In-season N application in corn to improve fertilizer efficiency in eastern South Dakota

Update Report for Year 1

February 2019

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Collaborator: Dr. Jason Clark, SDSU AHPS

Goals and Objectives

The goal of this project is to investigate the use of split N application in corn production to improve fertilizer use efficiency and optimize grain yield in the eastern part of SD. Specific objectives of the study are 1) compare single pre-plant and split N fertilization in their ability to optimize grain yield and fertilizer use efficiency, 2) determine the in-season N application timings that optimize grain yield and fertilizer use efficiency, and 3) determine whether corn N needs can be predicted using remote sensing tools and soil nutrient sampling.

We have established the project at three sites, two located on SDSU's research farms near South Shore and Beresford, and one site near Brookings. All sites have been planted between May 15 and May 22 due to the late arrival of spring, and low soil temperatures. Early season N application timing differences were evident by the V5 growth stages for both dry matter accumulation and N uptake (Table 1). These results for the early season dry matter accumulation and N uptake is not a big surprise due to the only 40 lbs N/ac pre-plant rate for the split application treatments. There were no similar differences between the single application timing and the split application (Tables 2-3). The N timing x N rate interaction at Beresford is likely due to the somewhat larger deviation in plant population at this site (data not shown).

Biomass harvest at physiological maturity did not result differences among N application timingsTable 1 (Tables 4-6). However, grain and cob dry matter has increased with increasing N rates in Brookings. On the other hand, machine harvested yield was better with split N application compared to a single pre-plant N application in Brookings and South Shore (Figures 1-2), but application timing resulted nearly identical response in Beresford (Figure 3). Nitrogen rate to maximize grain yield was varied among locations and N application strategies (ranged between 100 and 220 lbs /ac).

Grain N concentration and N removal increased with increased N rate in Brookings, but there was no difference in Beresford (Table 7).

The late-split N application strategy did not result substantial yield gain in the first year at either location (Figures 4-6).

A graduate student has started to work on the project on January 2019. We are still waiting for the laboratory to report some of the samples yet as the project has received a no cost extension until end of March. We will continue to analyze the remainder of the collected data as we continue the project for the second year.

This study will be repeated in 2019 and planning to do it in 2020.

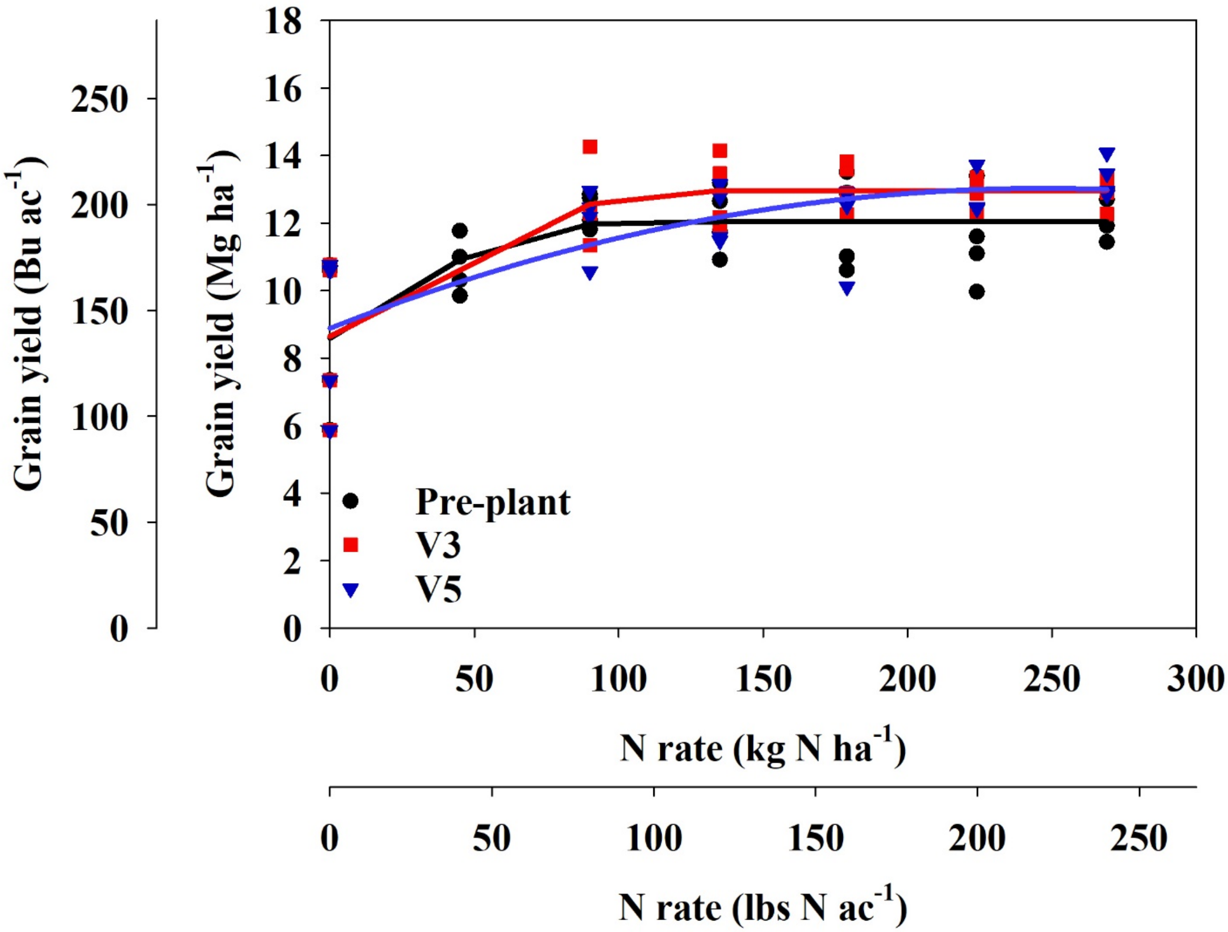

Figure 1. Corn yield response to N rate and N timing in 2018 near South Shore, SD.

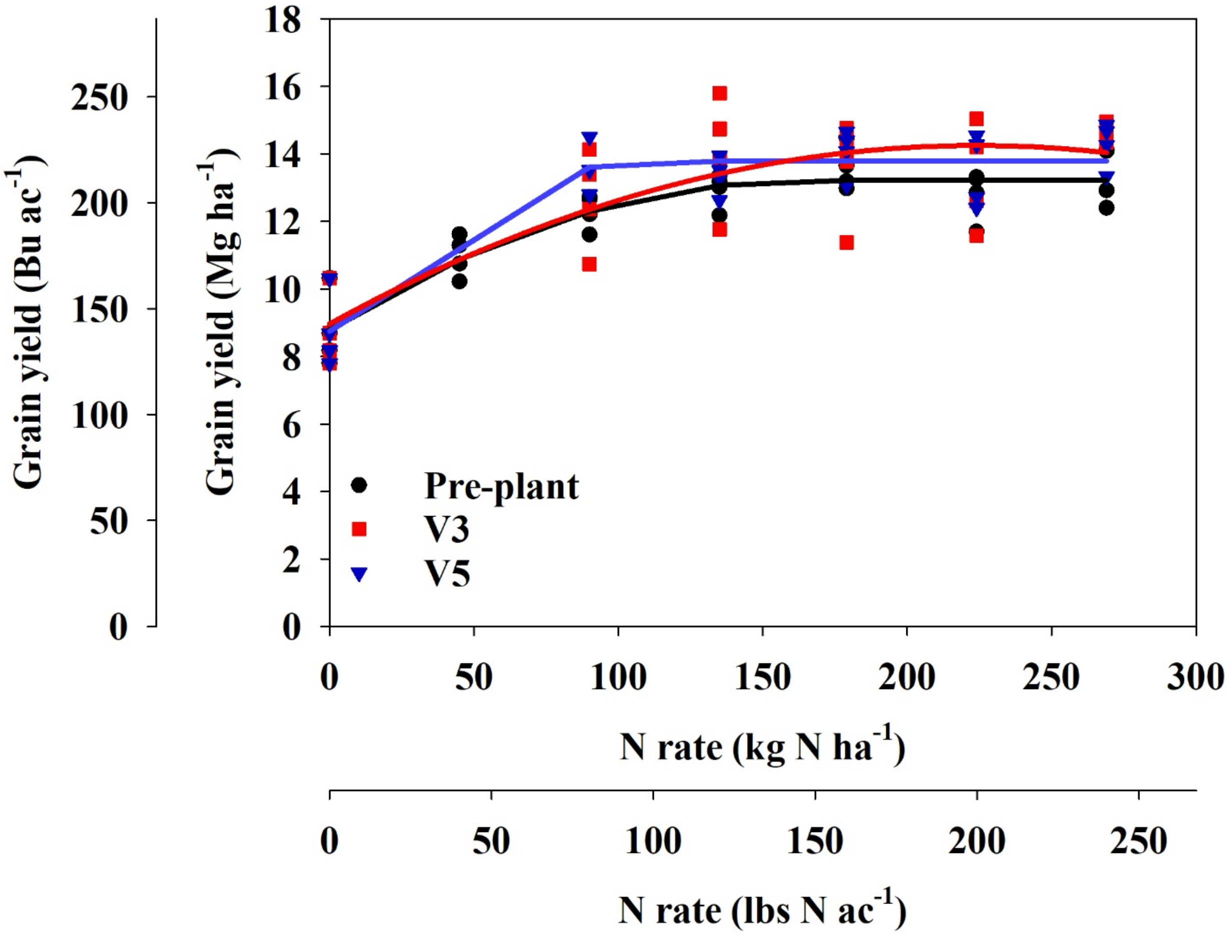

Figure 2. Corn yield response to N rate and N timing in 2018 near Brookings, SD.

