CHAPTER FIVE

Cover Crops in Rotations with Soybeans

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Cover crops, grown during or after cash crops, are used to improve soil health, increase organic matter, increase water infiltration, reduce erosion, reduce nutrient deficiencies, increase fertilizer efficiency, and increase available forage for livestock. Cover crops include a wide array plants including but not limited to: brassicas (sugar beet, turnips, radish) (Fig. 5.1); grasses (barley, winter wheat, rye); and legumes (chickling vetch, lentils, peas). The ability to benefit from cover crops depends on your ability to fit the cover crop into your rotation. This chapter provides background material using cover crops in rotations containing soybeans.

Figure 5.1. Brassicas (radishes and turnips) planted into spring wheat stubble after early August harvest. Photo taken in November, about 10 weeks after planting (11/10/2010). These radishes provide forage for livestock and help reduce soil compaction. (Photo courtesy of Cheryl L. Reese, SDSU)

Economic benefits from cover crops

Cover crops have been advertised as a one-step solution to many problems associated with row crop production. For example, they have been linked to increased fertilizer efficiency, improved soil quality, increased carbon sequestration, and reduced erosion. Cover crops can reduce nutrient losses. If using legumes, these crops may increase soil nitrogen, if N levels are low, by fixing atmospheric N. Brassica crops with large tap roots can help break compaction zones and increase water infiltration.

Cover crops also add organic matter, which improves soil quality, reduces erosion, and reduces runoff. Some cover crops also provide glucosides, which act as a biofumigant, and may reduce disease organisms.

While some of these benefits are more obscure than others, in a practical sense cover crops must have economic value within your rotation. Economic benefits from cover crops may include increased yields in row crops, increased fall and winter forage, reduced fertilizer requirements, improved soil yield potential, and under some conditions reduced iron deficiency chlorosis (IDC) in soybean (Chapter 26).

The definitive impact of cover crops on crop yields is often indirect. For example, research suggests that under some conditions cover crops can increase soybean yields by reducing iron deficiency chlorosis (IDC) (Chapter 26, Kaiser et al., 2011). This hypothesis is based on the plant releasing the negatively charged bicarbonate ion (HCO_3^-) when it takes up the negatively charged nitrate ion (NO_3^-). The bicarbonate ion then reacts with iron to form a relatively insoluble complex that cannot be taken up by the plant. Kaiser et al. (2011) suggests that cover crops can reduce the risk of IDC by decreasing the soil nitrate concentration and forcing the soybean to fix N.

Steps for introducing cover crops into a rotation

In the northern Great Plains, cover crops can be used fill specific and general needs within rotations. For example, a specific need might be to improve nutrient recycling while a general need is to increase the long-term yield potential by increasing soil organic matter content. The requirements for both systems are similar, yet slightly different. Implementing an effective cover crop program requires following several key steps (Table 5.1).

Table 5.1. Steps for integrating cover crops into your rotation.

1. Develop a cover crop plan.
2. Identify specific objectives.
3. Identify crop rotational requirements.
4. Determine agronomic requirements:
    a. desired species (single or mix), seeding rates, and landscape positioning (if any) for specific cocktails (i.e., seed mix);
    b. examine herbicide labels to determine if herbicide residuals will limit selected species growth.
5. Determine costs (seed, planting, future control, if needed) and expected returns.

Developing a cover crop plan and objectives

Developing a cover crop plan is critical for justifying your use of limited farm resources. Cover crop management objectives may include extending fall grazing, scavenging nutrients, reducing pests, wildlife habitat, and/or decreasing soil compaction. Each field is likely to have a different set of objectives. One producer might target increasing the soil organic matter content while a different farmer might target providing forage for fall grazing.

