

CONSERVATION CROPPING SYSTEMS PROJECT  
WILD RICE SOIL CONSERVATION DISTRICT  
8991 HWY 32 FORMAN, ND 58032

THE EFFECT OF ROTATION AND SEEDING  
TECHNIQUES IN NO-TILL CORN PRODUCTION  
2006

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## INTRODUCTION

Corn grain production has made amazing increases in both yield per acre and number of acres planted in ND in the past eight years, especially in regions outside the traditional growing area. Corn acreage in ND has increased from about 592,000 acres in 1997 to an estimated 1.2 million acres in 2005. North Dakota Corn production increased from about 49 million bushels in 1997 to an estimated 155 million bushels in 2006. The use of corn for ethanol production in the Midwest has increased from 1.3 billion gallons in 1997 to more than 4.8 billion gallons as of August, 2006. Ethanol production now uses more than 1.6 billion bushels of the corn grown in this country. High prices for fossil fuel have made corn a very competitive source of energy. According to NDSU Ag Engineering circular AE-735, corn grain at 8,200 BTU/lb at a 65% heating efficiency is valued at \$4.56 per bushel when propane at 75% efficiency is valued at \$1.21 per gal.

Current farm programs such as the Conservation Security Program and a possible change in farm payments from amber box payments to green payments necessitates information collection on cropping systems to meet these goals.

NDSU Extension Service in their projected 2007 crop budgets for southeastern ND show a projected gross income of \$409.50/ac and total costs of \$275.24/ac for growing corn. Input costs of fuel, chemicals, fertilizer, drying, and freight are significantly correlated to energy prices. Fuel and fertilizer are greatly affected by rising energy cost. Therefore no-till cropping systems combined with more efficient use of fertilizer N can cut input costs dramatically.

It is the goal of the Conservation Cropping Systems Project to manage no-till cropping systems which demonstrate how high levels of crop production can be attained while reducing input costs and sustaining our agricultural land for future generations.

## METHODS

The Conservation Cropping Systems Project (CCSP) is located on a 130-acre tract of farm land two miles south of Forman, ND along Highway 32, Figure 1. A twelve member Board of Directors composed of local producers in northeastern South Dakota and southeastern North Dakota advises the CCSP staff. Professionals from ag research, as well as natural resource conservation agencies and non-profit interest groups, assist the Board with technical advice and support.

Ten crop rotations ranging from 2 to 6 years in length are being studied, Table 1. Six crops are present in rotations: HRSW, HRWW, corn, soybean, alfalfa and flax. Three seeding techniques: disk drill, shank drill

and strip-till, are being studied within the HRSW-HRWW-corn-soybean rotation. Additional crops may be added and subtracted as deemed important. The key components of rotations are their moisture intensity and their plant diversity. Figure 2, shows the location of each crop within each rotation. Each plot is 60 feet by 200 feet. Each crop within the rotation sequence is present each year. Each rotation sequence has 3 replications. For example in rotation F, corn is replicated three times as Fc1, Fc2 and Fc3.



Figure 1. Aerial picture of the Conservation Cropping Systems Project.



Table 1. Moisture intensity and diversity in rotations.

Rotation	Legend	Moisture Intensity <sup>a</sup>	Crop Diversity <sup>b</sup>
sw/ww/c/s - disk drill	A	1.50	3.92
sw/ww/c/s - shank drill	B	1.50	3.92
sw/ww/c/s - strip till	C	1.50	3.92
sw/c/s	D	1.67	2.25
sw/s	E	1.50	0.50
c/s	F	2.00	0.00
sw/c/s/c/s	G	1.80	1.83
sw/ww/c/s/c/s	H	1.67	2.92
sw/ww/flx/c/c/s	I	1.50	3.08
ww/s/c/c/flx	J	1.60	4.33
sw/ww/c/c/s/s	L	1.67	2.92
sw/ww/a/a/c/s	N	1.67	2.08

sw=Hard Red Spring Wheat    ww=Hard Red Winter Wheat    c=Corn  
 flx=Flax                                    a=Alfalfa                                    s=Soybean

<sup>a</sup> 1.00 lowest water use, 2.00 highest water use.

<sup>b</sup> The larger the number the more diverse the rotation.

Seeding and harvesting conflicts are not considered in these diversity indexes

Dekalb DKC42-95 corn was planted at 29,000 seeds/ac on May 18-31, 2006. Corn was planted with an 8-row John Deere 7200 planter with 30-inch spacing equipped with residue cleaning wheels, spading wheels and seed firmers. Planter fertilizer in corn was applied in a band three inches to the side of the seed and two inches below at 97 lb/ac N and 32 lb/ac of P. In furrow application of 2.5 gallons 10-34-0 mixed with 2.5 gallons water added 3 lbs N and 10 lbs P

for total of 97 lbs nitrogen and 42 lbs P. Strip-till plots for 2006 were strip-tilled in November of 2006 to a depth of about 6 inches with no fertilizer applied.

Weed control in 2006 consisted of an application of 3 pt/ac Lumax and 22 oz/ac of Roundup Ultra Max II on May 30, followed by 30 oz/ac of Roundup Ultra Max II on June 23. Corn harvest began on October 14, 2006 but found corn was still quite wet, started again October 26 and finished plots October 29. An area of 6 rows by 200 feet (0.07 ac) was harvested in each plot.

