South Dakota State University
South Dakota Agricultural Experiment Station

ANNUAL PROGRESS REPORT 2021

SOUTHEAST SOUTH DAKOTA EXPERIMENT FARM

SOUTH DAKOTA AGRICULTURAL EXPERIMENT STATION

SOUTH DAKOTA STATE UNIVERSITY

Southeast Research Farm
Growing Ideas Harvesting Answers

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South Dakota State University, South Dakota Counties and U.S. Department of Agriculture Cooperating.

This is an annual report of the research program at the Southeast South Dakota Research Farm in cooperation with South Dakota Agricultural Experiment Station and the SDSU College of Agriculture, Food, and Environmental Sciences and has special significance for those engaged in agriculture and the agriculturally related businesses in the ten county area of Southeast South Dakota. The results shown are not necessarily complete or conclusive. Interpretations given are tentative because additional data resulting from continuation of these experiments may result in conclusions different from those based on any one year.

Trade names are used in this publication merely to provide specific information. A trade name quoted here does not constitute a guarantee or warranty and does not signify that the product is approved to the exclusion of other comparable products. Some herbicide treatments may be experimental and not labeled. Read and follow the entire label before using.

The Southeast Farm is located at 29974 University Road, Beresford, SD 57004. Telephone 605-563-2989; Fax 605-563-2941; Farm Supervisor, Peter Sexton; email (peter.sexton@sdstate.edu).

Report available on web https://openprairie.sdstate.edu/agexperimentsta_rsp/

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ACKNOWLEDGEMENTS

The Southeast Farm would not get very far in terms of research work done without the good work of the staff – Garold Williamson, Ruth Stevens, Brad Rops, Scott Bird, and Chelsea Sweeter. We also want to acknowledge all those from SDSU campus at Brookings and SDSU Extension that contribute toward the work done at the farm including Sandeep Kumar, Péter Kovács, Jason Clark, Sara Bauder, Anthony Bly, David Karki, Paul O. Johnson, Dave Vos, Jill Alms, Emmanual Byamukama, Dalitso Yabwalo, Graig Reicks, Sharon Clay, Melanie Caffe, Adam Varenhorst, Philip Rozeboom, John McMaine, Gared Shaffer, Febina Mathew, Julie Walker, Warren Rusche, Zachary Smith, Bob Thaler, Crystal Levesque, and many more. The Nutrient Research and Education Council, the South Dakota Oilseed Council, the Soybean Council, and the Corn Council, support the farm through research grants and need to be acknowledged for their help. Our friends at the USDA/NRCS also support research at the farm and work with us on outreach activities – so I want to acknowledge them as well.

The members of the farm board – Al Novak, Gordon Anderson, David Ostrem, John Fahlberg, Jonathan Hagena, Todd Bye, Lee Brockmueller, Travis Machmiller, Norm Uherka, Chuck Wirth, Shane Merrill, Shane Nelson, Greg Kleinhans, and Harley Lerseth need to be acknowledged for their critical contribution to the research farm and its continued success. They play an important role in guiding the farm's research work and allocation of resources.

Support of the Ag Experiment Station at SDSU lead by Dr. William Gibbons, David Wright, Dept. Head Agronomy, Hort. and Plant Science, and Joe Cassidy, Dept. Head Animal Science, have also been important for the farm's operation. We look forward to continuing and expanding our interaction with SDSU faculty and college administrators in the coming year.

As always, we are thankful to God for yet another year that we can move forward with work, and we look forward with a good hope and a good will that this coming season will be a productive one.

This publication was edited and compiled by Ruth Stevens and Peter Sexton. The 2021 Annual Report, as well as Annual Reports from other years, are available on website: https://openprairie.sdstate.edu/agexperimentsta_rsp/

OUTREACH ACTIVITIES

Dakota Farm Show Booth; January

Fall Field Tour; September

High School Research Day; September

Extension Conference / Annual Meeting; December

INTRODUCTION ……………...………………………………………………..Peter Sexton
Farm Supervisor

This annual report represents the work of many faculty and staff at SDSU and of the crew here at the Southeast Farm. We hope you find it useful and of benefit for your operation. In case you would like to visit the farm for a plot tour, our annual field days are scheduled for:

SUMMER FIELD DAY - JULY 5th (focus on grain crops)

FALL FIELD DAY - SEPT. 15th (focus on forages and livestock)

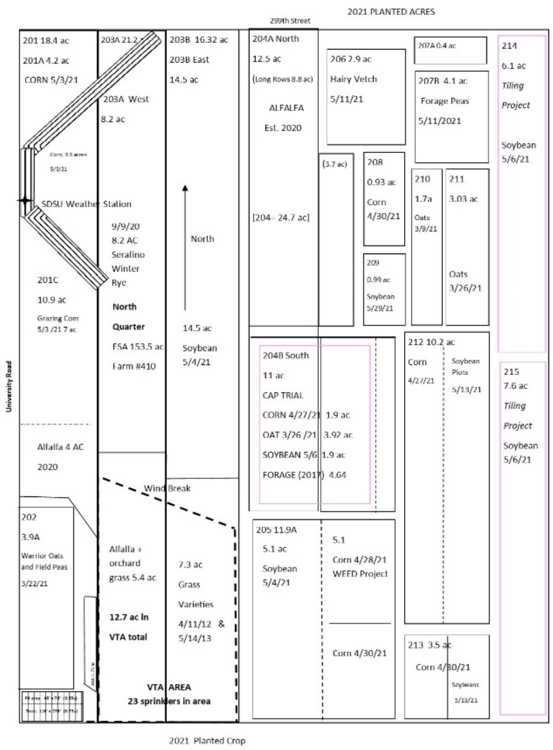
The 2021 season started out dry. From January of 2020, to the end of June of 2021, we were cumulatively behind 15.2" of moisture relative to our 60-year average. The drought stress became severe during June before we started to get some rainfall in July and August that kept the corn and soybean crops from being a total train wreck. Under these conditions, no-till corn and soybeans performed relatively well. In our long-term tillage trial, the no-till corn plots yielded 160 bu/ac on average, while in the tilled plots the average was 144 bu/ac. Similarly for soybeans, the no-till plots yielded 50 bu/ac while the conventional tilled plots yielded 40 bu/ac. The no-till corn did not look very good at the end of May, nevertheless the old saying of "don't judge by appearances" once again held true as it performed well by the end of the season.

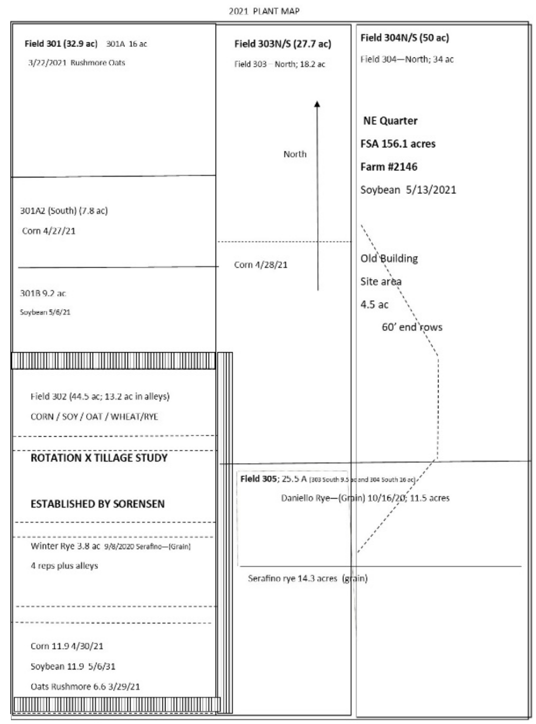
With the goal of adding profitable new crops to the rotation, we continue to work with hybrid rye in the hope that the market for it will develop enough for it to be grown on a large scale. In grain variety trials conducted in our part of the state, the better lines of hybrid rye showed a 15 bu/ac yield advantage over the better lines of open-pollinated rye - this in a drought year where yields were about half of expected. Given this yield advantage, it looks like the extra seed cost for hybrid lines should pay for itself. For forage production on the other hand, we don't see a significant benefit with hybrid lines. Hence the value of variety testing - for grain production hybrid lines appear to be a good investment (provided you have a market in hand for the grain), whereas for forage production it looks like cheaper open-pollinated lines such as 'Hazlett' perform as well as the hybrids. Given increasing concerns with herbicide resistant weeds and corn rootworm incidence, including a small grain crop in the rotation would have benefits for the whole system and should make it more resilient. Rye is very competitive with weeds. And its fibrous root system and potential for use of forage cover crops should also add to soil health and provide long-term benefit. We'll see how the rye market develops, and continue to work with improving corn and soybean agronomy as well.

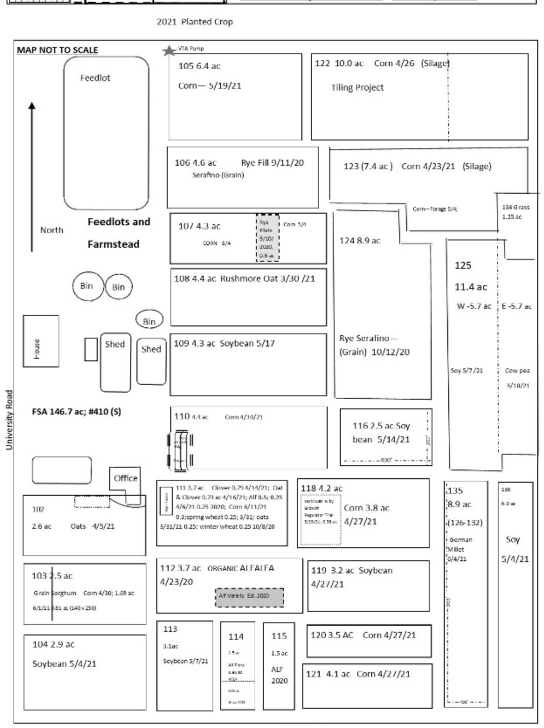
The world seems be getting shaken up by swings in politics, markets, supply chains, and climate. It’s good to reflect on resilience and to remember the everlasting things. In the meantime, we continue to go forward one day at a time thinking of Ben Franklin's words "distrust not Providence".

2021 Land Use Maps (maps not drawn to scale)

SDSU Southeast Research Farm, Beresford, SD







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Weather and Climate Summary; SDSU Southeast Farm Beresford, SD 2021

Ruth Stevens*, Peter Sexton,
Brad Rops, Scott Bird, Garold Williamson,
and Dr. Rueben Behnke[2]

The SDSU Southeast Research Farm (SERF) continued to experience drought conditions especially during the first half of 2021. Small grains suffered from lack of moisture and high temperatures in June. SERF did receive some well-timed rains in mid to late summer that helped row crops mature. Late summer and fall moisture helped with establishment of fall planted crops. SERF is still dealing with shortages of subsoil moisture resulting from drought conditions (Jan 2020 – Dec 2021 shortfall 13 in), and will need timely precipitation for crop development in the coming year.

The 2021 weather, long-term climate information and Ag Weather Summary[2] for the Southeast Farm is summarized in tables and figures found on pages 2 thru 7.

Average temperatures compared to daily temperatures are highlighted in Figure 1, and monthly temperature averages are shown in Table 1.

Annual precipitation for 2021 at SERF was 23.59" (92% of normal), (Table 2 and 3). Growing season precipitation measured from April through September was 79% of normal (-3.97"). SERF received 23" of snowfall in 2021; 16" in first half of year, and 7" in last half of year.

The coldest and hottest temperatures of the year were recorded on February 16th (-34°F) and June 5th and 6th (99°F) respectively, a 133-degree temperature range (Table 3). Frost-free season at the farm in 2021 was 158 days on a 32°F basis and on a 28°F-basis. The last spring frost/freeze was on May 11 (28°F). The first fall frost/freeze occurred on October 16 (27°F). The average annual high temperature was 61°F and average annual low temperature was 37°F; which were both above average (+1.6 and +1.1 degrees, respectively).

The 2021 growing season (April – October) accumulation of growing degree units (GDU's) was 3316 units, which is 112% (+350) of average. Evaporation recorded at the SERF from May through September was 40.3" (Fig. 6 & 7); while receiving 12.7" of rainfall during the same period.

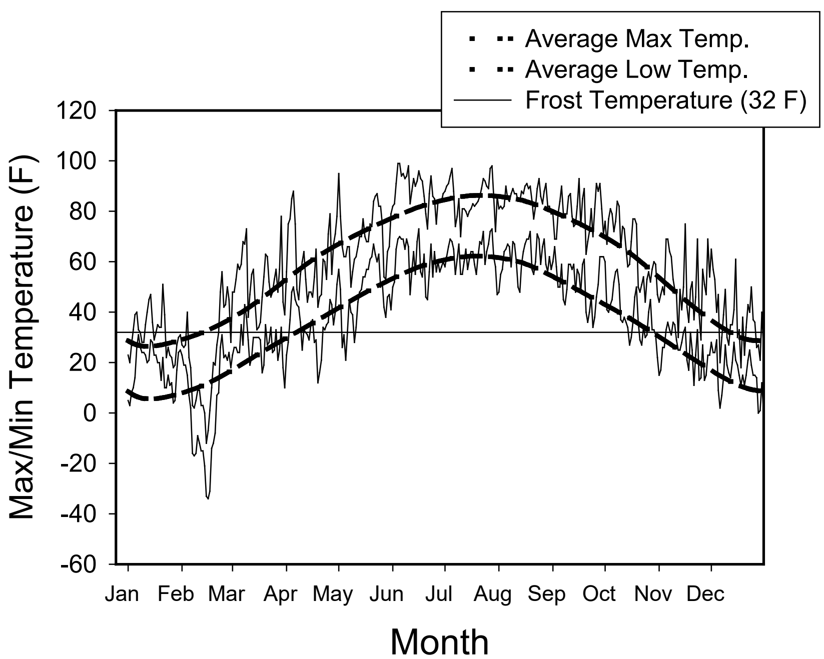
* *Corresponding author: Ruth.Stevens@sdstate.edu;*
[2]*Mesonet Research Climatologist, mesonet.sdstate.edu*

Table 1. Temperatures[a] at the Southeast Research Farm - 2021

	2021 Average Air Temps. (°F)		69-year Average Air Temps. (˚F)		Departure from 69-year Average (˚F)	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
January	31.8	17.6	26.7	6.0	+5.1	+11.6
February	20.3	-0.2	31.8	10.8	-11.5	-11.0
March	52.0	27.2	44.3	23.1	+7.7	+4.1
April	59.3	33.0	59.9	35.0	-0.6	-2.0
May	70.1	47.3	71.8	47.3	-1.7	0.0
June	88.4	59.4	82.9	58.9	+3.8	+4.0
July	85.4	62.9	87.2	63.1	-0.8	+6.2
August	85.8	61.4	85.1	60.3	+0.1	-1.1
September	79.8	51.8	76.8	50.2	-0.6	-2.7
October	65.8	40.2	64.1	37.9	-8.5	-8.6
November	50.5	25.0	46.1	24.0	+4.4	+0.7
December	38.0	16.5	31.4	11.8	+6.7	0.0

[a] Computed from daily observations

Figure 1. 2021 Average Temperatures



ACKNOWLEDGEMENT

Weather data is compiled from daily observations collected by SDSU Southeast Farm Personnel in cooperation with South Dakota State Climatologist, South Dakota Office of Climatology, and the National Weather Service, Sioux Falls, SD. More climate information available at South Dakota Mesonet - South Dakota State University: *mesonet.sdstate.edu*

Table 2. Precipitation[a] at the Southeast Research Farm - 2021

Month	Precipitation 2021 (inches)	69-year Average	Departure from Avg. (inches)
January	1.01	0.46	+0.55
February	0.30	0.78	-0.48
March	2.33	1.46	+0.87
April	2.45	2.53	-0.08
May	2.07	3.53	-1.46
June	0.71	4.14	-3.43
July	3.02	3.08	-0.06
August	3.88	3.05	+0.83
September	3.05	2.82	+0.23
October	3.32	1.94	+1.38
November	0.19	1.12	-0.93
December	1.26	0.67	+0.59
Totals	23.59	25.58	-1.99

[a] Computed from daily observations

Table 3. 2021 Climate Summary Southeast Research Farm, Beresford, SD

Annual Precipitation (inch)	23.59	92%* (-1.99)
Growing Season Precip (Apr-Sep, inch)	15.18	79% (-3.97)
Jan-Mar	3.64	135% (+0.94)
Apr-Jun	5.23	51% (-4.97)
Jul-Sep	9.95	111% (+1.00)
Oct-Dec	4.77	128% (+1.04)
Annual Snow (inch); (Jan-Jun/Jul-Dec)	23	16 / 7
Growing Degree Units (GDU); Apr – Oct (50 degree basis)	3316	112% (+350)
Minimum / Maximum Air Temp, ºF	-34°F Feb 16	99°F June 5 & 6
Last Spring Frost; 32º / 28º basis	28°F May 11	28°F May 11
First Fall Frost; 32º / 28º basis	27°F Oct 16	27°F Oct 16
Frost Free Period (days); 32º / 28º basis	158	158
Average Annual High / Low	61/ 37	+1.6 / +1.1

* % of Normal

Figure 2. 2021 Monthly Precipitation; Southeast Farm, Beresford, SD

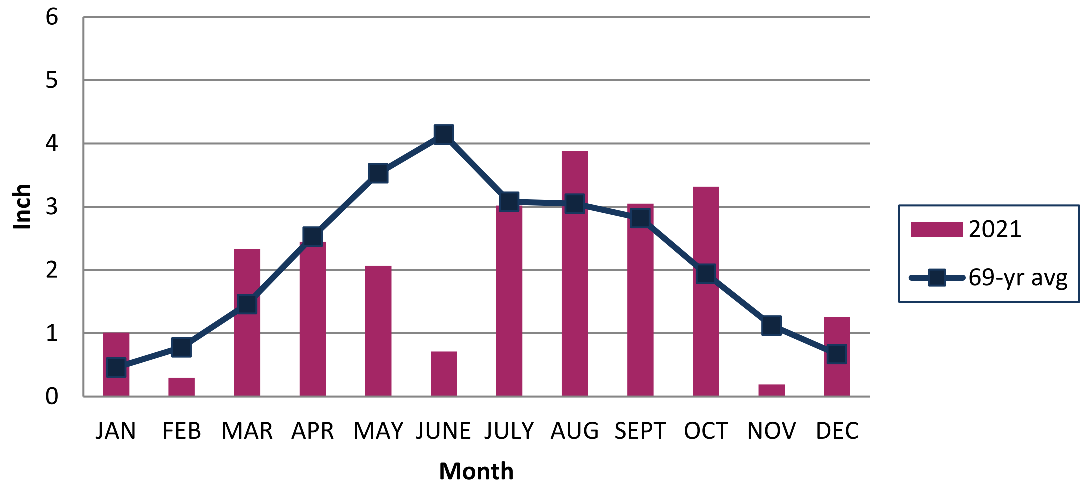


Figure 3. 2021 Cumulative Precipitation, Southeast Farm, Beresford, SD

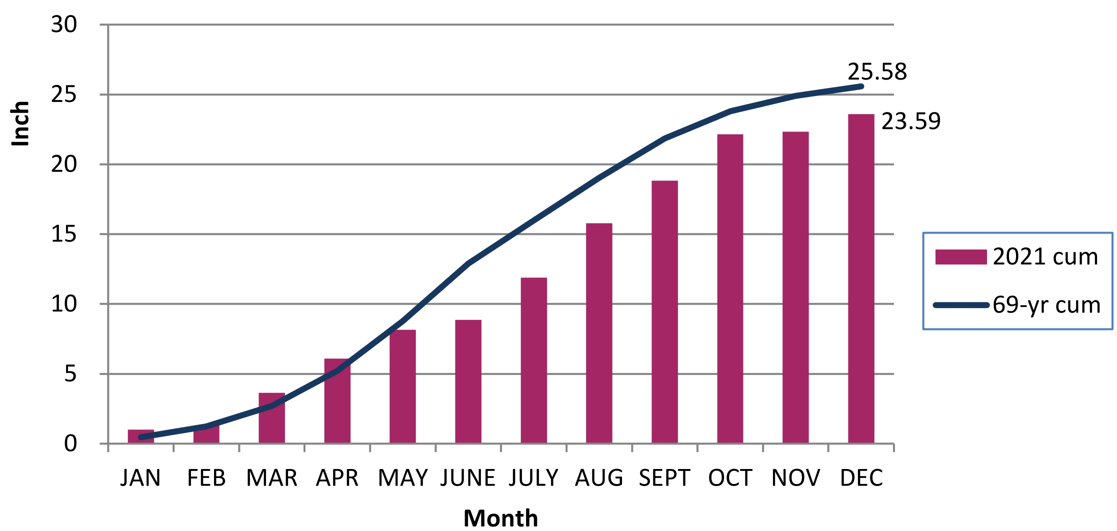


Figure 4. 2021 Growing Degree Units (GDU's); Southeast Farm, Beresford SD

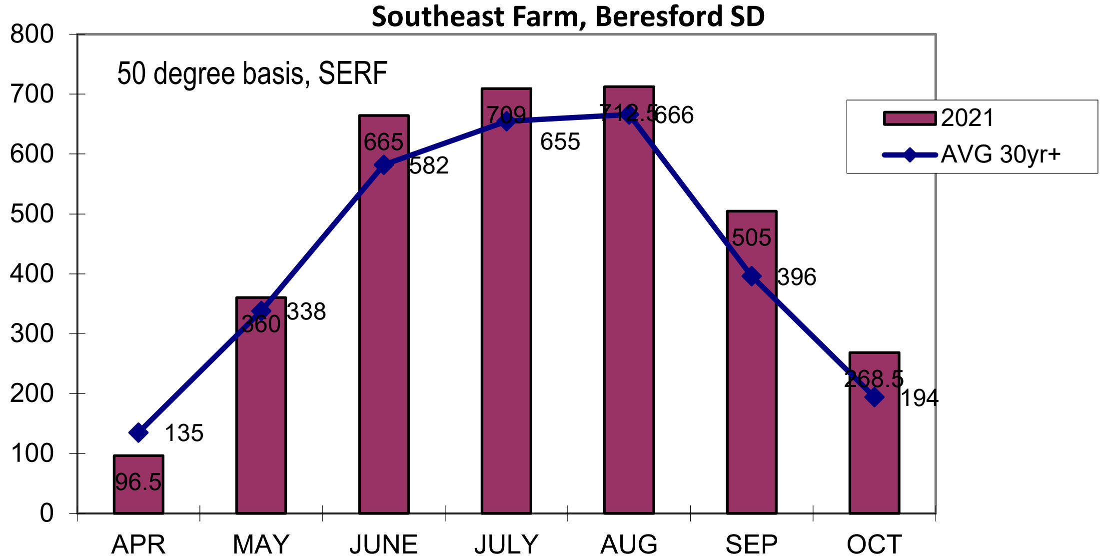


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Figure 5. 2021 Cummulative GDU's; Southeast Farm, Beresford, SD

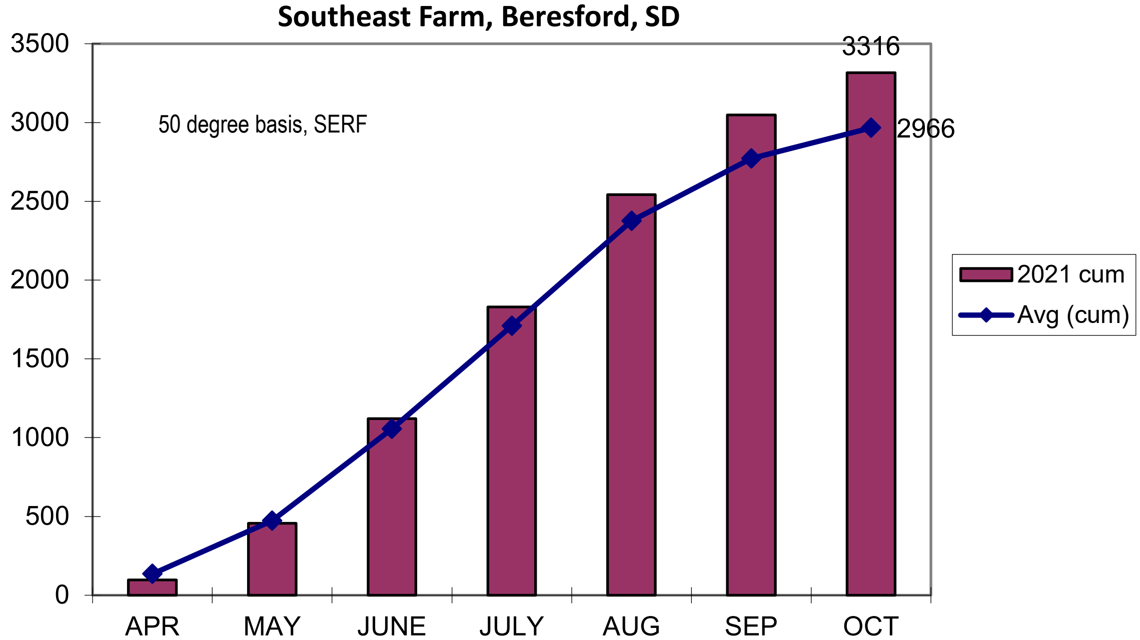


Figure 6. 2021 Growing Season (May-Sep)
Rainfall vs. Evaporation
Southeast Farm

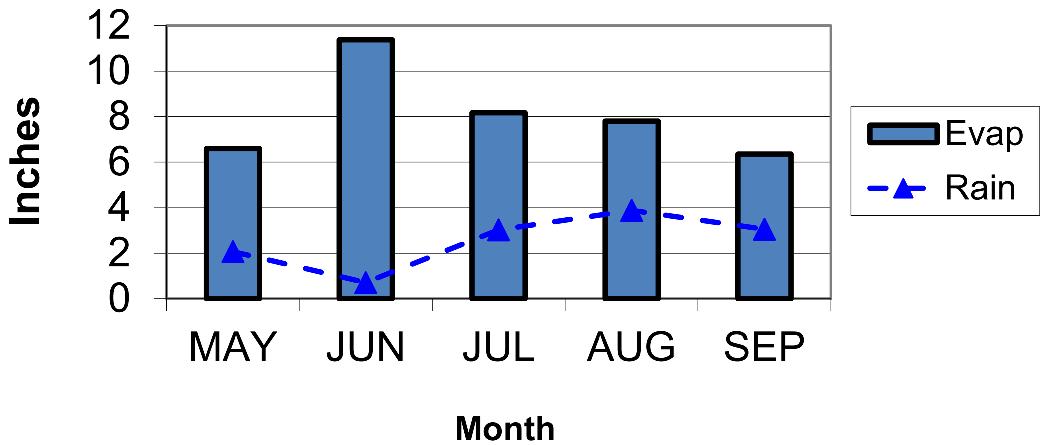
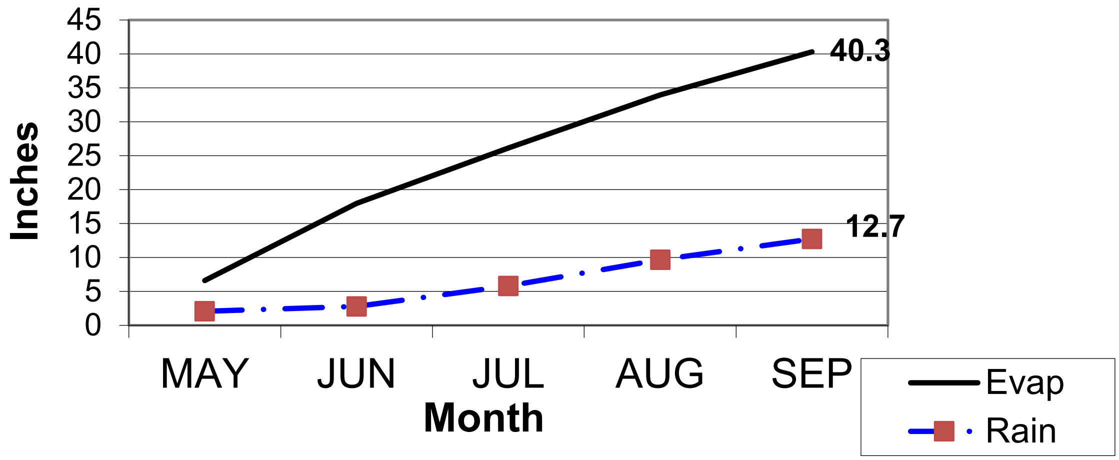


Figure 7. 2021 Growing Season (May-Sep)
Cumulative Rainfall vs. Evaporation
Southeast Farm



2021 Ag Weather Summary

Precipitation (May-September)

Total	11.77 in
Departure from Normal	-5.76 in
Greatest	1.42 in, Sep 20
Days with Precipitation	39 of 153

Reference Evapotranspiration

Total	28.21 in

Growing Season

Growing Degree Days	2931
Departure from Normal	+326
Stress Degree Days	290
Frost-Free Season	May 12 to Oct 15 (157 days)
Normal Season Frost-Free Season	Apr 11 to Oct 24 (197 days)

Air Temperature

Average	49°F
Departure from Normal	+3°F
Maximum	99°F, Jun 5
Minimum	-34°F, Feb 16
Frost Days	161

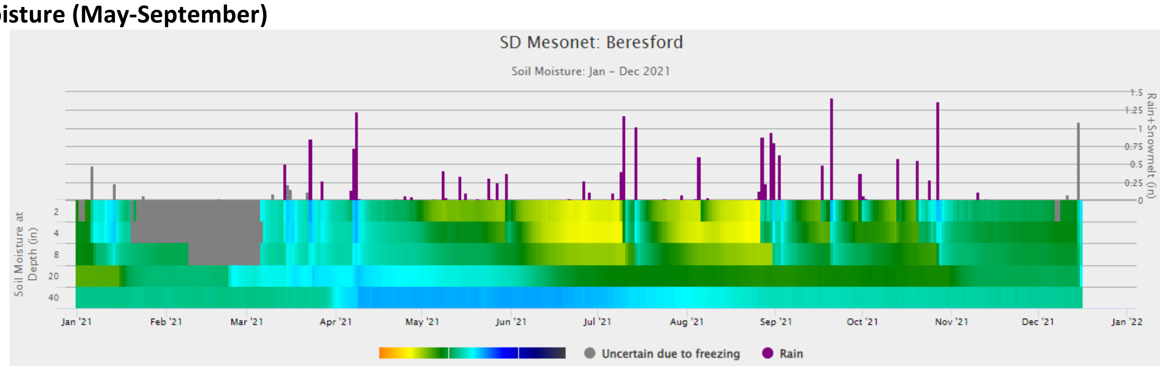
Soil Temperature

Average (4 in, bare)	55°F
Maximum (4 in, bare)	95°F, Jul 24
Minimum (4 in, bare)	28°F, Feb 17
First ≥ 40°F Daily Average (4 in, bare)	Mar 5
First ≥ 50°F Daily Average (4 in, bare)	Apr 3
Max Frost Depth (sod)	14 in, Feb 20
Frost-Free Season	Mar 7 to Dec 7 (276 days)

Wind

Maximum Gust (3 second)	48 mph, Mar 30
Maximum Speed (5 minute)	34 mph, Mar 30

Soil Moisture (May-September)



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Long-Term Rotation and Tillage Study: Observations on Corn and Soybean Yields in 2021

Peter Sexton[1], Brad Rops, Ruth Stevens, and Garold Williamson.

INTRODUCTION

In 1991 Dale Sorensen initiated a long-term rotation study at the Southeast Farm including comparison of no-till and conventional till under two year (corn-soybean), three year (corn-soybean-small grain or field pea) and a 4-year flex rotation (currently corn-soybean-oat-winter rye); note the three year and flex rotations have not been constant over the years. The advantages of no-till are many: savings on fuel, equipment and labor; residue on the surface protects the soil from erosion; it helps to maintain soil organic matter, which is important for good tilth; conserves moisture and limits run-off; requires fewer trips across the field. The disadvantages are the loss of tillage as a tool for weed control and slower warming of the soil in the spring. This report provides a short analysis of corn and soybean yield data from the 2021 season that was marked by drought stress in the first half of the season. This drought began the previous year (2020), so the crop began the 2021 season with very little moisture reserve and severe stress developed during June. Rainfall in July and August somewhat mitigated the effects of stress on yield of the corn and soybean crops, nevertheless yields were 20 to 30 % less than hoped for across the Southeast Farm.

METHODS

As mentioned earlier, this set of plots was first established in 1991. The two-year corn-soybean has been consistently followed. The three-year rotation started with corn, soybean, and small grain and then for several years field pea was substituted for small grains, and then it was later switched back to a corn-soybean-small grain pattern. The four year rotation initially included alfalfa, then after some years was changed to include peas, and later was changed again to include two soybean crops (corn-soybean-winter wheat-soybean), which was the case until the 2013 season. Since 2013, the 4-year 'flex' rotation has been in a corn-soybean-oat-winter wheat/rye sequence.

This trial is laid out in a randomized complete block design with four replications using a split-plot arrangement. Rotation is the main plot, with tillage (plot size was 60 by 300 feet) as the subplot. The no-till plots, as their name implies, have not been tilled since the trial began in 1991. The tilled plots have been chisel plowed in the fall following harvest of corn and small grains, and worked in the spring with a field cultivator. Where wet conditions in the fall prevented chisel plowing corn stubble, the tilled plots were disked in the spring and then field cultivated.

[1] *Corresponding author; Peter.Sexton@sdstate.edu*

Since 2013, the tilled plots have been split plus/minus the use of a cover crop (sub-subplot size of 30 by 300'). The cover crop treatment currently consists of winter rye after each crop in the two-year (corn/soybean) rotation; and winter rye following corn ahead of soybean in the three and four-year rotations, with a brassica/legume blend (radish, turnip, lentils, and peas) following small grain harvest going to corn.

Yield was determined using a Zürn small plot combine (Model 150) from the center 5' of corn plots and from the center 5' of soybean plots, running the whole length of the plot. A sample was kept for determination of moisture and test weight. Stands counts were taken from 6' of row out of each plot. Data was analyzed as a split-split plot design (main plots being rotation and tillage being the sub-plot with cover crop as the sub-subplot) for corn and soybean yields using the Proc GLM routine in SAS statistical software. All interaction terms were evaluated using the residual error term in the F-test. This report will only address results from the 2021 growing season.

RESULTS and DISCUSSION

Corn Yields

In the 2021 season marked by severe drought stress early in the season, the no-till plots showed a clear yield advantage over the tilled plots and there was a significant tillage by rotation interaction on corn yield (Table 1). The no-till plots showed higher grain moisture, seed weight, and yield relative to the tilled plots, and also showed a strong response to rotation, whereas the tilled plots did not show a rotation effect (Table 2). Looking at yield across rotation and cover crop treatments, the no-till plots averaged 160.5 bu/ac while the tilled plots averaged 144.2 bu/ac – a difference of 16 bu/ac (Table 3). The cover crop treatment did not show a significant effect on yield in this trial for the 2021 season (Table 3). In another part of the farm, we observed a negative effect of cover crop use on corn yield (see the results from the comparison of cover crops for corn on page 16 of this report; SERF AR 2104). The moisture used by the cover crop may have cancelled out the benefits of cover crop use on soil health this past season. There was a trend for poorer performance in terms of seed-size and yield in the tilled plots under a 3-year rotation. It is somewhat speculative, but one hypothesis for this may be that volunteer oats in the three year rotation used fall moisture, while tillage left no residue on the surface so that these plots tended to do poorer than either the no-till plots and the 2-year tilled plots.

Soybean Yields

Similar to corn, soybeans in the no-till system out-yielded those in the tilled system for the 2021 season in this trial (Table 4). Unlike the corn plots, the effect of rotation length on soybean yield was non-significant even in the no-till plots (Table 5). On average the no-till plots showed a 10 bushel per acre yield advantage of the tilled plots (50.5 vs. 40.5 bu/ac respectively – Table 6). Cover crops (in this case winter rye) did not show a consistent effect on yield one way or another across tillage and rotation treatments used in this trial for the 2021 season.

ACKNOWLEDGEMENT

The authors appreciate the contributions of the South Dakota Agricultural Experiment Station to support this research.

Table 1. Stand, test weight, grain moisture, 100-seed weight, and yield of corn in the 2021 season raised with conventional and no-till management in two, three, and four-year rotations at the Southeast Research Farm in Beresford, South Dakota. This is part of a long-term study that was initiated in 1991. The other crops in the rotations have changed sometimes over the years, but corn has always been raised on the given two, three or four year cycle.

Rotation	Tillage	Cover Crop	Stand	Test Wt	Moisture	100-Seed Wt.	Yield
(yr)			(plt/ac)	(lb/bu)	(%)	(g)	(bu/ac)
4	NT	Y	33396	58.9	15.8	29.8	177.9
4	NT	N	29766	58.2	15.8	29.7	173.0
4	CT	Y	31944	59.4	13.0	26.1	145.5
4	CT	N	28314	59.3	13.2	28.1	146.3
3	NT	Y	32670	58.6	14.9	28.0	153.4
3	NT	N	31944	59.1	14.4	29.0	161.9
3	CT	Y	31218	59.0	12.6	23.9	130.6
3	CT	N	29766	59.1	12.7	24.2	141.2
2	NT	Y	31218	58.9	13.7	25.5	147.4
2	NT	N	29766	58.7	13.6	25.6	149.6
2	CT	Y	29766	59.4	13.1	26.1	151.1
2	CT	N	29040	59.5	13.2	27.8	150.3
		Mean	*30734*	*59.0*	*13.8*	*27.0*	*152.4*
		CV (%)	*9.0*	*0.6*	*3.2*	*5.3*	*7.8*
		Rotation (A)	*NS*	*NS*	*NS*	*<0.10*	*<0.10*
		Tillage (B)	*<0.05*	*NS*	*<0.01*	*<0.01*	*<0.05*
		Cover Crop (C)	*<0.05*	*NS*	*NS*	*<0.10*	*NS*
		AxB	*NS*	*<0.10*	*<0.01*	*<0.01*	*<0.01*
		BxC	*NS*	*NS*	*NS*	*NS*	*NS*
		AxC	*NS*	*<0.10*	*NS*	*NS*	*NS*
		AxBxC	*NS*	*NS*	*NS*	*NS*	*NS*

Table 2. Grain moisture, 100-seed weight, and yield for corn grown under no-till and tilled systems with 2, 3, and 4-year rotations at the SDSU Southeast Research Farm in Beresford, SD in 2021. There were significant tillage by rotation interactions for these three variables. Note the no-till plots responded strongly to crop rotation while the tilled plots did not in this season.

