

EFFECT OF STUBBLE HEIGHT AND SOURCE, RATE, TIME AND METHOD OF
APPLICATION OF N ON YIELD OF SPRING AND WINTER WHEAT
GROWN UNDER ZERO TILL

C.A. Campbell, W. Nicholaichuk, D.W. McAndrew,
G.E. Parker and J.D. Beaton¹

Research Station,
Research Branch, Agriculture Canada,
Swift Current, Saskatchewan. S9H 3X2

INTRODUCTION

There is considerable interest in ways to increase cereal production under dryland cropping conditions in Western Canada. Some of the new technology being suggested include making use of snow trap strip techniques; adapting fertilizer management methods that improve its efficient use; reducing tillage; and possibly expanding winter wheat acreage.

Last year at these meetings we reported on the first year's results of a study that we had initiated at Swift Current which was designed to incorporate all the features mentioned above. We will only be reporting on the results of the second year's experiments at this time.

MATERIALS AND METHODS

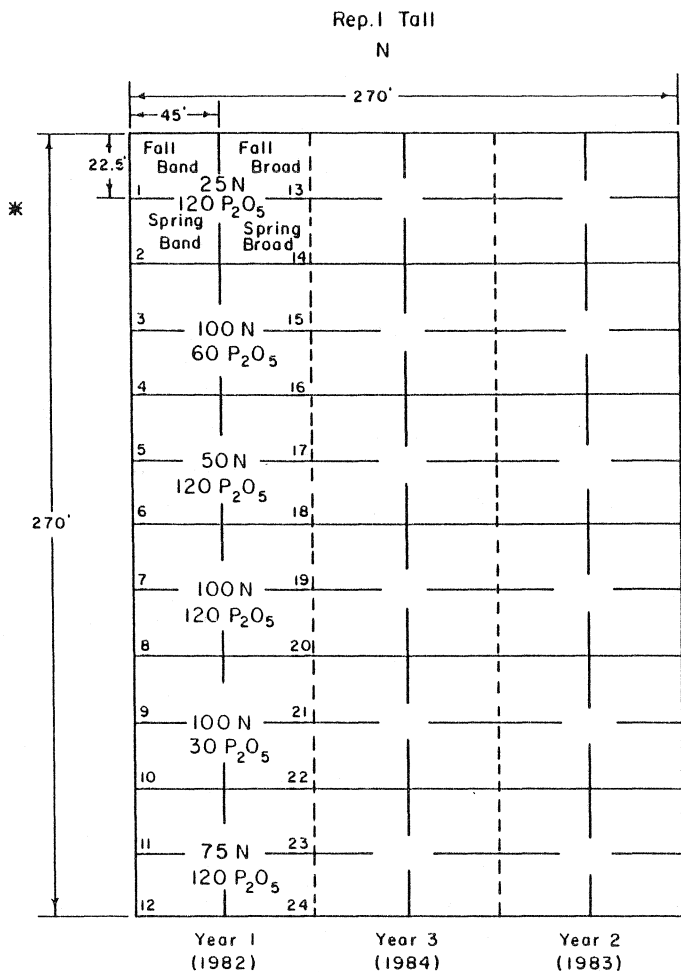
Two separate experiments, one with spring wheat and the other with winter wheat were initiated in 1981, when the stubble treatments were established. The first year's test was completed in 1982 (Campbell et al. 1983). The second year's test was run in a similar manner with a few minor changes. One of these involved dispensing with the 150 kg/ha rate and including a 75 kg N/ha rate instead.

Description of Treatments

Both experiments were composed of four replicates (blocks) (Fig. 1) each about 2.5 ha in size and carried out at two separate but nearby sites, 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,

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Spring Wheat (46-0-0)



* FOR WINTER WHEAT

2 Sources of N used : 34-0-0 and 46-0-0

(a) All N broadcast in fall

(b) All N " in spring

Dimensions : 258 x 384 (32' x 43')

