

CONSERVATION CROPPING SYSTEMS PROJECT
WILD RICE SOIL CONSERVATION DISTRICT
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THE EFFECT OF ROTATION AND SEEDING
TECHNIQUES IN NO-TILL CORN PRODUCTION
2004-2005

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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 of 155 million bushels in 2005. The use of corn for ethanol production in the Midwest has increased from 1.3 billion gallons in 1997 to more than 4 billion gallons in 2005. Ethanol production now uses more than 10% 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 2006 crop budgets for southeastern ND show a projected gross income of \$261/ac and indirect costs of \$178/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 canola. Three seeding techniques: disk drill, shank drill and strip-till, are being studied within the HRSW-HRWW-corn-

soybean rotation. Additional crops will be added and subtracted as deemed necessary. 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		Moisture Intensity ^a	Diversity ^b
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/(ds)canola/c/c/s	I	1.50	3.08
ww/s/c/c/can(ds)	J	1.60	4.33
sw/ww/c/c/s/s	<u>L</u>	1.67	2.92
sw/ww/a/a/c/s	N	1.67	2.08

sw = HRSW	ww = HRWW	c = corn	(ds) = dormant seeding
can = canola	a = alfalfa	s = soybean	

^a1.00 lowest water use, 2.00 highest water use.

^bThe 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 April 26-28, 2004 and on May 4-6, 2005. Corn was planted with an 8-row Case IH 1200 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 in both years at 12 lb/ac of N and 39 lb/ac of P in 2004 and 105 lb/ac N and 39 lb/ac of P in 2005. An exception was strip-tilled corn in 2004 when all the fertilizer was applied with the strip-till equipment on November 19. On that date 100 lb/ac of N as anhydrous ammonia, 9 lb/ac of N as 11-52-0 and 47 lb/ac of P as 11-52-0 was placed about 6 inches in depth

with a DMI unit. Strip-till plots for 2005 were strip-tilled in November of 2004 to a depth of about 6 inches with no fertilizer applied. All corn plots received an application of 106 lb/ac N as 28-0-0 pre-emerge in 2004. Corn planted on ground previously in corn, canola, HRSW and HRWW received applications of 43, 43, 55 and 43 lb/ac of N as 28-0-0 pre-emerge in 2005.

Weed control in 2004 consisted of an application of 1 pt/ac atrazine, 3 oz of Callisto and 22 oz/ac of Roundup Ultra Max II on June 4, followed by 30 oz/ac of Roundup Ultra Max II on June 25. Weeds were controlled with an application of 3 pt/ac of Lumax and 22 oz/ac Roundup Ultra Max II on May 31, followed by an application of 22 oz/ac of Roundup Ultra Max II, on July 5, in 2005. Corn harvest began on October 26, 2004 and on October 27, 2005. An area of 6 rows by 200 feet (0.07 ac) in 2004 and 9 rows by 200 feet (.10 ac) was harvested in each plot in 2004 and 2005, respectively.

RESULTS

Weather

The 2004 growing season can be characterized as being cold compared to a warm growing season in 2005, Table 2 & 3. Temperatures averaged 2.9, 3.1, 2.1, and 5.9 degrees below normal for May, June, July and August, respectively, in 2004. The corn crop would have been a bust except for a warm September when the temperature averaged 2.4 degrees warmer than the long time average. One thing the two growing seasons shared was a cold May, providing the acid test for no-till corn.

Figures 3 & 4 present the number of growing degree units (GDU) accumulated in 2004 and 2005, respectively, for corn. The difference between years is dramatic as May through September GDU's totaled 2,072 and 2,470 in 2004 and 2005. Growing degree units for 2004 are compared to those for 1993, a cold growing season that resulted in poor yields, low test weight and high moisture corn. Except for 11 days from May 1 through September 20, GDU's for corn were below those accumulated in 1993. The low point occurred on August 29 when GDU's accumulated at that time were 124 units below 1993 and about 332 units below the 15 yr mean. Things took a turn for the better in September as GDU's totaled 400 for the month. The 2004 season came to an end with a killing frost on October 2. Although corn had accumulated 273 GDU's less than the long-time average by September 30, the September heat advanced the corn more rapidly than the heat units indicated. Even though corn was not mature on this frost date it was far enough along to produce good yields, adequate test weights and reasonable moisture contents, unlike the disaster of 1993. Except for a cool May, conditions were very favorable in 2005 for corn production.

Table 2. Growing season temperature and precipitation at Forman, ND in 2004.

Month	Temperature		Precipitation	
	64 Yr Mean	2004 Mean	64 Yr Mean	2004 Total
April	44.0	44.7	2.0	0.6
May	55.7	52.8	3.0	7.1
June	65.0	61.9	3.6	1.5
July	70.1	68.0	2.9	2.3
August	68.2	62.9	2.8	0.6
September	59.5	61.9	2.1	4.4
October	46.0	47.7	1.4	3.2
MEAN	58.4	57.1		
TOTAL			17.6	19.6

Table 3. Growing season temperature and precipitation at Forman, ND in 2005.

Month	Temperature		Precipitation	
	64 Yr Mean	2005 Mean	64 Yr Mean	2005 Total
April	44.0	48.5	2.0	0.6
May	55.7	53.9	3.0	3.3
June	65.0	67.1	3.6	9.6
July	70.1	71.6	2.9	2.2
August	68.2	68.3	2.8	3.4
September	59.5	63.5	2.1	2.7
October	46.0	47.8	1.4	1.1
MEAN	58.4	60.1	17.6	22.9
TOTAL				

May precipitation in 2004 totaled 4.1 inches above the long time mean. This moisture was used in June through August as precipitation totaled 4.9 inches less than the long time mean. Although corn yields were capped by the dry conditions in August, moisture stress would have been severe had the temperatures not been cool. Precipitation was more than adequate in 2005.