Rotation Length	Moisture (%)		100-Seed Wt (g)		Yield (bu/ac)	
	Till	No-Till	Till	No-Till	Till	No-Till
4-year	13.1	15.8	27.1	29.7	145.9	175.5
3-year	12.6	14.7	24.1	28.5	135.9	157.6
2-year	13.1	13.7	26.9	25.6	150.7	148.5
Mean	*13.0*	*14.7*	*26.0*	*27.9*	*144.2*	*160.5*
CV(%)	*2.7*	*3.5*	*6.3*	*4.2*	*9.6*	*6.0*
LSD (0.10)	*NS*	*1.2*	*NS*	*1.0*	*NS*	*16.9*

Table 3. Comparison of average stand at harvest, test weight, moisture, 100-seed weight and yield for tillage treatments and cover crop use across all other treatments for corn grown in a long-term tillage by rotation study at the Southeast Research Farm in Beresford, South Dakota for the 2021 growing season.

Tillage	Stand	Test Wt	Moisture	100-Seed Wt.	Yield
	(plt/ac)	(lb/bu)	(%)	(g)	(bu/ac)
NT	31460	58.7	14.7	27.9	160.5
CT	30008	59.2	13.0	26.0	144.2
Mean	*30734*	*59.0*	*13.8*	*27.0*	*152.4*
P-value	*<0.05*	*NS*	*<0.01*	*<0.01*	*<0.05*

Cover Crop	Stand	Test Wt	Moisture	100-Seed Wt.	Yield
	(plt/ac)	(lb/bu)	(%)	(g)	(bu/ac)
N	29766	59.0	13.8	27.4	153.7
Y	31702	59.0	13.9	26.6	151.0
Mean	*30734*	*59.0*	*13.8*	*27.0*	*152.4*
P-value	*<0.05*	*NS*	*NS*	*<0.10*	*NS*

Table 4. Stand, test weight, grain moisture, 100-seed weight, and yield of soybean in the 2021 season raised with conventional and no-till management in two, three, and four-year rotations at the Southeast Research Farm in Beresford, South Dakota. This is part of a long-term study that was initiated in 1991. The rotation length has varied for soybeans in previous years, but since 2012 soybeans have been on a 2, 3, or 4-year rotation length as per the rotation length indicated. Winter rye is used as a cover proceeding soybeans in this study.

Rotation Length	Tillage	Cover Crop	Stand	Test Wt	Moisture	100-Seed Wt.	Yield
(yr)			(plt/ac)	(lb/bu)	(%)	(g)	(bu/ac)
4	NT	Y	96558	52.7	8.5	16.1	50.9
4	NT	N	84216	53.0	8.2	16.6	51.4
4	CT	Y	94380	52.7	8.3	16.8	41.4
4	CT	N	106722	52.9	8.2	16.6	41.2
3	NT	Y	100188	53.8	8.1	16.0	49.2
3	NT	N	92928	52.6	8.1	16.1	50.1
3	CT	Y	100188	52.5	8.3	15.1	38.7
3	CT	N	105270	50.9	8.2	14.9	37.8
2	NT	Y	94380	54.2	8.9	15.8	48.8
2	NT	N	95106	54.7	8.7	16.0	52.9
2	CT	Y	98736	52.4	9.0	16.3	41.7
2	CT	N	103818	53.3	8.5	16.2	42.0
		Mean	*97707*	*52.9*	*8.4*	*16.0*	*45.5*
		CV (%)	*6.7*	*2.2*	*3.2*	*4.4*	*6.0*
		Rotation (A)	*NS*	*NS*	*<0.05*	*<0.05*	*NS*
		Tillage (B)	*<0.05*	*<0.01*	*NS*	*NS*	*<0.01*
		Cover Crop (C)	*NS*	*NS*	*<0.05*	*NS*	*NS*
		AxB	*NS*	*NS*	*NS*	*<0.05*	*NS*
		BxC	*<0.01*	*NS*	*NS*	*NS*	*NS*
		AxC	*NS*	*<0.05*	*NS*	*NS*	*NS*
		AxBxC	*NS*	*NS*	*NS*	*NS*	*NS*

Table 5. Grain moisture, 100-seed weight, and yield for soybeans grown under no-till and tilled systems with 2, 3, and 4-year rotations at the SDSU Southeast Research Farm in Beresford, SD in 2021. Note the soybeans responded strongly to no-till management, but not to rotation length, in the 2021 season.

Rotation Length	Moisture (%)		100-Seed Wt (g)		Yield (bu/ac)	
	Till	No-Till	Till	No-Till	Till	No-Till
4-year	8.3	8.4	16.7	16.4	41.3	51.1
3-year	8.3	8.1	15.0	16.0	38.2	49.7
2-year	8.8	8.8	16.2	15.9	41.9	50.8
Mean	*8.4*	*8.4*	*15.7*	*16.1*	*40.5*	*50.5*
CV(%)	*3.7*	*2.7*	*4.5*	*4.3*	*8.3*	*3.8*
LSD (0.05)	*NS*	*0.2*	*1.2*	*NS*	*NS*	*NS*

Table 6. Comparison of average stand at harvest, test weight, moisture, 100-seed weight and yield for tillage treatments and cover crop use across all other treatments for soybeans grown in a long-term tillage by rotation study at the Southeast Research Farm in Beresford, South Dakota for the 2021 growing season.

Tillage	Stand	Test Wt	Moisture	100-Seed Wt.	Yield
	(plt/ac)	(lb/bu)	(%)	(g)	(bu/ac)
NT	93896	53.5	8.4	16.1	50.5
CT	101519	52.4	8.4	16.0	40.5
Mean	*97707*	*52.9*	*8.4*	*16.0*	*45.5*
P-value	*<0.05*	*<0.01*	*NS*	*NS*	*<0.01*

Cover Crop	Stand	Test Wt	Moisture	100-Seed Wt.	Yield
	(plt/ac)	(lb/bu)	(%)	(g)	(bu/ac)
N	98010	52.9	8.3	16.1	45.9
Y	97405	53.0	8.5	16.0	45.1
Mean	*97707*	*52.9*	*8.4*	*16.0*	*45.5*
P-value	*NS*	*NS*	*<0.05*	*NS*	*NS*

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Corn Row Width Study – 2021 Season

Peter Sexton[1], Jasdeep Singh, Garold Williamson, and Brad Rops

INTRODUCTION

There is increased interest in looking at wider row widths in order to facilitate inter-seeding of cover crops into corn. Also, there is interest in looking at narrower row spacing to increase grain yields. The effect of row width on corn yield has been studied in the past, but given the greater yield potential and higher seeding rates used with current-day hybrids, it was felt that it may be useful to revisit this topic. Understanding the effect of row width on yield would be helpful for those interested in either widening, or narrowing, their row spacing.

METHODS

The line 'Viking 051-04GS-P' was seeded at a depth of 2.5" on 04 May, 2021 at the Southeast Research Farm. Treatments consisted of row widths of 15, 30, 45, and 60" at a seed rate of 30,000 seeds per acre. Plots were 15’ wide by 30’ in length laid out in a randomized complete block design with three replications. Yield was determined by harvesting one (60" and 45" spacing), two (30" spacing), or four (15" spacing) inner rows from each plot with a Zürn Model 150 small plot combine.

RESULTS

Yield versus row spacing is plotted in Figure 1 along with data from last year's trial. The 2021 season had more severe drought stress so yields were lower than in 2020, but nevertheless, the slope of the yield response to row width was similar across the trials averaging 0.56 bu/ac per inch of increase in row width from 15" to 60". In order to pool the data together, the yields were normalized as a percent of 30" row yield for each trial and seed rate and then plotted against row width (Fig. 2). The pooled regression analysis predicts that yield will drop three-tenths of a percent for each inch that row spacing is increased from 15 up to 60". For example, this relation would predict that at expected yields of 150, 200, and 250 bu/ac, one would expect to see the yield shift 4.5, 6, and 7.5 bu/ac, respectively, for a 10-inch shift in row spacing. While the trials from 2020 and 2021 are consistent with each other, it would be good to repeat the study as both years experienced drought stress and the relation between yield and row spacing may be different in a wetter growing season.

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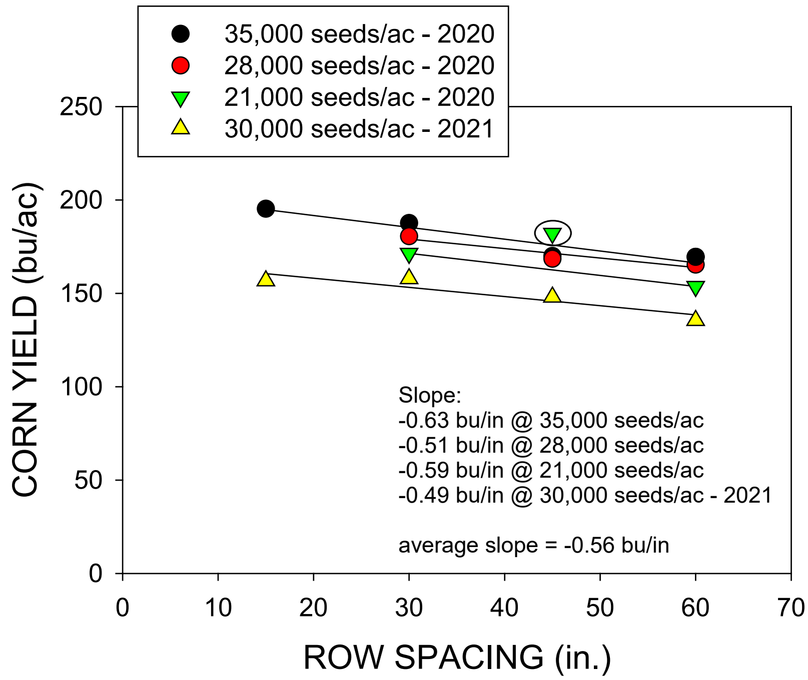

Figure 1. Corn yield versus row spacing from trials conducted in 2020, and 2021, at the Southeast Research Farm in Beresford, South Dakota. The trial in 2020 included 3 seed rates (21,000, 28,000, and 35,000 seeds per acre) while the trial in 2021 had only one seed rate (30,000 seeds per acre). The circled point was treated as an outlier and not included in the regression analysis.

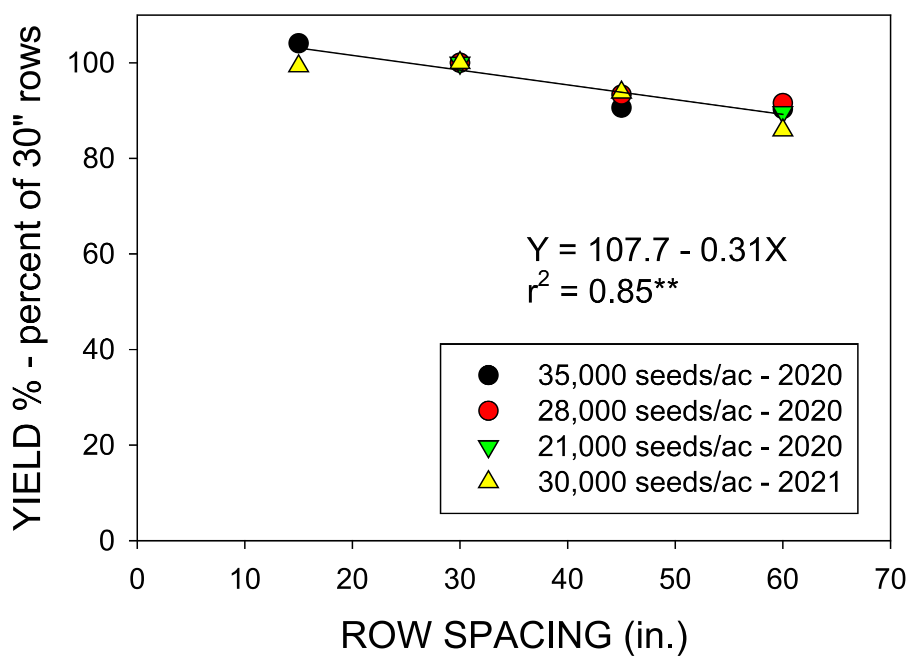

Figure 2. Corn grain yield normalized as a percent of yield at a 30" row spacing for two studies on row spacing conducted at the Southeast Research Farm in the 2020, and 2021, growing seasons. The regression line shown is on the pooled data from the two studies.

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Comparison of Banded and Solid Seeded Rye and Hairy Vetch as Cover Crops versus a Radish/Pea Blend and a No Cover Crop Control on Yield of the Following Corn Crop

Peter Sexton[1], Brad Rops,
and Chelsea Sweeter

INTRODUCTION

This trial was initiated to compare use of seeding alternating bands of a winter rye/hairy vetch blend with a pea/radish blend on 30" centers, versus solid seeding a mixture of all of them. The idea here is to establish the rye and hairy vetch in such a way as to maintain a living root system into the following spring while leaving open areas on 30" centers (where the radish and pea were banded – which will winter kill) to plant corn into. These two treatments were compared to a solid-seeded pea/radish blend and a no cover-crop control in a trial with four replications at the Southeast Farm.

METHODS

The cover crop treatments were direct seeded into winter rye stubble on 05 August, 2020 using a no-till drill. The row spacing on the drill was 7.5". It was set up so two adjacent rows delivered a rye/vetch mix, while the neighboring two adjacent rows delivered a radish/pea mix (i.e. alternating two rows of one mix followed by two rows of the other). Individual plots were 15' wide (6 rows) by 180' in length. Plots were laid out in a randomized complete block design with four replications. A burndown herbicide mixture was applied the following spring on 26 April, 2021 and corn (PIO 0306AM) was seeded on 30 April, 2021. Fertilizer was applied as 102 lbs/ac UREA and 62 lbs/ac AMS (60-0-0-15) on 14 April, 2021 Initially it was intended to side dress the corn with UAN; however, because of severe drought stress which developed in June, it was decided not to apply additional N fertilizer to this field. Plots were harvested on 14 October, 2021 using a two-row small plot combine (Zürn Model 150) taking out the two center rows of each plot. Data were subjected to standard ANOVA using the Proc GLM subroutine in SAS statistical software.

RESULTS

All of the three cover crop treatments tested caused corn yield to decline from 10 to 13 bu/ac relative to the control (Table 1). Other than work with winter rye, this is the first time we have observed decreased corn yield in response to use of a cover crop at the Southeast Farm. In other years working with cover crops that winter-kill, we have seen a positive yield effect

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(typically 8 to 14 bu/ac) with the use of radishes and cool-season broadleaf blends, or no effect with grass-based blends. However, in this case we observed a yield decline with the use of a radish/pea blend even though it did not survive the winter. We postulate that this was an effect of the severe drought stress which started last year (2020) and carried over into July of 2021. This drought meant that the profile was not recharged with moisture over the winter and spring. The cover crops used moisture in the fall that was not replaced. The radish/pea mix would not have used moisture in the spring, but it would most likely have contributed to more rapid decomposition of rye stubble – resulting in less moisture and less residue in June and July of the following year. The patterns including rye and vetch would have used moisture in the spring as well as in the fall. Looking back, if one wanted to use a cover crop, it may have been better in this situation to use a warm-season cover crop blend such as millet and cowpea at a low seed rate as this would not grow late into the fall but would die at the first frost – even without a frost once temperatures cooled below 50 F most of the day these crops would not grow much. This approach might conserve moisture more than a radish/pea blend would. This is speculative, but with a mid to late August planting date and a moderate seed rate, it might perform better at conserving moisture. This is an area that could use further research.

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Table 1. Stand, grain moisture, test wt., 100-seed wt., and grain yield at harvest for corn following three different cover crop treatments, along with a no-cover crop control. The cover crops were established the previous season (2020) following harvest of winter rye at the Southeast Research Farm in Beresford, South Dakota.

Treatment	Stand	Moisture	Test Wt.	100-Seed Wt.	Yield
	(plt/ac)	(%)	(lb/bu)	(g)	(bu/ac)
Control	29040	15.1	58.9	30.1	168.9
Radish/Pea	30492	14.8	59.2	27.8	158.9
Mixed	29040	15.3	59.2	28.4	156.0
Band	31218	15.0	58.9	28.1	154.8
mean	*29948*	*15*	*59.1*	*28.6*	*159.7*
CV (%)	*9.5*	*1.8*	*0.4*	*2.8*	*3.6*
LSD (0.05)	*NS*	*NS*	*NS*	*1.3*	*9.3*

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Winter Rye Grain Variety Trial - 2021 Season

Peter Sexton[1], Brad Rops,
Chelsea Sweeter, and David Karki

INTRODUCTION

With the advent of high-yielding lines of hybrid rye there appears to be some potential for this crop to be profitable in our region. Recent feeding trials at the Southeast Research Farm (SERF) with beef cattle and with swine indicate it has potential as a component of livestock rations. If this market develops, then there would be scope for rye grain production to expand in our work area. Rye would be a valuable addition to the corn-soybean rotation. It is very competitive with weeds, and adding a third crop would disrupt the lifecycle of pests such as the western and northern corn rootworms. It is a cool-season grass with a fibrous root system, which would benefit soil health. For farmers with livestock, it would provide an opportunity to produce straw, a place to put manure in the late summer, and potential to produce a cover crop for fall or winter grazing. Given its potential, it seems appropriate to conduct research with this crop to further evaluate its yield potential. With this in mind, a series of variety trials were conducted in southeastern South Dakota (Kimball, Artesian, Tyndall, Lennox, and Beresford) to compare lines of rye for grain yield production in our environment.

METHODS

At each site, rye was direct-seeded using a small plot drill. Plot size was 5 by 20' and plots were laid out in a randomized complete block design with four replications. Planting dates in 2020 were as follows: Tyndall, Sept. 16; Kimball, Sept. 30; Artesian, Oct. 5; Lennox, Nov 5; Beresford (SERF) Sept. 18. There were two locations with variety trials at the SERF (Beresford). Fertilizer was applied as 120 lbs/ac MAP and 80 lbs/ac AMS (30-62-0-19). Yields were determined at maturity by harvesting the plots with a small plot combine (Zürn Model 150).

RESULTS

Rye yields were low, only about half of expected, in 2021 due to drought stress. Nevertheless, on average across the six sites, the best hybrid lines yield about 15 bu/ac more than did the best open-pollinated lines (Table 1). The Artesian site had the greatest yields with the better lines producing over 80 bu/ac at that site (Table 2). Data from each individual location are shown in Tables 3 through 8. The hybrid lines tend to be shorter and less

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prone to lodging than the open-pollinated lines, and previous work at the Southeast Farm indicates they tend to have less ergot incidence also.

One would expect adding a small grain to the rotation would improve yields of the following crops as well as spread out workloads and diversify income streams. From a farming system point of view, it looks like rye has strong potential to improve soil health and profitability provided that the market for it develops. Also the more we have to contend with herbicide resistant weeds, the more attractive rye will become as it is very competitive with weeds and allows for another mode of action to control them. It looks like hybrid rye may have a future in our environment - the scale of its production will depend on how well the market develops and on seed costs.

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Table 1. Average values across six locations for a rye variety trial conducted in southeastern South Dakota in 2021. Lines not significantly different (P < 0.05) from the highest-ranking rye variety are marked in bold font. Measurements of 100-seed weight were only taken at three of the six sites. Height was measured as the plants stood.

Line	Apparent Height	Lodging	100-Seed Wt.	Moisture	Test Wt.	Yield
	(in.)	(0 to 5)	(g)	(%)	(lb/bu)	(bu/ac)
Tayo	36.4	**1.0**	1.89	12.9	49.6	**58.4**
Bono	36.1	1.4	1.88	12.8	**51.3**	**58.2**
Recepter	35.9	1.2	1.68	12.7	**50.7**	**54.8**
Brasetto	36.9	**0.8**	1.85	12.9	49.9	**54.5**
Untreated Bono	36.1	1.6	1.93	12.8	**51.1**	**53.8**
Serafino	37.4	1.4	1.66	12.6	49.4	**53.7**
Trebiano	37.5	1.4	1.78	12.9	49.8	**53.6**
Daniello	37.5	1.6	1.77	12.8	49.3	51.5
Hazlett	**44.4**	2.4	**2.17**	12.7	**50.7**	43.8
Rymin	**45.3**	2.7	1.96	12.8	50.0	39.9
Dylan	**45.1**	3.3	1.81	12.8	49.8	37.7
Elbon	**46.2**	1.6	1.98	12.8	**51.1**	33.5
Overland HRWW	*27.8*	*0.4*	*2.64*	*12.8*	*53.2*	*27.4*
Mean	*38.7*	*1.6*	*1.92*	*12.8*	*50.5*	*47.8*
CV (%)	*7.8*	*38.5*	*10.1*	*3.9*	*3.0*	*17.8*
Line, P-value	*<0.01*	*<0.01*	*<0.01*	*NS*	*<0.01*	*<0.01*
Site, P-value	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*<0.01*
*SITE * LINE*	*<0.01*	*<0.01*	*NS*	*NS*	*<0.01*	*<0.01*

Table 2. Yield analysis by site for six locations of a rye variety trial conducted at six sites in southeastern South Dakota in 2021. At each site, lines not significantly different (P < 0.10) from the highest-ranking rye variety are marked in bold font. For the pooled analysis (average across sites) the lines were compared at the P < 0.05 level of significance. Note there was substantial wildlife damage to 'Overland' HRWW at the Artesian site.

LINE	**Artesian Yield**	**Kimball Yield**	**Beresford-1 Yield**	**Tyndall Yield**	**Beresford-2 Yield**	**Lennox Yield**	**Across Sites Average Yield**
	(bu/ac)	(bu/ac)	(bu/ac)	(bu/ac)	(bu/ac)	(bu/ac)	(bu/ac)
Tayo	**80.8**	51.6	**58.3**	**55.7**	**53.8**	**50.0**	**58.4**
Bono	**84.0**	**72.3**	50.2	**52.2**	**48.5**	42.2	**58.2**
Recepter	**81.8**	**58.6**	47.2	**50.6**	**51.7**	38.8	**54.8**
Brasetto	**78.9**	52.5	46.8	**55.8**	43.1	**50.1**	**54.5**
Untreated Bono	63.6	**66.8**	**58.8**	46.4	45.9	41.3	**53.8**
Serafino	**82.3**	**57.1**	45.0	**50.7**	44.7	42.6	**53.7**
Trebiano	**76.0**	**56.6**	**53.1**	**55.4**	40.9	39.8	**53.6**
Daniello	**82.6**	44.7	**51.0**	**48.2**	40.5	41.9	51.5
Hazlett	66.0	36.4	43.7	38.5	42.9	35.1	43.8
Rymin	52.0	42.1	36.7	35.0	38.9	34.8	39.9
Dylan	54.3	33.3	40.4	30.0	36.5	31.5	37.7
Elbon	40.7	31.6	35.3	24.7	37.8	31.0	33.5
Overland HRWW	13.0	25.0	40.1	29.0	32.3	24.9	27.4
Mean	*65.9*	*48.3*	*46.7*	*44.0*	*42.9*	*38.8*	*47.8*
CV (%)	*11.5*	*29.4*	*14.5*	*15.5*	*14.2*	*16.2*	*17.8*
P-value	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*<0.01*	*< 0.01*

Table 3. Results of a rye variety trial conducted at Artesian, South Dakota in 2021. Lines not significantly different (P < 0.10) from the highest-ranking rye variety are marked in bold font. Note there was substantial wildlife damage to 'Overland' HRWW at this site. Height was measured as the plants stood.

SITE	**LINE**	**Height**	**Lodging Score**	**Moisture**	**Test Wt.**	**Yield**
		(in.)	(0 to 5)	(%)	(lb/bu)	(bu/ac)
Artesian	Bono	36.8	**0.2**	12.8	50.0	**84.0**
Artesian	Daniello	40.3	**0.5**	12.6	49.9	**82.6**
Artesian	Serafino	41.0	**0.3**	12.9	49.8	**82.3**
Artesian	Recepter	37.8	**0.3**	12.6	50.8	**81.8**
Artesian	Tayo	39.5	**0.1**	12.8	49.7	**80.8**
Artesian	Brasetto	38.5	**0.1**	12.6	49.6	**78.9**
Artesian	Trebiano	42.5	**0.5**	12.7	50.2	**76.0**
Artesian	Hazlett	45.0	1.2	12.9	50.2	66.0
Artesian	Untreated Bono	38.0	**0.4**	12.6	50.8	63.6
Artesian	Dylan	**48.3**	1.0	12.9	49.6	54.3
Artesian	Rymin	**46.5**	1.8	13.2	49.0	52.0
Artesian	Elbon	**47.8**	0.7	13.4	48.7	40.7
Artesian	Overland HRWW	29.3	2.3	12.8	49.1	13.0
	Mean	*40.8*	*0.7*	*12.8*	*49.8*	*65.9*
	CV (%)	*5.0*	*59.0*	*2.9*	*4.3*	*11.5*
	P-value	*< 0.01*	*< 0.01*	*NS*	*NS*	*< 0.01*

Table 4. Results of a rye variety trial conducted at Kimball, South Dakota in 2021. Lines not significantly different (P < 0.10) from the highest-ranking rye variety are marked in bold font. Height was measured as the plants stood.

SITE	LINE	Height	Lodging Score	Moisture	Test Wt.	Yield
		(in.)	(0 to 5)	(%)	(lb/bu)	(bu/ac)
Kimball	Bono	36.3	3.6	12.2	52.9	**72.3**
Kimball	Untreated Bono	34.8	4.5	12.2	52.4	**66.8**
Kimball	Recepter	33.3	**2.7**	12.1	51.7	**58.6**
Kimball	Serafino	35.0	4.0	11.3	48.6	**57.1**
Kimball	Trebiano	36.8	3.8	12.8	50.0	**56.6**
Kimball	Brasetto	35.8	**2.9**	12.5	50.6	52.5
Kimball	Tayo	34.5	3.1	12.5	49.5	51.6
Kimball	Daniello	36.5	4.3	12.3	50.0	44.7
Kimball	Rymin	**45.0**	3.6	12.2	50.9	42.1
Kimball	Hazlett	44.3	4.0	12.0	51.4	36.4
Kimball	Dylan	43.3	4.2	11.6	50.8	33.3
Kimball	Elbon	**46.8**	**2.2**	11.8	51.1	31.6
Kimball	Overland HRWW	27.0	*0.2*	12.1	54.3	25.0
	Mean	*37.6*	*3.3*	*12.1*	*51.1*	*48.3*
	CV (%)	*5.4*	*18.3*	*7.0*	*4.2*	*29.4*
	P-value	*< 0.01*	*< 0.01*	*NS*	*NS*	*< 0.01*

Table 5. Results of a rye variety trial conducted at the south quarter of the SDSU Southeast Research Farm near Beresford, South Dakota in 2021. Lines not significantly different (P < 0.10) from the highest-ranking rye variety are marked in bold font. Height was measured as the plants stood.

SITE	LINE	Height	Lodging Score	100-Seed Wt.	Moisture	Test Wt.	Yield
		(in.)	(0 to 5)	(g)	(%)	(lb/bu)	(bu/ac)
Beresford-1	Untreated Bono	35.8	**0.3**	**2.28**	13.3	**51.3**	**58.8**
Beresford-1	Tayo	35.0	**0.0**	2.10	13.5	49.1	**58.3**
Beresford-1	Trebiano	40.0	**0.3**	2.05	13.6	49.1	**53.1**
Beresford-1	Daniello	37.0	0.8	1.85	13.3	49.5	**51.0**
Beresford-1	Bono	35.3	**0.3**	2.00	13.3	**50.6**	50.2
Beresford-1	Recepter	35.3	0.8	1.75	13.2	49.3	47.2
Beresford-1	Brasetto	35.8	**0.3**	1.88	13.4	49.6	46.8
Beresford-1	Serafino	36.0	**0.5**	1.70	13.2	49.2	45.0
Beresford-1	Hazlett	43.5	2.1	**2.35**	13.5	50.1	43.7
Beresford-1	Dylan	**47.0**	3.5	1.83	13.6	48.2	40.4
Beresford-1	Overland HRWW	26.5	**0.0**	2.80	13.5	*53.6*	40.1
Beresford-1	Rymin	44.5	2.9	2.00	13.1	49.2	36.7
Beresford-1	Elbon	**45.5**	2.0	2.03	13.5	**50.9**	35.3
	Mean	*38.2*	*1.1*	*2.0*	*13.4*	*50.0*	*46.7*
	CV (%)	*3.6*	*44.0*	*9.5*	*1.7*	*1.4*	*14.5*
	P-value	*< 0.01*	*< 0.01*	*< 0.01*	*NS*	*< 0.01*	*< 0.01*

Table 6. Results of a rye variety trial conducted at Tyndall, South Dakota in 2021. Lines not significantly different (P < 0.10) from the highest-ranking rye variety are marked in bold font. Note this site did not receive spring fertilizer N. Height was measured as the plants stood.

SITE	LINE	Height	Lodging Score	Moisture	Test Wt.	Yield
		(in.)	(0 to 5)	(%)	(lb/bu)	(bu/ac)
Tyndall	Brasetto	38.0	**0.1**	11.8	**52.8**	**55.8**
Tyndall	Tayo	37.8	**0.2**	12.1	52.0	**55.7**
Tyndall	Trebiano	32.8	**0.2**	12.1	52.4	**55.4**
Tyndall	Bono	38.0	**0.4**	11.9	**54.1**	**52.2**
Tyndall	Serafino	38.8	**0.3**	12.1	52.4	**50.7**
Tyndall	Recepter	38.8	**0.2**	12.2	**52.8**	**50.6**
Tyndall	Daniello	40.0	**0.1**	12.2	50.7	**48.2**
Tyndall	Untreated Bono	38.7	**0.6**	12.1	52.6	46.4
Tyndall	Hazlett	**51.5**	1.1	12.2	51.9	38.5
Tyndall	Rymin	**50.8**	1.1	12.0	**52.8**	35.0
Tyndall	Dylan	**50.0**	2.7	11.6	**53.1**	30.0
Tyndall	Overland HRWW	29.8	*0.0*	12.1	*55.2*	29.0
Tyndall	Elbon	50.7	1.1	11.4	**54.5**	24.7
	Mean	*41.2*	*0.6*	*12.0*	*52.9*	*44.0*
	CV (%)	*15.4*	*65.7*	*3.3*	*2.6*	*15.5*
	P-value	*< 0.01*	*< 0.01*	*NS*	*< 0.05*	*< 0.01*

Table 7. Results of a rye variety trial conducted at the north quarter of the SDSU Southeast Research Farm, South Dakota in 2021. Lines not significantly different ($P < 0.10$) from the highest-ranking rye variety are marked in bold font. Height was measured as the plants stood.

SITE	LINE	Height	Lodging Score	100-Seed Wt.	Moisture	Test Wt.	Yield
		(in.)	(0 to 5)	(g)	(%)	(lb/bu)	(bu/ac)
Beresford-2	Tayo	38.8	**0.4**	1.60	13.5	46.6	**53.8**
Beresford-2	Recepter	38.8	**1.3**	1.48	12.9	**48.1**	**51.7**
Beresford-2	Bono	38.3	2.1	1.53	13.4	47.2	**48.5**
Beresford-2	Untreated Bono	37.5	**1.3**	1.63	13.6	47.6	45.9
Beresford-2	Serafino	39.8	**1.3**	1.48	13.0	45.3	44.7
Beresford-2	Brasetto	39.0	**0.3**	1.53	13.4	45.4	43.1
Beresford-2	Hazlett	47.8	2.9	**1.95**	13.3	**48.8**	42.9
Beresford-2	Trebiano	42.0	**0.6**	1.45	13.3	45.4	40.9
Beresford-2	Daniello	39.3	2.1	1.43	13.6	43.7	40.5
Beresford-2	Rymin	**49.8**	3.6	1.70	13.7	46.9	38.9
Beresford-2	Elbon	**48.5**	2.1	**1.93**	13.5	**49.5**	37.8
Beresford-2	Dylan	**48.0**	4.3	1.70	13.9	46.6	36.5
Beresford-2	Overland HRWW	27.5	0.0	2.43	13.5	52.3	32.3
	Mean	*41.1*	*1.7*	*1.7*	*13.4*	*47.2*	*42.9*
	CV (%)	*3.8*	*54.7*	*10.0*	*4.1*	*3.1*	*14.2*
	P-value	*< 0.01*	*< 0.01*	*< 0.01*	*NS*	*< 0.01*	*< 0.01*

Table 8. Results of a rye variety trial conducted at Lennox, South Dakota in 2021. Lines not significantly different (P < 0.10) from the highest-ranking rye variety are marked in bold font. Note this trial had rows plugged on the drill across the trial, so each variety was the same, but seed distribution was not optimum across the area. Height was measured as the plants stood.

SITE	LINE	Height	Lodging Score	100-Seed Wt.	Moisture	Test Wt.	Yield
		(in.)	(0 to 5)	(g)	(%)	(lb/bu)	(bu/ac)
Lennox	Brasetto	34.1	**1.0**	**2.15**	13.4	51.7	**50.1**
Lennox	Tayo	32.8	2.3	**1.98**	12.9	50.7	**50.0**
Lennox	Serafino	33.8	2.3	1.80	13.0	51.1	42.6
Lennox	Bono	32.0	2.0	**2.10**	13.1	**52.9**	42.2
Lennox	Daniello	32.3	2.0	**2.03**	13.0	52.1	41.9
Lennox	Untreated Bono	31.8	2.3	1.88	13.0	**52.3**	41.3
Lennox	Trebiano	31.1	3.3	1.83	13.0	51.5	39.8
Lennox	Recepter	31.9	2.3	1.83	13.2	51.5	38.8
Lennox	Hazlett	34.6	3.5	**2.20**	**12.5**	51.7	35.1
Lennox	Rymin	35.0	3.5	**2.18**	**12.9**	51.1	34.8
Lennox	Dylan	33.9	4.0	1.90	13.1	50.9	31.5
Lennox	Elbon	**38.0**	**1.3**	**1.98**	13.2	51.9	31.0
Lennox	Overland HRWW	26.6	*0.0*	*2.70*	12.5	55.0	24.9
	Mean	*32.9*	*2.3*	*2.0*	*13.0*	*51.9*	*38.8*
	CV (%)	*6.6*	*32.7*	*10.8*	*2.4*	*1.2*	*16.2*
	P-value	*< 0.01*	*< 0.01*	*< 0.01*	*< 0.01*	*< 0.01*	*< 0.01*

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2021 Evaluation of Winter Annual Forages

Peter Sexton[1], Brad Rops, Sara Bauder, and Chelsea Sweeter

INTRODUCTION

Winter annual forages offer opportunity for producing forage relatively early in the season and allow for double cropping if moisture is adequate. Forage taken as hay, silage or by grazing can be followed up with soybeans, forage sorghum, or other warm season forages. In addition, winter annuals will use up residual nitrogen in the fall, protect soil from wind and water erosion, and keep living roots in the soil benefiting soil microbiology. This trial evaluates several lines of rye for forage production, along with a forage wheat and a triticale line for comparison.

METHODS

Several varieties of hybrid rye, open-pollinated (OP) rye, triticale and a winter wheat variety were no-till drilled into oat on September 11, 2020. Plots were laid out in a randomized complete block design with four replications. Plot size was 5 by 20'. Plots were fertilized with 174 lb/ac UREA (80-0-0). Plant heights were taken along with growth stage using the Feekes scale before harvest. Most of the plots were between head emergence and flowering stage of development. The ends were trimmed, plot lengths were recorded, and plots were harvested with a small plot forage harvester on June 3, 2021. The 'Sams DQ' blend included pea and vetch that winterkilled and those plots became weedy. Accordingly, a visual rating of percent weed fraction of the sample was taken at harvest in order to differentiate the influence of weed growth on forage dry matter. Subsamples were taken for determination of percent moisture at harvest.

RESULTS

The fall of 2020 was dry and the rye did not have much opportunity for growth until the spring of 2021. Nevertheless, the higher yielding lines produced a little over 3 tons per acre of forage on a dry matter basis. Table 1 shows dry matter and silage yields for each line. This is the third season we have run this type of a winter annual forage trial; rye has outperformed wheat and triticale check lines in all three years of these trials. Among the rye lines tested, the OP line 'Hazlet' has performed as well as the hybrid lines included over the last three seasons. Rye forage quality declines sharply after the boot stage, so it is a good idea to be timely in getting it harvested once it gets to that stage.

The potential for double cropping depends on availability of soil moisture. If soil moisture is adequate, soybeans have produced very well (60 bu/ac in our trials in 2017) following a rye forage crop; however, if drought is a concern, it may be prudent either to kill the rye early to

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conserve soil moisture, or to double crop with forage sorghum rather than soybeans as forage sorghum is much more drought tolerant than are soybeans (see the paper on double cropping in this annual report; SERF AR 2110, page 42).

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The authors appreciate the contributions of the South Dakota Agricultural Experiment Station to support this research.

Table 1. Height, visual rating of percent weed fraction, forage dry matter, and silage yield from a winter annual forage trial conducted at the Southeast Research Farm in 2021. Dry matter is based on measurements from four field replicates laid out in a randomized complete block design. Plots were seeded on Sept. 11, 2020 and harvested on June 3, 2021. 'Willow Creek' wheat was at Feeke's stage '10' at the time of cutting, all other lines were between Feeke's stage '10.5' and 10.5-1'.

Line	**Type**	**Height**	**Weed Fraction**	**Forage Dry Wt.**	**Silage Yield**
		(in)	(%)	(tons/ac)	(ton/ac)
Progas	hybrid rye	42.0	2.5	3.43	9.81
Daniello	hybrid rye	38.6	11.3	3.25	9.27
Hazlet	OP rye	44.1	1.0	3.19	9.10
Rymin	OP rye	46.0	0.5	3.12	8.93
Propower	hybrid rye	40.9	1.0	3.08	8.81
Problend	hybrid rye	42.1	1.0	3.06	8.75
Nitrous Trit.	triticale	34.5	5.5	2.75	7.87
Willow Creek	wheat	29.1	12.5	2.10	6.00
SamsDQ	blend	32.8	57.5	1.94	5.55
	Mean	*38.9*	*10.3*	*2.88*	*8.23*
	CV (%)	*5.5*	*93.7*	*11.80*	---
	LSD (0.10)	*2.6*	*11.7*	*0.41*	---

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Alfalfa Variety Trial at the Southeast Research Farm – 2021 Season

Sara Bauder, Brad Rops, and Peter Sexton[1]

INTRODUCTION

Alfalfa is an important crop for most ruminant nutrition, and it is critical for profitable dairy production. The following is a report on forage yields observed in the second year of an alfalfa variety trial established the previous year (2020) at the SDSU Southeast Research Farm.