DIMENSIONS ARE APPROXIMATE

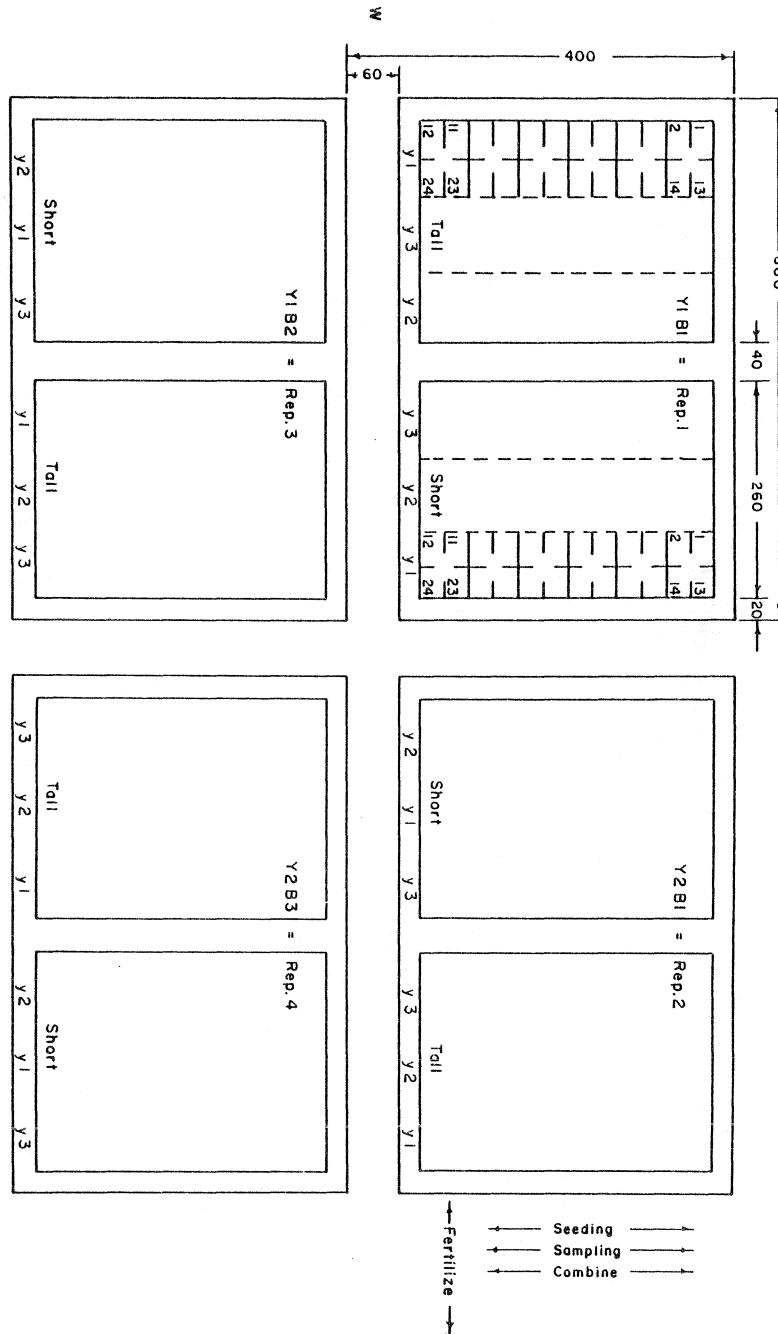


Fig. 1. Right - general field plan; left - details of a spring wheat plot for tall stubble treatment

yr 2, yr 3) to allow us to move the experiment to fresh unfertilized land for each of the first three years of the study. The year 1 sub-blocks were divided into six fertilizer rate sub-sub-blocks to allow four comparisons of N rates and three comparisons of P rates: [viz., 25/120, 50/120, 75/120, 100/120; 100/60, 100/30: (kg N/kg P₂O₅)]. Each fertilizer rate treatment was then divided into two sub-sub-sub-blocks comparing urea vs (AN) ammonium nitrate (winter wheat only), or banded vs broadcast urea N (spring wheat). There was a further split comparing fall vs early spring N application. The year-blocks not being used in a particular year (filler blocks) were seeded; 90 kg 28-28-0 fertilizer was applied at seeding. (See Fig. 1 for more details). In this study we attempted to use the zero till technique.

Table 1. Activities carried out in 1982-83

<u>Winter Wheat</u>			
<u>Activity</u>	<u>Date</u>	<u>Rate</u>	<u>Comments</u>
<u>Herbicides</u>			
Sweep	16/9/82	2.25 L product/ha	
2,4-D Ester 500	16/9/82	0.84 L product/ha	
Buctril M	25/5/83	1.4 L product/ha	
<u>*[†]Fertilizers</u>			
Sulfur	16/9/82	25 kg/ha	
Phosp. & Pot.	17&20/9/82	K at 60 kg K ₂ O/ha; P as per Fig. 1	
Urea & Am. nitrate	25/10/82	See Fig. 1	Fall-appli.
Urea & Am. nitrate	19-20/4/83	See Fig. 1	Spring-appli.
‡ Seeding (Norstar)	8/10/82	67 kg/ha	17.8 cm spac.
<u>Spring Wheat</u>			
<u>Activity</u>	<u>Date</u>	<u>Rate</u>	<u>Comments</u>
<u>Herbicides</u>			
2,4-D Ester 500	27/10/82	0.84 L product/ha	
Hoegrass	16/6/83	3.75 L product/ha	
Torch	16/6/83	1.25 L product/ha	
<u>*‡Fertilizers</u>			
Sulfur	26/10/82	25 kg/ha	
Phos. & Pot.	26/10/82	K at 60 kg K ₂ O/ha; P as per Fig. 1	
Urea	26/10/82	See Fig. 1	Fall-applied
Urea	20/4/83	See Fig. 1	Spring-appli.
Seeding (Canuck)	16/5/83	67 kg/ha	17.8 cm spac.

[†] All broadcast except the 90 kg of 28-28-0 that was placed with seed of all treatments and filler blocks as well.

‡ The crop germinated but did not emerge until April 1983.

*‡ The S was broadcast, P & K deep banded and urea either broadcast or banded as per Fig. 1. Allowances were made for the 90 kg of 28-28-0 placed with the seed.

* At seeding time spring wheat test plots had 13 kg NO₃-N/ha-60 cm and 15 kg P₂O₅/ha-15 cm; winter wheat had 22 kg NO₃-N and 25 kg P₂O₅.