Selecting the appropriate seeding data and plant species to use for a cover crop is critical for achieving your goals. Often a mix of species, i.e., a cover crop "cocktail," is used. Mixing many species allows for many goals to be addressed by a single planting, and often enhances the opportunity for successful establishment of at least one species. In South Dakota, considerable success has been achieved by seeding a cover crop after winter or spring wheat harvest in August. Other opportunities for seeding cover crops include following a failed crop (e.g., late frost or hail damage) or after the critical weed-free period in a row crop (about V4 to V5 in corn). Questions that should be considered when selecting a cover crop cocktail include:

1. Did prior herbicide use (or environmental conditions) result in carryover or residuals that will prevent successful cover crop establishment?
2. Will the soil chemical characteristics influence plant establishment? For example, in salty soils cocktails should include salt tolerant plants (Chapter 48).
    a. Salt tolerant plants include barley, sugarbeets, tall wheat grass, canola, and wheat grass.
    b. Soybeans is moderate tolerant, while corn is moderately sensitive.
3. Will the cover crop cocktail increase or decrease pests in the cash crop (insects, weeds, and diseases) the following spring? For example, grass species like barley, rye, oats, or corn can act as a secondary host for the wheat curl mite which vectors wheat streak mosaic virus. Planting these grasses may provide a 'green bridge' for this pest to over winter and cause significant disease problems in wheat planted the following spring.
4. Does the cocktail influence future management? For example, will the cover crop need to be killed? If a cover species is planted that can potentially over winter, make sure to apply needed treatments in the spring to cease the cover crop growth so that it does not interfere with the season's intended cash crop.
5. How will the cover crop cocktail influence fertilizer requirements? For example, legumes like clover may increase soil N or deep rooted brassicas will alleviate soil compaction.

Crop rotations and cover crops

There are many crop rotations that could be enhanced by including cover crops (Chapter 4). This chapter concentrates on three rotations: (1) corn grain followed by soybean; (2) corn for silage followed by soybean, and (3) soybean, wheat, and corn for grain (Table 5.2). Fall cover crops in South Dakota are difficult and risky to establish after harvest of both soybean and corn due to the cold, short, and often dry growing season remaining in September and October.

Table 5.2. Three crop rotations with cover crops and possible risk for successful cover crop emergence. (Cheryl L. Reese, SDSU)

	Year 1		Year 2		Year 3	
Rotation	**Crop**	**Fall Cover Crop Risk**	**Crop**	**Fall Cover Crop Risk**	**Crop**	**Fall Cover Crop Risk**
Corn (Grain)/ Soybeans/ Corn (Grain)	Corn (Grain)	High	Soybeans	Moderate to High	Corn (Grain)	High
Corn (Silage)/ Soybeans/ Corn (Grain)	Corn (Silage)	Moderate to Low	Soybeans	Moderate to High	Corn (Grain)	High
Soybeans / Wheat/ Corn (Grain)	Soybeans	Moderate to High	Wheat	Low	Corn (Grain)	High

Planting a cover crop into growing corn or soybeans in July and August (Figure 5.2) has produced mixed results (Mutch and Martin1998, http://www.covercrops.msu.edu/pdf_files/covercrop.pdf; authors unpublished data). These crops are often seeded aerially with an airplane and moisture is crucial for germination.

In South Dakota, research where a cover crop was seeded at the corn V5-V6 growth period showed that the cover crop has a minimal impact on the corn crop yield. For this application, cover crop cocktails should include plants that germinate and grow well under shade, such as red clover. If corn has been treated with atrazine, there may be few cover crops that will establish during the season, especially if conditions that minimize breakdown (dry or abnormally cool conditions) have occurred.

Drilling the cover crop between rows has produced a more consistent stand (Fig. 5.3) than broadcast applications (Figs. 5.2 and 5.4); however, either technique can be successful if growth characteristics, seeding requirements, and water are available. When cover crops are seeded in-season, the cover crop usually remains quite small until the main crop starts to senesce and approaches maturity, at which time growth accelerates. Following corn harvest, the cover crop can be fall and winter grazed.

In soybean, the canopy may be too dense to allow for good establishment of in-season cover crops and planting may need to be delayed until leaf senescence.