METHODS

The plots were laid out in a randomized complete block design with six replications. Plot size is 5’ by 18’. Whole plot yields were taken using a forage harvester (Model SMW-SCH-48; Swift Machine & Welding, Swift Current, Saskatchewan, Canada) on May 28, June 28, and on August 2, 2021. Subsamples of fresh material were weighed and dried at 140˚ F to determine percent moisture. Some plots had skipped rows due to a planter row plugging, in order to correct for this, yields in these plots were adjusted up 11.4 % (which was the average difference between the plots with and without skipped rows). All yield data are presented on a dry weight basis. The means were individually compared to the highest yielding line for that cutting and separated with an LSD test ($P < 0.05$) using SAS statistical software. Yields of the top 50 % of the lines entered in the trial are shown along with the check variety.

RESULTS

The drought from 2020 carried over into the first half of 2021 (Table 1). June was a particularly stressful period for crop production in our area, which was followed by more moderate weather in July and August. This is reflected in higher yields for the third cutting versus the second cutting (Table 2). This is the second year of this trial. We plan to continue this trial for one more season.

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Table 1. Precipitation[a] at the Southeast Research Farm – January 2020 thru November 2021

Month	Precipitation (inches)	Average (inches)**	Departure from Avg. (inches)	Cumulative Departure from Avg. (inches)
January 2020	0.39	0.45	-0.06	-0.06
February	0.08	0.79	-0.71	-0.77
March	2.73	1.45	+1.28	0.51
April	0.55	2.54	-1.99	-1.48
May	2.16	3.55	-1.39	-2.87
June	3.23	4.19	-0.96	-3.83
July	1.95	3.08	-1.13	-4.96
August	1.23	3.04	-1.81	-6.77
September	0.35	2.81	-2.46	-9.23
October	0.70	1.92	-1.22	-10.45
November	0.91	1.13	-0.22	-10.67
December	0.26	0.66	-0.40	-11.07
January 2021	1.01	0.46	+0.55	-10.52
February	0.30	0.78	-0.48	-11.00
March	2.33	1.46	+0.87	-10.13
April	2.45	2.53	-0.08	-10.21
May	2.07	3.53	-1.46	-11.67
June	0.71	4.14	-3.43	-15.10
July	3.02	3.08	-0.06	-15.16
August	3.88	3.05	+0.83	-14.33
September	3.05	2.82	+0.23	-14.10
October	3.32	1.94	+1.38	-12.72
November	0.19	1.12	-0.93	-13.65

[a] Computed from daily observations

** Average for 2020 based on 68 years, Average for 2021 based on 69 years of data

Table 2. Dry matter yields from an alfalfa variety trial conducted at the Southeast Farm in Beresford, South Dakota in the 2021 season. Plots were established in the spring of 2020, making this the second year of the trial. Plots were harvested on May 28, June 28, and Aug. 2 of 2021. Some plots had skipped rows due to a planter row plugging, in order to correct for this, yields in these plots were adjusted up 11.4 % (which was the average difference between the plots with and without skipped rows). Yields were impacted by drought, which was particularly severe during the month of June. Yields of the top 50 % of the entries included in the trial are shown in this table along with the check variety ('Vernal').

Line	First Cutting	Second Cutting	Third Cutting	Total
	(tons/ac)	(tons/ac)	(tons/ac)	(tons/ac)
Viking O. 5200	**1.96**	**1.42**	**1.42**	**4.80**
DSX174083	**2.15**	**1.21**	**1.39**	**4.76**
GA440XQ	**2.01**	**1.24**	**1.33**	**4.58**
DSX174082	**1.93**	**1.16**	**1.41**	**4.50**
Viking 394	**1.98**	1.09	**1.22**	**4.29**
Red Falcon	**1.86**	1.14	**1.27**	**4.27**
DB 540 Salt	1.80	**1.16**	**1.30**	**4.27**
HybriForce 4400	**1.94**	1.03	**1.24**	**4.22**
DB Rush Hour	1.81	1.09	**1.26**	**4.16**
DB HeavyWeight	1.82	1.10	**1.23**	**4.15**
Viking 342	1.72	1.07	**1.35**	**4.14**
C0415C3364	1.62	1.15	**1.34**	**4.10**
Check (Vernal)	1.63	0.76	0.97	3.36
Mean	*1.81*	*1.04*	*1.22*	*4.06*
CV (%)	*15.5*	*22.1*	*19.1*	*15.9*
LSD (0.05)	*0.32*	*0.26*	*0.27*	*0.74*
LSD (0.10)	*0.27*	*0.22*	*0.22*	*0.62*

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Soybean Planting Date by Maturity Group – 2021 Season

Peter Sexton[1], Brad Rops,
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INTRODUCTION

Soybeans are a short-day, photoperiod sensitive crop. They track day length and as days get shorter, they are triggered to begin reproductive growth. The later they are planted, the faster their development is accelerated, so to some extent they shorten their lifecycle to help compensate for late planting. This raises the question of how much should a person adjust the maturity of their soybean lines when circumstances allow for early planting, or when they force late planting. To help gather local data to address this question a set of plots with lines of differing maturity groups were established at the Southeast Research Farm in Beresford, South Dakota. This is the second year of this study.

METHODS

Soybeans lines ranging in maturity group from 0.7 to 2.7 were seeded with a small plot drill on April 29, May 19, and June 10, at the Southeast Research Farm in Beresford. Plot size was 5 by 20' and the plots were laid out in a randomized complete block design with four replications. The plots seeded in April were harvested on Sept 16 and Sept 27 (2.3 and 2.8 RM), May seeding was harvested on Sept 29, and June seeding was harvested on Nov 5 using a small plot combine (Zürn Model 150). Due to instrument difficulties, there were some missing values for grain moisture on the last planting date; where this occurred the average moisture for that line (or those lines immediately above and below it in maturity) were used to calculate yield for a given plot. Data were subjected to ANOVA using the Proc GLM subroutine in SAS statistical software.

RESULTS and DISCUSSION

The 2021 crop began the season under a drought, which had started in the middle of the previous (2020) growing season. With high temperatures, drought stress became severe in June and delayed emergence of the June planting date in this trial. The farm received moderate rains in July and August which helped alleviate stress, and the farm had a relatively late fall not receiving a frost until Oct. 16th. The fact that the crop began the season under drought and then received moisture later in the season, and the late frost, gave a clear advantage to later maturing lines in the 2021 season. Plant height near maturity and seed-size at harvest were greater with the May planting date than with April planting (Table 1). The June planting date also showed larger seed-size. The yield ranking

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followed the maturity ranking for the April planting date, with progressively later maturing lines showing progressively greater yield (Table 2). The trend for later maturing lines to perform better continued with the May 19th planting date. With late planting (June 10th), the early maturing lines seem to perform as well as the later ones with the numerically highest yield line having a 1.4 maturity group rating. Regarding early planting, soybeans planted in late April (49 F soil temperature at 4" depth) tended to yield less than those planted in mid-May for the 2021 growing season.

Comparing the 2020 and 2021 growing seasons, there is a strong contrast in the effect of maturity. In 2020 the drought affected the latter half of the growing season and resulted in early maturing lines (1.4 and 1.7 MG) tending to yield more than later maturing lines. In the 2021 season on the other hand, the crop started under drought stress which was lessened by rainfall in July and August. This gave a clear yield advantage to later maturing lines this year (2021). For those interested in following soybeans with winter wheat or winter rye, the data on growth stage in the second week of September suggest that in 2021 with an April planting date, an early group 2 line would have matured in time for a late September planting of winter cereals. With May 19th planting in 2021, a mid-group 1 line would have been a better fit for following with winter wheat or rye.

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Table 1. Soybean reproductive growth stages, plant height near maturity, and 100 seed-weight for seven soybean lines ranging in maturity group ranking from 0.7 to 2.7 planted at three dates (April 29th, May 19, and June 10) at the Southeast Research Farm in Beresford, South Dakota in 2021. The crop began the season under drought stress that was lessened by rainfall in July and August.

	Stage on Sept. 9			Oct. 4th Stage	Height		100-Seed Wt		
Maturity Group	April 29 Planting	May 19 Planting	June 10 Planting	June 10 Planting	April 29 Planting	May 19 Planting	April 29 Planting	May 19 Planting	June 10 Planting
	(R-stage)	(R-stage)	(R-stage)	(R-stage)	(in)	(in)	(g)	(g)	(g)
2.7	6.6	6.2	5.2	6.4	25.8	28.0	15.8	17.9	19.7
2.3	7.3	6.5	5.5	6.6	26.0	29.0	13.5	15.7	17.9
2.1	7.9	6.9	5.5	6.9	24.5	28.0	12.7	15.3	18.5
1.7	8.0	7.8	5.8	7.1	24.0	25.5	11.9	13.2	17.6
1.4	8.0	7.9	6.1	7.7	24.3	26.5	11.8	14.4	17.8
1.0	8.0	8.0	5.7	7.9	20.5	24.3	11.2	13.3	17.8
0.7	8.0	8.0	6.1	7.9	19.0	21.5	12.3	13.7	18.9
mean	*7.7*	*7.3*	*5.7*	*7.2*	*23.4*	*26.1*	*12.7*	*14.8*	*18.3*
CV (%)	*1.8*	*1*	*3.5*	*2.3*	*4.6*	*4.6*	*3.5*	*4.6*	*1.4*
LSD (0.10)	*0.2*	*0.1*	*0.2*	*0.2*	*1.3*	*1.5*	*0.5*	*0.8*	*0.4*

Table 2. Grain moisture at harvest, test weight, and yield for seven soybean lines ranging in maturity group ranking from 0.7 to 2.7 planted at three dates (April 29th, May 19, and June 10) at the Southeast Research Farm in Beresford, South Dakota in 2021. The crop began the season under drought stress that was lessened by rainfall in July and August. This resulted a trend for better yields with later maturity and also better yields with mid-May versus late-April planting.

	Moisture			Test Wt.			Yield		
Maturity Group	April 29 Planting	May 19 Planting	June 10 Planting	April 29 Planting	May 19 Planting	June 10 Planting	April 29 Planting	May 19 Planting	June 10 Planting
	(%)	(%)	(%)	(lb/bu)	(lb/bu)	(lb/bu)	(bu/ac)	(bu/ac)	(bu/ac)
2.7	10.3	11.0	14.6	56.5	52.9	56.4	48.6	57.7	44.4
2.3	9.4	9.8	14.9	56.9	54.8	56.2	46.8	53.2	42.2
2.1	11.6	9.4	14.4	55.4	54.0	56.3	45.5	46.9	38.9
1.7	9.8	9.3	14.2	55.1	53.7	55.6	43.4	39.2	34.9
1.4	10.5	9.5	15.4	55.2	53.4	56.7	40.9	46.7	48.0
1.0	9.7	9.2	.	54.7	52.6	.	36.1	39.7	31.9
0.7	9.7	9.2	15.0	56.3	53.8	55.9	33.8	36.7	39.4
mean	*10.2*	*9.6*	*14.8*	*55.7*	*53.6*	*56.2*	*42.2*	*45.7*	*39.9*
CV (%)	*4.3*	*5.4*	*1.5*	*1.2*	*1.0*	*1.0*	*5.6*	*10.4*	*13.8*
LSD (0.10)	*0.5*	*0.8*	*0.3*	*0.8*	*0.6*	***NS***	*3.4*	*5.8*	*7.9*

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Soybean Variety Evaluation - Dimock and Beresford - 2021 Season

Peter Sexton[1], Brad Rops, and Chelsea Sweeter

INTRODUCTION

Variety selection is an important component of profitable crop production. This being the case, the Southeast Farm Board sponsored a soybean variety trial to be run at three locations in southeastern South Dakota. Materials were selected by board members and the trial was planted at three locations: Dimock, Beresford, and Garretson.

METHODS

The trial had 34 entries and was laid out in a randomized complete block design with four replications at each site. Plot size was 5 by 25'. Plots were direct seeded with a small plot drill (7.5" row spacing) at a target seed rate of 160,000 seeds per plot. The plots were planted at Dimock on May 17, Garretson on May 18, and Beresford on May 21, 2021. The Dimock site was nested within a field that was treated with dicamba. The cooperator there sprayed different sides of the field on different days so the breeze was moving away from the trial area each time he sprayed. Nevertheless the plot area could have been exposed to dicamba that volatilized from foliage or soil in the days after application was made. The Bereford site did not have dicamba applied anywhere in the quarter where the trial was located. The Garretson site was lost due to a misunderstanding about herbicide use and weed control at that site. Whole plot yields were determined using a small plot combine (Zürn Model 150). Plots at Beresford were harvested October 4 and plots at Dimock on November 2, 2021. Plots at Beresford had 4 rows in 5' width (effectively 15" rows), but part way through the trial a row unit plugged and beyond that there were only 3 rows per plot. In order to correct for this, yields in the three row plots were adjusted up 15.6 % (which was the average difference between the 3 and 4 row plots). There were significant site by line interactions, so statistical analysis was done by individual site rather than with pooled data.

RESULTS

Average yields for each line at the two sites where the trial was completed are shown in Table 1. The 2021 season was marked by severe drought. This drought started the previous year, so the crop began the season without much of a moisture reserve in the soil. June was hot and dry creating severe drought stress; however, the area started to pick up rain in July, and August had average rainfall. Yields at Beresford averaged 63.3 bu/ac (Table 2). There was no difference between herbicide resistance groups, nor with dicamba tolerance or lack thereof at the Beresford site (Table 3). There were strong differences between maturity groups with later maturing lines showing greater yield (Table 4). At Dimock yields averaged 56.2 bu/ac (Table 5). There were significant differences in herbicide resistance groups at Dimock with dicamba

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resistant lines showing significantly greater yield than those lines that lack this trait (Table 6). Similar to what was observed at Beresford, later maturing lines showed greater yield at Dimock as they were better able to take advantage of late-season moisture (Table 7).

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Table 1. Yield of soybean lines from variety trials at Dimock and Beresford, South Dakota in 2021. There were significant site by line interactions, so statistical analysis was only done by site. Average yields across the two sites are shown for the reader's interest.

Brand	Variety	Dimock Yield	Beresford Yield	Average Yield
			(bu/ac)	(bu/ac)
Pioneer RL	P31A22X	**70.7**	**71.4**	71.0
Hefty	H28X8	**66.5**	**72.0**	69.2
Pioneer RL	P28A51X	**62.9**	**69.8**	66.3
Pioneer	P28T14E	**63.2**	**67.7**	65.5
Zinesto	Z2401E	62.2	**66.2**	64.2
Asgrow	AG26XF1	58.1	**69.2**	63.6
Asgrow	AG27XF0	59.4	**67.6**	63.5
Dyna Grow	S23XF11S	**64.8**	62.1	63.4
Channel	2418R2X	61.8	**64.7**	63.3
Golden Harvest	GH2505E3	56.3	**69.4**	62.8
Asgrow	AG24XF1	**63.3**	62.3	62.8
Channel	2222R2X	61.1	**64.3**	62.7
Golden Harvest	GH2818E3	61.8	62.5	62.2
Golden Harvest	GH2102XF	**62.7**	60.6	61.7
Innotech	IS2748E3	53.6	**69.2**	61.4
Golden Harvest	GH1915X Trt 1*	57.2	63.4	60.3
Golden Harvest	GH1915X Trt2*	60.6	58.4	59.5
Viking	2155N Conv	51.9	**66.6**	59.3
Pioneer	P26T23E	54.7	63.6	59.1
Zinesto	Z2700E	56.0	60.2	58.1
Zinesto	Z2101G	52.3	63.3	57.8
Hefty	H17XF1	55.4	58.0	56.7
Innotech	IS2342E3	49.1	**64.4**	56.7
Pioneer	P21A84L	49.8	63.0	56.4
Pioneer	P22T18E	50.7	59.9	55.3
Hoegemeyer	2240E	47.8	62.0	54.9
Golden Harvest	GH2041X	49.5	60.3	54.9
Golden Harvest	GH2011E3	46.0	61.5	53.7
Asgrow	AG21XF0	46.9	60.1	53.5
Viking	1700 Conv	44.9	58.6	51.7
Innotech	IS2089E3	46.6	55.9	51.3
Hoegemeyer	1910E	48.6	52.1	50.3
Viking	1940KN Conv	41.4	59.0	50.2
	Mean	*56.2*	*63.3*	*59.9*
	CV (%)	*10.7*	*9.3*	*n/a*
	LSD (0.05)	*8.4*	*8.3*	*n/a*

* Trt 1 = Cruiser Max + Vibrance; Trt 2 = Cruiser Max + Vibrance + Commence

Table 2. Percent stand (visual rating), moisture, test weight and yield for soybean lines included in a variety trial at the Southeast Research Farm in Beresford, South Dakota in 2021. Plots at Beresford had 4 rows in 5' width (effectively 15" rows), but part way through the trial a row unit plugged and beyond that there were only 3 rows per plot. In order to correct for this, yields in the three row plots were adjusted up 15.6 % (which was the average difference between the 3 and 4 row plots). Harvest date was Oct 4, 2021.

Brand	Line	Herbicide Trait	Dicamba Tolerant	Percent Stand	Moisture	Test Wt.	Corrected Yield
				(%)	(%)	(lb/bu)	(bu/ac)
Hefty	H28X8	X	Y	88.3	15.2	54.1	**72.0**
Pioneer RL	P31A22X	X	Y	90.3	15.5	53.1	**71.4**
Pioneer RL	P28A51X	X	Y	89.8	15.0	54.6	**69.8**
Golden Harvest	GH2505E3	E3	N	91.3	12.9	55.0	**69.4**
Asgrow	AG26XF1	XF	Y	92.5	13.8	55.6	**69.2**
Innotech	IS2748E3	E3	N	92.5	14.5	54.3	**69.2**
Pioneer	P28T14E	E3	N	90.5	14.6	54.2	**67.7**
Asgrow	AG27XF0	XF	Y	91.0	14.0	54.9	**67.6**
Viking	2155N Conv	CV	N	90.8	13.8	57.4	**66.6**
Zinesto	Z2401E	E3	N	91.5	13.1	55.0	**66.2**
Channel	2418R2X	X	Y	91.8	13.3	55.5	**64.7**
Innotech	IS2342E3	E3	N	92.5	13.3	55.7	**64.4**
Channel	2222R2X	X	Y	86.0	12.9	54.9	**64.3**
Pioneer	P26T23E	E3	N	92.0	13.9	54.5	63.6
Golden Harvest	GH1915X- trt 1*	X	Y	86.0	13.1	54.2	63.4
Zinesto	Z2101G	L-GT27	N	92.0	13.5	55.3	63.3
Pioneer	P21A84L	L	N	90.3	13.4	56.2	63.0
Golden Harvest	GH2818E3	E3	N	91.3	14.3	54.5	62.5
Asgrow	AG24XF1	XF	Y	89.8	13.7	56.3	62.3
Dyna Grow	S23XF11S	XF	Y	92.0	13.3	55.6	62.1
Hoegemeyer	2240E	E3	N	84.8	13.2	54.6	62.0
Golden Harvest	GH2011E3	E3	N	90.5	13.0	55.1	61.5
Golden Harvest	GH2102XF	XF	Y	89.3	12.9	55.9	60.6
Golden Harvest	GH2041X	X	Y	85.0	12.7	55.1	60.3
Zinesto	Z2700E	E3	N	89.3	13.3	55.3	60.2
Asgrow	AG21XF0	XF	Y	91.8	12.7	55.5	60.1
Pioneer	P22T18E	E3	N	88.5	13.2	55.1	59.9
Viking	1940KN Conv	CV	N	92.5	13.0	55.7	59.0
Viking	1700 Conv	CV	N	86.5	12.8	55.8	58.6
Golden Harvest	GH1915X-trt2*	X	Y	82.3	12.6	55.4	58.4
Hefty	H17XF1	XF	Y	85.8	12.6	55.2	58.0
Innotech	IS2089E3	E3	N	84.5	13.5	54.5	55.9
Hoegemeyer	1910E	E3	N	89.0	13.2	55.8	52.1
			Mean	*89.4*	*13.5*	*55.1*	*63.3*
			CV (%)	*5.4*	*4.1*	*1.3*	*9.3*
			LSD (0.05)	*NS*	*0.9*	*1.1*	*8.3*

* Trt 1 = Cruiser Max + Vibrance; Trt 2 = Cruiser Max + Vibrance + Commence

Table 3. Analysis by herbicide resistance trait and by dicamba tolerance among soybean lines evaluated at Beresford, South Dakota in 2021. Plots at Beresford had 4 rows in 5' width (effectively 15" rows), but part way through the trial a row unit plugged and beyond that there were only 3 rows per plot. In order to correct for this, yields in the three row plots were adjusted up 15.6 % (which was the average difference between the 3 and 4 row plots).

Herbicide Trait	# of lines	Stand	Moisture	Test Wt.		Corrected Yield
		(%)	(%)	(lb/bu)		(bu/ac)
X	8	87.4	13.8	54.6	c	65.5
L	2	91.1	13.4	55.8	ab	63.2
XF	7	90.3	13.3	55.6	b	62.9
E3	14	89.8	13.5	54.9	c	62.7
Conv.	3	89.9	13.2	56.3	a	61.4
	Mean	*89.4*	*13.5*	*55.1*		*63.3*
	CV (%)	*5.6*	*6.6*	*1.6*		*10.8*
	P-value	*NS*	*NS*	*< 0.01*		*NS*

Dicamba Tolerant	# of lines	Percent Stand	Moisture	Test Wt.	Yield	Corrected Yield
		(%)	(%)	(lb/bu)	(bu/ac)	(bu/ac)
No	18	90.0	13.5	55.2	58.9	62.5
Yes	15	88.8	13.6	55.0	60.7	64.3
	Mean	*89.4*	*13.5*	*55.1*	*59.7*	*63.3*
	CV (%)	*5.6*	*6.6*	*1.8*	*10.8*	*10.8*
	LSD (0.05)	*NS*	*NS*	*NS*	*NS*	*NS*

Table 4. Analysis by maturity group among soybean lines evaluated at Beresford, South Dakota in 2021. The season was marked by drought stress early in the season with moderate rainfall occurring later in the season which favored late-maturing lines.

Maturity Group	# of lines	Stand		Moisture		Test Wt.		Yield	
		(%)		(%)		(lb/bu)		(bu/ac)	
Late (2.6 to 3.1)	10	90.7	a	14.4	a	54.5	b	67.3	a
Mid-Season (2.1 to 2.5)	14	90.1	a	13.2	b	55.6	a	63.5	b
Early (1.7 to 2.0)	9	86.9	b	12.9	b	55.2	a	58.6	c
	Mean	*89.4*		*13.5*		*55.1*		*63.3*	
	CV (%)	*5.4*		*4.8*		*1.6*		*9.6*	
	P-value	*< 0.01*		*< 0.01*		*< 0.01*		*< 0.01*	

Table 5. Percent stand (visual rating), moisture, test weight and yield for soybean lines included in a variety trial at the Dimock, South Dakota in 2021. The percent stand value shown is a visual rating taken in mid-October. Harvest date was Nov 2, 2021.

Brand	Variety	Herbicide	Dicamba Trait	Stand	Moisture	Test Wt	Yield
				(%)	(%)	(lb/bu)	(bu/ac)
Pioneer RL	P31A22X	X	Y	95.3	9.7	49.5	**70.7**
Hefty	28X8	X	Y	90.3	9.6	51.6	**66.5**
Dyna Grow	S23XF11S	XF	Y	85.0	10.0	51.7	**64.8**
Asgrow	AG24XF1	XF	Y	88.0	9.9	51.3	**63.3**
Pioneer	P28T14E	E3	N	94.5	9.4	50.7	**63.2**
Pioneer RL	P28A51X	X	Y	89.0	10.0	49.7	**62.9**
Golden Harvest	GH2102XF	XF	Y	93.3	9.8	51.1	**62.7**
Zinesto	Z2401E	E3	N	92.3	9.5	50.8	62.2
Channel	2418R2X	X	Y	91.3	9.6	51.1	61.8
Golden Harvest	GH2818E3	E3	N	92.5	9.5	51.1	61.8
Channel	2222R2X	X	Y	94.0	9.6	50.9	61.1
Golden Harvest	GH1915X- trt2*	X	Y	87.3	9.4	50.0	60.6
Asgrow	AG27XF0	XF	Y	94.0	9.6	49.4	59.4
Asgrow	AG26XF1	XF	Y	88.0	9.9	50.6	58.1
Golden Harvest	GH1915X- trt1*	X	Y	85.3	8.8	49.1	57.2
Golden Harvest	GH2505E3	E3	N	91.8	9.5	51.3	56.3
Zinesto	Z2700E	E3	N	91.0	9.3	50.9	56.0
Hefty	H17XF1	XF	Y	86.3	8.6	44.2	55.4
Pioneer	P26T23E	E3	N	89.0	9.7	52.5	54.7
Innotech	IS2748E3	E3	N	92.5	9.4	48.5	53.6
Zinesto	Z2101G	L-GT27	N	81.3	9.8	49.5	52.3
Viking	2155N Conv	CV	N	89.8	9.8	50.6	51.9
Pioneer	P22T18E	E3	N	89.0	9.2	48.0	50.7
Pioneer	P21A84L	L	N	86.8	8.9	50.5	49.8
Golden Harvest	GH2041X	X	Y	86.8	9.6	50.2	49.5
Innotech	IS2342E3	E3	N	83.8	10.0	51.7	49.1
Hoegemeyer	1910E	E3	N	87.3	9.8	51.3	48.6
Hoegemeyer	2240E	E3	N	83.8	9.6	46.6	47.8
Asgrow	AG21XF0	XF	Y	84.8	9.0	45.7	46.9
Innotech	IS2089E3	E3	N	81.8	9.7	51.2	46.6
Golden Harvest	GH2011E3	E3	N	84.5	9.9	50.9	46.0
Viking	1700 Conv	CV	N	77.8	8.0	45.5	44.9
Viking	1940KN Conv	CV	N	84.0	9.4	47.9	41.4
			Mean	*88.2*	*9.5*	*50.0*	*56.2*
			CV (%)	*5.5*	*4.1*	*4.9*	*10.7*
			LSD (0.05)	*6.9*	*0.5*	*3.5*	*8.4*

* Trt 1 = Cruiser Max + Vibrance; Trt 2 = Cruiser Max + Vibrance + Commence

Table 6. Analysis by herbicide resistance trait and by dicamba tolerance among soybean lines evaluated at Dimock, South Dakota in 2021. There was a significant yield advantage associated with dicamba tolerance at this site as the trial was located in a field which had been treated with dicamba during the season.

Herbicide Trait	# of lines	Stand		Moisture	Test Wt.	Yield	
X	8	89.9	a	9.6	50.3	61.5	a
XF	7	88.5	abc	9.5	49.3	59.1	a
E3	13	88.7	ab	9.6	50.5	54.0	b
L	2	84.0	cd	9.2	50.1	50.9	bc
Conv.	3	83.8	d	9.3	48.5	46.3	c
	Mean	*88.2*		*9.5*	*50*	*56.2*	
	CV (%)	*6.6*		*5.4*	*5.6*	*13.9*	
	P-value	*<0.05*		*NS*	*NS*	*<0.01*	

Dicamba Trait	# of lines	Stand	Moisture	Test Wt.	Yield
Yes	15	89.2	9.6	49.8	60.3
No	18	87.4	9.5	50.1	52.5
	Mean	*88.2*	*9.5*	*50*	*56.2*
	CV (%)	*6.8*	*5.4*	*5.7*	*14.3*
	P-value	*NS*	*NS*	*NS*	*< 0.01*

Table 7. Analysis by maturity group among soybean lines evaluated at Dimock, South Dakota in 2021. The season was marked by drought stress early in the season with moderate rainfall occurring later in the season which favored late-maturing lines.

Maturity Group	# of lines	Stand		Moisture		Test Wt.	Yield	
		(%)		(%)		(lb/bu)	(bu/ac)	
Late (2.6 to 3.1)	10	91.6	a	9.6	a	50.4	60.7	a
Mid-Season (2.1 to 2.5)	14	88.1	b	9.6	a	50.2	56.1	b
Early (1.7 to 2.0)	9	84.5	c	9.3	b	49.0	50.4	c
	Mean	*88.2*		*9.5*		*50.0*	*56.2*	
	CV (%)	*6.1*		*5.3*		*5.6*	*14.3*	
	P-value	*< 0.01*		*< 0.05*		*NS*	*< 0.01*	

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Double Cropping Options Following Rye for Forage at Beresford in 2021

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INTRODUCTION

Double cropping, or raising two crops in the same space in the same growing season, has some obvious benefits. It can increase the total revenue for a field by raising additional crops in a season. It also reduces erosion and keeps living roots in the soil for more days. While a more common practice in the south, it is a challenge in the northern plains because of the shorter growing season. Winter annuals help make it work, since they are generally harvested sooner, especially if harvested for forage. The Southeast Research Farm did a double cropping observation looking at the performance of soybeans, corn, or sorghum following rye harvested for silage.

METHODS

KWS Daniello Hybrid Rye was planted Nov. 4, 2020 at a rate of 54 pounds per acre (800,000 seeds per acre). The rye was fertilized March 12, 2021 with 213 pounds urea, 29 pounds MAP, and 42 pounds AMS per acre (110-15-0-10). A portion of the field was cut for silage May 26, 2021. Fresh weight yield was 6 tons per acre. Following silage harvest, soybeans, sorghum, and corn (96d and 104d) were planted in 15' x 50' blocks with four blocks per crop on May 28, 2021. The corn and sorghum plots had 100 pounds per acre N applied on July 29, 2021. Sorghum plant samples from 10 feet of row were taken Oct 8, 2021 at soft dough stage. The plants were weighed, chipped, and a sample was taken to determine percent dry matter. The same process was done with corn plant samples on Nov. 17, 2021. Soybean plots were harvested for grain Oct. 20, 2021 and corn grain was harvested Nov. 5, 2021.

RESULTS AND DISCUSSION

Precipitation for the month of May was less than 60% of normal and June received less than 20% of normal with only 0.7 inches for the month. It was July 9 before any significant rain was received after planting. In nearby fields with similar soil types, soybeans averaged 63 bu/acre and 96d corn yielded 158 bu/acre. Without drought stress, we would have expected significantly higher grain yields given the May 28 planting date. Unfortunately the actively growing rye crop and the abnormally dry June severely stressed all three crops during establishment. Market prices from mid-January 2022 were used to calculate gross revenue per acre, but it is just a snapshot in time. Sorghum yielded more tons per acre than corn, but was valued at 85% of corn silage due to lower energy content, giving corn a higher gross revenue per acre. A second silage crop in this scenario,

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whether corn or sorghum, would have produced more revenue than grain crops.

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Table 1. Grain and forage yields of various row crops planted after rye harvested for silage at the SDSU Southeast Research Farm in 2021.

Crop	Bu/Acre	$/bu	$/Acre grain	Tons/Acre	$/ton	$/Acre silage
Soybeans	29.3	$13.30	$389.69			
Corn, 96 day	56.0	$5.85	$327.60			
Corn, 104 day	73.1	$5.85	$427.64	14.8	$50.00	$740.00
Sorghum				16.1	$42.50	$684.25

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Influences of Manure and Fertilizer Application in Corn-Soybean-Spring Wheat/Cover Crops Rotation on Water Availability and Quality, Soil Fertility, and Crop Yield

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Recently, X-ray computed tomography (CT) scanning technology has risen as an innovative advancement technique in the visualizing and quantifying soil structure (Taina et al., 2008). X-ray computed tomography scanning in addition with image analysis has been used as a non-invasive technique for characterization and quantification of soil pore characteristics with a higher resolution. This is an improved method of understanding the soil pore characteristics (Schulte et al., 2018; Tseng et al., 2018). Results can be achieved more accurately and faster, when compared to using soil water retention data. Soil structure is a vital assessment index in agricultural production and soil development (Six et al., 2004). Therefore, understanding the soil pore characteristics can give an overall sense of the soil structure. CT scanning is an efficient method to evaluate the effect of productive rejuvenation on aggregate stability, to visualize and quantify the 3-D soil pore network of different soil types (Zhao et al., 2017; Zhou et al., 2012). Macropore favors high infiltration rate, good tillage, and sufficient aeration, which are beneficial for plant growth. Soil macropores are more sensitive to management practices and thus are essential for assessing the structure of the soil. (Pires et al., 2020; Singh et al., 2020; Yang et al., 2018). It is crucial for crop growth in agricultural fields (Cercioglu et al., 2018; Koestel et al., 2019; Tifafi, et al., 2017). Therefore, it is essential for evaluating soil structure (Müller et al., 2018). Making it important to find a sustainable way to increase macroporosity in soil.

Study site

The study was conducted at Southeast Research Farm near Beresford, (43˚ 02’ 33.46” N and 96˚ 53’ 55.78” W) on Egan soil (Fine-silty, mixed, mesic Udic Haplustolls). The site included six different treatments: (i) low manure (LM) contained a quantity of manure based on recommended phosphorous requirement, (ii) medium manure (MM) contained a quantity of manure based on recommended nitrogen requirement, (iii) high manure (HM) contained a quantity of manure based on double the recommended nitrogen requirement, (iv) medium fertilizer (MF) contained the suggested inorganic fertilizer rate, (v) high fertilizer (HF) contained a high

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fertilizer rate, and (vi) control (CNT) contained no manure and no fertilizer. The research plots were initiated in 2003 to study the effect of manure and inorganic fertilizer application rates on crop production and soil quality. The experiments were a randomized complete block design with 4 replications. The plots were established in nearly flat areas with the slope of <1%, and elevation of 1279.5 feet. Dimensions for each plot at Beresford site are 15.1 by 65.6 feet.

Soil Sampling and Sample Preparation

Intact cores from the depths of 0-4" (0-100 mm), 4-8" (100-200 mm), 8-12" (200 -300 mm), and 12-16" (300-400 mm) were collected from all the plots in July 2020; 96 soil cores in total. Plexiglass cores were used for the sampling. The cores were extracted from the soil manually using a core sampler vertically inserted in the soil. For each depth, the plexiglass cores were inserted leaving 5" of soil at the top and bottom to minimize disturbance to the intact soil sample. Soil cores were then trimmed, using a serrated knife and sealed with plastic caps at both ends, labeled, and stored in plastic bags at 39 °F until analysis. In the laboratory, soil cores were slowly saturated from the bottom and then drained at −5.0 kPa using a low-tension table to remove water from macropores to improve image contrast for XCT scanning. Samples were secured at both the ends with wooden caps and masking tape and stored in cold room in preparation for scanning. The cores were transported in the cooler to the University of Missouri Veterinary Health Center at Columbia, MO for XCT scanning.
Soil organic carbon (SOC) and total nitrogen (TN) were determined by dry combustion method using a CN628 analyzer (LECO Corporation, St. Joseph, MI, USA).

RESULTS

Soil organic carbon (SOC) was only higher in the HM treatment compared to the MF, while all other treatments were not statistically different (Table 1). The HM had the highest TN as well and it was higher from all but one (LM) treatment (Table 1). The LM and MM treatment decreased the bulk density relative to the CN and the two treatments that received fertilizer (Table 1). The SOC and TN content decreased with increasing soil depth, while the bulk density increased with soil depth (Table 1).
Soil porosity improved with the use of manure (Table 2). Larger impact of the manure use was observed in the microporosity. Higher number of mesopores and total pore numbers were observed in the HM, MM, and HF treatments compared to the CNT (Table 2). With the increasing bulk density, the porosity, and the number of pores also decreased with increasing soil depths (Table 2). However, the structure of the pores (e.g. number of branches, or number of junction) did not differ among the different nutrient management treatments (Tables 3-4). However, the average branch length increased with soil depth (Table 4). The pores were less connected in the deeper soil layers than what the decreasing of tortuosity shows (Table 4).

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Table 1. Soil organic carbon (SOC), total nitrogen, and bulk density as influenced long term medium fertilizer (MF), high fertilizer (HF), low manure (LM), medium manure (MM), high manure (HM) rate applications, and control as a function of soil depths.

Treatment	SOC ($g\ kg^{-1}$)	TN ($g\ kg^{-1}$)	Bulk density ($g\ cm^{-3}$)
CNT	18.15[ab†]	1.19[b†]	1.45[a†]
MF	16.94[b]	1.10[b]	1.44[a]
HF	18.80[ab]	1.27[b]	1.42[a]
LM	19.78[ab]	1.39[ab]	1.35[bc]
MM	19.37[ab]	1.30[b]	1.33[c]
HM	23.80[a]	1.82[a]	1.41[ab]
p-value	**<0.0001**	**0.0022**	**<0.0001**
Soil Depth (")			
0 – 4	26.53[a†]	1.97[a†]	1.35[b†]
4 – 8	20.33[b]	1.38[b]	1.36[b]
8 – 12	17.62[b]	1.12[bc]	1.42[a]
12 – 16	13.42[c]	0.93[c]	1.46[a]
p-value	**<0.0001**	**<0.0001**	**<0.0001**

[†]Mean values within the same column followed by different small letters for each site are significantly different at $p<0.05$ for treatment

Table 2. Macroporosity, mesoporosity, total number of pores, macropores, and mesopore as influenced by long term medium fertilizer (MF), high fertilizer (HF), low manure (LM), medium manure (MM), high manure (HM) rate applications, and control as a function of soil depths.