The dates and rates of herbicide and fertilizer treatments and seeding of Canuck (spring wheat) and Norstar (winter wheat) are shown in Table 1.

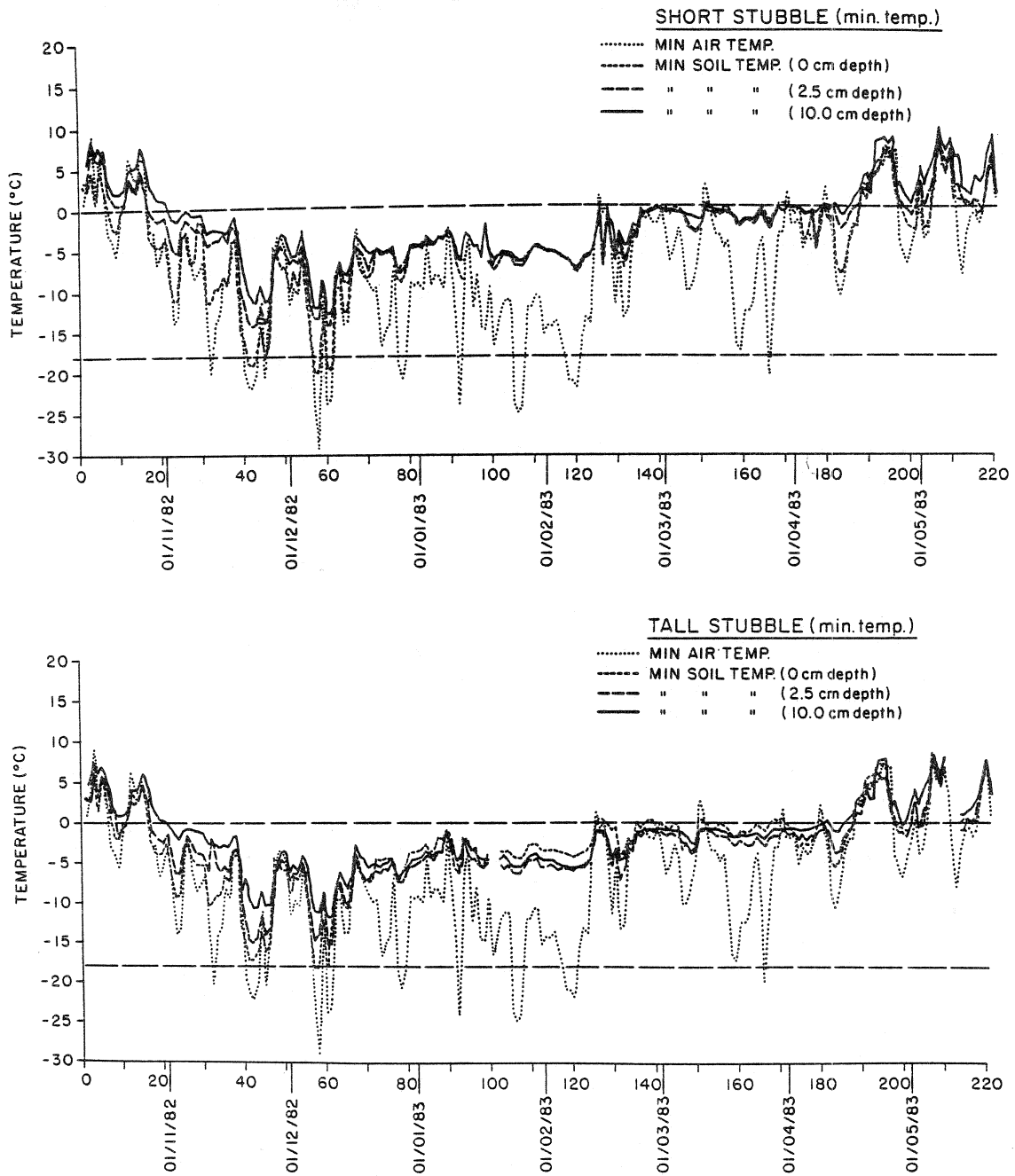


Fig. 2. Air and soil temperatures during winter of 1982-83 in tall and short stubble plots of winter wheat.

RESULTS

Weather and Snow Trap 1982-83

The winter of 1982-83 was generally warmer than average; thus soil temperatures were never below the critical -18°C that would have deleteriously affected Norstar winter wheat survival (Fig. 2).

Early fall 1982 was so dry that the zero till drill would not penetrate the soil in September and seeding of winter wheat had to be delayed until October 8, after rainfalls were received in late September.

The height of the tall stubble plots was 17% less than in 1982-83 underscoring one possible problem that might be encountered with this technique in the Brown soil zone, namely, the occurrence of short stubble when stubble cropping. The fall rains mentioned earlier eventually provided good fall moisture (better than in '81-'82). Of the 11.3 cm of precipitation received in the winter, tall stubble treatments in the spring wheat captured 28% (3.1 cm) and short stubble captured 23% (2.6 cm) for an average gain of 0.5 cm of water in favour of tall stubble (Table 2). In winter wheat tall stubble captured 43% (4.9 cm) of the 11.3 cm and short stubble captured 33% (3.7 cm) for an extra 1.1 cm in favour of tall stubble. It should be noted, however, that these measurements were made in the filler blocks and not in the plots to be used for the test. (We did this so as to reduce traffic, especially on the winter wheat test plot). The assumption was that the "filler" blocks and test plots would generally behave the same in trapping snow. However, we are beginning to have second thoughts regarding this assumption in the spring wheat system. In this latter case the test plots receive a deep banding of P and K fertilizer in fall which tends to "till" the very dry soil (Fig. 3). The latter might facilitate entry of snowmelt into the soil. The fertilizer is broadcast onto the winter wheat and so the soil is not generally disturbed (Fig. 4) thus the test and "filler" blocks might be quite similar in this case.