## Results

### Weather

The 2006 growing season can be characterized as starting wet, then in May transitioning to dry and hot compared to a warm, wet growing season in 2005., Temperatures averaged 1, 2, 5, and 2 degrees above normal for May, June, July and August, respectively, in 2006. Numbers do not always convey the dramatic impact seen on crops or people. The 5 degree above normal temperatures of July had a much higher negative impact on people and plants than the 17 degree above normal temps of January. In figure 3, you can see that a drier year like 2006, will have higher spreads between highs and lows. In wet years higher surface moisture tends to buffer out heat. These comparisons are between Oakes data in 2005, and Forman data in 2006, but serve to illustrate a well proven phenomena. GDU's for Forman were 2413 from May 1 through September 29. which was 68 higher than the 15 year average.

Table 2. Growing season temperature and precipitation at Forman, ND in 2006.

### Calender year 2006 Weather

Month	Temperature (f)			Precipitation (in)		
	64 Yr Mean	2006 Mean	deviation	64 Yr Mean	2006 Total	deviation
January	7.6	24.1	17	0.5	0.2	-0.3
February	11.9	15.3	3	0.5	0.4	-0.2
March	26.0	29.2	3	0.8	1.2	0.4
April	44.0	49.3	5	2.0	1.3	-0.7
May	55.7	56.6	1	3.0	2.8	-0.2
June	65.0	67.0	2	3.6	1.3	-2.3
July	70.1	75.4	5	2.9	1.7	-1.2
August	68.2	69.8	2	2.8	3.5	0.8
September	59.5	56.0	-4	2.1	3.3	1.2
October	46.0	42.3	-4	1.4	0.3	-1.1
November	28.6	30.7	2	0.6	0.1	-0.5
December	15.3	24.4	9	0.6	0.8	0.2
mean totals	<b>41.5</b>	<b>45.0</b>	<b>3.5</b>	<b>20.6</b>	<b>16.8</b>	<b>-3.8</b>

Precipitation in 2006 was below the long term average by 3.8 inches for the year. All growing season months except August were below normal on rain compounded with above normal temperatures. Mid July brought on visible drought symptoms in the plots. Starting on the 20<sup>th</sup> of July, we received several rains that substantially improved the looks of the corn and soybeans. Growing degree days were above the long term average as noted in figure 4. The high Gdu's were needed. We had extremely wet conditions in May which were the result of heavy rainfall in the fall of 2005, and possibly aggravated by an early winter ice storm that effectively capped the soil surface all winter. May brought average temperatures, and normal rainfall, but few really good drying days until late in the month.

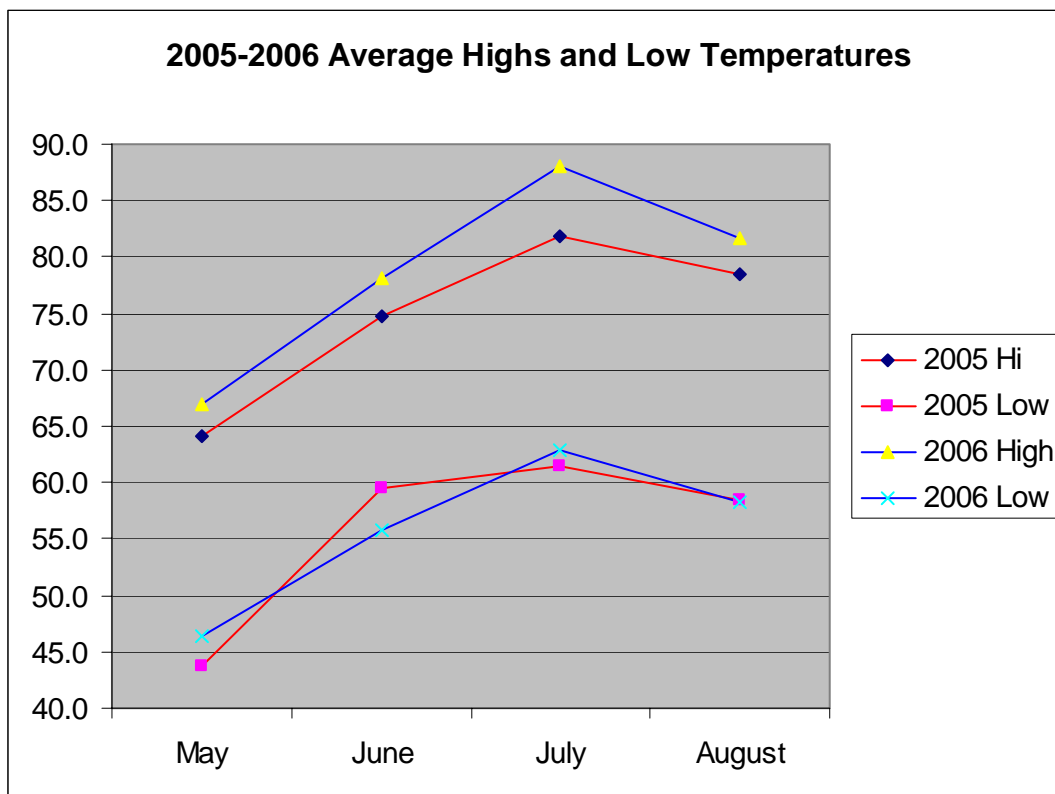


Figure 4. Average highs and lows of 2005 and 2006.

