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Maximizing Wheat Yields In North Dakota In A Crop Rotation System

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TITLE: Maximizing Wheat Yields in North Dakota in a Crop Rotation System

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LOCATION:

The experimental site is located in Ward County (NW¼-Sec 12-T 154N-R83W) on the North Central Experiment Station south of Minot, North Dakota. The area has a north facing slope at an elevation of 1770 feet. The soil is a Williams loam (fine-loamy, mixed typic argiboroll). Three (3) adjacent block areas were set up to accommodate the crop rotation as follows:

	Previous Crop	Year			
Block	(1981)	1982	1983	1984	1985
1	Flax	Flax	Durum	Sunflower	Flax
2	Flax	Durum	Sunflower	Flax	Durum
3	Wheat	Sunflower	Flax	Durum	Sunflower

Initial soil chemical and physical properties of the soil profiles is summarized in Table 1. Air temperature and precipitation data for the area is given in Table 13 and 14. Originally continuous monitoring soil temperature probes with recording charts were set out at the site

but malfunctioning occurred as a result of field rodents thus data was not available. Humidity data was recorded in the shelter but is not available at this time.

OBJECTIVES:

1. Maximize wheat yields in central North Dakota under a crop rotation system utilizing the best current management practices that influence ultimate yield.
2. Identify and quantify these management factors studied or combination of factors that contribute to maximum yields obtained.
3. Equate the chemical properties of the plant and soil and physical condition of the soil to the maximum yields obtained.
4. Evaluate the interaction of the management factors studied with wheat diseases.

PROCEDURE AND RESULTS:

The wheat experiment was set up in a split-split block arrangement with four replications. Individual unit plots were 24 feet x 24 feet (12 x 24 for yield measurements and 12 x 24 for plant soil and disease sampling). The two main split blocks were fertilizer treatment (F_1, F_2, F_3) and fungicide spray (S_1, S_2) with the spray treatments split by varieties (V_1, V_2). The treatments were as follows:

F_1 = Normal fertilizer rate deep placed based on soil tests and a yield goal of 35 bu/acre.

F_2 = Nitrogen and phosphorus fertilizer rates deep placed based on F_1 soil tests and a maximum yield goal of 80 bu/acre.

F_3 = Same as F_2 except a rate of K_2O broadcast as KCl was applied.

S_1 = No fungicide applied.

S_2 = Fungicide applied at head emergence and subsequently in 10 days.

V_1 = Cando durum (semidwarf).

V_2 = Vic durum (normal height).

Initial soil tests indicated adequate levels (NO_3-N = 104 lb/acre in 2 feet, P = 25 lb/acre and K = 425 lb/acre) for the F_1 fertilizer treatment. The F_2 and F_3 treatments had 100 lb N/acre and 30 lb P_2O_5/acre deep banded (7-8 inches) as a liquid prior to planting using 28-0-0 and 10-34-0. The F_3 treatment also received a broadcast application of 50 lb K_2O/acre as KCl. One week prior to planting the plots were sprayed with 1 pt/acre of Roundup (glyphosate) and 2 oz/acre Banvel (dicamba) with X-77 surfactant for initial weed burndown. The wheat was planted no-till on May 12 with a Haybuster drill with 6-inch spacing at 60 lb/acre seeding rate. The seed was treated with Vitavax 200 prior to seeding. All plots received 50 lb/acre 18-46-0 fertilizer with the seed at planting time. The concentration of N, P and K in the planted seed was 2.83, .38 and .56% respectively for Cando and 2.79, .38 and .54% for the Vic durum. The plots were sprayed on June 12 with 1 pt/acre Bronate (bromoxynil + MCPA) for broadleaf control. The fungicide Dithane M-45 was applied with a back sprayer on July 7 at a rate of 2 lb/acre just as the wheat heads were emerging from the boot stage. The second application was applied at the same rate 10 days later. Plant samples were collected at the milk to soft dough stage (July 26) for total dry matter production and nutrient analysis. The durum wheat was harvested on September 2 with a small research plot combine.

Gravimetric soil moisture samples were collected in the spring (April 22) on the wheat plots and again after harvest (September 2) to 4-foot depth (0-3, 3-6, 6-12, 12-24, 24-36 and 36-48 inch increments) to determine crop moisture use (Initial soil moisture + precipitation received - final soil moisture).

The flax area of the rotation (Block 1) was disked, field cultivated and planted with the Haybuster drill on May 22 with Culbert flax at a rate of 40 lb/acre for a yield goal of 25 bu/acre. Initial soil tests (NO_3-N = 96 lb/acre, P = 20 lb/acre and K = 380 lb/acre) indicated no fertilizer required for this yield goal. The area was sprayed with 1 pt/acre Bronate on June 12 for weed control. The flax area was harvested on September 1 and a yield of 25 bu/acre was obtained.

The sunflower area of the rotation (Block 3) was plowed and field cultivated once. Fargo (triallate) at 1 qt/acre and Treflan (trifluralin) at 1 qt/acre were applied and incorporated with two field cultivation for weed control. A yield goal of 1800 lb/acre was set and initial soil tests (NO_3-N = 101, P = 16, K = 450) indicated no fertilizer required. The sunflower seed (PAG-SF 102) was planted on May 26 in 30 inch spacing. Final plant population was 18,000 plants/acre. The sunflower area was harvested on November 17 and a final yield of 1824 lb was obtained.