The growing season was characterized by a wetter than average May and July and a dry, very hot August. The latter likely set back yields of both spring and winter wheat. Growing season precipitation was 176 mm; that is, about average for this area, but about 23% less than last year.

Yields of Spring Wheat

Average yields of spring wheat were 1681 kg/ha compared to 2365 kg/ha in 1981-82 (this difference was mainly due to the lower precipitation). Nonetheless, treatment responses were generally similar to last year's. For example:

- (i) yields increased curvilinearly with N rate (Fig. 5);
- (ii) deep banded N increased yields significantly over broadcast N (Fig. 5);

Table 2. Efficiency of snow capture by trap strips in 1981-82 and 1982-83

Stubble height and winter season	Total winter precip. cm	Rep. 1		Rep. 2		Rep. 3		Rep. 4		Mean	
		Soil water intake cm/ 120 cm	Snowmelt intake effic. %	Soil water intake cm/ 120 cm	Snowmelt intake effic. %	Soil water intake cm/ 120 cm	Snowmelt intake effic. %	Soil water intake cm/ 120 cm	Snowmelt intake effic. %	Soil water intake cm/ 120 cm	Snowmelt intake effic. %
		<u>Spring wheat</u>									
Tall 1981-82	11.0	4.60	41.8	6.63	60.3	3.25	29.5	4.12	37.5	4.65	42.3
Short 1981-82	11.0	3.90	35.5	4.54	41.3	3.65	33.2	0.97	8.8	3.78	34.4
Tall 1982-83	11.3	4.70	41.6	3.71	32.8	3.32	29.4	0.74	6.5	3.12	27.6
Short 1982-83	11.3	2.66	23.5	1.41	12.5	5.99	53.0	0.28	2.5	2.59	22.9
<u>Winter wheat</u>											
Tall 1981-82	11.0	4.29	39.0	3.97	36.1	4.67	42.5	4.37	39.7	4.32	39.3
Short 1981-82	11.0	3.61	32.8	2.82	25.6	4.47	40.6	2.84	25.8	3.44	31.3
Tall 1982-83	11.3	3.60	31.9	3.61	31.9	5.26	46.5	7.08	62.7	4.89	43.3
Short 1982-83	11.3	4.50	39.8	2.79	24.7	2.34	20.7	5.36	47.4	3.75	33.2

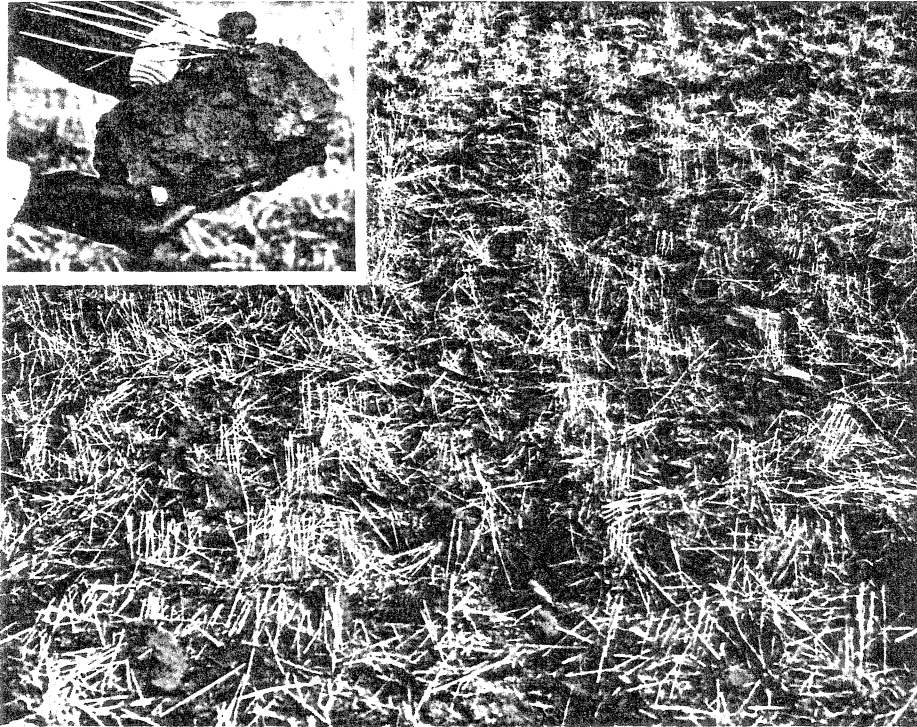


Fig. 3. Spring wheat after deep banding in the fall - note "tillage" effect.



Fig. 4. Winter wheat seeding and fall fertilization complete - note relatively smooth surface.