Treatment	Total no. of pores	Total no. of macropores	Total no. of mesopores	Porosity (cm^{3}cm^{-3})	Macroporosity (cm^{3}cm^{-3})	Mesoporosity (cm^{3}cm^{-3})
CNT	2176.06[b†]	189.81[a†]	1986.25[b†]	0.020[c†]	0.014[b†]	0.006[c†]
MF	2609.12[ab]	188.56[a]	2420.56[ab]	0.024[bc]	0.016[ab]	0.008[bc]
HF	2910.88[a]	234.81[a]	2676.06[a]	0.024[bc]	0.014[b]	0.010[ab]
LM	2702.50[ab]	213.94[a]	2488.56[ab]	0.028[ab]	0.019[a]	0.009[abc]
MM	2888.44[a]	236.50[a]	2651.94[a]	0.025[bc]	0.017[ab]	0.008[abc]
HM	2964.81[a]	241.68[a]	2723.13[a]	0.031[a]	0.020[a]	0.011[a]
p-value	**0.0036**	**0.0318**	**0.0044**	**<0.0001**	**<0.0001**	**<0.0001**
Soil Depth (")						
0 – 4	3127.96[a†]	258.46[a†]	2169.67[a†]	0.029[a†]	0.020[a†]	0.010[a†]
4 – 8	2836.29[a]	230.17[ab]	2602.37[ab]	0.025[ab]	0.018[ab]	0.008[a]
8 – 12	2724.92[a]	199.42[bc]	2524.79[ab]	0.026[ab]	0.015[bc]	0.008[a]
12 – 16	2145.38[b]	182.17[c]	2667.50[a]	0.023[b]	0.014[c]	0.008[a]
p-value	**<0.0001**	**<0.0001**	**0.0200**	**0.0035**	**<0.0001**	**0.2291**

[†]Mean values within the same column followed by different small letters for each site are significantly different at p<0.05 for treatment

Table 3. Number of branches, junctions, triple points, and quadruple points as influenced by long term medium fertilizer (MF), high fertilizer (HF), low manure (LM), medium manure (MM), high manure (HM) rate applications, and control as a function of soil depths.

Treatment	No. of Branches	No. of junction	No. of triple	No. of Quadruples
CNT	6004.31[a†]	2228.25[a†]	1758.94[ab†]	351.37[a†]
MF	6408.31[a]	2483.44[a]	1823.50[ab]	389.69[a]
HF	5995.88[a]	2177.37[a]	1635.06[b]	338.00[a]
LM	6891.62[a]	2734.81[a]	2162.37[a]	454.87[a]
MM	6828.25[a]	2499.94[a]	1838.19[ab]	409.62[a]
HM	6490.56[a]	2469.44[a]	1933.18[ab]	407.44[a]
p-value	**0.4542**	**0.1942**	**0.0555**	**0.2238**
Soil Depth (")				
0 – 4	7847.04[a†]	3030.58[a†]	2274.46[a†]	515.96[a†]
4 – 8	6746.21[b]	2338.50[b]	1817.42[b]	387.58[b]
8 – 12	6307.87[b]	2283.50[b]	1810.83[b]	363.96[b]
12 – 16	4844.83[c]	2076.25[b]	1531.46[b]	299.83[b]
p-value	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**

[†]Mean values within the same column followed by different small letters for each site are significantly different at p<0.05 for treatment

Table 4. Average branch length, tortuosity, Degree of anisotropy, and Fractal Dimension as influenced by long term medium fertilizer (MF), high fertilizer (HF), low manure (LM), medium manure (MM), high manure (HM) rate applications, and control as a function of soil depths.

Treatment	Avg Branch length (mm)	Tortuosity	Degree of Anisotropy	Fractal Dimension
CNT	0.818[a†]	1.209[a†]	0.644[a†]	2.460[a†]
MF	0.812[a]	1.207[a]	0.654[a]	2.466[a]
HF	0.844[a]	1.210[a]	0.583[a]	2.451[a]
LM	0.842[a]	1.216[a]	0.623[a]	2.487[a]
MM	0.846[a]	1.211[a]	0.650[a]	2.420[a]
HM	0.878[a]	1.211[a]	0.631[a]	2.495[a]
p-value	**0.7524**	**0.8799**	**0.6688**	**0.4525**
Soil Depth (")				
0 – 4	0.650[c†]	1.228[a†]	0.684[a†]	2.529[a†]
4 – 8	0.884[b]	1.221[a]	0.704[a]	2.515[a]
8 – 12	0.867[b]	1.200[b]	0.697[a]	2.505[a]
12 – 16	0.958[a]	1.195[b]	0.439[b]	2.303[b]
p-value	**<0.0001**	**<0.0001**	**<0.0001**	**<0.0001**

[†]Mean values within the same column followed by different small letters for each site are significantly different at $p<0.05$ for treatment

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Late-season Soybean Fertilizer Application

Péter Kovács[1]

INTRODUCTION

Soybean yields increased over the last century, and this coupled with a slow decrease of protein concentration in the seeds. In addition, total nutrient uptake has also been increased and uptake shifted later in the growing season.

The majority of N being supplied is through N fixation. However, N demand maybe larger during the grain-filling period than can be obtained by N fixation (Wesley et al., 1998). Wesley et al. (1998) documented yield increase with late season N application in an irrigated environment.

The objective of this research was to investigate late-season (early – mid grain filling) N and S fertilizer application effects on grain yield and protein concentrations in dryland growing environments.

MATERIALS AND METHODS

Soybeans were planted in no-till ground at 140,000 seeds per acre on May 14th in 2020 and on May 11th in 2021 on 30" row spacing. The previous crop was corn (*Zea mays* L.). Two soybean varieties were planted (AG11X8 and AG24X7; 1.1 and 2.4 maturity group, respectively in 2020 and AG12XF1 and AG20XF1; 1.2 and 2.0 maturity group, respectively in 2021). 20 lbs S/ac as ammonium sulfate (AMS) was applied at different times in the growing season. One treatment received a broadcast application at planting. For the other treatments fertilizer was Y-Drop applied at 30 gal/ac rate at either the R3 (beginning of pod), R5 (beginning seed), or R6 (full seed) growth stage. Two additional treatments were included: additional inoculant application with Bradyrhizobium japonicum at V4 (four leaf) growth stage, and inoculum at V4 and a fertilizer application at R5 growth stages. Twenty fluid oz/ac of America's Best Inoculant was applied at 30 gal/ac rate with Y-Drop. Treatments were arranged in a complete randomized block design with 4 replications.

Pre-plant soil samples from 0-6" and 6-24" layers were taken from each replication. Each composite sample contained 12 soil cores. Samples were analyzed by a commercial certified laboratory for the basic soil chemical parameters (soil pH, organic matter, NO_3-N, P, K, and SO_4-S concentration).

Soybeans were harvested on September 30th in 2020 and on October 16th in 2021. Yield

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data was recorded through a Kincaid 8XP plot combine; and yields were adjusted to 13% moisture content. Seed protein and oil concentrations were determined by InfraTec Nova (FOSS Analytics, Hillerød, Denmark). Statistical analyses were carried out with SAS 9.4 statistical software package. Years were considered fixed effect in the statistical model and were combined during the analysis.

RESULTS

Pre-plant soil test results are presented in Table 1.

Final plant stands were about 6,000 plants/ac higher in 2020 compared to 2021 (data not shown). In 2020 there were also about 6,000 plants/ac difference between the varieties, however there were no plant stand differences among the treatments (data not shown).

Average grain yield was about 4 bu/ac higher in 2020 compared to 2021 averaged across maturity groups and fertilizer treatments (data not shown). Looking at the fertilizer application responses there were no statistical differences among the different treatments within either of the maturity groups (Table 2). However, fertilizer application at the early part of grain filling period and the additional inoculum application resulted in a 3-4 bu/ac gain for the shorter maturity group variety relative to the untreated control across the two years (Table 2).

Results from the grain analysis only contains information from 2020. Grain protein concentration in the MG2 variety averaged at 34.5%, and for the MG1 variety at 33.8%. However, fertilizer application treatments did not differ from the untreated control (Table 2). Variety also influenced grain oil concentration, as MG1 variety had higher concentration (19.3%) compared to the MG2 variety (18.7%), but there were no differences among fertilizer treatments. Heavier seeds in MG2 variety also contributed to the higher grain yield compared to the MG1 variety (Table 2).

Onset of droughty conditions in early July, hindered pod setting and seed filling, and also likely limited nutrient movement and nutrient uptake from the late-season fertilizer application resulting in lack of response to the treatments.

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Table 1. Pre-plant soil chemical properties near Beresford, SD in 2020.

	2020		2021	
Soil parameter	**0-6”**	**6-24”**	**0-6”**	**6-24”**
Soil pH	**5.58**	**6.63**	**5.53**	**6.67**
Soil organic matter (%)	**3.8**	**3.1**	**3.6**	**2.5**
NO_3^--N (ppm)	**2.95**	**3.13**	**1.0**	**1.96**
Bray-1 P (ppm)	**20.3**	**4.98**	**16.5**	**3.73**
K (ppm)	**195**	**105**	**172**	**127**
SO_4-S (ppm)	**6.0**	**4.5**	**7.6**	**7.3**

Table 2. Late-season fertilizer application timing and maturity group interaction effect on grain yield near Beresford, SD in 2020 and 2021.

Fertilizer application timing	MG1	MG2
Control	42.5	51.4
Pre-plant	44.5	50.2
R3	45.7	49.9
R5	47.3	50.2
R6	40.8	50.9
V4 inoculation	47.1	48.7
V4 inoculation + R5 fertilizer	47.2	52.8

Table 3. Late-season fertilizer application effect on grain yield, protein and oil concentrations near Beresford, SD in 2020.

Maturity group	Fertilizer application timing	Grain Protein Concentration (%)	Grain Oil Concentration (%)	500 Seeds weight (g)
MG 1	**Control**	33.5	19.5	63.6
	Pre-plant	33.5	19.4	63.7
	R3	33.9	19.3	61.8
	R5	33.9	19.3	64.5
	R6	34.0	19.2	64.4
	V4 inoculation	34.0	19.2	63.0
	V4 inoculation + R5 fertilizer	33.9	19.1	62.6
MG 2	**Control**	34.5	18.8	67.6
	Pre-plant	34.1	18.8	65.3
	R3	34.7	18.7	68.7
	R5	34.7	18.7	69.5
	R6	34.3	18.8	65.1
	V4 inoculation	34.5	18.7	68.5
	V4 inoculation + R5 fertilizer	34.7	18.6	66.1

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Investigating the Impact of Starter Fertilizer Placement on Plant Development, Grain Yield, and Nutrient Uptake

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INTRODUCTION

Starter fertilizer is often associated with early plant development and plant-to-plant uniformity especially for early-planted crop or in no-till growing conditions. Application of starter fertilizer and proper fertilizer placement can have a significant positive impact on corn (*Zea mays* L.) grain yield (Osborne, 2005; Vetsch et al., 2002). Approximately 60% of the producers apply starter fertilizer in South Dakota according to a recent producer survey. However, the yield impact and benefit of starter fertilizer is inconsistent (Gordon et al., 2006).

OBJECTIVES

The goal of the project is to compare the effect of starter fertilizer placement and plant development in addition to grain yield effect. Specific objectives are 1) to determine if the use of starter fertilizer increases grain yield in Southeastern, SD, 2) to determine if planting date influences corn response to starter fertilizer 3) to determine the starter fertilizer impact on plant development and nutrient uptake.

METHODS

We compared an early planting date with a normal/late planting date response with different starter fertilizer placement and starter fertilizer combination.
The first planting date (early planting) treatments were planted on April 26th while the second planting date treatments (normal/late planting window) were planted on May 12th near Beresford. Two starter fertilizers were used (10-34-0 and 8-21-5 with and without additional Zn fertilizer). Starter fertilizers were placed in the following ways:

- in-furrow lower rate (IFL),
- in-furrow higher rate (IFH),
- 2 x 2, and a
- combination of in-furrow lower rate and 2 x 2 placements.
- control (did not receive starter fertilizer)

The in-furrow low-rate treatment provided approximately 9 lbs P_2O_5/ac (same amount for the two fertilizer types); the in-furrow high-rate placement treatment provided approximately 14 lbs P_2O_5/ac, while the 2 x 2 starter placement provided 23 lbs P_2O_5/ac. P0421AM hybrid were seeded at a rate of 34,000 seeds ac^{-1}. Urea was applied to balance the nitrogen fertilizer requirements (to 150 kg N ha^{-1}) of the corn plants regardless of the starter fertilizer treatment.

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Early season plant development, nutrient uptake and grain yield were determined. Whole plant samples were taken at V6 and R6 growth stages for biomass accumulation and nutrient uptake determination. Ear-leaf samples were also taken at the early reproductive stage (R1) for nutrient concentration determination as well. Stand count was conducted at the V4 growth stage. Growth stage of 20 consecutive individual plants were determined at V3, V7 growth stages and plant height was also measured on the same plants at V3, V7 and V10 growth stages. Center two rows harvested on October 7th by Kincaid 8XP Plot combine and yield was adjusted to 15.5% moisture.

RESULTS

Pre-plant soil test results presented in Table 1. The planting date had the largest influence on the measured crop physiological parameters (Table 2). This is likely due to the minor plant development differences (growth stage) when sampling or when plant measurement occurred for the two planting dates. Dry matter accumulation and nutrient uptake at the V6 growth stage, plant growth stage, plant height and the grain were significantly affected by planting date (Table 2 and 3). Starter fertilizer placement affected V6 dry matter accumulation, and N, P, and Zn uptake at V6 growth stage, plant heights at V7 and V10 growth stages, and plant population (Tables 2 and 3).

The starter fertilizer itself or other interactions did not affect these early season measurements except for V6 dry matter accumulation where the interaction between starter fertilizer and planting date were statistically significant (Table 2).

All starter fertilizer placement increased nominally the dry matter accumulation at V6 compared to the control treatment, but only the low rate in-furrow placement and the combination of in-furrow low rate and 2x2 treatment proved statistically higher (Table 4). However, these early season differences disappeared for the comparison of whole season dry matter accumulation. The growth stage of the plant development was not influenced by either the starter fertilizer placement or source, however, the combination of 2x2 and low rate in-furrow starter fertilizer placement increased plant height (Table 4). The other starter fertilizer placements also marginally help to enhance plant growth through higher plant height relative to the control treatment (Table 4).

All starter fertilizer placement increased nominally the N, P, and Zn uptake at V6 growth stage compared to the control treatment; however, the only statistically different was the combination of 2x2 and low rate in-furrow fertilizer placement (Table 5). Early planted corn yielded nearly 10 bu/ac higher averaged across fertilizer placements and sources compared to the late-planted corn (Table 5). The fertilizer placement resulted about 8 bu/ac differences between the treatments, but statistically they did not differ (Table 5). Both the low rate in-furrow, the 2x2 and their combination showed a promising 5-6 bu/ac yield gain compared to the control in the first year of the experiment.

Preliminary findings after the first season, which was impacted by the drought, are that starter fertilizer enhanced plant growth, but this was not translated to statistical differences in grain yield.

The starter fertilizer effect on whole-season nutrient uptake and the impact on the mid-season tissue (ear-leaf) concentration will be determined yet. Additionally, we will complete the yield component measurements and analysis.

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Table 1. Pre-plant soil chemical properties near Beresford, SD (SERF) in 2021.

Soil parameters	0-6”	6-24”
pH	6.05	7.65
OM (%)	3.1	2.3
NO_3^--N (ppm)	1.9	4.03
K (ppm)	197	119
Bray-1 P (ppm)	11.8	2.5
Zn (ppm)	1.03	0.217

Table 2. Analysis of variance of the dry matter accumulation, plant growth stages, plant heights and plant population in studies near Beresford (SERF) in 2021.

	Dry matter		Growth stage		Height			Population
	V6	R6	V3	V7	V3	V7	V10	V4
Starter Fertilizer source (F)	0.64	0.71	0.73	0.16	0.90	0.11	0.57	**0.03**
Fertilizer Placement (PL)	**0.001**	0.76	0.99	0.31	0.20	**0.001**	**0.003**	**<0.001**
Planting date (PD)	**<0.001**	0.13	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.02**
F x PL	0.82	0.97	1.00	0.71	0.90	0.73	0.89	0.26
F x PD	**0.01**	0.41	0.70	0.27	0.90	0.39	0.80	0.23
PL X PD	0.50	0.72	0.98	0.62	0.98	0.72	0.95	0.79
F x PD x PL	0.84	0.74	1.00	0.93	1.00	0.52	0.81	0.58

Table 3. Analysis of variance of grain yield, N, P, K, and Zn uptake at V6 growth stage, and grain yield near Beresford in 2021.

	N	P	K	Zn	Grain Yield
Starter Fertilizer source (F)	0.68	0.87	0.82	0.86	0.29
Fertilizer Placement (PL)	**0.01**	**0.01**	0.14	**0.004**	0.07
Planting date (PD)	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**0.0008**
F x PL	0.86	0.80	0.86	0.42	0.90
F x PD	0.05	**0.04**	0.16	0.42	0.44
PL X PD	0.36	0.43	0.25	0.15	0.15
F x PD x PL	0.93	0.95	0.61	0.26	0.23

Table 4. Starter fertilizer placement, planting date, fertilizer type main effects, and planting date x fertilizer placement, and planting date x starter fertilizer type interaction effects on dry matter accumulation at V6 (6 leaf growth stage), and at R6 (physiological maturity), plant growth stage and plant height near Beresford, SD in 2021.

	Dry matter lbs./acre		Growth stage		Plant Height (in)		
	V6	R6	V3	V7	V3	V7	V10
Starter Fertilizer Placement							
Control	445.8 b	17,946	3.22	7.09	2.00	11.2 b	37.8 b
IFL	525.6 a	17,104	3.22	7.13	2.20	11.8 ab	40.0 ab
IFH	491.0 ab	17,188	3.20	7.34	2.24	11.8 ab	38.5 b
2*2	511.2 ab	17,657	3.19	7.17	2.22	11.6 ab	40.6 ab
Both	547.5 a	18,176	3.19	7.33	2.28	12.7 a	42.3 a
Planting date							
Pdate1	356.3 b	18,079	2.96 b	7.57 a	1.8 b	12.3 a	41.8 a
Pdate2	652.4 a	17,150	3.45 a	6.83 b	2.6 a	11.4 b	37.8 b
Fertilizer Source							
10-34-0	489.6	17,924	3.2	7.24	2.2	12.0	39.6
10-34-0 + Zn	514.9	17,761	3.26	7.35	2.2	12.2	40.7
8-21-5	512.6	17,775	3.22	7.04	2.2	11.5	39.2
8-21-5 + Zn	500.4	16,998	3.15	7.21	2.2	11.8	39.7
Pdate*Placement							
Pdate1 control	287.8	18,862	3.00	7.47	1.7	11.7	39.8
IFL	405.0	17,077	2.96	7.47	1.8	12.2	42.4
IFH	340.0	17,376	2.93	7.81	1.9	12.3	40.4
2*2	361.6	18,730	2.95	7.53	1.8	12.5	42.8
both	387.0	18,349	2.95	7.58	1.9	12.9	43.8
Pdate2 control	603.7	17,030	3.43	6.70	2.4	10.7	35.7
IFL	646.2	17,131	3.48	6.78	2.6	11.4	37.5
IFH	642.1	17,001	3.48	6.83	2.6	11.3	36.6
2*2	662.1	16,584	3.44	6.80	2.6	11.2	38.3
both	707.8	18,003	3.44	7.07	2.6	12.5	40.8
Pdate*Starter Fertilizer source							
Pdate1:10-34-0	383.9 b	19,181	2.93	7.60	1.8	12.7	42.3
10-34-0 + Zn	337.2 b	18,330	3.07	7.83	1.8	12.7	42.8
8-21-5	363.4 b	17,966	2.99	7.40	1.9	12.0	41.0
8-21-5 + Zn	340.6 b	16,839	2.86	7.44	1.8	11.9	41.3
Pdate2:10-34-0	595.3 a	16,667	3.45	6.87	2.6	11.4	37.0
10-34-0 + Zn	692.5 a	17,193	3.45	6.83	2.6	11.7	38.7
8-21-5	661.8 a	17,583	3.45	6.65	2.6	11.0	37.4
8-21-5 + Zn	660.2 a	17,157	3.44	6.97	2.5	11.6	38.0

Table 5. Starter fertilizer placement, planting date, fertilizer type main effects, and planting date x fertilizer placement, and planting date x starter fertilizer type interaction effects on of nitrogen, phosphorus, potassium, and zinc uptake at V6 growth stage and grain yield at near Beresford in 2021.

	N (lbs/ac)	P (lbs/ac)	K (lbs/ac)	Zn (lbs/ac)	Plant population (plants/acre)	Grain Yield (bu/ac)
Starter Fertilizer Placement						
Control	15.4 b	1.5 b	11.4	0.019 b	30,900 a	158.36
IFL	17.6 ab	1.8 ab	12.1	0.022 ab	31,200 a	164.89
IFH	16.3 ab	1.6 ab	11.3	0.020 ab	30,700 ab	155.01
2*2	17.7 ab	1.8 ab	11.9	0.021 ab	31,200 a	163.93
Both	18.4 a	1.9 a	12.4	0.024 a	30,000 b	163.45
Planting date						
Pdate1	12.2 b	1.4 b	10.4 b	0.013 b	30,600 b	165.52 a
Pdate2	21.8 a	2.0 a	13.0 a	0.029 a	31,000 a	156.76 b
Starter Fertilizer Source						
10-34-0	16.5	1.7	11.7	0.021	31,300 a	163.45
10-34-0 + Zn	17.3	1.7	11.5	0.021	30,500 b	163.29
8-21-5	17.5	1.7	12.0	0.022	30,700 ab	160.27
8-21-5 + Zn	17.0	1.7	11.4	0.021	30,700 ab	157.40
Pdate*Placement						
Pdate1 control	9.8	1.2	8.5	0.012	31,000	157.56
IFL	14.0	1.6	12.0	0.015	31,000	168.39
IFH	11.4	1.3	10.1	0.013	30,400	158.04
2*2	12.8	1.4	13.1	0.013	30,800	171.58
both	13.4	1.5	11.0	0.014	29,800	171.90
Pdate2 control	21.0	1.9	12.4	0.027	30,900	159.15
IFL	21.2	2.0	12.2	0.029	31,400	161.38
IFH	21.2	2.0	13.5	0.027	31,000	151.98
2*2	22.2	2.1	13.4	0.029	31,500	156.28
both	23.3	2.2	13.9	0.035	30,300	154.85
Pdate*Starter Fertilizer source						
Pdate1:10-34-0	13.1	1.5 bc	11.4	0.014	31,000	171.10
10-34-0 + Zn	11.5	1.3 c	9.5	0.012	30,000	167.76
8-21-5	12.3	1.4 c	10.5	0.014	30,900	162.50
8-21-5 + Zn	12.0	1.4 c	10.5	0.013	30,300	160.75
Pdate2:10-34-0	19.8	1.8 ab	12.0	0.027	31,500	155.65
10-34-0 + Zn	22.8	2.1 a	13.1	0.0297	30,800	158.83
8-21-5	22.6	2.1 a	13.5	0.0200	30,600	158.36
8-21-5+Zn	22.1	2.1 a	13.1	0.0298	31,100	154.05

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Sulfur Application Effect on Soybean Yield and Seed Protein Content

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INTRODUCTION

The implementation of stricter emission regulations, increasing yield over the years, and intensive cultivation practices in recent years have resulted in decreasing of the soil Sulfur (S) levels throughout the Midwestern United States. Changes vary across the Midwest. Sulfur is now becoming one of the limiting factors affecting soybean yield and seed protein content in many production areas. Soybean yield response to S application has been reported in several studies in soybean producing regions across the US. We conducted two field studies to observe the effect of S sources, rates, and application timing on soybean yield and protein content in SD, where S emission changes were less severe than the eastern Corn Belt.

The goal of this research project is to determine the effect of S application on soybean yield and seed protein content with the following specific objectives:

- Determine the effect of S sources and rates on soybean yield and seed protein content.
- Determine the effect of S application timing on soybean yield and seed protein content.
- Determine the effect of S sources and rates and S application timing on S uptake.

METHODS

S source studies

This study was conducted between 2019 and 2021 at Southeast Research Farm, near Beresford, SD to investigate the effect of S sources and rates on soybean yield, seed protein content, and nutrient uptakes. Experimental plots contained six rows of soybeans with 30” row spacing following corn in a no-till field. The treatments received 0, 5, 10, 20, and 30 lbs S ac^{-1} from three S sources which included ammonium sulfate (AMS, 21-0-0-24S), Microessential (MES 10; 12-40-0-10S), and Tiger XP (0-0-0-80S). Additional N and P were added to the treatments to provide equal amounts of

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nutrients within the same S rates from different S sources. Whole plant biomass was collected at R8 (maturity) growth stage and nutrient uptakes in grains and stover were determined. Fertilizer treatments were broadcasted right after the planting. The treatment means were separated at *p*=0.05 significance level.

S season studies

This study was conducted to determine the effect of foliar S application timing on soybean yield, seed protein content and nutrient uptakes. Soybean followed corn in a no-till field in each of three years. The applications included single foliar applications, double foliar application, and pre-plant application of AMS (21-0-0-24S). Single foliar application with 5 lbs S ac^{-1} rate was applied at V4 (four fully extended trifoliate), R2 (full bloom), R3 (beginning pod), and R4 (full pod) growth stage and double foliar applications each with 5 lbs S ac^{-1} was applied at V4+R2, V4+R3, R2+R3 growth stages. Pre-plant applications at the rate of 5 lbs ac^{-1} and 10 lbs ac^{-1} were also included for comparison with single and double foliar applications respectively. In addition, S application with micronutrient (32 fl oz ac^{-1} of Brandt Smart Quattro) at the V4 growth stage was included. Pre-plant treatments were broadcast applied right after planting while in-season applications were foliar applied at 15 GPA rate.

RESULTS AND DISCUSSION

S source studies

Spring, pre-plant soil test results presented in Table 1.

The results of S source studies showed that S sources, S rates and their interaction did not affect soybean yield, seed protein and oil content in 2019 and 2020 (Table 2). To date, we have analyzed the grain yield results for 2021 so far, and the seed protein and oil content and nutrient uptake results are currently being processed. In 2021, the interaction of S sources and S rates for yield was statistically significant, and the application of 10 lbs ac^{-1} AMS resulted in higher soybean yield and all other S applications resulted in similar soybean yield as compared to control (Table 2).

The nutrient uptake results showed that S sources, S rates and their interaction did not affect the S uptake in grains and stover as well as total S uptake at R8 (physiological maturity) growth stage in either of the analyzed years (Table 3).

S season studies

Spring pre-plant soil chemical characteristics are presented in Table 4. In 2019, S application timing affected soybean yield but did not affect the seed protein and oil content (Table 5). In 2019, the R4 single foliar application resulted in lower soybean yield while all other S applications resulted in similar soybean yield as compared to control treatment. In 2020, S application timing affected the seed protein concentration only and did not affect the soybean yield and seed oil content. In 2020, application resulted in lower seed protein content while all other S applications resulted in similar seed protein content as compared to control (Table 5).
S application timing did not affect the S uptake in grains and stover and total S

uptake in 2019 and 2020 in Beresford (Table 6).

The organic matter in the top layer (0-6") of the soil was above 3 % in all three years, which is considered as sufficient nutrient level to supply nutrients to the plant. Generally, the possibility of positive soybean response to S application decreases as the soil organic matter % increases as higher soil organic matter soil could release SO_4^{2-} ion throughout the growing season through the mineralization process that would meet the soybean plant's requirement.

CONCLUSION

In both S source and S season studies, we observed soybean yield response in only one year out of three. S applications did not (positively) affect the seed protein content in both studies. Positive soybean responses to S application largely depends on soil organic matter content and SO_4^{2-} soil level, and other soil and climatic factors. In our study, higher soil organic matter content in the top soil could be the reason for unresponsiveness of soybeans to S application.

Table 1. Pre-plant soil chemical properties for the S Sources study near Beresford, SD (SERF) between 2019 and 2021.

Soil Parameters	2019		2020		2021	
	0-6"	6-24"	0-6"	6-24"	0-6"	6-24"
Soil pH	6.2	7.9	5.8	7.0	5.6	6.6
Organic matter (%)	3.1	2.3	3.6	2.8	3.7	2.7
NO_3-N (ppm)	8.0	7.0	2.0	3.4	1.7	3.7
Bray-1 P (ppm)	18.7	6.6	21.4	3.2	28.6	3.1
SO_4-S (ppm)	3.3	4.0	6.3	4.5	8.3	5.3

Table 2. S application effect on grain yield and seed protein and oil content near Beresford, SD.

S source and rate (lbs ac^{-1})	2019			2020			2021
	Yield (lbs ac^{-1})	Protein (%)	Oil (%)	Yield (lbs ac^{-1})	Protein (%)	Oil (%)	Yield (lbs ac^{-1})
Control	55.90	33.6	18.8	45.9	34.5	19.3	48.50 bcd
AMS 5	55.31	33.5	19.0	48.0	34.9	19.0	50.60 bc
AMS 10	54.27	33.4	19.0	47.5	34.9	18.8	57.80 a
AMS 20	56.92	33.8	18.8	46.4	35.0	18.6	46.80 cd
AMS 30	54.04	33.5	18.8	46.1	34.3	19.1	45.60 d
MES 5	54.70	33.5	18.8	45.6	35.1	18.8	49.80 bcd
MES 10	54.07	33.2	19.0	45.2	35.0	18.8	49.30 bcd
MES 20	53.98	33.5	18.8	40.6	34.9	18.8	52.00 b
MES 30	54.82	33.8	18.8	44.6	34.9	18.6	49.60 bcd
Tiger XP 5	53.86	33.4	19.0	46.2	34.8	19.0	46.90 cd
Tiger XP 10	55.21	33.9	18.8	44.8	34.8	19.0	46.00 d
Tiger XP 20	56.39	33.6	18.9	49.5	34.9	18.9	49.50 bcd
Tiger XP 30	53.93	33.5	18.9	45.4	34.9	18.7	49.30 bcd
p<F							
S source	0.77	0.87	0.71	0.13	0.62	0.61	0.137
S rate	0.61	0.84	0.42	0.91	0.66	0.73	**0.004**
S source x S rate	0.83	0.35	0.61	0.43	0.79	0.62	**0.002**

Table 3. S application effect on S uptake at R8 growth stage near Beresford, SD in 2019 and 2020.

S application	2019			*2020*		
	Nutrient uptake (lbs ac^{-1})					
	Grain S	Stover S	Total S	Grain S	Stover S	Total S
Control	10.78	2.11	12.88	6.87	2.41	9.28
AMS 5	11.05	2.17	13.22	7.54	2.25	9.79
AMS 10	11.99	2.60	14.59	5.94	1.89	7.83
AMS 20	10.50	2.09	12.59	7.90	4.24	12.13
AMS 30	10.26	2.32	12.57	7.43	3.39	10.82
MES 5	11.91	2.00	13.90	5.95	2.24	8.20
MES 10	10.55	2.50	13.05	6.66	3.02	9.67
MES 20	10.26	2.04	12.31	6.49	2.17	8.65
MES 30	11.38	2.16	13.53	7.98	2.08	10.05
Tiger XP 5	11.42	2.04	13.46	5.90	2.86	8.76
Tiger XP 10	10.97	2.23	13.19	6.56	2.30	8.86
Tiger XP 20	10.82	2.42	13.24	7.98	2.88	10.87
Tiger XP 30	10.78	2.42	13.19	7.03	2.51	9.53
p<F						
S sources	0.98	0.86	0.98	0.94	0.94	0.85
S rates	0.37	0.35	0.54	0.046	0.68	0.064
S source x S rate	0.57	0.86	0.72	0.46	0.64	0.51

S season studies

Table 4. Pre-plant soil chemical properties for the S Season study near Beresford, SD (SERF) in 2019 and 2020

Soil Parameters	2019		2020		2021	
	0-6”	6-24”	0-6”	6-24”	0-6”	6-24”
Soil pH	6.9	7.6	5.9	7.0	5.7	6.9
Organic matter (%)	3.1	2.9	3.5	3.0	3.9	2.7
NO_3-N (ppm)	5.5	6.8	2.3	2.7	2.5	4.7
Bray-1 P (ppm)	22.0	14.5	24.7	16.2	20.9	2.3
SO_4-S (ppm)	6.0	13.0	6.8	4.8	7.5	6.0

Table 5. S application timing effect on grain yield and seed protein and oil content near Beresford, SD

S application timing	2019			2020			2021
	Yield (lbs ac^{-1})	Protein (%)	Oil (%)	Yield (lbs ac^{-1})	Protein (%)	Oil (%)	Yield (lbs ac^{-1})
Control	58.92 a	33.4	19.0	45.24	34.2 ab	19.4	52.06
Pre-plant 5 lbs ac^{-1}	58.84 a	33.5	18.9	43.30	34.1 ab	19.4	53.48
V4	58.69 a	33.6	18.8	45.39	34.1 ab	19.4	53.38
V4 dry 5 lbs ac^{-1}				44.23	34.0 ab	19.4	54.00
R2	59.34 a	33.7	18.9	46.95	34.0 ab	19.5	51.37
R3	59.28 a	33.6	18.8	43.97	33.9 ab	19.5	53.09
R4	51.71 b	33.2	18.9	42.58	34.0 ab	19.3	53.58
V4 + micronutrient	58.59 a	33.8	18.8	44.35	34.0 ab	19.5	52.79
Pre-plant 10 lbs ac^{-1}	56.9 a	33.6	18.8	43.27	33.3 b	19.7	50.11
V4 + R2	57.93 a	33.4	18.9	44.75	33.7 ab	19.6	56.28
V4 + R4	58.24 ab	33.7	18.8	43.46	34.1 ab	19.3	52.30
R2 + R4	55.69 ab	33.3	19.0	44.22	34.6 a	19.1	51.76
p<F							
Application timing	**0.006**	0.63	0.80	0.8	**0.02**	0.44	0.896

Table 6. S application timing effect on S uptake maturity stage near Beresford, SD

S application timing	2019			2020		
	Nutrient uptake (Kg ha^{-1})					
	Grain S	Stover S	Total S	Grain S	Stover S	Total S
Control	10.36	4.18	14.54	7.68	1.55	9.23
Pre-plant 5 (lbs ac^{-1})	10.24	3.70	13.94	7.65	3.16	10.80
V4	9.71	3.27	12.97	7.57	2.22	9.79
V4 dry (5 lbs ac^{-1})				7.31	2.68	9.98
R2	10.22	3.17	13.39	7.32	2.30	9.62
R3	9.63	2.71	12.34	7.61	2.48	10.09
R4	9.68	3.52	13.19	5.81	2.70	8.51
V4 + micronutrient	9.87	2.85	12.71	6.26	2.11	8.37
Pre-plant 10 (lbs ac^{-1})	9.74	3.28	13.02	6.76	2.83	9.59
V4 + R2	9.75	3.25	13.00	8.74	2.93	11.67
V4 + R4	10.52	2.84	13.35	6.25	2.66	8.92
R2 + R4	9.97	3.55	13.52	7.24	1.77	9.02
p<F						
Application timing	0.96	0.56	0.64	0.62	0.31	0.73

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Can Soil Health Measurements be used to Predict Yield Responses to Fertilizer Additions in Corn?

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INTRODUCTION

Soil health and fertility are important aspects in corn production. Both can play an important role in the yield of a corn crop as well as the profitability of a farming operation. While soil fertility is typically adjusted yearly by adding inorganic fertilizers, soil health is changed long-term and is not an exact science. Recently, methods that improve soil health have been promoted by agronomists and environmentalists alike. These include reduced tillage practices, organic matter additions, soil water management, crop rotations and many others. While conservation management practices have become widely used, a correlation between soil health and fertility has not been made in a way that would help producers make management decisions. Soil health indicators along with soil fertility data could be used to reduce fertilizer inputs as well as increase yield.

The objectives of this project are to (1) determine if the critical values for phosphorus (P), potassium (K), and sulfur (S) fertilizer recommendations need to be adjusted and (2) determine the effect of including soil health indicators on the accuracy of yield response to fertilizer addition predictions.

METHODS

N only	P 100 lbs
K 100 lbs	S 25 lbs

Figure 1. Fertilizer Treatment layout that was replicated four times at each research location.

Between 2019 and 2021, twenty-eight locations were chosen throughout central and eastern South Dakota that varied in management practices, previous crops, and environmental conditions. Each location had four treatments replicated four times: 1, a control (no P, K, or S); 2, 100 lbs. P_2O_5/ac; 3, 100 lbs. K_2O/ac; and 4, 25 lbs. S/ac (**Figure 1**).

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All treatments received N fertilizer at the rate the farmer applied to the remaining field area. Each replication of the four treatments had a deep (2 ft.) core taken where soil fertility and textures were measured at intervals of 0-6 in., 6-12 in., and 12-24 in. Soil fertility samples were obtained from 0-4 in. and 0-6 in., and soil health from 0-2 in. and 2-6 in. These samples were taken before fertilizer application and planting. Around the time of planting, fertilizer was surface applied by hand to the plots. Whole plant samples were obtained at V6 and analyzed for nutrient content and uptake. At harvest, fields were harvested either by using a plot combine or by hand. A grain sample was ground and analyzed for nutrient content and uptake. Final grain yield was adjusted to 15.5% moisture. Statistical tests used include linear plateau, Kate-Nelson test, stepwise regression, and random forest modeling.

RESULTS

P 100 lbs.

The stamps fertilized with P had yields that ranged from 35-284 bu/ac with an average of 162 bu/ac. The yield response ratio averaged 0.98 while the V6 tissue response averaged at 0.9 (**Figures 2 and 3**). Of the 97 stamps, 59 were below the current critical value of Olsen 16 ppm. Of the 59 insufficient stamps, 64% showed an increase in yield with P additions. When P was sufficient, yield was still raised at 39% of stamps (**Table 1**). By running linear plateau and Kate-Nelson analysis of the dataset, a new critical value of Olsen 24 ppm was obtained. Using 24 as the new critical value, 60% of insufficient P stamps (decrease of 4%) and 33% of sufficient stamps showed a yield increase. While the percentage of insufficient stamps that responded slightly decreased (-4%), the percentage of sufficient stamps that positively responded was reduced by 6%.

When searching for new variables to be used in the phosphorus recommendations, stepwise regression and random forest analysis were used to find important variables. The soil health measurements of total carbon and soil respiration both showed promise in being useful to help with phosphorus recommendations. For example, soil respiration along with Olsen P improved the R-squared for the linear regression equation (0.09 to 0.12) and was significantly better than using Olsen P alone ($p = 0.05$). Random forest analysis showed total carbon as being the most useful by being the root of decision trees more than any other variables (120 of 1000 trees) and had the second lowest mean minimum depth in the tree behind Olsen P.