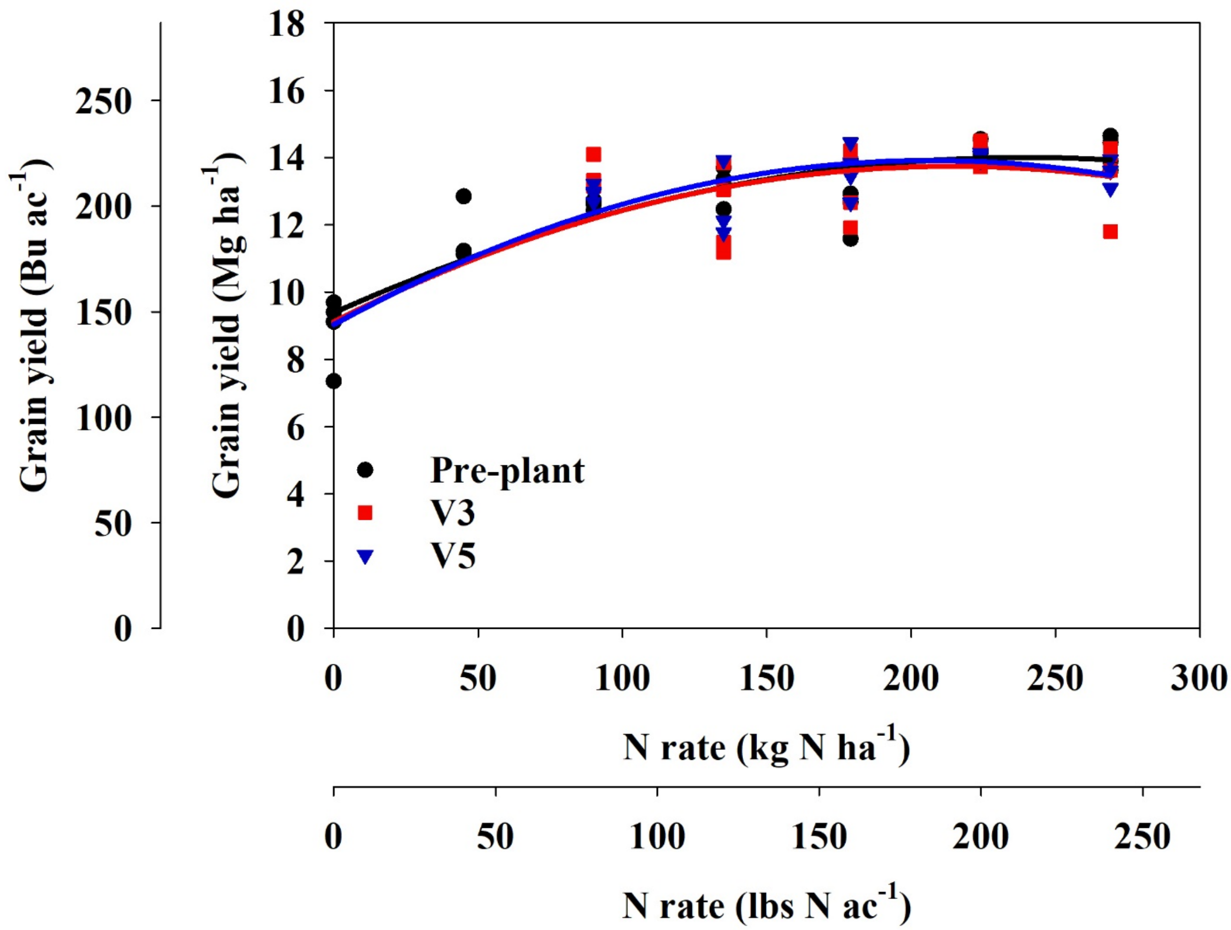

Figure 3. Corn yield response to N rate and N timing in 2018 near Beresford, SD.

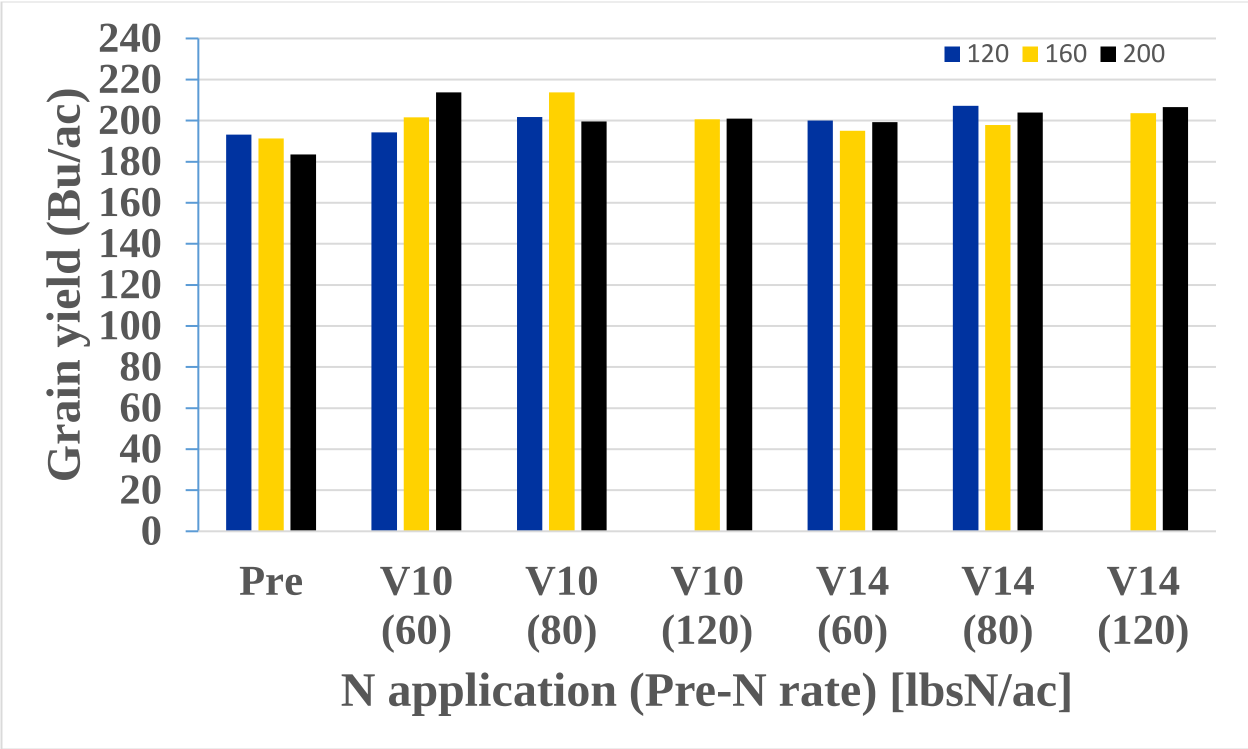

Figure 4. Grain yield with the late-season split N application strategy near South Shore. The pre-plant application rate is displayed in parenthesis following the growth stage of the second N application timing.

