EFFECT OF SOURCE, PLACEMENT AND TIME OF N APPLICATION ON WINTER WHEAT GROWN ON STUBBLE IN THE BROWN AND BLACK SOIL ZONES

C.A. Campbell, W. Nuttall, F. Selles, H. Ukrainetz,
C. Vera and T. Wright
Research Station, Agriculture Canada, Research Branch,
Box 1030, Swift Current, Saskatchewan, S9H 3X2
(A WestCo. Agron. Committee Funded Study)

During these difficult economic times for the farming community, any management option that increases the efficient use of fertilizers or improves the economic benefits, is welcomed by producers. In 1985 the Agronomy Committee of WestCo. asked us to undertake a study to determine if there was any time, other than at seeding or early spring, when N fertilizers could be advantageously applied to winter wheat. As well, they wished to know how N source and fertilizer placement might influence N use efficiency and net returns.

Yield responses to applied nitrogen have been related to the time of application of N. Several studies (Malhi and Nyborg 1979; Grant 1982) have shown that fall- or winter-applied fertilizer N has less effect on yields than spring-applied N. In Manitoba, Grant et al. (1985) found that yield of winter wheat responded to N applied at different times in the order spring > freeze-up > seeding > applied on the snow in winter. In a recent study carried out on forage grasses on a Brown and a Dark Brown soil in Saskatchewan, Campbell et al. (1986) showed that yields were highest when N was applied in mid April of the crop year and got progressively lower when N was applied the previous mid-October, mid-November, and mid-March. Malhi and Nyborg (1986) showed large losses of N from soils in early spring, which they suggested was mainly due to denitrification.

However, the reduced efficiency of winter applied N may be offset if fertilizer purchased in fall is much cheaper than that bought in spring. Furthermore, fall application offers some advantage to producers wishing to shift the workload from the customarily busy spring period to the fall and winter.

The objective of this study is to determine when is the best time to apply N to winter wheat so as to optimize net returns, and also to determine how N source and method of application affect the results. In this paper only yields will be assessed since there is presently insufficient data to permit the economic analysis to be done.

MATERIALS AND METHODS

The 22 treatments used in this study at Swift Current (Brown Soil Zone) and Melfort (Black Soil Zone) are shown in Table 1. The main difference between the two sites was that while 60 kg N ha^{-1} was applied at Swift Current, 100 kg ha^{-1} was applied at Melfort; in both places only 30 kg N ha^{-1} was seed-placed. In case of banding, the N was placed 5 cm deep midway between rows. The dates of application were dictated by weather conditions and these, therefore, also differ at each site (Table 1). Norstar winter wheat was seeded into stubble at a rate of 60 kg ha^{-1}; 45 kg P_2O_5 ha^{-1} was seed placed. A small zero till drill which seeds 4 rows, 22.5 cm apart was

Table 1. Fertilizer treatments and dates N applied at Swift Current and Melfort in the two years

Treatment No.	N source	Conditions when N applied	Application of fertilizer N: First 1/2	Second 1/2	All at once	Swift Current 1985-86	Swift Current 1986-87	Melfort 1985-86	Melfort 1986-87
1	34-0-0	warm	seed	band		Sept. 16	Sept. 11	Sept. 10	Sept. 9
2	34-0-0	warm	seed	broad		Sept. 16	Sept. 11	Sept. 10	Sept. 9
3	34-0-0	warm			broad	Sept. 16	Sept. 11	Sept. 10	Sept. 9
4	34-0-0	warm			band	Sept. 16	Sept. 11	Sept. 10	Sept. 9
5	34-0-0	cool	seed	broad		Oct. 2	Oct. 28	Sept. 28	Sept. 22
6	34-0-0	cool			broad	Oct. 2	Oct. 28	Sept. 28	Sept. 22
7	34-0-0	froz	seed	broad		Dec. 4	Dec. 11	Oct. 31	Oct. 28
8	34-0-0	froz			broad	Dec. 4	Dec. 11	Oct. 31	Oct. 28
9	34-0-0	spr	seed	broad		April 7	April 7	May 13	May 6
10	34-0-0	spr			broad	April 7	April 7	May 13	May 6
11	34-0-0	no N (discs in soil) (check 1)				--	--	--	--
12	46-0-0	warm	seed	band		Sept. 16	Sept. 11	Sept. 10	Sept. 9
13	46-0-0	warm	seed	broad		Sept. 16	Sept. 11	Sept. 10	Sept. 9
14	46-0-0	warm			broad	Sept. 16	Sept. 11	Sept. 10	Sept. 9
15	46-0-0	warm			band	Sept. 16	Sept. 11	Sept. 10	Sept. 9
16	46-0-0	cool	seed	broad		Oct. 2	Oct. 28	Sept. 28	Sept. 22
17	46-0-0	cool			broad	Oct. 2	Oct. 28	Sept. 28	Sept. 22
18	46-0-0	froz	seed	broad		Dec. 4	Dec. 11	Oct. 31	Oct. 28
19	46-0-0	froz			broad	Dec. 4	Dec. 11	Oct. 31	Oct. 28
20	46-0-0	spr	seed	broad		April 7	April 7	May 13	May 6
21	46-0-0	spr			broad	April 7	April 7	May 13	May 6
22	46-0-0	no N (discs out of soil) (check 2)				--	--	--	--

used to make 2 passes and provide 8 rows per plot. Treatments were completely randomized in 4 blocks (reps).

At Swift Current the wheat was seeded September 16, 1985 and harvested August 7, 1986 in the first year and seeded September 11, 1986 and harvested July 16, 1987 in the second year. At Melfort the corresponding dates of seeding and harvesting were September 9, 1985, August 15, 1986 and September 9, 1986, July 27, 1987, respectively.

Both plant density and yields were taken, but at Melfort, plant density were only judged qualititively in 1987.

At each site, the results for yield, and at Swift Current plant density, were analysed in three ways. First, linear contrast single degree of freedom analyses was used to compare each fertilizer N treatment with the average of the two checks (treatments 11 and 22) which were themselves found to be no different. Secondly, a factorial analysis of N source x 4 methods of N application at seeding (treatments 1-4 and 13-16) was done. Thirdly, a factorial analysis of 4 times of application x 2 sources x 2 methods (1/2 seed-placed, 1/2 broadcast vs all broadcast) was run. These three analyses were also done on the combined results for the two years as a split plot with year as the first factor.

Weather and Soil Nutrient Status

(a) At Swift Current

(i) 1985-1986

Due to frequent small rain showers that occurred in the early fall 1985, moisture in the top 120 cm of soil was fair in stubble at seeding time (191 mm/120 cm soil). This soil holds 154 mm water/120 cm soil at -4.0 MPa moisture potential (wilting point of wheat). However, due to (i) the prolonged drought that had occurred during the summer of 1985, (ii) the very short stubble from that crop (17 cm height), (iii) below average precipitation received during the winter of 1985-86, and (iv) a 24-hr thaw that occurred in late February 1986 which induced considerble runoff of snowmelt water, soil moisture recharge of the profile over winter was small and early spring soil moisture was only 180 mm/120 cm soil.