Figure 5.2. Aerial seed application of cover crops into August corn crop. (Photo courtesy of Dan Forgey)

Figure 5.3. Crimson clover drilled into corn at V6 on June 30, 2011. Photo 09/15/2011, Trail City, SD. (Photo, C. Reese, SDSU)

Figure 5.4. Crimson clover broadcast seeded into corn at V6 on June 22, 2010. Photo 10/12/2010, Andover, SD. (Photo, C. Reese, SDSU)

Opportunities for planting fall cover crops exist in rotations where a short-season crop like wheat is harvested in July or if corn is harvested as silage in August (Fig. 5.5). In this application, the cover crop should be seeded as soon as possible after harvest. Seeding before September 1 improves the ability of the cover crop to be established before a killing frost. Cover crops can provide fall and winter grazing, reduce compaction, and increase nutrient cycling. A cocktail that includes cereals such as rye or oats, broadleaves like radishes or turnips, and legumes are desirable and can provide excellent livestock forage (Fig. 5.6).

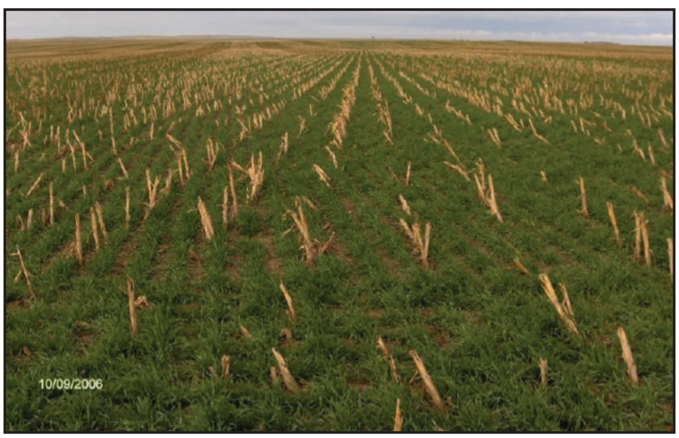

Figure 5.5. Cereal rye planted as a cover crop into silage stubble. (Photo courtesy of Dan Forgey)

Figure 5.6. Cattle grazing on radishes in November. (Photo courtesy of Dan Forgey)

In the soybean, wheat, and corn rotation, a cover crop after the wheat harvest has been used to increase the yield in the following corn crop. In South Dakota wheat is typically harvested in July or early August which provides the best opportunity to establish fall cover crops. Generally there is an ample opportunity to seed the cover crop cocktail and have a longer time for establishment and growth. Care must be taken to choose herbicides with short residuals or to provide ample time between application and seeding to optimize growth and development (see Table 5.8).

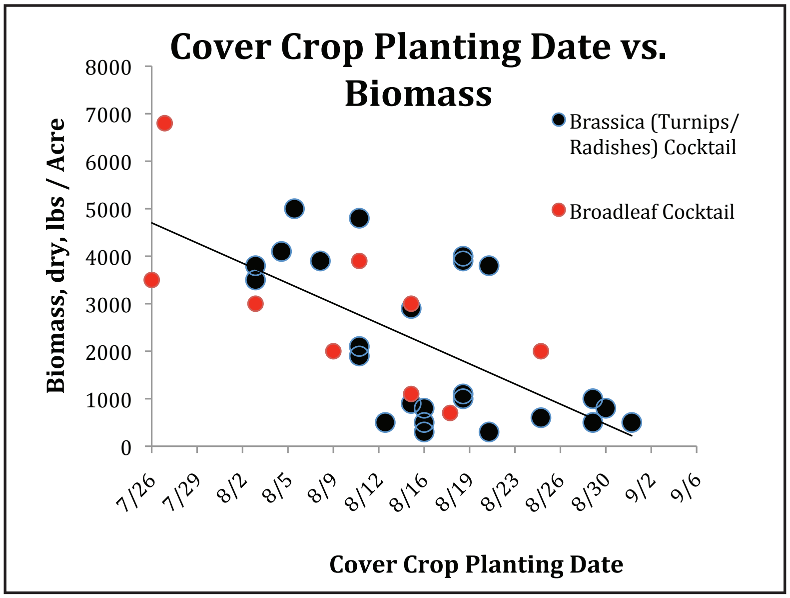

Figure 5.7. Cover crop dry biomass by planting date.
(Adapted from South Dakota NRCS Cover Crop Survey 2008-2010)