K 100 lbs.

The stamps fertilized with K had yields ranging from 28 to 273 bu/ac with an average of 150 bu/ac. The yield response ratio averaged at 1.05 and the V6 tissue response averaged at 0.97 (**Figures 4 and 5**). Using the current critical value of K 160 ppm, 32 of the 97 stamps were insufficient in K. By running linear plateau and Kate-Nelson analysis of the dataset, a new critical value of 120 ppm was obtained. Using 120 ppm as the critical value, for the insufficient stamps yield was raised on 33% of stamps compared to 25% when the critical value was at 160 ppm. The same trend continued with the sufficient K stamps where 28% still responded at 160 ppm but is decreased to 26% when the critical value is set at K 120 ppm. (T**able 1**). By lowering the critical value to 120 ppm, a higher percentage of insufficient stamps (+8%) and a lower percentage of sufficient stamps (-2%) responded to K fertilizer application, although only 6 stamps were insufficient in K at the new critical value.

New variables for K recommendations included soil K, the smectite:illite ratio, acid phosphatase, and beta glucosidase. This combination of variables, given by running stepwise regression was significantly better than using soil K alone (p = 0.07). Random forest gave beta glucosidase as the best variable, even better than soil K. Beta glucosidase had the lowest mean minimal depth in the decision tree and was the root a high number of times (90 of 1000).

S 25 lbs.

The stamps fertilized with S had yields ranging from 18 to 249 bu/ac with an average of 155 bu/ac. The yield response ratio averaged at 1.00. and the V6 response ratio averaged 0.90 (**Figures 6 and 7**). All soil test S levels were grouped together as our sampling method and lab data does not match the South Dakota standards of 0-6 and 6-24 in. sampling. Of the 97 stamps, 37 showed a positive yield response while 27 showed a negative response to sulfur application (**Table 1**). There was no trend in the data and a critical value could not be determined.

Stepwise regression could not find any other variables that were better than soil S at predicting yield responses, and soil S was a very poor predictor by itself ($r^2 = 0.02$). That same trend continued with random forest as no variables could be found that improved the sulfur recommendation.

DISCUSSION

Objective 1

Overall, P-fertilized stamps averaged a positive yield response, likely due to 60% of stamps having insufficient P levels. When below the critical value, yield correlated well with Olsen P and showed a positive linear relationship. Once past the critical value, the data points leveled off, indicating that addition of more P would not further increase yields. A slight increase in the critical value from 16 to 24 (Olson ppm, 0-6”) slightly decreased the percentage of stamps that had insufficient P and had a positive yield response (-4%) but reduced the number of stamps where there was sufficient P and still a positive yield response (-6%).

Both K and S fertilized stamps did not show a linear relationship up until a certain point which indicated a linear plateau model would not work well with our data set. For K, there were very few stamps with insufficient levels. A lower critical value, like the proposed K 120 ppm, could only be verified if lower K locations could be tested. For S, there was almost no correlation between soil test S and yield, indicating that no critical value could be determined.

Objective 2

For phosphorus, the use of soil respiration and soil carbon as potential new variables showed that phosphorus released by soil microbes and organic matter may help supply P needs to corn plants. This means management practices that improve soil microbial communities and raise organic matter levels may lead to decreased phosphorus fertilizer need.

Once again, K and S were more difficult to correlate with soil health indicators compared to P. Beta glucosidase showed itself as a potential indicator in the random forest model for K, but a simple scatterplot shows almost no relationship between the enzyme and yield responses. Sulfur is even more difficult. Neither random forest nor stepwise regression found any variables that were significantly better than using S alone, and S ppm levels had almost no correlation to yield responses. It seems a new sulfur test will need to be found that can relate yield responses to sulfur in the soil.

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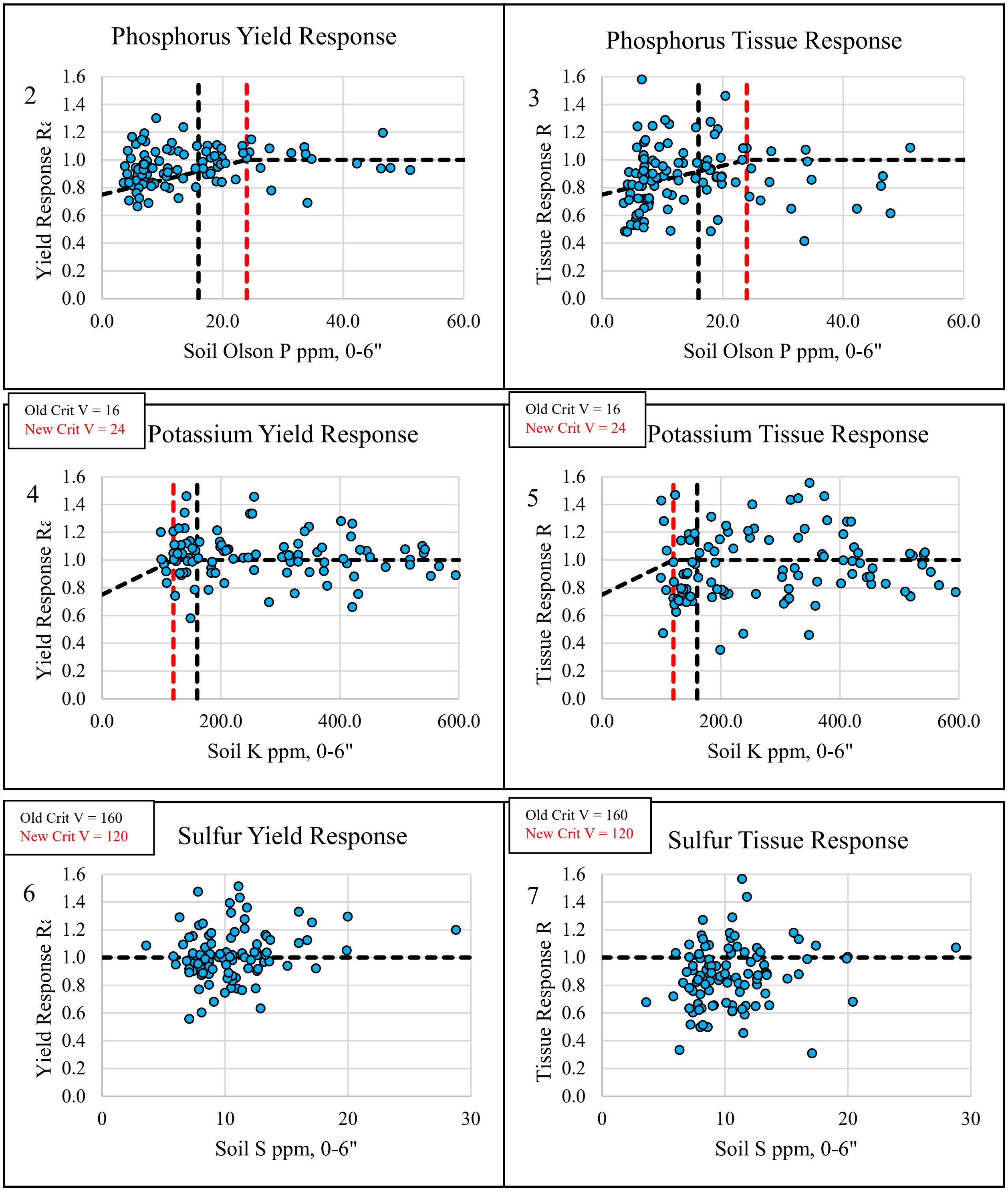
Phosphorus							
Olsen P, 0-6 in.	Number of Stamps			Yield Response Ratio			
	Lowered	Constant	Raised	Lowered		Raised	
				Maximum	Average	Minimum	Average
Very Low	0	1	1	NA	NA	0.84	0.84
Low	6	5	22	1.19	1.13	0.72	0.88
Medium	5	1	10	1.30	1.12	0.80	0.86
High	2	1	5	1.23	1.17	0.72	0.85
Very high	11	12	15	1.36	1.13	0.69	0.88
Potassium							
K ppm, 0-6 in.	Number of Stamps			Yield Response Ratio			
	Lowered	Constant	Raised	Lowered		Raised	
				Maximum	Average	Minimum	Average
Medium	1	3	2	1.20	1.20	0.83	0.88
High	12	8	6	1.67	1.22	0.58	0.82
Very High	27	20	18	1.80	1.20	0.66	0.86
Sulfur							

Table 1. This table shows the preplant Olsen P ppm, K ppm, and S ppm levels and looks at stamps in South Dakota from 2019-2021. Column one shows the soil test P, K, and S levels according to the South Dakota Fertilizer Recommendations Guide. All soil test S levels were grouped together. Columns 2-4 show the number of stamps where the yield was lowered (less than 95% yield of the control plot), stayed the same, or raised (more than 105% yield of the control plot). Columns 4-8 show the maximum/minimum yield response ratio as well as the average when yield was raised or lowered. Yield response ratio was calculated by taking the control plot yield divided by the treatment plot yield, meaning a lower response ratio means yields increased.



Figures 2-7. These graphs show both the yield response and the V6 tissue response at all plots from 2019-2021. The yield response graphs show the soil test P, K, and S levels compared to the yield response ratios. The V6 tissue response graphs show the soil test P, K, and S levels compared to nutrient uptake at V6. Both tissue and yield response ratios were calculated by taking the control yield/uptake and dividing it by the treatment. The vertical dotted lines represent the current critical value according to the South Dakota Fertilizer Recommendations Guide (Olson P 16 ppm and K 160 ppm). Since our soil test S procedure was only 0-6 in. and did not include 6-24 in., the critical value line was not added for the sulfur graph.

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Influence of Clay Mineralogy for Improved Correlation and Calibration of Potassium Fertilizer Guidelines for Corn in South Dakota: Year 2

Jason Clark[1], Kris Osterloh, Doug Malo, Shaina Westhoff, and Andrew Ahlersmeyer

INTRODUCTION

Corn yield is optimized when there is a sufficient amount of K (>160 ppm) in the soil solution. However, in eastern South Dakota, where a majority of the state's corn production occurs, intensive corn-soybean crop rotations have begun to deplete exchangeable-K reserves. As a result, an increase in soil test K (STK) deficiencies has been reported by Agvise Laboratories (Northwood, ND). Improving the accuracy of a K fertilizer rate (KFR) is essential not only to optimize corn yield, but also to ensure that overapplication does not occur, thus limiting unnecessary costs. However, there are multiple factors that can influence the optimal amount of K fertilizer needed. One particular topic of interest is clay mineralogy, which has been found to be successful in the calibration of KFRs in North Dakota. Breker et. al. (2019) used a cluster analysis to partition field trials in North Dakota based upon the respective portion of smectite clays, relative to illite clays. They discovered that the K critical level was higher for fields with a smectite:illite (S:I) ratio greater than 3.5. Conversely, fields with a ratio less than 3.5 had a lower K critical level. These findings are consistent with the fact that smectite clays are highly charged and hold onto K^+ ions more tightly compared to illite clays. Therefore, the relative amounts of smectite and illite clays in different soil types may influence the optimum amount of K that should be applied for corn.

OBJECTIVES

The objectives of this study were 1) determine preliminary relationships among soil clay mineralogy, K uptake by corn, and K fertilizer requirements, and 2) calibrate and adjust our current K fertilizer recommendations in South Dakota to include clay mineralogy as a variable.

MATERIALS AND METHODS

In 2021, nine field trials were conducted across eight counties in eastern South Dakota (Brookings, Codington, Hutchinson, Lincoln, Minnehaha, Roberts, Turner, and Yankton). The experimental design used was a randomized complete block design with 4 replications. Treatments of potash

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fertilizer were broadcast applied at planting (0-150 lbs. K_2O ac.$^{-1}$ in 30 lb. increments). Soil samples were collected at depths of 0-4, 0-6, 6-12, and 12-24 in. prior to treatment application from each block. Whole plant samples were collected at V6 in every plot. Grain yield, moisture, and test weight were recorded at harvest, and a grain sample was collected from every plot.

Table 1: Agronomic data for the 2021 growing season.

	Soil Test Parameter†				
Site	K	Smec.	Ill.	S:I	Text.‡
Brookings	327	14.3	70.8	0.20	SiCL
Codington	155	39.8	47.0	0.85	SiCL
Hutchinson	132	43.5	44.8	0.97	L
Lincoln	436	54.0	36.8	1.47	SiCL
Minnehaha E	170	41.0	45.3	0.90	SiCL
Minnehaha W	161	19.0	65.0	0.29	SaL
Roberts	287	34.8	51.5	0.68	SaL
Turner	143	80.8	13.0	6.21	SiCL
Yankton	241	51.5	38.8	1.33	L

†K, potassium, ammonium acetate extractable-K, ppm, composite, 0-6 in. depth; Smec., smectite, <2 µm fraction, mean of 4 replications, 0-6 in. depth; Ill., illite, <2 µm fraction, 0-6 in. depth; S:I, smectite:illite ratio; Text., soil texture, hydrometer.
‡SiL, silt loam; SiCL, silty clay loam; CL, clay loam; SiC, silty clay; L, loam; SaL, sandy loam.

RESULTS

Table 1 displays the agronomic data collected from each site in 2021. Similar to 2020, 6 of our 9 sites had STK values exceeding 160 ppm, indicating additional K fertilizer would not be necessary based on current SDSU recommendations.

The S:I ratio was generally near 1.00 for every site except Turner. Similar values were observed during the 2020 growing season. Further statistical analysis will be conducted to relate S:I to other variables. Figure 1 depicts normalized yield responses during the 2021 growing season. Overall, high STK values resulted in poor yield responses, if any, to K fertilizer treatments. Interestingly, the Brookings site had a tremendously high STK, but the drought conditions of 2021 caused visible K deficiency symptoms and a positive yield response up to 60 lbs. K_2O ac.$^{-1}$. Further statistical analysis and research of this topic will continue as we prepare for the 2022 growing season.

ACKNOWLEDGEMENTS

This study is funded by USDA-NIFA, USDA-NRCS NR203A7500010C00C, and SD NREC. We thank Dr. Peter Kovacs and the Southeast and Northeast South Dakota Agricultural Experiment Stations for their assistance with this project. We also appreciate the various corn producers throughout the state who allowed us to use their land to conduct our field trials.

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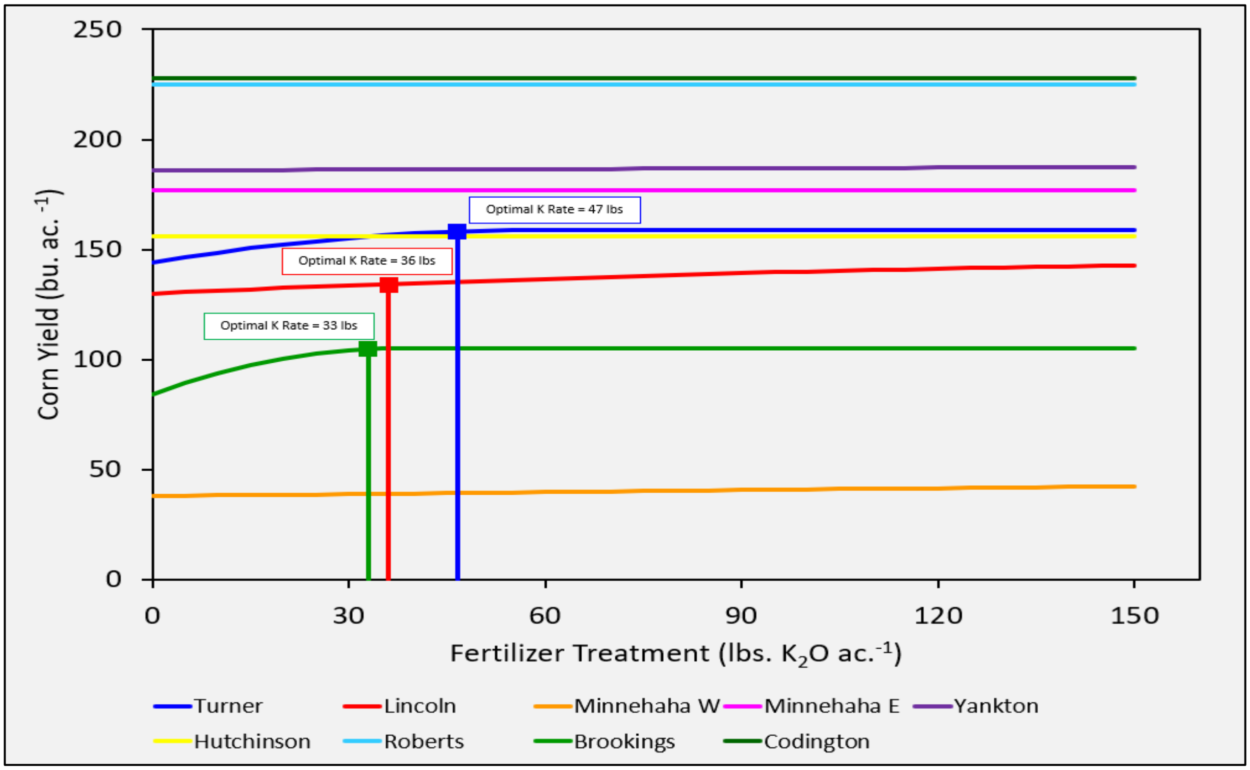

Figure 1: Quadratic-plateau corn yield response curves for 9 sites in eastern South Dakota during the 2021 growing season. Corn yields positively responded to applied K fertilizer at the Brookings, Turner, and Lincoln sites. For all other sites, 0 lbs. K_2O ac.$^{-1}$ was required to achieve the optimum yield.

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Inter-seeded Cover Crops Influence on Corn Nitrogen Fertilizer Needs and Corn Yield – Years 1–3

Jason D. Clark[1], Shannon Osborne, Peter Sexton, and Peter Kovacs

INTRODUCTION

Moving from conventional to no-till with the inclusion of cover crops can improve soil organic matter, soil structure, and water and nutrient holding capacity that may reduce environmental degradation from the loss of fertilizers and improve crop yield. Cover crops can be inter-seeded directly into standing corn with a high clearance planter. This innovative method of planting cover crops lowers seeding rate requirements and increases the time cover crops are growing and taking up excess nutrients and water. Inter-seeding cover crops may change the amount and timing of nitrogen (N) provided to the crop from decomposition (mineralization), which may increase or decrease needed N fertilizer to optimize corn grain yield.

The objectives of this project were to 1) compare the effect of inter-seeded cover crop mixtures on corn production. This review will focus on summarizing the yield results of the first three years.

METHODS

This rotational cover cropping and N rate study was established in 2019. A corn and soybean block were planted in adjacent fields to minimize soil variation. These blocks are then rotated between corn and soybean each year. Cover crop treatments were inter-seeded for corn at the V5–V6 corn growth stage and the V5 soybean growth stage. Cover crop treatments were: 1) no cover crop, 2) single grass species (annual rye grass), and 3), grass/broadleaf mixture (annual rye grass, crimson clover, turnip, and radish). Six nitrogen rates from 0–250 lbs ac^{-1} in 50 lb increments were applied near planting to only the corn block.

RESULTS

Zero Nitrogen Corn Yield

Corn yield of the control varied by year with an average of 177, 137, and 110 bu ac^{-1} in 2019, 2020, and 2021, respectively (Figure 1). These decreasing yields are likely due to the limited precipitation in the 2020 and 2021 growing seasons. Without N fertilization during these three years, the grass, grass/broadleaf, and no cover crop treatments yielded within 5 bu ac^{-1}. These results show that after three years of including cover crops in the rotation the natural supply of N from decomposition has not been influenced enough to change the corn yield. However, many other studies

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show it may take five or six years of including cover crops before observable changes in soil quality and nutrient cycling are observed.

Corn Yield at Optimal Nitrogen Rate

Corn yield at the optimal N rate varied between an average of 169 and 204 bu ac^{-1} (Figure 2). In two of three years, corn yield of the grass, grass/broadleaf, and no cover crop treatments were within 5 bu ac^{-1}. Optimal corn yield of the grass/broadleaf and control treatments were always within 1 bu ac^{-1}. Changes in optimal corn yield came between the grass and no cover crop treatment in 2020 where the grass cover crop treatment yielded 8 bu ac^{-1} less. Overall, these changes in yield due to cover crop are small and show that cover crops can be interseeded into corn without substantially increasing or decreasing crop yield.

Optimal Nitrogen Rate

The N rate to achieve maximum corn yield (Optimal N rate) varied by year with an average of 77, 119, and 88 lbs N ac^{-1} in 2019, 2020, and 2021, respectively (Figure 3). The optimal N requirement of corn among the cover crop treatments varied substantially except in 2021. In 2019 and 2020, compared to the no cover crop treatment, the grass cover crop increased corn optimal N rate by 25 and 67 lbs N ac^{-1}. Similarly, the grass/broadleaf cover crop increased corn optimal N rate by 36 and 208 lbs N ac^{-1} in 2019 and 2020. The yield results previously discussed showed that corn yield at the optimal N rate was minimally affected by the inclusion of cover crops. However, these results indicate that to achieve those similar yields interseeding cover crops into corn does normally increase N fertilizer requirements. This has been true in the first three years of this research project. However, the long-term effect of growing cover crops on corn yield and N requirements is yet to be determined.

Economic Return to Added Nitrogen

To evaluate the economics of the three treatments, we determined the profit from increased corn yield with the addition of N fertilizer and the cost of N required to achieve optimal yield. To determine the profit, we determined the increase in corn yield from adding fertilizer and multiplied that by the corn price. To determine cost, we multiplied the optimal N rate by the cost of N. For this example, we used a long-term average corn price of $4.00/bu and N rate of $0.40/lb N. After adding the net profit of each treatment across the three years, our results showed that no cover had the highest return ($399 ac^{-1}) followed by the grass/broadleaf mixture ($354 ac^{-1}) and the grass only cover crop ($318 ac^{-1}) (Figure 4). These results indicate that there was a greater return for N fertilizer applied without cover crops by $45-$81 ac^{-1}. However, it is important to note that improving soil health and demonstrating its cost savings is a long-term endeavor. Therefore, we are continuing this project for three additional years to see if these trends continue.

ACKNOWLEDGMENT

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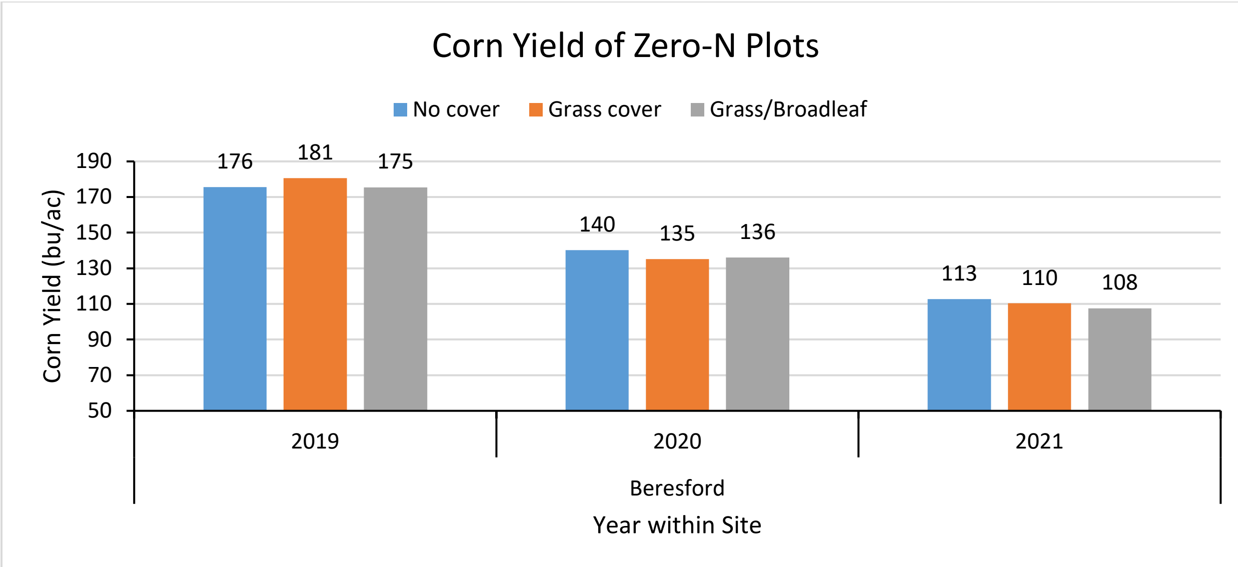

Figure 1. Corn grain yield response to the addition of three cover crop treatments when zero N fertilizer was applied across three years at the Southeast Research Farm near Beresford, SD. Cover crop treatments consisted of 1) no cover crop, 2) single grass species (annual rye grass), and 3), grass/broadleaf mixture (annual rye grass, crimson clover, turnip, and no cover crops).

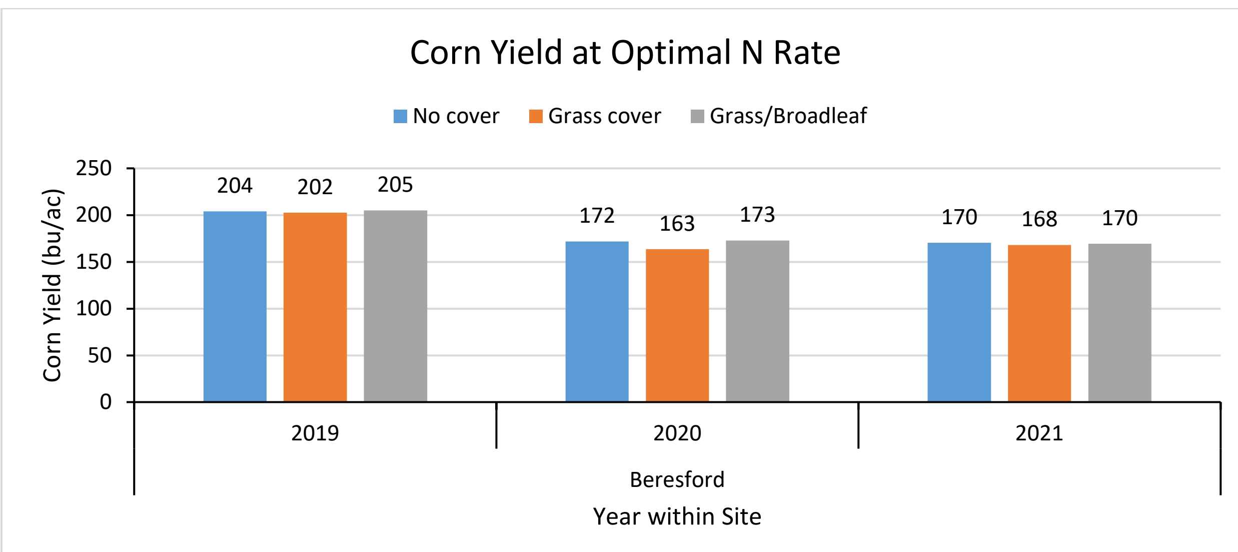

Figure 2. Corn grain yield response to the addition of three cover crop treatments at the optimal N fertilizer rate of three different cover crop treatments across three years at the Southeast Research Farm near Beresford, SD. Cover crop treatments consisted of 1) no cover crop, 2) single grass species (annual rye grass), and 3), grass/broadleaf mixture (annual rye grass, crimson clover, turnip, and no cover crops).

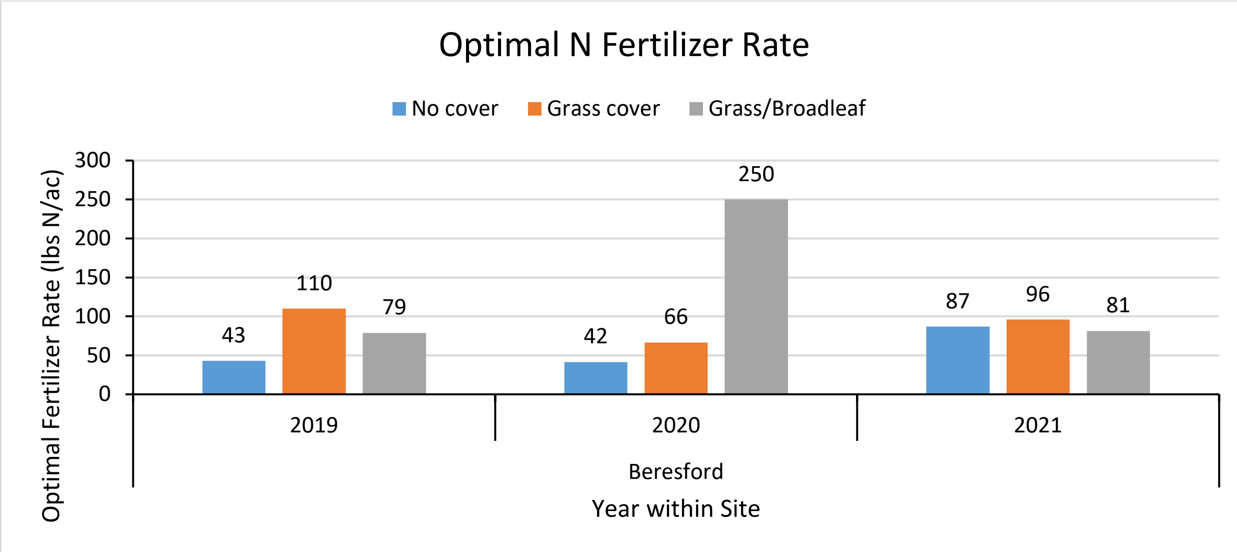

Figure 3. Optimal N fertilizer rate to maximize corn grain yield of three cover crop treatments across three years at the Southeast Research Farm near Beresford, SD. Cover crop treatments consisted of 1) no cover crop, 2) single grass species (annual rye grass), and 3), grass/broadleaf mixture (annual rye grass, crimson clover, turnip, and no cover crops).

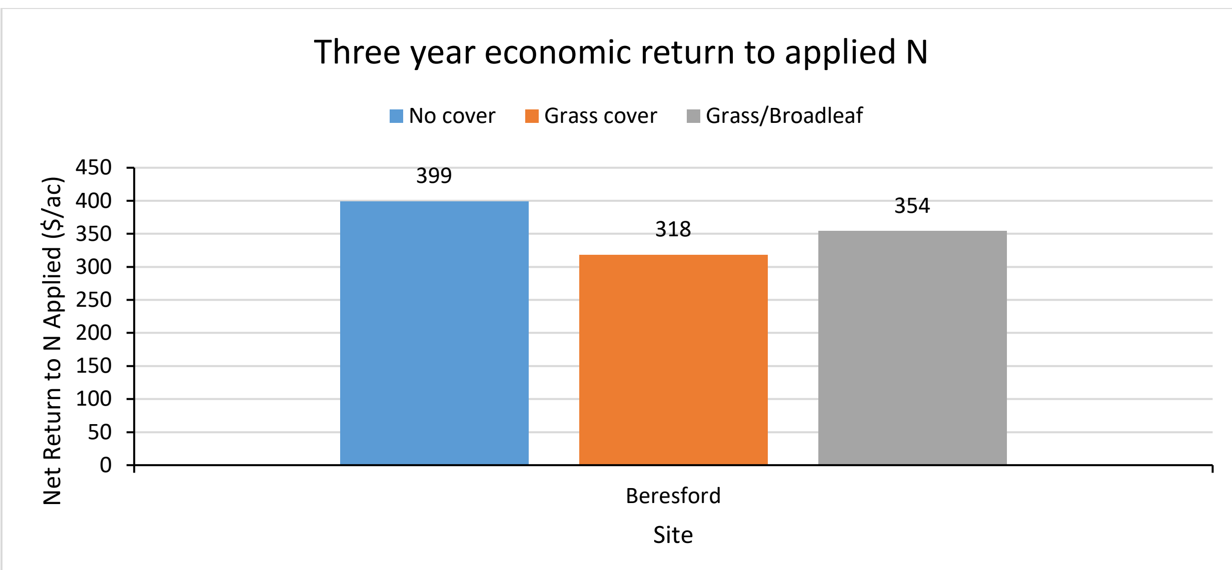

Figure 4. Comparison of the accumulative economic net return from applying the optimal N fertilizer rate to corn for the first three years of including three different cover crop treatments at the Southeast Research Farm near Beresford, SD. Cover crop treatments consisted of 1) no cover crop, 2) single grass species (annual rye grass), and 3), grass/broadleaf mixture (annual rye grass, crimson clover, turnip, and no cover crops).

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Oat Response to Various Nitrogen Regimes

David Karki[1] and Anthony Bly

BACKGROUND

The fertilizer recommendations guide for South Dakota (SD) crops was last updated in 2005 (EC750, 2005), and the nitrogen (N) recommendations for the oat grain crop are higher than guidelines recommended by other public institutions. The SD guideline uses expected yield goal to be multiplied by 1.3 (minus soil test N and legume credit) to estimate total N requirement by the oat crop. Perhaps, due to improved genetics and other management tools, producers in productive environments have consistently grown oat crop with yield of more than 100 bu/ac with significantly lower levels of nitrogen than recommended in the EC750 guide. The proposed study aims at developing an up-to-date nitrogen fertilizer recommendation for oats grown for grain production in SD. This will help narrow the knowledge gap among oat growers in terms of applying the correct amount of nitrogen fertilizer on oat crops to maximize production and profitability and avoid lodging. Application of fertilizer N as required by the crops will benefit growers to obtain the highest yield potential without a negative impact on environment.

GOAL

The goal of the proposed study is to develop a revised nitrogen fertilizer recommendation for oat grown for grain production in SD environments. Some SD growers have shown interest in using plant growth regulators (PGR) to shorten plant height as a means to prevent lodging.

METHODS

The trial at Southeast Research Farm was originally planned for testing 'PGR' along with nitrogen treatments but due to rapid plant growth, the labeled PGR application time was missed. Therefore, we used this site as 'N rate only' site. Five additional locations- SDSU Brookings Research Farm (Plant Pathology Farm), farmer cooperators fields in Garretson, Hand, Hyde, and McCook Counties were also used to study the nitrogen response. Total of five N rates 20, 40, 60, 100 and 140 lbs/ac were used in the study with additional 'control' treatment that did not receive any nitrogen. At planting, the field had about 55 lbs/ac of available N (15 lbs soil test N and 40 lbs soybean legume credit). All treatments were arranged in Randomized Complete Block (RCB) design with three replicates. The plot size was 15' x 30'. Variety 'Saddle' was used for the study.

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RESULTS

At Southeast Farm, the yields ranged from 69 bu/ac (140 lbs N) to 78 bu/ac (60 lbs N). The 'check' treatment yielded 70 bu/ac. The yields did not show any significant differences for the applied N treatments. The ratios of total N to grain yield ranged from 0.7 (check) to 2.8 (140 lbs N/ac). The non-significant yield response suggests that 0.7 lbs of N would be optimum to obtain a bushel of grain.

All experimental sites had soybean residue except Hyde Co. (near Stephan) which had sunflower residue. At site in Minnehaha County. near Garretson, the yield ranged from 83 bu/ac (check) to 87 bu/ac (100 lbs N) and did not show any significant response to applied N treatments. The pre-trial soil test N including legume credit was 50 lbs/a. The ratio of total N to grain yield ranged from 0.6 to 2.2 with optimum required N of 0.6 lbs for producing one bushel of grain. The response was similar at Brookings location as well. We lost two locations near Miller (Hand Co.) and Salem (McCook Co.) due to extreme drought

At site in Hyde Co., the pre-trial soil test N was 23 lbs N/ac. The grain yields ranged from 75 bu/ac (control) to 96 bu/ac (100 lbs). At this site, yields were significantly different for applied N treatments. The rate of yield increase was extremely low beyond 40 lbs N/ac. The ratios of total N to grain yield ranged from 0.3 to 1.9 with 0.7 (for 40 lbs applied N) as the optimum amount required to produce a bushel of grain.

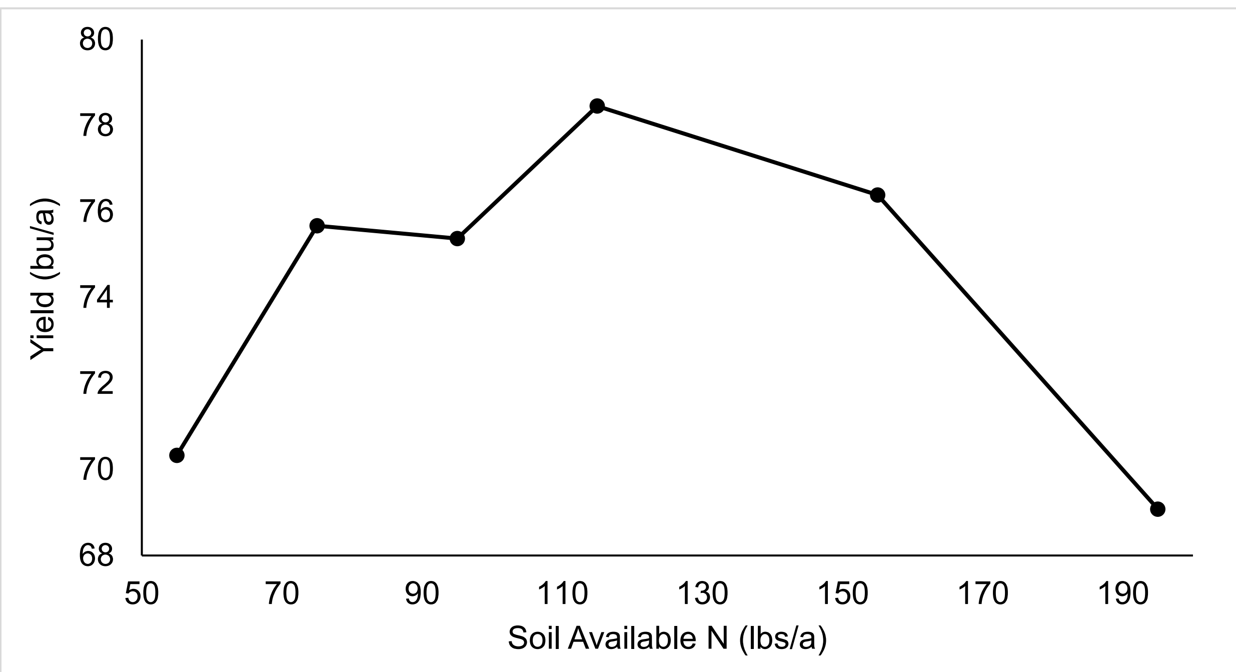

Figure 1. Average Oat Yields under Various Nitrogen Rates The 'control' or 'no nitrogen' plots had approximately 55 lbs/ac pre-trial nitrogen.