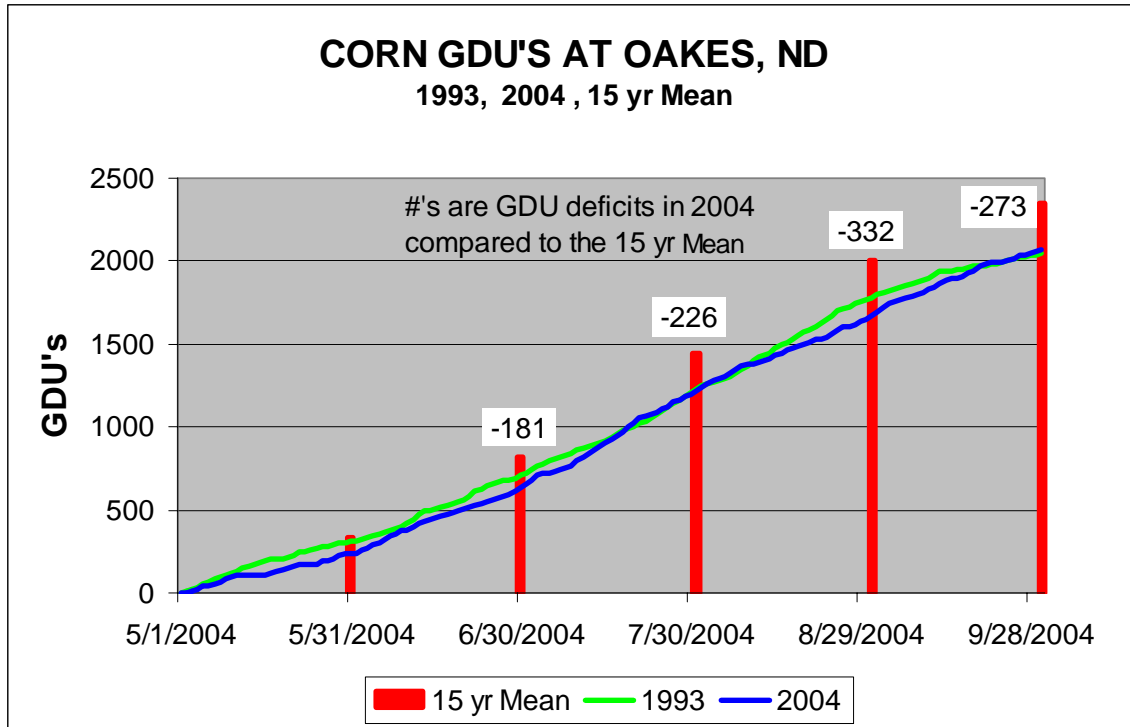


Figure 3. Growing degree units accumulated for corn at Oakes, ND in 2004 compared to 1993 and the 15-yr mean.

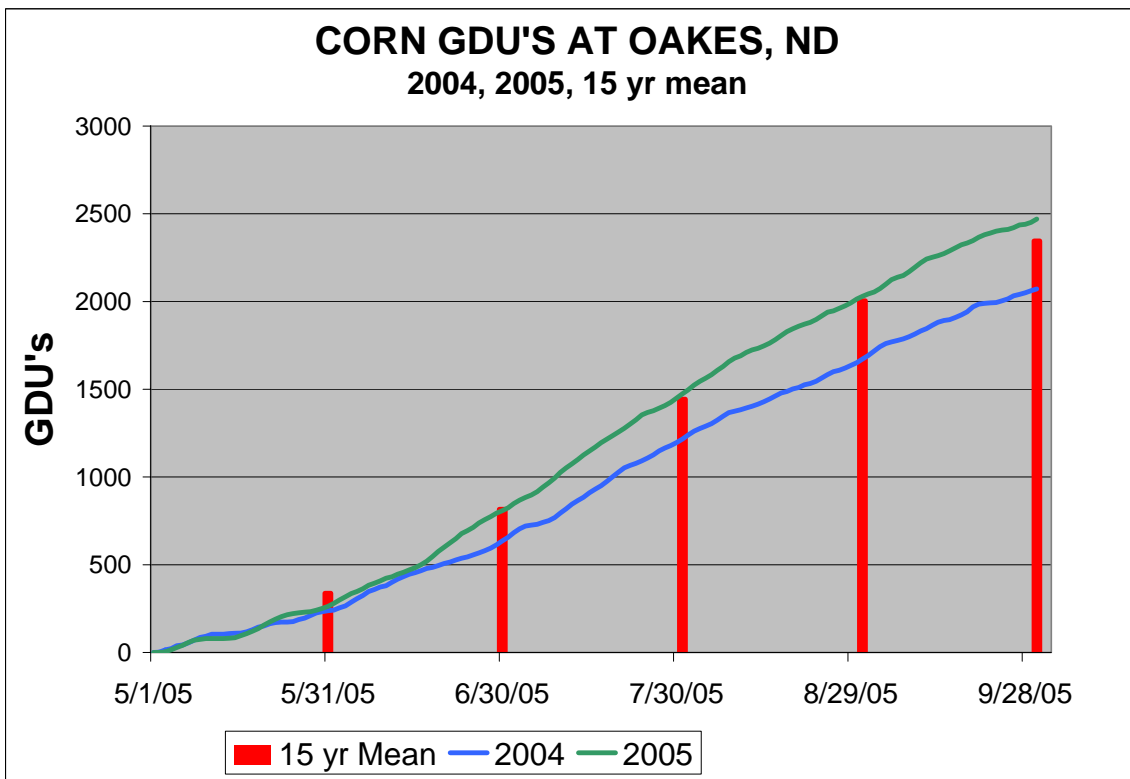


Figure 4. Growing degree units accumulated for corn at Oakes, ND in 2005 compared to 2004 and the 15-yr mean.

Rotation effect on corn yield

With the exception of alfalfa, the effect of a prior crop sequence on corn yield was similar in 2004 and 2005, Figures 5 & 6. The yield of corn on alfalfa ground was repressed by droughty conditions in August of 2004. Up until then the yield potential on alfalfa ground was higher than other prior crops. When moisture was not limiting in 2005, corn on alfalfa ground yielded 20 bu/ac higher than corn on other previous crops.

