INFLUENCE OF NITROGEN RATE, FORM AND PLACEMENT ON THE ESTABLISHMENT OF NO-TILL WINTER WHEAT SEEDLINGS

A.M. Johnston and D.B. Fowler
Crop Development Centre
University of Saskatchewan

Introduction

The increased interest in the production of winter wheat in Saskatchewan has come about as a result of the crop being successfully overwintered utilizing a stubble-in or zero-till seeding technique (Fowler and Gusta, 1978). This production of the winter wheat crop on stubble results in soil nitrogen deficiencies which must be corrected if optimum yields are to be achieved. The recommended practice for correcting these nitrogen deficiencies has been the broadcast application of ammonium nitrate nitrogen fertilizer in the early spring prior to regrowth (Fowler, 1982).

The increased interest in zero-till seeding equipment for winter wheat production has resulted in the development of several seed drills capable of applying nitrogen at seeding time in a band separated from the seedrow. There is considerable producer interest in this type of specialized seeding equipment as a result of concerns that broadcast applications of nitrogen are more subject to immobilization in surface residues, that nitrogen may become stranded at the soil surface as a result of poor spring precipitation, that broadcast applications of urea nitrogen could be subject to high losses by volatilization, and the general lack of interest in handling ammonium nitrate nitrogen fertilizer by fertilizer companies. For these reasons several alternate methods of fertilizer nitrogen application to winter wheat have been investigated.

Foster and Austenson (1985) reported that highest grain yields were obtained in an experiment where nitrogen was seedplaced or sidebanded at seeding. They reported no damaging effects on seedling establishment or winter hardiness associated with the seed placement of 60 kg N/ha as either ammonium nitrate or urea.

Fowler (1986), summarizing results of 14 years of field observations of winter survival associated with N and P_2O_5 fertilizer trials, indicated that the application of high rates of seedplaced N result in a reduction in the winter survival ability of winter wheat seedlings (Table 2a). The application of recommended rates of N surface broadcast, or banded away from the seed in the fall did not influence the winter survival potential of wheat. It is interesting to note that the impact of 101 kg N/ha seedplaced, by reducing the winter survival ability of winter wheat, is similar to the effect of not correcting a phosphorus deficiency (Table 1a).

The objective of the experiment reported here was to determine the effects of nitrogen rate, form and placement on no-till winter wheat seedling establishment, seedling size as related to seedling vigor and the uptake of nitrogen in the fall of the year.

Table 1a. Effect of Phosphate Fertilizer on Winter Survival of Winter Wheat.

Phosphate added (kg/ha)	Subtract (FSI)
0	26
17	0
34	6
50	10

Fowler (1986)

Table 2a Effect of Seedplaced Nitrogen Fertilizer on Winter Survival of Winter Wheat.

Nitrogen added (kg/ha)	Subtract (FSI)
0	0
34	18
67	24
101	25

Fowler (1986)

1983 Experiment

Materials and Methods:

Norstar winter wheat seedling samples were collected from plots established at Clair, Kernen, Outlook and Paddockwood in the third week of October after fall growth had stopped. Treatments involved ammonium nitrate (AN) nitrogen fertilizer applied in the seedrow at rates of 0, 34, 67 and 101 kg N/ha. The experiment was laid out as a randomized complete block design with four replicates. Plots were seeded using a small plot hoe-press drill with 20 cm seed rows. Monoammonium phosphate fertilizer was seedplaced at a rate of 34 kg P_2O_5/ha to all plots.

Approximately 100 seedlings were collected from each plot for tissue analysis. Crowns were separated from leaves and roots, quick dried using forced air, and ground using a Udy Cyclone sample mill with a 0.5 mm screen size. The crown tissue samples were analyzed for nitrogen and phosphorus concentration by the Saskatchewan Soil Testing Laboratory using the autoanalyzer procedure outlined by Thomas et al. (1967).

Results and Discussion:

The addition of AN nitrogen in the seedrow resulted in a significant increase in crown tissue N concentration at only the Kernen site (Table 1). Phosphorus concentration was unaffected by increasing N rate at all of the test locations. This highly significant increase in crown tissue N concentration at Kernen, while phosphorus concentration remained unchanged, resulted in a significant increase in the nitrogen to phosphorus ratio. Combined analysis of the four test locations indicates results similar to those obtained for Kernen (Table 1).

The mean tissue N concentrations for each location and combined locations are listed in Table 2. It shows that at every location maximum crown tissue nitrogen was attained at the 67 kg N/ha rate, beyond which N concentration declined slightly.

