1987.

INTERPRETIVE SUMMARY

Interaction of Fertilizer N and P and Snow Conservation on Yield of Spring and Winter Wheat in Southeastern Saskatchewan /C. Campbell

Wheat production in the driest part of the prairies is primarily influenced by precipitation received during the growing season (range 73 to 205 mm during the 6 trial years). Stubble cut to different heights trapped snow equivalent to 11 mm of soil moisture (range 0-27 mm). The additional moisture was more efficiently utilized than moisture retained through conventional fallow practices although its effect on N use and yield diminished as growing season precipitation increased. The level of N that maximized yields varied from 85 kg/ha in dry years to 125 kg/ha in wet years. The additional snow trapped moisture raised slightly the N rate required to maximize yields. Generally, N placement and timing of application had little to no effect regardless of snow trapping or general soil moisture content. P rate did not effect yield regardless of moisture regimes although soil levels were high. Economic evaluation of the zero-till with snow trapping and fertilizer management systems indicate that in dry years fall broadcast N was most profitable, in wet years net returns were independant of N timing and placement, while in moderate precipitation years broadcast N was the least profitable. Net returns to snow trapping increased from $0/ha in wet years to $4-8/ha in moderate precipitation years, to $15-25/ha in dry years.

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1987

ANNUAL REPORT

(Final Year Report)

PPI-SUPPORTED PROJECT

Agriculture Canada Research Station
Swift Current, Saskatchewan

1. Title of Project ... "Interaction of Fertilizer N and P and Snow Conservation on Yield of Spring and Winter Wheat in Southwestern Saskatchewan"

2. Project Leader & Cooperators ... C.A. Campbell (Project Leader)
F. Selles (Cooperator)
B.G. McConkey (Cooperator)
R.P. Zentner (Cooperator)
W. Nicholaichuk
V.O. Biederbeck
M. Schnitzer

3. Location of Research Demonstration ... Agriculture Canada Research Station, Swift Current, Saskatchewan

4. Objectives of the Study ...

4.1 To determine advantage in stored soil water that can be expected from leaving strips of tall cereal stubble to trap snow as compared to stubble cut at one uniform, short height (standard practice).

4.2 To determine the optimum rate, method and time of application of N for spring wheat production under conditions of improved snow management and zero-tillage.

4.3 To determine the optimum rate of P application for spring wheat production under conditions of improved snow management and zero-tillage.

4.4 To determine the maximum yield achievable for spring wheat under dryland culture.

4.5 To determine whether zero-tillage, snow trapping and various fertilizer treatments (cited in 4.3) are economically feasible in southwestern Saskatchewan.

4.6 To determine effect of zero-tillage on soil quality.

5. Results and Conclusions ...

Objective 4.1 ... In the spring wheat test the 6-year average extra soil moisture stored in soils using cereal trap strips was 11 mm more than standard short stubble. This was only about 25% of the hoped for 46 mm usually conserved in summerfallow. The range was 0 to 27 mm. There were indications that in drought years this stored moisture was being used more efficiently than water stored in fallow. Considerable more water could be conserved if some method can be found to enhance water infiltration into the frozen soil (e.g., deep ripping). In winter wheat, carried out for 3 years, the average advantage of trap strips was also 10 mm, but there was no yield advantage observed from this extra moisture. Over the 6 years, spring wheat yield (kg/ha) was related to growing season (M-J-Jy) precipitation ($R^2 = 0.80^{**}$) by the equation Y = 328 + 11.87 Precip. where precipitation is in mm.

Objective 4.2 ... The level of available N (soil test NO_3-N to 60 cm plus applied fertilizer N) that maximizes yields increased with available soil moisture from 85 kg/ha in dry years to about 125 kg/ha in wet years. The level was slightly higher for tall than for short stubble in dry years, but neither N placement nor timing of application affected the level in dry years, and in wet years neither stubble height, placement or time of application influenced the level of available N that maximized yield. In years of moderate moisture there was also no effect on any of the three treatments on the level of available N if N was applied in the spring, but if applied in the fall the level of available N that maximized yields was greater for tall stubble than for short stubble.

These interactions are not surprising, but bearing in mind that this region is prone to droughts, these limited results suggest (a) that, based on yields, the 60 kg/ha upper limit of fertilizer N recommended for this region for stubble-seeded wheat is quite appropriate (soil test NO_3-N in stubble avg. 25 kg/ha/60 cm); (b) that there is no need to increase N rates in zero tilled systems in this region to satisfy immobilization.

In general, broadcasting N in the fall gave lowest yields; the 6-year ranking of yields was 100, 97, 95 and 90 for spring-band, fall-band, spring-broadcast and fall-broadcast, respectively.

Objective 4.3 ... In 1987 P again had no significant effect on yields as again available soil P was high (34 kg/ha in the 0-15 cm depth). The available soil P averaged 24 kg/ha in the first 3 years and 36 kg/ha in the second 3-year period perhaps reflecting the regular useage of P by the farmer owning the land and later, our own use of high P rates. Thus, it might not be so surprising that in most years we did not obtain a yield response to P.

Objective 4.4 ... Maximum yields in 1987 did not reach 2000 kg/ha. Thus over the 6-year study period the highest yield ever obtained for any one treatment was 4909 kg/ha (73 bu/ac) obtained in 1986 for the

100 kg/ha N, 30 kg/ha P_2O_5, N deep banded in tall stubble in spring. In 1986, the wettest year, growing season precipitation was 205 mm or 23% above average.

Objective 4.5 ... In the economic analysis we assumed that N fertilizer could be purchased more cheaply if bought in the fall and that the cost of labour was also cheaper in the fall. Further, we assumed that deep banding was more expensive than broadcasting the fertilizer. Results of the economic analysis indicated that fall broadcast N, although giving the lowest yields, may in most cases provide the most economical scenario. For example, in dry years broadcast application of N was more profitable than deep banding; in wet years net returns were independent of time or method of N application; only in years of average moisture did broadcasting result in lowest net returns.

Net returns averaged 15-25 $/ha higher on trap strips than on standard short stubble plots in dry years, but the advantage was only 4-8 $/ha higher in years with average moisture, and no different in wet years.

The economics of deep banding would improve if this operation could be combined with another field operation, or if the seeding equipment was also capable of banding the fertilizer separately from the seed.

Objective 4.6 ... The combined use of zero tillage-continuous cropping-adequate fertilization has resulted in significant measureable improvement in soil productivity, as evidenced by increases in total organic matter, potentially mineralizable N and C, amino acid content and some soil enzyme activities. As well, there appears to be an improvement in water infiltration.

The only limitation to the adoption of this system is the increased tendency for grassy weeds to invade the test site.

6. Yield Limiting Factors Observed ...

The main limitation to the adoption of this system is the increased tendency for grassy weeds to invade the test site.

In some years grasshopper infestation was also a problem, though not in 1987.

7. Comments ...

This is the final report on this study. The results from the study have been published and presented in numerous forums, meetings and featured in many farmer magazines. The study is very popular with producers and the Research Station has agreed to allow us to continue it in a limited format so that we can obtain sufficient data to allow us to quantify yield and economics as a continuous function of available moisture and available N, rather than presenting the data categorized as dry, moist, and wet years. Publications emanating from this study to date are listed below.

The winter wheat experiment was less successful and only lasted 3 years (see summary at end of report). We will try to publish this information sometime in the future.

It has been a pleasure working with you and we have appreciated your assistance in this project, especially since the P and K aspects were so minimal.

Published Scientific and Technology Transfer Articles

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Zentner, R.P., Campbell, C.A., Selles, F., McConkey, B. Nicholaichuk, W. and Beaton, J.D. 1988. Nitrogen fertilizer management for maximum economic yields of spring wheat in Southwestern Saskatchewan. A paper presented at Soils & Crops Workshop, University of Saskatchewan, Saskatoon, Sask., Feb. 18-19, 1988.

NOTE: Study featured in Farmer periodicals several times (e.g., Grain News, Western Producer, The Furrow, Farm Light and Power, etc.).

Campbell, C.A., Zentner, R.P., Selles, F., McConkey, B.G., Nicholaichuk, W., Biederbeck, V.O. and Schnitzer, M. 1987.
Report on Joint Study with PPI

Project 22310-1580-81-51

A. INTERACTION OF FERTILIZER N AND P AND SNOW CONSERVATION ON MOISTURE CONSERVED AND ON SPRING WHEAT YIELDS AND PROTEIN IN SOUTHWESTERN SASKATCHEWAN

Annual Report 1987

Last year we had anticipated ending this study; however, a preliminary economic analysis of the 5-year results indicated a need to continue until a more varied combination of micro-climatic conditions could be obtained so as to allow a moisture variable to be included in the analysis of yields. Consequently, our Research Station agreed to allow this study to be continued for another 3 or 4 years using A-Base funding. With the substantial scaling down of PPI funding this year and the complete removal of funding in future years, it was necessary to reduce the detailed work to a minimum. Thus, detailed sampling of soil and plants during the growing season was omitted this year and will be in future years. Changes made to the study are described later.

1. Description of Treatments for Spring Wheat Test

This experiment was composed of four replicates (Blocks) (Fig. 1) each about 2.5 ha in size and carried out on a Brown Chernozem (Wood Mountain loam). Each replicate was split into two main treatments [short (standard height) stubble vs. tall (alternate height) stubble]. Each stubble treatment block was divided equally and randomly into three year-sub-blocks (viz., yr 1, yr 2, yr 3) to allow us to move the experiment to a different area each year. The test-year sub-blocks (in 1986-87, the sixth year of study, these were the year 3 blocks) were divided into six fertilizer rate sub-sub-blocks to allow five comparisons of N rates and two comparisons of P rates: (viz., 0/60, 25/60, 50/60, 75/60, 100/60; 100/30: ($kg.ha^{-1}$ N/$kg.ha^{-1}$ P_2O_5) (i.e., the 100/45 treatment was replaced with the 0/60 to obtain a check yield). Each fertilizer rate treatment was divided into two sub-sub-sub-blocks allowing comparison of banded vs. broadcast urea N. There was usually a further split comparing fall vs. early spring N application. However, in 1987, as in 1985, this became Early (April) and Later (May) spring because N was not applied in fall (since study was to be stopped). The year-blocks that were not being used in a particular year (filler blocks) were seeded and 28-28-0 fertilizer applied at 90 $kg.ha^{-1}$ (product) on these at seeding. No S or K was applied as we try to strive for better net returns and they are not customarily needed in this soil. In this study we use the zero-till seeding technique.

2. Establishment and Management of Crop

The 1986 crop was harvested on August 26, and the trap strips sculptured.

The various herbicide and fertilizer treatments, the dates of application, and the seeding and harvest dates are shown in Table 1. Because we were going to end the study no 2,4-D was applied in the fall. Hoegrass II was applied in June to control wild oats which were bad this year (Fig. 2). There was also a severe infestation of foxtail barley (Fig. 2) thus we had to apply Roundup.