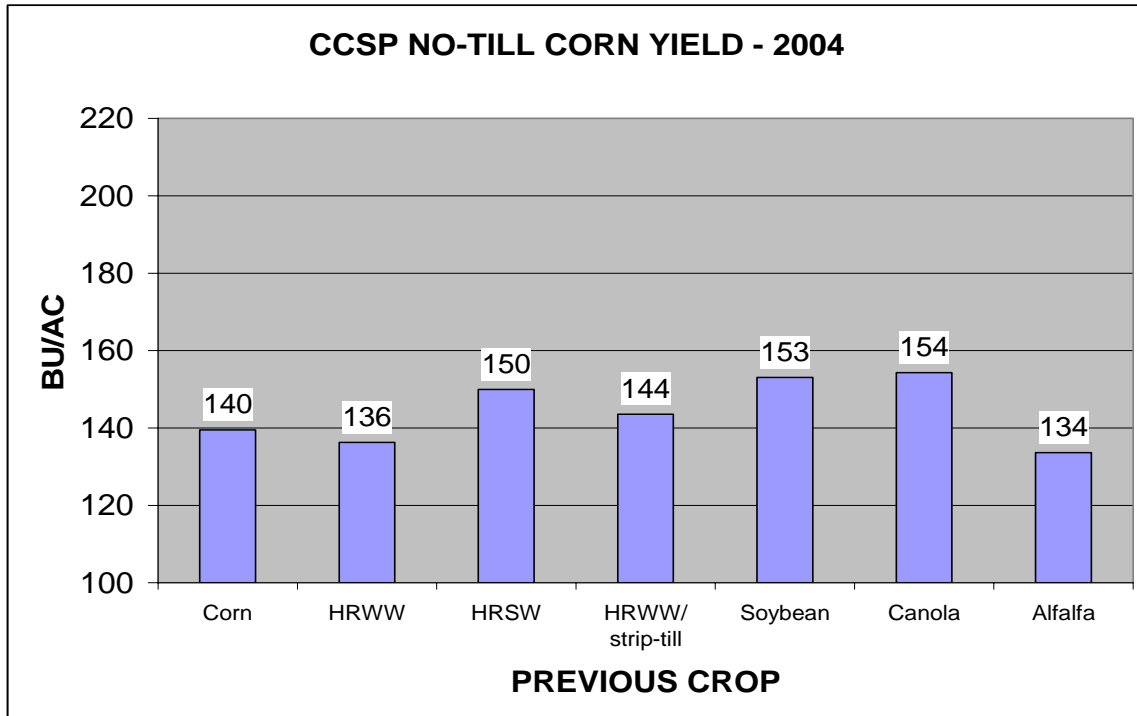


Figure 5. The effect of previous crop on corn yield in 2004.

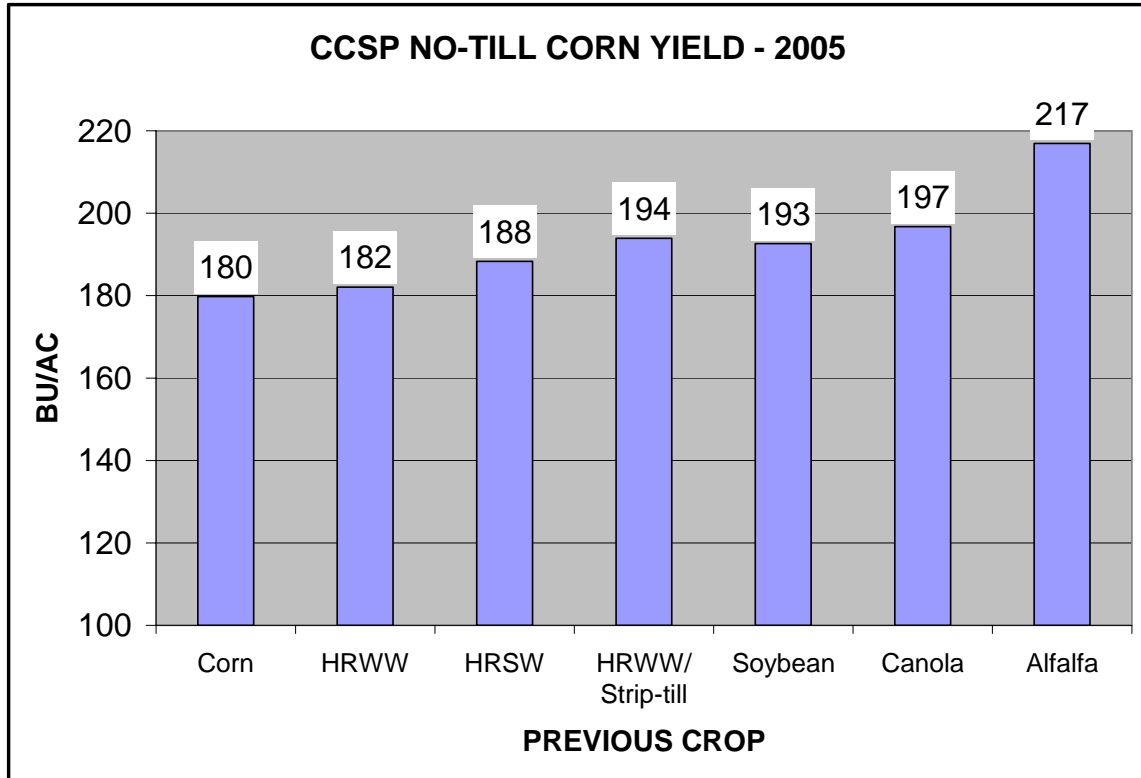


Figure 6. The effect of previous crop on corn yield in 2005.

Two year averages in Figure 7, 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.

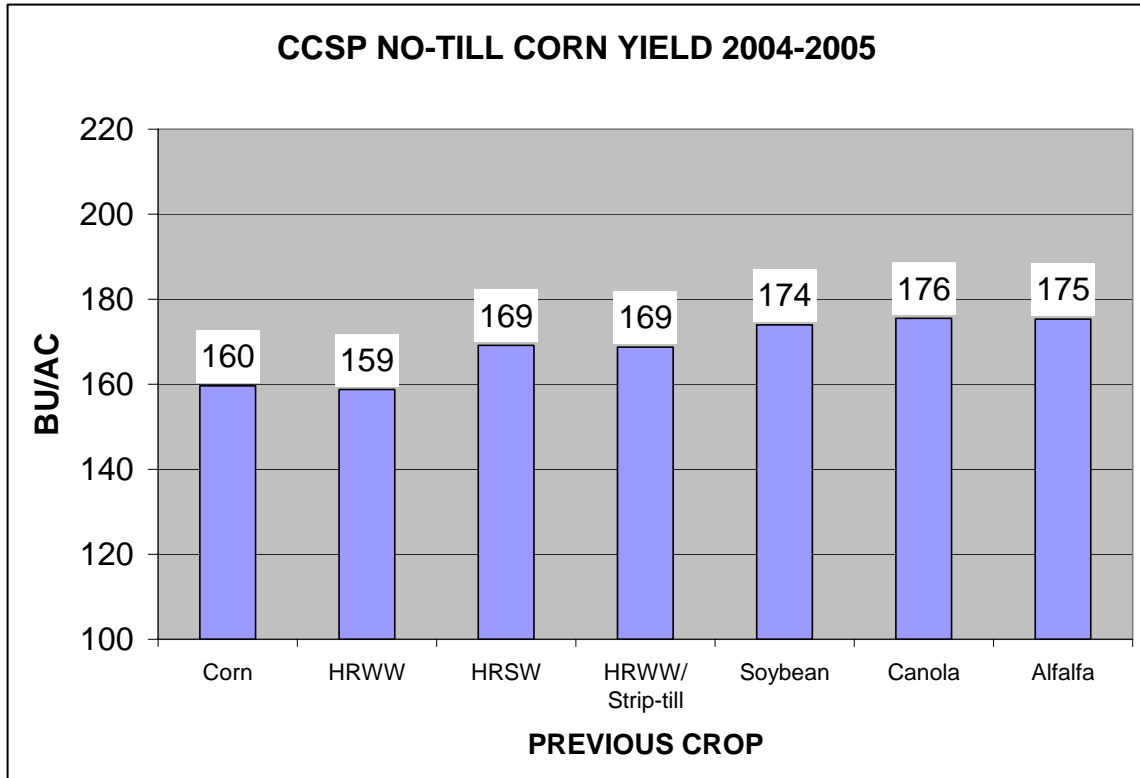


Figure 7. The effect of previous crop on corn mean yield from 2004-2005.