Statistical analysis of the data was performed on a computer utilizing the SAS procedures with tests of significance by Ducan-Waller K-Ratio T test (Bayes LSD). These results are summarized in Table 12.

Plant Growth and Yield

Data on dry matter production, plant height, yield, test weight and kernal weight are summarized in Tables 2, 3 and 5. Plant dry matter was significantly increased by the F_2 and F_3 maximum fertilizer treatments and showed significant interactions with the Fertilizer x Spray and Fertilizer x Spray x Variety. Grain yields followed the same sequence, however, although yields were not significant at the .05 level, the potassium treatment (F_3) showed the greatest response when averaged over

all the treatment variables. It is interesting to note that the Cando variety (semi-dwarf) showed a decrease in yield when the fungicide was applied whereas the Vic variety (normal height) showed a positive yield response to fungicide spray. Both test weight and seed weight were significantly decreased by the high fertilizer rates with a Fertilizer x Variety interaction, the Cando (V_1) variety affected substantially more than the Vic (V_2) variety. This tends to suggest that, although moisture appeared to be adequate, it was lacking in sufficient amounts to fill out the kernals at the maximum fertilizer rates, unless maturity delay was a contributing factor. Moisture use by the durum crop (Table 4) was significantly higher on the two maximum fertilizer treatments but not influenced by the other variables or their interactions. Plant height was significantly increased by the two maximum fertilizer treatments and showed a significant Variety x Fertilizer interaction, the normal height durum (Vic) increased more than the semi-dwarf (Cando) which showed an increase in height only with the addition of potassium fertilizer.

Foliar and Root Rot Diseases

The leaf spot ratings are summarized in Table 4. There were distinct differences in tan spot (caused by Pyrenophora trichostoma fungus) severity on the flag leaves among plots. However, these differences do not fit any pattern but seem to fluctuate at random throughout the fertilizer, variety, and protective fungicide treatments. These ratings were made when the plants were at early to late dough. To clearly distinquish spotting significant ratings are usually made at late milk to early dough, however in this case spotting was still distinct on August 9. Tan spot severity was at the upper end of the 0-9

rating scale, so a percent of flag leaf damaged scale was used. Disease did not develop early in these 48 plots. At early heading (following the first fungicide spray) spotting (principally tan spot) was appearing only on the bottom most plant leaves in trace amounts. By August 9 distinct differences in spotting would have been expected between sprayed and unsprayed plots. Instead the differences seem to be occurring at random throughout the plots. The only significant differences in ratings was observed on the Fertilizer x Variety interaction with the disease ratings higher on the Vic variety (normal height) at the two maximum fertilizer rates.

Root rot rating was begun on July 20. Immediate difficulty was encountered as only a small proportion of plants had usable (>1 inch) sub-crown internodes because of shallow seeding. All rateable plants came from a few rows--probably where the drill coulters were slightly deeper than the rest. By the time one complete replicate was examined, it was obvious that this problem was not limited but throughout the plot. Since the validity of the sub-crown internode indexing method for evaluating common root rot relies on a random sample of multiple drill rows, any data collected on root rot occurrence in these plots would be seriously in question. Upon examination of the roots an obvious presence of Fusarium--another soil fungus was noted which can incite or enhance root/crown rot. Evaluation of Fusarium was not part of the initial plan for this experiment but its presence suggests that it might be important here and should be noted. This potentially pathogenic second fungus would further confuse any results. For these reasons no data is regarded on root rot.

Plant Nutrient Concentrations and Uptake

Plant samples at the soft dough stage of the Cando variety (V_1) had significantly higher N and P concentration than the Vic variety (V_2). Both maximum fertilizer rates increased K percent in the durum plants over the standard F_1 treatment. Plant uptake of N, P and K were significantly higher when maximum fertilizer rates were applied. P uptake by the Cando variety was higher than the Vic variety.

The K concentration in the Cando durum seed was higher than the Vic variety. Uptake of N and K by the seed was enhanced by the application of potassium fertilizer. Also a significant Variety x Spray interaction occurred on N uptake where the seed of the variety Cando decreased when sprayed with fungicide but increased with spraying of the Vic variety.

SUMMARY:

The 1982 growing season appeared to be ideal for maximizing yields as 11.58 inches of precipitation was received from planting to harvest and air temperatures were moderately cool as very few daily high temperatures reached 90 degrees (7 days in August). The maximum yield obtained on individual plots was 81.3 bu/acre and the lowest 45.3 bu/acre with an average for the area of 59.1 bu/acre. The maximum wheat yield ever recorded at this station was 70 bu/acre, thus some factor was limiting yield. Some variation occurred among treatments which lowered the yield levels which may have resulted from previous management of this site. The apparent decrease in yield of the Cando variety with spraying certainly had an effect on the overall analysis of the data. In another trial at this location, fungicide treatment related to yield increase with Vic and yield decrease with Cando. The lack of uniform control of foliar diseases with the fungicide also contributed to yield

levels, assuming the disease was significant to cause yield losses. The high soil fertility levels at this site lowered the response that would normally be expected, however, the nutrient levels measured in the plants suggested that these nutrients were not the factor limiting yield. The low amount of precipitation during late July and early August, which was during the grain filling period, probably contributed most to not maximizing yields as exhibited by the lower test and seed weights, especially on the Cando variety.