Sampling for soil and plant samples (10 plants per plot) was only taken at harvest. However, soil samples were taken in fall (Oct. 7, 1986) and in from seeding to harvest, it was 167 mm or second highest in the 6-year period (Table 2). Further, if precipitation is summed for the period from fall soil sampling during the previous year to harvest, then precipitation received was 255 mm for the 1987 crop year ranking third lowest as well. Regression and correlation analysis between average yields and these various period precipitations showed that GSP gave the best relationship ($R^2 = 0.80^{**}$) (Table 2). This shows that much of the 255 mm of rainfall arrived too late in 1987 to provide the excellent yields that this amount of precipitation would imply. Heads per plant (Fig. 4, top), which is the most important component of yield, had already been limited by the early season drought; however, the late rainfalls probably helped yield by increasing seed size (data not shown).

3.2 Soil Moisture Conservation

The height of stubble for constructing trap strips was good in 1986-87 (Fig. 5) due to the excellent 1986 crop (but stubble height was not, and will not be measured in future years). Available soil moisture in the top 120 cm in fall 1986 was, on average, 43 mm in tall and short stubble plots (second highest in the 6 years), due to good fall precipitation (Table 3). Tall stubble conserved 42 mm and short stubble 34 mm over winter, for an overwinter advantage of 8 mm due to stubble height [but this difference was not statistically significant ($P > 0.05$)]. The 6-year average advantage in moisture conservation therefore dropped by 1 mm to 11 mm. Moisture intake efficiency [(water conserved ÷ water received) x 100] was 57% and 46% for tall and short stubble, respectively in 1986-87, i.e., second highest in 6 years, even though the fall soil moisture was also second highest in the 6 years. This contrasts with observations in the literature which show an inverse relationship between fall soil moisture and intake of winter precipitation. The latter discrepancy can probably be credited to the long warm winter that we experienced in 1986-87. This intake contrasts with 1985-86 when we had thawing and re-freezing conditions in winter which led to the soil surface being sealed by ice which prevented snowmelt water from penetrating the soil in spring and thus resulted in high runoff losses. Intake efficiency, averaged over the 6 years of study, was 33% for short stubble (similar to values obtained in conventional till studies) and 45% in tall stubble (showing the benefit of snow trap).

In the fall of 1986, the 197 mm of total moisture to 120 cm (i.e., 43 mm available moisture) was mainly located in the top 30 cm of soil (Table 4). By early spring the extra 38 mm of moisture conserved in the soil had penetrated to at least 90 cm depth with most of the storage located in the 30-60 cm depth.

4. Results

4.1 Moisture in Soil

As stated earlier, detailed measurements of soil moisture during the growing season were not made this year due to lack of resources. At harvest, however, soil moisture was depleted to at least the -4.0 MPa moisture potential equivalent (Table 4). Furthermore, the higher fertilizer rate treatments depleted the moisture to a greater degree ($P < 0.05$) reflecting the growth and yield responses (shown later).

4.2 Mineral N and P in Soil

Because we had planned to end this experiment in 1986, no fall NO_3 or bicarbonate soluble-P were measured in 1986. However, these measurements were made at spring sampling in 1987 and are shown together with similar values for the experimental period in Table 5. It can be seem that NO_3-N levels were again down, following the excellent crop in 1986; but, bicarbonate soluble-P levels were still high. One would therefore expect some response to N but little response to P if rainfall was near average in 1987; as seen later these were the results obtained.

4.3 Plant Population

Plant measurements were only made at harvest. The number of heads per plant increased with N rate, slightly when N broadcast, and more steeply when N was banded (Fig. 4, top). A comparison of the effect banding vs broadcast N application on plant density and N uptake is shown during the growing season in Figure 6 (top).

Because the rainfall was so low in April and May the banded N remained near the point of application for a long time causing alternate green and yellow strips of vegetation to be visible in these plots throughout most of the vegetative period (Fig. 6, bottom).

4.4 Grain Yields and Grain/Straw Ratios

In 1987 P had no effect on yields (data not shown). The only factors influencing grain yields were N rate and placement which also showed a significant ($P < 0.01$) interaction (Fig. 4, bottom). Grain yields increased curvilinearly with N rate to 100 kg ha^{-1} N. Banded N gave greater ($P < 0.01$) yields than broadcast N with the difference increasing with N rate. Stubble height did not influence yields significantly ($P > 0.05$) because it had no effect on moisture stored overwinter.

When the 6-year yield data were pooled and analysed for only N rates 25, 50, 75 and 100 kg ha^{-1}, there were three significant ($P < 0.01$) 3-way interactions [viz., (i) year x fert x stubble height; (ii) year x N placement x stubble height and (iii) stubble height x fert x time].

As shown earlier (Table 2) yields were directly related to GSP (Y = -328 + 11.87 GSP; R^2 = 0.80) indicating a need of at least 28 mm of GSP before 1 kg ha^{-1} of grain is produced. There was no response to N rates > 25 kg ha^{-1} in the two driest years (1984 and 1985) and these were the years when snow management showed their greatest benefit (Fig. 7). As shown earlier, 1987 yields were unaffected by stubble height while in the three wetter years (1982, 83 and 86) the effect of stubble height varied with the rate of N applied.

In the two driest years, placement of N had no significant effect on yields; but, in all other years yields were generally greater for deep banded urea-N as compared to broadcast N (Fig. 8).

On the average, yields were greater for spring applied than for fall applied N in the short stubble treatment at all N rates; but, in the tall stubble treatment the yield increase favouring spring application decreased with increasing N rate (Fig. 9). The difference in yields due to time of N application was rarely more than 100 kg ha^{-1} and in the dry years (1984 and 1985) time of application did not influence yield (data not shown).

Because April and May were so dry in 1987 (Fig. 3), vegetative growth was restricted; but, late rains allowed good filling of grains and this resulted in grain/straw ratios that were between 0.93 and 1.0 with the lower values corresponding to lower N rates and vice versa (data not shown). This compares with grain/straw ratios of 0.65, and 0.73 obtained in 1986 and 1985, respectively.

5. Analyses That Were Incomplete in 1986

Grain N conc. increased almost linearly with N rate in 1986 (Fig. 10).

Time of N application had no effect on grain N concentration for short stubble treatments but for the tall stubble treatments grain N was higher for spring applied N than for fall applied. On the average, grain N concentration was higher for short stubble treatments than for tall stubble. There was no effect of the treatments on P conc. of the grain (data not shown) which averaged 0.32%.

6. N Content of Grain and Straw (1982-86)

The amount of N taken up in the grain and straw (% N x wt) were calculated and analysed for the first 5 years of the study. As with yields, all the main factors and numerous interactions were significant; however, only means for the interaction of straw height and N fertility are presented here (Tables 6 and 7). The N exported from the system as grain was also equated with N input in fertilizers to determine whether there should be an increase or a decrease in soil N (Table 6).

These results show that the N exported in grain was as low as 11.7 kg ha^{-1} in the very dry 1984 and as high as 71 kg ha^{-1} in wet 1986 (the 100 kg ha^{-1} rate of N, short stubble treatment). The total N exported in grain over the 5 years was between 139 and 215 kg ha^{-1} (Table 6). Generally, only at rates of N $\geq$ 50 kg ha^{-1} was there an indication that there should be a net residual build-up of N in the soil over the 5 years. (However, there could be a redistribution of mineral N from lower depths into organic N nearer the soil surface due to continuous zero till cropping and plant transfer via roots).

Straw yield response paralleled grain yield response to the various treatments (Table 7). Amount of N in the straw was about one-third of that found in the grain.

7. Seed Weight 1982-87

Seed weight varied between 23 mg/kernel in the dry 1985 and almost 34 mg/kernel in the wet 1982 (Table 8). Though effects were generally significant, treatments such as stubble height, N placement (deep banding vs broadcast), N rate, and time of application (fall vs spring) only had a small effect on seed weight (i.e., no more than 1.5 mg/kernel); year (weather) was the main factor affecting seed weight. Generally seed weights were greater for tall stubble, low N rates (Table 8), deep banding and fall applied N.

In all years volume weight (kg/hl) was excellent, being 80 kg/hl or greater (data not shown) which would have resulted in the grain being graded No. 1 for quality.

Table 1. Management activities in 1986-87

Activity	Date	Rate	Comments
Herbicides			
Roundup	1/5/87	1.11 kg ha^{-1} Ag Surf 350 ml/ha	There was no fall 2,4-D treatment because of intermittent rainfall.
Hoegrass II	16/6/87		
Sweep	24/9/87	2.5 l ha^{-1}	To control wild oats.
2,4-D Ester	21/10/87	0.84 l ha^{-1}	
Fertilizers			
+P	23/4 and 8/5/87	Required rates (see text)	Banded at 10 cm depth (except for 30 kg ha^{-1} P_2O_5 placed with seed)
+Urea	23/4/87	Required rates (see text)	Banded & broadcast (see Fig. 1). (Fall)
+Urea	8/5/87	Required rates (see text)	Banded & broadcast (see Fig. 1).(Spring)
Seeding			
Leader	16/5/87	67 kg/ha	17.8 cm spacing using offset disc drill.
Harvest	3/9/87		(6.4 m x 1.37 m per plot) Wintersteiger combine.

‡ All test plot treatments received 30 kg ha^{-1} P_2O_5 as 0-45-0 with seed while filler plots received 90 kg ha^{-1} of 28-28-0 with the seed.

+ The 45 kg ha^{-1} P_2O_5 - 100 kg ha^{-1} N treatment was dropped and thus replaced by a 60 P_2O_5 - no n (check) treatment. This will be continued in future years. This resulted in no N being seed placed in test plots and 28-28-0 could not be used to supply P; instead 0-45-0 was used on test plots, but 28-28-0 was still used on filler plots. No fertilizer had been applied in the 1986 fall, therefore fall treatment was replaced by early spring (April) treatment and spring remained early May. So all N treatments were applied at time of fertilizer application, none with seed as was done in past.