The poor soil moisture situation in April was alleviated by the occurrence of above average rainfall received in May (Figure 1). Although growing season precipitation was above average, the rainfall distribution was less than ideal for winter wheat (it was more ideal for spring wheat). For example, between May 22 and June 15 (about 5-leaf to shot blade stage) only one rainfall of 8 mm was received.

The winter of 1985-86 was generally fairly mild. For example, except for a period from late November to mid-December and from mid to late February, temperatures at the soil surface were rarely $< -10°C$ and they were never as low as -18°C (Figure 2).

Soil samples taken in the fall prior to seeding showed the amount of NO_3-N in the top 60 cm of soil to be 45 kg/ha while the bicarbonate extractable P in the top 15 cm was 38 kg/ha.

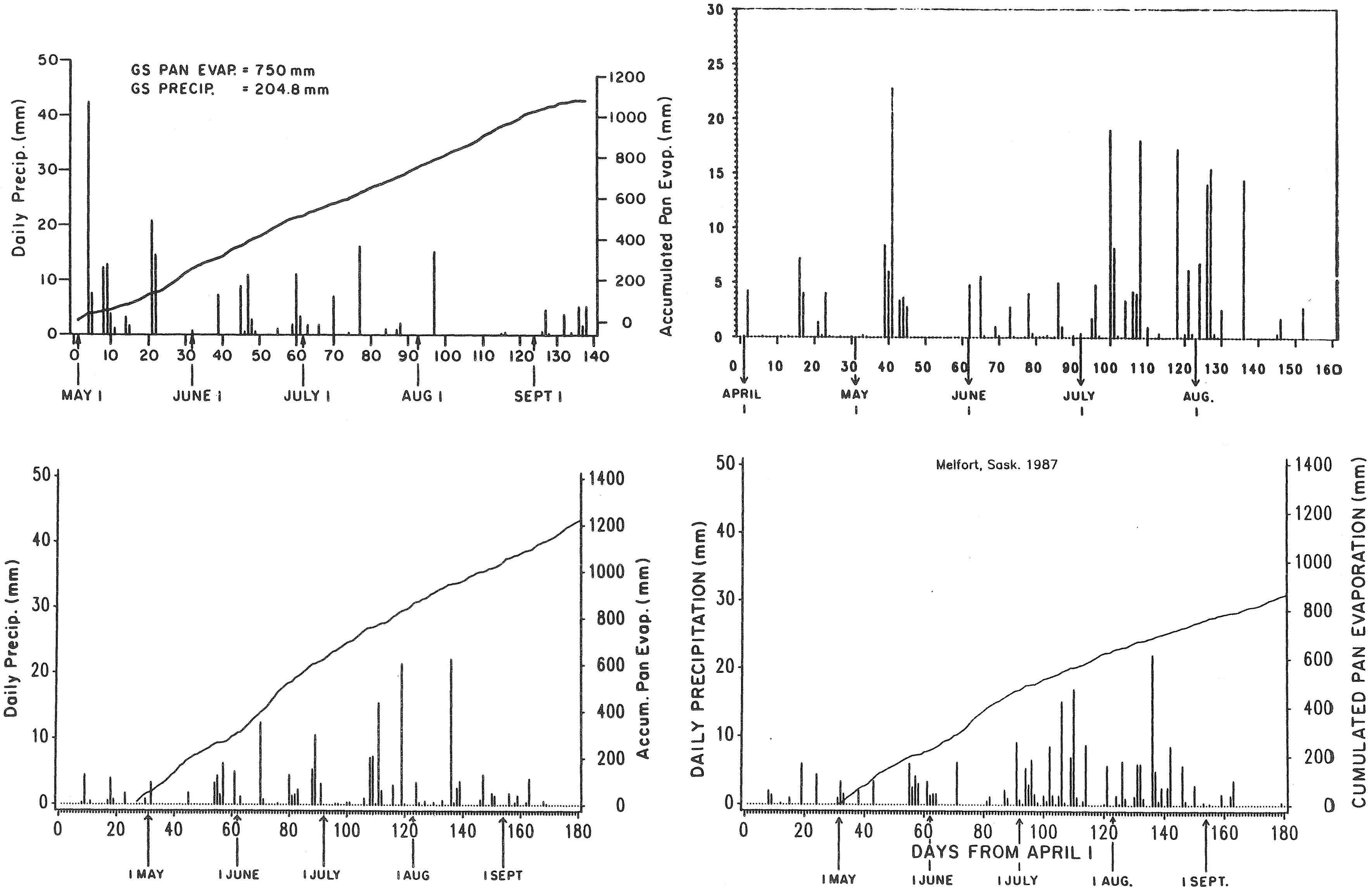

Figure 1. Growing season precipitation and accumulated pan evaporation at Swift Current (left) and Melfort (right) in 1986 (top) and 1987 (bottom).