AGRONOMIC TRAITS

Silk Date

Figures 8 and 9 show the relationship between silk date and corn yield. Since planting date was the same, except for strip-till corn in 2004 being planted 2 days earlier, the difference in silk date was due to previous crop history. Delayed silk dates were a function of slower germination, emergence and early season growth among rotations. Any combination of factors that extended the silk date reduced yield. The effect of previous crop on silk date is shown in figure 10. The effect of previous crop on corn maturity dates is shown in figure 11.

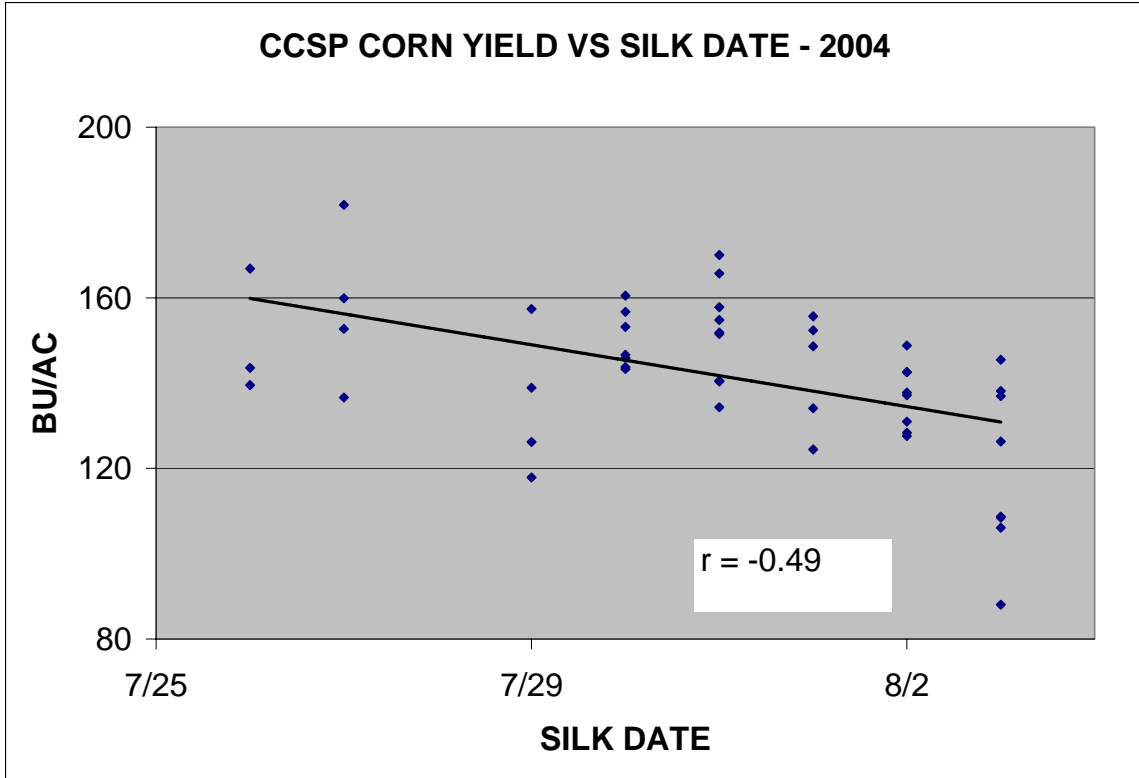


Figure 8. Corn silk date vs yield 2004.

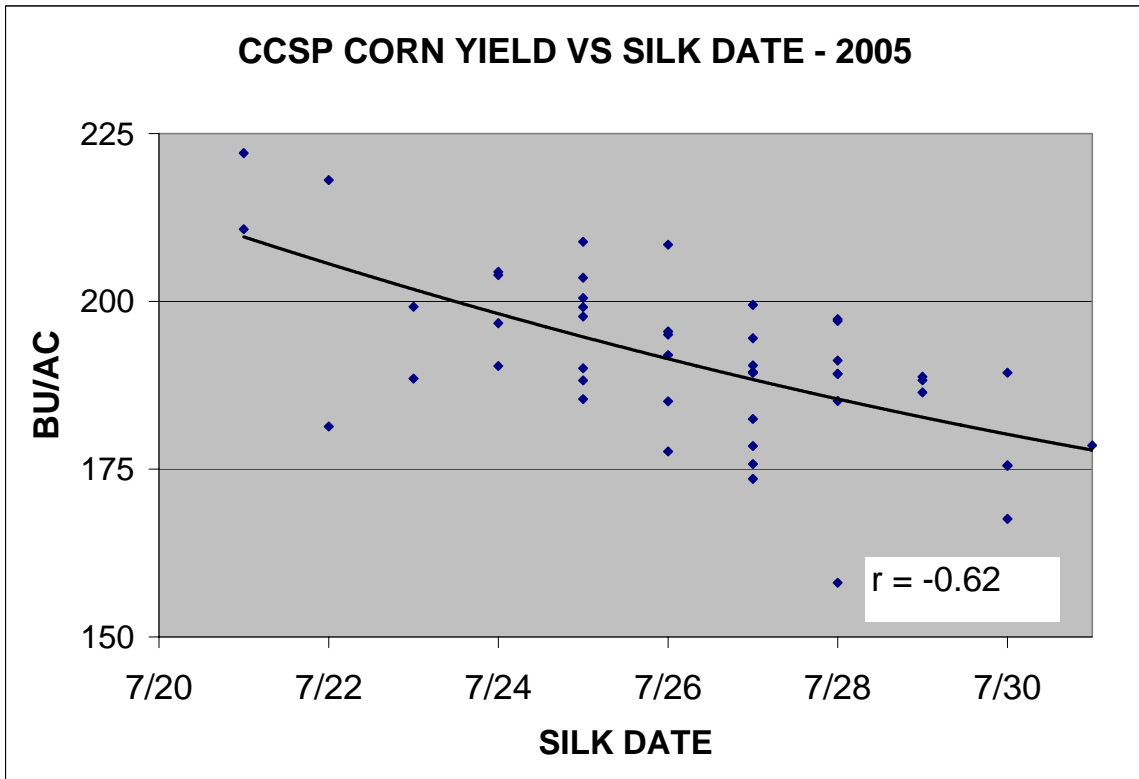


Figure 9. Corn silk date vs yield 2005.