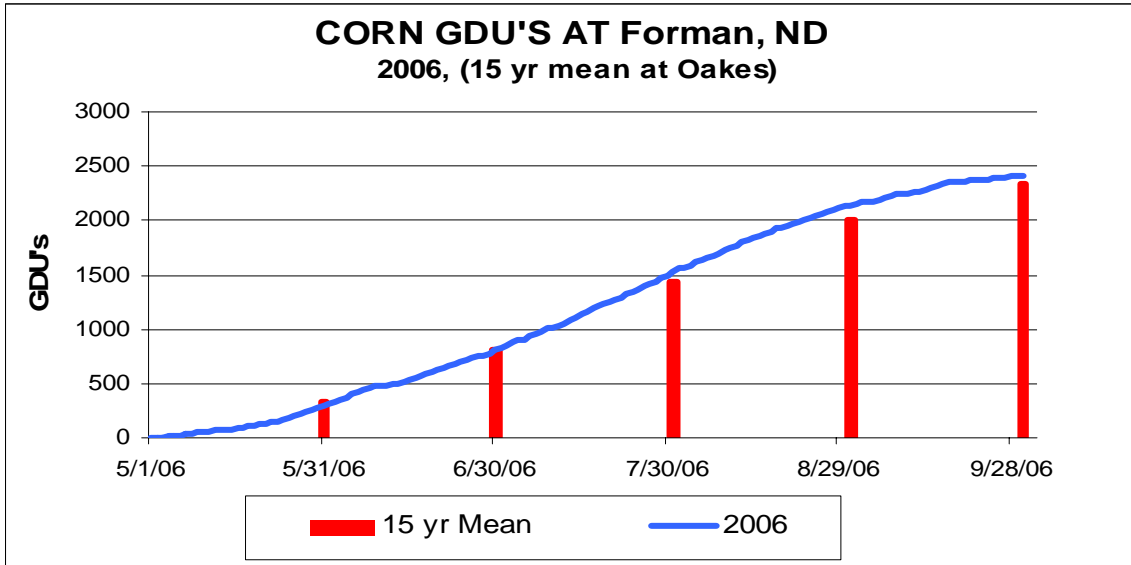


Figure 5. Growing degree units accumulated for corn at Forman, ND, 2413 in 2006 and the 15-yr mean of 2345.

**Rotation effect on corn yield**

The most dramatic observation of 2006 for corn was the highest yield coming on strip-tilled wheat and the much lower yield of the “corn on corn”. The same nitrogen rate was used across all rotations for reasons relating to late planting and the limitations of the corn planter. Compare the yields from 2006, Figure 6, to the yields from 2005 in figure 7.

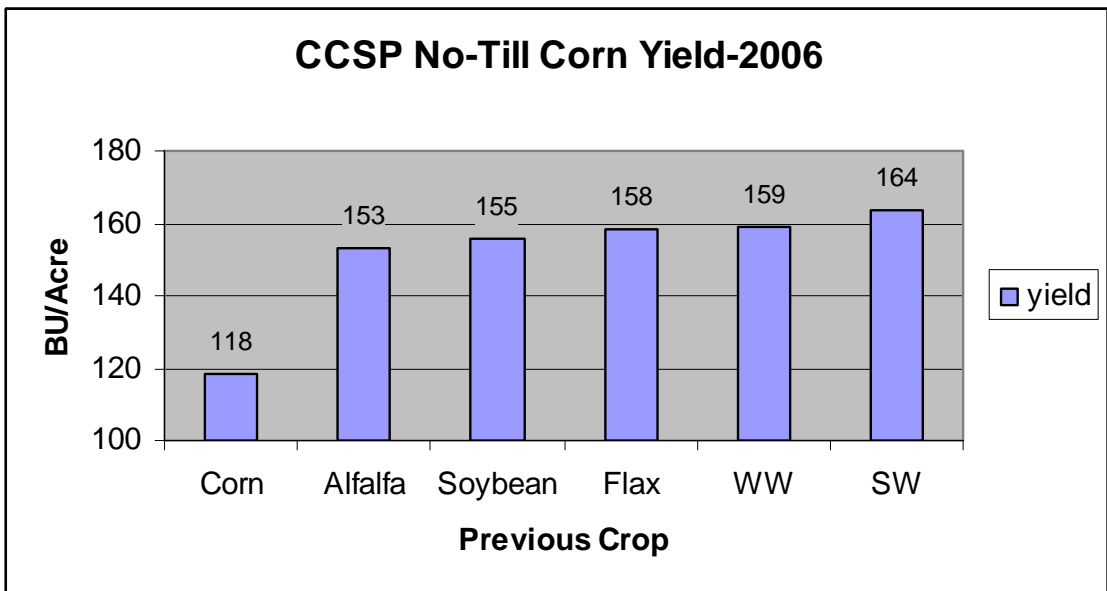


Figure 6. The effect of previous crop on corn yield in 2006.