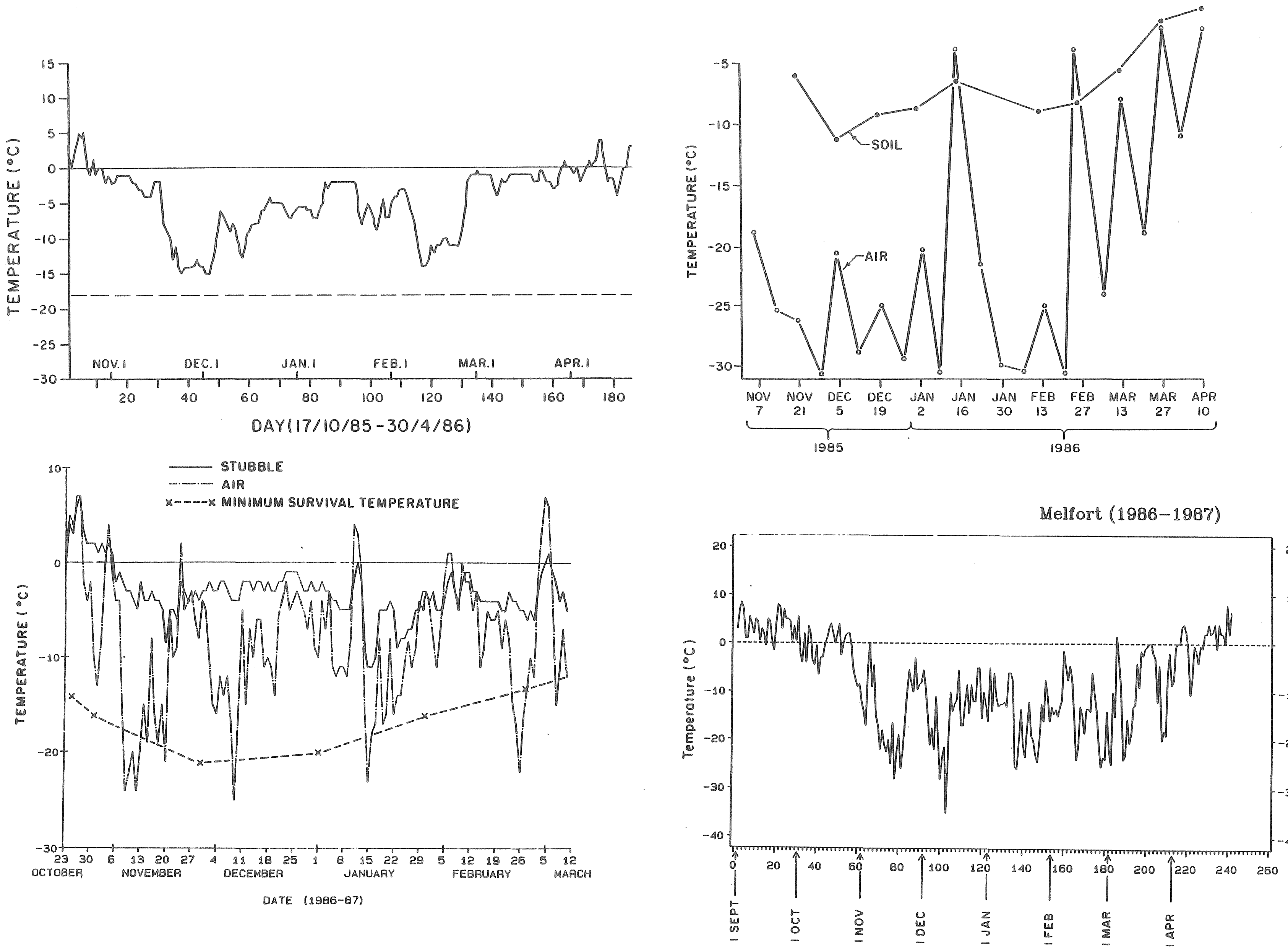

Figure 2. Minimum daily air and/or soil temperature at 5 cm depth at Swift Current (left) and Melfort (right) in 1985-86

(ii) 1986-1987

Precipitation between August 1, 1986 and end of October, 1986 was 124 mm, well above the long-term average of 86 mm for this period at Swift Current. Further, the precipitation was well distributed (Figure 3). Soil moisture on September 8, three days prior to seeding, was only 158 mm/120 cm. However, frequent rainfalls immediately after seeding resulted in excellent germination as seen later. Furthermore, there was no visible effect of seed-placed N on plant stand, no doubt because the fertilizer was readily diluted and dissipated throughout the soil. In contrast to 1985-86, we had good soil moisture conserved in the spring of 1987 (225 mm/120 cm soil).

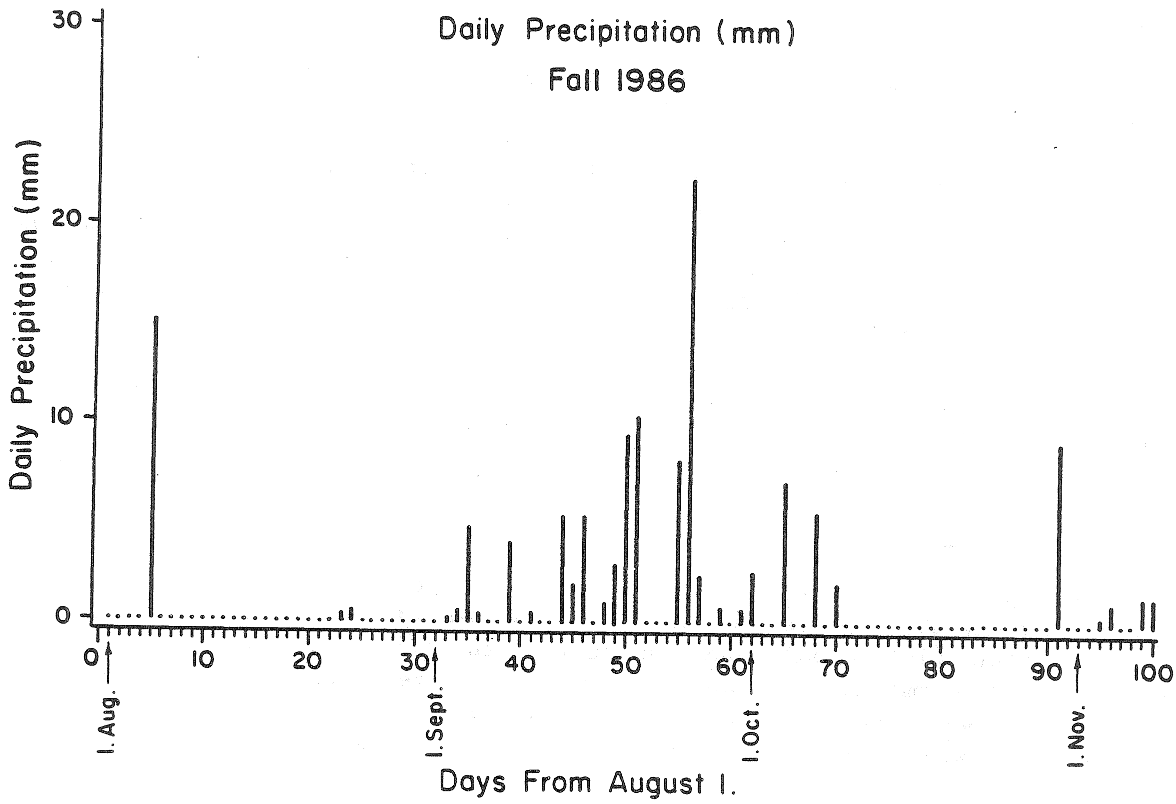

Figure 3. Daily precipitation at Swift Current during late summer and fall 1986.

Unfortunately, precipitation during April to June was well below average (Figure 1) and stubble-seeded winter wheat suffered drought stress from about heading. Total precipitation from April to maturity (July 16) was only 92 mm.

This second winter (1986-87) was even milder (Figure 2, bottom, left) than 1985-86 and there was little chance of winter kill occurring. Minimum soil temperatures were rarely below -10°C.

During the growing season there was one week of very hot weather in early June when plants suffered some heat shock, otherwise temperatures were not excessive.

The soil test NO_3-N in the top 60 cm of soil at seeding was low, only 10 kg/ha, but soil test bicarbonate soluble P in the 0-15 cm depth was moderate (i.e., 26 kg/ha).