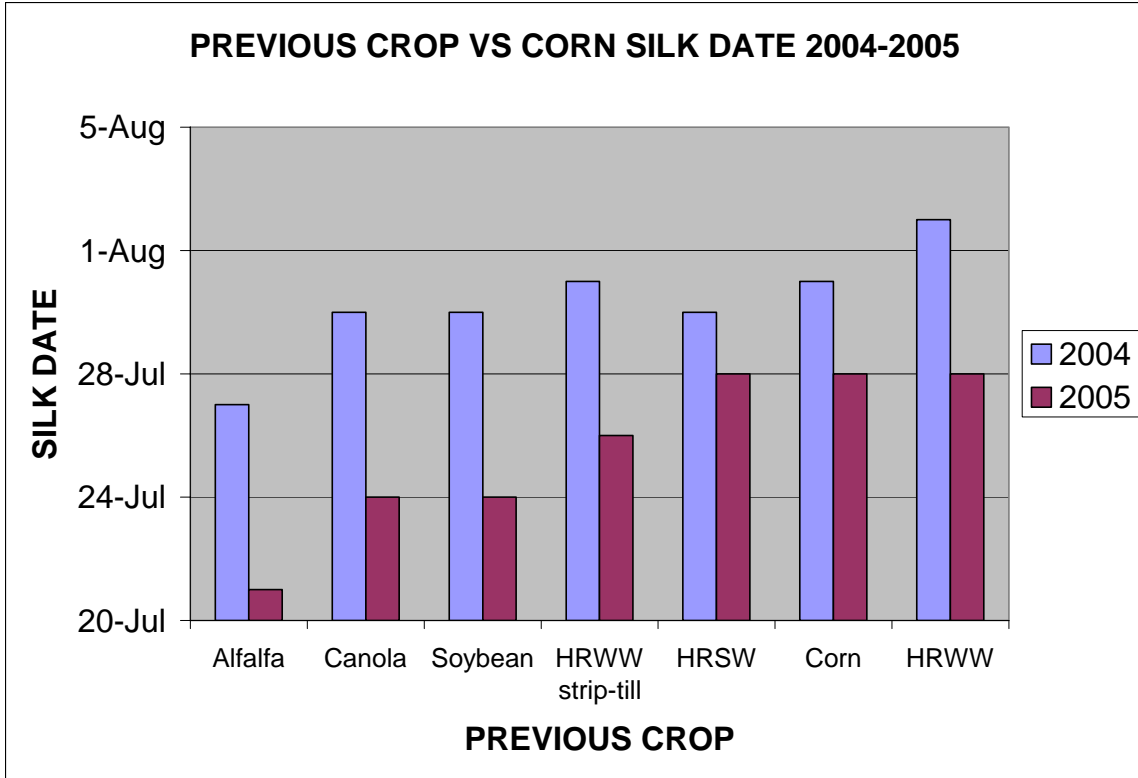


Figure 10. The effect of crop sequence on silk dates in 2004 and 2005.

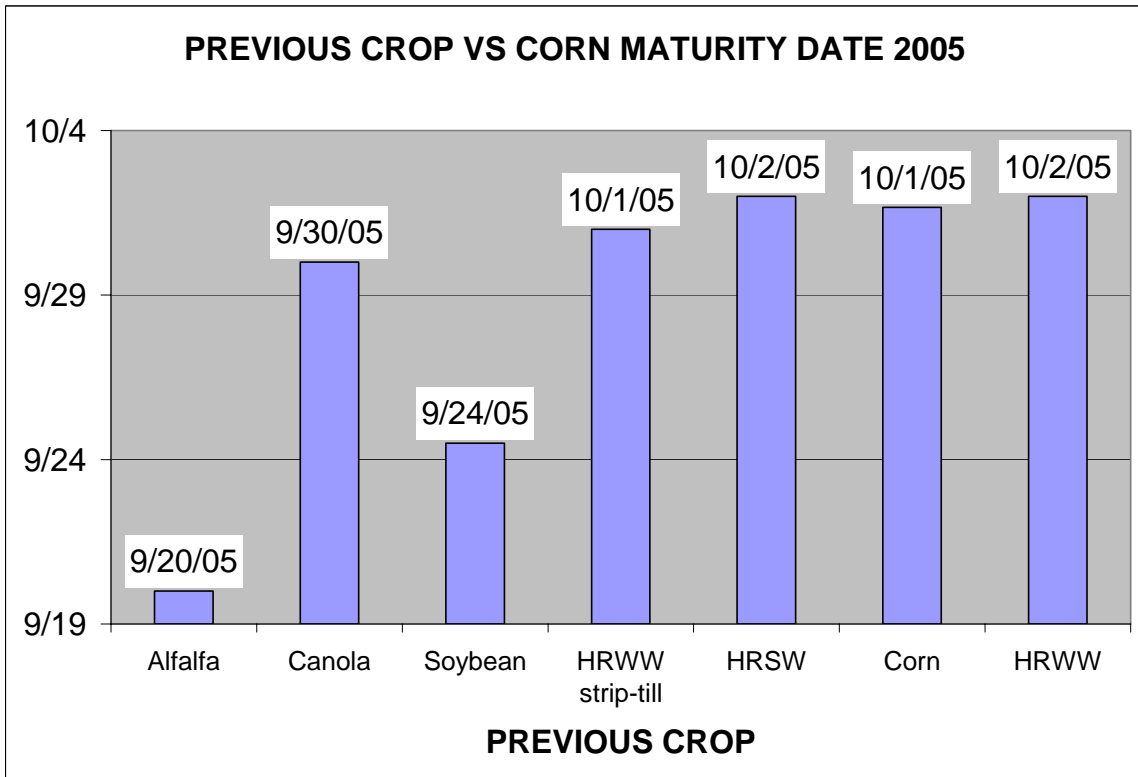


Figure 11. The effect of previous crop on corn maturity in 2005.

Test Weight

A grain sample from each corn plot was air dried below 10% moisture and test weights measured in 2004, figure 12.