Table 3. Conservation and efficiency of intake of fall and winter precipitation by cereal stubble treatments (1981-87)

Season	Precip.[+] fall to spring (mm)	Stubble Ht (cm) Tall[+]	Stubble Ht (cm) Short	Mean Snow Depth (cm) Tall	Mean Snow Depth (cm) Short	Water in snow (mm) Tall	Water in snow (mm) Short	Available water in soil ($mm\ 120cm^{-1}$) Fall Tall	Fall Short	Spring Tall	Spring Short	Water Conserved ($mm\ 120\ cm^{-1}$) Tall	Water Conserved Short	Advtg. of Tall Stubble ($mm\ 120\ cm^{-1}$)	% Efficiency of intake of precip. Tall	% Efficiency of intake of precip. Short
1981-82	132	60	20	39	17	97	43	-10	-10	38	28	47	38	9	35	29
1982-83	93	52	19	20	17	40	34	80	67	111	93	31	26	5	33	28
1983-84	68	45	15	25	12	69	27	14	22	58	42	45	20	25	66	29
1984-85	131	40	14	41	24	122	61	-1	0	82	56	83	56	27	63	43
1985-86	63	39	13	38	24	100	60	30	16	39	33	8	14	-6	13	22
1986-87	75	ND	ND	ND	ND	ND	ND	41	45	83	80	42	34	8	57	46
Mean	94	47	16	33	19	85	45	26	23	68	55	43	31	11	45	33
$S\bar{x}$ (stub. ht)		1.0		1.0		2		--		3		3		--	5	
$S\bar{x}$ (yr)		1.7		1.4		3		4		6		7		8	7	
$S\bar{x}$ (ht x yr)		2.2		1.5		4		--		--		9		--	9	
Significant Factors																
Stubble height (Ht)		**		**		**		NS		**		**		--	**	
year (yr)		**		**		**		**		**		**		*	**	
Ht x yr		**		**		**		NS		NS		*		--	*	

[+] Available water = water held by soil at potentials about -4 MPa; at -4 MPa this soil retains 154 mm of water in 120 cm depth.
*,** Significant at $P < 0.05$ and at $P < 0.01$, respectively; NS, not significant, and ND, not determined.

Table 2. Soil sampling and cropping dates and precipitation received during crop years (1981-87)

Year seeded	Date soil sampled		Date Crop		Precipitation received (mm)										
							Seeding to harvest								
	Fall	Spring	Seeded	Harvested	Fall to Spring	Spring sampling to seeding	Seeding to May 31	June	July	Aug.	Sept.	Total	+Previous fall to harvest	‡Growing season (May-June-July)	Avg. yield (kg/ha)
1982	23 Sept. 81	13 May 82	25 May	15 Sept.	132	26	47	43	119	41	4	254	412	244	2252
1983	1 Oct. 82	3 May 83	16 May	24 Aug.	93	54	8	29	96	18	-	151	298	187	1690
1984	27 Sept. 83	25 April 84	8 May	21 Aug.	68	2	18	67	15	16	-	116	186	100	566
1985	18 Sept. 84	26 April 85	14 May	19 Aug.	131	18	14	17	25	30	-	86	235	73	589
1986	15 Oct. 85	3 April 86	14 May	26 Aug.	63	95	41	51	32	16	-	140	298	205	2665
1987	7 Oct. 86	13 April 87	16 May	3 Sept.	75	13	21	44	59	43	0	167	255	129	1406

+ Relationship between avg. yield and fall to harvest precip: $Y = -891 + 8.62$ precip ($R^2 = -0.50^*$).

‡ Relationship between avg. yield and growing season precip (M-J-J): $Y = -328 + 11.87$ precip ($R^2 = 0.80^{**}$).

Table 4. Effect of fertilizer on soil moisture at harvest (Sept. 9, 1987) compared to moisture present the previous fall and early spring

Depth (cm)	Moisture in soil prev. fall sampling[+]	Moisture held at spring sampling[+]	Fertilizer rate (kg/ha) 0	25	50	75	100	Moisture in soil at -4.0 MPa (mm)
	----------	----------	----------	mm/segment	----------	----------	----------	----------
0-15	41.0	46.2	25.4	23.8	22.9	22.6	23.1	20.1
15-30	37.4	40.1	21.5	17.4	15.6	14.5	14.6	18.0
30-60	44.3	64.9	33.6	30.5	29.0	28.4	27.0	34.5
60-90	35.3	42.3	33.5	29.9	30.7	29.0	29.0	40.4
90-120	38.9	41.8	39.3	38.8	39.9	36.8	39.1	41.1
Total	196.9	235.2	153.2	140.4	138.0	131.4	132.9	154.1

[+] Previous fall = Oct. 7, 1986 and spring = April 13, 1987.

Table 5. Soil test levels of N & P (1981-87)

Crop Year	Time Sampled	NO_3-N in 0-60 cm	Bicarb-P in 0-15 cm
		----------- kg/ha	----------
1982	Fall '81	26	25
1983	Fall '82	13	23
1984	Fall '83	14	23
1985	Spring '85	25	42
1986	Fall '85	49	33
1987	Spring '87	23	34

Table 6. N content of grain as influenced by N rate and stubble height (1982-86)

Crop Year	N rate 25	50	75	100	Crop Year	N rate[+] 25	50	75	100
Grain N (kg ha^{-1})						N surplus (+) Deficit (kg ha^{-1})[‡]			
		Short Stubble				Short Stubble			
1982	34.20	41.07	50.0	59.47	1982	-9	+9	+25	+41
1983	21.94	31.63	38.88	43.13	1983	+3	+18	+36	+57
1984	13.33	11.68	11.68	12.24	1984	+12	+38	+63	+88
1985	13.30	12.73	13.19	11.95	1985	+12	+37	+62	+88
1986	55.76	64.19	65.83	71.27	1986	-31	-14	+9	+29
Total	138.55	161.30	179.58	198.06					
		Tall Stubble				Tall Stubble			
1982	38.99	46.60	54.00	61.37	1982	-14	+3	+21	+39
1983	25.90	35.23	44.78	50.30	1983	-1	+15	+30	+50
1984	15.99	15.53	18.60	19.12	1984	+9	+34	+56	+81
1985	17.53	17.10	14.17	17.16	1985	+7	+33	+61	+83
1986	53.71	57.76	66.44	66.51	1986	-29	-8	+9	+33
Total	152.10	172.20	197.99	214.46					

[+] Test plots were rested two years in three during which time they only received 25 kg N/ha.

[‡] Difference of N applied (gain) and N removed in grain (loss) from system.

Table 7. Yields and N content of straw as influenced by N rate and stubble height (1982-86)

Crop Year	N rate 25	50	75	100	Year	N rate 25	50	75	100
Straw yield (kg ha^{-1})					Straw N (kg ha^{-1})				
		Short Stubble					Short Stubble		
1982	3232	3869	4500+	5122	1982	9.27	12.01	17.07*	22.14
1983	1741	2358	2541	2587	1983	6.67	9.08	12.42	13.34
1984	785	710	703	849	1984	6.35	4.80	5.34	6.35
1985	699	692	707	628	1985	3.72	4.03	4.31	3.86
1986	3648	3958	3873	4142	1986	18.06	23.68	25.49	28.13
Total	10105	11585	12324	13328	Total	44.07	53.60	64.63	73.82
		Tall Stubble					Tall Stubble		
1982	3727	4121	4513+	4914	1982	11.69	13.99	20.70*	27.42
1983	2135	2615	3124	3347	1983	8.54	11.60	14.75	18.00
1984	1055	949	1106	1149	1984	10.06	9.25	11.18	10.05
1985	1075	966	747	960	1985	5.18	5.53	4.42	5.56
1986	3811	4313	4494	4474	1986	15.74	21.31	27.43	26.16
Total	11805	12965	13984	14844	Total	51.21	61.68	78.48	89.19

+ Estimated by interpolation in 1982.

Table 8. Effect of stubble height and rate of fertilizer N on seed weight

Stubble Height	Year	Fertilizer N rate 25	50	75	100	Mean
		---- thousand kernel wt (g) ----				
Short	1982	33.9	34.2	33.6+	33.0	33.7
	1983	31.6	31.2	30.9	30.6	31.1
	1984‡	-	-	-	-	-
	1985	23.4	23.4	23.1	23.1	23.3
	1986	29.8	28.7	28.4	28.2	28.8
	1987	26.2	26.2	26.6	26.5	26.4
	Mean	29.0	28.7	28.5	28.3	28.6
Tall	1982	34.0	33.3	32.7+	32.1	33.0
	1983	30.6	31.1	31.1	30.4	30.8
	1984‡	-	-	-	-	-
	1985	24.4	23.9	24.0	23.6	24.0
	1986	31.1	30.4	29.6	29.6	30.2
	1987	26.0	25.9	26.0	25.8	25.9
	Mean	29.2	28.9	28.7	28.3	28.8

+ Estimated by interpolation in 1982.

‡ Data lost.

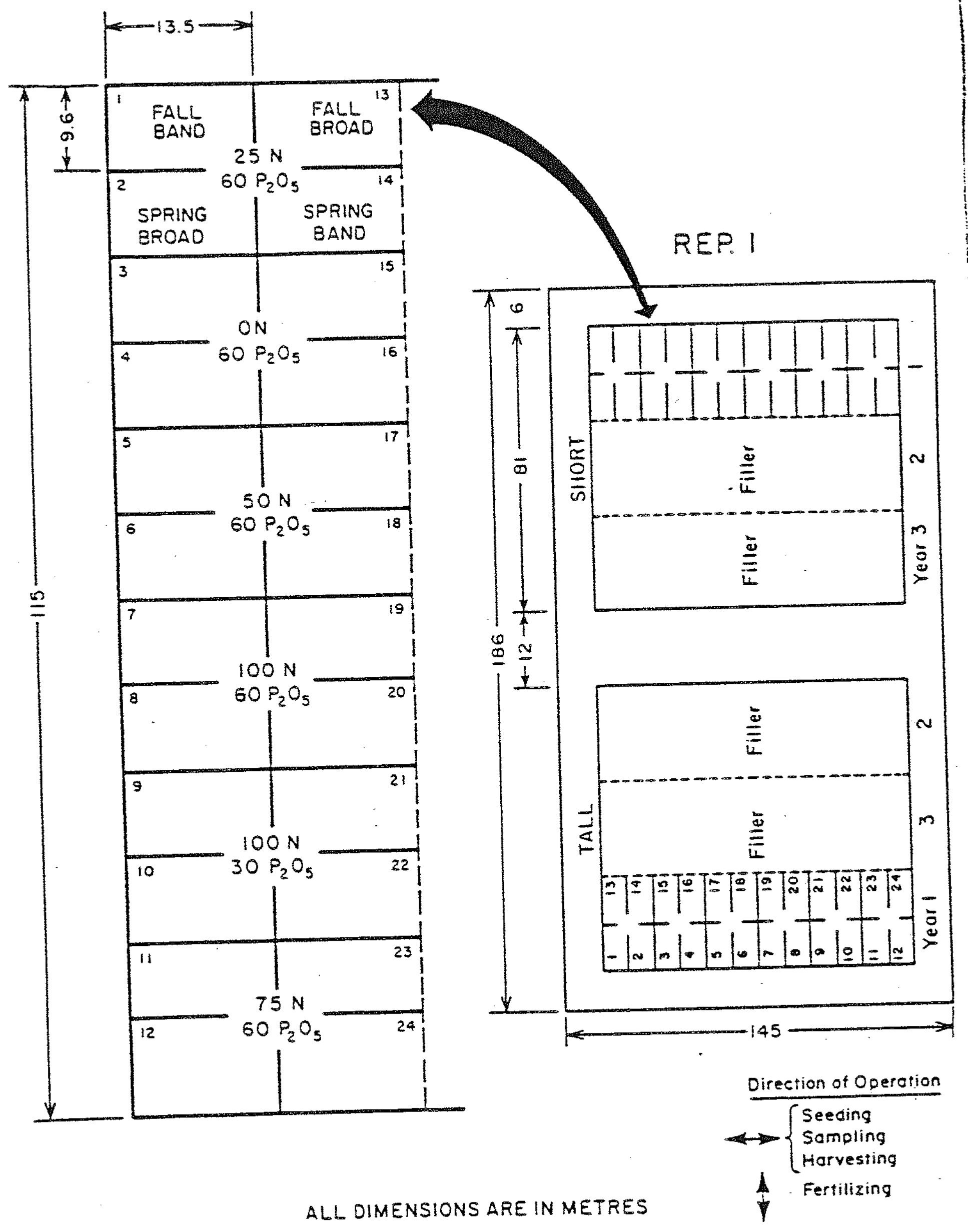


Figure 1. Right: General field plan and direction of operations.

