil + Oat + Winter Brassica + Radish + Sunflower	4010 Forage pea + Indianhead + Morton, + Winfred + Tillage + Viper	75 (52 + 17 + 24 + 2 + 2 + 3)	43.02	1443	0.030	70.3	0.612
Soybean + Millet + Sunflower + Turnip	Not stated + Manta Siberian + Black Oil + Purple Top	28 (55 + 30 + 11 + 4)	21.45	1245	0.017	59.8	0.359

Planted July 22, 2011

[1]Seed cost per pound of nutrient (N+P+K) captured.

[2]Ethiopian Cabbage was noted to be severely infested with Checkered White (*Pontia protodic*) on Sept 2.

Cover crop dry matter yield and nutrient content on the Ernie Holzemer Farm, Amidon, ND, 2011.

		Sept 23							Nov 3
Strip No	Species	Dry wt by sp.	Dry wt by mix	N	Ca	P	Mg	K	Dry wt by sp.
		lbs./acre							
1	Tillage radish	518	-	13.1	7.5	1.1	2.7	10.6	528
2	Graza radish	516	-	9.4	14.5	0.9	3.2	11.5	527
3	Winfred winter brassica	452	-	8.3	8.7	1.0	2.7	11.7	574
4	Winfred winter brassica	503	-	9.3	9.7	1.1	3.0	13.0	661
5	Ethiopian cabbage	516	-	8.6	3.8	0.8	2.2	8.9	421
6	Alfalfa	360	-	14.1	7.3	0.8	1.4	9.4	111
7	Soybean	427	-	11.6	7.8	1.2	2.9	7.0	-
8	Cowpea	222	-	4.8	4.3	0.7	1.6	4.9	-
9	Field pea	661	-	23.1	6.7	1.4	2.5	10.6	-
10	Sunflower	628	-	11.5	9.7	1.8	3.8	21.3	-
11	Oat	692	-	13.3	1.4	1.2	1.2	13.2	-
12	Millet	551	-	6.8	1.1	0.9	1.4	8.9	-
13	Black lentil	376	-	13.3	3.6	1.1	1.5	8.7	245
14	Teff grass	554	-	8.0	1.6	1.1	1.2	8.7	-
15	Soybean	370	931	20.0	6.0	1.8	4.6	24.6	-
15	Sorghum-sudan	561							-
16	Soybean	396	798	15.8	6.5	1.6	3.6	15.2	-
16	Millet	403							-
17	Cowpea	259	1274	23.6	14.8	2.7	6.4	33.1	-
17	Soybean	324							-
17	Winfred winter brassica	344							349
17	Millet	346							-
18	Field pea	323	1443	24.7	16.6	2.6	5.8	43.0	-
18	Oat	287							-
18	Lentil	264							-
18	Graza radish	257							-
18	Winfred winter brassica	312							323
19	Millet	347	1245	20.3	11.1	2.4	4.9	37.1	-
19	Sunflower	340							-
19	Purple top turnip	295							295
19	Soybean	264							-

Water % by Mass

Site - 1 Rhoades-Belfield Complex

Depth	Chem-fallow	Cover crop
0-1	18%	18%
1-2	18%	11%
2-3	24%	16%
3-4	24%	23%

Site -2 Vebar-Talley fine sandy loam

Depth	Chem-fallow	Cover crop
0-1	13%	12%
1-2	14%	13%
2-3	19%	15%
3-4	23%	23%

Water content of soil for chem-fallow and cover crop treatments sampled on March 23, 2012 is shown on the left. Rhoades-Belfield is a silty clay loam while the Vebar-Talley is a fine sandy loam located on a ridge that bisects the plot area. Depths given are 0 to 1 ft, 1 to 2 ft, 2 to 3 ft and 3 to 4 ft. In the fine sandy loam under cover crop, soil appears to be at or very near field capacity even with the below normal winter precipitation. Fine sandy loam holds less moisture per foot of soil than silty clay loams.