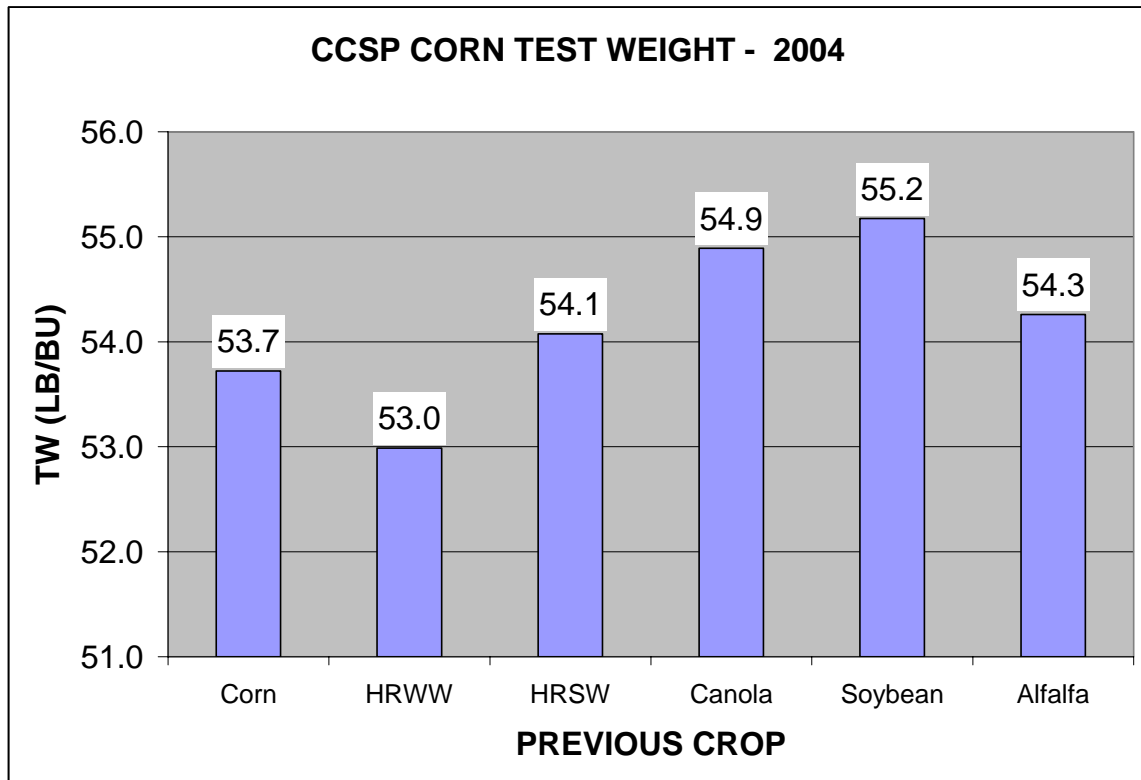


Figure 12. The effect of previous crop on corn test weight 2004.

Corn Grain Protein

Protein content in grain corn grown on previous crops in 2005 is shown in figure 13. The relationship between grain protein content and yield is shown in figure 14. As yield increased protein content in grain also increased. Figure 15 shows the relationship between protein content in corn grain and starch content.

Ear Leaf Chlorophyll Meter Readings and Yield

Chlorophyll meter readings were taken on corn ear leaves shortly after all plots were at 50% silk with a Minolta SPAD 502 chlorophyll meter. Figures 16 and 17 show the relationship between chlorophyll meter readings and yield. Yield increased as values increased.

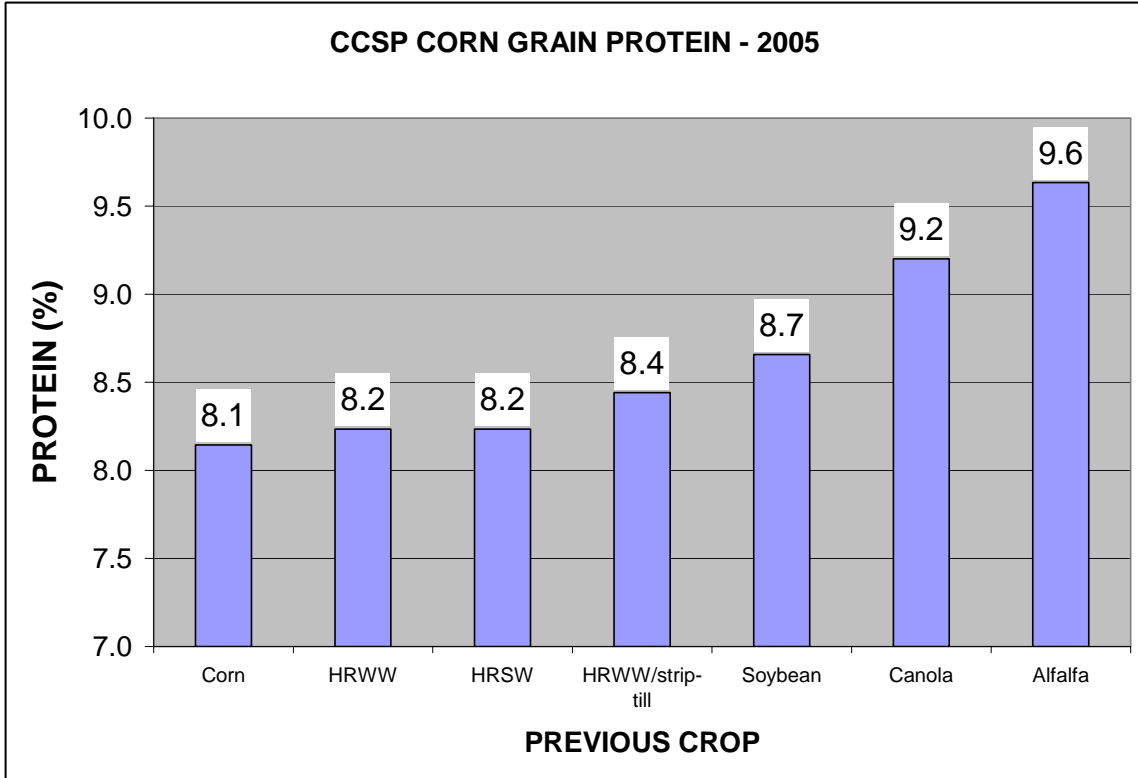


Figure 13. The effect of previous crop on corn grain protein 2005.