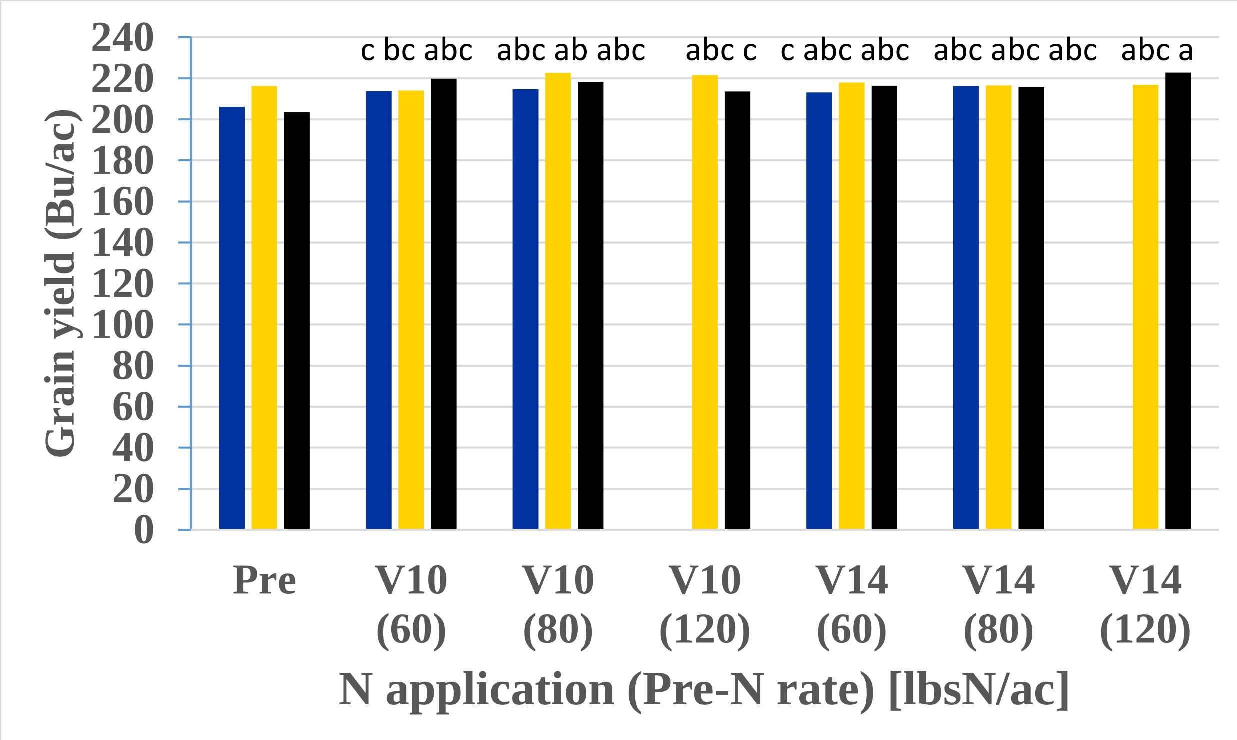

Figure 5. Grain yield with the late-season split N application strategy near Brookings. The pre-plant application rate is displayed in parenthesis following the growth stage of the second N application timing.

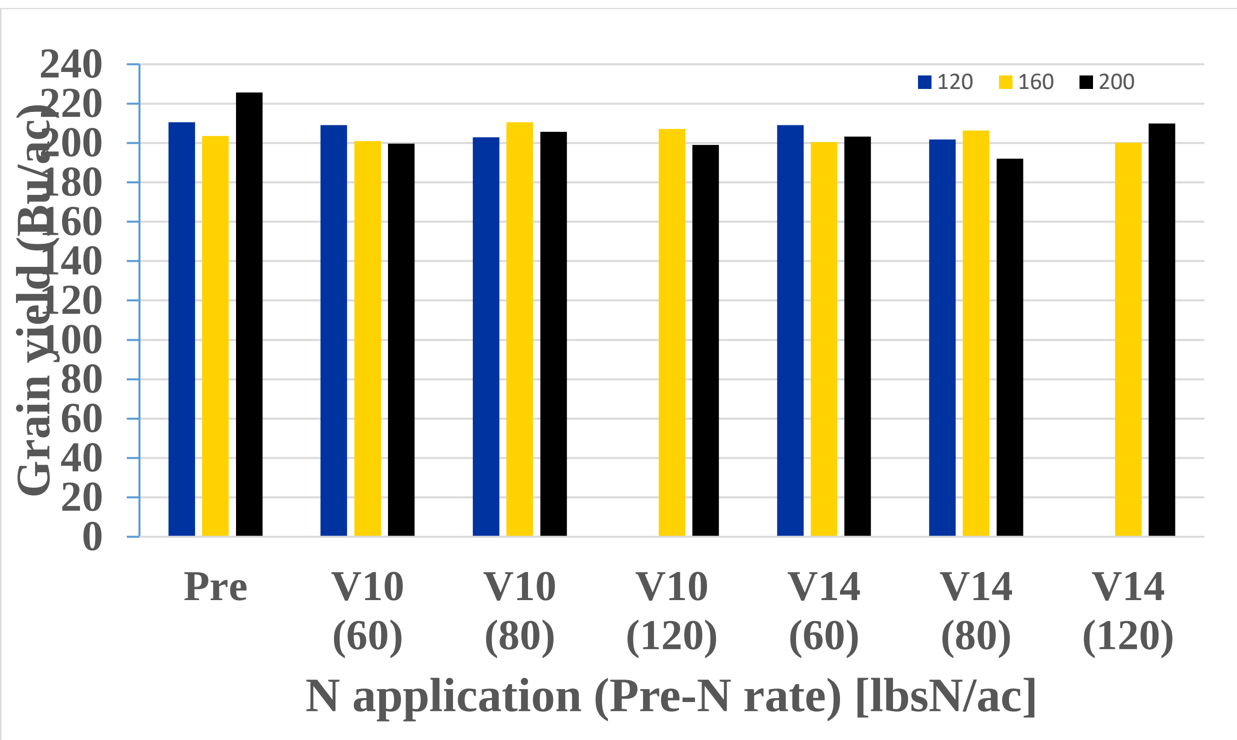

Figure 6. Grain yield with the late-season split N application strategy near Brookings. The pre-plant application rate is displayed in parenthesis following the growth stage of the second N application timing.

Table 1. Nitrogen timing and N rate effect on dry matter accumulation and N uptake at V3 and V5 growth stages near Brookings, SD in 2018.

		Dry matter (lbs/ac)		N uptake (lbs/ac)	
N timing	**N rate**	**V3**	**V5**	**V3**	**V5**
Pre	**80**	49.1	544	2.33	25.3
	120	41.6	513	1.99	24.5
	160	50.1	538	2.45	25.0
	200	47.9	574	2.29	26.8
V3	**80**	40.0		1.88	
	120	46.9		2.26	
	160	43.0		2.03	
	200	41.0		1.97	
V5	**80**		518		24.0
	120		512		23.0
	160		512		23.5
	200		494		23.3
p<*F*					
N rate		0.89	0.79	0.87	0.64
Timing		0.09	**0.05**	0.08	**0.02**
Timing x N rate		0.19	0.37	0.17	0.70

Table 2. Nitrogen timing and N rate effect on dry matter accumulation and N uptake at V3 and V5 growth stages near Beresford, SD in 2018.

		Dry matter (lbs/ac)		N uptake (lbs/ac)	
N timing	**N rate**	**V3**	**V5**	**V3**	**V5**
Pre	**80**	63.6 ab	374	3.3 ab	16.9 ab
	120	93.2 a	467	4.7 a	21.0 a
	160	69.3 ab	458	3.6 ab	20.9 a
	200	46.9 b	254	2.4 b	11.8 b
V3	**80**	63.7 ab		3.2 ab	
	120	70.4 ab		3.4 ab	
	160	53.5 b		2.6 b	
	200	85.4 a		4.3 a	
V5	**80**		524		22.3 a
	120		419		17.4 ab
	160		438		18.4 ab
	200		504		23.0 a
p<*F*					
N rate		0.24	0.65	0.31	0.83
Timing		1.00	0.08	0.77	0.19
Timing x N rate		**0.04**	0.09	**0.04**	**0.05**

Table 3. Nitrogen timing and N rate effect on dry matter accumulation and N uptake at V3 and V5 growth stages near South Shore, SD in 2018.

		Dry matter (lbs/ac)		N uptake (lbs/ac)	
N timing	**N rate**	**V3**	**V5**	**V3**	**V5**
Pre	**80**	55.6	613	2.5	28.2
	120	49.5	565	2.2	26.6
	160	42.9	622	1.9	29.7
	200	50.3	579	2.4	26.5
V3	**80**	44.8		1.9	
	120	51.1		2.1	
	160	50.1		2.3	
	200	45.4		2.0	
V5	**80**		543		25.2
	120		574		25.9
	160		555		25.2
	200		588		25.8
p<*F*					
N rate		0.76	0.95	0.95	0.85
Timing		0.57	0.23	0.25	0.07
Timing x N rate		0.19	0.47	0.19	0.59

Table 4. Grain, stover, cob and total dry matter accumulation (lbs/ac) at physiological maturity harvest index (HI) near Brookings, SD in 2018.