CONCLUSION

Plants were comparatively shorter at all locations due to extreme high temperatures and water stress. The data collected in 2021 suggest that optimum (and/or economical) rate of N required to produce a bushel of oat is about 0.7 lbs N/ac. Due to stressful growing conditions, we lost two sites this year and the sites that were able to be harvested had relatively lower yields than previous study years.

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SDSU Oat Breeding

Melanie Caffe[1], Nick Hall and Paul Okello

In 2021, drought severely affected oat production in the Northern Plains and in Canada. Oat production was down 39% from 2020 in the US and down 44% in Canada. Oat stocks were low going into 2021. The demand for oats for the food market is increasing, especially for markets such as oat milk. As a result of the low production in 2021, oat prices reached levels that were unseen before.

Oat is a low input crop requiring less fertilizer than other cereal crops such as corn and wheat. Including a small grain in the rotation provides benefit to soil health. Those agronomic benefits combined with high oat prices make oat an attractive crop to consider for this coming season, especially considering high fertilizer prices.

Oat varieties differ for their agronomic and milling characteristics. Choosing a variety that is suited for the intended market and adapted for the field location can have a significant impact on the revenue per acre. The goal of SDSU oat breeding program is to develop improved oat varieties that will increase the profitability for oat growers. Our focus is to improve agronomic characteristics (i.e., grain and forage yield, lodging resistance, disease resistance), as well as characteristics that are essential to market the grain (i.e., test weight, milling quality). SDSU oat breeding program uses the Southeast Research Farm (SERF) as one of its multiple testing locations to ensure that new varieties developed by the breeding program are adapted to the environmental conditions encountered in this area of the state.

In 2021, approximately 1500 test plots were seeded at SERF. Those included:

- An organic oat variety trial seeded on March 31st, 2021 to compare the performance of 30 oat cultivars and breeding lines under organic management.
- The South Dakota Crop Performance Testing Oat Variety Trial (SD CPT OVT) seeded on March 29th, 2021 to evaluate the performance of 27 oat varieties under both no fungicide treatment and fungicide treatment.
- Breeding trials including a forage trial (**Table 1**), regional nurseries (Uniform Early Oat Performance Nursery, Uniform Mid-season Oat Performance Nursery, Mid-West Cooperative

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Nursery), Advanced Yield Trials, Preliminary Yield Trials and early generation nurseries seeded on March 29th, 2021.

Summary of agronomic and milling quality performance from the SD CPT OVT can be found at Oat Variety Trial Results (sdstate.edu). The relative performance among varieties for grain yield can be affected by the environment, it is therefore recommended to consider data from multiple years when selecting a variety.

In fall 2021, breeding line SD150012 was released as 'SD Buffalo'. It is a white hulled oat cultivar derived from the three-way cross SD081107//SD07984/SD06130. Experimental line SD150012 was then evaluated in the Advanced Yield Trial in 2017, in the Uniform Early Oat Performance Nursery from 2018 to 2019, and in the SD CPT OVT from 2018 to 2021. When averaged over four years of evaluation in the SD CPT OVT (32 location-year combinations), SD Buffalo exhibited a significantly higher yield (109 Bu/a) than Rushmore (104.7 Bu/a) and Warrior (102.2 Bu/a). In the same trial, test weight of Buffalo averaged 33.6 lb/bu, which was significantly lower than Rushmore (34.7 lb/bu) but significantly higher than Warrior (32.9 lb/bu). Heading for SD Buffalo occurred at approximately the same time as Rushmore and approximately half a day later than Warrior. Plants of SD Buffalo (33.9 inches) had approximately the same height as Rushmore (33.8 inches) but were significantly taller than Warrior (32.4 inches). On a scale 1 to 5, with 1: no lodging and 5: entire plot being lodged, lodging score for SD Buffalo (2.08) was significantly higher than Warrior (1.81) but lower than Rushmore (2.39). SD Buffalo is moderately resistant to crown rust and Barley Yellow Dwarf Virus, and resistant to smut.

Based on quality evaluation performed on grain samples collected in the SD CPT OVT from 2019 to 2021, SD Buffalo was characterized by significantly higher thousand kernel weight (34.3g) than Rushmore (31.9g) and Warrior (31.4g). The percentage of plump kernels for SD Buffalo (45.1%) was significantly lower than Rushmore (51.5%) but significantly higher than Warrior (39.2%). The percentage of thin kernels for SD Buffalo (5.5%) was not significantly different than Rushmore (5.8%) and significantly lower than Warrior (6.3%). Groat percent for SD Buffalo (71.2%) was significantly lower than Rushmore (72.7%) and Warrior (72.3%). Grain composition was evaluated by scanning groat samples with NIR spectroscopy. Groat protein content for SD Buffalo (17.7%) was equivalent to Rushmore (17.9%) and Warrior (17.8%). Groat beta-glucan for SD Buffalo (4.68%) was significantly lower than Warrior (4.91%) but significantly higher than Rushmore (4.57%). Groat oil content for SD Buffalo (5.2%) was significantly higher than Rushmore (4.2%) and Warrior (4.7%).

Seed increase and purification of SD Buffalo was initiated in 2017. Early off-types remains at a frequency of approximately 6.25%. The off-types are visible during heading but showed no difference with the main plant type based on HPLC analysis performed at the SDSU Seed Testing Laboratory. An application will be submitted for Plant Variety Protection. Foundation seed of SD Buffalo is available for Certified Seed Producer.

Table 1. Dry matter yield (t/a) of entries evaluated at Southeast Research Farm in 2021. Numbers highlighted are not significantly different.

Entry	SERF Dry t/a	Heading date Julian	2021 Height inches	Wet t/a	Dry t/a
SD181286	**2.3**	164.8	29.5	8.2	**2.6**
SD170777	**2.2**	164.6	26.3	7.2	2.3
Deon	**2.1**	164.8	27.5	7.9	**2.5**
SD191016	**2.1**	165.2	32.8	7.6	**2.3**
SD190569	**2.1**	163.8	29.9	7.8	**2.3**
Jerry	**2.1**	162.3	28.0	7.9	**2.6**
SD170463	**2.1**	165.4	28.0	7.2	**2.3**
SD190601	**2.1**	165.0	28.9	8.0	**2.4**
SD181245	**2.1**	165.8	30.6	8.9	**2.5**
SD170935	**2.0**	167.0	30.5	8.3	**2.3**
SD190752	**2.0**	165.0	29.0	7.7	**2.3**
SD191397	**2.0**	164.0	26.7	7.2	**2.3**
SD190784	**1.9**	163.7	27.3	7.1	2.2
Hayden	**1.9**	165.3	26.3	8.2	**2.5**
Rockford	**1.9**	165.9	28.3	8.1	**2.3**
SD181237	1.9	166.2	33.3	8.7	**2.3**
SD180580	1.9	164.1	26.7	7.1	2.1
Rushmore	1.9	163.1	27.7	7.3	**2.4**
SD150012	1.9	163.1	25.7	7.0	2.3
SD190053	1.8	166.0	30.4	8.0	**2.3**
SD190038	1.8	167.4	31.5	7.8	2.3
Warrior	1.8	162.4	26.8	7.1	2.3
ForagePlus	1.8	171.9	24.6	8.2	2.0
Laker	1.8	168.2	25.0	7.7	2.2
SD190565	1.8	164.6	30.0	8.3	**2.4**
SD190592	1.8	165.3	29.1	7.5	2.3
SD190568	1.8	165.0	28.5	7.7	**2.3**
SD190054	1.8	164.6	30.6	7.8	**2.4**
MN Pearl	1.7	165.1	26.3	6.9	2.2
Goliath	1.7	166.6	32.2	7.7	**2.3**
SD190154	1.7	163.2	29.1	7.3	**2.3**
SD180754	1.6	166.4	28.3	7.8	2.3
WIX9772-1	1.6	167.1	25.2	8.3	2.2
SD191512	1.6	166.0	30.3	8.0	2.4
SD190901	1.5	164.3	29.7	7.3	2.2
Mean	1.9	165.2	28.6	7.7	2.3
LSD (0.05)	0.3	1.2	1.5	0.9	0.3
CV %	11.35	0.8	6.6	14.1	14.1

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Impacts of Crop Rotation and Cover Crops on Soil Physical Properties, Carbon Stocks, and Microbial Community in Southeast SD

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PROJECT INTRODUCTION

Adopting conservation practices in cropland management has been considered pivotal in reversing trends created by conventional practices and restoring soil quality. Three principles, such as (a) minimal disturbance of soil surface or no-till, (b)continuous soil cover via cover cropping, residue retention, and crops, and (c) crop rotations, constitute the framework of conservation practices. These conservation practices have profoundly enhanced soil physical, chemical, and biological properties. However, there are inconsistencies in how varying combinations of these conservation practices, namely no-till combined with different rotation lengths with or without cover crops, altered soil physical and hydrological properties, deep soil carbon stocks, and microbial communities.

Therefore, the objective of this study is to determine how a corn-soybean-oat-winter wheat rotation and a corn-soybean rotation managed with or without cover crops under no-till management influence (a) soil pore characteristics and porosity using X-ray computed tomography (b) soil hydrologic properties such as soil water retention, saturated hydraulic conductivity (Ksat), (c) soil organic carbon (SOC) and total nitrogen (TN) in deep soil layers, and (d) soil carbon fractions and distribution as influenced by microbial communities.

METHODS

The treatment structure is a two factorial treatment structure with rotation and cover cropping as factors, with rotation having two levels: 2-year corn-soybean (2Yr) and 4-year corn-soybean-oat-winter wheat (4Yr) rotations. The cover cropping factor also has two levels: cover crop (CC) and no cover crop (NCC). The treatments were laid out in a randomized complete block split-plot design with four replicates, whereby rotations were randomly assigned to the whole plot within each block, and cover cropping was randomly assigned to the subplot within the whole plot in each block. This experiment has been established since 1991.

In July 2021, undisturbed cores were collected at 0-10 cm from each plot to assess the influences of crop rotation and cover cropping practices on soil pore structures and physical properties. Soil cores were

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transported to the University of Missouri Veterinary Center at Columbia, MO, for CT scanning to assess total porosity (macroporosity plus coarse mesoporosity), macroporosity, and coarse mesoporosity. After that, soil cores were used to determine soil water retention, plant available water (PAW), Ksat, bulk density (ρ_b), and thermal conductivity (λ).

In October 2021, soils were collected from 0-7.5 cm to analyze soil microbial communities, enzyme activities, and aggregate distribution.

In November 2021, soil cores were collected from 0-75 cm and divided into six depths for analyzing total SOC and N, SOC distribution in labile and stable fractions, and SOC concentration in aggregates.

PROGRESS AND PRELIMINARY FINDINGS

Analysis on intact cores collected in July 2021 was completed. Results showed that total porosity and macroporosity in the 4Yr rotation with CC was the highest among treatments. No differences were found in either 4Yr or 2Yr rotation between cover crop and no cover crop treatments for total pores, macropores, coarse mesopores, and SOC, although 4Yr rotation tended to increase SOC compared to 2Yr rotation. Soil water retention and plant available water content was similar among treatments. Nonetheless, the 4Yr rotation showed significantly higher Ksat than the 2Yr rotation.

Soils collected in October and November 2021 have had initial processing such as air drying and sieving done. Some analysis, such as bulk density, moisture, and PLFA, have been completed.

PLAN FOR THE YEAR 2022

Data analysis and manuscript writing will be completed in 2022 for the results obtained from July 2021 sampling for soil physical analysis.

Lab analysis on microbial community, enzyme activities, aggregate, and carbon stocks and distribution will be conducted on soils collected in October/November 2021.

Deep soil intact cores (0-40 cm) for analyzing soil physical properties will be collected in May/June 2022.

SOUTHEAST RESEARCH FARM ANNUAL REPORT
South Dakota State University
2021 Progress Report
Agricultural Experiment Station
Plant Science Department
South Dakota State University, Brookings, SD 57007
Southeast Research Farm, Beresford, SD 57004

Soil Health Under Cover Crops and Livestock Integration in SD Row Cropping Systems

Namrata Ghimire[1] (MS student, advisor: Dr. Sutie Xu)
Department of Agronomy, Horticulture and Plant Science
SDSU, Brookings, SD 57007

PROJECT INTRODUCTION

To improve soil health, wise selection of agroecosystem management is critical. Among different sustainable management strategies, cover cropping is an effective technique to improve soil fertility and quality. Integrating livestock in the cropping system, on the other hand, is also a useful method for enhancing overall ecosystem functions. Thus, the objective of this study is to understand the impacts of livestock and cover crop integration on soil health and carbon dynamics.

METHODS

The experiment was conducted in research plots at Southeast Research Farm. Treatments include corn-soybean-oat rotation with and without cover crops, and the cover crop included plots have livestock included treatments and no livestock included treatments. All treatments were replicated four times. Soils were collected from 0-10 cm in Oct 2021 to analyze soil health indicators, aggregates, microbial communities, and carbon associated enzyme activities.

PROGRESS, PRELIMINARY FINDINGS, AND PLAN FOR 2022

Soil moistures ranged from 2.1-2.3%. Soil microbial biomass carbon ranged from 103-139 µg/g dry soil. Statistical analysis will be conducted to further understand the treatment effects. Lab analysis on soil health indicators, soil carbon and microbial properties will be conducted. Soils will be collected again in spring 2022 to assess the same soil parameters. Meanwhile, soils from 0-80 cm will be collected to determine the SOC stocks in deep soils. Further, intact soil cores collected from 2020 will be used to determine soil physical properties.

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South Dakota State University
2021 Progress Report
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Southeast Research Farm, Beresford, SD 57004

Soil Biophysics and Hydrology Lab Project Report from SDSU Southeast Research Farm Plots

Project Leaders: Dr. Peter Sexton[1] and Dr. Sandeep Kumar[2]

Project 1 (Long-Term Rotation Plots / Field 302)

Title. Tillage, crop rotation, and cover crops impacts on soil properties.

Project personnel: Peter Sexton, Sutie Xu, Sainfort Vital (PhD candidate), Goutham Thotakuri (MS), Poulamee Chakraborty (Post-Doc), Sandeep Kumar.

Summary. The experimental site is located at the SDSU Southeast Research Farm, Beresford, South Dakota. The experiment was initiated in 1990 to assess the impact of different tillage systems and crop rotations on the long term production and economics of cropping systems. The experimental site has 80 plots distributed randomly in a complete block design. Each plot has a width of 20 m and a length of 100 m. The experimental plots were designed to be large so that field operations could be carried out using commercial sized farm equipment. The experiment had three different tillage systems which were no till (NT), conventional till (CT), and ridge till (RT). Ridge till system had only a two-year crop rotation of corn (*Zea mays* L.) – soybean (*Glycine max*. L.). In the fall of every year after harvest, residues of corn, soybean, and wheat were disked and chiseled in all the conventionally tilled plots. Both NT and CT had three rotation systems, which were a two-year rotation of corn-soybean, a three-year rotation of corn-soybean-wheat (*Triticum aestivum* L.), and a four-year rotation of corn-soybean-wheat-oat (*Avena sativa*). Later in the year 2013, the plot layout was modified to include a cover crop system. Winter rye (*Secale cereale* L.) was used as winter cover crop (CC) in this study which was direct seeded between corn and soybean immediately after corn harvest or soybean harvest in a two-year corn-soybean rotation system in half of the NT plots to observe the influence of CC with NT on soil properties.

Task 1. *Measurement of Soil Organic Carbon and Nitrogen.* Soil samples were collected from NT-CC and NT-NoCC plots in the summer of 2021. Three cores of soil samples from each plot were collected at a depth of 0-10 cm using a 3.5-cm diameter and 50-cm-tall hand probe (Inc. JMC Soil Samplers) and mixed to make a composite sample. Composited soil samples were labeled, sealed in plastic zip-lock bags, and transported to the laboratory. All the analyses were carried out using the soil

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[2] *Division of Environmental Systems; NIFA; USDA*

fine fraction (< 2 mm in diameter). Around 0.025 g of the 2 mm sieved soil samples were finely ground and used to measure soil organic carbon (SOC) and total nitrogen (TN) contents using dry combustion method with a TruSpec carbon/hydrogen/nitrogen analyzer (LECO Corporation, St. Joseph, MI, USA). Post-harvest soil samples were also collected from the depths of 0-5, 5-15, 15-30, 30-60 and 60-70 cm for determining the vertical distribution of SOC and Nitrogen in the CC and NoCC plots. (The results would be a part of the PhD dissertation of Sainfort Vital).

Task 2. <u>Measuring Hydrological Properties</u>. Influence of winter CC on soil hydrological and physical properties are to be observed. Water infiltration and soil penetration resistant data were collected in the summer of 2021. Intact soil cores of 7.6 cm were collected from the 0-10 cm depth using plexiglass to obtain soil water retention and Plant available water content. The cores were subjected to X-ray computed tomography analysis for determining the pore-size distribution (Data would be included in PhD dissertation of Sainfort Vital).

Task 3. <u>Impacts of cover crop on soil water status:</u> To observe the impact of cover crops on soil water status, we installed sensors in six plots under two-year corn-soybean rotation and NT system for three consecutive years (2017, 2018, and 2019), three plots with and three plots without winter cover crop. Volumetric soil water content (%) and soil tension were obtained using WaterScout SM 100 soil moisture sensors (Spectrum Technologies Inc., Aurora, IL) and Watermark soil moisture sensor (Spectrum Technologies Inc., Aurora, IL), respectively at 15, 30 and 45 cm soil depth. Push probe augers were used to make sensor access holes at the desired depths near the effective root zones. Soil moisture tension sensors were fit inside the PVC pipes and installed at the specific depths. The holes were then carefully filled with moist soil to eliminate air pockets. Sensors were connected to battery powered WatchDog 1000 series micro stations to record hourly volumetric soil water content and soil tension data. The range for the Watermark soil tension sensors is 0-200 kPa. The continuous moisture and tension data was collected for the late cash crop growing period for the year 2017 and the entire cash crop growing period for the years 2018 and 2019. Hydrus 1D modelling was used in combination with the measured soil moisture and tension data to observe the impact of CC on soil water status

Project deliverables/products.

- Submitted papers:
    - Chakraborty P, Singh J, and Kumar S (2021). *Assessing the influence of cover crop on soil water status using daily soil moisture measurements and Hydrus-1D simulation.* (Submitted to Agricultural Water Management, Task 3)

- Oral presentation at CSA conference by Poulamee Chakraborty.
    - Chakraborty P, Singh J, Sexton P, and Kumar S. *Assessing the*

Influence of Cover Crops on Soil Water Potential and Soil Water Storage Using in Situ Daily Moisture and Tension Data and Hydrus 1D Modeling. Oral Presentation at the ASA-CSSA-SSSA. International Annual Meeting at Salt Lake City, UT., Nov., 2021(Task 3)

Project 2. (Manure Plots / Field 103)

Title. Response of manure and inorganic fertilizer applications on soil properties.

Project personnel: Peter Kovács, Anuoluwa Sangotayo (PhD student), Poulamee Chakraborty (Post-Doc), Sandeep Kumar

Summary. The experimental site for SDSU soil fertility project is located at the Southeast Research Farm of the South Dakota State University located at Beresford, South Dakota. The experiment was established in 2003 to assess the influences of beef manure and inorganic fertilizer on the long-term corn (*Zea mays* L.) – soybean (*Glycine max*. L.) rotation. The experimental site has 24 plots with 4.6 to 20 m dimensions into complete randomized block design. Study treatments included: three manure (dairy and beef manure) [P-based recommended manure application rate (P), N-based recommended manure application rate (N), nitrogen-based double of recommended manure application rate (2N)], two fertilizers [recommended fertilizer (F) and high fertilizer (HF)], and a control (CK) with no manure application]. The manure was applied in the spring in a manual application and incorporated by disk at 6-cm deep for 1 to 3 days before planting at either site. Manure of the study was analyzed by South Dakota Agricultural Laboratories. Fertilizer treatments for 179.3 kg ha^{-1} yield goal for corn and 44.8 kg ha^{-1} for soybean were used for both the sites; however, no nutrient recommendation of fertilizer for soybean was used.

Task 1. *Measurement of Soil organic carbon and Nitrogen.*

Soil samples were extracted from 0-10, 10-20, 20-30 and 30-40 cm depths in 4 replicates and mixed together to make a composite sample for each plot in 2015 to analyze selected soil quality indicators. Composited soil samples were labeled, sealed in plastic zip-lock bags, and transported to the laboratory. After bringing the soil samples to the laboratory, all of them were air dried, ground, and sieved to pass a 2-mm sieve. The method outlined by Stetson, Osborne, et al. (2012) was used to determine carbon (C) and nitrogen (N) concentrations after removing visible crop residues and sieved through a 0.5 mm. Total C (TC) and nitrogen (TN) were analyzed by combustion using a Tru-Spec-CHN analyzer (LECO Corporation, St. Joseph, MI). Soil inorganic carbon (SIC) was measured using 1M 10 ml of HCI addition to the one gram of the 0.5 mm sieved soil samples. The loss of the weight from the initial weight of the total was given as SIC. Soil organic carbon (SOC) was calculated by subtracting SIC from TC and expressed in g kg^{-1}. (Results would be included in the PhD dissertation of Anuoluwa Sangotayo)

Task 2. *Measuring Soil Hydro-physical Properties*.

The impact of long-term manure and inorganic fertilizer application on selected soil physical and hydrological properties of bulk density, soil penetration resistance, soil water retention, water infiltration was determined by a combination of field measurements and by collecting intact cores from the depth of 0-10, 10-20, 20-30, and 30-40 cm in the summer of 2020 and consecutive laboratory measurements. The intact cores were scanned using X-Ray computed tomography to determine the pore size distribution. (Results would be included in the PhD dissertation of Anuoluwa Sangotayo)

Project deliverables/products.

- Oral presentation at CSA conference by Anuoluwa Sangotayo.
    - Sangotayo A., Chakraborty P., Kovacs P., and Kumar, S. (2021). Impacts of Long-Term Fertilizer and Manure on Soil Organic Carbon and Plant Available Water Content. Oral Presentation at the ASA-CSSA-SSSA International Annual Meeting, Nov. 21, Salt Lake City, UT.
    - Sangotayo A., Chakraborty P., Kovacs P., and Kumar, S. (2021). Influence of Manure Application on Computed Tomography Measured Soil Pore Characteristics. Poster presentation at the ASA-CSSA-SSSA International Annual Meeting, Nov. 2, Salt Lake City, UT.

Project 3. (**Grazing Cover Crops / Beresford site)**

Title. Demonstrating Short-Term Impacts of Grazing Cover Crops on Soil Hydro-Physical Properties in South Dakota.

Project personnel: Sutie Xu, Peter Sexton, Namrata Ghimire (MS student), Poulamee Chakraborty (Post-Doc), and Sandeep Kumar

Summary. Grasslands have been rapidly converted to croplands over the last decade in the northern Great Plains. This conversion has the potential to reduce soil health and increase the region's ability to pollute the Missouri and Mississippi rivers. Therefore, the need for integrated crop livestock (ICL) practices that protect the region's native prairies are strongly encouraged. Introducing livestock into arable cropping systems can improve nutrient cycling, soil health, and provide economic benefits. The present study was conducted under a corn (*Zea mays* L.)-soybean (*Glycine max* L.)-rye (*Secale cereale* L.) rotation with no-till system at the Southeast Research Farm near Beresford, South Dakota to assess the effects of ICL systems on selected soil physical parameters. Cover crops blends (Brassica/Legume-based blend, Grass-based blend, Equal blend) were planted after the rye (*Secale cereale* L.) crop, and grazing treatments (with and without) were applied after the cover crops establishment. Concerns regarding the role of hoof traffic from livestock adversely affecting the near-surface soil conditions, soil health, and hydrological properties under no-till systems will be discussed. Data showed that the use of diverse cover crop mixtures provided increased biomass on the surface that can alleviate the compaction impact under these integrated crop-livestock systems. Surface bulk density was not significantly impacted by grazing but deeper than 5cm was. Some soil physical and hydrological properties were significantly affected due to the high moisture content of the soil during the grazing period. Carbon fraction data was studied to find the impact of short-term grazing on the microbial biomass, labile and stable carbon fractions from 0-5 cm and 5-10 cm depths. Grazing

had no effect on beta-glucosidase enzyme activity or microbial biomass carbon. This study provides useful information about short-term (4-year) grazing impacts on soil physical, hydrological, and biological properties in southeastern South Dakota.

Task 1. *Measuring Soil Hydro-physical Properties*.

The impact of short-term livestock grazing on cover crops for no till plots on selected soil physical and hydrological properties of bulk density, soil penetration resistance, soil water retention, water infiltration would be determined by a combination of field measurements and by collecting intact cores from the depth of 0-10, 10-20, 20-30, and 30-40 cm and consecutive laboratory measurements. The intact cores would be scanned using X-Ray computed tomography scanner to determine the pore size distribution. (Results would be included in the MS dissertation of Namrata Ghimire)

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WEED CONTROL DEMONSTRATIONS and EVALUATION TESTS for 2021

Southeast South Dakota Research Center
Paul O. Johnson*, Ext. Weed Science Coordinator; David Vos, SDSU Ag Research Manager, and Jill Alms, SDSU Ag Research Manager

INTRODUCTION:

Experiment stations have an important role in the WEED (Weed Evaluation and Extension Demonstration) Project. Plots provide weed control data for the area served by the Southeast South Dakota Research Center. The station is one of the major sites for corn, soybean and sorghum weed control studies. Tests at the station focus on common waterhemp, velvetleaf, marestail, dandlelion and foxtail.

2021 TESTS:

Several studies were established to evaluate new weed control technologies. The demonstration plots centered around programs that would answer questions on the glyphosate resistance issue around the state, especially as it relates to waterhemp management in soybeans and corn. The year started out good with moisture until post spraying was done then the summer stayed very dry and yields were about half of normal.

NOTE:

Data reported in this publication are results from field tests that include product uses, experimental products or experimental rates, combinations or other unlabeled uses for herbicide products. Trade names of products used are listed; there frequently are other brand products available in the market. Users are responsible for applying herbicide according to label directions. Refer to the appropriate pest guide available from regional extension offices or https//extension.sdstate.edu for herbicide recommendations.

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Studies listed below are summarized in the following tables. Information for each study is included as part of the summary.

1. Corn Herbicide Demonstration
2. Weed Control with Maverick in Corn
3. Reviton Burndown in Corn
4. Weed Control with Restraint in Corn
5. Shieldex and Other Postemergence Herbicides in Corn
6. Weed Control with Impact Corn and Sinate
7. Program Treatments for Weed Control in Corn
8. Roundup Ready Soybean Demonstration
9. Dicamba Soybean Demonstration
10. Enlist Soybean Demonstration
11. Liberty Link Soybean Demonstration
12. LLGT27 Soybean Demonstration
13. XtendFlex Soybean Herbicide Recommendations
14. Zidua Pro Residual Weed Control Comparison
15. Zone Defense Pre in Soybeans
16. Reviton in Soybean
17. MON 301668 Pre in Soybean
18. Xtendimax Pre in Conventional Till Soybean
19. Xtendimax Pre in No-Till Soybean
20. Xtendimax + Glufosinate Tank-Mix for Broadleaf Control in Soybeans-Bareground
21. Huskie FX in Sorghum
22. MON 301668 in Grain Sorghum

ACKNOWLEDGEMENTS:

We greatly appreciate the cooperation and assistance provided by the station personnel.

Due to the distance from the SDSU campus, assistance with field preparation and daily oversight of the fields is critical to the success of the weed control research. Field equipment and management of the plot areas are important contributions to the project. Regional Extension field specialists and program technicians provide assistance with tours and utilize the data in direct producer programs, publications and news releases. In addition to the Southeast Farm Report, research results will be published in the annual Weed Control Field Test Data Book, SDSU Pest Management Guides and Weed Control guides updated annually for major South Dakota commodities, and on the internet at https://extension.sdstate.edu

Program input and partial support for field programs is also acknowledged.

South Dakota Soybean Research and Promotion Council
Crop Protection Industries

2021
CORN HERBICIDE DEMONSTRATION
Southeast Research Farm

Treatment	Rate/A	6/9/21 Vele	6/9/21 Cowh	6/21/21 Grft	6/21/21 Vele	6/21/21 Cowh	9/22/21 Vele	9/22/21 Cowh	9/23/21 Yield bu/A
Check	---	0	0	0	0	0	0	0	60
Pre									
Balance Flexx + Harness Xtra 6L	4 oz + 2 qt	94	99	99	91	99	96	99	96
Pre & Post									
Surestart II + Atrazine & Resicore + Durango DMA + Amsol	2 pt + 1 pt & 1.5 qt + 1 qt + 2.5%	63	94	99	99	99	99	99	102
Acuron & Callisto Xtra + RU Powermax + AMS	1.75 qt & 24 oz + 32 oz + 1.7 lb	88	95	99	99	99	99	99	101
Acuron & Acuron + RU Powermax + AMS	1.25 qt & 1.25 qt + 32 oz + 1.7 lb	89	93	99	99	99	99	99	111
Lumax EZ & Acuron GT + Aatrex + NIS + AMS	1.5 qt & 3.75 pt + 0.5 pt + 0.25% + 1.7 lb	91	96	99	99	99	99	99	99
Verdict + Atrazine & Status + Atrazine + RU Powermax + Zidua SC + COC	10 oz + 16 oz & 4 oz + 16 oz + 32 oz + 2.5 oz + 1%	92	97	99	99	99	99	99	114
Resicore + Atrazine & Durango DMA + Incinerate + Amsol	2 qt + 1 pt & 1 qt + 3 oz + 2.5%	92	97	99	99	99	99	99	107
Harness & RU Powermax + Atrazine + AMS	1.75 pt & 32 oz + 1 pt + 2.5 lb	10	94	99	99	99	99	99	91
Dual II Mag & Sinate + Atrazine + MSO + AMS	1.33 pt & 24 oz + 16 oz + 1% + 3 lb	10	90	99	99	99	99	98	97
Dual II Mag & Impact Core + RU Powermax + Aatrex + NIS + AMS	1.33 pt & 24 oz + 32 oz + 1.5 pt + 0.25% + 2.5 lb	15	89	99	99	99	99	99	106
Dual II Mag & Shieldex + RU Powermax + MSO + AMS	1.2 pt & 1.35 oz + 32 oz + 0.5% + 2.5%	10	90	99	99	99	99	98	93
Harness Xtra 6L & Laudis + RU Powermax + NIS + Amsol	2 qt & 3 oz + 32 oz + 0.25% + 2.5%	38	95	99	99	99	99	99	102
Harness Max + Atrazine & Harness Max + RU Powermax + Amsol	40 oz + 1 pt & 40 oz + 32 oz + 2.5%	90	95	99	99	99	99	99	99
Fearless & Katagon + Atrazine + Destiny HC	1.25 pt & 3.2 oz + 1 pt + 1%	13	93	99	93	99	99	99	117
Epost									
Harness Max + Atrazine + RU Pmax + AMS	55 oz + 1 pt + 32 oz + 1.5 lb	98	99	99	95	99	98	99	101
Anthem Maxx + Callisto + Atrazine + RU Pmax	3 oz + 3 oz + 1 pt + 1 qt	98	99	98	98	99	99	99	98
Armezon Pro + Atrazine + RU Pmax + COC	20 oz + 16 oz + 32 oz + 1%	98	99	98	95	99	98	99	104
LSD (0.05)		7	2	0.5	1	--	1	1	27

2021
CORN HERBICIDE DEMONSTRATION
Southeast Research Farm

RCB: 4 reps
Variety: DKC 51-38 RIB
Planting Date: 4/29/21
Pre: 4/30/21
Epost: 6/1/21 Corn V3, 6-8 in; Vele 1-3 in; Cowh 0.5-2 in; Grft 1-3 in.
Post: 6/9/21 Corn V4-5, 12-18 in; Vele 1-3 in; Cowh 1-3 in; Grft 2-4 in.

Precipitation: (inches)
Pre: 1st week 0.00 2nd week 0.45

Soil: Silty Clay; 4.3% OM; 6.7 pH

Vele=Velvetleaf
Cowh=Common waterhemp
Grft=Green foxtail

Comments: Objective of the study was to look at program treatments for corn weed control. Heavy velvetleaf and common waterhemp pressure. The year started out with moisture to activate preemergence treatments and enough moisture until post treatments were sprayed and then severe drought set in. Corn yields were about half of normal and were variable due to variations in soils which caused uneven midseason moisture stress. No yield differences were noted besides the check.

2021
WEED CONTROL WITH MAVERICK IN CORN
Southeast Research Farm

Treatment	Rate/A	5/18/21 VCRR	5/25/21 Vele	6/9/21 Vele	6/9/21 Cowh	6/29/21 Vele	6/29/21 Cowh	9/23/21 Yield bu/A
Check	---	0	0	0	0	0	0	83
Epost								
Acuron + RU Powermax + Induce + AMS	3 pt + 1 qt + 0.25% + 3 lb	--	--	99	99	98	99	99
Halex GT + Induce + AMS	2 qt + 0.25% + 3 lb	--	--	99	99	97	99	116
Armezon Pro + RU Pmax + Induce + AMS	24 oz + 1 qt + 0.25% + 3 lb	--	--	99	99	97	99	102
Resicore + RU Pmax + Induce + AMS	44 oz + 1 qt + 0.25% + 3 lb	--	--	99	99	96	99	110
Maverick + RU Pmax + Induce + AMS	14 oz + 1 qt + 0.25% + 3 lb	--	--	99	99	96	99	118
Maverick + Aatrex + RU Powermax + Induce + AMS	14 oz + 1.5 pt + 1 qt + 0.25% + 3 lb	--	--	99	99	98	99	125
Pre & Post								
Acuron & Acuron + RU Powermax + Induce + AMS	1.5 qt & 1.5 qt + 1 qt + 0.25% + 3 lb	0	88	94	96	99	99	95
Maverick & Maverick + RU Pmax + Induce + AMS	18 oz & 14 oz + 1 qt + 0.25% + 3 lb	0	90	91	95	99	99	106
Maverick + Aatrex & Maverick + Aatrex + RU Powermax + Induce + AMS	18 oz + 1 pt & 14 oz + 1 pt + 1 qt + 0.25% + 3 lb	0	89	89	94	99	99	108
Maverick & RU Powermax + Induce + AMS	1 qt & 1 qt + 0.25% + 3 lb	0	90	94	97	99	99	126
Maverick + Aatrex & RU Powermax + Induce + AMS	1 qt + 1.5 pt & 1 qt + 0.25% + 3 lb	0	91	90	97	99	99	112
LSD (0.05)		--	2	2	2	1	--	33

RCB: 4 reps
Variety: DKC 51-38 RIB
Planting Date: 4/29/21
Pre: 4/30/21
Epost: 6/1/21 Corn V3, 6-8 in; Vele 1-3 in; Cowh 0.5-2 in.
Post: 6/9/21 Corn V4-5, 12-18 in; Vele 1-3 in; Cowh 1-3 in.

Precipitation: (inches)
Pre: 1st week 0.00 2nd week 0.45

Soil: Silty Clay; 4.6% OM; 6.6 pH

Vele=Velvetleaf
Cowh=Common waterhemp
VCRR=Visual Crop Response Rating
(0=no injury; 100=complete kill)

Comments: Objective of the study was to look at treatments for corn weed control. Heavy velvetleaf and common waterhemp pressure. The year started out with moisture to activate preemergence treatments and enough moisture until post treatments were sprayed and then severe drought set in. Corn yields were about half of normal and were variable due to variations in soils which caused uneven midseason moisture stress. Only two treatments were better than the check on yield.

2021
REVITON BURNDOWN IN CORN
Southeast Research Farm

Treatment	Rate/A	5/18/21	5/25/21		6/2/21		6/9/21	
		Dali	Dali	Prle	Dali	Prle	Dali	Prle
Check	---	0	0	0	0	0	0	0
Pre								
Reviton + MSO	2 oz + 1%	94	92	95	60	85	40	67
Reviton + RU Powermax + AMS + MSO	1 oz + 32 oz + 1.7 lb + 1%	92	92	98	84	97	83	97
Sharpen + RU Powermax + AMS + MSO	1.5 oz + 32 oz + 1.7 lb + 1%	92	92	97	82	97	78	95
Reviton + RU Powermax + AMS + Fearless + Atrazine + MSO	1 oz + 32 oz + 1.7 lb + 2.1 pt + 1.5 qt + 1%	95	96	99	86	98	70	96
LSD (0.05)		4	4	2	5	--	14	13

RCB: 3 reps
Variety: DKC 53-56
Planting Date: 5/11/21
Pre: 5/11/21 Dali 2-8 in diameter

Soil: Clay; 3.0% OM; 7.8 pH

Precipitation: (inches)
Pre: 1st week 0.43 2nd week 0.34

Dali=Dandelion
Prle=Prickly lettuce

Comments: Objective of the study was to look at treatments for corn weed control. Moderate dandelion and prickly lettuce pressure. Year started out with moisture for active weed growth. Good initial burndown of dandelion and prickly lettuce. Later in the season a couple treatments had reduced control.

2021
WEED CONTROL WITH RESTRAINT IN CORN
Southeast Research Farm

		5/18/21		6/21/21				7/15/21				9/23/21
Treatment	Rate/A	Vele	VCRR	Grft	Vele	Cowh	VCRR	Grft	Vele	Cowh	VCRR	Yield bu/A
Check	---	0	0	0	0	0	0	0	0	0	0	23
Pre & Post												
Restraint + Atrazine & Shieldex + Atrazine + COC	36 oz + 1 qt & 1 oz + 1 qt + 1%	88	0	96	98	99	0	95	99	99	0	100
Restraint + Atrazine & Restraint + Atrazine + COC	18 oz + 1 qt & 18 oz + 1 qt + 1%	83	0	97	99	99	0	95	99	99	0	98
Resicore + Atrazine & Restraint + Atrazine + COC	40 oz + 1 qt & 30 oz + 1 qt + 1%	91	0	98	99	99	0	96	99	99	0	100
Resicore + Atrazine & Resicore + Atrazine + COC	40 oz + 1 qt & 40 oz + 1 qt + 1%	93	0	94	99	99	0	91	99	99	0	91
LSD (0.05)		4	--	3	2	--	--	3	--	--	--	14

RCB: 4 reps
Variety: DKC 51-38 RIB
Planting Date: 4/29/21
Pre: 4/30/21
Post: 6/9/21 Corn V4-5, 12-18 in; Vele 2-5 in; Cowh 1-4 in; Grft 3-6 in.