Cover crop planting dates

To optimize fall growth of cover crops, the earlier the crop is seeded, the more biomass will be produced. In Figure 5.7, regardless of the cover crop mixtures, either brassicas or broadleaf mixture, dry biomass averaged approximately 3,800 lbs/acre when planted on August 1 and decreased to about 200 lbs/acre when cover crops were planted on August 31. Similar results have been observed in South Dakota demonstration studies where dry biomass production was 1091 and 237 lbs biomass/acre when seeded on 8/17/2010 and 9/19/2009, respectively.

Cover crops composition: Warm-season vs. cool-season

Selecting an appropriate seeding mixture is critical. Cover crop composition could be warm- or cool-season plants or a mixture depending on when the cover crop is seeded. Cool-season plants grow best in cool temperatures. Cool-season species start growth when air and soil temperatures are cool and will continue to grow during the spring and fall but go dormant or quickly die off when temperatures are warm (>80°F). Cool-season broadleaves can be typically divided into (1) brassicas like canola, radishes, or turnips or (2) legumes including clovers, peas, and vetch. Cool-season grasses include barley, oats, winter wheat, and rye. In a South Dakota fall, cool-season cover crops often blend broadleaf and grass species to provide the most biomass and potentially survive light frosts.

Warm-season plants grow best with warm temperatures. Warm-season species typically start growth in late spring when soil and temperatures are warm. These plants thrive during the warm summer weather. Examples of warm-season plants are big blue stem, corn, and sorghum. Warm-season species typically do not tolerate frost and will die out quickly as fall temperatures fall at or below freezing. In South Dakota, cool-season species are used for cover crops in most cases.

Cover crop categories and uses

In compacted soils, cover crop cocktails that include brassicas (grazing radish) can be used to reduce soil compaction (bulk density). These plants produce a tap root that penetrates soils up to two feet (Fig. 5.8). These plants can rapidly decompose leaving large pores in the soil. In Figure 5.9, a knife is inserted in a root channel of a decomposing tillage radish.

Figure 5.8. Diakon radishes and purple top turnips root size. (Photo, C. Reese, SDSU)

Figure 5.9. Knife inserted into macro channel created by decomposing radish root, May, 2012. (Photo, C. Reese, SDSU)

Cover crop impacts on soil health

Cover crops mixtures can help increase the diversity of the soil biota which can help increase aggregate stability (Fig. 5.10, Ketterings et al., 1996) and N mineralization (Fig. 5.11). Plants with high C to N ratios, such as wheat straw or corn stover, generally mineralize slowly, whereas plants with low C to N ratios, brassicas or turnips, peas or soybean residue, generally mineralize fast. The mineralization rate influences how much of the N contained in residue will be available to the following crop early in the growing season (Fig. 5.11).

Figure 5.10. Earthworms associated with a decomposing radish root. May, 2011. (Photo, C. Reese, SDSU)

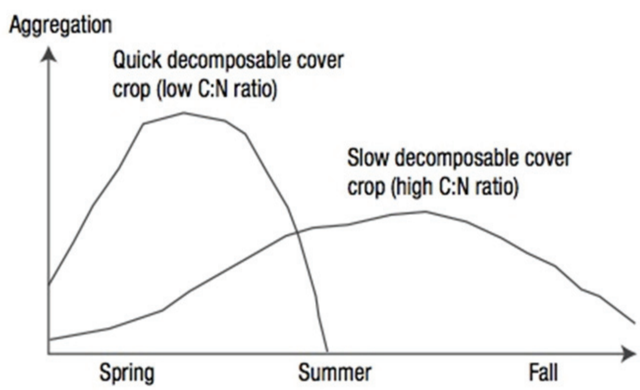

Figure 5.11. Crop residue decomposition based cover crop C:N ratios.
(Source: http://www.weblife.org/humanure/chapter3_7.html)

