North Dakota – Cover Crops Report 2015-2016

April, 2015 to February 2016

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COMPLETED RESEARCH

1. Cover crops variety trial at two seeding dates (NDSU Development Foundation)

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Cover crops were planted at two different dates in Fargo, ND and Prosper, ND to demonstrate farmers the importance of planting date and cover crop selection on growth and biomass yield. Cover crops can provide many ecosystem services but if they don't grow there are no benefits to the soil or next crop.

Planting dates were July 21 and August 20, 2015. The experimental design was a randomized complete block with three replicates. The first date include 16 cool- and warm-season cover crops (Table 1) while the second date only 14 cool-seasons (Table 2). Cover crops were planted after fallow (July 20) and after barley residue (August 20). No fertilizers were applied to any of the crops. Biomass yield (leaf and top part of roots), N uptake, P uptake and crude protein content are presented in (Tables 1 and 2)

Results clearly indicate that end-of-July planting is favorable for warm-season cover crops (Table 1). Thus in a 'prevent plant' situation including warm-season cover crops in the mix is very beneficial. In many instances, 'prevent plant' occurs due to excess of soil moisture in the spring. In this situation, including crops such as forage sorghum and millets is highly beneficial to dry up the soils. The highest dry matter biomass yield, N and P uptake in the first date of planting was for sorghum Pampa Verde and forage triticale. Nutrient uptake of cover crops is directly related to biomass yield. The highest the yield the highest the extraction. Nitrogen uptake fluctuated from 74 to 314 lbs N/acre and P uptake between 7.1 and 25.8 lbs P/acre. This clearly shows the scavenging abilities of the different cover crops. Plots were not fertilized so nutrient extraction represents what was in the soil. Crude protein was slightly higher for legumes than cereals as expected.

In the second planting date, rape 'Dwarf Essex' and radish 'Daikon' were the top biomass yielders and had the highest N uptake (Table 2). Biomass yield in the fall it is important to provide soil cover and greater biomass usually is related with greater root growth and capacity to scavenge nutrients. Clearly the deep tap root of both rape and radish were able to extract both N and P, which will be available to the next crop in the following season. Although winter camelina varieties biomass yield were the lowest, this crop has the advantage of being very winter hardy, thus providing green cover in the spring. Currently, our only winter-hardy cover crop is cereal rye. Camelina comes as a broadleaf option to cereal rye alone on in mixtures.

A mixture of cover crops with different functions is desirable. Cereals are high biomass producers protecting the soil from erosion, they can draw moisture from the soil and also they build soil organic matter increasing soil biodiversity. Cover crops in the Brassicaeae family, radish, turnip, rape, camelina have a deep tap root. These crops can scavenge nutrients from deep in the soil, off the root zone and move the nutrients to the top soil.

Table 1. Cover crops variety trial planted in 21 July 2015, in Fargo, ND.

Crop	Variety	Biomass yield	N uptake	P uptake	Crude protein
		tons/acre	kg N/acre	kg P/acre	%
Forage sorghum	Pampa Verde BMR 6	4.59	231	25.8	15.4
Sudangrass	Piper	3.31	116	15.4	11.7
Foxtail millet	Manta	1.97	99	10.0	15.6
Forage triticale	2700	4.97	314	29.7	19.4
Cereal rye	ND Dylan	2.89	148	14.9	16.1
Forage barley	Haybet	3.27	126	15.5	11.8
Forage oat	Colt	2.40	100	8.9	11.2
Annual ryegrass	VNS	2.20	113	10.6	16.1
Crimson clover	Dixie	1.18	103	7.1	16.6
Forage Pea	Arvika	1.95	114	12.5	18.5
Hairy Vetch	VNS	1.80	120	11.8	20.8
Turnip	Appin	2.43	119	14.8	15.5
Radish	Daikon	3.18	131	17.4	13.2
Cowpea	VNS	2.00	103	10.8	15.7
Buckwheat	Manor	2.01	74	9.9	11.3
Phacelia	VNS	2.25	108	12.4	15.2
LSD (0.05)		1.10	95	8.4	NS
CV, %		25	35.6	43.8	31.7

Harvest date: warm-seasons: 6 October; cool-seasons: 21 October

Table 2. Cover crops variety trial planted in 20 August 2015, in Fargo and Prosper, ND. Data combined across locations.

Crop	Variety	Biomass yield	N uptake	P uptake	Crude protein
	kg N/ha	tons/acre	kg N/acre	kg N/acre	%
Turnip	Pointer	1.17	52.2	10.0	13.2
Turnip	Appin	1.36	57.0	11.9	12.3
Radish	Daikon	1.43	77.5	11.9	14.3
Radish	Groundhog	1.37	35.1	7.9	18.1
Winter cereal rye	ND Dylan	0.77	46.3	5.9	19.6
Winter cereal rye	NY	0.63	45.7	7.8	17.9
Winter camelina	Joelle	0.69	31.3	5.3	15.8
Winter camelina	WG4-1	0.61	21.0	3.5	14.4
Winter camelina	WG1-35	0.76	30.5	5.1	16.6
Winter camelina	Bison	0.94	20.3	3.4	16.0
Pennycress	VNS	0.79	25.2	4.4	18.3
Forage Pea	Arvika	0.85	53.4	5.3	21.2
Winter Triticale	VNS	0.49	26.3	4.3	17.6
Rape	Dwarf Essex	1.47	71.6	10.0	17.0
LSD (0.05)		NS	NS	4.3	NS
CV, %		46.3	35.1	36.1	21.1

Harvest date: 2 November 2015.

Fig. 1 Prevent plant cover crops. Planting date July 21, Fargo ND.

2. **Timing of winter rye removal for weed control in soybeans.**
Mike Ostlie and Steve Zwinger

Soybean production in North Dakota is currently threatened by numerous factors which include glyphosate resistant weeds, root and foliar diseases, soil erosion, and creeping salinity. Winter rye is growing in popularity due to a number of different niches it can fill in a crop rotation. Besides being harvested for grain, rye can also be used as a forage or cover crop. One of the main benefits it provides as a cover crop is weed control through a combination of allelopathy and heavy competition. The strengths of rye can also be used to supplement the weaknesses of soybeans. Rye can be used to break up disease cycles, provide weed suppression, provide winter cover, use excess spring moisture, or be used for fall or spring grazing; all while still utilizing the growing season for a cash crop.