Precipitation: (inches)
Pre: 1st week 0.00 2nd week 0.45

Soil: Clay Loam; 4.4% OM; 6.8 pH

Vele=Velvetleaf
Cowh=Common waterhemp
Grft=Green foxtail

Comments: Objective of the study was to look at treatments for corn weed control. Heavy velvetleaf and common waterhemp pressure. Year started out with moisture to activate preemergence treatments and enough moisture until post treatments were sprayed and then severe drought set in. Corn yields were about half of normal and were variable due to variations in soils which caused uneven midseason moisture stress. All treatments were better than the check on yield.

2021
SHIELDEX AND OTHER POSTEMERGENCE HERBICIDES IN CORN
Southeast Research Farm

		6/16/21			6/21/21			7/16/21			9/23/21
Treatment	Rate/A	Vele	Cowh	VCRR	Vele	Cowh	VCRR	Vele	Cowh	VCRR	Yield bu/A
Check	---	0	0	0	0	0	0	0	0	0	62
Pre											
Bicep II Mag	1.67 qt	33	97	0	35	90	0	23	91	0	74
Pre & Post											
Bicep II Mag & Shieldex + Aatrex + COC + Amsol	1.67 qt & 1 oz + 1 qt + 1% + 2.5%	95	99	0	95	98	0	99	99	0	88
Bicep II Mag & Impact + Aatrex + COC + Amsol	1.67 qt & 0.75 oz + 1 qt + 1% + 2.5%	96	99	0	96	98	0	99	99	0	98
Bicep II Mag & Laudis + Aatrex + COC + Amsol	1.67 qt & 3 oz + 1 qt + 1% + 2.5%	96	99	0	97	98	0	99	99	0	91
Bicep II Mag & Shieldex + Aatrex + RU Powermax + Amsol	1.67 qt & 1 oz + 1 qt + 30 oz + 2.5%	99	99	0	98	98	0	99	99	0	103
Bicep II Mag & Shieldex + Aatrex + Liberty + COC + Amsol	1.67 qt & 1 oz + 1 qt + 32 oz + 1% + 2.5%	98	99	0	98	98	0	99	99	0	99
Fearless & Katagon + Destiny HC	1.25 pt & 3.2 oz + 1%	87	99	0	83	93	0	98	99	0	97
Fearless & Katagon + Atrazine + Destiny HC	1.25 pt & 3.2 oz + 1 pt + 1%	92	99	0	93	98	0	99	99	0	95
LSD (0.05)		3	0.5	--	3	1	--	3	1	--	21

RCB: 4 reps
Variety: DKC 51-38 RIB
Planting Date: 4/29/21
Pre: 4/30/21
Post: 6/9/21 Corn V4-5 12-18 in; Vele 2-5 in; Cowh 1-4 in.

Precipitation: (inches)
Pre: 1st week 0.00 2nd week 0.45

Soil: Silty Clay; 4.6% OM; 6.6 pH

Vele=Velvetleaf
Cowh=Common waterhemp
VCRR=Visual Crop Response Rating
(0=no injury; 100=complete kill)

Comments: Objective of the study was to look at treatments for corn weed control. Heavy velvetleaf and common waterhemp pressure. Year started out with moisture to activate preemergence treatments and enough moisture until post treatments were sprayed and then severe drought set in. Corn yields were about half of normal and were variable due to variations in soils which caused uneven midseason moisture stress. All treatments except one were better yielding than the check. This treatment had very poor velvetleaf control.

2021
WEED CONTROL WITH IMPACT CORE AND SINATE
Southeast Research Farm

Treatment	Rate/A	6/16/21 Vele	6/16/21 Cowh	6/21/21 VCRR	7/6/21 Grft	7/6/21 Vele	7/6/21 Cowh	8/2/21 Grft	8/2/21 Vele	8/2/21 Cowh	9/23/21 Yield bu/A
Check	---	0	0	0	0	0	0	0	0	0	46
Epost											
Impact Core + Aatrex + MSO + AMS	30 oz + 1.5 pt + 0.5% + 2.5 lb	97	98	0	92	99	99	82	97	99	107
Post											
Liberty + AMS	32 oz + 3 lb	98	98	0	99	99	99	99	99	96	89
Sinate + MSO + AMS	24 oz + 1% + 3 lb	96	98	0	99	99	99	93	99	97	95
Sinate + Aatrex + MSO + AMS	24 oz + 1 pt + 1% + 3 lb	98	98	0	99	99	99	96	99	99	100
Sinate + Dual II Mag + MSO + AMS	24 oz + 1.5 pt + 1% + 3 lb	97	98	0	99	99	99	98	99	98	94
Sinate + Dual II Mag + Aatrex + MSO + AMS	24 oz + 1.5 pt + 1 pt + 1% + 3 lb	98	98	0	99	99	99	96	99	99	106
Pre & Post											
Dual II Mag & Sinate + MSO + AMS	1.33 pt & 24 oz + 1% + 3 lb	98	98	0	99	99	99	98	99	98	101
Dual II Mag & SInate + Aatrex + MSO + AMS	1.33 pt & 24 oz + 1.5 pt + 1% + 3 lb	98	98	0	99	99	99	99	99	99	101
Dual II Mag & Sinate + MSO + AMS	1.33 pt & 28 oz + 1% + 3 lb	96	98	0	99	99	99	97	99	98	111
Dual II Mag & Sinate + Aatrex + MSO + AMS	1.33 pt & 28 oz + 1.5 pt + 1% + 3 lb	98	98	0	99	99	99	99	99	99	107
Dual II Mag & Impact Core + RU Powermax + Aatrex + NIS + AMS	1.33 pt & 24 oz + 32 oz + 1.5 pt + 0.25% + 2.5 lb	98	98	0	99	99	99	99	99	99	112
Dual II Mag & Impact + Aatrex + MSO + AMS	1.33 pt & 1 oz + 1.5 pt + 1% + 2.5 lb	92	97	0	99	99	99	97	99	99	108
Dual II Mag & Halex GT + Aatrex + NIS + AMS	1.33 pt & 3.6 pt + 1 pt + 0.25% + 2.5 lb	98	98	0	99	99	99	99	99	99	105
Pre & Lpost											
Dual II Mag & Impact + MSO + AMS	1.33 pt & 2 oz + 1% + 2.5 lb	30	86	0	99	86	98	89	99	99	106
LSD (0.05)		2	2	--	3	2	0.5	8	1	1	16

2021
WEED CONTROL WITH IMPACT CORE AND SINATE
Southeast Research Farm

RCB: 4 reps
Variety: DKC 51-38 RIB
Planting Date: 4/29/21
Pre: 4/29/21
Epost: 6/1/21 Corn V3, 6-8 in; Vele 1-3 in; Cowh 0.5-2 in.
Post: 6/9/21 Corn V4-5, 12-18 in; Vele 2-5 in; Cowh 1-6 in.
Lpost: 6/15/21 Corn V5-6, 22-24 in; Vele 2-8 in; Cowh 3-6 in; Grft 6-12 in.

Precipitation: (inches)
Pre: 1st week 0.00 2nd week 0.45

Soil: Clay Loam; 4.4% OM; 6.8 pH

Vele=Velvetleaf
Cowh=Common waterhemp
Grft=Green foxtail
VCRR=Visual Crop Response Rating
(0=no injury; 100=complete kill)

Comments: Objective of the study was to look at treatments for corn weed control. Heavy velvetleaf and common waterhemp pressure. Year started out with moisture to activate preemergence treatments and enough moisture until post treatments were sprayed and then severe drought set in. Corn yields were about half of normal and were variable due to variations in soils which caused uneven midseason moisture stress. All treatments were better than the check. Also a couple of treatments were significantly lower in yield than the top yielding treatment.

2021
PROGRAM TREATMENTS FOR WEED CONTROL IN CORN
Southeast Research Farm

		5/25/21	6/2/21		6/16/21			6/29/21			7/16/21		9/23/21
Treatment	**Rate/A**	**Vele**	**Vele**	**Cowh**	**Vele**	**Cowh**	**VCRR**	**Vele**	**Cowh**	**VCRR**	**Vele**	**Cowh**	**Yield bu/A**
Pre & Epost													
Bicep II Mag & Halex GT + Aatrex + NIS + AMS	1.5 qt & 3.6 pt + 1 pt + 0.25% + 1.7 lb	23	30	97	98	99	0	96	99	0	95	99	109
Acuron & Callisto Xtra + RU Powermax + AMS	1.75 qt & 24 oz + 32 oz + 1.7 lb	90	90	98	98	99	0	97	99	0	95	99	97
Acuron & Acuron + RU Powermax + AMS	1.25 qt & 1.25 qt + 32 oz + 1.7 lb	89	90	97	98	99	0	97	99	0	96	99	110
Lexar EZ & Acuron GT + Aatrex + NIS + AMS	1.75 qt & 3.75 pt + 0.5 pt + 0.25% + 1.7 lb	90	90	98	98	99	0	97	99	0	95	99	120
Lumax EZ & Acuron GT + Aatrex + NIS + AMS	1.5 qt & 3.75 pt + 0.5 pt + 0.25% + 1.7 lb	87	90	98	97	99	0	97	99	0	95	99	110
Check	---	0	0	0	0	0	0	0	0	0	0	0	93
LSD (0.05)		3	1	1	1	0.5	--	1	--	--	1	--	19

RCB: 4 reps
Variety: DKC 51-38 RIB
Planting Date: 4/29/21
Pre: 4/30/21
Epost: 6/1/21 Corn V3, 6-8 in; Vele 0.5-1.5 in; Cowh 0.5-1 in.

Precipitation: (inches)
Pre: 1st week 0.00 2nd week 0.45

Soil: Silty Clay; 4.6% OM; 6.6 pH

Vele=Velvetleaf
Cowh=Common waterhemp
VCRR=Visual Crop Response Rating
(0=no injury; 100=complete kill)

Comments: Objective of the study was to look at treatments for corn weed control. Heavy velvetleaf and common waterhemp pressure. Year started out with moisture to activate preemergence treatments and enough moisture until post treatments were sprayed and then severe drought set in. Corn yields were about half of normal and were variable due to variations in soils which caused uneven midseason moisture stress. Only one treatment was better than the check on yield.

2021
ROUNDUP READY SOYBEAN DEMONSTRATION
Southeast Research Farm

Treatment	Rate/A	6/16/21		6/29/21		9/22/21		10/6/21
		Vele	Cowh	Vele	Cowh	Vele	Cowh	Yield bu/A
Check	---	0	0	0	0	0	0	10
PPI & Post								
Treflan + Dimetric 3L & RU Powermax + Flexstar + Amsol	1.5 pt + 10.67 oz & 32 oz + 1 pt + 2 qt	76	86	99	90	93	88	21
Prowl H2O + Dimetric 3L & RU Powermax + Avalanche Ultra + Amsol	3 pt + 10.67 oz & 32 oz + 1.5 pt + 2 qt	74	88	99	87	94	86	21
Pre & Post								
Sonic & Flexstar + Select Max + COC	5 oz & 1 pt + 12 oz + 0.25%	86	86	94	94	91	92	23
Authority MTZ & Avalanche Ultra + Section Three + NIS	14 oz & 1.5 pt + 5.33 oz + 0.25%	81	81	78	84	68	90	16
Spartan Charge & Cobra + Select Max + NIS	8.5 oz & 12.8 oz + 12 oz + 0.25%	78	84	77	91	69	90	16
Sonic & EverpreX + Durango DMA + Amsol	4.5 oz & 1 pt + 1 qt + 2.5%	89	91	99	92	98	93	21
Broadaxe XC + Dimetric 3L & Flexstar GT + Dual Magnum + AMS + MSO	28 oz + 10 oz & 56 oz + 1 pt + 3.4 lb + 1%	78	93	99	97	93	96	22
Authority MTZ & Anthem Maxx + RU Powermax + COC + AMS	14 oz & 3 oz + 32 oz + 1 pt + 1.7 lb	71	89	99	93	99	88	20
Zidua SC + Verdict & RU Powermax + Outlook + AMSOL	4 oz + 5 oz & 32 oz + 10 oz + 2 qt	91	94	99	96	97	95	22
Fierce MTZ & Perpetuo + RU Powermax + Amsol	1 pt & 6 oz + 32 oz + 2 qt	55	88	95	88	93	88	20
Dimetric Charged & RU Powermax + Amsol	15 oz & 32 oz + 2 qt	78	87	99	89	97	89	22
Surveil + Dimetric 3L & Durango DMA + Amsol	3.25 oz + 8 oz & 1 qt + 2.5%	84	89	99	92	98	86	24
LSD (0.05)		18	11	11	9	11	7	6

RCB: 4 reps
Variety: S20-E3
Planting Date: 5/12/21
PPI: 5/12/21
Pre: 5/12/21
Post: 6/18/21 Soy 3 tri, 7-9 in; Vele 1-7 in; Cowh 2-8 in.

Precipitation: (inches)
Pre: 1st week 0.44 2nd week 0.35

Soil: Clay; 4.8% OM; 7.0 pH

Vele=Velvetleaf
Cowh=Common waterhemp

Comments: Objective of the study was to look at program treatments for soybean weed control. Heavy velvetleaf and common waterhemp pressure. The year started out with moisture to activate preemergent treatments and enough moisture until post treatments were sprayed and then severe drought set in. Soybean yields were about half of normal and were variable due to variations in soils which caused uneven moisture stress. A couple of the non GMO herbicide treatments were significantly lower than the top treatment. All treatments were better than the check.

2021
DICAMBA SOYBEAN DEMONSTRATION
Southeast Research Farm

Treatment	Rate/A	6/16/21 Vele	6/16/21 Cowh	6/29/21 Vele	6/29/21 Cowh	9/22/21 Vele	9/22/21 Cowh	10/6/21 Yield bu/A
Check	---	0	0	0	0	0	0	16
Pre & Epost								
Authority First & Anthem Maxx + Xtendimax + Intact + Volt-Edge	4 oz & 3 oz + 22 oz + 0.5% + 26 oz	85	80	87	80	91	96	27
Broadaxe XC + Dimetric 3L & RU Powermax + Tavium + Volt-Edge + Class Act Ridion + OnTarget	28 oz + 10 oz & 27 oz + 56.5 oz + 26 oz + 0.5% + 0.5%	72	90	83	92	95	98	31
Prefix + Firstrate & Tavium + RU Powermax + Volt-Edge + Class Act Ridion + OnTarget	2 pt + 0.5 oz & 56.5 oz + 27 oz + 26 oz + 0.5% + 0.5%	86	90	92	92	98	98	35
Fierce EZ & RU Pmax + Xtendimax + Perpetuo + Select Max + Intact + Induce + Volt-Edge	6 oz & 32 oz + 22 oz + 6 oz + 9 oz + 0.5% + 0.25% + 26 oz	72	83	89	82	95	98	35
Fierce MTZ & RU Pmax + Xtendimax + Perpetuo + Select Max + Intact + Induce + Volt-Edge	1 pt & 32 oz + 22 oz + 6 oz + 9 oz + 0.5% + 0.25% + 26 oz	73	83	86	84	95	97	36
Warrant + Mauler & Liberty + Xtendimax + Volt-Edge + Intact + Class Act Ridion	48 oz + 8 oz & 32 oz + 22 oz + 26 oz + 0.5% + 1%	76	90	71	91	63	97	44
Warrrant + Mauler & RU Powermax + Xtendimax + Volt-Edge + Intact + Class Act Ridion	48 oz + 8 oz & 32 oz + 22 oz + 26 oz + 0.5% + 1%	68	86	91	92	97	99	37
LSD (0.05)		10	5	8	3	9	2	7

RCB: 4 reps
Variety: AG21XF0
Planting Date: 5/12/21
Pre: 5/12/21
Post: 6/18/21 Soy 3 tri, 7-9 in; Vele 1-7 in; Cowh 2-8 in.

Soil: Clay; 4.8% OM; 7.0 pH

Precipitation: (inches)
Pre: 1st week 0.44 2nd week 0.35

Vele=Velvetleaf
Cowh=Common waterhemp

Comments: Objective of the study was to look at dicamba program treatments for soybean weed control. Heavy velvetleaf and common waterhemp pressure. The year started out with moisture to activate preemergent treatments and enough moisture until post treatments were sprayed and then severe drought set in. Soybean yields were about half of normal and were variable due to variations in soils which caused uneven moisture stress. Six treatments were significantly lower than the top treatment. All treatments were better than the check.

2021
ENLIST SOYBEAN DEMONSTRATION
Southeast Research Farm

Treatment	Rate/A	6/16/21 Vele	6/16/21 Cowh	6/29/21 Vele	6/29/21 Cowh	7/15/21 Vele	7/15/21 Cowh	9/22/21 Vele	9/22/21 Cowh	10/6/21 Yield bu/A
Pre & Post										
Sonic & Enlist One + Durango DMA + Amsol	5 oz & 32 oz + 32 oz + 2.5%	83	86	99	98	99	99	96	95	23
Sonic & Enlist One + Liberty + Amsol	5 oz & 2 pt + 2 pt + 2.5%	86	89	99	99	99	99	99	99	32
Sonic & Enlist One + EverpreX + Durango DMA + Amsol	5 oz & 2 pt + 1 pt + 2 pt + 2.5%	83	88	99	98	99	99	99	99	25
Kyber & Enlist One + Durango DMA + Amsol	1 pt & 32 oz + 32 oz + 2.5%	49	89	99	98	99	99	99	99	28
Kyber & Enlist One + Liberty + Amsol	1 pt & 2 pt + 2 pt + 2.5%	53	88	99	99	99	99	99	99	32
Kyber & Enlist One + EverpreX + Durango DMA + Amsol	1 pt & 2 pt + 1 pt + 2 pt + 2.5%	43	87	99	98	99	99	99	99	23
Kyber & Enlist One + EverpreX + Liberty + Amsol	1 pt & 2 pt + 1 pt + 2 pt + 2.5%	45	87	99	99	99	99	98	99	32
Verdict + Outlook & Liberty + Enlist One + Zidua SC + AMS	5 oz + 8 oz & 32 oz + 32 oz + 2.5 oz + 3 lb	93	96	99	99	99	99	99	99	33
Sonic & EverpreX + Enlist One + Liberty + Amsol	5 oz & 1 pt + 1 qt + 32 oz + 2.5%	86	90	99	99	99	99	99	99	32
Check	---	0	0	0	0	0	0	0	0	8
LSD (0.05)		9	5	--	1	0.5	--	3	3	5

RCB: 4 reps
Variety: NK S20-E3
Planting Date: 5/12/21
Pre: 5/12/21
Post: 6/18/21 Soy 3 tri, 7-9 in; Vele 1-7 in; Cowh 2-8 in.

Precipitation: (inches)
Pre: 1st week 0.44 2nd week 0.35

Soil: Clay; 4.6% OM; 7.4 pH

Vele=Velvetleaf
Cowh=Common waterhemp

Comments: Objective of the study was to look at Enlist program treatments for soybean weed control. Heavy velvetleaf and common waterhemp pressure. The year started out with moisture to activate preemergent treatments and enough moisture until post treatments were sprayed and then severe drought set in. Soybean yields were about half of normal and were variable due to variations in soils which caused uneven moisture stress. Three of the treatments were significantly lower than the top treatment. All treatments were better than the check.

2021
LIBERTY LINK SOYBEAN DEMONSTRATION
Southeast Research Farm

		6/16/21			6/29/21		9/22/21		10/6/21
Treatment	**Rate/A**	**Grft**	**Vele**	**Cowh**	**Vele**	**Cowh**	**Vele**	**Cowh**	**Yield bu/A**
Check	---	0	0	0	0	0	0	0	7
Pre & Post									
Authority MTZ & Cheetah + AMS	14 oz & 32 oz + 3 lb	55	61	84	94	97	90	88	27
Dimetric Charged & Total SL + AMS	15 oz & 32 oz + 1.5 lb	53	60	89	96	98	92	77	29
Moccasin MTZ & Interline + AMS	3.56 pt & 32 oz + 3 lb	75	70	90	96	97	93	84	29
Fierce EZ & Scout + Perpetuo + AMS	6 oz & 32 oz + 6 oz + 3 lb	60	55	85	98	99	94	76	29
Fierce MTZ & Scout + Perpetuo + AMS	16 oz & 32 oz + 6 oz + 3 lb	50	54	81	94	96	88	81	29
Zidua Pro & Liberty + RU Powermax + Outlook + AMS	4.5 oz & 32 oz + 32 oz + 10 oz + 3 lb	75	84	89	99	99	99	97	40
LSD (0.05)		6	9	7	2	3	2	5	7

RCB: 4 reps
Variety: NK S20-LLGT27
Planting Date: 5/12/21
Pre: 5/12/21
Post: 6/15/21 Soy 2-3 tri, 6-8 in; Grft 4-7 in; Vele 2-7 in; Cowh 2-7 in.

Precipitation: (inches)
Pre: 1st week 0.44 2nd week 0.35

Soil: Clay; 4.6% OM; 7.4 pH

Grft=Green foxtail
Vele=Velvetleaf
Cowh=Common waterhemp

Comments: Objective of the study was to look at Liberty Link program treatments for soybean weed control. Heavy velvetleaf and common waterhemp pressure. The year started out with moisture to activate preemergent treatments and enough moisture until post treatments were sprayed and then severe drought set in. Soybean yields were about half of normal and were variable due to variations in soils which caused uneven moisture stress. One treatment was significantly better than all other treatments. All treatments were better than the check.

2021
LLGT27 SOYBEAN DEMONSTRATION
Southeast Research Farm

Treatment	Rate/A	6/16/21 Grft	6/16/21 Vele	6/16/21 Cowh	6/29/21 Grft	6/29/21 Vele	6/29/21 Cowh	9/22/21 Vele	9/22/21 Cowh	10/6/21 Yield bu/A
Check	---	0	0	0	0	0	0	0	0	7
Post										
RU Powermax + AMS	32 oz + 1.7 lb	--	--	--	99	99	44	97	76	18
Liberty + AMS	32 oz + 1.7 lb	--	--	--	99	99	97	90	67	16
Liberty + RU Powermax + AMS	32 oz + 32 oz + 1.7 lb	--	--	--	99	99	97	94	77	13
Pre & Post										
Alite 27 + Dimetric 3L & RU Powermax + AMS	3 oz + 10.67 oz & 32 oz + 1.7 lb	94	95	92	99	99	94	99	94	22
Alite 27 + Dimetric 3L & Liberty + AMS	3 oz + 10.67 oz & 32 oz + 1.7 lb	95	95	94	99	99	97	98	98	25
Alite 27 + Dimetric 3L & Liberty + Outlook + AMS	3 oz + 10.67 oz & 32 oz + 12 oz + 1.7 lb	94	95	94	99	99	99	99	98	22
Alite 27 + Outlook & Liberty + AMS	3 oz + 10 oz & 32 oz + 1.7 lb	96	96	95	99	99	99	99	99	22
Alite 27 + Zidua SC & Liberty + RU Pmax + Outlook + AMS	2 oz + 2.5 oz & 32 oz + 32 oz + 10 oz + 3 lb	93	94	93	99	99	99	99	99	23
LSD (0.05)		2	1	2	--	1	3	2	3	4

RCB: 4 reps
Variety: S20-LLGT27
Planting Date: 5/12/21
Pre: 5/12/21
Post: 6/15/21 Soy 2-3 tri, 6-8 in; Grft 4-7 in; Vele 1-7 in; Cowh 2-7 in.

Precipitation: (inches)
Pre: 1st week 0.44 2nd week 0.35

Soil: Clay; 4.6% OM; 7.4 pH

Grft=Green foxtail
Vele=Velvetleaf
Cowh=Common waterhemp

Comments: Objective of the study was to look at LLGT-27 program treatments for soybean weed control. Heavy velvetleaf and common waterhemp pressure. The year started out with moisture to activate preemergent treatments and enough moisture until post treatments were sprayed and then severe drought set in. Soybean yields were about half of normal and were variable due to variations in soils which caused uneven moisture stress. Only the post alone treatments were significantly lower than the top treatment. All treatments were better than the check.

2021
XTENDFLEX SOYBEAN HERBICIDE RECOMMENDATIONS
Southeast Research Farm

Treatment	Rate/A	6/29/21 Vele	6/29/21 Cowh	6/29/21 VCRR	7/15/21 Vele	7/15/21 Cowh	9/22/21 Vele	9/22/21 Cowh	10/6/21 Yield bu/A
Check	---	0	0	0	0	0	0	0	21
Pre & Epost									
Xtendimax + VRA + MON 301668 + Mauler & Xtendimax + VRA + RU Powermax 3 + MON 301668 + Class Act Ridion + Intact	22 oz + 20 oz + 30 oz + 8 oz & 22 oz + 20 oz + 30 oz + 30 oz + 1% + 0.5%	99	98	0	99	99	99	99	41
Xtendimax + VRA + MON 301668 + Mauler & RU Powermax 3 + MON 301668 + Amsol	22 oz + 20 oz + 30 oz + 8 oz & 32 oz + 30 oz + 30 oz + 2.5%	97	99	0	94	96	93	97	47
Xtendimax + VRA + MON 301668 + Mauler & Liberty + RU Powermax 3 + Amsol	22 oz + 20 oz + 30 oz + 8 oz & 32 oz + 30 oz + 2.5%	98	99	0	99	96	97	98	45
Xtendimax + VRA + MON 301668 + Mauler & Liberty + Select Max + Amsol	22 oz + 20 oz + 30 oz + 8 oz & 32 oz + 12 oz + 2.5%	98	99	0	96	97	95	97	45
Xtendimax + VRA + Fierce & Liberty + RU Powermax 3 + MON 301668 + Amsol	22 oz + 20 oz + 3 oz & 32 oz + 30 oz + 30 oz + 2.5%	98	99	0	98	99	97	99	40
Xtenimax + VRA + Fierce & Xtendimax + VRA + RU Powermax 3 + MON 301668 + Class Act Ridion + Intact	22 oz + 20 oz + 3 oz & 22 oz + 20 oz + 30 oz + 30 oz + 1% + 0.5%	99	97	0	99	99	99	99	44
MON 301668 + Mauler & Xtendimax + VRA + RU Powermax 3 + MON 301668 + Class Act Ridion + Intact	30 oz + 8 oz & 22 oz + 20 oz + 30 oz + 30 oz + 1% + 0.5%	99	98	0	99	99	99	99	42
MON 301668 + Mauler & Liberty + RU Powermax 3 + MON 301668 + Amsol	30 oz + 8 oz & 32 oz + 30 oz + 30 oz + 2.5%	98	98	0	93	96	94	94	46
MON 301668 + Mauler & RU Powermax 3 + Liberty + Amsol	30 oz + 8 oz & 30 oz + 32 oz + 2.5%	97	99	0	97	97	95	95	40
MON 301668 + Mauler & Liberty + Select Max + Amsol	30 oz + 8 oz & 32 oz + 12 oz + 2.5%	95	98	0	91	91	90	85	35
MON 301668 + Mauler & Liberty + MON 301668 + Xtendimax + VRA + Class Act Ridion + Intact	30 oz + 8 oz & 32 oz + 30 oz + 22 oz + 20 oz + 1% + 0.5%	93	99	0	91	96	93	99	41
MON 301668 + Mauler & Liberty + MON 301668 + Xtendimax + VRA + Class Act Ridion + RU Powermax 3 + Intact	30 oz + 8 oz & 32 oz + 30 oz + 22 oz + 20 oz + 1% + 30 oz + 0.5%	97	99	0	97	98	95	98	44
MON 301668 + Mauler & Warrant Ultra + Liberty + Amsol	30 oz + 8 oz & 48 oz + 32 oz + 2.5%	91	98	0	80	86	86	87	37
Xtendimax + VRA + Warrant Ultra + Class Act Ridion + Intact & Xtendimax + VRA + RU Powermax 3 + MON 301668 + Class Act Ridion + Intact	22 oz + 20 oz + 48 oz + 1% + 0.5% & 22 oz + 20 oz + 30 oz + 30 oz + 1% + 0.5%	98	99	0	99	99	99	99	45
Xtendimax + VRA + Warrant Ultra + Class Act Ridion + Intact & Liberty + RU Powermax 3 + MON 301668 + Amsol	22 oz + 20 oz + 48 oz + 1% + 0.5% & 32 oz + 30 oz + 30 oz + 2.5%	98	99	0	97	97	96	99	42
LSD (0.05)		2	1	--	5	5	3	5	7

2021
XTENDFLEX SOYBEAN HERBICIDE RECOMMENDATIONS
Southeast Research Farm

RCB: 4 reps
Variety: AG21XF0
Planting Date: 5/12/21
Pre: 5/12/21
Epost: 6/15/21 Soy 2-3 tri, 6-8 in; Vele 2-6 in; Cowh 1-6 in.

Precipitation: (inches)
Pre: 1st week 0.44 2nd week 0.35

Soil: Clay; 4.6% OM; 6.1 pH

Vele=Velvetleaf
Cowh=Common waterhemp
VCRR=Visual Crop Response Rating
(0=no injury; 100=complete kill)

Comments: Objective of the study was to look at treatments for soybean weed control. Heavy velvetleaf and common waterhemp pressure. The year started out with moisture to activate preemergence treatments and enough moisture until post treatments were sprayed and then severe drought set in. Soybean yields were about half of normal and were variable due to variations in soils which caused uneven moisture stress. Three of the treatments were significantly lower than the top treatment. All treatments were better than the check.

2021
ZIDUA PRO RESIDUAL WEED CONTROL COMPARISON
Southeast Research Farm

		6/9/21		6/21/21	
Treatment	**Rate/A**	**Vele**	**Cowh**	**Vele**	**Cowh**
Check	---	0	0	0	0
Pre					
Boundary	24 oz	86	90	43	80
Zidua Pro	6 oz	96	96	90	90
Zidua Pro	4.5 oz	95	96	89	86
Sonic	5 oz	93	93	84	73
Authority Supreme	6.5 oz	91	87	78	75
Fierce MTZ	16 oz	91	94	73	80
Authority Edge	9 oz	92	91	74	78
LSD (0.05)		4	3	4	5

RCB: 4 reps
Variety: AG21XFO
Planting Date: 5/12/21
Pre: 5/12/21

Precipitation: (inches)
Pre: 1st week 0.44 2nd week 0.35

Soil: Clay; 4.6% OM; 6.1 pH

Vele=Velvetleaf
Cowh=Common waterhemp

Comments: Objective of the study was to look at treatments for soybean weed control. Heavy velvetleaf and common waterhemp pressure. The year started out with moisture to activate preemergence treatments and enough moisture early and then severe drought set in. Velvetleaf control varied among treatments.

2021
ZONE DEFENSE PRE IN SOYBEANS
Southeast Research Farm

		6/2/21		6/9/21			6/21/21		
Treatment	**Rate/A**	**Vele**	**VCRR**	**Grft**	**Vele**	**Cowh**	**Grft**	**Vele**	**Cowh**
Check	---	0	0	0	0	0	0	0	0
Pre									
Zone Defense	4 oz	83	0	81	76	94	55	43	88
Zone Defense + Helmet	4 oz + 2 pt	87	0	89	85	95	84	50	90
Zone Defense	5 oz	84	0	88	79	94	58	45	89
Zone Defense + Helmet	5 oz + 2 pt	89	0	89	88	94	84	60	90
Fierce	3 oz	89	0	84	86	94	63	72	88
Zone Maxx	8 oz	86	0	86	84	94	81	60	86
LSD (0.05)		2	--	5	8	3	8	8	4

RCB: 4 reps
Variety: AG21XFO
Planting Date: 5/18/21
Pre: 5/18/21

Soil: Clay; 4.6% OM; 7.4 pH

Precipitation: (inches)
Pre: 1st week 0.34 2nd week 0.64

Vele=Velvetleaf
Cowh=Common waterhemp
Grft=Green foxtail
VCRR=Visual Crop Response Rating
(0=no injury; 100=complete kill)

Comments: Objective of the study was to look at treatments for soybean weed control. Heavy velvetleaf and common waterhemp pressure. The year started out with moisture to activate preemergence treatments and enough moisture early and then severe drought set in. Velvetleaf control dropped off with no post treatments to clean up escapes.

2021
REVITON IN SOYBEAN
Southeast Research Farm

		5/18/21		5/25/21		6/2/21		6/9/21		6/16/21	
Treatment	**Rate/A**	**Dali**	**Prle**	**Dali**	**Prle**	**Dali**	**Prle**	**Dali**	**Prle**	**Dali**	**Prle**
Check	---	0	0	0	0	0	0	0	0	0	0
EPP											
Reviton + Destiny HC	2 oz + 1%	86	74	50	50	22	70	0	33	0	67
Reviton + RU Powermax + AMS + Destiny HC	1 oz + 32 oz + 1.7 lb + 1%	91	88	98	99	97	99	99	97	92	90
Sharpen + RU Powermax + AMS + Destiny HC	1..5 oz + 32 oz + 1.7 lb + 1%	78	83	94	99	94	99	99	97	88	93
Reviton + RU Powermax + AMS + Zone Elite + Destiny HC	1 oz + 32 oz + 1.7 lb + 32 oz + 1%	93	91	95	99	94	99	99	97	90	97
LSD (0.05)		3	6	1	--	4	4	--	5	3	6

RCB: 3 reps
Variety: AG12XF1
Planting Date: 5/29/21
EPP: 5/11/21 Dali 2-10 in diam.

Soil: Clay; 3.1% OM; 7.1 pH

Precipitation: (inches)
EPP: 1st week 0.43 2nd week 0.24

Dali=Dandelion
Prle=Prickly lettuce

Comments: Objective of the study was to look at treatments for soybean weed control. Heavy dandlelion and prickly lettuce pressure. The year started out with moisture to activate early preplant treatments and enough moisture early and then severe drought set in. Some variation in dandelion weed control but overall good burndown weed control.

2021
MON 301668 PRE IN SOYBEAN
Southeast Research Farm

		6/2/21	6/9/21			6/16/21		6/21/21		
Treatment	**Rate/A**	**VCRR**	**Grft**	**Vele**	**VCRR**	**Grft**	**Vele**	**Grft**	**Vele**	**Cowh**
Check	---	0	0	0	0	0	0	0	0	0
Pre										
Warrant + Xtendimax + Volt-Edge	48 oz + 22 oz + 20 oz	0	93	93	0	91	92	87	86	97
MON 301668 + Xtendimax + Volt-Edge	30 oz + 22 oz + 20 oz	0	95	95	0	93	94	89	91	97
Zidua + Xtendimax + Volt-Edge	2 oz + 22 oz + 20 oz	0	92	95	0	90	93	85	90	97
Outlook + Xtendimax + Intact + Volt-Edge	14 oz + 22 oz + 0.5% + 20 oz	0	94	94	0	92	93	89	87	97
Dual II Mag + Xtendimax + Intact + Volt-Edge	1 pt + 22 oz + 0.5% + 20 oz	0	94	95	0	90	91	88	86	97
Warrant + Mauler	48 oz + 8 oz	0	92	91	0	87	84	76	78	97
MON 301668 + Mauler	30 oz + 8 oz	0	93	92	0	86	82	85	81	97
Zidua + Mauler	2 oz + 8 oz	0	91	90	0	89	83	79	79	97
Outlook + Mauler	14 oz + 8 oz	0	94	91	0	91	84	85	82	97
Dual II Mag + Mauler	1 pt + 8 oz	0	92	91	0	91	86	86	82	97
Warrant + Mauler + Xtendimax + Volt-Edge	48 oz + 8 oz + 22 oz + 20 oz	0	93	94	0	90	94	86	90	97
MON 301668 + Mauler + Xtendimax + Volt-Edge	30 oz + 8 oz + 22 oz + 20 oz	0	94	95	0	91	93	90	92	97
Zidua + Mauler + Xtendimax + Volt-Edge	2 oz + 8 oz + 22 oz + 20 oz	0	93	95	0	91	94	85	91	97
Outlook + Mauler + Xtendimax + Intact + Volt-Edge	14 oz + 8 oz + 22 oz + 0.5% + 20 oz	0	94	95	0	93	94	91	93	97
Dual II Mag + Mauler + Xtendimax + Intact + Volt-Edge	1 pt + 8 oz + 22 oz + 0.5% + 20 oz	0	93	96	0	91	92	90	90	97
LSD (0.05)		--	2	3	--	2	3	4	3	--

RCB: 4 reps
Variety: AG21XF0
Planting Date: 5/18/21
Pre: 5/18/21

Soil: Silty Clay; 4.2% OM; 5.7 pH

Precipitation: (inches)
Pre: 1st week 0.34 2nd week 0.64

Grft=Green foxtail
Vele=Velvetleaf
Cowh=Common waterhemp
VCRR=Visual Crop Response Rating
(0=no injury; 100=complete kill)

Comments: Objective of the study was to look at treatments for soybean weed control. Heavy velvetleaf and common waterhemp pressure. The year started out with moisture to activate preemergence treatments and enough moisture early and then severe drought set in. Some variation in weed control but fairly good control without a post treatment for cleanup.