When determining a cover crop blend, consideration should be made for the current soil residue cover. If the desired outcome is crop residue retention, cover crops with high C:N ratios should be considered. However, if the goal is to improve soil nutrient recycling from one crop to the next, then crops with a low C to N ratio should be seeded. http://soils.usda.gov/sqi/management/files/C_N_ratios_cropping_systems.pdf

Cover crops can be used to help manage high salt soils. Cover crops can be useful in salt management by increasing water loss through transpiration vs. evaporation, and reducing capillary movement of water and salts into surface soil. For cover crops to be effective they must germinate and reduce evaporative water loss. In South Dakota, barley, sugarbeets, rape, rye, canola, and western wheat grass can be seeded into salty soil zones (Chapter 53). Challenges using this cover crop seeding include (1) a good method to plant the cover crop into the growing corn and (2) seed germination.

Developing a cover crop cocktail

Determining the blend is accomplished by establishing the cover crop goals, evaluating seeding season characteristics of the plants (warm- vs. cool-season), and considering soil variability. Tables 5.3 to 5.7 summarize cover crop blends that provide options for various cover crop management objectives. An important note here is that after producers have some experience with cover crops, they often will modify seed mixtures to fit their needs. Cool-season grazing blends will often consist of turnips, radishes, and grasses whereas cowpeas, millet, and sudangrass can be used for warm-season grazing.

Table 5.3. Cover crop blends for grazing. (Revised from Jason Miller, NRCS, Pierre, SD).

Grazing Blends			Option 1		Option 2		Warm-season grazing		Grazing / Compaction	
		Full Seeding Rate Pounds	Percent	Rate in Mixture	Percent	Rate in Mixture	Percent	Rate in Mixture	Percent	Rate in Mixture
Species	Type	lbs A^{-1}	%	lbs A^{-1}	%	lbs A^{-1}	%	lbs A^{-1}	%	lbs A^{-1}
Lentils	Cool Broad	30	30	9	40	12				
Turnip	Cool Broad	4	30	1.2	30	1.2			20	0.8
Radish	Cool Broad	8	10	0.8					20	1.6
Rapeseed	Cool Broad	5			30	1.5				
Oat	Cool Grass	70	30	21						
Cowpea	Warm Broad	30					40	12	30	9
Millet	Warm Grass	25					60	15	20	5
Sudangrass	Warm Grass	25							20	5

Table 5.4. Cover crops that may aid in reducing compaction. (Revised from NRCS, Pierre, SD)

Compaction Blends			Compaction		Grazing / Compaction		Residue Cycling / Compaction	
		Full Seeding Rate Pounds	Percent	Rate in Mixture	Percent	Rate in Mixture	Percent	Rate in Mixture
Species	Type	lbs A^{-1}	%	lbs A^{-1}	%	lbs A^{-1}	%	lbs A^{-1}
Lentils	Cool Broad	30	30	9	40	12		
Radish	Cool Broad	8	60	4.8				
Canola	Cool Broad	5	10	0.5			50	2.5
Cowpea	Warm Broad	30					40	12
Millet	Warm Grass	25					60	15
Sudangrass	Warm Grass	25						
Turnip	Cool Broad	4	30	1.2	30	1.2		

Table 5.5. Cover crops that may enhance residue cycling compaction. (Revised from NRCS, Pierre, SD)

Residue Cycling Blends			Residue Cycling		Residue Cycling / Compaction	
		Full Seeding Rate Pounds	Percent	Rate in Mixture	Percent	Rate in Mixture
Species	Type	lbs A^{-1}	%	lbs A^{-1}	%	lbs A^{-1}
Lentils	Cool Broad	30	50	15	30	9
Canola	Cool Broad	5	50	2.5	40	2
Radish	Cool Broad	8			30	2.4

Table 5.6. Cover crops that may potentially germinate under saline conditions. (Revised from NRCS, Pierre, SD)

Salinity Blends			Option 1		Option 2		Option 3	
		Full Seeding Rate Pounds	Percent	Rate in Mixture	Percent	Rate in Mixture	Percent	Rate in Mixture
Species	Type	lbs A^{-1}	%	lbs A^{-1}	%	lbs A^{-1}	%	lbs A^{-1}
Sugarbeets	Cool Broad	4	50	2	60	2.4	30	1.2
Barley	Cool Broad	50	50	25			40	20
Canola	Cool Broad	5	5		40	2	30	1.5