Soil moisture conditions at or shortly following seeding were reported as excellent with September precipitation of 62.2 mm, 196% of the thirty year average. Detailed weather records indicate that at Saskatoon 20 mm of precipitation occurred the day immediately following seeding. This was in addition to 24 mm of precipitation which fell the first six days of September. The occurrence of these favorable soil moisture conditions at seeding resulted in no noticeable difference in either stand establishment or on winter survival.

These good soil moisture conditions in 1983, and the occurrence of 132% of the long-term September precipitation in 1982 at Saskatoon, help explain the yield results reported by Foster and Austenson (1985). It also helps to explain the lack of any apparent damage to seedling establishment or overwinter survival at the Kernen site. Soil moisture was reported as good at the other test locations and there was no evidence of any effects of nitrogen rate on seedling establishment or overwinter survival.

Table 1. Effect of seedplaced ammonium nitrate on the nitrogen and phosphorus concentration and N:P ratio of winter wheat crown tissue (1983).

Location	% N	% P	N:P Ratio
Clair	NS	NS	NS
Kernen	**	NS	*
Outlook	NS	NS	NS
Paddockwood	NS	NS	NS
Combined Sites	**	NS	*

* Significant (0.05)

** Significant (0.01)

NS Nonsignificant

Table 2. Effect of seedplaced ammonium nitrate nitrogen rate on fall winter wheat seedling mean crown tissue nitrogen concentration.

	N Rate (kg N/ha)			
Location	0	34	67	101
Clair	2.79	3.28	3.55	3.49
Kernen	3.26	3.22	3.76	3.50
Outlook	2.92	3.13	3.27	3.17
Paddockwood	3.13	3.33	3.62	3.55

1985 Experiment

Materials and Methods:

Norstar winter wheat seedlings were collected from plots established at Clair, Watrous, Perdue, Outlook and Floral after fall growth had stopped in mid-October. The experimental design used was a randomized complete block design with four replicates. Plots were seeded using a small plot disc-press drill seeding on 22 cm (9 in) centers. Ammonium nitrate nitrogen fertilizer was applied either in the seedrow or midrow banded 11.4 cm to the side and 5.0 cm (4.5 x 2.0 in) below the seedrow at seeding, at rates of 0, 45, 90 and 123 kg N/ha. Monoammonium phosphate fertilizer was seedplaced at a rate of 34 kg P_2O_5/ha to all plots.

Seedling samples were collected from an area of 0.84 m^2 representing 6 rows by 60 cm, with the sampling locations assigned within each plot at random. The samples were dried, ground and analyzed using the same procedure outlined for the 1983 experiment.

Data collected on the seedling samples prior to grinding and nutrient analysis included seedling number, sample dry weight and dry weight per 10 seedlings. Seedlings collected from the Floral site were large enough to permit separation of leaves from crowns and the collection of additional information on crown and leaf weight. Tissue sample analysis was carried out to determine seedling N and P concentration for the Clair, Watrous, Perdue and Outlook sites. At Floral N and P concentration was determined for both leaf and crown tissues.

Dry matter yield, nitrogen yield, phosphorus yield, and N:P ratio were calculated for seedlings, leaves and/or crowns. Dry matter yield was determined by multiplying sample air dry weight by a conversion factor to give kg dry matter/ha. The value for air dry weight was influenced by both seedling number and seedling weight. Nitrogen and P yield were calculated by multiplying N or P concentration by dry matter yield. Nitrogen:phosphorus ratio was determined by dividing tissue N concentration by tissue P concentration.

The graphics in the figures presented were produced using a computer graphics package capable of drawing trend lines through plotted points.

Results and Discussion:

Evaluation of the data collected in the fall of 1985 indicates two completely different types of N responses. At the Clair, Watrous, Perdue and Outlook sites soil moisture conditions at seeding were dry, as estimated by the absence of any apparent soil moisture in the surface 30 cm, while at Floral surface soil moisture was available at seeding (Table 3). September precipitation ranged from 80 to 100% of the 30-year average at those locations where data was available. These two different soil moisture conditions at seeding resulted in considerable differences in seedling development (Table 3). Seedling number, sample weight and weight per 10 seedlings were considerably lower for the Clair, Watrous, Perdue and Outlook locations when compared with Floral. For this reason the results will be presented for the Clair, Watrous, Perdue and Outlook locations combined and the Floral site alone.