Left: Details of plot layout for tall stubble (1987).

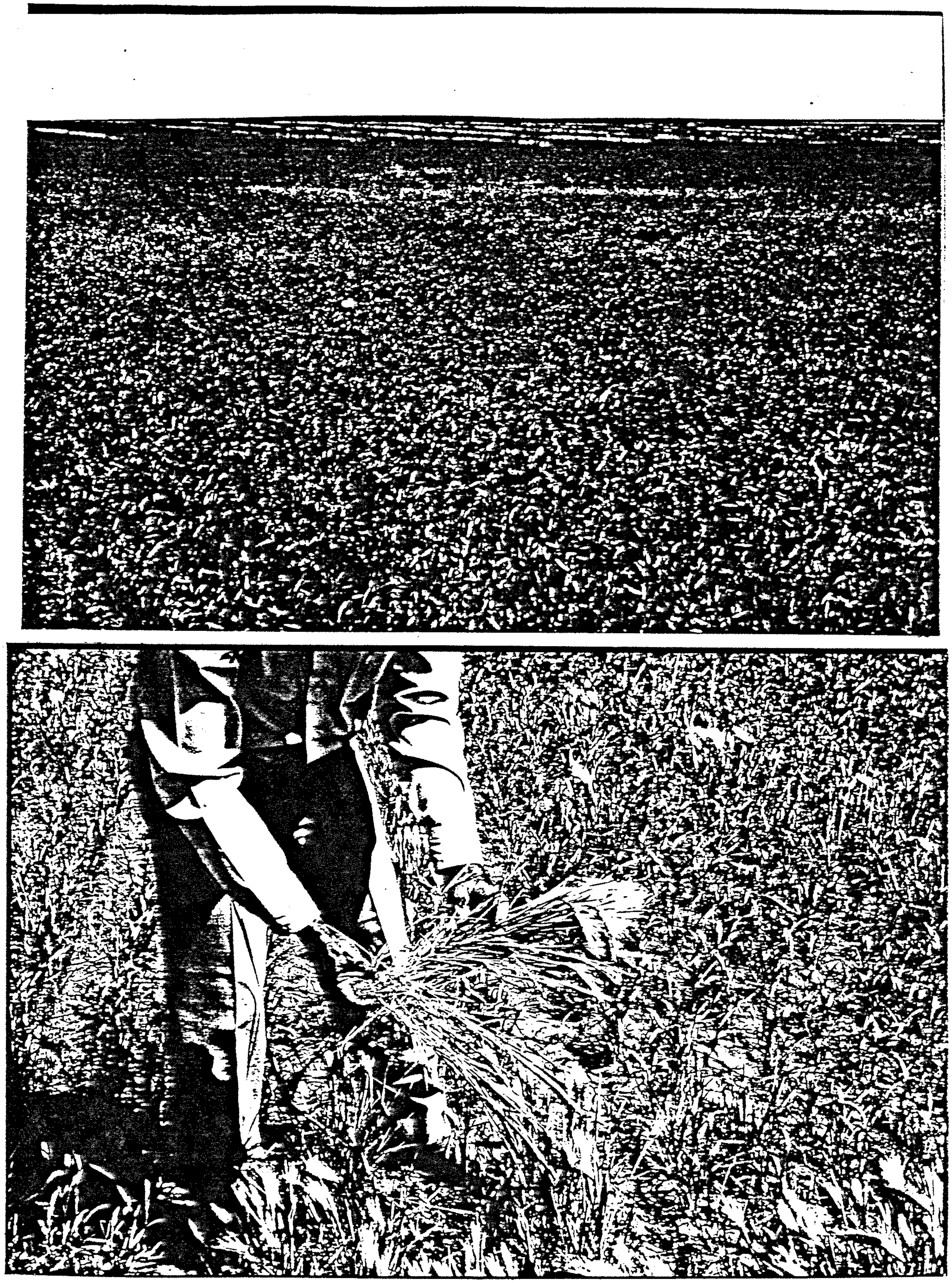


Figure 2. Top: Wild oats remain a problem even after 6 yr of annual Hoegrass treatment.

Bottom: Wild barley became a problem in last 2 yr of study; had to spray with Roundup this year.

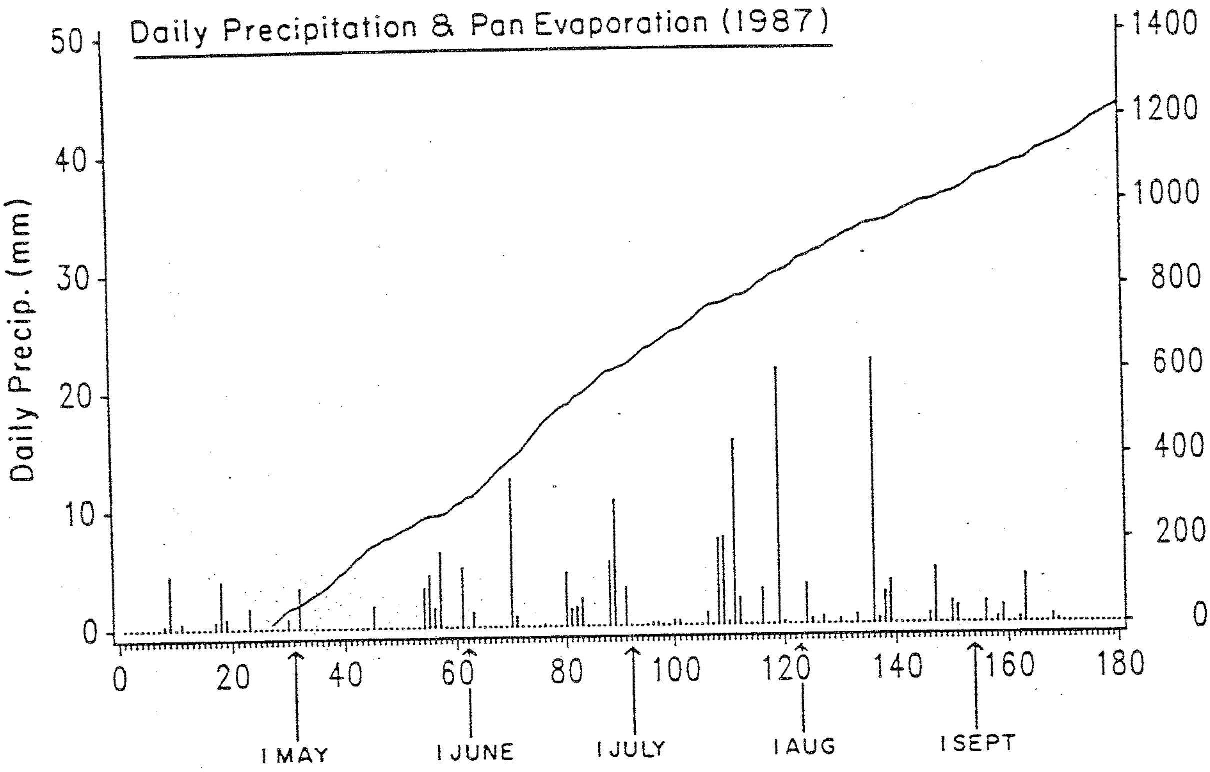

Daily Precipitation & Pan Evaporation (1987)
Daily Precip. (mm)
Accum. Pan Evap. (mm)
50
40
30
20
10
0
1400
1200
1000
800
600
400
200
0
0
20
40
60
80
100
120
140
160
180
1 MAY
1 JUNE
1 JULY
1 AUG
1 SEPT

Figure 3.