Table 5.7. Cover crops that may reduce soil moisture and enhance nitrogen cycling. (Revised from NRCS, Pierre, SD)

Spring Moisture or N Cycling Blends			Spring Moisture / N Cycling 1		Spring Moisture / N Cycling 2		Spring Moisture	
		Full Seeding Rate Pounds	Percent	Rate in Mixture	Percent	Rate in Mixture	Percent	Rate in Mixture
Species	Type	lbs A^{-1}	%	lbs A^{-1}	%	lbs A^{-1}	%	lbs A^{-1}
Hairy Vetch	Cool Broad	15	50	7.5	50	7.5		
Canola	Cool Broad	5					50	2.5
Rye	Cool Grass	100	50	50			50	50
Triticale	Cool Grass	60			50	30		

Other considerations

The cover crop should be matched to the drainage characteristics of the soil. For example, annual rye is a cool-season grass and has a weight of 26 lbs per bushel. Annual rye will grow under wet soil conditions and tends to grow better on both poor, rocky soils and heavy clay soils than cereal rye, although cereal rye can grow under dry to excessive moisture conditions if the soils are more loamy.

Both cereal and annual rye will overwinter like winter wheat. The major problem with cereal rye is excessive spring growth that is not controlled. Under these circumstances, soil moisture is depleted and the producer is left with reside that can be up to six feet tall. The mat of residue can be difficult to manage in the spring and cause soils to dry out and warm up slowly.

Annual rye is typically burned down with an herbicide in the spring when its growth is between 8 to 16 inches. Annual rye has been reported to be difficult to control by many producers during cool weather when glyphosate does not translocate well in the plant. Annual ryegrass can go to seed in the spring and become a weed in future crops if not closely monitored.

Cover crops may reduce available moisture for the row crop; however, they also increase water infiltration and snow catch. Our research suggests that they can reduce as well as increase available moisture for the row crop.

Cover crops increase plant diversity which can increase soil biological diversity. It has been hypothesized that cover crops increase soil mycorrhizae. These organisms can help the row crop utilize nutrients and water (Fig. 5.12).

Figure 5.12. Fungi (not mycorrhizae) associated with a decomposing corn root. (Photo, C. Reese, SDSU)

Many herbicides have activity for a relative long period of time. For example, Roundup® (glyphosate) has no residual soil activity and there are no restrictions to planting any crop after application. In comparison, Maverick® (sulfosulfuron) has a long residual activity (22 months) and planting to any cover crop species except small grain crops may result in reduced populations or less growth (Table 5.8). Matching the herbicide rotation to the desired cover crop is critical for the cover crop success (Table 5.8). Table 5.8 lists estimated rotation restrictions for wheat herbicides based on label information or limited field research. It is important to carefully follow labeled rotation guidelines and contact the appropriate herbicide industry representative if there are any questions regarding rotational restrictions.

Many soybean herbicides may not cause injury to fall-planted cover crops since soybeans are a broadleaf species. Some soybean herbicides that are a moderate to high risk of injuring fall-planted cover crops include products containing fomesafen (Flexstar®, Reflex®, Prefix®, etc.), sulfentrazone (Authority® products, Sonic, etc.), chlorimuron (Enlite® and others), and perhaps other products.

Cost share programs may be available for cover crop seeding from county USDA-NRCS offices. EQIP and CSP are programs that typically allow some cost share benefits for cover crops. The best way to take advantage of the programs is to check early with your county NRCS office for applications and deadlines.