1985 Combined Sites

Increasing N rate significantly reduced seedling number, weight per 10 seedlings, dry matter yield, nitrogen and phosphorus yield when nitrogen was seedplaced (Table 4). Seedling N concentration was significantly increased with increasing seedplaced N rate while seedling P concentration and seedling N:P ratio were not significantly affected. When N was midrow banded, increasing rate had no significant effect on any of the components measured. The effect of N placement is illustrated for seedling number, weight per 10 seedlings, dry matter yield, seedling N and P concentration and seedling N and P yield in Figures 1,2,3, 4 and 5, respectively. Analysis of the data with respect to the effect of N rate with the check treatments removed resulted in a nonsignificant rate effect for all components measured. This indicates that the significant response to increasing N rate with seedplaced N was as a result of the difference between the check and the nitrogen treatments for these dry sites.

Low soil moisture at seeding resulted in poor seedling establishment and development with both banded and seedplaced N treatments. A significant effect of N placement occurred only with seedling number and dry matter yield. Weight per 10 seedlings (Figure 2) was used as a means of comparing the effects of treatment on seedling size and does not reflect in any way the impact of treatment on seedling number. The occurrence of no significant difference in weight per 10 seedlings between the two nitrogen placement positions, while the effect of placement on seedling number was highly significant, indicates that seedlings that did survive to be collected must have been escapes and established out of direct contact with the seedplaced N band. This is further illustrated by the nonsignificant placement effect on tissue N concentration. Uptake of N from seedplaced N bands for those seedlings that did become established appear to have been inhibited, likely due to inadequate soil moisture to allow N movement out from the point of placement.

The absence of a significant effect of placement on nitrogen yield is a reflection of the nonsignificant response of tissue N concentration to placement while dry matter yields were significantly affected by placement.

<u>1985 Floral Site</u>

Increasing N rate had a significant effect on almost all of the variables measured when nitrogen was seedplaced (Table 5). The two variables where increasing seedplaced N rate did not result in a significant response were seedling number (Figure 6) and leaf phosphorus concentration (Figure 11). Favorable soil moisture conditions at seeding minimized the damaging effects of seedplaced N on seedling establishment. The lack of response of leaf P concentration to increasing N rate, while crown P was significantly increased by seedplaced N, appears to be a result of crown P being more closely associated with changes in crown N than leaf P is with leaf N.

Increasing seedplaced N rate resulted in a reduction of weight per 10 seedlings, dry matter yield, leaf and crown weight and N and P yield as is illustrated in Figures 7,8,9 and 10, respectively The exceptions were leaf N concentration (Figure 11), crown N and P concentration (Figure 12) and N:P ratio which all responded positively to increasing nitrogen rates.

When N fertilizer was midrow banded, increasing N rate had no significant effect on any of the variables measured with the exception of crown P concentration. Increasing the rate of midrow banded N resulted in a small but significant decline in crown P concentration (Figure 12). There appears to be a trend to increasing seedling number, weight per 10 seedlings, dry matter yield, leaf and crown weight and N yield associated with increasing the rate of midrow banded N. This type of response indicates seedling access to banded N, although not to the extent that a significant response was obtained.

A highly significant placement effect resulted for all of the variables measured with the exception leaf P concentration which was unaffected. This response was a result of seed placement of N producing a highly significant reduction in seedling number, weight per 10 seedlings, dry matter yield, N yield and P yield when compared with midrow banded N. For leaf N concentration, leaf N:P ratio, crown N concentration and crown N:P ratio, seed placement of N increased the response variable as a result of increased N availability to seedlings. There was no significant effect of placement on leaf P concentration.

A rate by placement interaction was recorded for N and P yield. As outlined previously, the calculation of N and P yield involves multiplying N and P concentration by dry matter yield. The interaction produced occurred as a result of seedplaced N causing leaf and crown weights to decrease and N and P concentrations to increase (Figure 9, 11 and 12). The opposite situation occurs for banded N treatments where leaf and crown weights increase with increasing N rate while N and P concentration decrease, reflecting the dilution effect of N and P in the larger seedlings.