FUTURE PLANS:

The maximum yield trial will be continued in 1983 according to the crop rotation sequences and methods outlined in the original proposal with only a few minor changes. The wheat will be planted deeper to provide a rateable sub-crown internode for root rot evaluation. Also Fusarium will be added to the root/crown rot ratings which can be readily accomplished within the present experimental framework. The spraying of plots with fungicide for leaf spot control using larger field sprayers is being considered instead of hand back sprayers to try and obtain uniform spray coverage (assuming this was the reason for lack of uniform control in 1982). Additional monitoring of humidity within the various variety canopies is being considered, assuming reliable equipment is available, to relate to disease incidence and control. Evaluation of the percent hard and vitreous kernals of the durum seed is being considered as there appears to be a relationship between this test and yield in relation to nitrogen deficiency.

The data as presented is available for use by PPI/FAR, the project supporter. Currently there are no plans to do an economic evaluation of yearly data, however, an economic evaluation is being considered for the project after the crop rotation sequence is complete.

Table 1. Initial Chemical and Physical Properties in the Soil Profile by Block Areas for the Maximum Wheat Yield Trial in A Crop Rotation System: Minot, ND - 1982.

Soil Property	Soil Profile Depth (inches)					
	0-3	3-6	6-12	12-24	24-36	36-48
			Block 1			
NO_3-N (lb/acre)	7.5	9.2	31.5	90.5	67.0	36.0
Organic Matter (%)	3.00	2.95	1.80	1.05	0.55	0.32
Total N (%)	.168	.167	.115	.074	.054	.040
P (lb/acre)	24.0	29.2	6.00	2.25	1.00	1.75
K (lb/acre)	430	436	316	220	193	205
SO_4-S (ppm)	5.0	5.0	6.0	6.0	8.0	9.2
Zn^4 (ppm)	1.15	1.10	0.30	0.18	0.18	0.68
Fe (ppm)	48.0	54.0	26.0	9.7	5.8	5.6
Mn (ppm)	33.4	32.3	22.6	8.4	3.3	2.9
Cu (ppm)	.75	.75	.75	.82	.72	.70
pH (1:1)	6.78	7.12	7.78	8.55	8.10	8.10
Bulk Density (g/cm^3)	1.27	1.35	1.42	1.39	1.48	1.51
			Block 2			
NO_3-N (lb/acre)	8.0	11.5	39.2	66.0	31.5	20.0
Organic Matter (%)	3.52	3.75	2.12	1.22	0.78	0.48
Total N (%)	.188	.194	.128	.086	.057	.039
P (lb/acre)	24.8	30.8	5.7	2.2	1.8	1.5
K (lb/acre)	491	498	380	287	252	242
SO_4-S (ppm)	5.5	4.2	6.0	6.8	25.2	32.8
Zn^4 (ppm)	1.48	1.42	0.25	0.10	0.12	0.35
Fe (ppm)	59.9	58.5	24.4	11.6	6.9	5.2
Mn (ppm)	41.5	40.6	20.0	10.4	4.2	2.9
Cu (ppm)	.80	.78	.72	.78	.80	2.3
pH (1:1)	6.20	6.18	6.52	7.35	8.28	8.70
Bulk Density (g/cm^3)	1.17	1.26	1.47	1.55	1.48	1.52
			Block 3			
NO_3-N (lb/acre)	8.2	14.8	34.5	58.5	47.0	29.5
Organic Matter (%)	4.00	3.82	2.20	1.38	0.80	0.60
Total N (%)	.202	.194	.127	.088	.042	.027
P (lb/acre)	26.5	13.0	4.8	3.2	3.2	1.8
K (lb/acre)	639	476	430	316	261	225
SO_4-S (ppm)	15.8	7.0	6.0	13.2	25.0	26.8
Zn^4 (ppm)	1.90	1.60	0.50	0.55	0.35	0.35
Fe (ppm)	58.6	60.5	31.2	24.8	13.8	7.4
Mn (ppm)	41.8	34.1	19.8	14.4	4.8	4.1
Cu (ppm)	.85	.80	.80	.90	.90	.90
pH (1:1)	6.60	6.40	6.70	6.95	7.90	8.42
Bulk Density (g/cm^3)	1.09	1.25	1.31	1.30	1.46	1.52

Table 2. Grain Yield and Grain Test Weight of Durum Wheat As Influenced by Fertilizer Treatment, Variety and Fungicide Spray: Minot, ND - 1982.