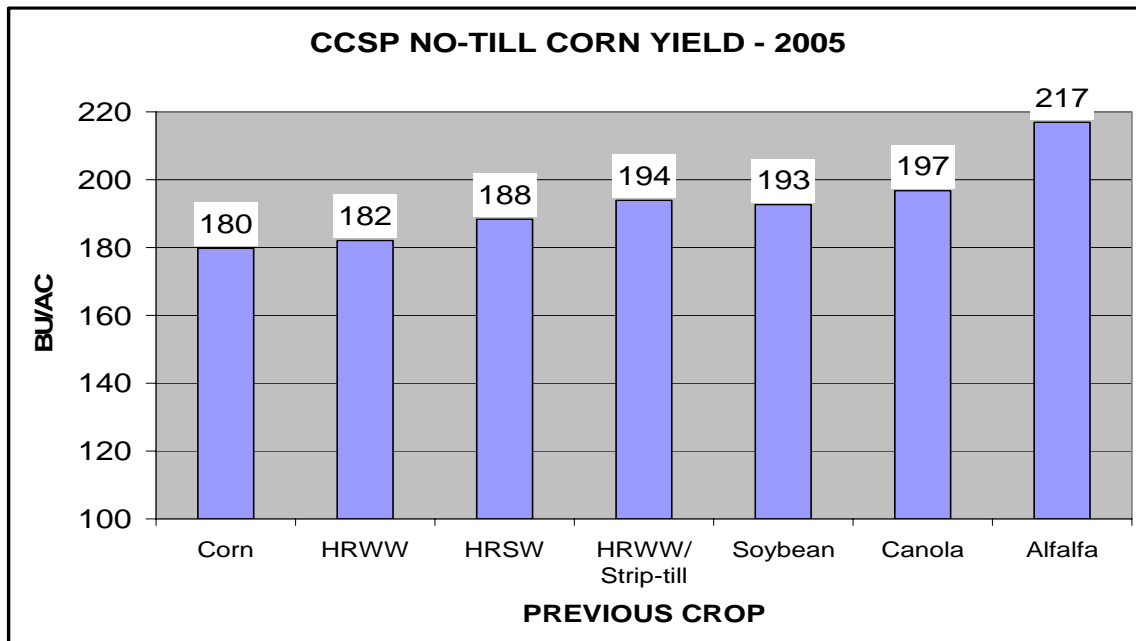


Figure 7. The effect of previous crop on corn yield in 2005.

Two year averages in Figure 8, shows three yield groupings for crop sequence. Corn grown on land previously in corn or hard red winter wheat crop (HRWW) averaged about 160 bu/ac. Corn on hard red spring wheat (HRSW) or strip-tilled HRWW averaged about 169 bu/ac. Corn grown on canola, soybean or alfalfa ground yielded about 175 bu/ac. Corn grown on strip-tilled HRWW yielded 8 and 12 bu/ac higher than when directly no-tilled, in 2004 and 2005, respectively. Interestingly, corn on strip-tilled HRWW in 2005 yielded similar to corn grown on soybean ground. In 2006, the best yielding corn was on strip-till wheat ground which was the first dry hot year we have had since the start of the project. It is important to note that we had as much stored soil moisture possible. Much speculation can be made, but as an observation made in wheat stubble the 3<sup>rd</sup> week in June was to find nearly saturated soil under the residue. This would indicate the wheat residue was holding moisture that corn and soybean residue did not. Soil temperature could also be an issue as high soil temperature in mid-season can reduce corn yields. The strip-till effect was very pronounced at planting as the soil conditions in the strip were good for planting. Using residue managers to clear residue was not an option, as the freshly exposed soil was too wet for planting. Planting straight into stubble was the only option which allowed the planting to proceed but with the usual problems of poor seed placement. The warm moist soil did allow for rapid germination and emergence. All corn, even the corn on corn looked good early season, with some problems from black birds, geese, gophers, and rabbits. The corn on corn plots yielded far less in the end however. They were all strip-tilled in the fall with 2.5 gallons of 10-34-0 in furrow

fertilizer applied at planting. The drier conditions this year seemed to make for an even larger yield difference than previous years.