N timing	**N rate**	**Grain**	**Stover**	**Cob**	**Total**	**HI**
Pre	**80**	11952	9561	1518	23031	51.8
	120	11976	8970	1612	22558	53.4
	160	12779	9218	1750	23748	53.8
	200	11828	8648	1493	21970	53.8
V3	**80**	11434	8648	1481	21562	52.9
	120	11122	9402	1555	22079	50.2
	160	12434	8751	1695	22881	54.3
	200	11882	8408	1766	22057	53.8
V5	**80**	11018	9324	1478	21820	50.5
	120	11211	8350	1500	21061	50.2
	160	13195	11485	1775	26455	50.4
	200	11460	8528	1518	21509	53.9
p<*F*						
N rate		**0.04**	0.32	**0.02**	0.08	0.52
Timing		0.58	0.59	0.69	0.74	0.63
Timing x N rate		0.92	0.42	0.47	0.58	0.41

Table 5. Grain, stover, cob and total dry matter accumulation (lbs/ac) at physiological maturity harvest index (HI) near Beresford, SD in 2018.

N timing	N rate	Grain	Stover	Cob	Total	HI
Pre	**80**	10841	6183	1139	18163	59.6
	120	12297	6977	1198	20473	60.1
	160	11214	6125	1173	18512	60.5
	200	11366	6650	1188	19205	59.5
V3	**80**	10572	5905	1167	17645	60.1
	120	11248	6049	1121	18418	61.2
	160	11324	5985	1134	18443	61.6
	200	11391	7078	1122	19594	58.1
V5	**80**	12004	6392	1162	19557	61.4
	120	10654	6284	1084	18060	59.1
	160	11377	6425	1156	18959	60.2
	200	12593	7299	1259	21151	59.6
p<*F*						
N rate		0.70	0.23	0.85	0.41	0.52
Timing		0.55	0.68	0.76	0.56	0.96
Timing x N rate		0.42	0.91	0.87	0.65	0.82

Table 6. Grain, stover, cob and total dry matter accumulation (lbs/ac) at physiological maturity harvest index (HI) near South Shore, SD in 2018.

N timing	N rate	Grain	Stover	Cob	Total	HI
Pre	**80**	9894	7893	1190	19294	51.2
	120	10492	7432	1289	19213	54.7
	160	10596	8297	1266	18350	55.9
	200	11815	11195	1446	24456	48.9
V3	**80**	10829	7842	1304	19975	54.4
	120	10343	8050	1244	19637	52.5
	160	10469	7306	1247	19022	55.0
	200	12041	8541	1437	22020	54.9
V5	**80**	10289	7232	1238	18731	54.8
	120	10591	7695	1292	19578	54.0
	160	11046	9872	1336	23124	49.4
	200	11857	8552	1295	20715	53.4
p<*F*						
N rate		0.12	0.14	0.21	0.15	0.85
Timing		0.90	0.57	0.96	0.96	0.51
Timing x N rate		0.99	0.35	0.78	0.43	0.12

Table 7. Nitrogen rate and N timing effects on grain N concentration (%) and grain N removal (lbs/ac) in Brookings and Beresford, SD in 2018

		Brookings		Beresford	
N timing	**N rate**	**Grain conc.**	**N removal**	**Grain conc.**	**N removal**
Pre	**80**	1.09	145.6	1.20	147.4
	120	1.21	163.1	1.19	164.7
	160	1.29	184.3	1.19	148.9
	200	1.28	169.0	1.24	158.2
V3	**80**	1.10	142.6	1.18	141.8
	120	1.23	154.0	1.15	146.0
	160	1.29	180.2	1.22	155.2
	200	1.29	171.3	1.28	164.6
V5	**80**	1.15	141.9	1.16	157.1
	120	1.16	145.9	1.20	143.7
	160	1.23	183.2	1.26	160.3
	200	1.28	165.1	1.32	185.9
p<*F*					
N rate		**<.0001**	**0.002**	0.07	0.24
Timing		0.68	0.74	0.71	0.57
Timing x N rate		0.63	0.99	0.88	0.71

Publications:

Kovács, P., and J. Clark. 2019. In-season N application in corn to improve fertilizer efficiency in eastern South Dakota. Southeast Research Farm Annual Report

Clark, J. and P. Kovács. 2019. Nitrogen fertilizer timing in South Dakota. Dakota Farm Show, Vermillion, SD, January 4, 2019 (invited presentation)

Kovács, P. 2018. Nitrogen application timing in corn and foliar nutrient applications in soybean. SD Agronomy Conference, Sioux Falls, SD, December 13, 2018 (invited speaker)

Kovács, P., and J.D. Clark. 2018. Split-N application effect in grain yield and nutrient use efficiency in Eastern South Dakota. ASA-CSSA-SSSA International Annual Meetings, Baltimore, MD.

Kovács, P., Clark, J. 2018. Split N management in corn. Northeast Research Farm Summer Field Day, South Shore, SD, July 12, 2018

Clark, J., Kovács, P. 2018. Corn – N timing. Southeast Research Farm Summer Field Day, Beresford, SD, July 10, 2018

In-season N application in corn to improve fertilizer efficiency in eastern South Dakota
Final Report for Year 2

Dr. Péter Kovács and Dr. Jason Clark
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Department of Agronomy, Horticulture & Plant Science

Goals and Objectives

The goal of this project is to investigate the use of split N application in corn production to improve fertilizer use efficiency and optimize grain yield in the eastern part of SD. Specific objectives of the study are 1) compare single pre-plant and split N fertilization in their ability to optimize grain yield and fertilizer use efficiency, 2) determine the in-season N application timings that optimize grain yield and fertilizer use efficiency

Both studies (early and late side-dress application) have been planted at three locations. We planted one study on May 14th near Aurora, another one on May 15th near South Shore, and the third locations at near Beresford on May 16th. Initial soil samples have been collected and all pre-plant fertilizer applications have been applied on the same day. However, the Beresford location received close to 4.6” rain in the following weeks, which had detrimental effect on the seedlings emergence. We have re-planted this location on June 8th.

Grain yield response plateaued for the pre-plant application at around 40 lbs N ac^{-1} for V3 split application at 70 lbs N ac^{-1}, and for the V5 application at around 251 lbs N ac^{-1} (outside of the N range we have applied) at the Aurora site (Figure 1). Grain yield levels were the same (~187 bu ac^{-1}) for the pre-plant and V3 split application, but with V5 split the yield maximized at around 202 bu ac^{-1} using much more fertilizer, however the yields averaged within the application timings were not statistically different.
At the South Shore site yield increased with the V5 split application compared to the V3 split or pre-plant application (212 bu ac^{-1} vs. 203.5 or 198 bu ac^{-1}, respectively; Figure 2). At this site the split application not just increased the yield, but also lowered the N requirement that was maximizing this yield levels (248 lbs N ac^{-1} for pre-plant, 2\\0148 lbs N ac^{-1} for V3 split, and 259 lbs N ac^{-1} for V5 split application.
At Beresford, both split N application strategy out yielded the pre-plant application (Figure 3). It is likely the result of substantial rain after the pre-plant application, which also caused a poor plant stand and the requirement of re-planting the study. As those pre-plant treatments did not received more N could limit the yield. Similarly to the South Shore site, we also maximum yield was also obtained with lower N requirements utilizing the split N application strategy.
For the mid-season N application methods, at the Brookings site some of the treatments which received 60 or 80 lbs N ac^{-1} at pre-plant increased grain yield relative to the yield with same N rate but only pre-plant application (Figure 4). The other treatments were not different from the pre-plant treatments.
At South Shore, most of the V14 split application (urea as pre-plant and 28-0-0 Y-Dropped at V14) increased the grain yield compared to the pre-plant only N application strategy (Figure 5).

At the Beresford site, only one late-split application treatment was able to increase grain yield when we were comparing them to the pre-plant treatments (Figure 6).

The second year of the study also showed that utilizing the early-split N application strategy can further increase grain yields compared to the pre-plant only application strategy, and at many cases even delaying the second N application until mid-season also increased grain yields.