Fertilizer Treatment[1]	Fungicide Spray Treatment[2]						Variety[3]		
	S_1			S_2					
	V_1	V_2	Ave.	V_1	V_2	Ave.	V_1	V_2	Ave.
	Grain Yield (bu/acre)								
F_1	58.4	55.8	57.1	52.4	59.2	55.8	55.4	57.5	56.4
F_2	62.6	56.5	59.6	50.9	61.1	56.0	56.8	58.8	57.8
F_3	61.9	61.4	61.7	62.3	66.7	64.5	62.1	64.1	63.1
Ave.	61.0	57.9	59.4	55.2	62.3	58.8	58.1	60.1	
	Grain Test Weight (lb/bu)								
F_1	59.4	61.2	60.3	58.9	60.6	59.8	59.1	60.9	60.0
F_2	56.4	60.2	58.3	56.2	60.0	58.1	56.3	60.1	58.2
F_3	58.0	60.6	59.3	57.6	60.5	59.1	57.8	60.5	59.2
Ave.	57.9	60.6	59.3	57.6	60.4	59.0	57.8	60.5	

[1] Fertilizer treatment
- F_1 = Normal fertilizer rate based on soil tests and yield goal of 35 bu/acre (none required in 1982).
- F_2 = Nitrogen (100 lb N/acre) and phosphorus (30 lb P_2O_5/acre) fertilizer rate deep placed based on F_1 soil tests and maximum yield goal of 80 bu/acre.
- F_3 = Same as F_2 except 50 lb/acre K_2O fertilizer applied broadcast as KCl.

Note: all treatments received 50 lb/acre 18-46-0 applied with the seed at planting.

[2] Fungicide spray treatment
- S_1 = No fungicide applied.
- S_2 = Fungicide applied in two applications at recommended rates of Dithane M-45 (2 lb/A). (First applied July 7 and second 10 days later).

[3] Variety
- V_1 = Cando durum.
- V_2 = Vic durum.

Table 3. Plant Height and Seed Weight Of Durum Wheat As Influenced by Fertilizer Treatment, Variety and Fungicide Spray: Minot, ND - 1982.

Fertilizer Treatment[1]	Fungicide Spray Treatment[2]						Variety[3]		
	S_1			S_2					
	V_1	V_2	Ave.	V_1	V_2	Ave.	V_1	V_2	Ave.
	Plant Height (inches)								
F_1	27.0	35.7	31.3	28.5	37.5	33.0	27.8	36.6	32.2
F_2	27.8	38.6	33.2	28.5	40.2	34.4	28.2	39.4	33.8
F_3	29.8	39.1	34.4	28.9	41.4	35.2	29.4	40.3	34.8
Ave.	28.2	37.8	33.0	28.7	39.7	34.2	28.4	38.8	
	Seed Weight (gram/1000)								
F_1	35.4	45.0	40.2	37.6	45.6	41.6	36.5	45.3	40.9
F_2	31.2	41.4	36.3	30.6	42.2	36.4	30.9	41.8	36.4
F_3	34.8	44.1	39.5	33.1	43.6	38.4	34.0	43.9	38.9
Ave.	33.8	43.5	38.6	33.8	43.8	38.8	33.8	43.7	

[1] Fertilizer treatment
- F_1 = Normal fertilizer rate based on soil tests and yield goal of 35 bu/acre (none required in 1982).
- F_2 = Nitrogen (100 lb N/acre) and phosphorus (30 lb P_2O_5/acre) fertilizer rate deep placed based on F_1 soil tests and maximum yield goal of 80 bu/acre.
- F_3 = Same as F_2 except 50 lb/acre K_2O fertilizer applied broadcast as KCl.

Note: all treatments received 50 lb/acre 18-46-0 applied with the seed at planting.

[2] Fungicide spray treatment
- S_1 = No fungicide applied.
- S_2 = Fungicide applied in two applications at recommended rates of Dithane M-45 (2 lb/A). (First applied July 7 and second 10 days later).

[3] Variety
- V_1 = Cando durum.
- V_2 = Vic durum.

Table 4. Leaf Spot Disease Rating and Moisture Use of Durum Wheat As Influenced by Fertilizer Treatment, Variety and Fungicide Spray: Minot, ND - 1982.

Fertilizer Treatment[1]	Fungicide Spray Treatment[2]						Variety[3]		
	S_1			S_2					
	V_1	V_2	Ave.	V_1	V_2	Ave.	V_1	V_2	Ave.
	Leaf Disease Rating (% Flag Leaf Damaged)[4]								
F_1	55.0	67.5	61.2	90.0	55.0	72.5	72.5	61.2	66.9
F_2	82.5	90.0	86.2	95.0	77.5	86.2	88.8	83.8	86.2
F_3	55.0	95.0	75.0	87.5	82.5	85.0	71.2	88.8	80.0
Ave.	64.2	84.2	74.2	90.8	71.7	81.2	77.5	77.9	
	Moisture Use (inches)[5]								
F_1	18.6	18.2	18.4	18.8	17.4	18.1	18.7	17.8	18.3
F_2	19.2	18.4	18.8	18.9	18.7	18.8	19.1	18.6	18.8
F_3	18.9	18.8	18.8	19.0	18.6	18.8	19.0	18.7	18.8
Ave.	18.9	18.5	18.7	18.9	18.2	18.6	18.9	18.3	

[1] Fertilizer treatment
- F_1 = Normal fertilizer rate based on soil tests and yield goal of 35 bu/acre (none required in 1982).
- F_2 = Nitrogen (100 lb N/acre) and phosphorus (30 lb P_2O_5/acre) fertilizer rate deep placed based on F_1 soil tests and maximum yield goal of 80 bu/acre.
- F_3 = Same as F_2 except 50 lb/acre K_2O fertilizer applied broadcast as KCl.

Note: all treatments received 50 lb/acre 18-46-0 applied with the seed at planting.