- (iii) except at the highest N rate, spring-applied N outyielded fall-applied N (Fig. 5);
- (iv) yields were significantly greater in tall stubble than short stubble at the two highest rates of N (Fig. 5).

Point (iv) is somewhat different from results we obtained in 1981-82 when an interaction was observed between stubble height and N rate. We believe that the difference in results was due to the difference in rainfall distribution between the two years. In 1982 good, early rains had caused lush early vegetative growth but when this growth was not supported by adequate rainfall during grain filling yields of high N treatments diminished (Campbell et al. 1983). In 1983 the crop was not overly vegetative because early precipitation was less and more evenly distributed over the growth period.

Deep banded P resulted in significant though likely uneconomical yield increases at the highest P rate (Fig. 5).

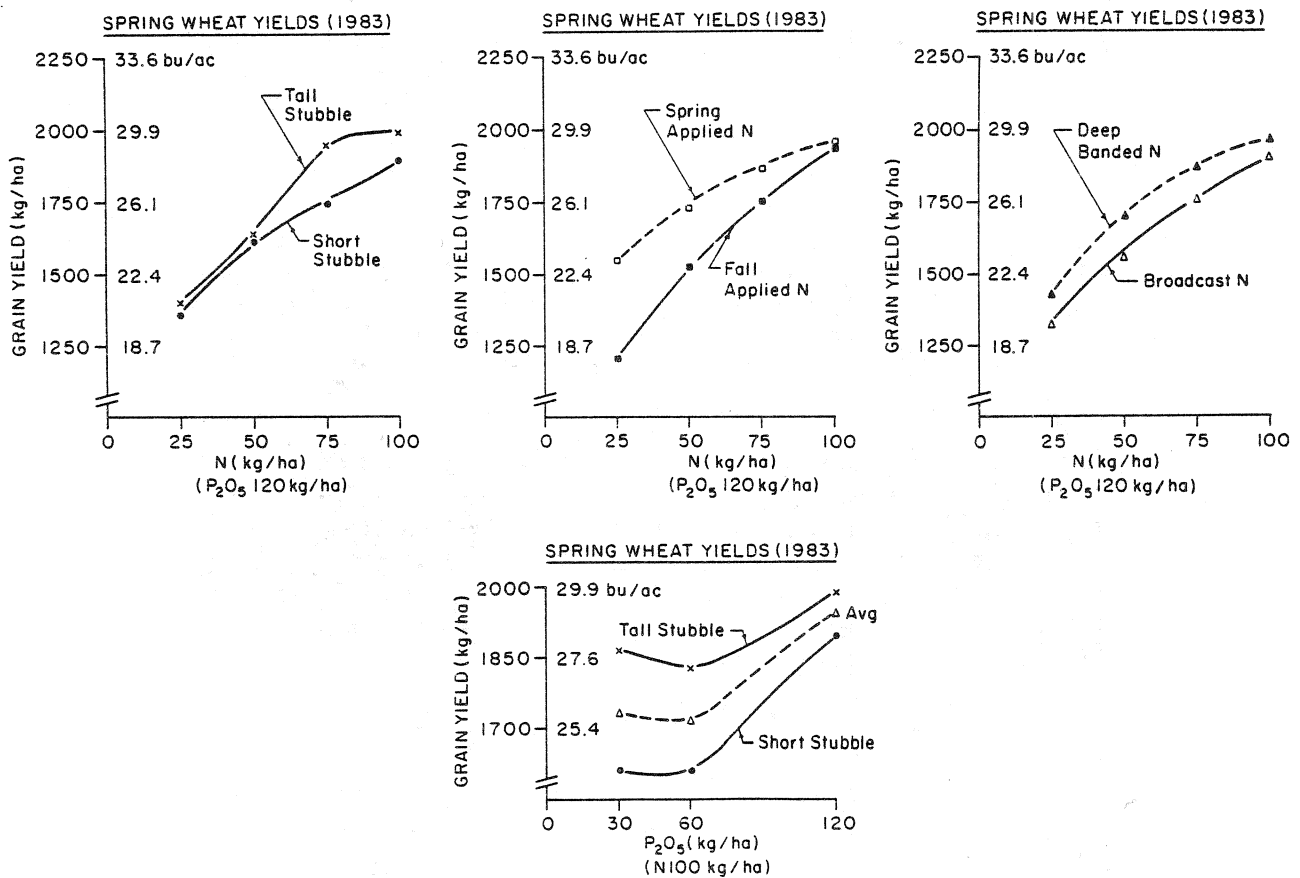


Fig. 5. Effect of N rate, placement, time of application, P rate and stubble height on spring wheat yields.

Highest spring wheat yield obtained was 2378 kg/ha (compared to 3283 kg/ha in 1983). This yield was obtained when N was 100 and P₂O₅ 120 kg/ha, deep banded in the fall with wheat seeded in the tall stubble. "Filler" block yield was only 1144 kg/ha (it received 25 kg N/ha and 25 kg P₂O₅ with the seed). This then underscores the benefits of using proper fertilization.

Yields of Winter Wheat

The winter wheat crop looked fairly good until late July when an infestation of leaf blight (*Helminthosporium sativum*) was observed during the grain filling period. This, plus the very hot conditions in August must have reduced the potential yield.