(b) At Melfort

(i) 1985-1986

Precipitation during September and October, 1985 were 26.7 and 14.8 mm, which were well below the long-term average of 61 and 56 mm, respectively. This might have contributed to the low plant population obtained (see later discussion).

Soil temperatures were relatively high, never dropping below -10°C at 5 cm soil depth throughout the 1985-86 winter (Figure 2, top, right).

Growing season rainfall in 1986 was good but poorly distributed (Figure 1). Except for a few days in mid-May, rainfall was sporadic and low from April to mid-July and by the time the rains came in late July and early August, the crop had already suffered considerable drought stress. As seen later, this affected yield deleteriously. Rust was not a problem at Melfort as it was at Swift Current.

At seeding, soil test levels of NO_3-N in the top 60 cm of soil was 16 kg/ha, exchangeable NH_4-N was 160 kg/ha and $NaHCO_3$-P in the 0-15 cm depth was 12 kg/ha. Soil moisture totalled 366 mm in 120 cm of soil.

(ii) 1986-1987

Precipitation between August 1, 1986 and October 31, 1986 was 103.5 mm, the long-term average is 115 mm for this period at Melfort. Most of this precipitation (100.8 mm) came in August and September which was good for winter wheat germination. Soil moisture measured three weeks after seeding in the fall was 399 mm in the top 120 cm and in early spring it was still 397 mm which was very good for this silty clay loam soil.

As at Swift Current, growing season precipitation for winter wheat in 1986-87 was low and poorly distributed (Figure 1). For example, precipitation in April, May, June and July, respectively, was 15.0, 30.7, 25.0 and 87.8 mm for a total of 70.7 mm from April 1 - June 30 and 158.5 to July 31. In comparison, the long-term average precipitation for these months at Melfort are 19.2, 36.5, 77.0 and 65.8 mm, respectively, for totals of 132.7 mm from April 1 to the end of June and 198.5 mm to the end of July. As seen later, the failure of June rainfalls to materialize severely restricted growth and yields of winter wheat even more than was the case in 1986.

The winter of 1986-87 was even milder than was the relatively mild 1985-86 and air temperatures rarely reached -30°C (Figure 2), thus winter killing should not have been a problem. Unfortunately, no plant counts were taken to confirm this.

Soil test NO_3-N was very low in the fall 1986, being only 7.3 kg/ha in the top 60 cm and bicarbonate soluble P was only moderate (19.2 kg/ha in the top 15 cm). Thus this soil should show response to N if growing season precipitation was even moderate.

RESULTS AND DISCUSSION

Swift Current

(a) Plant Density

(i) 1985-1986

When all the N was applied at seeding, plant density was similar whether N was broadcast, or mid-row banded at 5 cm depth (Figure 4). Seed-placed N at 30 kg N/ha drastically reduced overwinter survival (and/or germination) of winter wheat. The effect of seed-placed urea (46-0-0) was much more severe than ammonium nitrate (34-0-0). However, wheat displayed its ability to compensate through its later developing yield components in that the number of heads/plant and the number of grains/head responded inversely compared to plant survival (Table 2). Kernel weight generally responded to N placement in a manner similar to overwinter plant survival (perhaps due to delayed maturity caused by rust damage.

(ii) 1986-1987 and 2-yr Combined

The mild winter and excellent fall moisture in 1986-87 resulted in excellent plant density with the check having 165 plants/m^2, about 27%

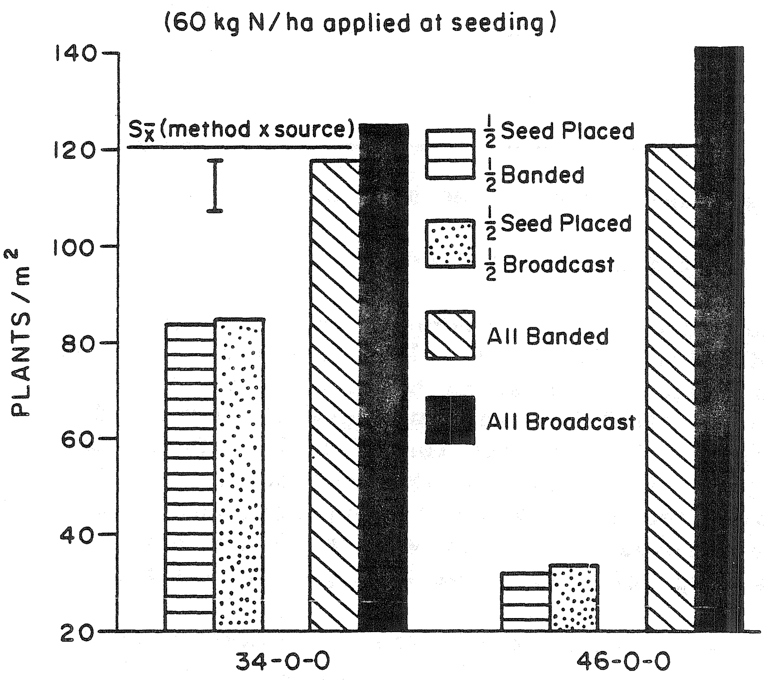

Figure 4. Effect of N source and method of application at seeding on plant density at Swift Current in 1985-86.

greater than in 1985-86 (Table 3). In 1987, in most instances, neither

Table 2. +Effect of ‡N source and method of application on yield components of winter wheat at Swift Current in 1985-86.

Source (s) of N	Method (M) of N application: All Broadcast	1/2 with seed/1/2 broadcast	Mean
	Heads/plant		
34-0-0	2.1	2.6	2.4
46-0-0	1.9	3.7	2.8
Mean	2.0	3.2	2.6
$S\bar{x}$ (S*M)	0.2		
	Grain/head		
34-0-0	19.7	22.0	20.8
46-0-0	19.2	25.0	22.1
Mean	19.5	23.5	21.5
$S\bar{x}$ (S*M)	0.6		
	1000 kernel wt (g)		
34-0-0	31.5	30.8	31.2
46-0-0	31.6	29.5	30.5
Mean	31.6	30.2	30.9
$S\bar{x}$ (S*M)	0.3		

\+ All values averaged across time of N application.

‡ - A total of 60 kg N/ha was applied.

seed-placed ammonium nitrate (34-0-0) nor urea (46-0-0) significantly affected plant density relative to the check (Table 3), although seed-placed urea tended to reduce plant stand by about 12%. When all the N was applied at seeding, plant densities were not greatly depleted by seed-placed N in 1986-87 (Figure 5). The results for 1986-87 at Swift Current are similar to those we obtained at Melfort in 1985-86 (shown later). They show that if the soil is moist immediately after N application, it will dilute and dissipate the N and germination injury will be minimized. The problem is how do we predict what type of weather we will get in the fall?