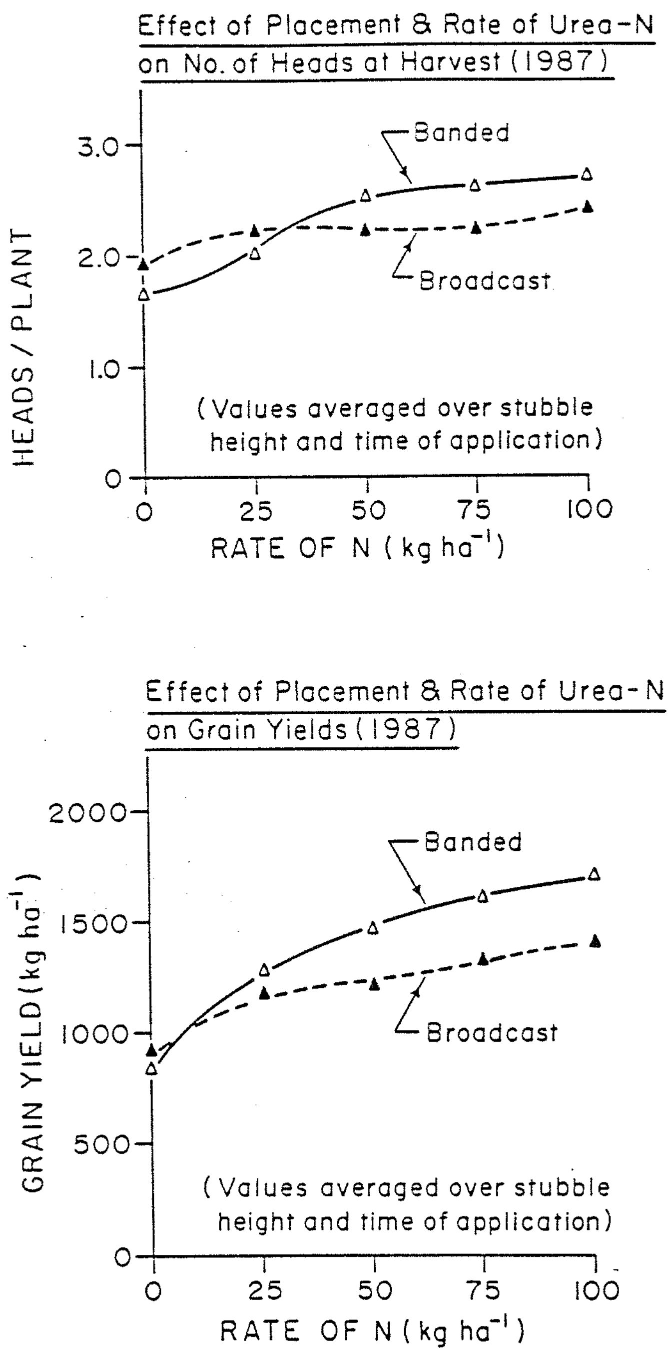
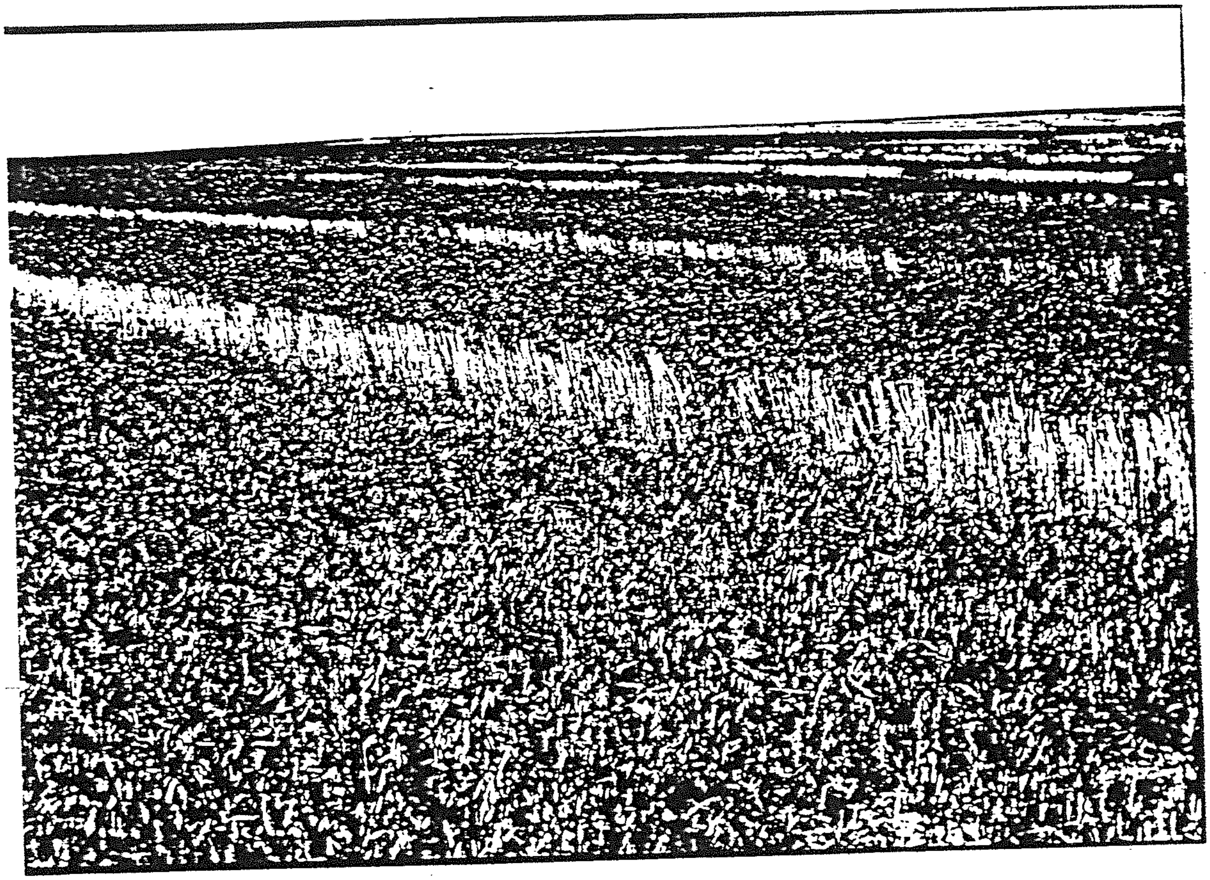
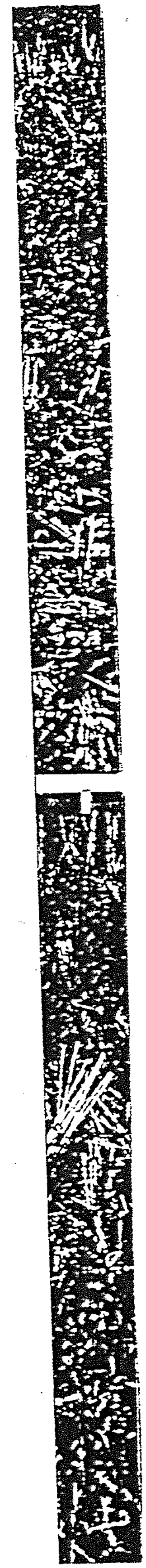

Effect of Placement & Rate of Urea-N on No. of Heads at Harvest (1987)
HEADS / PLANT
3.0
2.0
1.0
0
Banded
Broadcast
(Values averaged over stubble height and time of application)
0
25
50
75
100
RATE OF N (kg ha⁻¹)
Effect of Placement & Rate of Urea-N on Grain Yields (1987)
GRAIN YIELD (kg ha⁻¹)
2000
1500
1000
500
0
Banded
Broadcast
(Values averaged over stubble height and time of application)
0
25
50
75
100
RATE OF N (kg ha⁻¹)

Figure 4.

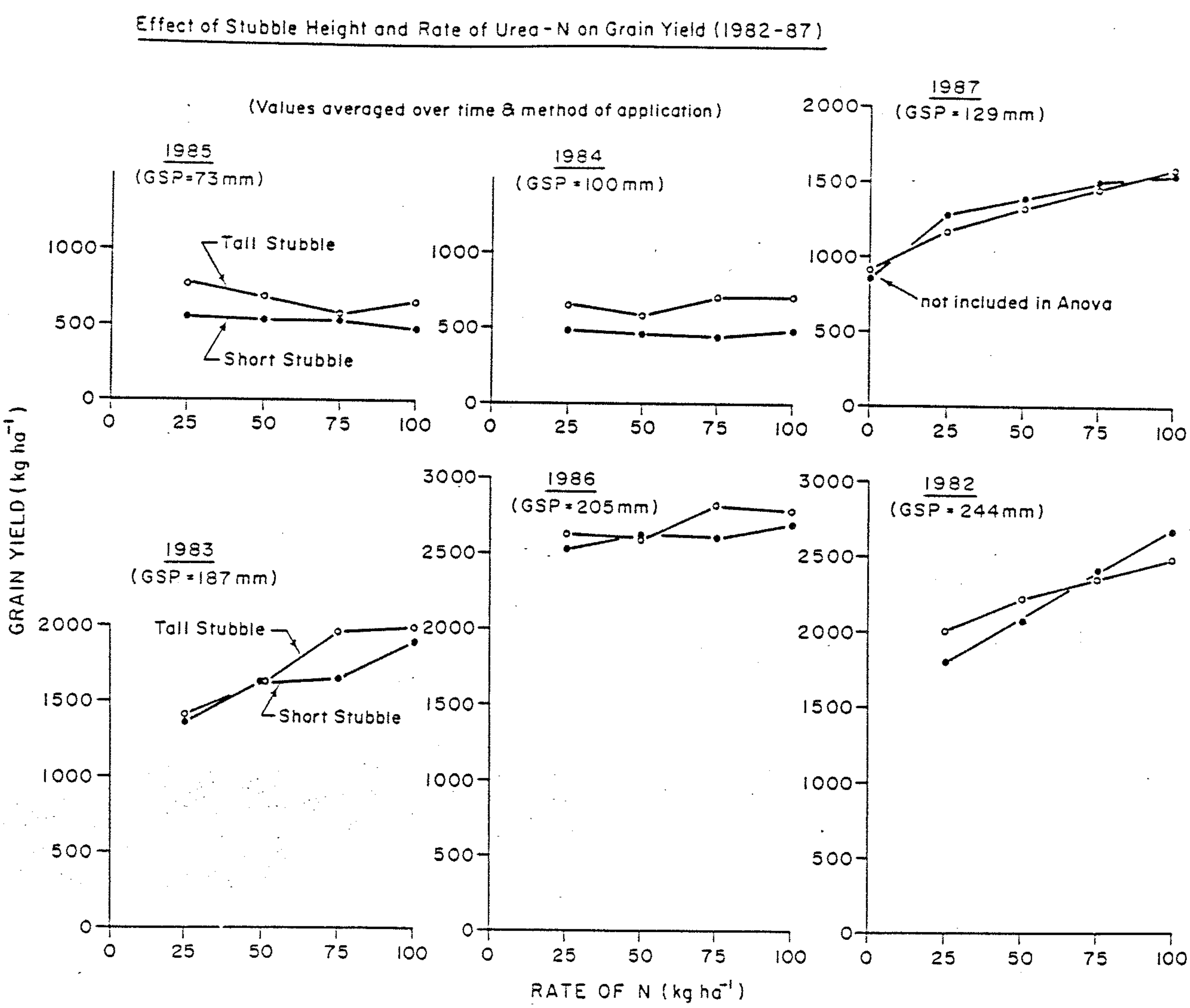


gure 5. A good crop in 1986 provided tall straw and a good trap strip for 1987. Straw persists for a long time into the growing season.



stand

int of
streaks



Effect of Stubble Height and Rate of Urea-N on Grain Yield (1982-87)
(Values averaged over time & method of application)
1985
(GSP=73mm)
Tall Stubble
Short Stubble
1984
(GSP=100mm)
1987
(GSP=129mm)
not included in Anova
1983
(GSP=187mm)
Tall Stubble
Short Stubble
1986
(GSP=205mm)
1982
(GSP=244mm)
GRAIN YIELD (kg ha⁻¹)
RATE OF N (kg ha⁻¹)

Figure 7.