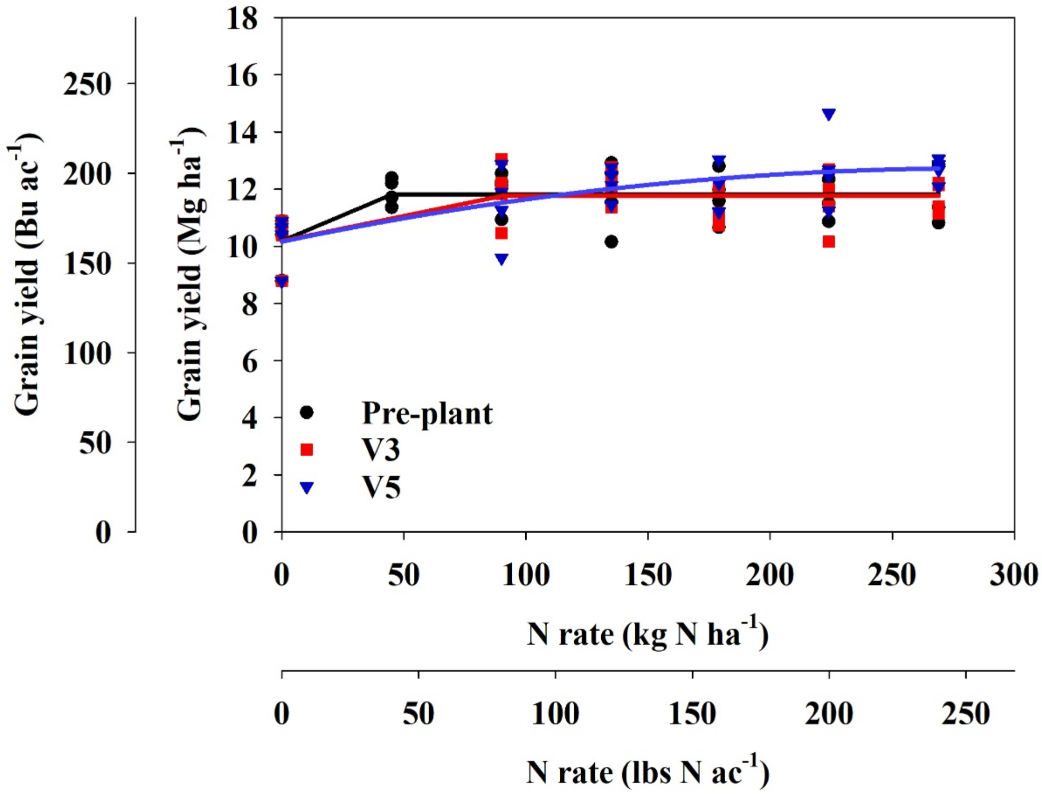

Figure 1. Nitrogen application timing effect on grain yield near Aurora, SD in 2019.

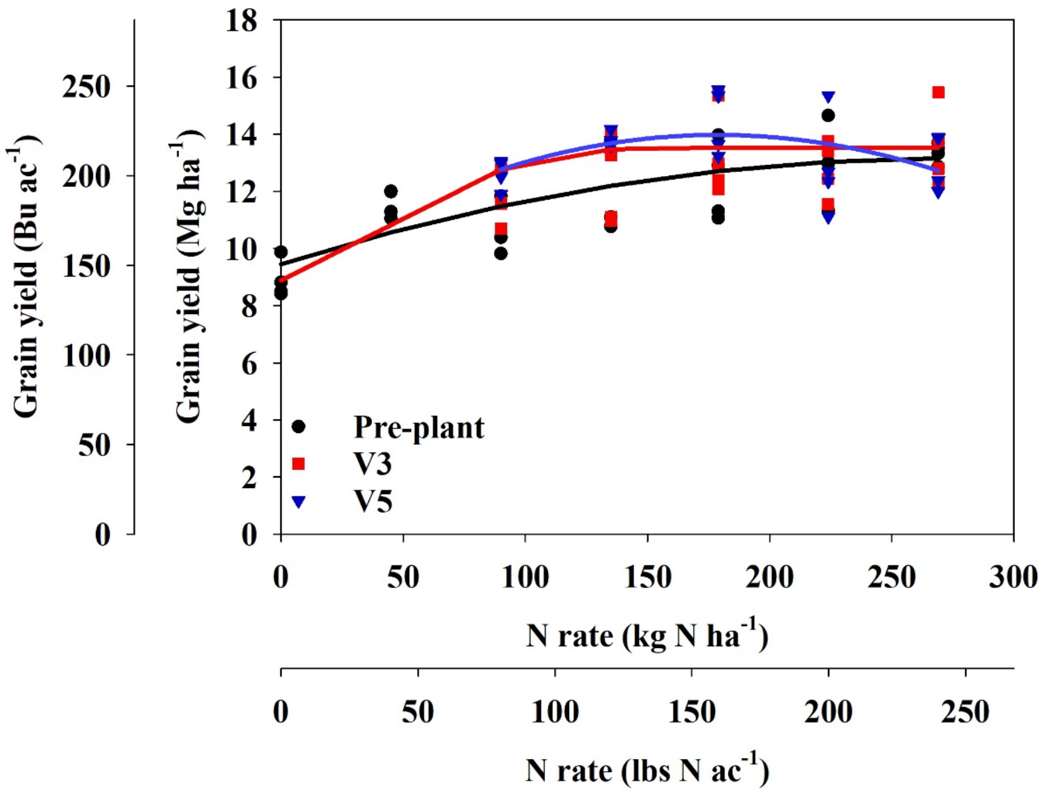

Figure 2. Nitrogen application timing effect on grain yield near South Shore, SD in 2019.

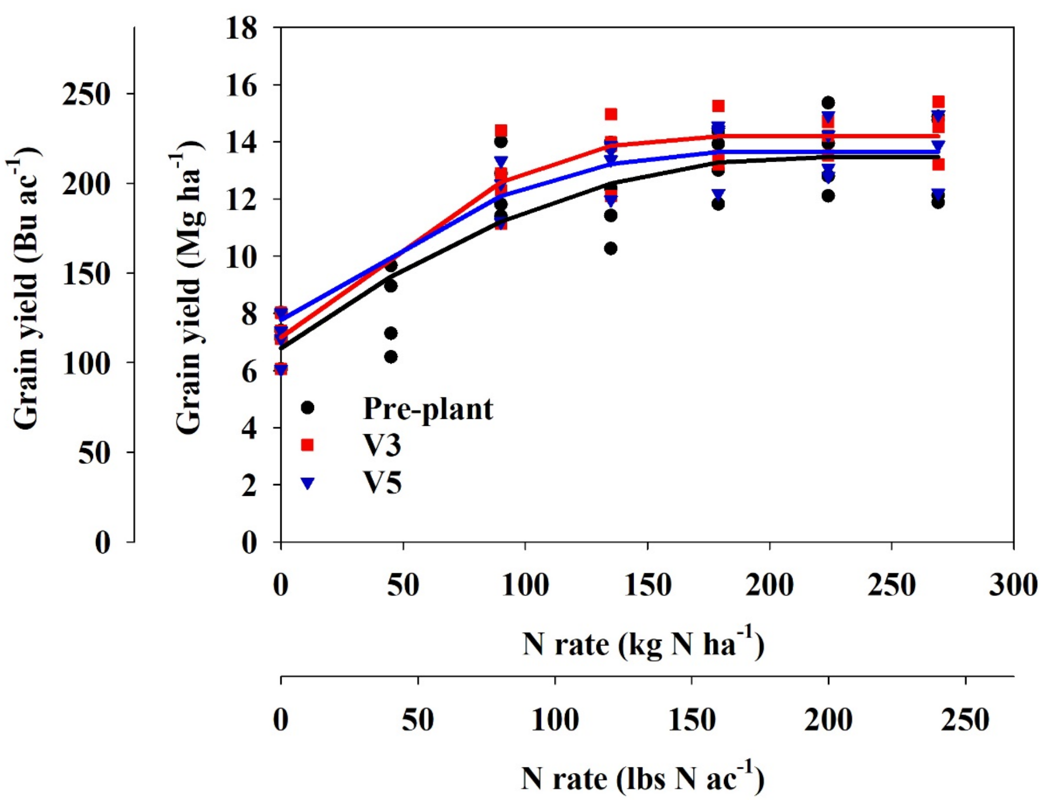

Figure 3. Nitrogen application timing effect on grain yield near Beresford, SD in 2019.