Time of N application only affected plant density slightly, with the latter tending to increase with delayed application of N in 1985-86 and, except for at seeding, tending to show the opposite trend in 1986-87 (Figure 6, left). When averaged over time of N application, the deleterious effect of seed-placed N was obvious in both years, but moreso in 1985-86 (the drier fall); however, even in a wet fall such as 1986-87 urea still tended to reduce plant stand (Figure 6, right). Even with these reductions, the plant stand in all treatments was adequate to sustain good yields if growing season precipitation was adequate and well distributed.

Table 3. Linear contrast comparisons of fertilizer N treatments vs check+ for plant density and grain yields at Swift Current for 1986, 1987, and 1986 and 1987 combined

					1986 alone				1987 alone				1986 and 1987			
		Application of fertilizer N			Plant Density (pl/m^2)		Grain Yield** (kg/ha)		Plant Density (pl/m^2)		Grain Yield (kg/ha)		Plant Density (pl/m^2)		Grain Yield (kg/ha)**	
Treatment No.	Conditions when N applied	First 1/2	Second 1/2	All at once	34-0-0	46-0-0	34-0-0	46-0-0	34-0-0	46-0-0	34-0-0	46-0-0	34-0-0	46-0-0	34-0-0	46-0-0
1, 12	warm	seed	band		84**	32**	1996	1434	156	131	1210	1276*	120*	82**	1603	1355
2, 13	warm	seed	broad		85**	34**	1850	1275	161	146	1371**	1240*	123*	90**	1611	1258
3, 14	warm			broad	25	141*	1829	1616	163	160	1345**	1218	144	150	1587	1417
4, 15	warm			band	118	121	1864	1954	194*	174	1004	1195	156	148	1434	1574
5, 16	cool	seed	broad		88*	49**	1898	1316	168	144	1421**	1257*	128	97**	1659	1286
6, 17	cool			broad	128	118	2085	2082	193*	166	1278*	1379**	161*	142	1682	1731
7, 18	frozen	seed	broad		97	42**	2023	1340	161	142	1461**	1267*	129	92**	1742	1303
8, 19	frozen			broad	134	126	1842	1655	160	184	1074	1114	147	155	1458	1385
9, 20	spring	seed	broad		104	53**	2151	1509	156	135*	1404**	1295*	130	94**	1778	1402
10, 21	spring			broad	136	117	1978	1867	149*	160	1384**	1175	143	139	1681	1521

+ In 1986 avg check plant density = 117 pl/m^2 and avg check yields = 863 kg/ha; 1987 avg check plant density = 165 pl/m^2 and avg check yields = 951 kg/ha; 1986 and 1987 combined avg check plant density = 140 pl/m^2 and avg check yields = 907 kg/ha.

*, ** denote significance at 5% and 1% level of probability, respectively; in 1986 and 1987 combined all yields were significantly ($P < 0.01$) greater than the check. In 1986 all treatment yields were significantly greater than the check ($P < 0.01$).

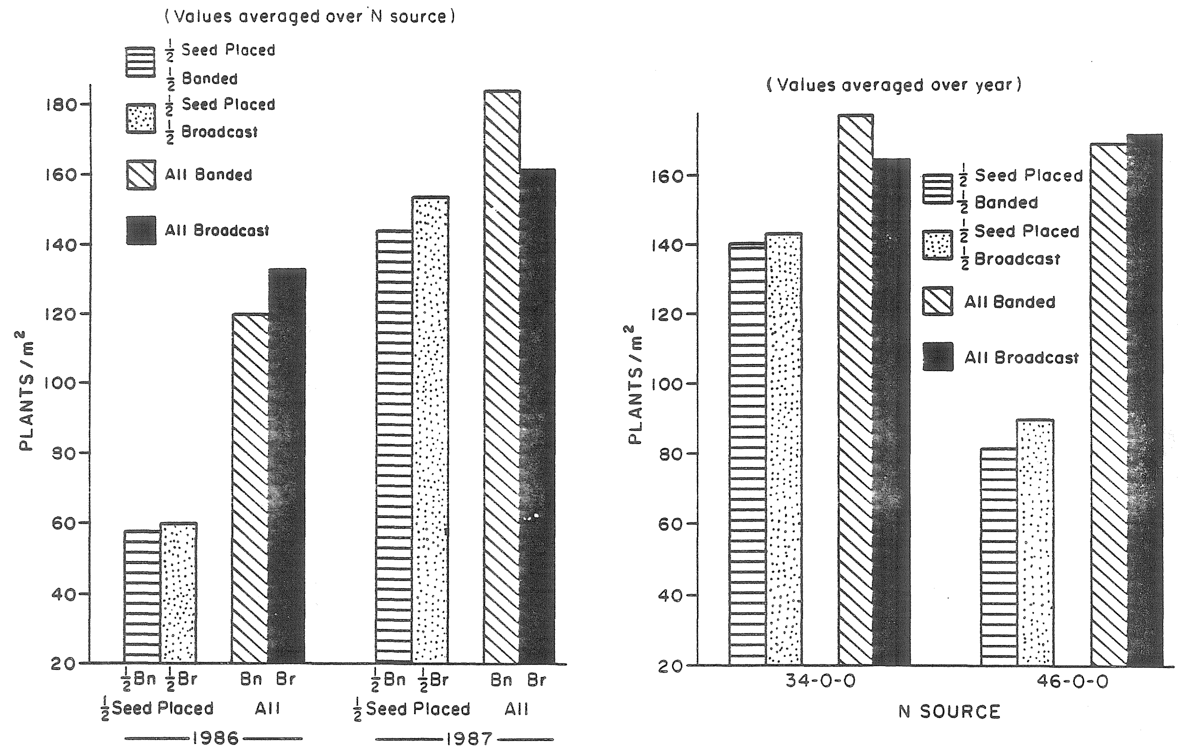

Figure 5. (left) Effect of method of N applied at seeding and year, and (right) effect of method and N source on plant density of winter wheat seeded on stubble at Swift Current for 1986 and 1987 combined.