A study was conducted at the Carrington Research Extension Center in 2014 to evaluate weed control and soybean yields under different scenarios of removing rye. The treatments consisted of a no-rye check, plots with rye tilled into the soil or sprayed prior to planting soybeans, treatments where rye was either mowed, harvested for forage or sprayed at anthesis, and a treatment where rye was left for the duration of the soybean growing season. The rye was planted on 26 September 2013. Soybeans were planted on 3 June 2014 into rye that was just entering the boot stage. A supplemental glyphosate application was made to all soybeans (except in treatments 6 and 7) on 16 June.

Kochia control varied by rep, based on plant stand, and ranged from 30 to 70%. When averaged across treatments, there was no pre-existing treatment differences in kochia stand prior to implementing the rye removal strategies. The weed suppression was largely in the form of reduced kochia growth and vigor, but not necessarily reduced plant numbers. Soybean growth and development did not appear to be influenced by the presence of rye, nor the removal strategies (other than mechanical damage) through the 16 June rye removal treatments, when rye was at anthesis and the soybeans were developing their first true leaves. The weed suppression of the 'Hancock' rye disappeared once the rye began the senescence process and the canopy opened up. At that point, the stunted kochia within the canopy began more vigorous growth. By the middle of August, this rye variety on its own lost most of its effectiveness on kochia. The other treatments, aided by the application of glyphosate continued to maintain a high level of suppression, even though the rye had been removed quite some time ago. The most impressive treatment was the application of glyphosate at anthesis, in which the rye carcasses remained intact (retaining some canopy coverage) until soybean harvest, although there was not statistically more weed control than treatments 3-5. This data suggests that the longer the rye remains in the field, up until anthesis, the better the weed control. There is also preliminary data to suggest that different rye varieties have different levels of allelopathy (data not shown). Hancock is a variety that appears to be effective until flowering, while some other varieties appear to maintain a higher level of allelopathic activity for longer. This could possibly be related to reallocating resources for seed production in some of these varieties.

In the treatments where rye remained past anthesis, soybean yields were heavily influenced (~75% reduction compared to other treatments). Meanwhile, in the plot where rye was harvested as grain, the rye yielded 27 bu/a. Letting the rye remain until soybean harvest reduced those yields to roughly eight bu/a. When rye was harvested as grain, the total bu/a for the soybeans and rye was roughly the same as the soybean bu/a for most other treatments. If soybeans were $10/bu and rye was $6/bu (based on recent pricing) that would put the total revenue from producing the two crops at roughly the same level as producing only the soybeans. Rye harvested as a forage resulted in over one ton of dry matter per acre, plus over 35 bu/a soybeans. However, in field scale operations, the soybean yield would likely be lower due to the mechanical damage from the baling operation and bale removal, although the soybeans may still be small enough to recover from some of the damage. The highest soybean yield was achieved with the pre-plant burndown of the rye. This likely resulted in lower early season competition with the soybeans. It was different from the tilled treatment for two possible reasons; 1) due to the dry conditions at the end of the growing season, the no-till nature of the burndown treatment provided a moisture bonus to those plots, or 2) incorporating rye residue into the soil caused some allelopathic damage to the soybeans. The no-rye check plot had a fairly low yield as well. Much of that is attributed to lack of weed control early in the season, as all other plots retained an average of ~50% kochia suppression.

Overall, the rye and soybeans grew well together. The rye recovered remarkably well from the soybean planting operation, and the soybeans grew through the rye canopy with ease for the first month or so (through rye anthesis). The soybeans didn't seem heavily influenced by any direct rye allelopathic effects. This could be due to the soybean planting operation clearing a path around the soybean root zone. The soybean yields could have been higher in the treatments involving rye that was harvested as grain if more moisture was received during the latter portion of the growing season, making the income from of harvesting both crops potentially similar to harvesting a single soybean crop, but with the added benefits of low input costs and more winter cover. Treatments that had rye growing until anthesis or beyond would also provide more ground cover for the winter. This means that a single winter rye crop could provide cover for the winters prior to and after soybean production. Ultimately, the rye was a benefit to the soybean production system in most scenarios. The decision about a specific method and time of removal could be left to an individual producer to fit within existing production framework and objectives.

Fig. 1. Cereal rye termination at three different growth stages.

3. Corn-alfalfa intercropping: alfalfa as a cover crop in corn

Marisol Berti, Johanna Lukascheswky, and David Ripplinger

Corn (*Zea mays* L.) and alfalfa (*Medicago sativa* L.) are two of the most important forages for livestock production in North Dakota. Silage corn and alfalfa provide high biomass yield for silage and hay in the Great Plains, respectively. Corn and alfalfa intercropping could provide high biomass yield of silage corn in the first year and high productivity of alfalfa the second year. The objective was to determine the productivity of alfalfa established in intercropping with corn the previous season. An experiment designed as randomized complete block, with a split-plot arrangement with four replicates, was started in Fargo and Prosper in 2014 with the objective of optimizing productivity and economic feasibility of alfalfa by establishing it as an intercrop into the previous year's corn crop. Treatments included: Silage corn (hybrid 2 MD 96 RR) and alfalfa (Presteez RR), 4 monocultures and 4 intercropped corn-alfalfa and the use of a growth regulator in alfalfa-prohexadione (PHX). Treatments described in Table 1. The seeding date was 29 May 2014 and 1-2 Jun 2015 at both locations. Seeding rate was 12 kg alfalfa/ha and corn plant density was targeted to 87,932 plants/ha at both row spacings.

Table 1. Eight different monoculture and intercropping alfalfa and corn treatments and row spacings evaluated in Fargo, and Prosper, ND, in 2014 and 2015.

Treatment	Row spacing
	cm
Monoculture	
Silage corn (C)	61 (4-rows)
	76 (4-rows)
Alfalfa (A)	61 (16-rows)
	76 (16-rows)
Mixtures-Intercroping	
Corn + alfalfa (C+A)	61 (16-rows)
	76 (16-rows)
Corn + alfalfa + Phx (C+A+Phx)	61 (16-rows)
	76 (16-rows)
Phx: Prohexadione calcium	

Biomass yield from the 2-center rows of each plot (silage corn), and biomass yield from 6-center rows of each plot (alfalfa) was harvested. Alfalfa was harvested in 2015 between late vegetative and bloom (0.48- to 0.62-m in height) depending the harvest date. Corn biomass was harvested at kernel milk stage (70% moisture). Dry matter content and forage quality parameters were determined with a NIRS.