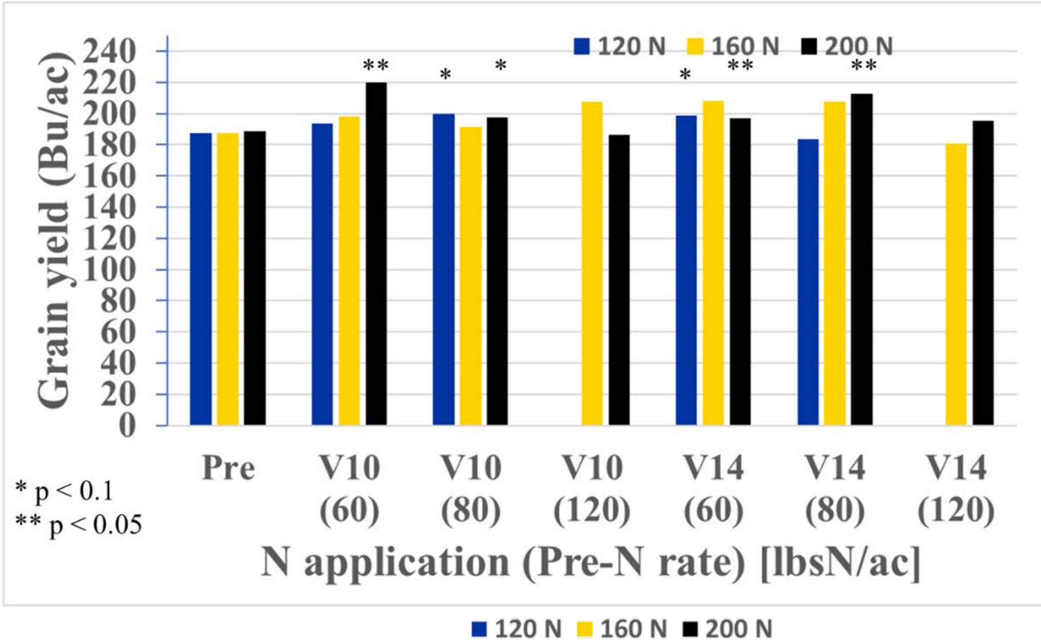

Figure 4. Mid-season N application timing effect on grain yield near Aurora, SD in 2019. Color of the bars represent the total N rates. Grouping of the bars presented by the split N application timing (V10 or V14), and the pre-plant N application rate (presented in parenthesis under the split application timing). Asterisk(s) above the graph would indicate that mid-season split application was statistically different from the pre-plant only treatment within the same total N rate (same colored bar).

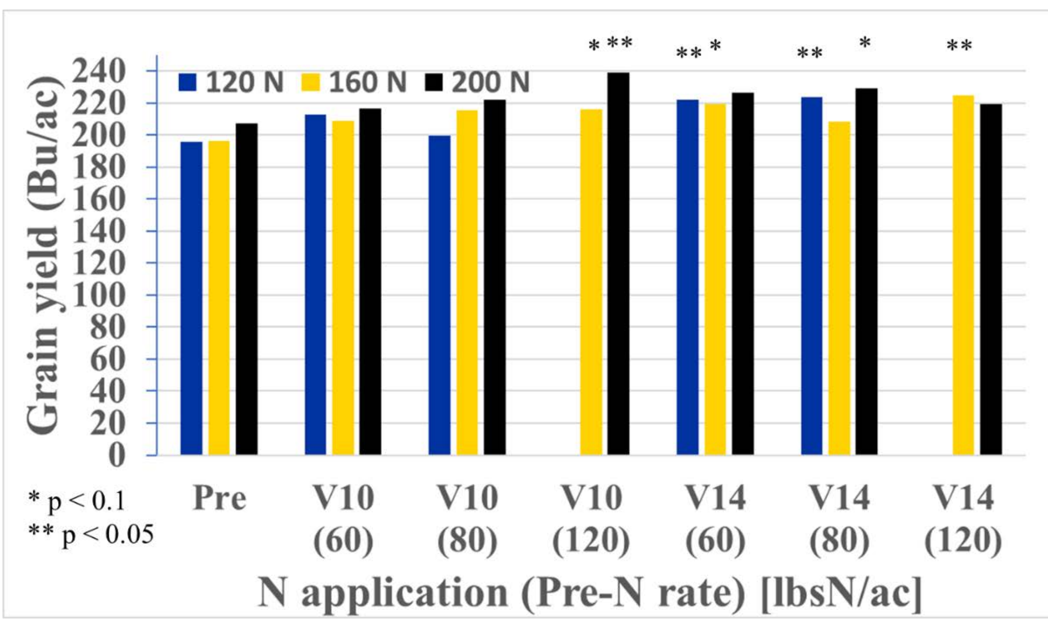

Figure 5. Mid-season N application timing effect on grain yield near South Shore, SD in 2019. Color of the bars represent the total N rates. Grouping of the bars presented by the split N application timing (V10 or V14), and the pre-plant N application rate (presented in parenthesis under the split application timing). Asterisk(s) above the graph would indicate that mid-season split application was statistically different from the pre-plant only treatment within the same total N rate (same colored bar).

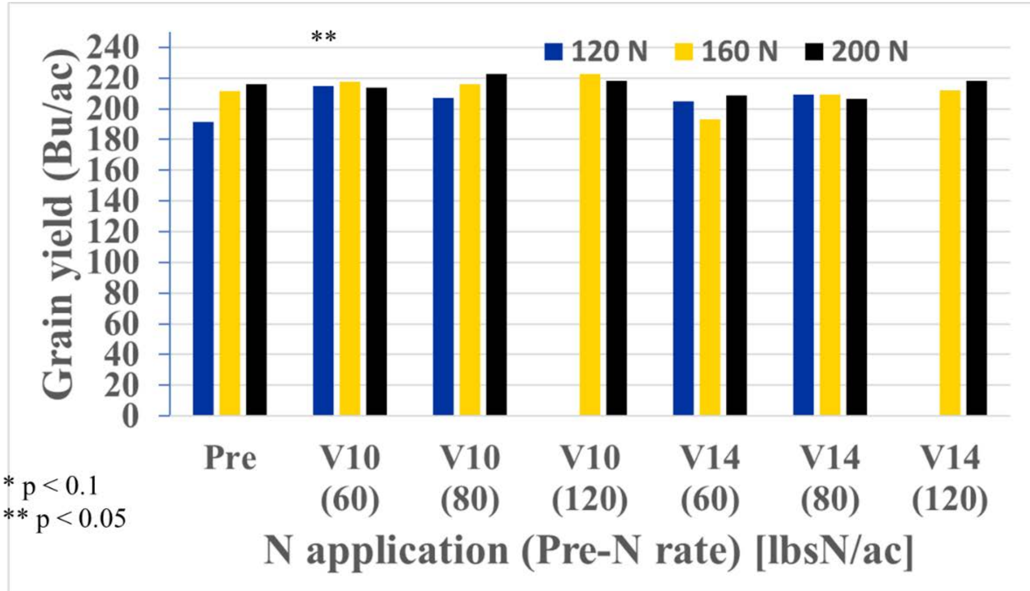

Figure 6. Mid-season N application timing effect on grain yield near Beresford, SD in 2019. Color of the bars represent the total N rates. Grouping of the bars presented by the split N application timing (V10 or V14), and the pre-plant N application rate (presented in parenthesis under the split application timing). Asterisk(s) above the graph would indicate that mid-season split application was statistically different from the pre-plant only treatment within the same total N rate (same colored bar).

Presentation from this research in 2019:

Jason Clark and Peter Kovacs: Timing of N Fertilizer Application in Corn. Dakota Farm Show, Vermillion, SD. Jan. 4, 2019

Jason Clark: Principles of N Fertilizer Application in Corn - Southeast Research Farm Annual Meeting, Beresford, SD Jan. 29, 2019

Kovács, P., and J. Clark. 2019. In-season N application in corn to improve fertilizer efficiency in eastern South Dakota, Northeast Research Farm Summer Field Day, South Shore, SD, July 11, 2019 (approved for CEU credits)

Kovács, P., and J. Clark. 2019. In-season N application in corn to improve fertilizer efficiency in eastern South Dakota, Southeast Research Farm Summer Field Day, Beresford, SD, July 9, 2019 (approved for CEU credits)

Gilliland, C. and P. Kovács. 2019. Exploring the possibilities for late season N application in corn in South Dakota. ASA-CSSA-SSSA International Annual Meetings, San Antonio, TX - poster presentation.

Saucerman, R., and P. Kovács. 2019. Preplant and split N application effect on nitrogen use efficiency in South Dakota maize. ASA-CSSA-SSSA International Annual Meetings, San Antonio, TX - poster presentation.