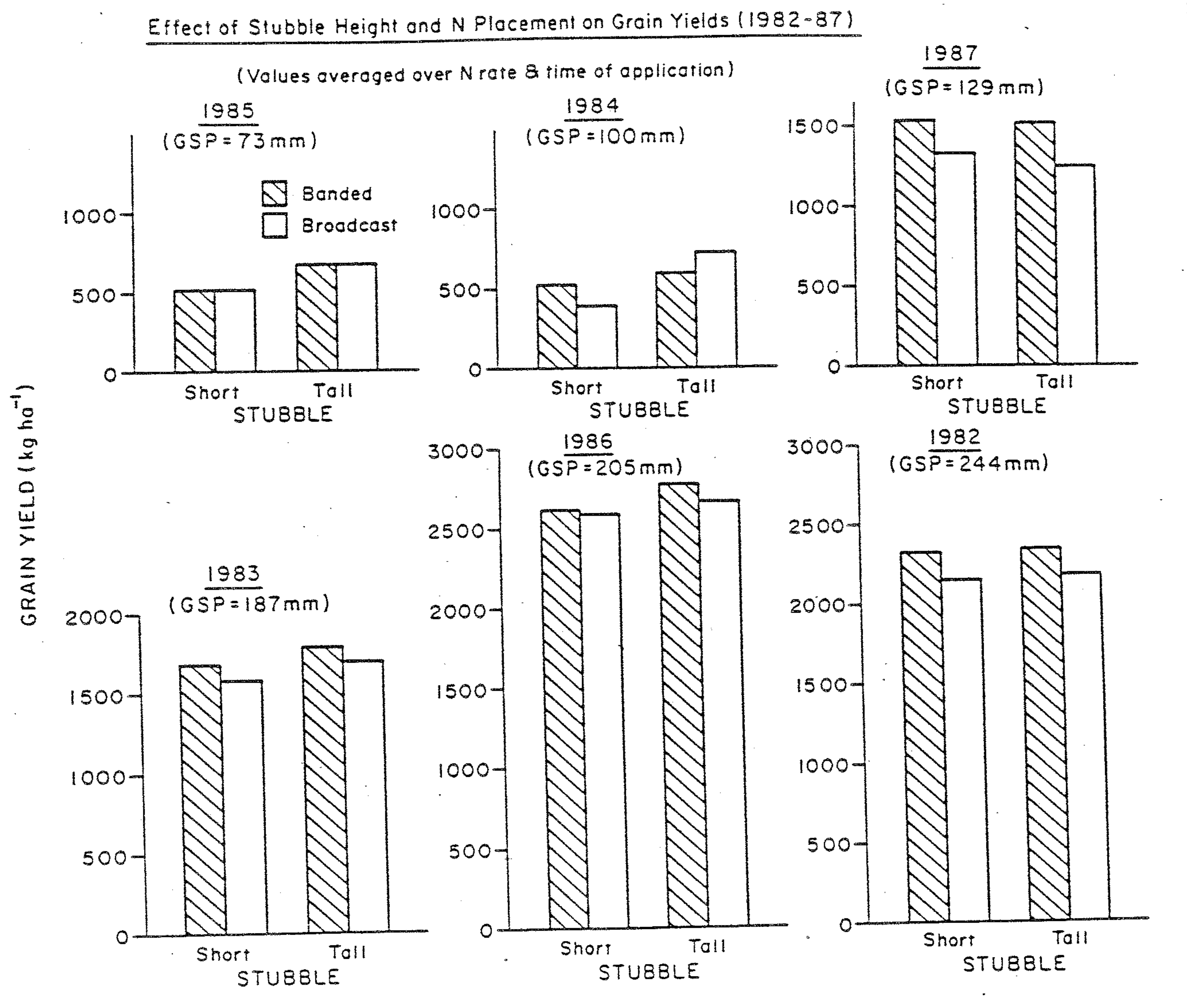

Effect of Stubble Height and N Placement on Grain Yields (1982-87)
(Values averaged over N rate & time of application)
1985
(GSP = 73 mm)
Banded
Broadcast
1984
(GSP = 100 mm)
1987
(GSP = 129 mm)
1986
(GSP = 205 mm)
1982
(GSP = 244 mm)
1983
(GSP = 187 mm)
GRAIN YIELD (kg ha⁻¹)
Short
Tall
STUBBLE
0
500
1000
1500
2000
2500
3000

Figure 8.

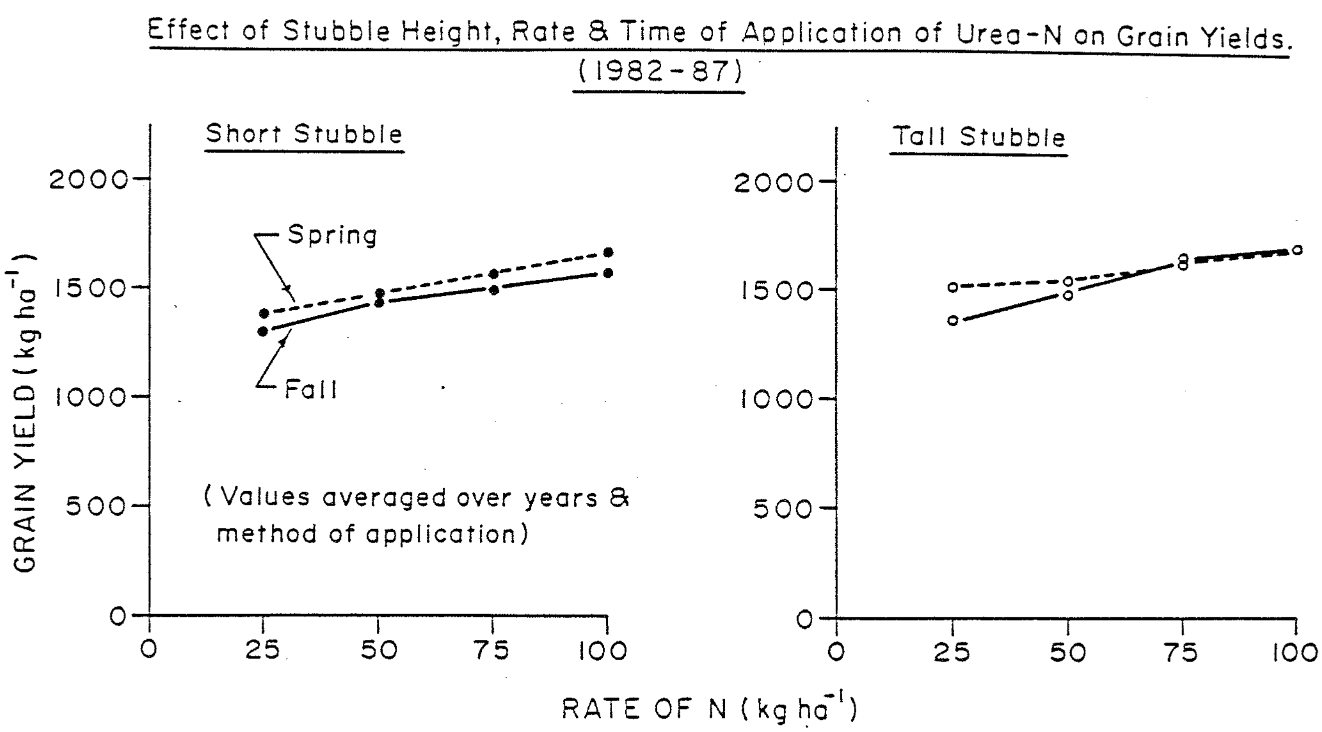

Effect of Stubble Height, Rate & Time of Application of Urea-N on Grain Yields.
(1982-87)
Short Stubble
Tall Stubble
Spring
Fall
(Values averaged over years & method of application)
GRAIN YIELD (kg ha⁻¹)
2000
1500
1000
500
0
0
25
50
75
100
RATE OF N (kg ha⁻¹)

Figure 9.

Effect of Time, Rate & Placement of N and Height of Stubble on N Concentration of Grain (1986)

(% N in N banded treatments were significantly (P < 0.05) but only slightly > that in N broadcast treatments (2.48 vs 2.45 %)

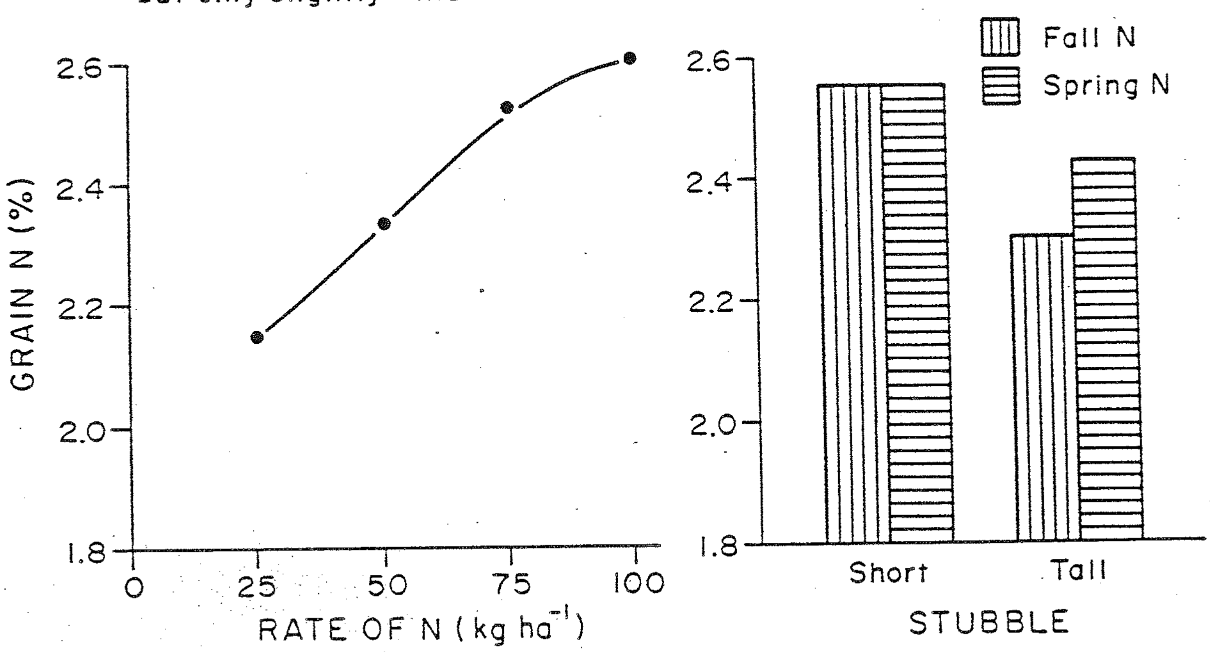


Figure 10.