Corn biomass yield was between 24.1 and 27.9 Mg/ha, without significant differences among treatments (monoculture and intercropping system) (Fig. 2). This indicates alfalfa did not reduce biomass yield in corn when intercropped. The row spacing across treatments did not affect corn biomass yield. The yield was not different (P<0.05) between row spacings (Fig. 2).Total seasonal biomass yield for alfalfa established in May 2015 was 5.6 Mg/ha, total of two harvests (5 Aug. and 16 Sept.) (Fig. 3). Total seasonal biomass yield for alfalfa established in May 2014 in intercropping was 11.3 Mg/ha, total of four harvests (19 Jun., 10 Jul., 5 Aug., and 16 Sept.)

(Fig. 3).Biomass yield of alfalfa with or without prohexadione was similar (Fig. 3). Prohexadione did not improve alfalfa winter survival (Fig. 4).Corn biomass yield in monoculture was not different than the biomass yield in corn intercropped with alfalfa. Row spacing did not have an effect on corn and alfalfa biomass yield across locations. The use of prohexadione in alfalfa (C+A+Phx) did not affect corn nor alfalfa biomass yield. Alfalfa intercropped with corn in 2014 accumulated more than twice the biomass of alfalfa seeded in the spring of 2015.This system can provide a head start for alfalfa skipping the typical low productivity of the seeding year.

Fig. 1. Corn and alfalfa intercropping compared with alfalfa monoculture in 2014 before harvest and in 2015, Fargo, ND.

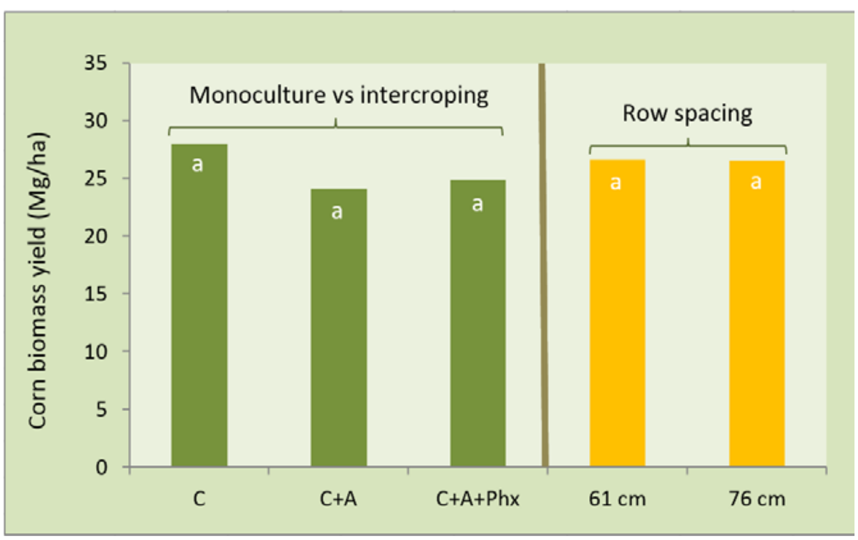

Fig. 2. Corn biomass yield of six different monocultures and intercropping treatments across location, Fargo and Prosper, ND. Means with different lower case letters within the same main effect indicate significant differences, LSD test *P*=0.05.

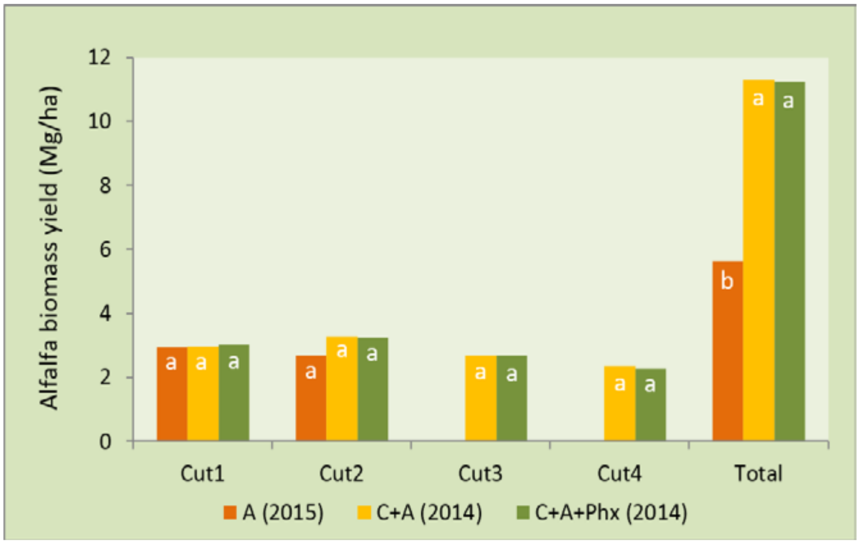

Fig. 3 Alfalfa biomass yield from four harvests in 2015 (established in 2014) and two harvests (established in 2015) in different monoculture and intercropping treatments across locations, Fargo and Prosper, ND. Means with different lower case letters within a same cut or total indicate significant differences, LSD test *P*=0.05.

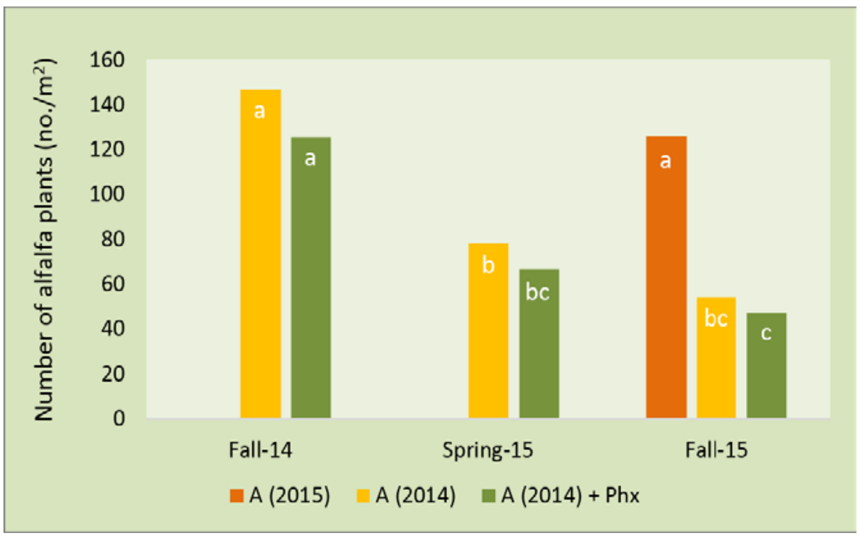

Fig. 4. Number of plants of alfalfa combined across locations, Fargo and Prosper, ND and row spacings. Means with different lower case letters among all columns indicate significant differences, LSD test *P*=0.05.