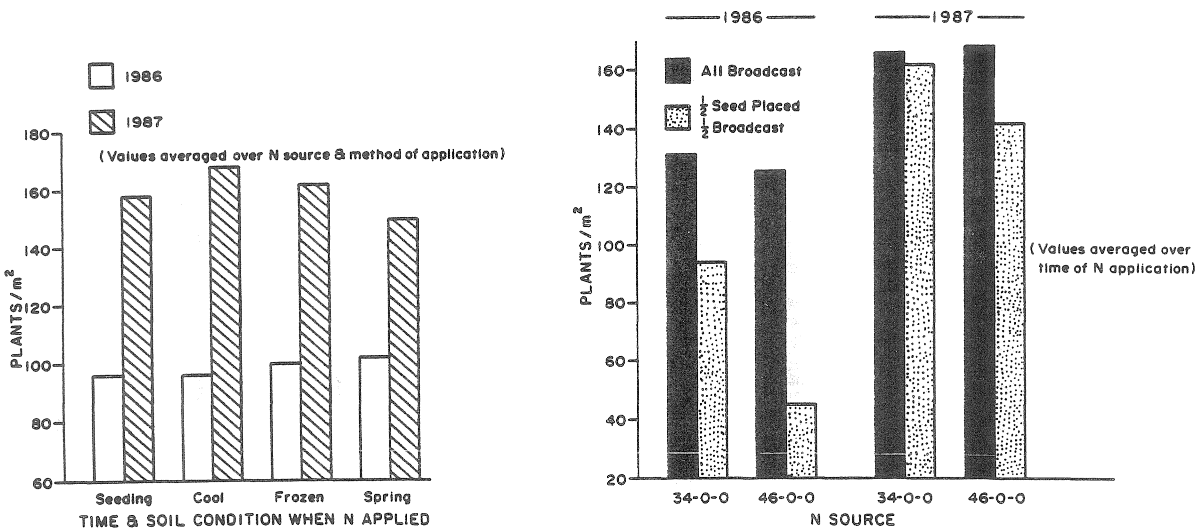

Figure 6. (left) Effect of year and time of N application, and (right) effect of N source and method of broadcast N application on plant density of winter wheat seeded on stubble at Swift Current for 1986 and 1987 combined.

(b) Grain Yields

(i) 1985-1986

Check yields were 863 kg/ha and fertilized treatment yields averaged 1777 kg/ha (Table 3). Generally, yields were directly related to plant density because moisture was good.

When 46-0-0 was applied at seeding, grain yields generally reflected plant population, but in the case of 34-0-0, the depression of overwinter plant survival by seed-placement of 30 kg N/ha was not reflected in the yields (Figures 4 and 7). When all the N was broadcast at seeding, yield was not significantly lower for 46-0-0 than for 34-0-0, but when half the N was seed-placed and half broadcast, yields for 46-0-0 treatments were on average, 30% lower (significant $P < 0.01$) than when 34-0-0 was used (Figure 7). When 30 kg N/ha was seed-placed, yields tended to be greater if the other 30 kg N/ha was mid-row banded at 5 cm depth than if it was broadcast (Figure 7, left). However, if all 60 kg/ha of the N was either banded or broadcast at seeding time, yields for the banded 46-0-0 treatment were significantly greater than for broadcast 46-0-0 while there was no difference due to placement of 34-0-0. The yields for 34-0-0 were similar

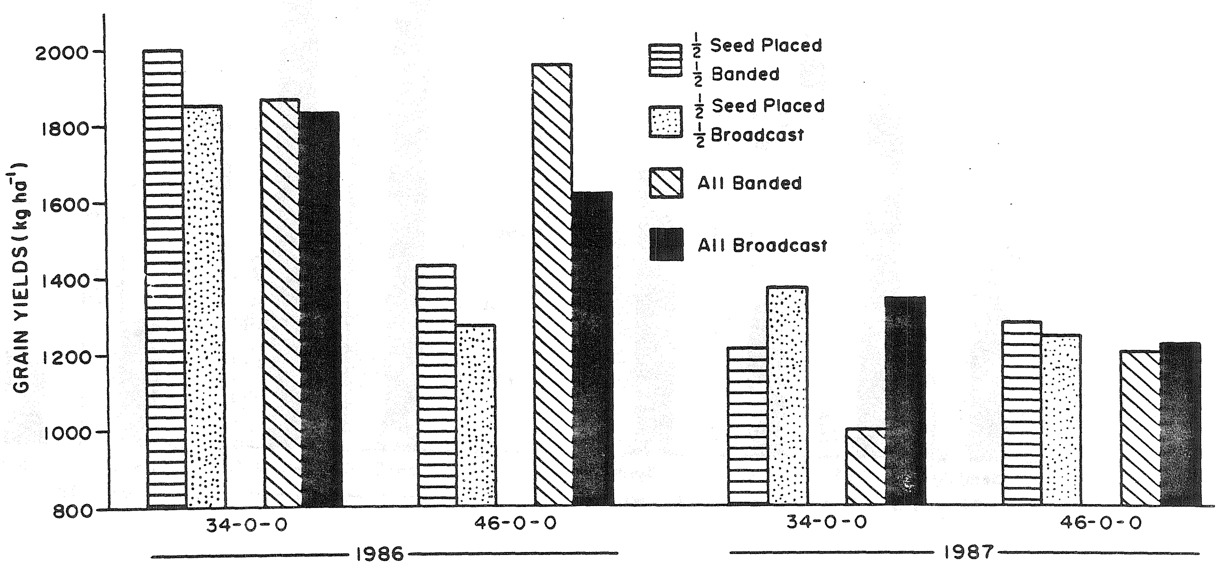

Figure 7. Effect of year, N source and method of application at seeding on grain yields of winter wheat seeded on stubble at Swift Current for 1986 and 1987 combined.

to those for 46-0-0 banded (Figure 7, left). This then shows the need to cover up urea when it is applied since it is easily lost by volatilization.

Grain yields were highest when all N was broadcast under cool, unfrozen conditions in early October (average 2085 kg/ha), second highest when broadcast in early spring, and lowest when applied at seeding or onto frozen soil in early December (Data not shown, but see Figure 8, left). For split applications, when 30 kg N/ha was applied with the seed and the other 30 kg N/ha broadcast at various times, delaying the broadcast application appeared to be more beneficial the longer it was delayed, and yields were significantly improved by waiting until early spring (April) before broadcasting the second half of the N (Data not shown, but see Figure 8, left).