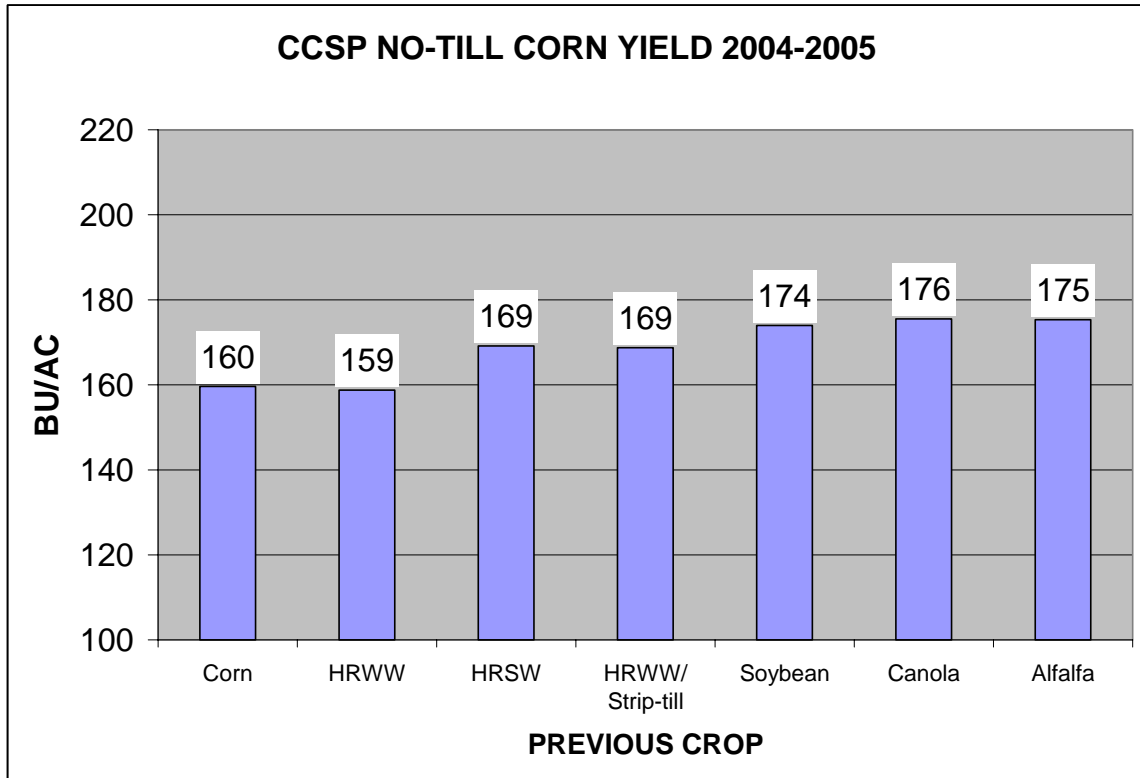
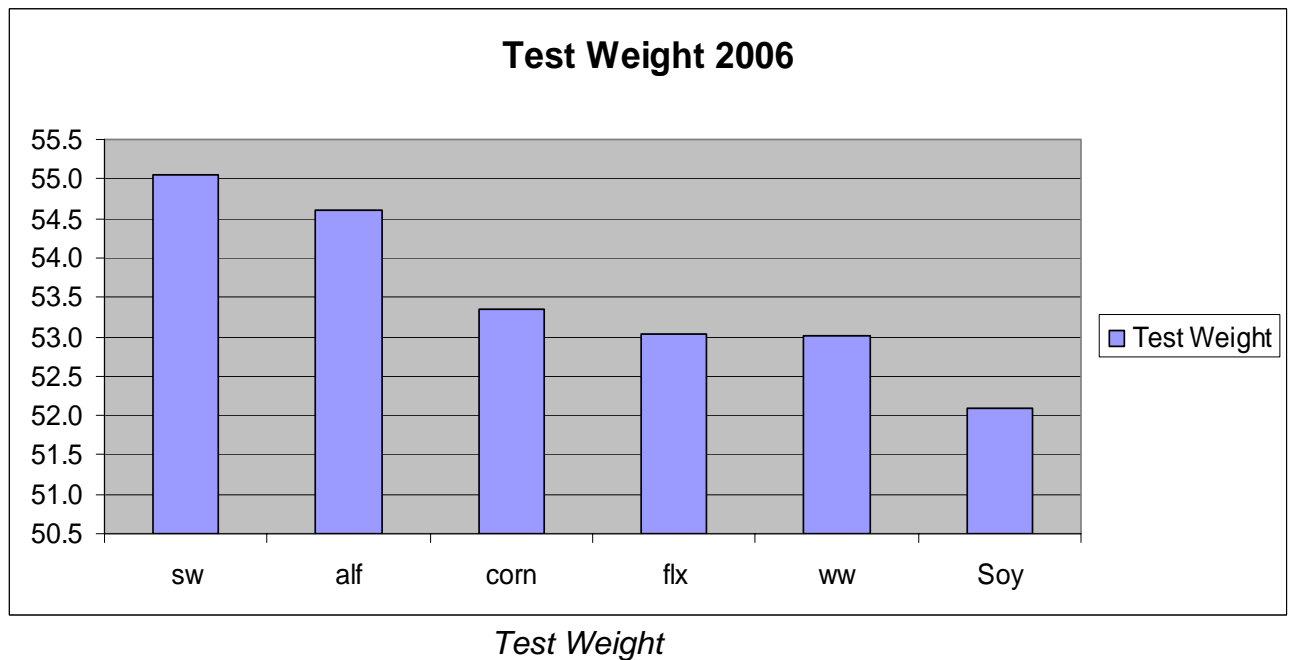


Figure 8. The effect of previous crop on corn mean yield from 2004-2005.



A grain sample from each corn plot was checked for moisture and test weights measured in 2006, figure 9.

## Corn Grain Protein

Protein content in grain corn grown on previous crops in 2005 is shown in figure 9. The relationship between grain protein content and yield is shown in figure 10. As yield increased protein content in grain also increased. Figure 13 shows the relationship between protein content in corn grain and starch content. In 2006, the relation between protein and yield was opposite as it was in 2005, however protein overall was higher.