However, reasonable yields were obtained. The average yield was 2367 kg/ha (41% greater than average spring wheat yield). The highest yield was 3253 kg/ha, obtained on a treatment receiving 75 kg ammonium nitrate-N/ha, 120 kg P₂O₅-/ha, broadcast in spring and the crop grown in tall stubble treatment. The filler blocks had a yield of 1971 kg/ha compared to 2670 kg/ha for similar plots in 1982.

Yields increased with N up to 75 kg N/ha but, as noted by Fowler (1983), high rate of N depressed yields (Fig. 6). The ammonium nitrate-N produced greater yields than the urea N, except at rates of 75 kg N/ha or more. The latter suggests that early losses of urea, likely by volatilization, was probably responsible for the lower yields at the lower N rates. Fall-applied N resulted in significantly ($P > 0.01$) greater yields of winter wheat than spring-applied N (Fig. 6). This result is in contrast to the response we obtained for spring wheat and also in contrast to the usual findings for winter wheat (Fowler 1983). The amount of mineral N recovered in the soil at the 3 leaf stage of growth showed the same general trend as did the winter wheat yield (Fig. 6).

As noted for spring wheat, only the highest rate of phosphorus increased winter wheat yields significantly, and this occurred only when N was applied in the fall (Fig. 6). The phosphorus was broadcast and not incorporated for winter wheat. We did this although this is perhaps the least desirable method of application because, as shown in 1982, deep banding before seeding winter wheat into stubble is too risky in the Brown soil zone.

DISCUSSION

Since the N fertilizer was applied at the same times in both winter and spring wheat experiments (Table 1), it is difficult to explain the contrasting difference in response to time of N application. In a separate study with grass in which the effect of fall-applied N (on October 28, November 23 or December 21) is being compared to spring-applied N (April 14), it was found that the October and November treatments significantly outyielded the April treatment

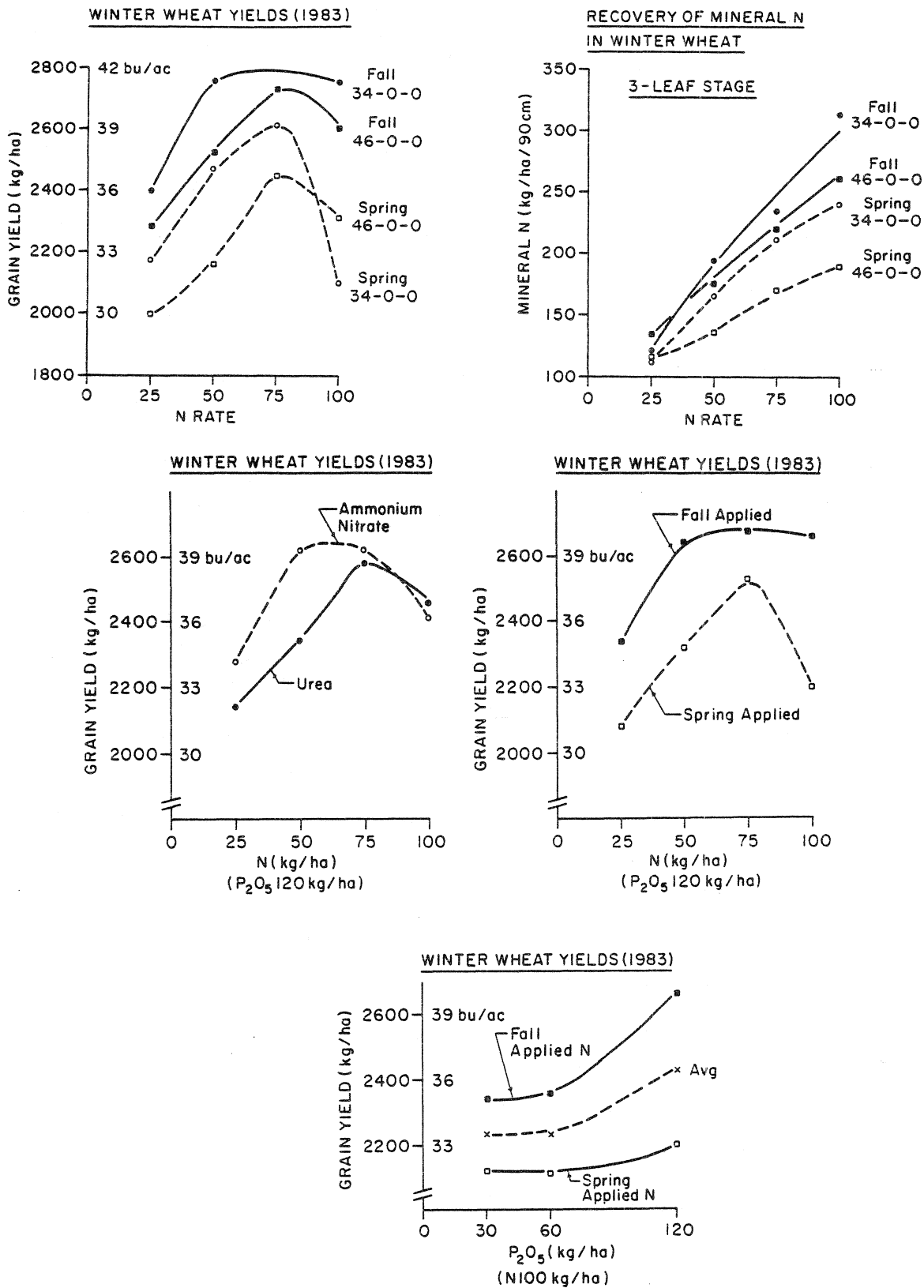


Fig. 6. Effect of N rate, type, time of application and P rate on winter wheat yields.