Kovács, P., and J. Clark. 2019. In-season N application in corn to improve fertilizer efficiency in eastern South Dakota. Southeast Research Farm Annual Report

Kovács, P. 2019. Nitrogen application timing in corn and foliar nutrient applications in soybean. SD Agronomy Conference, Sioux Falls, SD, December 11, 2019 (approved for CEU credits)

Saucerman, R., J.D. Clark, and P. Kovács. 2020. Early season split N application in corn. Northeast Research Farm Annual Report 2019.

Saucerman, R., J.D. Clark, and P. Kovács. 2020. Early season split N application in corn. Southeast Research Farm Annual Report 2019. Pg. 109-111.

Gilliland, C., and P. Kovács. 2020. Exploring late-season nitrogen treatments in corn in eastern South Dakota. Southeast Research Farm Annual Report 2019. Pg. 112-115.

Kovács, P. Corn nutrient management. Water Management N Certification Classes, Columbus, NE, January 29, 2020 (approved for CEU credits)

In-season N application in corn to improve fertilizer efficiency in eastern South Dakota
Preliminary Final Report for Year 3

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This project received a 6 month extension; therefore we present the preliminary final report.

Goals and Objectives:
The goal of this project is to investigate the use of split N application in corn production to improve fertilizer use efficiency and optimize grain yield in the eastern part of SD. Specific objectives of the study are 1) compare single pre-plant and split N fertilization in their ability to optimize grain yield and fertilizer use efficiency, 2) determine the in-season N application timings that optimize grain yield and fertilizer use efficiency

Both studies (early and late side-dress application) have been planted at three locations. We planted one study on May 8th near Beresford, another one on May 12th near Brookings, and the third locations at near South Shore on May 15th. Initial soil samples have been collected and all pre-plant fertilizer applications have been applied on the same day.

Grain yield response plateaued for the pre-plant application at around 202 lbs N ac^{-1}, for V3 split application at 238 lbs N ac^{-1}, and for the V5 application at around 170 lbs N ac^{-1} at the Brookings site (Figure 1). Grain yield levels were similar (~224 bu ac^{-1}) for the pre-plant and V5 split application, but with V3 split the yield maximized at 229 bu ac^{-1} although using much more fertilizer.
At the South Shore site yield was slightly higher with the V5 split application compared to the V3 split or pre-plant application (221 bu ac^{-1} vs. 219 or 217 bu ac^{-1}, respectively; Figure 2). At this site the split application not just increased the yield (or maintained same yield for V3 split application), but also lowered the N requirement that was maximizing this yield levels (211 lbs N ac^{-1} for pre-plant, 154 lbs N ac^{-1} for V3 split, and 177 lbs N ac^{-1} for V5 split application.
At Beresford, the pre-plant application strategy resulted higher maximum yield than both split N application strategy (Figure 3). Similarly, to the South Shore site, the maximum yield was also obtained with lower N requirements utilizing the V3 split N application strategy compared to the pre-plant fertilizer treatments (130 lbs N ac^{-1} vs. 161 lbs N ac^{-1}).

For the mid-season N application methods, at the Brookings site some of the treatments which received 60 or 80 lbs N ac^{-1} at pre-plant decreased grain yield relative to the yield with same N rate but only pre-plant application (Figure 4). The other treatments were not different from the pre-plant treatments.
At South Shore, most of the mid to late season N application (V10 or V14 split application produced similar grain yield compared to the pre-plant only N application strategy (Figure 5).

However the treatments which received 80 lbs N ac^{-1} at planting and total of 200 lbs N ac^{-1} produced lower yield than the pre-plant treatment (Figure 5).
At the Beresford site, all late-split application treatment produced similar grain yield to the pre-plant treatments (Figure 6).

The final year of the study also showed that utilizing the early-split N application strategy can further increase grain yields compared to the pre-plant only application strategy, and even lower the fertilizer application rate. However, the mid or late vegetative stage split N application strategy did not produce consistent results during the 3 years.
We are currently analyzing the nutrient uptake data, and processing the final biomass samples to calculate season long nutrient uptake and removal, and nutrient use efficiency.

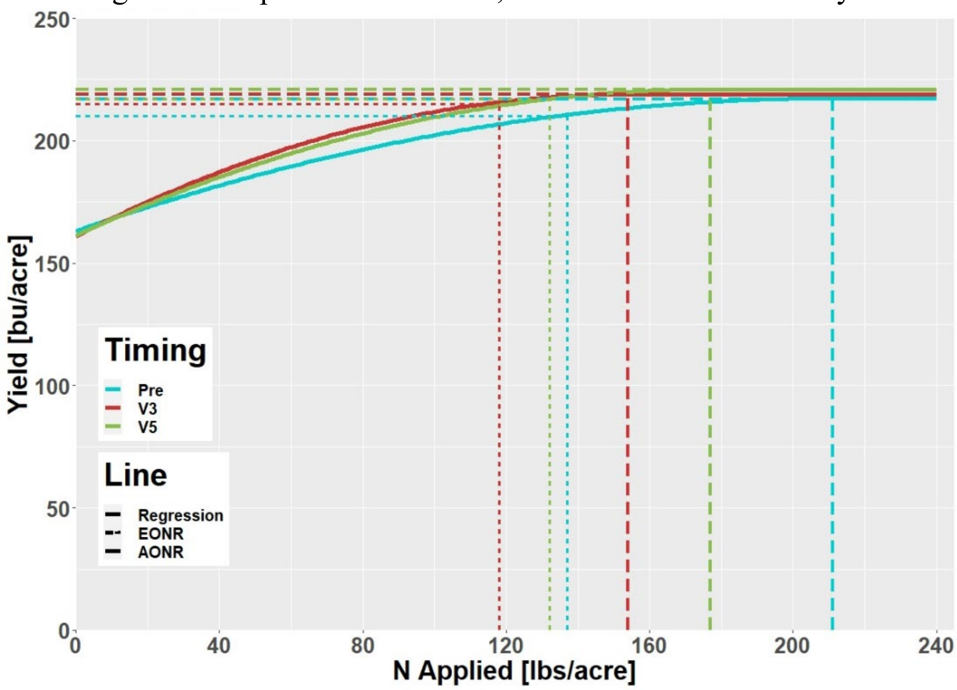

Figure 1. Nitrogen application timing effect on grain yield near Brookings, SD in 2020.

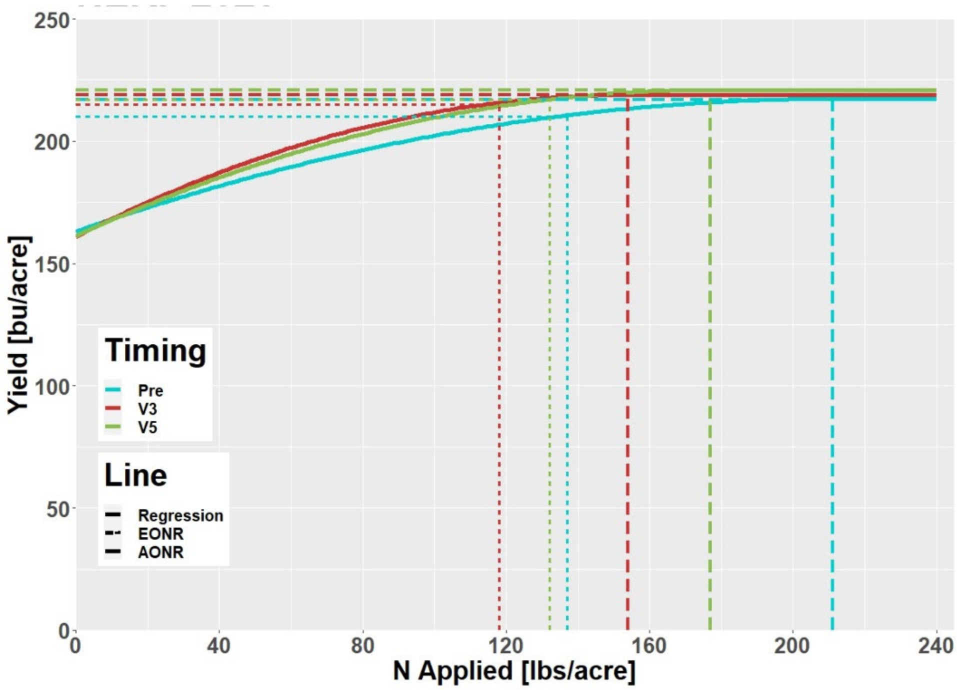

Figure 2. Nitrogen application timing effect on grain yield near South Shore, SD in 2020.