B. EFFECT ON NET RETURNS

1. Method of Analysis

The economic optimum rates of N fertilizer and the associated net returns for each method and time of N placement were calculated for a range of wheat prices and fertilizer costs. Multiple regression was used to relate yields for each fertilizer management treatment to total available N at time of planting (i.e., soil test NO_3-N in 0-60 cm depth plus applied N fertilizer). For this purpose, the data were arbitrarily separated into dry years (1984 and 1985), normal years (1983 and 1987), and wet years (1982 and 1986) and second degree polynomial relationships (regressed through the origin) were determined. The first derivative of the relationships were solved for rates of total available N that maximized physical yields and for rates of total available N that maximized net returns at various fertilizer N cost/wheat price ratios. Net return was defined as income above the cost of the fertilizer and fertilizer application. A risk allowance factor of 1.5 (i.e., the last dollar spent of fertilizer N provides 1.5 dollars of return) as defined by the Saskatchewan Soil Testing Laboratory was assumed. In the analysis, emphasis was placed on the assumed higher cost of N fertilizer and farm labor in the spring compared to fall, the higher costs for energy and equipment ownership for banding compared to broadcasting fertilizer, and the interest charges on operating capital (Table 1).

2. Results and Discussion

2.1 Relationship of Yields to Total Available N and Optimal Levels of Available N

Regression analysis showed that yields responded in a curvilinear fashion to increasing levels of total available N at time of planting

(Table 2). The economic optimum levels of available N were lower than those which maximized grain yields; they increased with the level of available water, and decreased as the ratio of N fertilizer cost to wheat price increased (Table 3). In dry years the optimum levels of available N averaged about 5 to 15 $kg.ha^{-1}$ higher on tall than on short stubble because of the greater available soil moisture, and were similar regardless of time or method of N application used. In years with average moisture, the optimum levels of available N for wheat grown on tall stubble plots averaged 10 to 15 $kg.ha^{-1}$ higher when the N was applied in fall compared to spring; this effect was not evident for wheat grown on short stubble. In wet years, the optimum available N levels were higher when the N fertilizer was broadcast compared to banded; no other factors were significant.

2.2 Effects of Fertilizer Management System on Net Returns

Net returns (i.e., revenue above the cost of fertilizer and fertilizer application) averaged 15-25 $\$.ha^{-1}$ higher on tall stubble than on short stubble in dry years, but only 4-8 $\$.ha^{-1}$ higher in years with average moisture, and no difference in wet years (Table 4). In dry years, broadcasting N fertilizer was more profitable than banding it. Further, fall application of fertilizer N was generally more profitable than spring application because of the assumed lower fertilizer and labor costs in the fall period. In contrast, in years with average moisture, fall broadcasting provided the lowest net return; there was little difference in net returns among the other fertilizer management systems. In wet years, banding provided similar net returns as broadcasting, with fall application slightly more profitable than spring application.

Table 1. Summary of economic assumptions

Item	Cost	Units
Farm Labor - Fall	6.00	$\$.hr^{-1}$
- Spring	12.00	$\$.hr^{-1}$
Fertilizer N Cost - Fall	0.85	index
- Spring	1.00	index
Banding - variable plus fixed cost	14.62	$\$.ha^{-1}$
- labor required	0.201	$hr.ha^{-1}$
Broadcasting - variable plus fixed cost	3.60	$\$.ha^{-1}$
- labor required	0.124	$hr.ha^{-1}$
Interest Rate	10.	%

Table 2. Regression coefficients for second order polynomial of yield and total available N (TN) by fertilizer management system[+]

Stubble Height/Time/Method	Regression Coefficients[‡]		
	TN	TN^2	R^2
Dry Years			
Tall - Fall & Spring - Band & Broadcast	17.53	-0.104	90
Short - Fall & Spring - Band & Broadcast	13.12	-0.079	86
Normal Years			
Tall - Fall - Band	34.37	-0.155	97
- Broadcast	30.19	-0.141	96
- Spring - Band	40.30	-0.217	97
- Broadcast	37.75	-0.208	94
Short - Fall - Band	36.37	-0.191	98
- Broadcast	32.12	-0.165	96
- Spring - Band	38.76	-0.201	98
- Broadcast	37.11	-0.205	97
Wet Years			
Short & Tall - Fall & Spring - Band	45.95	-0.191	98
Short & Tall - Fall & Spring - Broadcast	41.90	-0.165	97

[+] Total available N refers to soil NO_3-N in 0 to 60 cm depth plus applied N fertilizer.

[‡] All regression coefficients are significant at $P < 0.05$ or higher.

Table 3. Economic optimum levels of total available N

Stubble Height/Time/Method	Maximum Yield [+]	Fertilizer N Cost/Wheat Price [‡] 2	3	4	5	6
	---------- (kg/ha) ----------					
Dry Years						
Tall - Fall & Spring - Band & Broadcast	85	70	63	56	48	41
Short - Fall & Spring - Band & Broadcast	83	64	55	45	36	26
Normal Years						
Tall - Fall - Band	111	101	96	91	87	82
- Broadcast	107	96	91	86	80	75
- Spring - Band	93	86	82	79	75	72
- Broadcast	91	84	80	76	73	69
Short - Fall - Band	95	87	84	80	76	72
- Broadcast	97	88	84	79	75	70
- Spring - Band	97	89	85	82	78	74
- Broadcast	91	83	80	76	72	69
Wet Years						
Tall & Short - Fall & Spring - Band	120	112	109	105	101	97
Tall & Short - Fall & Spring - Broadcast	127	118	113	109	104	100

[+] Level of total available N that maximizes yield.

[‡] Values include a risk factor, i.e., the last $1.00 expenditure on fertilizer N returns $1.50 of additional yield.

Table 4. Effect of changes in wheat prices and fertilizer costs on net returns[+]

Stubble Height/Time/Method	Wheat Price = $90/t N Fertilizer Cost ($/kg)[‡] 0.33	0.44	0.55	Wheat Price = $110/t N Fertilizer Cost ($/kg)[‡] 0.33	0.44	0.55	Wheat Price = $130/t N Fertilizer Cost ($/kg)[‡] 0.33	0.44	0.55
	($/ha)								
Dry Years									
Tall - Fall - Band	25	17	10	39	32	24	54	46	39
- Broadcast	37	30	23	52	44	37	67	59	51
- Spring - Band	22	15	8	37	29	21	51	43	35
- Broadcast	35	27	20	49	41	33	64	55	47
Short - Fall - Band	8	1	-5	19	12	5	29	22	15
- Broadcast	21	14	7	31	24	17	42	35	27
- Spring - Band	6	-1	-7	16	9	2	27	19	12
- Broadcast	19	12	5	29	22	15	39	32	24
Normal Years									
Tall - Fall - Band	121	110	100	159	148	137	197	186	175
- Broadcast	109	98	89	141	130	120	173	162	152
- Spring - Band	120	110	101	157	147	137	194	184	174
- Broadcast	119	110	100	153	143	134	187	177	168
Short - Fall - Band	110	101	92	145	135	126	179	170	161
- Broadcast	107	98	89	138	128	119	169	159	150
- Spring - Band	119	109	99	156	146	136	193	183	173
- Broadcast	116	107	98	150	140	131	183	173	164
Wet Years									
Tall - Fall - Band	195	183	172	250	238	227	305	294	282
- Broadcast	196	184	172	249	237	225	302	290	278
Short - Spring - Band	191	178	166	246	233	221	301	288	275
- Broadcast	192	179	165	245	231	218	298	284	270

[+] Income above costs of fertilizer and fertilizer application.

[‡] N fertilizer cost in spring; fall fertilizer costs are 85% of spring.

C. EFFECT OF ZERO TILL AND N & P FERTILITY ON SOIL QUALITY

1. Method of Analysis

In October, 1986 after 6 consecutive crops of wheat were taken off the zero till snow trap study area, the soil from the Yr 2 test plot site was sampled together with the fallow, and the cropped phases of a wheat-fallow rotation situated on the adjacent conventionally tilled area which had been kept in this type of rotation since the inception of the study. Prior to the initiation of our study this entire area had customarily been in a fallow-wheat rotation for about the previous 70 years.

Twenty soil samples were taken at random from two soil depths (0-7.5 and 7.5-15 cm) of each replicate of the short stubble area. These sub-samples were bulked by depth and replicate to provide 8 samples (2 depths x 4 reps). A preliminary test in 1985 had showed no significant difference due to stubble height for the parameters assessed. In the conventional fallow-wheat area, each of the fallow and stubble areas were split into quadrats and 10 soil samples per depth per quadrat were taken and these bulked to provide 1 sample per depth per quadrat (called replicate in future).

Soil samples were passed field moist through a 2 mm sieve and kept in plastic bags in the cold room at 0°C until analysed. The following soil characteristics were measured: total C & N, respiration of CO_2 at 20°C for 10 days, amino acids and amino sugars after acid hydrolysis of soil, potentially mineralizable N (N_o) and rate constant (k) calculated from a 16-week aerobic incubation and leaching procedure, microbial biomass C & N, soil enzymes (e.g., alkaline and neutral phosphatase, and urease) and aggregate stability by dry sieving. Ten separate samples per depth per quadrat, and also per replicate in the zero till study, were taken with a soil corer and these used for bulk density determinations.

2. Results and Discussion

We assumed that the 70-year wheat-fallow system is now in equilibrium and that the level of the components found in this system is equal to the levels that would have been found 6 years earlier when the study was initiated; and we further assumed that since this area is uniform and adjacent to the zero till test, then the soil quality of the wheat-fallow area now is as it was in the zero till test site in 1981.

If these assumptions hold true, then it appears that some significant improvements in soil quality have occurred due to the combined effects of zero tillage, continuous cropping and regular fertilization (Tables 1-3). For example, the following soil biochemical characteristics all show either significant ($P < 0.05$) or near significant improvement due to the zero till, etc., treatments: In the top 7.5 cm of the soil, total N & C concentration, total amino acids and amino sugars, biomass N, and in the 7.5-15 cm depth total C concentrations were increased by zero tillage (Table 1). Furthermore, the following criteria for assessing microbial and enzyme activity were also significantly increased in the 0-7.5 cm depth: CO_2 respiration, phosphatase activity, and rate of net N mineralization (Table 2 and Fig. 1). Neutral phosphatase was the only one of the latter factors showing an increase in the 7.5-15 cm depth. Although the crop residues from the most recent crop were responsible for part of the increases noted in amino compounds and neutral phosphase activity (compare *F-W to F*-W), by far the greatest effect was due to the cumulative effect of 6 years cropping and fertilizing using zero tillage. The individual amino acids were all increased by recent crop residues and increased further by zero till-fertilizer management (Table 3). However, the relative molar fraction of amino acid N was not affected by treatment for any acid, showing that although the quantity of amino acids has been increased the quality of the soil protein has not changed.

Bulk density was not affected by the cropping system or phase at either depth. The average densities were 1.29 and 1.42 g cm^{-3} for the 0-7.5 and 7.5-15 cm depth, respectively. The erosive fraction of soil aggregates (< 0.84 mm) were significantly decreased by a single year of cropping but was not decreased further by zero tillage (Table 1).