4. Short-Term Soil Responses to Late-Seeded Cover Crops in a Semi-Arid Environment

Mark Liebig, J.R. Hendrickson, D.W. Archer, M.A. Schmer, K.A. Nichols, and D.L. Tanaka

Cover crops can expand ecosystem services, though sound management recommendations for their use within semiarid cropping systems is currently constrained by a lack of information. This study was conducted to determine agroecosystem responses to late-summer seeded cover crops under no-till management, with particular emphasis on soil attributes. Short-term effects of late-summer seeded cover crops on soil water, available N, near surface soil quality, and residue cover were investigated during three consecutive years on the Area IV Soil Conservation Districts Research Farm near Mandan, ND. Mean aboveground cover crop biomass was highly variable across years (1430, 96, and 937 kg ha^{-1} in 2008, 2009, and 2010, respectively), and was strongly affected by precipitation received within 14 d following cover crop seeding. During years with appreciable biomass production (2008 and 2010), cover crops significantly reduced available N in the 0.9-m depth the following spring (P= 0.0291 and 0.0464, respectively). Cover crop effects on soil water were subtle, and no differences in soil water were found between cover crop treatments and a no cover crop control before seeding cash crops the following spring. Late-summer seeded cover crops did not affect near-surface soil properties or soil coverage by residue. Soil responses to late-summer seeded cover crops did not differ between cover crop mixtures and monocultures. Late-summer seeded cover crops may enhance ecosystem services provided by semiarid cropping systems through biomass production and N conservation, though achieving these benefits in a consistent manner appears dependent on timely precipitation following cover crop seeding. *(Published in Agronomy J.*).

5. 2015 Cowpea Variety Trial Prosper North Dakota

Hans Kandel, Burton Johnson, and Frank Kutka.

Cowpea (*Vigna unguiculata*) is a summer annual legume species from West Africa. Cowpea varieties are fairly drought and heat tolerant, and are used for forage, food, and soil building around the world. In various parts of the world people eat the leaves, pods, immature seeds, and/or dry seeds. The plants are sensitive to cold, as are soybean (*Glycine max*), and they do very well in low fertility conditions. While intolerant of heavy weed pressure and wet soils, they can in thick plantings smother later germinating weeds and may have some allelopathic characteristics. Cowpea also does well in crop mixtures, due to some shade tolerance, and they are often interplanted with corn or sorghum in warm regions.

Our objective was to find cowpea varieties, which can be used for both seed production and cover cropping purposes in North Dakota.

In a preliminary study a number of potential suitable cowpea varieties and lines were identified. In this study eight accessions were included:

1) Iron and Clay: A late maturing variety mixture that is commercially sold further south in the US for high protein forage and cover cropping. This is a check variety.2) Red Ripper: A late maturing variety that is commercially sold further south in the US for food (green or dry seeds), forage, and cover cropping. Known for its long vines and red seeds. This is a check variety. 3) PI 293499: Called Davis Pea, this upright variety developed somewhere in the USA is said to be

productive. Seeds are brown.4) PI 293525: Called Jackson Purplehull for the distinct hull color. This upright variety was developed somewhere in the USA. It is said to be productive and efficient with phosphorus. Seeds are white with pink eyes (hilum). 5) PI 293570: Called Speckled Purplehull, also for obvious reasons. Was donated to the USA by the International Institute of Tropical Agriculture. It is upright with speckled, brown seeds. 6) PI 352903: This upright variety is from Sirsa, Haryana, India. It was donated by the Indian Agricultural Research Institute and is said to be moderately productive. Seeds are a speckled gray color. 7) PI 491446: This productive and upright variety is from the village of Machanang in Botswana's Central District. The seeds have a patchy color, like a red shorthorn, and mature earlier than many cowpeas. 8) PI 491468: This productive and very upright variety is also from the country of Botswana. The seeds are mostly red and small. Said to be much earlier than many cowpeas.

Research was conducted near Prosper, ND, in 2015. Prosper is in Cass County and the plot was located on a Kindred-Bearden silty clay loam soil (USDA, 2015). The soil test indicated that there was 72 lbs of N in the top 24 inches and no P or K limitation. Seed was inoculated with 'Guard N' seed inoculant 200 million viable cells per gram of rhizobia: *Bradyrhizobium* sp. (Vigna), *Rhizobium leguminosarum* biovar *viceae*, *Rhizobium leguminosarum* biovar *phaseoli*, and *Bradyrhizobium japonicum*. Seed was packed for individual rows at a rate of 150 seeds per 25 ft of row. The plots were planted on June 1, 2015, with a research planter, four rows wide (row spacing 14 inch) and about 25 feet long. The experimental design was a complete randomized block design with five replicates. The previous crop was sugarbeet (*Beta vulgaris*).

Stand counts were recorded within the two middle rows for each plot with a 1 m measuring stick. A vigor score, scale of 1-9 with 9 being the most vigorous, was recorded on July 6th. Canopy closure was evaluated 5 weeks after emergence on a scale of 1 no canopy closure to 5 canopy completely closed. The date when the cowpea line started to bloom (about 10% bloom) was recorded. Farmers visited the plot (September 9) and evaluated the entries for maturity (1 not ready for harvest and 9 ready for harvest). Percent of the soil covered was evaluated by looking down on the canopy and estimating the area in view covered by the crop (in reverse what percent soil could be observed). One hundred percent means no soil could be seen. The harvestability was evaluated based on the plant architecture, pod distribution uniformity and lodging.

Plant height was measured just before harvest. Plots were harvested on September 28. The two late maturing varieties only had a few pods and plants were still green. Other varieties were ready to harvest. Waiting to harvest at a later date probably would have resulted in shatter loss of the crop of the earlier maturing lines. Plot lengths were measured in order to calculate the actual harvested area. If there were large gaps in stand in the middle of a plot, not caused by the treatment, the harvested area was corrected.