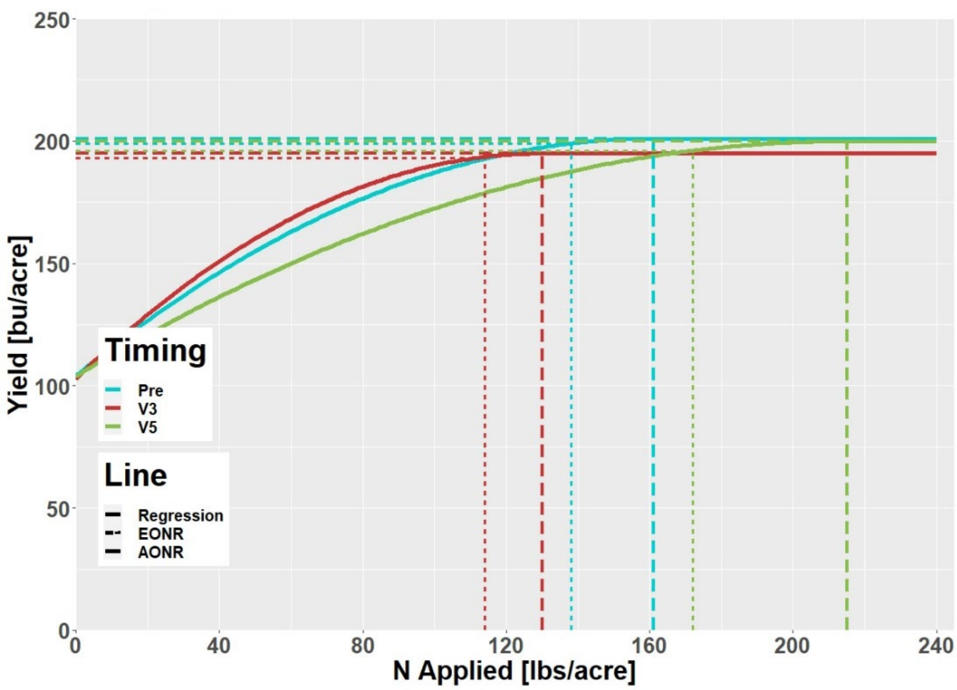

Figure 3. Nitrogen application timing effect on grain yield near Beresford, SD in 2020.

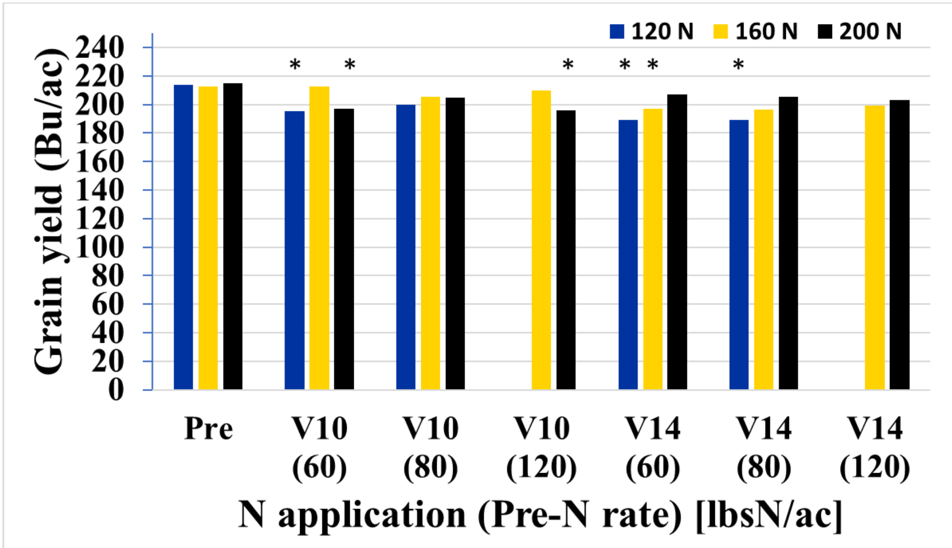

Figure 4. Mid-season N application timing effect on grain yield near Brookings, SD in 2020. Color of the bars represent the total N rates. Grouping of the bars presented by the split N application timing (V10 or V14), and the pre-plant N application rate (presented in parenthesis under the split application timing). Asterisk above the graph indicates that mid-season split application was statistically different from the pre-plant only treatment within the same total N rate (same colored bar).

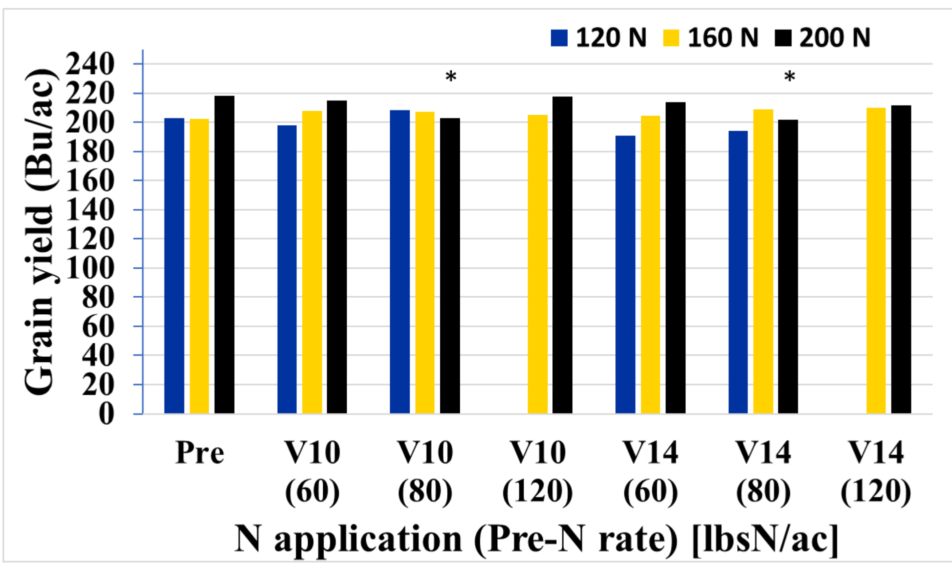

Figure 5. Mid-season N application timing effect on grain yield near South Shore, SD in 2020. Color of the bars represent the total N rates. Grouping of the bars presented by the split N application timing (V10 or V14), and the pre-plant N application rate (presented in parenthesis under the split application timing). Asterisk above the graph indicates that mid-season split application was statistically different from the pre-plant only treatment within the same total N rate (same colored bar).

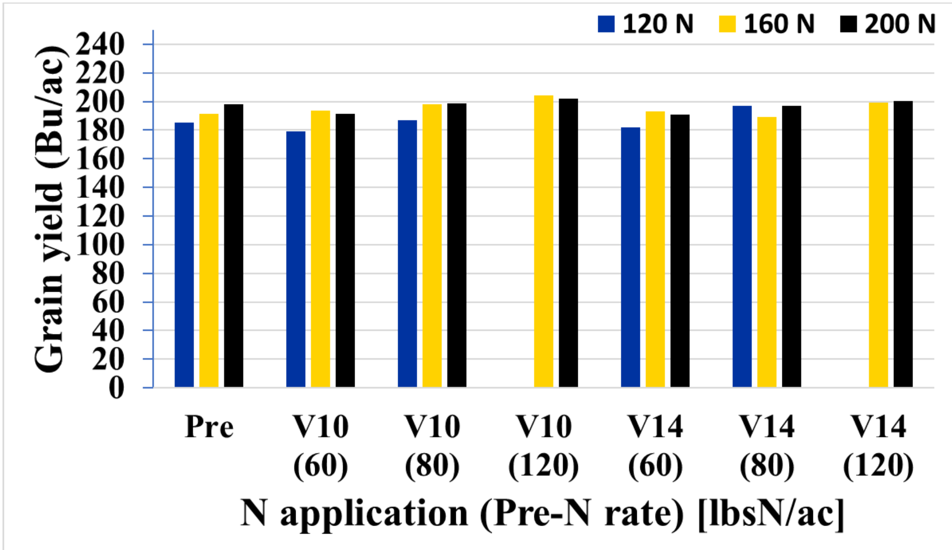

Figure 6. Mid-season N application timing effect on grain yield near Beresford, SD in 2020. Color of the bars represent the total N rates. Grouping of the bars presented by the split N application timing (V10 or V14), and the pre-plant N application rate (presented in parenthesis under the split application timing). Asterisk above the graph indicates that mid-season split application was statistically different from the pre-plant only treatment within the same total N rate (same colored bar).