(Fig. 7). This is not usually the case. The winter wheat has one thing in common with the forage crop, i.e., its early spring growth.

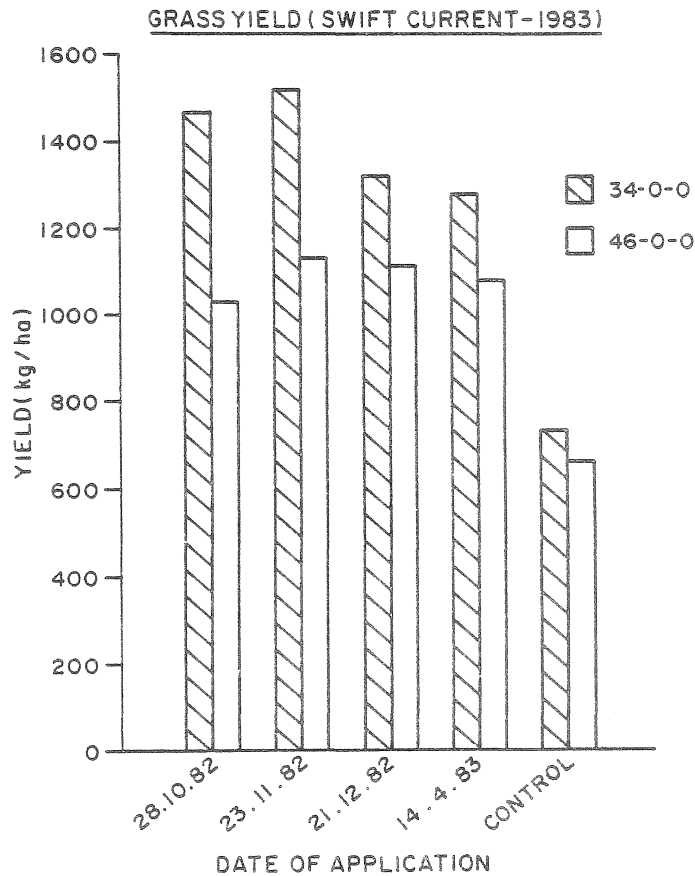


Fig. 7. Response of grass to N fertilizer

In contrast, the spring wheat was not seeded until May 16. It is likely that the main difference in response by spring and winter wheat was due to some difference between the two systems during the period mid-April to late May.

Reactions overwinter would be low since soil temperatures were below 0°C from late October to mid-April (Fig. 2). In any event, N losses would have been similar for both of these systems during this period. During the last week of April there was some rain and on the 7th and 9th of May almost 50 mm of rain fell (Fig. 8). The latter