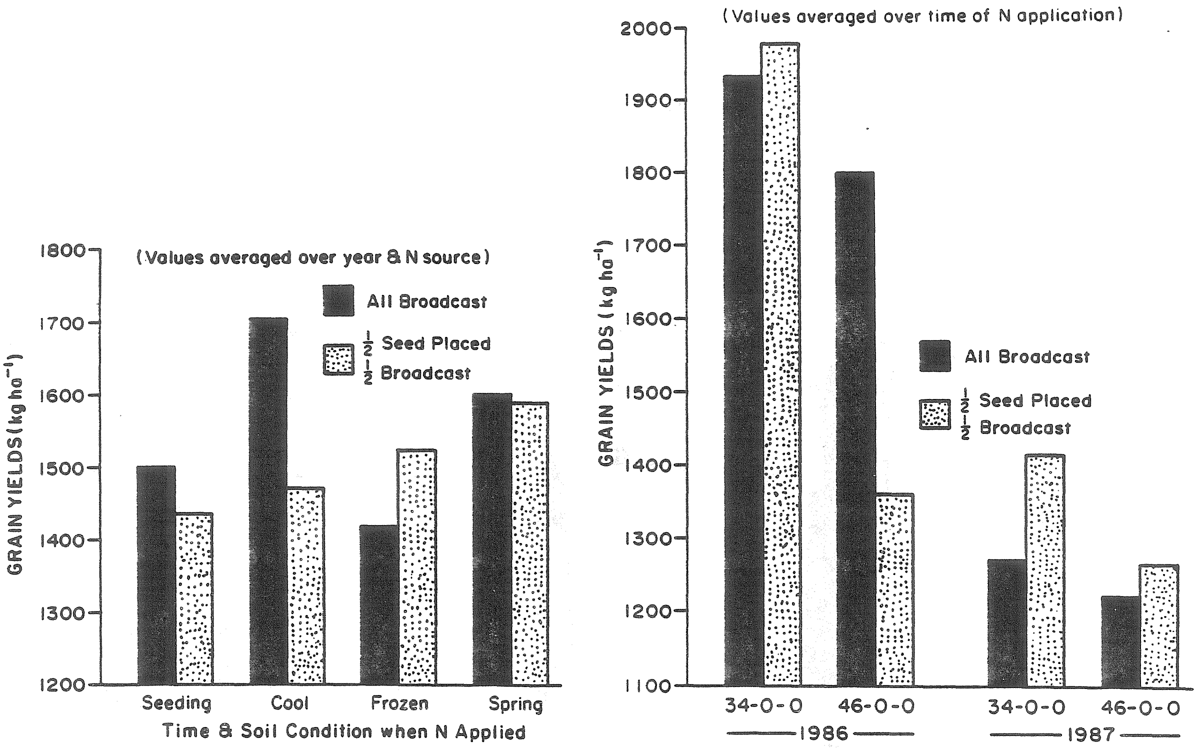

Figure 8. (left) Effect of method of broadcast N application and time of application, and (right) effect of year and method of broadcast N application on yields of winter wheat seeded on stubble at Swift Current for 1986 and 1987 combined.

(ii) 1986-1987 and 1985-1987 Combined

Check yields in 1986-87 were 951 kg/ha, almost 100 kg/ha greater than in 1985-86, but fertilized treatment yields averaged only 1268 kg/ha (Table 3) reflecting dry conditions in this second year.

In 1986-87, fertilization generally increased yields compared to the check (Table 3). In all cases where plant population was reduced by fertilizer treatment (e.g., for seed-placed urea) yields were significantly greater than check yields because the limited moisture was preserved longer when the plant population was lower. This contrasts with 1985-1986, and the combined data for the two years where yields were directly related to plant density (Table 3).

In 1986-87, when all the N was applied at seeding, the banded 34-0-0 treatment, which had the highest plant population, resulted in the lowest yield (Figure 7, right). Thus this response reflects the competition for scarce moisture in the dry conditions prevailing in 1987.

When the combined data for two years were analysed for treatments that received broadcast N at various times between seeding and spring, yield response (Figure 8, left) reflected results previously described for 1985-86. Similarly when all the N was broadcast at various times, the yield results also mimicked primarily the 1985-86 response.

Yields were greater for ammonium nitrate than for urea in both years, but moreso in 1986 (Figure 8, right). However, while seed-placed urea reduced yields severely in 1986 (compared to all the N broadcast), in 1987 the converse was true for both urea and ammonium nitrate. Again this can be explained in terms of treatments with lower plant density in the dry year being less taxing on limited moisture and thus yielding more than those with higher density while in wet years, when moisture is not limiting, yields are directly proportional to plant density.

MELFORT

(a) Plant Density

(i) 1985-1986

In the spring, plant counts revealed a relatively low plant population of 35 plants/m^2, much lower than obtained at Swift Current where even the urea-affected counts were 45 plants/m^2. This poor germination at Melfort was due to moist soil surface conditions at harvest of the previous crop which caused the harvest equipment to pack the soil and the hoe drill had trouble penetrating the soil and maintaining a uniform seeding depth. None of the fertilizer treatments significantly affected plant stand; this contrasts with Swift Current's results in 1985-86.

(ii) 1986-1987

No systematic rating of plant density was done in this second year. However, the prolonged drought in spring reduced plant density, consequently some plots later became weedy and had to be sprayed with Buctril M (1 L/ha) on June 4.

(b) Grain Yields

(i) 1985-1986

Check yields averaged 1713 kg/ha even with the low plant densities already noted (Table 4). Most of the N treatments tended to increase yields, but only a few treatments showed significance (Table 4).

When application of 34-0-0 was split, yields were increased over the

Table 4. Linear contrast contrast comparisons of fertilizer N treatments vs check[+] yields at Melfort for 1986, 1987, and 1986 and 1987 combined

Treatment No.	Conditions when N applied	Application of fertilizer N: First 1/2	Second 1/2	All at once	Grain yields (kg/ha): 1986 alone 34-0-0	1986 alone 46-0-0	1987 alone 34-0-0	1987 alone 46-0-0	1986 & 1987 34-0-0	1986 & 1987 46-0-0
1, 12	warm	seed	band		2183*	2024	811	1198**	1497*	1611**
2, 13	warm	seed	broad		2250**	1857	625	1058*	1438*	1458*
3, 15	warm			broad	1995	1930	768	1079*	1381	1504*
4, 15	warm			band	2015	1936	674	1113**	1345	1525*
5, 16	cool	seed	broad		2047	2162*	877	1094*	1462*	1628**
6, 17	cool			broad	2144*	2039	759	1044*	1452*	1542*
7, 18	frozen	seed	broad		2062	2298**	730	861	1396	1579**
8, 19	frozen			broad	1977	2162*	788	1042*	1382	1602**
9, 20	spring	seed	broad		2227**	1904	818	1035*	1523*	1469*
10, 21	spring			broad	2110*	2006	919	968*	1514*	1487*

[+] Avg check yields for 1986 = 1713 kg/ha, for 1987 = 558 kg/ha and for the two years combined = 1135 kg/ha.

*, ** denote significance at 5% and 1% level of probability, respectively, other values are not significant relative to the check.

check whether the remaining 70 kg N/ha was broadcast or side banded at seeding time or in spring, but when 46-0-0 was applied, yield was not significantly affected (Table 4).

Split applications of 46-0-0 only increased yield when the remaining 70 kg/ha of N was applied onto cool or frozen soil, perhaps indicating some urea damage to plants receiving large amounts of N under warm conditions at seeding or in spring (Table 4). When all the N was broadcast, 46-0-0 increased yields only when applied on frozen soil where considerable N can be volatilized thereby reducing N concentrations and plant damage. Broadcast 34-0-0 increased yields when it was applied in spring (active growth occurring thus rapid uptake possible) and onto cool moist soil (N losses minimized).