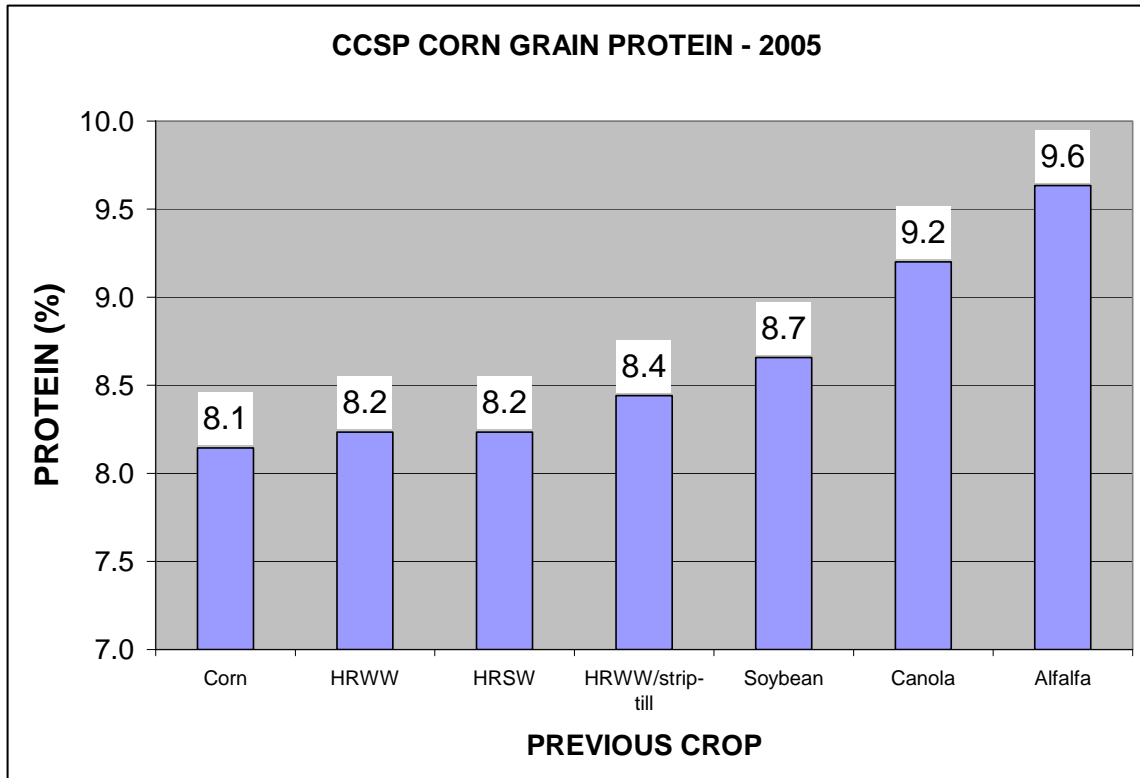


Figure 10. The effect of previous crop on corn grain protein 2005.