[2] Fungicide spray treatment
- S_1 = No fungicide applied.
- S_2 = Fungicide applied in two applications at recommended rates of Dithane M-45 (2 lb/A). (First applied July 7 and second 10 days later).

[3] Variety
- V_1 = Cando durum.
- V_2 = Vic durum.

[4] Tan spot severity rating on August 9 when plants were at early to late dough stage.

[5] Moisture use by the crop which is determined by equation: MU = (initial soil moisture + precipitation - final soil moisture) where soil moisture determined gravimetrically in 4-foot profile and precipitation is the amount received between initial and final soil sampling dates.

Table 5. Plant Dry Matter and Seed Dry Matter of Durum Wheat As Influenced By Fertilizer Treatment, Variety and Fungicide Spray: Minot, ND - 1982.

Fertilizer Treatment[1]	Fungicide Spray Treatment[2]						Variety[3]		
	S_1			S_2					
	V_1	V_2	Ave.	V_1	V_2	Ave.	V_1	V_2	Ave.
	Plant Dry Matter (lb/acre) - Soft Dough Stage								
F_1	5570	5627	5599	5152	5925	5539	5361	5776	5569
F_2	6213	7114	6664	7781	7393	7587	6997	7254	7125
F_3	7316	7666	7491	6822	7450	7136	7069	7558	7314
Ave.	6366	6803	6584	6585	6922	6754	6476	6863	
	Seed Dry Matter (lb/acre)								
F_1	3065	2927	2996	2751	3108	2930	2908	3017	2963
F_2	3266	2968	3127	2672	3208	2940	2979	3087	3034
F_3	3251	3226	3239	3272	3502	3387	3262	3364	3313
Ave.	3201	3040	3120	2898	3272	3085	3050	3156	

[1] Fertilizer treatment
- F_1 = Normal fertilizer rate based on soil tests and yield goal of 35 bu/acre (none required in 1982).
- F_2 = Nitrogen (100 lb N/acre) and phosphorus (30 lb P_2O_5/acre) fertilizer rate deep placed based on F_1 soil tests and maximum yield goal of 80 bu/acre.
- F_3 = Same as F_2 except 50 lb/acre K_2O fertilizer applied broadcast as KCl.

Note: all treatments received 50 lb/acre 18-46-0 applied with the seed at planting.

[2] Fungicide spray treatment
- S_1 = No fungicide applied.
- S_2 = Fungicide applied in two applications at recommended rates of Dithane M-45 (2 lb/A). (First applied July 7 and second 10 days later).

[3] Variety
- V_1 = Cando durum.
- V_2 = Vic durum.

Table 6. Nitrogen Concentration and Uptake by Durum Wheat Plants As Influenced by Fertilizer Treatment, Variety and Fungicide Spray: Minot, ND - 1982.

Fertilizer Treatment[1/]	Fungicide Spray Treatment[2/]						Variety[3/]		
	S_1			S_2					
	V_1	V_2	Ave.	V_1	V_2	Ave.	V_1	V_2	Ave.
	Plant N Concentration (%) - Soft Dough Stage								
F_1	1.85	1.50	1.67	1.57	1.56	1.57	1.71	1.53	1.62
F_2	1.95	1.65	1.80	1.90	1.66	1.78	1.92	1.65	1.79
F_3	1.83	1.51	1.67	1.75	1.62	1.68	1.79	1.56	1.68
Ave.	1.88	1.55	1.71	1.74	1.61	1.68	1.81	1.58	
	Plant N Uptake (lb/acre) - Soft Dough Stage								
F_1	102.9	83.5	93.2	79.4	92.7	86.0	91.2	88.1	89.6
F_2	121.3	117.2	119.3	148.3	122.6	135.5	134.8	119.9	127.4
F_3	133.3	115.9	124.6	120.3	120.4	120.4	126.8	118.2	122.5
Ave.	119.2	105.5	112.4	116.0	111.9	114.0	117.6	108.7	

[1/] Fertilizer treatment
- F_1 = Normal fertilizer rate based on soil tests and yield goal of 35 bu/acre (none required in 1982).
- F_2 = Nitrogen (100 lb N/acre) and phosphorus (30 lb P_2O_5/acre) fertilizer rate deep placed based on F_1 soil tests and maximum yield goal of 80 bu/acre.
- F_3 = Same as F_2 except 50 lb/acre K_2O fertilizer applied broadcast as KCl.

Note: all treatments received 50 lb/acre 18-46-0 applied with the seed at planting.

[2/] Fungicide spray treatment
- S_1 = No fungicide applied.
- S_2 = Fungicide applied in two applications at recommended rates of Dithane M-45 (2 lb/A). (First applied July 7 and second 10 days later).

[3/] Variety
- V_1 = Cando durum.
- V_2 = Vic durum.

Table 7. Phosphorus Concentration and Uptake by Durum Wheat Plants As Influenced by Fertilizer Treatment, Variety and Fungicide Spray: Minot, ND - 1982.