Since none of the N treatments applied at seeding showed a differential influence on plant density, it is not surprising that none of these methods of placement significantly affected yields either (data not shown). However, as at Swift Current, yields tended to be higher when 34-0-0 was applied at seeding (average 2110 kg/ha) than when 46-0-0 was used (average 1937 kg/ha) with the difference being significant at $P < 0.09$. No doubt the contrasting results for seed-placed N at Melfort and Swift Current (1985-86) was due to much moister soil conditions at seeding time at Melfort.

(ii) <u>1986-1987 and 1985-1987 Combined</u>

Check yields in 1987 were 558 kg/ha, half that obtained in 1986 (1135 kg/ha) (Table 4). Although there was a consistent trend for yields to be greater when 34-0-0 was applied, compared to the check, the differences were never significant in 1987. In contrast, most of the urea treatments increased yields significantly compared to the check. This response was unusual in that generally yields tend to be greater when ammonium nitrate is applied than for urea. The likely explanation for this response is again found in the limited precipitation received in April to June. If one assumes that a greater proportion of the urea-N was lost from the system than ammonium nitrate (this is often observed when N is broadcast) then the urea-treated plants would have used available soil moisture more slowly and thus have more available moisture for grain development than the ammonium nitrate treatment which may have squandered the limited available water on vegetative growth. Similar results were not obtained at Swift Current in 1987 even though the same phenomenon existed (as discussed earlier); this was probably because the rate of N applied was much higher at Melfort (100 kg/ha) compared to Swift Current (60 kg/ha).

When N was applied at seeding in 1986-87, neither seed-placed N nor banding differentially affected yields. These results are similar to those obtained in 1985-87 and contrast with the first years' results at Swift Current where seed-placed N resulted in lowered plant stands and yields, but are similar to 1987 results at Swift Current. This indicates that the deleterious effect of seed-placed N, especially urea, will depend primarily on soil moisture conditions existing immediately after N is applied - good rainfall is required to dissipate the N and reduce chances of seedling injury. Thus, at Swift Current, seed-placed N concentration, especially urea must be less than 25 kg/ha; at Melfort N concentrations can be slightly higher but one should still be cautious.

When the 2-years data were analysed, using only treatments that received some broadcast N, yields were not affected by time of N application nor method of application (broadcast vs 1/2 seed-placed, 1/2 broadcast). The results (Figure 9) were as shown before, yields being much greater for 1986 than 1987 with no effect of N source in 1986, but yields being greater for urea than ammonium nitrate in 1987.

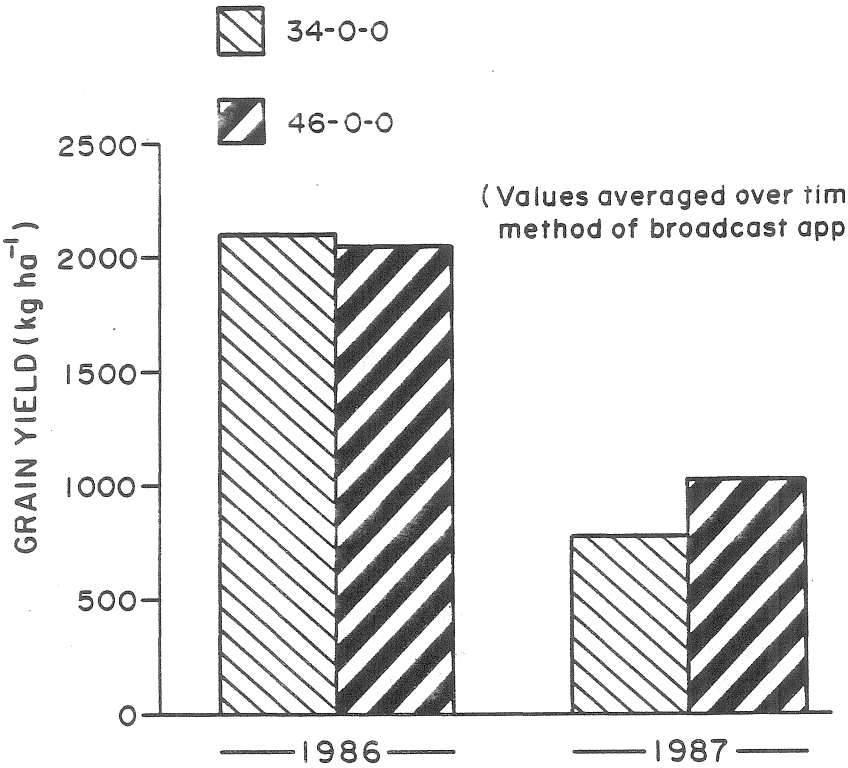

Figure 9. Effect of year and N source on grain yields of winter wheat grown on stubble at Melfort for 1986 and 1987 combined (neither method of broadcast nor time of N application was significant).

SUMMARY

A two-year study designed to determine the influence of N source, method of placement, and time of application on yield of stubbled-in winter wheat in the Brown and Black soil zones of Saskatchewan, showed that plant density (which is controlled by fall moisture and winter temperatures) and growing season precipitation (amounts and distribution) are the main factors affecting yields. For example, seed-placed N, especially urea, must be less than 25 kg/ha in the Brown soil zone to avoid seedling damage; in the Black soil zone, high incidence of good fall moisture allows greater laxity in this regard. Sometimes this plant-thinning can be of benefit if growing season precipitation is below optimal since high plant population densities may encourage inefficient early moisture use, to the detriment of grain filling and yields.

Urea should be banded to reduce N loss, but generally there has been little difference observed between broadcast and banding of ammonium nitrate. At Swift Current, yields were generally best when N was applied onto cool, unfrozen soil in early October, second highest when applied in April, and lowest when applied at seeding or onto frozen soil in December. At Melfort, time of application was ony significant in the first year and here urea gave best yields when applied onto frozen soil, while 34-0-0 was best when applied onto cool, unfrozen soil, or in spring.

At least two more years' results are required before more general recommendations can be made from this study.

REFERENCES

Campbell, C.A., Leyshon, A.J., Ukrainetz, H. and Zentner, R.P. 1986. Time of application and source of nitrogen fertilizer on yield, quality, nitrogen recovery, and net returns for dryland forage grasses. Can. J. Plant Sci. 66: 915-931.

Grant, C.A. 1982. Fertilizer management in zero tillage winter wheat production. pp. 20-38 In Proc. Fourth Manitoba-North Dakota Zero Tillage Workshop, held at Ramada Inn, Minnesota, N.D. Jan. 21 and 22, 1982.

Grant, C.A., Stobbe, E.H. and Racz, G.J. 1985. The effect of fall applied N and P fertilizer and timing of N application on yield and protein content of winter wheat grown on zero tilled land in Manitoba. Can. J. Soil Sci. 65: 621-628.

Malhi, S.S. and Nyborg, M. 1979. Nitrate formation during winter from fall-applied urea. Soil Biol. Biochem. 11: 439-441.