These results suggest that large improvements in soil quality may be expected even in a short period by the adoption of a zero till-continuous wheat system that uses adequate fertilizer applications. Yields such as those obtained in 1986 support the improvement in soil quality measured here. However, as stated earlier, weed infestation remains a significant problem area to contend with.

Table 1. Effect of 6 years zero till continuous wheat on some biochemical and physical characteristics of a loam

Treatment and Depth (cm)	% N	% C	Total Amino Acids (mg N/kg soil)	Total Amino Sugar (mg N/kg soil)	Microbial Biomass C (μg/g soil)	Microbial Biomass N (μg/g soil)	Microbial Biomass C/N Ratio	+Erodibility (%)
<u>0-15 cm</u>								
#F-W	0.127	1.27	337	68	368	40	9.2	64
F-W#	0.131	1.12	384	84	397	44	9.0	40
Zero till	0.149	1.68	483	87	415	74	5.6	43
Signif. (F)	*	*	(0.10)	*	NS	*	*	*
$S\bar{x}$	0.007	0.11	43	4.7	26	9	1.3	5
<u>7.5-15 cm</u>								
#F-W	0.118	1.14	302	85	260	18	14.4	
F-W#	0.107	0.98	268	70	233	18	12.9	
Zero till	0.135	1.49	356	89	283	18	15.7	
Signif. (F)	NS	*	NS	NS	NS	NS	NS	
$S\bar{x}$	0.010	0.14	37	10	21	7	13	

+ Proportion of aggregates with size less than 0.84 mm as determined by dry sieving (erosive aggregates).

Phase of crop rotation sampled.

*, NS = significant at $P < 0.05$ and not significant, respectively.

Table 2. Effect of 6 years zero till continuous wheat on some biological activities of a loam

Treatment and Depth	Cum. Respiration $\mu g\ g^{-1}$ CO_2 in 10 days at 20°C	Phosphatase Activity P-Nitrophenol ($\mu g\ g^{-1}\ hr^{-1}$) Alkaline	Phosphatase Activity P-Nitrophenol ($\mu g\ g^{-1}\ hr^{-1}$) Neutral	Urease Activity $\mu g\ g^{-1}$ soil	Potentially Min. N, N_o, ($\mu g\ g^{-1}$)	Rate Constant (k) (wk^{-1})
0-7.5 cm						
#F-W	116	378	438	74	94	0.188
F-W#	126	416	529	72	85	0.216
Zero till	214	568	669	80	121	0.235
Signif. (F)	**	*	*	NS	*	*
$S\bar{x}$	14	28	50	4	8	0.008
7.5-15 cm						
#F-W	38	430	314	80	37	0.214
F-W#	40	386	370	89	37	0.200
Zero till	45	436	504	91	53	0.203
Signif. (F)	NS	NS	*	NS	NS	NS
$S\bar{x}$	11	38	42	12	7	0.006

Phase of crop rotation sampled.
*, **, NS = significant at $P < 0.05$, $P < 0.01$ and not significant, respectively.

Table 3. Amino acid content of a fallow-wheat and a 6-year zero till continuous wheat system (0-7.5 cm depth)

Amino Acids	Stubble treatments		
	#F-W	F-W#	Zero till
Alanine	28.5	36.4	43.3
Argenine	39.0	43.7	58.1
Asparagine	41.3	46.0	57.7
Cystine	15.5	17.1	21.2
Glutamine	28.5	32.6	40.2
Glycine	40.8	48.4	61.0
Histidine	12.4	14.6	17.1
Isoleucine	9.5	10.2	13.7
Leucine	16.2	18.1	23.7
Lysine	33.8	37.4	46.4
Methionine	1.0	1.2	1.2
Phenylalanine	7.7	8.6	11.2
Proline	14.9	17.3	19.7
Serine	21.7	23.3	30.4
Threonine	19.2	22.0	28.0
Tyrosine	2.6	3.0	3.2
Valine	4.4	5.1	5.9
Total	337	385	482

Phase of crop rotation sampled.

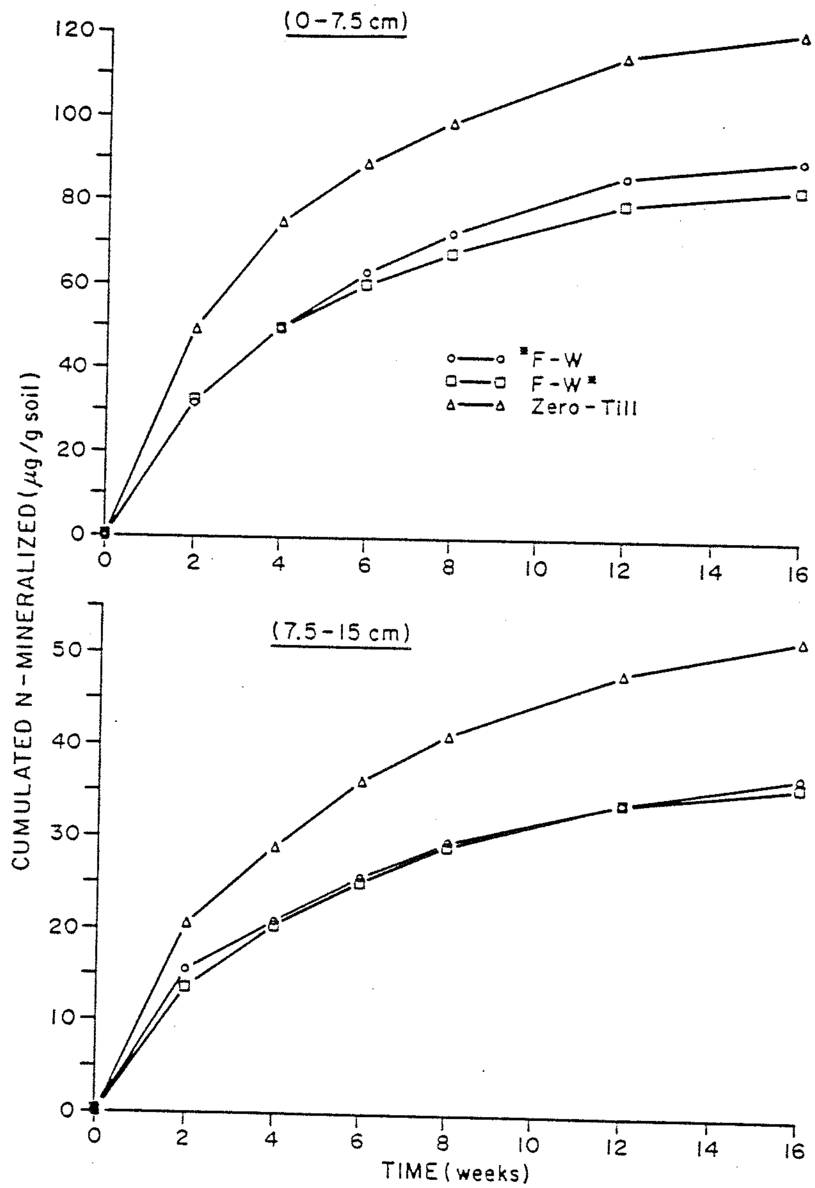


Figure 1. Effect of stubble management on cumulated net N mineralized in 0-7.5 and 7.5-15 cm depths.

CONCLUSIONS OF STUDY

1. By using cereal trap strips instead of stubble cut at standard 15 cm height we have only been able to conserve 11 mm of extra water, instead of the 46 mm that we had hoped for (average difference between stubble and fallow systems in Brown soils at seeding). However, it appears that this conserved water is being used more efficiently than that stored in fallow.
2. Yield analysis shows clearly that broadcasting N in the fall is the worst scenario of the band-broadcast-fall-spring application combinations. The 6-yr average ranking in yields is 100, 97, 95 and 90 for spring-band, fall-band, spring-broadcast and fall-broadcast, respectively.
3. But the economic analysis suggests that fall broadcast may well be the best scenario. In dry years broadcast application was more profitable than deep banding; in wet years net returns were independent of time or method of N application, but in moist years (average moisture) fall broadcast resulted in lowest net returns.
4. Net returns averaged 15-25 $\$.ha^{-1}$ higher on trap strip plots than on standard stubble plots in dry years, but the advantage was only 4-8 $\$.ha^{-1}$ higher in years with average moisture, and no different in wet years.
5. The economic picture for deep banding fertilizer would improve if it could be combined with another field operation or if zero till seeding equipment capable of banding fertilizer separate from the seed were to become readily available.
6. The combination of zero tillage-continuous cropping with adequate

fertilization has improved the quality of the soil significantly in the short space of 6 years and water infiltration may also have improved.

7. But the greatest drawback to this system so far has been the increase in grassy weeds with time.

D. INTERACTION OF FERTILIZER N & P AND SNOW CONSERVATION ON MOISTURE CONSERVED AND ON WINTER WHEAT YIELDS IN SOUTHWESTERN SASKATCHEWAN

Summary

Interest in winter wheat production increased in Saskatchewan in the 1980's. Research was required to provide a suitable agronomic package to ensure successful production of this crop under Saskatchewan's harsh winter conditions. A 3-year study was carried out on a loam soil in the Brown soil zone in which stubbled-in winter wheat was grown under zero-till management and the efficacy of snow trapping and various fertilizer management procedures designed to improve nutrient efficiency examined. In the first year, the combination of a very dry fall and preseeding deep banding of fertilizer with a hoe drill resulted in considerable soil disturbance and a very poor plant stand in the test plots, but adjacent filler plots (extra plots used to avoid residual fertilizer effects) which received 25 kg $N.ha^{-1}$ broadcast fertilizer yielded 2660 $kg.ha^{-1}$. In the third year, fall soil moisture was very low and no germination occurred until spring; even then germination was so poor that the test was terminated. In contrast, winter wheat seeded nearby on chemical fallow that year yielded 2700 $kg.ha^{-1}$. Only in the second year was the experiment successfully performed. Cereal trap strips conserved 10 mm of additional soil water each of the 3 winters, but this had no effect on yields. Yields in the second year were greater for fall-applied N than for spring-applied N; this response was explained in terms of the amount of precipitation received soon after the fertilizer was applied. Yields were greater for the ammonium nitrate source of N than for urea at N rates less than 75 $kg.ha^{-1}$; the

converse was true at higher N rates. Yields peaked at 50-75 kg $N.ha^{-1}$; above this rate yields declined. P fertilizer increased yield significantly only at the highest rate (120 kg $P_2O_5^{-1}$ broadcast applied) on this soil which has adequate available P. Several options were suggested for producers that are interested in growing winter wheat in the Brown soil zone. Perhaps the best is for them to seed winter wheat on stubble in early September and if insufficient precipitation is received for good fall germination either re-seed to spring wheat in the spring (stored soil moisture permitting) or chemical fallow with the option of seeding winter wheat in the fall or spring wheat the following spring.