Table 3. 1985 Winter wheat seedling samples:check plot means

Variable	Clair	Watrous	Perdue	Outlook	Floral
Seedling number	122	141	126	110	208
Dry matter yield (kg/ha)	31	24	32	36	142
Weight 10 seedlings (g/10 seedlings)	.204	.154	.250	.315	.564
Soil moisture at seeding*	Dry	Dry	Dry	Dry	Wet
Sept. precipitation (% L.T. Average)	85	100	-	-	80
Soil type	Black Loam	Dk.Br. Clay Loam	Dk.Br. Clay Loam	Dk.Br. Silty Loam	Dk.Br. Silty Loam

*Estimated at seeding time.

Table 4. 1985 Combined locations:level of significance of response.

Variable	Rate		Placement	Rate x Placement
	SP	BD		
Seedling number	**	NS	**	NS
Weight 10 seedlings	*	NS	NS	NS
Dry matter yield	**	NS	*	NS
Seedling concentration	**	NS	NS	NS
Seedling P concentration	NS	NS	NS	NS
Seedling N:P ratio	NS	NS	NS	NS
Nitrogen yield	**	NS	NS	NS
Phosphorus yield	**	NS	NS	NS

* Significant (0.05)
** Significant (0.01)
NS Nonsignificant

Table 5. 1985 Floral location:Level of significance of response

Variable	Rate SP	Rate BD	Placement	Rate x Placement
Seedling number	NS	NS	**	NS
Weight per 10 seedlings	**	NS	**	NS
Dry matter yield	*	NS	**	NS
Leaf N concentration	**	NS	**	NS
Leaf P concentration	NS	NS	NS	NS
Leaf N:P ratio	**	NS	**	NS
Crown N concentration	**	NS	**	NS
Crown P concentration	*	*	**	NS
Crown N:P ratio	**	NS	**	NS
Nitrogen yield	*	NS	**	*
Phosphorus yield	**	NS	**	**

* Significant (0.05)
** Significant (0.01)
NS Nonsignificant

1986 Experiment

Materials and Methods

Norstar winter wheat seedlings were collected from plots established at Clair, Watrous, Kernen and Hagen after fall growth had stopped in mid-October. The experimental design used was a split-plot design with 4 replicates, the main plots being N rates and the subplots N form by placement combinations. Plots were seeded using a self-propelled small plot disc-press drill seeding on 25 cm (10 in) centers. Both ammonium nitrate (AN) and urea fertilizer were applied either in the seedrow, sidebanded at 2.5 x 2.5 cm (1 x 1 in) or sidebanded 5.0 x 5.0 cm (2 x 2 in) at seeding at rates of 0, 34, 67 and 101 kg N/ha. Monoammonium phosphate fertilizer was seedplaced at a rate of 34 kg P_2O_5/ha to all treatments.

Seedling samples were collected from an area of 0.93 m^2, representing 4 rows by 91 cm. The samples were dried, ground and analyzed using the same procedure as outlined for the 1983 experiment.

The data collected on the seedling samples was the same as that outlined for the 1985 experiment. The seedlings from the Clair and Watrous locations were separated for independent nutrient analysis of crowns and leaves while entire seedlings were analyzed for the Kernen and Hagen sites.

Results and Discussion

Soil moisture conditions at seeding ranged from poor to excellent in the fall of 1986. However, reasonably good establishment was achieved at all four test locations (Table 6). The wide range in gravimetric soil moisture measured at seeding was minimized considerably by sampling time in the third week of October. The only exception to this was the Hagen site where soil moisture was very dry at seeding and continued to be dry at sampling time. The impact of these low soil moisture conditions are reflected in the increased effect of N rate and N form on the variables measured.

The presentation of results will involve a discussion of each variable measured at each location. Levels of significant responses by variables are listed in Table 7 as well as illustrated in figures.

Seedling Number

Increasing N rate had a highly significant effect on seedling number at 3 of the 4 sites when N was seedplaced (Table 7, Figure 13). Increasing seedplaced N rates resulted in a decline in seedling numbers at Clair, Watrous and Hagen while there was no effect at Kernen. The nonsignificant effect of seedplaced N on seedling number at Kernen is similar to the results reported by Foster and Austenson (1985) at the same location. This response is likely attributable to the clay soil type at this location. The high cation exchange capacity of this clay soil is capable of minimizing the damaging effect of seedplaced N (Harapiak et al., 1986). Only at Watrous did increasing N rate at the 2.5 x 2.5 cm sidebanded placement have a significant effect with seedling numbers increasing as rate increased.

With the exception of Hagen there was no form (rate) effect on seedling number at any placement position. At Hagen, the dry site, there was a highly significant form (rate) effect with seedplaced urea N reducing seedling numbers to a greater degree than AN N.