Fertilizer Treatment[1]	Fungicide Spray Treatment[2]						Variety[3]		
	S_1			S_2					
	V_1	V_2	Ave.	V_1	V_2	Ave.	V_1	V_2	Ave.
	Plant P Concentration (%) - Soft Dough Stage								
F_1	.260	.220	.240	.252	.230	.241	.256	.225	.241
F_2	.265	.222	.244	.245	.215	.230	.255	.219	.237
F_3	.248	.200	.224	.245	.202	.224	.246	.201	.224
Ave.	.258	.214	.236	.248	.216	.232	.252	.215	
	Plant P Uptake (lb/acre) - Soft Dough Stage								
F_1	14.5	12.4	13.4	13.0	13.6	13.3	13.8	13.0	13.4
F_2	16.5	15.8	16.2	19.1	16.1	17.6	17.8	16.0	16.9
F_3	17.9	15.1	16.5	16.7	15.1	15.9	17.3	15.1	16.2
Ave.	16.3	14.4	15.4	16.3	14.9	15.6	16.3	14.5	

[1] Fertilizer treatment
- F_1 = Normal fertilizer rate based on soil tests and yield goal of 35 bu/acre (none required in 1982).
- F_2 = Nitrogen (100 lb N/acre) and phosphorus (30 lb P_2O_5/acre) fertilizer rate deep placed based on F_1 soil tests and maximum yield goal of 80 bu/acre.
- F_3 = Same as F_2 except 50 lb/acre K_2O fertilizer applied broadcast as KCl.

Note: all treatments received 50 lb/acre 18-46-0 applied with the seed at planting.

[2] Fungicide spray treatment
- S_1 = No fungicide applied.
- S_2 = Fungicide applied in two applications at recommended rates of Dithane M-45 (2 lb/A). (First applied July 7 and second 10 days later).

[3] Variety
- V_1 = Cando durum.
- V_2 = Vic durum.

Table 8. Potassium Concentration and Uptake by Durum Wheat Plants As Influenced by Fertilizer Treatment, Variety and Fungicide Spray: Minot, ND - 1982.

Fertilizer Treatment[1]	Fungicide Spray Treatment[2]						Variety[3]		
	S_1			S_2					
	V_1	V_2	Ave.	V_1	V_2	Ave.	V_1	V_2	Ave.
	Plant K Concentration (%) - Soft Dough Stage								
F_1	1.91	2.00	1.96	1.97	2.04	2.00	1.94	2.02	1.98
F_2	2.61	2.12	2.36	2.36	2.55	2.46	2.48	2.33	2.41
F_3	2.79	2.27	2.53	2.46	2.40	2.43	2.63	2.33	2.48
Ave.	2.44	2.13	2.28	2.26	2.33	2.30	2.35	2.23	
	Plant K Uptake (lb/acre) - Soft Dough Stage								
F_1	107.8	112.6	110.2	101.3	122.3	111.8	104.5	117.5	111.0
F_2	162.3	151.3	156.8	185.1	190.0	187.6	173.7	170.7	172.2
F_3	205.7	174.0	189.8	168.8	178.6	173.7	187.3	176.3	181.8
Ave.	158.6	146.0	152.3	151.7	163.6	157.7	155.2	154.8	

[1] Fertilizer treatment
- F_1 = Normal fertilizer rate based on soil tests and yield goal of 35 bu/acre (none required in 1982).
- F_2 = Nitrogen (100 lb N/acre) and phosphorus (30 lb P_2O_5/acre) fertilizer rate deep placed based on F_1 soil tests and maximum yield goal of 80 bu/acre.
- F_3 = Same as F_2 except 50 lb/acre K_2O fertilizer applied broadcast as KCl.

Note: all treatments received 50 lb/acre 18-46-0 applied with the seed at planting.

[2] Fungicide spray treatment
- S_1 = No fungicide applied.
- S_2 = Fungicide applied in two applications at recommended rates of Dithane M-45 (2 lb/A). (First applied July 7 and second 10 days later).

[3] Variety
- V_1 = Cando durum.
- V_2 = Vic durum.

Table 9. Nitrogen Concentration and Uptake by Durum Wheat Seed As Influenced by Fertilizer Treatment, Variety and Fungicide Spray: Minot, ND - 1982.

Fertilizer Treatment[1]	Fungicide Spray Treatment[2]						Variety[3]		
	S_1			S_2					
	V_1	V_2	Ave.	V_1	V_2	Ave.	V_1	V_2	Ave.
	Seed N Concentration (%)								
F_1	2.44	2.55	2.50	2.47	2.57	2.52	2.46	2.56	2.51
F_2	2.45	2.60	2.53	2.61	2.62	2.62	2.53	2.61	2.57
F_3	2.50	2.65	2.57	2.54	2.55	2.55	2.52	2.60	2.56
Ave.	2.46	2.60	2.53	2.54	2.58	2.56	2.50	2.59	
	Seed N Uptake (lb/acre)								
F_1	74.5	74.7	74.6	67.5	79.7	73.6	71.0	77.2	74.1
F_2	79.3	77.1	78.2	69.8	83.8	76.8	74.6	80.4	77.5
F_3	80.3	85.6	83.0	83.0	89.3	86.1	81.7	87.4	84.5
Ave.	78.0	79.1	78.6	73.4	84.2	78.8	75.7	81.7	

[1] Fertilizer treatment
- F_1 = Normal fertilizer rate based on soil tests and yield goal of 35 bu/acre (none required in 1982).
- F_2 = Nitrogen (100 lb N/acre) and phosphorus (30 lb P_2O_5/acre) fertilizer rate deep placed based on F_1 soil tests and maximum yield goal of 80 bu/acre.
- F_3 = Same as F_2 except 50 lb/acre K_2O fertilizer applied broadcast as KCl.