Once all samples were harvested and dried, they were cleaned with an air blast seed cleaner (Allan Machine Company, Nevada, IA) to remove dirt and plant material. The sample was weighed and analyzed for yield and 1000 kernel weight. Weather data was collected from the weather station at the Prosper research site. Statistical analyses for experiments were conducted using standard procedures for a randomized complete block design using Statisix8 software.

The maximum, minimum, and average temperatures during the growing season where slightly above the 30 year average. Precipitation during the growing season in 2015 was about 2.5 inches less than normal.

Table 1. Cowpea plant density, early vigor, bloom date, canopy closure, and plant height, Prosper ND, 2015.

Variety/line	Plant Density	Early Vigor 9 best	Bloom		27 Jul Canopy Closure 5 best		Plant Height	
	Plt/a	(1-9)	(date)		(1-5)		(cm)	
Iron and Clay	125,700ab†	5.9b	no	d	3.4	ab	60.9	a
Red Ripper	128,200ab	4.6bc	late	c	3.6	ab	51.8	b
PI 293499	136,900a	5.4bc	26-Jul	ab	3.4	ab	43.7	de
PI 293525	11,450c	1.1d	27-Jul	b	1.0	c	38.1	f
PI 293570	146,200a	7.5a	26-Jul	ab	4.1	ab	45.4	cde
PI 352903	134,800ab	4.7bc	25-Jul	a	4.3	a	48.5	bcd
PI 491446	99,600b	4.2c	25-Jul	a	3.3	b	49.3	bc
PI 491468	139,400a	5bc	26-Jul	ab	3.5	ab	42.7	ef

†Within columns, means followed by at the same letter are not significantly different at ($P \leq 0.05$).

Although the plots were overseeded, the final stands were significantly different with PI 293525 only having 11,450 plants per acre (Table 1). The vigor score is a combination of the stand and the quickness of plant growth. The highest plant density also had the highest score for vigor. Bloom for all the PI lines was within three days of each other. The check varieties stayed in the vegetative state until very late in the season. Red Ripper had a few plants blooming but some of the pods were not harvestable by the end of September. Normal frost date at Prosper is around 22 September. We rated the Iron and Clay and Red Ripper as not suitable for seed production is North Dakota. Around the beginning of bloom there was a difference in canopy closure between PI 352903 and PI 491446.

Table 2. Cowpea harvestability, maturity, ground cover, seed yield, and thousand kernel weight Prosper, ND, 2015.

	Farmer observation Sept 9 2015								
Variety/line	Harvestability 1 = poor		Maturity 1 not ready		Ground cover		Seed yield		1000 KW
	(1-9)		(1-9)		(%)		(lb/acre)		
Iron and Clay	1.0	f†	1.0	b	100	a	18	e	104.4c
Red Ripper	2.3	e	2.0	b	100	a	237	e	114.8c
PI 293499	6.3	ab	5.0	a	55	b	1481	b	135.2c
PI 293525	4.3	d	5.3	a	26	c	794	d	146.9ab
PI 293570	4.6	cd	5.0	a	51	b	1097	c	161.3ab
PI 352903	5.5	bc	5.8	a	61	b	1733	a	77.8d
PI 491446	7.3	ab	5.8	a	34	c	1722	ab	116.2c
PI 491468	3.8	d	4.5	a	56	b	1206	c	81.4d

†Within columns, means followed by at the same letter are not significantly different at ($P \leq 0.05$). KW= Kernel weight

Fig. 1. Photo: September 9, 2015 line PI491446 and line PI293499.
At the end of the season there was significant height difference. The check varieties, which stayed vegetative had the tallest plants and the most biomass (visual observation).

On 9 September, a small group of farmers observed the cowpea plots. At that time it was clear that the check plots were not blooming and therefore were scored low for harvestability (Table 2, 3). On the other hand as the check varieties stayed vegetative throughout the season the canopy closure was rated at 100% and was deemed excellent for the cover crop function. As some of the PI lines started to mature there were significant differences in how much soil was still covered. The most mature (PI 491446) had a high harvestability score and high maturity score and due to the earlier dry down it had the lowest ground cover percent (34%). In the end PI 352903 and PI 491446 provided the highest seed yield with PI 352903 having a significantly lower seed weight.

Table 3. Summary of cowpea bloom color, plant type, seed color, and seed size, Prosper, 2015.

Variety/line	Bloom color	Plant type	Seed color	Seed size
Iron and Clay	n/a	Tall erect	Brown	medium
Red Ripper	n/a	Bush some vines lateral	Red	medium
PI 293499	Purple	Bit bush mostly prostrate vine	Brown	med/large
PI 293525	White	Prostrate	White with pink eyes	med/large
PI 293570	Purple	Bush/ prostrate	Speckled brown	large
PI 352903	Purple	Bush upright / some top vine	Speckled gray	small
PI 491446	White	Tall bush / compact	Patchy red	medium
PI 491468	Purple	Bush / vine	Red and small	small

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United States Department of Agriculture. 2015. Available at http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

RESEARCH IN PROGRESS

1. PDP SARE Enhancing Soil Health with Cover Crops in North Dakota: Training Program. *Marisol Berti and Abbey Wick*

Research in cover crops management practices and soil health benefits has been going on for at least the last five years in North Dakota. Research plots and a few on-farm research trials initiatives have generated interesting information but cover crop adoption is been very slow. It is our goal to bring to county agents and farmers the knowledge acquired by NDSU researchers. Our proposal has the two main components of a successful educational project: 1) Good and complete local information collected in the field through replicated trials and on-farm experiences and out of state workshops and conferences, and 2) farmers in the Red River Valley (RRV) eager to learn about cover crops management and benefits. Adopting cover crops in the RRV is not easy because most of the area is planted to corn and soybean in no-till and both crops are harvested too late in the season to plant a cover crop. Our target audience will be farmers mainly from SE North Dakota but not limited to that area. We propose to train county extension agents and farmers about management and benefits of cover crops. We seek an increase in adoption and the integration of cover crops into existing cropping systems to increase resiliency. As a result of this project, at least 10 county agents and 70 farmers in North Dakota will learn about cover crops and soil health in several activities. Incorporating cover crops in their practices will have a tremendous impact in soil health and other ecosystem services.