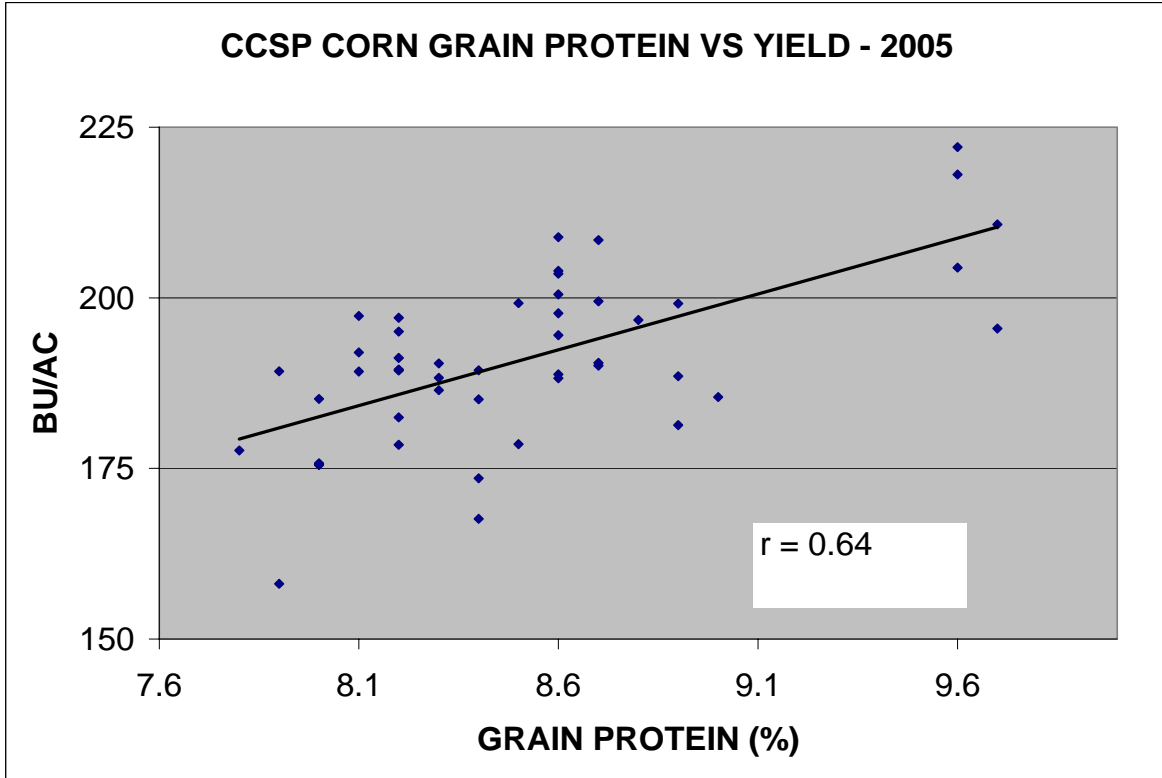


Figure 11. The relationship between protein content in corn grain and yield in 2005.

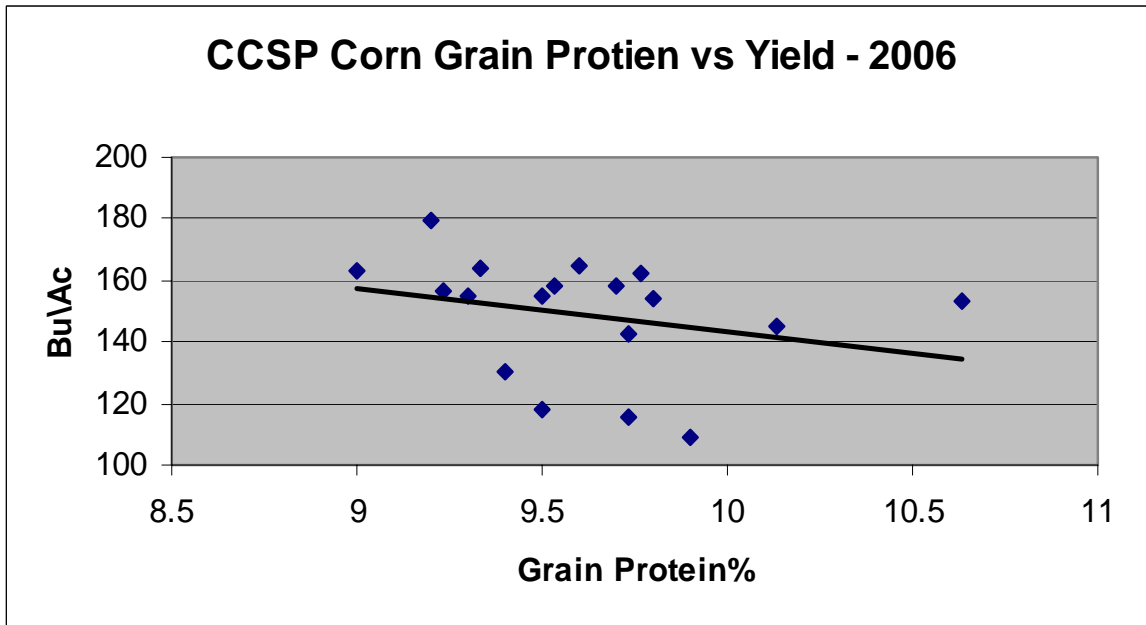


Figure 12. The relationship between protein content in corn grain and yield in 2006.

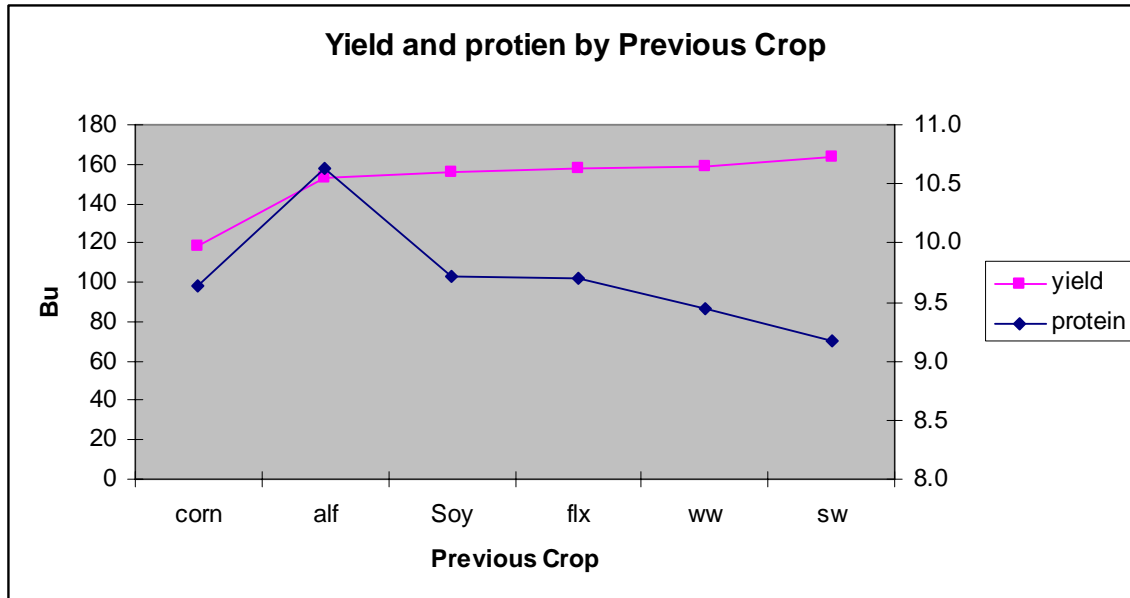


Figure 13. The relationship between protein content in corn grain, yield and previous crop in 2006.