Note: all treatments received 50 lb/acre 18-46-0 applied with the seed at planting.

[2] Fungicide spray treatment
- S_1 = No fungicide applied.
- S_2 = Fungicide applied in two applications at recommended rates of Dithane M-45 (2 lb/A). (First applied July 7 and second 10 days later).

[3] Variety
- V_1 = Cando durum.
- V_2 = Vic durum.

Table 10. Phosphorus Concentration and Uptake by Durum Wheat Seed As Influenced by Fertilizer Treatment, Variety and Fungicide Spray: Minot, ND - 1982.

Fertilizer Treatment[1/]	Fungicide Spray Treatment[2/]						Variety[3/]		
	S_1			S_2					
	V_1	V_2	Ave.	V_1	V_2	Ave.	V_1	V_2	Ave.
	Seed P Concentration (%)								
F_1	.378	.365	.371	.370	.362	.366	.374	.364	.369
F_2	.388	.358	.372	.380	.372	.376	.384	.365	.374
F_3	.368	.350	.359	.382	.365	.374	.375	.358	.366
Ave.	.378	.358	.368	.378	.367	.372	.378	.362	
	Seed P Uptake (%)								
F_1	11.5	10.7	11.1	10.2	11.3	10.8	10.9	11.0	10.9
F_2	12.7	10.6	11.6	10.2	11.9	11.1	11.4	11.2	11.3
F_3	12.0	11.3	11.6	12.5	12.8	12.7	12.2	12.0	12.1
Ave.	12.1	10.8	11.4	11.0	12.0	11.5	11.5	11.4	

[1/] Fertilizer treatment
- F_1 = Normal fertilizer rate based on soil tests and yield goal of 35 bu/acre (none required in 1982).
- F_2 = Nitrogen (100 lb N/acre) and phosphorus (30 lb P_2O_5/acre) fertilizer rate deep placed based on F_1 soil tests and maximum yield goal of 80 bu/acre.
- F_3 = Same as F_2 except 50 lb/acre K_2O fertilizer applied broadcast as KCl.

Note: all treatments received 50 lb/acre 18-46-0 applied with the seed at planting.

[2/] Fungicide spray treatment
- S_1 = No fungicide applied.
- S_2 = Fungicide applied in two applications at recommended rates of Dithane M-45 (2 lb/A). (First applied July 7 and second 10 days later).

[3/] Variety
- V_1 = Cando durum.
- V_2 = Vic durum.

Table 11. Potassium Concentration and Uptake by Durum Wheat Seed As Influenced by Fertilizer Treatment, Variety and Fungicide: Minot, ND - 1982.

Fertilizer Treatment[1/]	Fungicide Spray Treatment[2/]						Variety[3/]		
	S_1			S_2					
	V_1	V_2	Ave.	V_1	V_2	Ave.	V_1	V_2	Ave.
	Seed K Concentration (%)								
F_1	.565	.530	.548	.578	.505	.541	.571	.518	.544
F_2	.590	.505	.548	.592	.530	.561	.591	.518	.554
F_3	.558	.518	.538	.582	.538	.560	.570	.528	.549
Ave.	.571	.518	.544	.584	.524	.554	.578	.521	
	Seed K Uptake (lb/acre)								
F_1	17.2	15.5	16.4	15.9	15.7	15.8	16.6	15.6	16.1
F_2	19.2	14.9	17.1	15.9	17.0	16.4	17.5	16.0	16.7
F_3	18.2	16.7	17.5	19.1	18.9	19.0	18.6	17.8	18.2
Ave.	18.2	15.7	17.0	16.9	17.2	17.1	17.6	16.4	

[1/] Fertilizer treatment
- F_1 = Normal fertilizer rate based on soil tests and yield goal of 35 bu/acre (none required in 1982).
- F_2 = Nitrogen (100 lb N/acre) and phosphorus (30 lb P_2O_5/acre) fertilizer rate deep placed based on F_1 soil tests and maximum yield goal of 80 bu/acre.
- F_3 = Same as F_2 except 50 lb/acre K_2O fertilizer applied broadcast as KCl.

Note: all treatments received 50 lb/acre 18-46-0 applied with the seed at planting.

[2/] Fungicide spray treatment
- S_1 = No fungicide applied.
- S_2 = Fungicide applied in two applications at recommended rates of Dithane M-45 (2 lb/A). (First applied July 7 and second 10 days later).

[3/] Variety
- V_1 = Cando durum.
- V_2 = Vic durum.

Table 12. Tests of Significance For Variables Measured In The Maximum Durum Wheat Yield Study As Influenced by Fertilizer Treatment, Variety, Fungicide Spray and Subsequent Interactions: Minot, ND - 1982.