Project description.

The use of cover crops, common in the East and central Corn Belt, are uncommon in corn-soybean systems in North Dakota. Intensive management practices that include fall tillage to optimize yields have led to serious soil erosion problems. Researchers in North Dakota have collected valuable information about cover crops management and performance, but there is a need to transfer this knowledge to county agents and producers which is the aim of this project.

2. Adaption of cover crops to build soil health in the northern Plains NCR-SARE, on farm-research demonstration and educational. *Abbey Wick*

Summary

Producers in the Northern Plains, specifically North Dakota, Minnesota and South Dakota, struggle with the incorporation of cover crops into rotations because of a short growing season and limited, regionally-specific information. To compound the issue, there is a desperate need to manage the extensive salinity issues in this region brought upon by a 20 year wet cycle and shift in management to shorter growing season crop rotations. Producers in this area estimate that 15-35% of their cropland is impacted by salinity, drastically reducing yields and degrading soil health. The current management approach used by a majority of producers in the region is “business as usual” with excessive fall and spring tillage and planting of non-salt tolerant crops – the exact opposite of what needs to happen. A recommended management approach to combat the issue is to use water with cropping systems to drive the salts deeper into the soil profile. Using an early season, more salt-tolerant crop, such as a small grain, followed by a cover crop will increase the duration of “something growing and using water” by up to four months. Additionally, the lengthened growing season improves our ability to build soil health and develop more sustainable agronomic systems.

Objective/Performance Targets
Objective 1: Collect regionally-specific data throughout the northern and southern Red River Valley on the effectiveness of various cover crop mixes following small grains using replicated plots.

Objective 1 accomplishments to date: Four replicated cover crop plots were established across the Red River Valley near De Lamere, Wahpeton, Cummings, and Thompson, ND. Sites are located in visible areas so neighboring farmers can monitor the cover crop plots throughout the seasons. After small grain harvest, prior to cover crop planting, a Veris cart was used to map the entire field for salinity. The salinity map will be used as a baseline to track the effectiveness of cover crops as a salinity management tool. Cover crop biomass was collected along with soil samples, which are being analyzed for nutrient content/fertility and soil organic matter; this will establish baseline levels for the plots. Cover crops will be planted on the same plot locations in 2016. Again, cover crop and soil samples will be collected in late fall, at each location, to track the changes and potential benefits associated with two years of cover cropping in the Red River Valley.

Objective 2: Demonstrate the use of various cover crop mixes using full-scale plots installed by partnering producers in close proximity to other established salinity demonstration locations.
Objective 2 accomplishments to date: Farmer cooperators were crucial in the planning and installation of the cover crop plots. With farmer and seed dealer's input three mixes were selected. Mix 1: cereal rye, radish, and turnip. Mix 2: cereal rye, radish, turnip, forage pea, and Crimson Clover. Mix 3: cereal rye, radish, turnip, forage pea, crimson clover, sorghum/sudangrass, and Dwarf Essex rapeseed. The mixes were designed to be additive, with the same basic species in all mixes and additional species added to investigate the potential cost or benefits associated with higher species mixes. Check plots were left as a comparison. With NDSU support, the farmer cooperators completed the plot installation using full size equipment. The use of field scale plots allows farmers to see what using cover crops will look like on-farm, as opposed to small plots.

Objective 3: Increase education opportunities by demonstrating additional practices for salinity management and opportunities for improving soil health to an already existing framework of demonstration sites that have well attended annual field days.
Objective 3 accomplishments to date: Field days were held at each field site during late fall, at peak cover crop productivity, drawing a total of 284 participants. The group of participants included farmers, government agencies, Ag industry professionals, and Ag students from a local college. Field day agendas featured talks on salinity management, reduced tillage practices, cover crops, and general soil health management. Based on surveys collected from the field days, participates noted an averaged 31% increase in knowledge on how to build soil health with cover crops. To build on the success of the first field day season, winter workshops will be held and field days will take place at each site in the fall of 2016.

Accomplishments/Milestones
Plot installation was the major milestone for the 2015 field season, along with four successful field days and plant/soil sampling in the late fall. Plot installation was made possible by the four farmer cooperators for this project. The cooperators have been willing and eager to assist with

this project; mainly because results from this project will influence how and if they incorporate cover crops in their long-term management plan.

The four field days were well attended and received positive feedback from the farmer participants. NDSU Extension's County Agents were paramount in the planning, facilitation and execution of the field days. The first sampling event was also completed in 2015, providing a solid baseline for comparing the impact of cover crops on soil health.

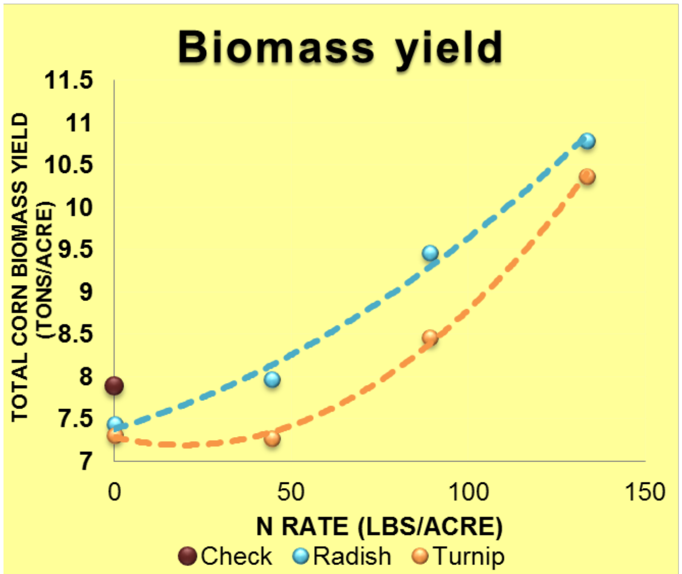
Impacts and Contributions/Outcomes

In year one of this project the impact has been considerable. Firstly, with the farmer cooperators, through the planning process, installation, and monitoring they have gained knowledge in cover crops and soil health. By working one-on-one with NDSU specialists, extension agents, and seed salesman each cooperator has obtained a wealth of knowledge on cover crops and salinity management, making them a local expert. Farmer cooperators have also tried cover crops in other problem areas on-farm and are seeing positive results; thus, this project is impacting acres beyond the plots. Extension County Agents have gained experience working with cover crops and soil health, making them a resource for producers in their county interested in soil health and salinity management. The cooperating extension agents have also built successful soil health programs in their counties. Finally, this project has reached over 250 farmers and ag industry leaders displaying that cover crops can be a incorporated into rotations, even with the short growing season of the Northern Great Plains.