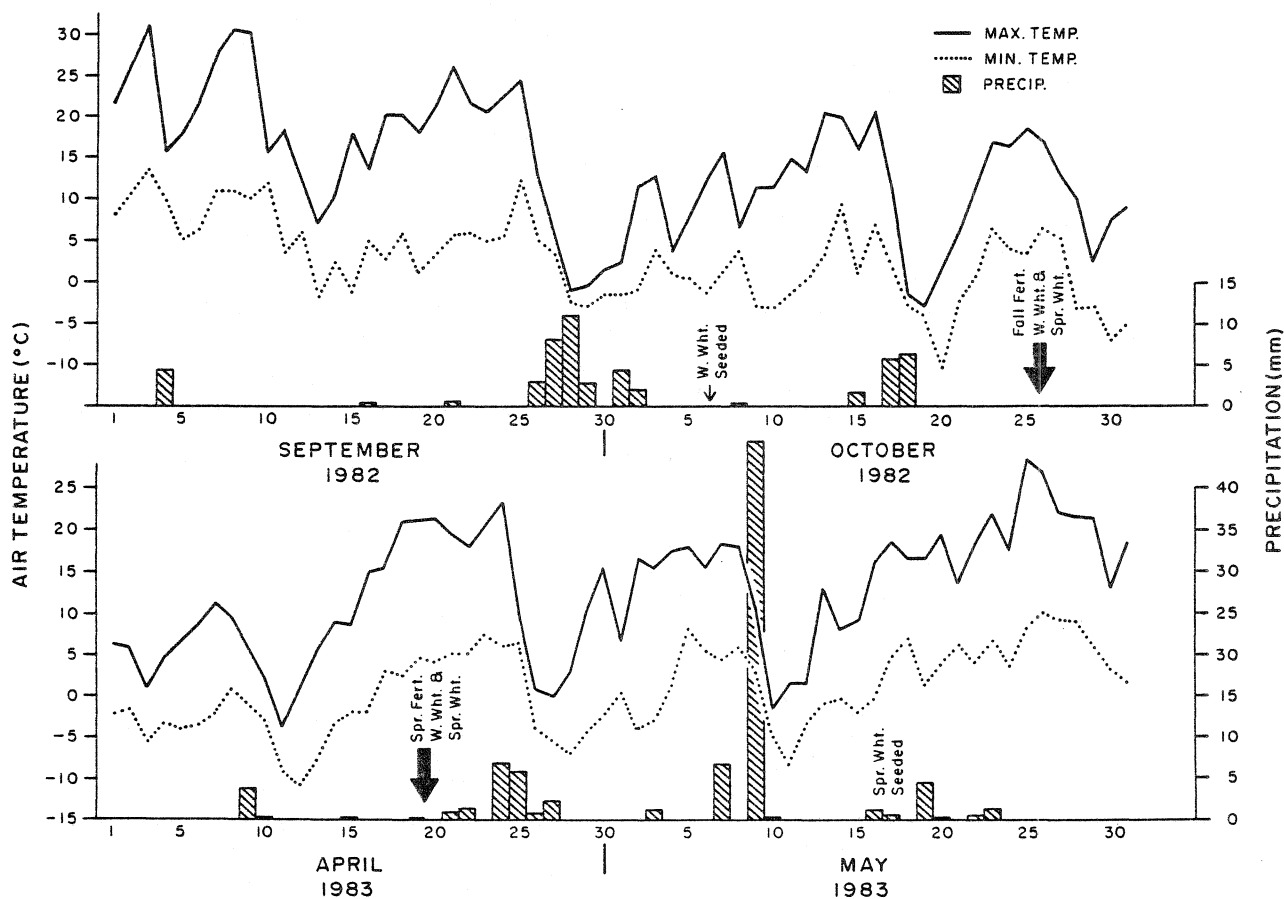


Fig. 8. Daily weather during periods when fertilization and seeding was performed.

precipitation might have resulted in N losses by denitrification of nitrates. Nyborg (1983) has identified this period as the main time when much soil N is lost by denitrification. Also, Aulakh and Rennie (1983) have found that denitrification can be quite significant in zero till systems. The presence of carbonaceous substrate (zero till), nitrates from fertilizer and wet conditions are ideal for denitrification losses of N. These losses would be relatively less where a crop had already had an opportunity to take up some of the N (e.g., in the case of winter wheat and the forage experiment cited earlier). Further, the winter wheat would have had a greater chance to have used the fall-applied N than the more recently spring-applied N. Thus, under winter wheat more spring-applied N would be lost. In contrast, with spring wheat, no crop was present to use any of the fall- or spring-applied N before the rains came in May. But since

losses of fall-applied N would have been occurring for a longer period than for the spring-applied N, the losses from fall-applied source would likely be greater in the case of spring wheat.

Another peculiar observation emanating from this study was the significant increase in yield due to tall stubble for spring wheat but not for winter wheat. Although we attempted to measure differences caused by differences in stubble height on such meteorological factors as wind, evaporation and soil temperature we could find no difference due to stubble height (data not shown). However, as discussed earlier the apparent difference in degree of "tillage" between the winter wheat and spring wheat test plots might be responsible for the difference in response observed. The spring wheat test plots might actually have absorbed more water from snowmelt than we measured in the adjacent tiller blocks.

SUMMARY

1. System: zero till, wheat on stubble using Canuck and Norstar.
2. Weather: relatively warm winter, good growing season except for very hot August.
3. Snow trap: Spring wheat - tall stubble trapped 28% of 11.3 cm winter precipitation obtained; short stubble trapped 23%; difference was 0.5 cm water in favour of tall stubble.
Winter wheat - tall stubble trapped 43% of 11.3 cm; short stubble 33% for difference of 1.1 cm water for tall stubble.
These measurements made in filler blocks; we suspect they may be low compared to real situation in spring wheat test plots because the latter tend to be "tilled" by deep banding and the filler blocks and winter wheat are not deep banded.
4. Yields: Spring wheat (urea N used)
 - Average for all treatments 1681 kg/ha
 - Highest was 2378 kg/ha (100 N, 120 P₂O₅, banded, tall stubble)
 - Filler blocks 1144 kg/ha (25 N, 25 P₂O₅)
 - Yield increased with rate of N to 100 kg N/ha
 - Yield increased by as much as 200 kg/ha for tall > short stubble at high N rates
 - Spring-applied N gave greater yields than fall-applied
 - Deep banded N outyielded broadcast
 - Compared to 30 kg P₂O₅/ha, 60 kg rate not significant, 120 kg rate significant but not economic (P deep banded).

5. Yields: Winter wheat
- Average for all treatments 2367 kg/ha
 - Highest was 3253 kg/ha (75 N, 120 P₂O₅ banded, AN)
 - Filler blocks 1971 kg/ha (25 N, 25 P₂O₅)
 - Yield increased with rate of N to 75 kg N/ha then tended to level off or decrease
 - Stubble height did not influence yield
 - Fall-applied N surprisingly outyielded spring-applied N
 - Ammonium nitrate source resulted in greater yields than urea
 - Broadcast P at 120 kg rate increased yield slightly over 60 and 30 kg rates but uneconomical.
6. Study will be repeated for third year in attempt to obtain a drier more typical Swift Current year.

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