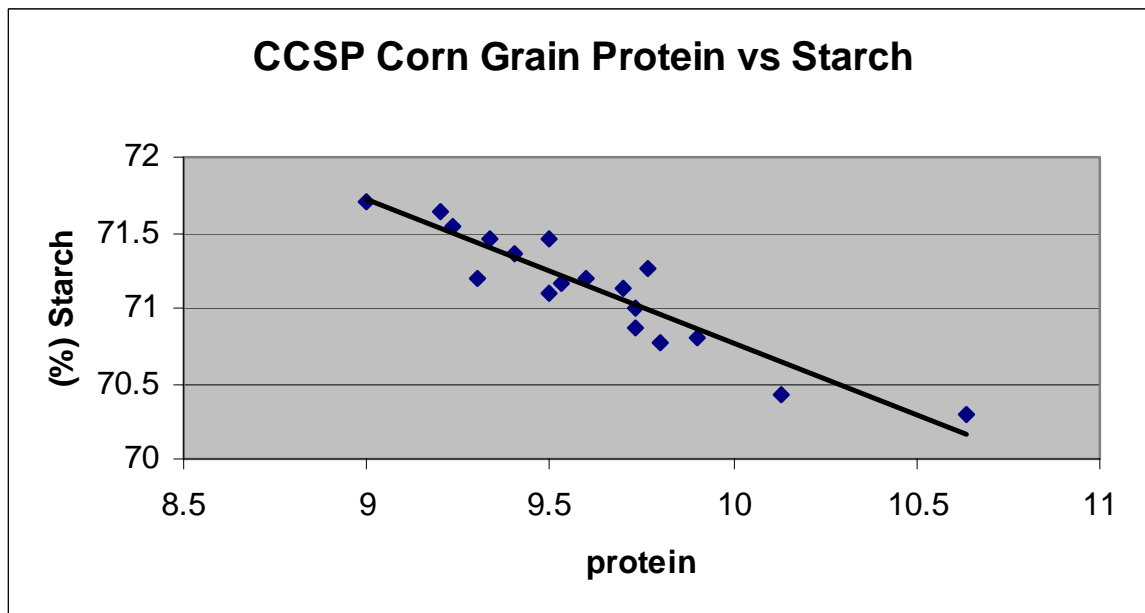


Figure 14. The effect of grain protein on grain starch 2006.

#### Nitrogen Required Per Bushel of Yield

Table 3 show corn yields compared to available soil N plus fertilizer N in 2006. Soil samples were taken to a 24-inch depth and analyzed for nitrate-N. Nitrogen credits of 40 and 100 lb/ac of N were added on land previously soybean and

alfalfa. Corn required 1.16 lb/ac of soil plus fertilizer N per bushel of production in 2004, 0.96 lb/ac in 2005, and 1.0 in 2006. Carry over nitrogen in the top 2 feet this fall was low, with 15-32 lbs nitrate nitrogen in all corn plots except the 2 alfalfa rotations, which were 45 and 70 lbs. Much work is being done with nitrogen. Fertilizer recommendations are being changed or have been changed all over the corn belt. It has been my personal observation that in good years, farmers would routinely have higher yields than what they fertilized for and would still have high nitrate levels in their soil. Keep in mind that high rain fall can leach out nitrogen, especially in sandy soils. Also, in a soybean rotation, the soybeans will “mop up” any carry over nitrogen left by a previous crop.

Previous Crop	Fall soil		Bu/AC	N Credit +	
	nitrate 2005	Fertilizer N		Soil N+Fert N Lb/bu	Fertilizer N Lb/bu
Alfalfa	46	97	153	1.6	0.6
Corn	20	97	119	1.0	0.8
flax	70	97	158	1.1	0.6
Soybean	20	97	155	1.0	0.6
HRSW	35	97	163	0.8	0.6
HRWW	43	97	163	0.9	0.6
HRWW/No stip-till	43	97	143	1.0	0.7

Table 3. Nitrogen per bushel of corn production for total soil N plus fertilizer N plus an N credit where appropriate and fertilizer N alone in 2006.

### **Future work**

Strip-till appears to be a viable option for successful no-till corn production in the Eastern Dakotas. Plans were to initiate a fertilizer N rate strip-till project in the spring of 2006. The late wet spring did not allow that to happen. We now have the means to do RTK strip tilling which has already been started as of last fall. We have plans to put in a No-Till variety trial in co-operation with NDSU. Details still need to be worked out on this. With ethanol currently a huge driving force for planting corn on corn, rotations with more corn are being considered. With the price of grains on an upward course, many ideas and products are certain to be of great interest. Farm program goals will possibly shift away from subsidy to conservation and production. It is our hope to keep this project on the cutting edge of conservation farming while maintaining maximum production.



Figure 15. Soil pit at 2006 Field Day.