2021
XTENDIMAX PRE IN CONVENTIONAL-TILL SOYBEAN
Southeast Research Farm

Treatment	Rate/A	5/25/21 VCRR	6/2/21 Vele	6/2/21 Cowh	6/16/21 Vele	6/16/21 Cowh
Check	---	0	0	0	0	0
Pre						
MON 301668 + Mauler	30 oz + 8 oz	0	89	96	84	93
MON 301668	30 oz	0	81	93	77	91
Warrant Ultra	50 oz	0	90	94	80	93
Fierce EZ	6 oz	0	89	95	82	90
Valor EZ	2 oz	0	90	94	85	82
Authority MTZ	10 oz	0	88	91	85	79
MON 301668 + Mauler + Xtendimax + VRA	30 oz + 8 oz + 22 oz + 20 oz	0	95	98	94	96
MON 301668 + Xtendimax + VRA	30 oz + 22 oz + 20 oz	0	96	98	93	95
Warrant Ultra + Intact + Xtendimax + VRA	50 oz + 0.5% + 22 oz + 20 oz	0	94	98	91	94
Fierce EZ + Xtendimax + VRA + Intact	6 oz + 22 oz + 20 oz + 0.5%	0	96	98	95	93
Valor EZ + Xtendimax + VRA	2 oz + 22 oz + 20 oz	0	96	98	94	93
Authority MTZ + Xtendimax + VRA	10 oz + 22 oz + 20 oz	0	94	97	92	89
LSD (0.05)		--	3	3	4	3

RCB: 4 reps
Variety: AG21XF0
Planting Date: 5/12/21
Pre: 5/12/21

Precipitation: (inches)
Pre: 1st week 0.44 2nd week 0.35

Soil: Clay; 4.6% OM; 6.1 pH

Vele=Velvetleaf
Cowh=Common waterhemp
VCRR=Visual Crop Response Rating
(0=no injury; 100=complete kill)

Comments: Objective of the study was to look at treatments for soybean weed control. Heavy velvetleaf and common waterhemp pressure. The year started out with moisture to activate preemergence treatments and enough moisture early and then severe drought set in. Some variation in weed control but fairly good control without a post treatment for cleanup.

2021
XTENDIMAX PRE IN NO-TILL SOYBEAN
Southeast Research Farm

Treatment	Rate/A	5/25/21 Fipc	5/25/21 Prle	5/25/21 VCRR	6/2/21 Fipc	6/16/21 Prle	6/16/21 Vele
Pre							
RU Powermax 3 + Class Act Ridion	30 oz + 1%	99	98	0	96	88	0
MON 301668 + Mauler + RU Powermax 3 + Class Act Ridion	30 oz + 8 oz + 30 oz + 1%	99	99	0	99	99	50
MON 301668 + RU Powermax 3 + Class Act Ridion	30 oz + 30 oz + 1%	99	99	0	99	97	30
Warrant Ultra + RU Powermax 3 + Class Act Ridion	50 oz + 30 oz + 1%	99	99	0	99	99	35
Fierce EZ + RU Powermax 3 + Class Act Ridion	6 oz + 30 oz + 1%	99	99	0	99	99	40
Valor EZ + RU Powermax 3 + Class Act Ridion	2 oz + 30 oz + 1%	99	99	0	99	99	43
Authority MTZ + RU Powermax 3 + Class Act Ridion	10 oz + 30 oz + 1%	99	99	0	99	99	66
MON 301668 + Mauler + Xtendimax + RU Powermax 3 + Class Act Ridion + Intact + VRA	30 oz + 8 oz + 22 oz + 30 oz + 1% + 0.5% + 20 oz	99	99	0	99	99	68
MON 301668 + RU Powermax 3 + Class act Ridion + Xtendimax + Intact + VRA	30 oz + 30 oz + 1% + 22 oz + 0.5% + 20 oz	99	99	0	99	99	55
Warrant Ultra + RU Powermax 3 + Class Act Ridion + Xtendimax + Intact + VRA	50 oz + 30 oz + 1% + 22 oz + 0.5% + 20 oz	99	99	0	99	99	68
Fierce EZ + RU Powermax 3 + Class Act Ridion + Xtendimax + Intact + VRA	6 oz + 30 oz + 1% + 22 oz + 0.5% + 20 oz	99	99	0	99	99	75
Valor EZ + RU Powermax 3 + Class Act Ridion + Xtendimax + Intact + VRA	2 oz + 30 oz + 1% + 22 oz + 0.5% + 20 oz	99	99	0	99	99	80
Authority MTZ + RU Powermax 3 + Class Act Ridion + Xtendimax + Intact + VRA	10 oz + 30 oz + 1% + 22 oz + 0.5% + 20 oz	99	99	0	99	99	88
Check	---	0	0	0	0	0	0
LSD (0.05)		0.5	1	--	1	4	16

RCB: 4 reps
Variety: AG14X0
Planting Date: 5/13/21
Pre: 5/11/21

Precipitation: (inches)
Pre: 1st week 0.43 2nd week 0.34

Soil: Silty Clay; 3.7% OM; 6.6 pH

Fipc=Field pennycress
Prle=Prickly lettuce
Vele=Velvetleaf
VCRR=Visual Crop Response Rating
(0=no injury; 100=complete kill)

Comments: Objective of the study was to look at treatments for soybean weed control. Moderate velvetleaf, field pennycress and prickly lettuce pressure. The year started out with moisture to activate preemergence treatments and enough moisture early and then severe drought set in. Velvetleaf came on late and was not controlled well with pre alone. The addition of Xtendimax preemergence improved velvetleaf control.

2021
XTENDIMAX + GLUFOSINATE TANK-MIX FOR BROADLEAF CONTROL IN SOYBEANS-BAREGROUND
Southeast Research Farm

		6/29/21			7/6/21			7/15/21		
Treatment	**Rate/A**	**Grft**	**Vele**	**Cowh**	**Grft**	**Vele**	**Cowh**	**Grft**	**Vele**	**Cowh**
Check	---	0	0	0	0	0	0	0	0	0
Post										
Xtendimax + VRA + Intact + Class Act Ridion	22 oz + 20 oz + 0.5% + 1%	0	65	93	13	79	87	13	86	84
Liberty + Amsol	32 oz + 2.5%	99	99	99	99	98	93	94	96	85
RU Powermax 3 + Xtendimax + VRA + Intact + Class Act Ridion	30 oz + 22 oz + 20 oz + 0.5% + 1%	99	98	92	99	99	88	98	98	91
Xtendimax + VRA + Intact + Class Act Ridion + Liberty	22 oz + 20 oz + 0.5% + 1% + 32 oz	99	85	98	99	92	92	93	90	85
RU Powermax 3 + Xtendimax + VRA + Intact + Class Act Ridion + Liberty	30 oz + 22 oz + 20 oz + 0.5% + 1% + 32 oz	99	99	98	99	99	90	97	98	86
MON 301668 + Xtendimax + VRA + Intact + Class Act Ridion + Liberty	30 oz + 22 oz + 20 oz + 0.5% + 1% + 32 oz	98	89	98	98	91	95	93	88	93
Liberty + MON 301668 + Amsol	32 oz + 30 oz + 2.5%	98	99	99	99	98	96	91	94	91
RU Powermax 3 + Liberty + MON 301668 + Amsol	30 oz + 32 oz + 30 oz + 2.5%	99	99	99	99	99	99	98	98	94
Liberty + Warrant Ultra + Amsol	32 oz + 50 oz + 2.5%	98	98	99	99	95	93	86	91	86
RU Powermax 3 + Xtendimax + VRA + Intact + Class Act Ridion + Liberty + MON 301668	30 oz + 22 oz + 20 oz + 0.5% + 1% + 32 oz + 30 oz	99	99	99	99	99	99	98	98	96
Durango DMA + Enlist One + Amsol	36 oz + 32 oz + 2.5%	99	99	96	99	99	98	99	99	98
Liberty + Enlist One + Amsol	32 oz + 32 oz + 2.5%	99	99	99	98	99	99	96	99	98
Durango DMA + Liberty + Enlist One + Amsol	36 oz + 32 oz + 32 oz + 2.5%	99	99	99	99	99	99	99	99	99
Durango DMA + Outlook + Liberty + Enlist One + Amsol	36 oz + 14 oz + 32 oz + 32 oz + 2.5%	99	99	99	99	99	99	99	99	99
LSD (0.05)		1	3	1	2	2	3	3	2	4

RCB: 4 reps
Post: 6/17/21 Grft 3-8 in; Vele 2-6 in; Cowh 2-7 in.

Soil: Silty Clay; 4.2% OM; 5.7 pH

Grft=Green foxtail
Vele=Velvetleaf
Cowh=Common waterhemp

Comments: Objective of the study was to look at treatments for soybean weed control. Heavy velvetleaf and common waterhemp pressure. The year started out with enough moisture until post treatments were sprayed and then severe drought set in. Some variation in weed control but fairly good control without a second post treatment for cleanup.

2021
HUSKIE FX IN SORGHUM
Southeast Research Farm

		6/29/21			7/6/21				8/2/21		
Treatment	**Rate/A**	**Vele**	**Cowh**	**VCRR**	**Grft**	**Vele**	**Cowh**	**VCRR**	**Vele**	**Cowh**	**VCRR**
Check	---	0	0	0	0	0	0	0	0	0	0
Post											
Huskie FX + AMS + Atrazine	18 oz + 1 lb + 16 oz	97	92	20	88	99	99	10	99	99	0
Huskie + AMS + Atrazine	16 oz + 1 lb + 16 oz	95	93	19	87	99	99	9	99	99	0
LSD (0.05)		1	2	3	2	--	--	3	--	--	--

RCB: 4 reps
Variety: DKS 29-28
Planting Date: 5/21/21
Post: 6/22/21 Sorg 6 lf, 14-16 in; Vele 2-10 in; Cowh 2-10 in.

Soil: Clay Loam; 4.4% OM; 6.8 pH

Vele=Velvetleaf
Cowh=Common waterhemp
Grft=Green foxtail
VCRR=Visual Crop Response Rating
(0=no injury; 100=complete kill)

Comments: Objective of the study was to look at treatments for sorghum weed control. Heavy velvetleaf, common waterhemp and moderate green foxtail pressure. The year started out with moisture for sorghum emergence and enough moisture until post treatments were sprayed and then severe drought set in. No variation in weed control noted.

2021
MON 301668 IN GRAIN SORGHUM
Southeast Research Farm

Treatment	Rate/A	6/9/21			6/16/21			6/29/21				7/6/21			
		Grft	Vele	Cowh	Vele	Grft	Cowh	Grft	Vele	Cowh	VCRR	Grft	Vele	Cowh	VCRR
Check	---	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre															
Dual II Mag + Atrazine	1.33 pt + 1 qt	65	33	60	28	95	95	86	25	91	0	89	20	83	0
Warrant + Atrazine	48 oz + 1 qt	88	35	89	33	96	97	93	23	93	0	90	23	90	0
MON 301668 + Atrazine	30 oz + 1 qt	91	40	90	50	96	97	94	23	91	0	89	23	89	0
Epost															
Dual II Mag + Atrazine	1.33 pt + 1 qt	--	--	--	--	--	--	76	45	83	0	85	71	90	0
Warrant + Atrazine	48 oz + 1 qt	--	--	--	--	--	--	78	44	64	0	83	71	88	0
MON 301668 + Atrazine	30 oz + 1 qt	--	--	--	--	--	--	70	44	70	0	85	67	91	0
Warrant + Atrazine + Huskie + NIS + Amsol	48 oz + 0.5 qt + 1 pt + 0.25% + 5%	--	--	--	--	--	--	77	97	94	20	88	99	99	10
MON 301668 + Atrazine + Huskie + NIS + Amsol	30 oz + 0.5 qt + 1 pt + 0.25% + 5%	--	--	--	--	--	--	77	97	94	20	88	99	99	10
Huskie FX + Atrazine + NIS + Amsol	18 oz + 0.5 qt + 0.25% + 5%	--	--	--	--	--	--	65	97	95	20	81	99	99	10
Warrant + Huskie FX + Atrazine + NIS + Amsol	48 oz + 18 oz + 0.5 qt + 0.25% + 5%	--	--	--	--	--	--	71	97	94	19	82	99	99	10
MON 301668 + Huskie FX + Atrazine + NIS + Amsol	30 oz + 18 oz + 0.5 qt + 0.25% + 5%	--	--	--	--	--	--	70	97	92	20	83	99	99	10
LSD (0.05)		11	7	15	5	2	2	11	5	8	1	6	8	4	--

RCB: 4 reps
Variety: DKS 29-28
Planting Date: 5/21/21
Pre: 5/21/21
Epost: 6/22/21 Sorg 6 lf, 14-16 in; Vele 2-10 in; Cowh 2-10 in.

Precipitation: (inches)
Pre: 1st week 0.58 2nd week 0.37

Soil: Clay Loam; 4.4% OM; 6.8 pH

Grft=Green foxtail
Vele=Velvetleaf
Cowh=Common waterhemp
VCRR=Visual Crop Response Rating
(0=no injury; 100=complete kill)

Comments: Objective of the study was to look at treatments for sorghum weed control. Heavy velvetleaf and common waterhemp and moderate green foxtail pressure. The year started out with moisture to activate preemergence treatments and enough moisture until post treatments were sprayed and then severe drought set in. Some variation in weed control noted with preemergence and postemergence treatments.

SOUTHEAST RESEARCH FARM ANNUAL REPORT
South Dakota State University
2021 Progress Report
Agricultural Experiment Station
Plant Science Department
South Dakota State University, Brookings, SD 57007
Southeast Research Farm, Beresford, SD 57004

Evaluating Corn Silage by Chop Length and Packing Density

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Over 360,000 acres of corn silage were harvested in South Dakota during 2020 yielding 6,480,000 tons total, making the state one of the top producers of the feedstuff in the nation. Our neighbors in Nebraska harvested 260,000 acres of corn silage yielding a total of 4,940,000 tons total in 2020, a smaller, yet very significant amount. With so many producers using corn silage as a main feedstuff in grower livestock diets and for breeding stock, it's important that we continue to evaluate maximizing yields as well as best cutting, packing, and storage processes.

The objectives of this study were to 1) evaluate corn silage quality and losses based upon 3 different common chop lengths, 2) evaluate corn silage quality and losses based upon three different packing densities, 3) evaluate the interaction between packing density and chop length as it relates to corn silage quality and losses. This project is specifically designed to provide data that is applicable to farmers in South Dakota and Nebraska that will assist with improving quality and quantity at feeding time.

METHODS

The silage for this project was cut and packed on August 25 and 26, 2021 at the Southeast Research farm near Beresford, SD. After running a microwave test, average dry matter of 39% (61% moisture) was found. Each chop length was cut separately and covered until all replications involving that length were completed. Then, the next chop length treatment was cut and covered, and so on. Chop length was changed using sprocket adjustments on the silage chopper until the acceptable chop length was achieved for each treatment. Chop length and density treatments can be viewed in Table 1.

In order to make the project feasible, mini silos were used to simulate bunker silos or silage piles. The silos consisted of a 3 foot length with a 7.75 inch inside diameter PVC sewer and drain pipe. The bottom end of each pipe was sealed using a rubber end-cap clamped on with a hose clamp, creating a tight seal.

Before packing, each silo was weighed empty. Then, each silo replication was filled in 6 layers with different weights of silage per the density required by the treatment. Total silage weight for each treatment was calculated using desired as-fed density multiplied by tube volume multiplied by silage dry matter. Silage was packed into the tubes in layers by placing known weights of material in the tube, and compressing silage to a known depth using a specially designed steel plunger with down pressure applied by a skid steer loader bucket.

Each tube was sealed using an oxygen barrier covered with a traditional silage tarp. A large rubber band and rubber clamp was used to seal each tube. The mini silos were stored upright, under roof in a cold storage shed for the

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remainder of the experiment. Initial composite samples of each chop length were taken and sent in for quality analysis at the time the tubes were sealed.

On December 13, 2021 (~110 days after cutting), the silage tubes were weighed and sampled for losses and quality analysis. Tubes appeared to be unaffected by any wildlife or other issues and all seals appeared to have stayed intact. Each silage tube was opened and the top foot was removed, mixed, and sub sampled. Then, the bottom two feet were removed from each tube, mixed, and sub sampled in the same manner. Silage was immediately bagged, cooled and shipped for quality analysis.

All quality analysis was performed by Rock River Laboratory in Watertown, WI using a comprehensive nutrition analysis by near infrared (NIR).

Table 1. Explanation of Treatments for a Silage Packing Density and Chop Length Study near Beresford, SD, 2021.

Treatment	Chop Length (inches)	Density (lbs. dry matter/ft^3)
1	1/4	12
2	1/4	15
3	1/4	17
4	1/2	12
5	1/2	15
6	1/2	17
7	3/4	12
8	3/4	15
9	3/4	17

RESULTS AND CONCLUSIONS

The quality results on this study arrived shortly before the deadline for this report. Results are currently being analyzed and will be reported in the 2022 annual report. On first glance, it is clear that some quality differences occurred, this data will be very interesting to review. Note that although 12, 15, and 18 lbs. dry matter per cubic foot was the goal for the density treatments in this trial, 18 lbs/ft^3 was not physically feasible so the highest density treatment was dropped to 17 lbs/ft^3.

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Impact of corn silage moisture and kernel processing at harvest on finishing steer growth performance, efficiency of dietary net energy utilization and carcass traits

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PURPOSE

Corn silage is a cornerstone feed ingredient in the Northern Plains. Corn silage production in the United States has been a widely adapted for over a century. Based upon recent USDA data (2019) corn silage was grown on 340,000 acres in SD with an average yield (as-is basis) of 17.5 tons per acre resulting in 5.95 million tons of corn silage produced. Corn silage is typically harvested in early fall once whole plant DM is near 35 to 40% which coincides with one half to two thirds milk line. Once harvested corn silage is stored in variety of suitable structures such as up-right silos, bunker silos, oxygen exclusion bags, pits, or piles in the absence of oxygen where it is allowed to ferment for a minimum of 3 weeks prior to feeding. Advantages of using corn silage as a roughage source in finishing cattle diets is that is can be harvested in a single event annually compared to multiple harvests required to generate sufficient inventory for feeding as with other forage sources.
Timing of harvest dictates total DM tonnage produced. Corn silage differs from other forage crops in that maximal yield and feeding quality occur around the same time. It is recommended that corn silage be harvested when whole plant moisture is around 65%. Unfortunately, whole plant moisture content for an entire field is difficult to determine and as such milk line checks across a field are used to gauge field plant moisture content. In addition, meteorological challenges and other workload demands at harvest can very easily result in corn silage being harvested at a greater DM content than deemed ideal (i.e. after black layer). Harvesting corn silage at a greater DM content can cause issues related to inability to properly pack the harvested feed that in turn can result in aerobic stability issues that result in inventory losses due to spoiled feed.
Kernel processing (KP) of corn silage has gained wide acceptance in the last 20 y, especially on dairy operations. Kernel processing effects on diet digestibility and growth performance have yielded inconsistent results in beef cattle. This is in part a function of differing DM content of corn silage at harvest and inclusion levels of corn silage in the diet. Kernel processing has proven beneficial in growing cattle diets (Ovinge, 2019) at a high inclusion level (greater than 50% DM inclusion), however, no improvements in growth performance or gain efficiency were noted in finishing cattle diets due to kernel processing (Ovinge, 2019).

OBJECTIVE

The objective of this experiment was to investigate the impact of corn silage moisture content and kernel processing at harvest has on growth performance, efficiency of dietary net energy utilization, and carcass traits in finishing steers when fed at 20% DM inclusion in diets

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containing modified distillers grains plus solubles.

APPROACH

Animal care and handling procedures used in this study were approved by the South Dakota State University Animal Care and Use Committee (Approval Number: 2008-033E). Red Angus steers (n = 192; initial shrunk BW = 983 ± 62.3 lbs) were used in the 112 d finishing experiment at the Southeast Research Farm (SERF) of the South Dakota Agricultural Experiment Station in Beresford. Steers were from a single source and obtained from a local SD auction facility. Steers were received 2 weeks prior to trial initiation. Steers were offered a common diet containing 60% concentrate upon arrival. Steers were transitioned to a 90% concentrate diet over the course of 14 d. Steers were consuming the finishing diet (Table 1) at the initiation of the experiment. Diets were fortified to provide vitamins and minerals to meet or exceed nutrient requirements and provided monensin sodium (DM basis) at 30 g/ton (NASEM, 2016). Steers were fed ractopamine hydrochloride (OPTAFLEXX 45, Elanco, Indianapolis, IN) at a rate of 250 mg/steer·d^{-1} for the final 28 d prior to harvest. There was no morbidity or mortality noted in the present study. Fresh feed was manufactured once daily for each treatment in a single batch using a stationary mixer (5.2 m^3; scale readability 2.0 lbs) and bunks were managed for *ad libitum* access to feed. Orts were collected, weighed, and dried in a forced air oven at 100°C for 24 h to determine DM content if carryover feed went out of condition, or was present on weigh days. If carryover feed was present on weigh days, the residual feed was removed prior to the collection of BW measurements. The dry matter intake (DMI) of each pen was adjusted to reflect the total DM delivered to each pen after subtracting the quantity of dry orts for each interim period. Actual diet formulation and composition was based upon weekly DM analyses (drying at 60°C till no weight change), tabular nutrient values, and corresponding feed batching records. Diets presented in Table 1 are actual DM diet composition, tabular nutrient concentrations, and tabular energy values (Preston, 2016).

Steers were weighed and processed 3 d prior to study initiation. Initial processing included individual BW measurement (scale readability 2.0 lb), application of a unique identification ear tag, vaccination for viral respiratory pathogens (Bovi-Shield Gold 5, Zoetis, Parsippany, NJ) and *clostridial* species (Ultrabac/Somubac 7, Zoetis) and application of a 200 mg trenbolone acetate and 28 mg estradiol benzoate steroidal implant (Synovex-Plus, Zoetis). An implant retention check was conducted 31 d later, any steers with missing implants were re-administered their steroidal implant. On the day of experiment initiation, all steers were administered pour-on moxidectin (Cydectin, Bayer Animal Health, Shawnee Mission, KS) to control for internal and external parasites according to the manufacturer's recommendation. The processing BW (d -3) was used for allotment purposes. Steers were blocked by pen location (n = 6) and allotted to their study pens on d 1. The study used 6 replicate pens of 8 steers assigned to each of the 4 dietary treatments (2 × 2 factorial arrangement of treatments).

Factors included silage moisture at harvest and kernel processing.

Silage moisture at harvest:

1. 1/2 to 2/3 milk line (ML)
2. Black line (BL)

Kernel processing (KP):

1. No KP (KP-)
2. KP (KP+)

Growth Performance Calculations

Steers were individually weighed on d -3, 1, 28, 56, 84, and 112. Cumulative growth performance was based upon initial BW (average BW from d -3 and 1 with a 4% shrink applied to account for gastrointestinal tract fill) and carcass-adjusted final BW (FBW; HCW/0.625). Average daily gain (ADG) was calculated as the difference between FBW and initial shrunk BW, divided by days on feed and feed efficiency was calculated from ADG/DMI.

Carcass trait determination

Steers were harvested after 112 d on feed. Steers were shipped the afternoon following final BW determination and harvested the next day at

Tyson Fresh Meats in Dakota City, NE. Steers were comingled at the time of shipping and remained this way until 0700 h the morning after shipping. Hot carcass weight (HCW) was captured immediately following the harvest procedure. Video image data were obtained from the packing plant for rib eye area, rib fat, and USDA marbling scores. A common kidney, pelvic, heart (KPH) fat percentage of 2.5% was applied to all calculations requiring a KPH%. Yield grade was calculated according to the USDA regression equation (USDA, 1997). Dressing percentage was calculated as HCW/(final BW × 0.96). Estimated empty body fat (EBF) percentage and final BW at 28% EBF (AFBW) were calculated from observed carcass traits (Guiroy et al., 2002), and proportion of closely trimmed boneless retail cuts from carcass round, loin, rib, and chuck (Retail Yield, RY; Murphey et al., 1960). Carcass data were available for all but four steers: ML/KP- (2), BL/KP- (1), BL/KP+ (1).

Efficiency of dietary NE utilization calculations

Observed dietary NE was calculated from daily energy gain (EG; Mcal/d): $EG = ADG^{1.097} \times 0.0557W^{0.75}$, where W is the mean equivalent BW [average initial shrunk BW and FBW × (478/AFBW), kg; (NRC, 1996)]. Maintenance energy required (EM; Mcal/d) was calculated by the following equation: $EM = 0.077BW^{0.75}$ (Lofgreen and Garrett, 1968) where BW is the mean shrunk BW (average of initial shrunk BW and FBW). Using the estimates required for maintenance and gain the observed dietary NEm and NEg values (Owens and Hicks, 2019), of the diet were generated using the quadratic formula: $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2c}$, where x = NEm, Mcal/kg, a = -0.41EM, b = 0.877EM + 0.41DMI + EG, c = -0.877DMI, and NEg was determined from: 0.877NEm – 0.41 (Zinn and Shen, 1998; Zinn et al., 2008). The ratio of observed-to-expected NE ratio was determined from observed dietary NE for maintenance or gain/tabular NE for maintenance or gain.

Statistical analysis

Growth performance, carcass traits, and efficiency of dietary NE utilization were analyzed as a randomized complete block design using the GLIMMIX procedure of SAS 9.4 (SAS Inst. Inc., Cary, NC) with pen as the experimental unit. The model included the fixed effects harvest time, kernel processing, and their interaction; block (location) was included as a random variable. Least squares means were generated using the LSMEANS statement of SAS and treatment effects were analyzed using the pairwise comparisons PDIFF and LINES option of SAS 9.4. Distribution of USDA Yield and Quality grade data as well as carcass weight distributions were analyzed as binomial proportions in the GLIMMIX procedure of SAS 9.4 with fixed and random effects in the model as described previously. If a significant harvest time by processing interaction was detected ($P <$ 0.05), simple treatment means were separated. An α of 0.05 or less determined significance and tendencies are discussed between 0.05 and 0.10.

RESULTS

Growth performance

Growth performance data are located in Table 2. No Harvest time × KP interaction was detected ($P \geq 0.16$) for any growth performance parameters. Initial BW was not influenced by harvest time ($P = 0.53$) or KP ($P = 0.95$). Final BW was not affected by harvest time ($P = 0.66$) or KP ($P = 0.14$). Cumulative ADG was not influenced by harvest time ($P = 0.60$) but ADG was numerically decreased by 3.6% ($P = 0.12$) for KP+ steers. Daily DMI was not influenced by harvest time ($P = 0.23$) by KP ($P = 0.22$) . Additionally, growth efficiency was not impacted by harvest time ($P = 0.93$) or KP ($P = 0.21$).

Efficiency of dietary NE utilization

Observed dietary NE and the ratio of observed-to-expected dietary NE are presented in Table 2. No Harvest time × KP interaction was detected ($P \geq 0.26$) for any parameters related to the efficiency of dietary NE utilization. Observed dietary NE values for maintenance and gain were not influence by harvest time ($P \geq 0.43$) or KP ($P \geq 0.21$). The ratio of observed-to-expected dietary NE for maintenance and gain were not influenced by harvest time ($P \geq 0.55$) or KP ($P \geq 0.29$). Based upon observed NE (determined through observed steer performance), the comparative NEm value for varying harvest time and kernel processing of corn silage were estimated using the replacement technique assuming that corn silage has a NEm value of 75 Mcal/cwt. Using the replacement technique, the comparative NEm value was determined as follows: corn silage NEm, Mcal/cwt = [(test diet NEm – control diet NEm)/0.20] + 75, where 0.20 represents the proportion of the replacement and 75 is the NEm value of corn silage (Mcal/cwt). Comparative NE for harvest time indicates that delayed harvest enhanced corn silage NE by 6% (79 Mcal/cwt NEm) compared to current standards (Preston, 2016) and comparative NE for KP indicates that kernel processing decreased apparent corn silage NE by 9% (68 Mcal/cwt NEm) compared to current feed ingredient standards (Preston, 2016). Ingredient NEg values can be derived from the following equation NEg (Mcal/cwt) = 0.877NEm-18.6 (Zinn, 1987). The corresponding NEg values for delayed harvest corn silage are 51 Mcal/cwt and for use of KP are 41 Mcal/cwt in finishing diets containing 20% DM basis inclusion of corn silage.

Carcass traits

Carcass trait responses are located in Table 3. There was no interaction between harvest time and KP ($P \geq 0.18$) for hot carcass weight, dressing percentage, 12th rib fat thickness, ribeye area, marbling, calculated YG, retail yield, estimated EBF, or final BW at 28% EBF. Harvest time did not influence ($P \geq 0.17$) hot carcass weight, dressing percentage, 12th rib fat thickness, ribeye area, marbling, calculated YG, retail yield, or estimated EBF. However, delayed harvest time tended ($P = 0.07$) to reduce final BW at 28% EBF by 1.6%. No interaction between harvest time and KP was noted ($P \geq 0.32$) for the distribution of USDA yield grades. Harvest time ($P \geq 0.18$) nor KP ($P \geq 0.18$) affected the distribution of USDA yield grades. No interaction between harvest time and KP was noted ($P \geq 0.08$) for the distribution of USDA Select, Low Choice, Average Choice, or High Choice quality grades. A harvest time × KP interaction ($P = 0.04$) was detected for the distribution of USDA Prime carcasses. Steers from ML/KP- had the fewer ($P = 0.05$) USDA Prime carcasses compared to ML/KP+, BL/KP-, and BL/KP+. Harvest time did not influence ($P \geq 0.14$) the distribution of USDA Select, Low Choice, or Prime carcasses. Delayed harvest time had a tendency to reduce USDA Average Choice carcasses ($P = 0.09$) and increase USDA High Choice carcasses ($P = 0.06$). Kernel processing had no appreciable influence ($P \geq 0.14$) on the distribution of USDA Quality Grades. No interaction between harvest time and KP was noted ($P \geq 0.59$) for the distribution of carcass weights. Delayed harvest resulted in fewer carcasses less than 900 lbs ($P = 0.01$) and a greater number of carcasses between 900 and 1,050 lbs ($P = 0.02$). Harvest time did not influence carcass weighing greater than 1,050 lbs ($P = 0.42$). The main effect of KP did not have any influence of the proportion of carcasses weighing less than 900 lbs, 900 to 1,050 lbs or greater than 1,050 lbs ($P \geq 0.28$).

Conclusion

Harvest time and kernel processing of corn silage have minimal effects on animal growth performance and only moderately affect carcass traits in finishing steers. Delayed harvest enhanced the comparative NE value of corn silage by 6% above current feed standards and kernel processing decreased comparative NE value of corn silage by 9% compared to current feeding standards. These data indicate that corn silage harvest can be delayed without detriment to growth performance and kernel processing does not enhance the apparent feeding value of corn silage when corn silage is fed as the sole roughage component of a feedlot finishing diet (i.e. 20% inclusion DM basis).

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Table 1. Diet formulation and composition.[1]

Item	1to7				8to56				57to84				85to112			
	ML/KP-	ML/KP+	BL/KP-	BL/KP+	ML/KP-	ML/KP+	BL/KP-	BL/KP+	ML/KP-	ML/KP+	BL/KP-	BL/KP+	ML/KP-	ML/KP+	BL/KP-	BL/KP+
Dry-rolled corn, %	54.86	53.72	53.55	53.92	55.67	55.34	55.32	55.68	55.51	55.31	56.44	55.81	54.59	54.48	55.14	55.13
LS[2], %	4.20	4.11	4.10	4.13	3.96	3.93	3.93	3.96	3.90	3.89	3.97	3.92	3.97	3.97	4.01	4.01
Dried distillers grains plus solubles (DGS), %	20.86	20.43	20.36	20.50	4.90	4.87	4.87	4.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RH[3], %	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.81	1.80	1.83	1.83
Modified DGS, %	0.00	0.00	0.00	0.00	15.58	15.49	15.46	15.58	20.54	20.48	20.90	20.67	19.89	19.86	20.07	20.05
Corn Silage, %	20.08	21.74	21.99	21.44	19.89	20.37	20.43	19.89	20.05	20.32	18.70	19.60	19.74	19.89	18.95	18.98
Dry matter, %	70.07	71.55	74.99	74.47	67.23	68.26	71.44	70.25	65.64	66.70	68.38	67.96	64.45	65.39	67.64	66.52
Crude protein, %	12.23	12.08	12.06	12.11	12.10	12.06	12.05	12.10	12.10	12.08	12.22	12.14	12.40	12.39	12.47	12.46
Neutral detergent fiber (DF), %	18.97	19.33	19.39	19.27	18.85	18.96	18.96	18.85	18.91	18.97	18.62	18.81	19.09	19.12	18.91	18.91
Acid DF, %	10.06	10.38	10.43	10.32	9.98	10.07	10.08	9.98	10.02	10.08	9.77	9.94	10.10	10.13	9.95	9.96
Ash, %	5.47	5.46	5.46	5.46	5.31	5.30	5.30	5.30	5.28	5.28	5.29	5.28	5.37	5.37	5.37	5.37
Fat, %	4.20	4.18	4.18	4.18	4.21	4.20	4.20	4.21	4.21	4.20	4.23	4.21	4.23	4.23	4.24	4.24
Net energy for maintenance, Mcal/cwt	93.09	92.71	92.65	92.78	93.27	93.16	93.15	93.27	93.26	93.20	93.57	93.37	93.33	93.30	93.51	93.50
Net energy for gain, Mcal/cwt	63.18	62.87	62.82	62.92	63.30	63.21	63.20	63.30	63.29	63.24	63.55	63.38	63.37	63.34	63.52	63.51

[1] All values except DM on a DM basis.

ML = silage harvested at ½ to 2/3 milk line, BL = silage harvested at black line, KP- = No kernel processing, and KP+ = kernel processing.

[2] Liquid supplement that contained monensin sodium at 731 g/ton (DM basis) and vitamins and minerals to exceed nutrient requirements for growing and finishing cattle.

[3] Ractopamine HCl (OPTAFLEXX 45, Elanco, Indianapolis, IN) supplement that contained 812 g/ton of

Table 2. Cumulative growth performance responses.[1]

Item	ML/KP-	ML/KP+	BL/KP-	BL/KP+	SEM	*P* - value		
						Harvest time	Kernel processing	Interaction
Pens, n	6	6	6	6	-	-	-	-
Steers, n	48	48	48	48	-	-	-	-
Initial body weight (BW)[2], lbs	982	983	984	983	1.7	0.53	0.95	0.35
Final BW[3], lbs	1586	1560	1574	1561	18.4	0.66	0.14	0.63
Average daily gain (ADG), lbs	5.40	5.15	5.27	5.16	0.159	0.60	0.12	0.55
Dry matter intake (DMI), lbs	31.63	31.58	31.58	30.83	0.447	0.23	0.22	0.28
ADG/DMI (G:F)	0.171	0.163	0.167	0.168	0.0039	0.93	0.21	0.16
F:G[4]	5.85	6.13	5.99	5.95	-	-	-	-
Observed dietary net energy (NE), Mcal/cwt								
Maintenance	95.7	93.0	95.3	95.3	1.61	0.43	0.21	0.26
Gain	65.3	62.6	64.9	64.9	1.41	0.43	0.21	0.26
Observed-to-expected NE[5]								
Maintenance	1.02	0.99	1.02	1.02	0.017	0.55	0.29	0.35
Gain	1.03	0.99	1.02	1.02	0.022	0.57	0.30	0.37

[1] ML = silage harvested at ½ to 2/3 milk line, BL = silage harvested at black line, KP- = No kernel processing, and KP+ = kernel processing.

[2] Average of d -3 and d 1 BW; a 4% pencil shrink was applied to account for gastrointestinal tract fill.

[3] Final BW = HCW/0.625.

[4] F:G = 1/G:F

[5] Dietary NEm and NEg (Mcal/cwt) was 93.4 and 63.5 for ML/KP-, BL/KP-, and BL/KP+; dietary NEm and NEg (Mcal/cwt) was 93.0 and 63.0 for ML/KP+.

Table 3. Carcass trait responses.[1]

Item	ML/KP-	ML/KP+	BL/KP-	BL/KP+	SEM	*P* - value Harvest time	Kernel processing	Interaction
Pens, n	6	6	6	6	-	-	-	-
Steers, n	48	48	48	48	-	-	-	-
Hot carcass weight, lbs	992	975	984	975	11.5	0.66	0.14	0.63
Dressing percentage[2], %	62.27	62.06	62.03	62.44	0.497	0.84	0.78	0.40
Rib fat, in	0.62	0.61	0.66	0.62	0.031	0.22	0.25	0.43
Ribeye area, in^2	14.82	14.77	14.61	14.99	0.220	0.99	0.30	0.18
Marbling[3]	543	540	566	563	23.0	0.17	0.84	0.98
Calculated Yield Grade (YG)	3.56	3.50	3.71	3.45	0.125	0.55	0.08	0.28
Retail Yield, %	48.90	49.05	48.60	49.14	0.257	0.57	0.07	0.28
Estimated empty body fatness (EBF), %	32.62	32.38	33.38	32.59	0.530	0.21	0.18	0.48
Final BW at 28% EBF, lbs	1381	1365	1343	1358	16.7	0.07	0.99	0.20
USDA Yield Grade distribution								
YG 1, %	0.0	0.0	0.0	0.0	-	-	-	-
YG 2, %	25.0	22.9	16.7	27.1	6.15	0.74	0.51	0.32
YG 3, %	58.3	68.8	58.3	56.3	7.37	0.41	0.58	0.41
YG 4, %	16.7	8.3	22.9	16.7	5.21	0.18	0.18	0.84
YG 5, %	0.0	0.0	2.1	0.0	1.04	0.33	0.33	0.33
USDA Quality Grade distribution								
Select, %	2.1	0.0	0.0	4.5	1.76	0.51	0.51	0.08
Low Choice, %	26.2	41.1	29.8	23.5	6.47	0.29	0.51	0.12
Average Choice, %	48.2	35.7	28.0	33.9	6.27	0.09	0.61	0.16
High Choice, %	23.5	10.4	29.5	27.7	5.77	0.06	0.21	0.34
Prime, %	0.0[b]	12.8[a]	12.7[a]	10.4[a]	3.40	0.14	0.14	0.04
HCW distribution, %								
< 900, %	14.6	20.8	6.3	8.3	3.78	0.01	0.28	0.59
> 900 and < 1050, %	66.7	64.6	79.2	79.2	5.21	0.02	0.84	0.84
>1050, %	18.7	14.6	14.5	12.5	3.81	0.42	0.42	0.79

[1]ML = silage harvested at ½ to 2/3 milk line, BL = silage harvested at black line, KP- = No kernel processing, and KP+ = kernel processing.

[2] Calculated as: (HCW/Final live body weight pencil shrunk 4%) × 100.

[3] 400 = small00 = USDA Low Choice.

[a, b] Means within a row lacking a common superscript differ ($P \le 0.05$).