Table 5.8. Approximate months required between wheat herbicide applications and cover crop seeding. Carryover risk high (black); moderate (gray); and low (white). (Revised from M. Moechnig, SDSU)

Approximate months required between wheat herbicide applications and cover crop seeding	Application Timing	Forage Legumes (alfalfa, clover, vetch)	Pulse Crops (peas, dry beans, lentils)	Seed Mustards (canola, rape)	Root Mustards (turnips, radish)	Small Grains (rye, wheat, triticale, millet)	Other Grasses (sorghum, sudan)	Oilseeds (sunflower, safflower)	Other Broadleaf (flax, buckwheat)
Maverick (sulfosulfuron)	Fall	22	22	22	22	3	22	22	22
Olympus (propoxy-carbazone	Fall	24	12-24	12	12-24	4	12	12	24
Rimfire (propoxy-carbazone + mesosulfuron)	Spring	10	10	10	10	0-4	12	10	10
Power (pyroxsulam)	Fall	9	9	9	9	1	9	9	9
GoldSky (pyroxsulum + florasulam + fluroxypyr)	Spring	9	9	9	9	1	9	9	9
Everest (flucarbazone)	Spring	24	9-24	9-24	9-24	4-11	11-24	9	11-24
Beyond (imazamox)	Spring	3	3	18-26	9-18	4-9	9	9	9-18
Ally (metsulfuron)	Spring	22	22	22	22	1-10	12	22	22
Harmony (thifensulfuron)	Spring	1-2	1-2	2	2	0	1-2	1-2	1-2
Express (tribenuron)	Spring	1-2	1-2	2	2	0	1	1-2	1-2
Buctril (bromoxynil)	Spring	1	1	1	1	1	1	1	1
Huskie (pyrasulfotole + bromoxynil)	Spring	9	9	9	9	0-4	4	9	9
WideMatch (clopyralid + fluroxypyr)	Spring	10.5	18	4	4	0	10.5	18	4
Starane (fluroxypyr)	Spring	4	4	4	4	4	4	4	4

Potential Cover Crop Seed Suppliers in South Dakota

Spink County Fertilizer & Chemical
Dylan Troske
10 Main St
Northville, SD 57465
Phone: 605-887-3422
Email: dylan.troske@uap.com

Prairie States Seed
Brad Young
Wausa, NE
Phone: 866-373-2514
Email: prairie@gpcom.net

Millborn Seeds Inc.
Matt Fenske
1335 Western Avenue
Brookings, SD 57006
Phone: 888-498-7333
Email: mattf@millbornseeds.com
Web: www.millbornseeds.com

Hansmeier Seed Inc.
Floyd & Keith Hansmeier
Bristol, SD
Phone: 605-492-3611
Email: hansson1@midconetwork.com

Howe Seeds, Inc.
Charles Howe
Box 496
McLaughlin, SD 57642
Phone: 605-823-4892
Cell: 605-845-5892
Email: charleshowe@westriv.com

Cronin Farms
Dan Forgey
30431 167th St
Gettysburg, SD 57442
Phone: 605-765-9287
Email: dcforgey@venturecomm.net

Henry Roghair
PO Box 16
Okaton, SD 57562
Phone: 605-669-2819
Email: hgrseeds@gwtc.net
Pulse USA
Brad Meckle
1900 Commerce Drive
Bismarck, ND 58501
Phone: 1-888-530-0734
Email: brad@pulseusa.com

Mark Stiegelmeier
13402 306th Avenue
Selby, SD 57472
Phone: 605-649-7009
Email: mstiegel@sbtc.net

Sunbird Inc.
Lee Klocke
PO Box 942
702 3rd St SW
Huron, SD 57350
Phone: 605-353-1321 Ext 212
Email: lklocke@sunbird-inc.com
Web: http://www.sunbird-inc.com

Jerome Webb
32050 201st ST
Harrold, SD 57536
Phone: 605-875-3558
Sioux Nation of Fort Pierre
Steve Magdanz
504 Deadwood Ave
Fort Pierre, SD 57532
Phone: 605-223-2427 (seed house)
Email: Sioux.nation2@plantpioneer.com

Winner Seed,
Gene Brondsema
E. HWY 44,
27763 317th Ave
Winner, SD 57580
Phone: 605-842-0481
Cell: 605-680-9886

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Available at http://www.sare.org/Learning-Center/Books*

*Millborn Seeds, Cover Crop
http://www.millbornseeds.com/documents/CoverCropGuide.pdf
www.Millbornseeds.com*

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