3. **Nutrient cycling ability of forage radish and turnip previous to corn and soybean**
   Marisol Berti, Osvaldo Teuber, Alfredo Aponte, Johanna Lukaschewsky, and Dulan Samarappuli

An experiment was established in Fargo and Prosper, ND, to determine the ability of forage radish and turnip to recycle nutrients. Turnip and radish were planted in the fall of 2014, and in the spring of 2015 corn and soybean will be planted no till into the residue of the cover crops. Treatments will also include four nitrogen rates in the corn experiment.

Combined results across locations indicate biomass yield responded to N rates but corn grain yield did not. Interestingly, grain yield was different at the 0 lbs N/acre. The treatment with no N and no cover crop the previous fall had a grain yield of 184 bu/acre, while grain yield on plots that had turnip or radish was 202 and 218 bu/acre, respectively. Having a cover crop in the previous fall increased grain yield in 15.5% with radish and in 7.3% with turnip.



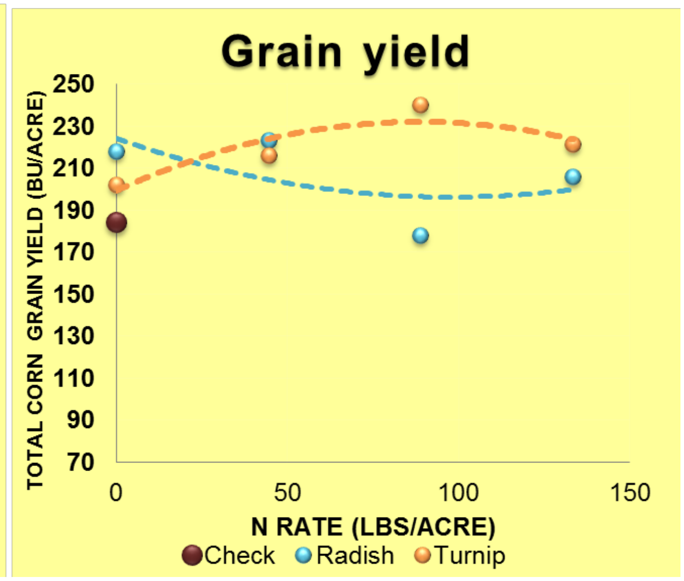


Fig.1 Turnip and radish Fargo, and Prosper, ND.

4. **Winter Rye Research at the CREC - Using winter rye as a forage crop.** ***Steve Zwinger***

The winter rye focus at the CREC is quite broad ranging from small plot research related to grain, forage, cover crop, weed control, and variety development to field scale seed and forage production. Winter rye has been evaluated as forage crop at the CREC demonstrating its value as reliable forage crop that provides cover and can extend the haying/grazing season. The use of winter rye as forage is a method of integrating cropland into a livestock system. In harsher northern climates like North Dakota, fall grazing of winter rye is limited although spring grazing is a possibility as rye is one of the first plants to initiate growth and accumulate biomass in the spring. Therefore advantages of using winter rye as a forage crop include the early spring growth along with an associated early harvest, providing an opportunity to sown a second crop for haying, grazing or cover cropping if adequate moisture and fertility levels are present. Average harvest dates of winter rye as a forage crop compared to other winter forages are presented in table 1. Average harvest date (10 year) compared to the past two growing season are presented illustrating differences within years.

Fig. 1 Spring growth of winter rye on April 14, 2008 at the CREC.

Spring stand data (not presented) illustrate that rye is the most winter hardy compared to the other winter cereals. Average harvest dates (table 1.) gathered over the years show the differences among the crop types in maturity. Forage treatment harvest dates were determined by the growth stage of the forage each year. Rye was harvested first, followed by triticale, wheat and then spelt. Harvest stage for all treatments was early to mid-anthesis or 5-10 days after heading depending on forage species. Results (table 2.) illustrate the relative yield differences among the winter cereal types trialed. Forage yields for winter rye, 2.5 ton/ac DM, are similar to winter wheat and triticale during the years of these trials. Forage yield of winter spelt is greater than the other winter cereals compared. This yield difference may in part be due to the later maturity of spelt. Rye tends to be lower in quality when compared to wheat or other crops used. Although significant quality differences exist they are minor comparing the crops. Winter wheat has the highest crude protein and TDN along with the lowest fiber values. Average protein for rye has been 11.5% with a TDN of 54. Relative Feed Value (RFV) which use multiple parameters to measure the forage quality show rye to be at 97.

Table 1. Forage harvest dates of winter cereals at the CREC.

Crop type	Average	2014	2015
Rye	6/12	6/23	6/8
Triticale	6/21	7/2	6/8
Wheat	6/24	6/26	6/16

Spelt	7/5	7/7	6/29

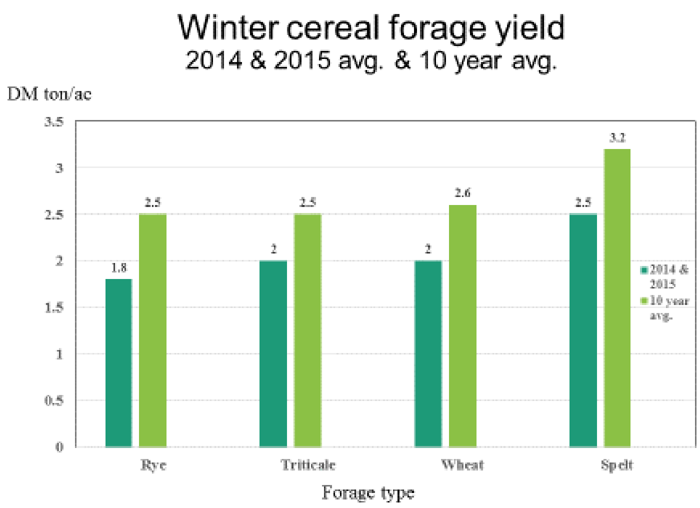


Fig. 1. Cereals forage yield at Carrington, ND. Winter rye at anthesis on June 7, 2010 at the CREC.