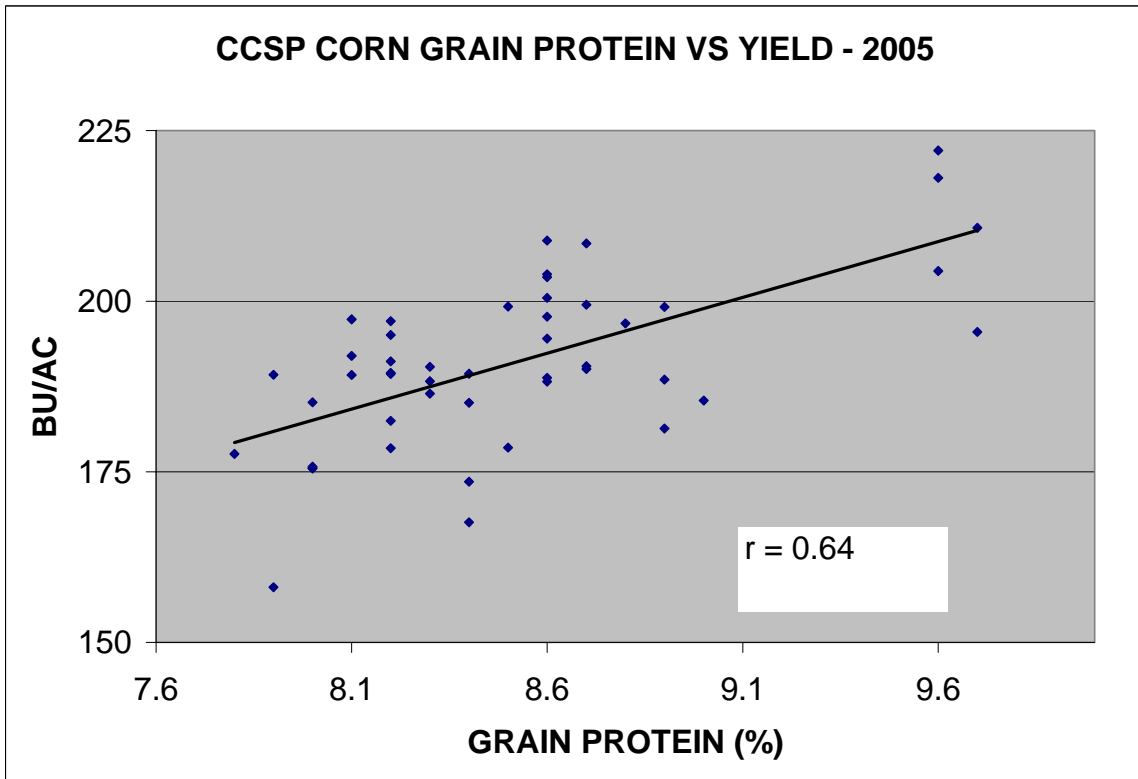


Figure 14. The relationship between protein content in corn grain and yield in 2005.

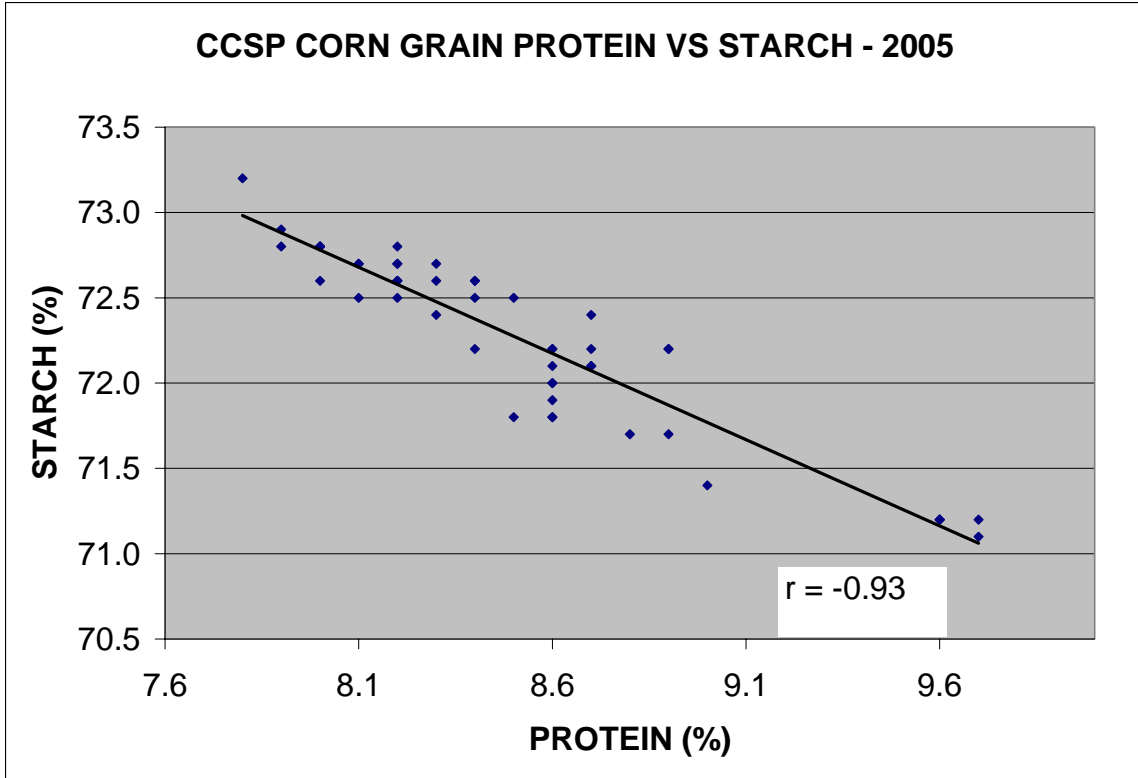


Figure 15. The effect of grain protein on grain starch 2005.