Variable		Source						
		Fertilizer	Spray	Variety	Variety x Spray	Fertilizer x Spray	Fertilizer x Variety	Fertilizer x Spray x Variety
Grain Yield (bu/acre)		NS	NS	NS	NS	4.09	NS	6.21
Grain Test Weight (lb/bu)		0.84	NS	***	NS	NS	0.74	NS
Plant Height (inches)		1.36	NS	***	NS	NS	0.94	1.56
Foliar Disease Rating (number)		NS	NS	NS	NS	NS	19.8	NS
Plant Dry Matter (lb/acre)		1304	NS	NS	NS	554	NS	846
Plant Nutrients								
Concentration (%)	N	NS	NS	**	.155	NS	NS	NS
	P	NS	NS	***	NS	NS	NS	NS
	K	.066	NS	NS	NS	NS	NS	NS
Uptake (lb/acre)	N	23.8	NS	NS	NS	NS	NS	29.3
	P	3.16	NS	*	NS	NS	NS	2.83
	K	42.1	NS	NS	NS	29.7	NS	NS
Seed Dry Matter (lb/acre)		NS	NS	NS	NS	215	NS	326
Seed Nutrients								
Concentration (%)	N	NS	NS	NS	NS	.082	NS	NS
	P	NS	NS	NS	NS	NS	NS	NS
	K	NS	NS	**	NS	NS	NS	NS
Uptake (lb/acre)	N	7.16	NS	*	8.31	NS	NS	NS
	P	NS	NS	NS	NS	1.18	NS	NS
	K	1.60	NS	NS	NS	1.58	NS	2.32
Kernal Weight (gm/1000)		2.79	NS	***	NS	NS	NS	NS
Moisture Use (inches)		0.48	NS	NS	NS	NS	NS	NS

1/ Statistical analysis run on the computer using SAS procedures. Tests of significance were determined by Waller-Duncan K-Ratio T Test (Bayes LSD) at the .05 level of significance. NS = non significant, * = comparing only two means with significance at .05 level (** = .01 level and *** = .001 level), Number value = unit of difference required to be significant at the .05 level according to Bayes LSD.

Table 13. Daily Growing Season Precipitation Received at the Maximum Wheat Yield Trial: Minot, ND - 1982.

Day	Month						
	April	May	June	July	August	September	October
	inches						
1					T		.07
2							.31
3	.08						T
4	T			.07		T	
5	.12		.04	.25			T
6			T		.23		1.30
7	T	T	1.05	T	.14		.09
8	T		.13	.07			
9	T	.38	1.82	.70			.57
10	T	.46	.02	T			.60
11		.02		T		T	.48
12	T			T			.04
13		.04		.52	.11	.02	.01
14	.10	T	.02				
15	.07	.78			.02		
16	.03	.46	.02		T		
17		.63	.13	T			T
18		T	.02		.05		.17
19			.03	T	.09		.04
20							
21					T		
22		T			T		
23				.04	.03		
24		.70	.03	T	.01		
25							
26					T	T	
27			.09	.19	T	.06	
28			1.50		T	2.13	.57
29		.04	.08		T	.49	.22
30	.03	T			.17	.01	
31		.01			.36		
Total	.43	3.52	4.98	1.84	1.21	2.71	4.47

Table 14. Daily Growing Season Maximum and Minimum Air Temperatures at the Maximum Wheat Yield Trial: Minot, ND - 1982.

Day	Month													
	April		May		June		July		August		September		October	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
	°F													
1	33	19	67	37	66	38	73	48	91	57	77	48	45	29
2	35	17	77	43	68	41	80	54	93	69	73	46	42	36
3	18	3	82	54	71	44	82	59	87	53	76	46	49	36
4	22	0	88	47	71	48	86	62	84	55	84	52	48	34
5	22	7	65	35	76	50	87	59	85	55	81	45	66	36
6	24	6	61	35	79	55	79	55	90	57	70	42	39	31
7	31	19	42	26	67	47	72	50	88	63	79	47	36	31
8	31	20	50	25	65	45	74	48	80	52	88	48	49	33
9	38	26	45	27	50	42	77	55	70	44	92	56	46	39
10	35	13	44	35	68	40	73	55	70	43	94	58	46	35
11	37	17	45	34	72	42	80	57	72	42	97	53	42	33
12	57	35	54	39	72	45	82	60	81	50	74	51	42	37
13	57	31	58	45	75	46	86	58	82	51	74	41	51	34
14	63	36	59	47	80	52	78	58	86	53	61	41	63	34
15	71	34	70	47	76	49	79	58	90	57	54	29	72	37
16	55	33	54	47	78	55	86	64	81	54	61	30	69	37
17	53	29	55	48	81	47	89	53	88	57	66	38	64	42
18	59	32	56	47	55	47	75	49	90	58	68	39	71	40
19	65	31	62	49	66	48	79	56	94	59	79	39	41	30
20	48	24	65	46	73	45	86	56	83	54	57	31	37	29
21	50	28	59	43	74	48	86	56	86	54	65	33	41	24
22	55	35	67	44	75	51	79	55	91	51	73	42	55	27
23	72	44	71	45	84	54	82	58	75	44	76	48	62	30
24	83	48	74	43	83	50	88	63	70	44	72	32	67	49
25	77	37	68	43	71	46	84	60	73	44	65	32	68	41
26	46	26	73	44	74	47	83	58	60	36	71	46	70	38
27	59	28	78	51	83	55	92	53	64	32	68	42	67	40
28	63	38	67	54	81	56	80	56	59	31	52	46	54	43
29	64	39	75	39	63	46	81	53	81	51	52	34	45	30
30	52	36	61	36	68	47	77	51	76	47	49	29	45	25
31			56	37			86	53	53	42			47	28