PUBLICATIONS (list within each category)

Peer-reviewed journal publications

Berti, M.T., R.W., Gesch, B.L. Johnson, Y. Ji, W. Seames, and A. Aponte. 2015. Double- and relay-cropping of energy crops in the Northern Great Plains. Ind. Crops Prod. 75B:26-34

Liebig, M.A., J.R. Hendrickson, D.W. Archer, M.A. Schmer, K.A. Nichols, and D.L. Tanaka. 2015. Short-Term Soil Responses to Late-Seeded Cover Crops in a Semi-Arid Environment Agron. J. 107(6):2011-2019

Abstracts/ Presentations

1. Berti, M.T., 2015. How to select a cover crop to maximize the benefits of having a cover crop. 11th Conservation Tillage Conference. Wilmar, MN. 15-16 December, 2015.
2. Lukaschewsky, J., A. Aponte, M.T. Berti, D. Samarappuli, O. Teuber, D. Undersander. 2015. Intercropping Silage Corn and Alfalfa in Eastern North Dakota, USA. ASA-CSSA-SSSA International Annual Meetings. Minneapolis, MN. 15-18 November 2015.
3. Johnson, B.L., M.T. Berti, S. Dash, P.K. Gilbertson, K. Sahu, and P.J. Petersen. 2015. Screening new crops for adaptation promotes agricultural sustainability. In Proc. 2nd International Conference on Sustainable Agriculture and Environment. Selcuk University, Konya, Turkey, Sept. 30 - Oct. 3, 2015.
4. Berti , M.T., O. Teuber, D. Samarappuli, A. Aponte, J. Lukaschewsky, G. Gramig, D. Ripplinger, A. Wick, C. Heglund, E.M. Gaugler, K.K. Sedivec, D.L. Whitted, B.W. Neville, S. Zwinger, S. Schaubert, and P. Carr. 2015. North Dakota report 2014. Annual Midwest Cover Crops Council conference. Ames, IA., 16-19 February, 2015.
5. Kandel, H. 2015. Cowpea trial evaluation. Northern Plains Ag Association Breeding Club Members. Prosper ND, September 9, 2015.
6. Ostlie, M. 2015. Utilizing winter rye for weed suppression in soybeans. Western Society of Weed Science annual meeting. Portland, OR, March 2015.

Proceedings publications

Grants

USDA-NIFA- 01/2016-12/2020, $3,739,199. CropSys-CAP- A novel management approach to increase productivity, resilience, and long-term sustainability of cropping systems in the northern Great Plains. PI: M. Berti Co-Pis: A. Wick, B.L. Johnson, D. Franzen, D. Ripplinger, A. Akyuz, H. Kandel, J. Ransom, A. Lenssen, K. Moore, R. Gesch, F. Forcella, and S. Wells

NC-SARE Professional Development Grant 10/2015-09/2016, $71,012. Enhancing soil health with cover crops in North Dakota: Training program PI M. Berti Co-Pi A. Wick

North Dakota Soybean Council- 04/2016-04/2017. $22,790. Broadcast seeding of cover crops into standing soybean to improve soil health. PI: M. Berti

Adaptation of cover crops to build soil health in the northern Plains, (5/2015-4/2017), amount: $27,020 PI: A. Wick

Eastern North Dakota Soil Salinity Demonstration Network, amount: $145,321 ($242,202 with match) PI: A. Wick

Extension publications/ field days

1. **Berti, M.T.,** and A. Wick. 2015. How to select a cover crop or cover crop mix? NDSU Forages webpage. Available at: http://www.ag.ndsu.nodak.edu/research/plantsciences/forages

Extension Field Days and Workshops

1. NDSCS Mentor meeting, 24 February, 2016, Havana, ND (30 participants)
2. Café Talks, Q&A session with farmers about cover crops 15 January and 16 February, 2016, Grand Forks, ND, farmers (30 participants).
3. Cover crops farmers meeting, Havana, ND, 21-22 January 2016, (30 participants).
4. Café Talks, Q&A session with farmers about cover crops 14 January and 11 February, 2016, Jamestown, ND, Stutsman county farmers (40 attendees).
5. Café Talks, Q&A session with farmers about cover crops 12 January 2016, Arthur, ND Cass-Traill counties. (20 attendees).
6. Café Talks, Q&A session with farmers about cover crops 5 January 2016 and 18 February, Milnor, ND. (30 attendees)
7. Cover crops in the northern Great Plains. Table talks, Conservation Tillage Annual Conference 15-16 December 2015, Wilmar, MN. (200 attendees)
8. NDSCS mentor Meeting, 110 December 2015, Havana, ND (30 attendees)
9. Cover crop field day, Toussaint's Farm, 27 October, 2015, Wahpeton, ND. (70 attendees)
10. Cover crop Tour, Soil Conservation District, Sargent County. 9 October, 2015. (70 attendees)
11. 2015 Cover Crops Field day. Cover crops field tour, NDSU Experimental Station, Fargo, ND, 2 October 2015. (50 attendees)
12. Traill County Soil Health Field Day, 29 September, Cummings, ND (20 attendees)
13. Grand Forks County Soil Health Field Day, 24 September, 2015, Grand Forks, ND (45 attendees)
14. Sargent County Soil Health Field Day, 9 September 2015, DeLamere, ND (100 attendees)
15. 2015 Soil Health Field Day. Cover crops workshop, Barney, ND - Marisol Berti. 6 August 2015. (100 attendees)
16. Enger Farm Tour, Cover crops Soil Health & Land Management, 20 July 2015, Hatton, ND.
17. Carrington REC field days 16 July 2015. Livestock Tour: Using winter rye, oats, and hairy vetch for haying and grazing. Organic tour: Using radish for a cover crop. Utilizing Winter Rye for Weed Suppression in Soybeans. (50 attendees)
18. Soil Health Train the Trainer Workshop for NDSU Ext Agents, 16-17 March 2015, Fargo, ND (5 attendees)
19. Managing for Soil Health Workshop, 5 March 2015, Havana, ND. (40 participants)
20. Café Talks, Q&A session with farmers about cover crops 5 February 2015, Milnor and Wahpeton, ND. (30 participants).

IMPACT STATEMENT (no more than 4 sentences)
Cover crops will impact North Dakota's economy by improving soil health, nutrient cycling, productivity of grain and energy crops, reducing expensive nitrogen inputs, and as a source of supplemental summer and fall forage.