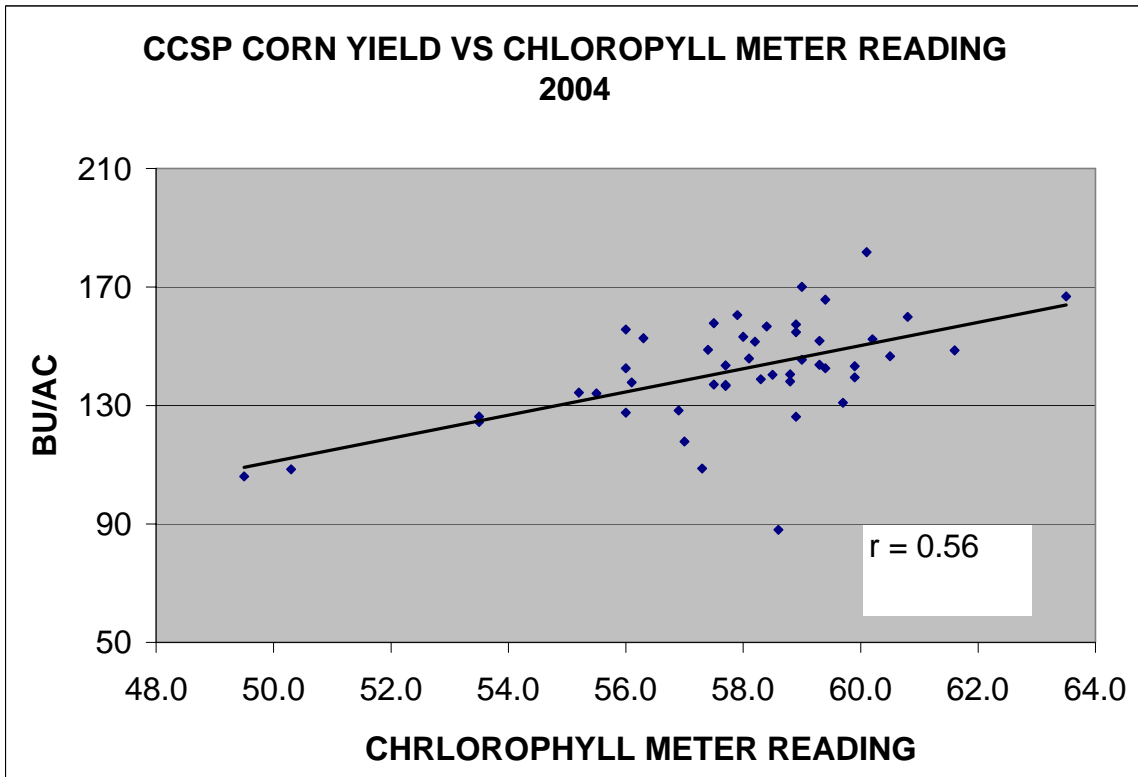


Figure 16. The relationship between ear leaf chlorophyll on August 5, 2004 and yield.

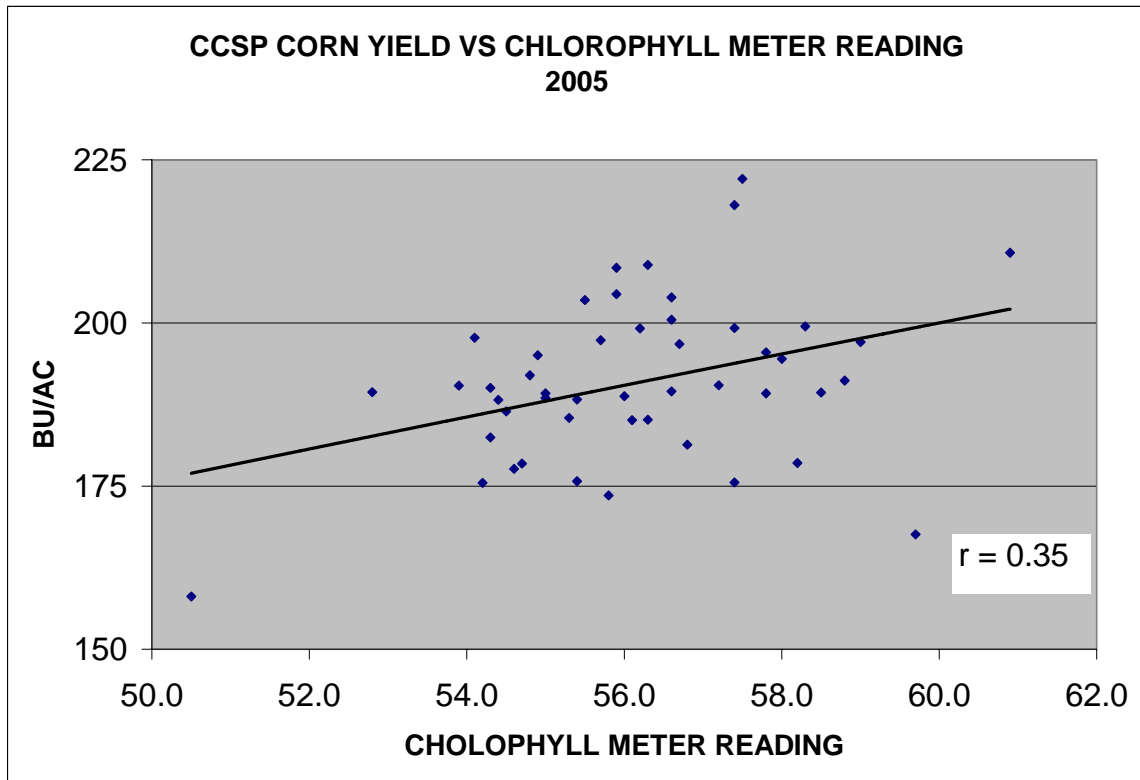


Figure 17. The relationship between ear leaf chlorophyll on August 8, 2005 and yield.

Nitrogen Required Per Bushel of Yield

Tables 4 and 5 show corn yields compared to available soil N plus fertilizer N in 2004 and 2005, respectively. 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. Corn required 0.96 lb/ac of soil plus fertilizer N per bushel of production in 2005.

Table 4. Nitrogen per bushel of corn production for total soil N plus fertilizer N plus an N credit where appropriate and fertilizer N alone in 2004.

Previous Crop	Fall soil		Yield 2004	N Credit +	
	Nitrate 2003	Fertilizer N 2004		Soil N+ Fert N	Fertilizer N
		lb/ac	bu/ac	lb/bu	lb/bu
Corn	48	118	140	1.2	0.8
Canola	49	118	154	1.1	0.8
Soybean	33	118	156	1.2	0.8
HRSW	42	118	150	1.1	0.8
HRWW	46	118	138	1.2	0.9

Table 5. Nitrogen per bushel of corn production for total soil N plus fertilizer N plus an N credit where appropriate and fertilizer N alone in 2005.

Previous Crop	Fall soil		Yield 2005	N Credit +	
	Nitrate 2004	Fertilizer N 2005		Soil N+ Fert N	Fertilizer N
		lb/ac	bu/ac	lb/ac	lb/bu
Alfalfa	11	105	217	1.0	0.5
Corn	36	148	180	1.0	0.8
Canola	36	148	197	0.9	0.8
Soybean	33	105	193	0.9	0.5
HRSW	19	160	188	1.0	0.9
HRWW	35	148	182	1.0	0.8
HRWW/Strip-till	35	148	194	0.9	0.8

Future work

Strip-till appears to be a viable option for successful no-till corn production in the Eastern Dakotas. Plans are to initiate a fertilizer N rate strip-till project in the spring of 2006. A plot diagram is shown in figure 17. A corn-soybean rotation would be used. Treatments would include N rates of 0, 50, 100 and 150 lb/ac of fertilizer N applied with strip-till in the fall and a 100 lb/ac N rate treatment applied with the planter the next spring in non-strip-tilled soil.