Weight per 10 Seedlings

Increasing seedplaced N rate resulted in a reduction in weight per 10 seedlings at the Clair and Hagen sites (Table 7, Figure 14). At both of these locations increasing the rate of seedplaced N resulted in a reduction in 10 seedling weight. A significant form (rate) effect occurred at both of these locations with urea causing a greater reduction in weight than AN. This form (rate) effect was highly significant at Hagen where only seedplaced urea resulted in any decline in weight compared with the check.

When the N was sidebanded 2.5 x 2.5 cm there was a significant rate effect on weight per 10 seedlings at the Watrous, Kernen and Hagen sites. At all sites increasing sidebanded N rate increased the weight per 10 seedlings, indicating that sidebanding at as little as 2.5 x 2.5 cm eliminated the negative impact associated with seedplaced N. There was also a form (rate) effect at Hagen where the ammonium nitrate sidebanded at 2.5 x 2.5 cm was still producing a significantly increased 10 seedling weight compared to urea. This response is likely due to the dry conditions maintaining more of the urea in a form unavailable to plant uptake.

Dry Matter Yield

Increasing seedplaced N rate resulted in a highly significant reduction in dry matter yield at Clair, Watrous and Hagen locations (Table 7, Figure 15). As seedplaced N rates increased dry matter yield declined. There was a significant form (rate) effect at the Clair and Watrous sites and a highly significant form (rate) effect at the dry Hagen site. At all 3 locations seedplaced urea resulted in greater reductions of dry matter yield than did ammonium nitrate. At Kernen there was no significant effect of N rate or form (rate) on dry matter yield, again a reflection of the nonsignificant effect of rate or form (rate) on seedling number or 10 seedling weight associated with the clay soil type.

Sidebanded N at 2.5 x 2.5 cm resulted in a significant rate effect at Clair, Watrous and Hagen where increasing N rate increased dry matter yield relative to the check.

Leaf Nitrogen Concentration

At the Clair and Watrous sites, where leaves and crowns were separated for independent analysis, increasing N rate had a highly significant effect on leaf N concentration at all 3 placement positions (Table 7, Figure 16). Increasing N rate resulted in increasing leaf N concentrations with seed placement>sidebanded 2.5 x 2.5 cm>sidebanded 5.0 x 5.0 cm. There was no significant form (rate) effect at either location. This response indicates access of seedlings to the applied N at all placement positions.

Leaf Phosphorus Concentration

Only at the Watrous site did N rate have an effect on leaf P concentration with both seedplaced and sidebanded 2.5 x 2.5 cm placement (Table 7, Figure 16). Increasing N rate resulted in a decrease in leaf P at both placement positions while leaf N concentration increased.

Leaf Nitrogen:Phosphorus Ratio

Nitrogen rate had a significant effect on increasing the leaf N:P ratio at all 3 N placement positions at both Clair and Watrous (Table 7, Figure 18). This increase in leaf N:P ratio is a result of increasing leaf N concentration with increasing N rate while leaf P was either unaffected or reduced (Watrous).

Crown Nitrogen and Phosphorus Concentration

Crown N concentration was increased significantly at the Clair site only when N rate was increased and when N was seedplaced or banded 2.5 x 2.5 cm (Table 7, Figure 17). There was no effect of N rate on crown N at Watrous. This variable effect of N rate on crown N, while leaf N was highly significant increased at all placements, indicates that winter wheat seedling leaves act as a sink for the bulk of the N taken up in the fall of the year. This is important since leaves play no role in winterhardiness. It's also important to note that fall developed leaves die over winter and new leaves develop the following spring resulting in a temporary immobilization of a small amount of nitrogen that was taken up in the leaves.

There was no significant effect of N rate or N form (rate) on crown P concentration at any of the placement positions at either site.

Crown Nitrogen:Phosphorus Ratio

Nitrogen rate had a significant effect on crown N:P ratio at Clair for both the seedplaced and sidebanded 2.5 x 2.5 cm treatments (Table 7, Figure 18). Increasing N rate resulted in an increase in N:P ratio. These two responses correspond with the responses obtained for crown N concentration. There was also a form (rate) effect of seedplaced N on crown N:P ratio at Clair. At all rates, urea resulted in a higher N:P ratio than did AN. Although not significant, crown N concentration was always higher with urea than AN at Clair. The opposite was true at Watrous where crown N concentration was usually always lower for urea than AN. Although only speculative at this time the increased crown N associated with urea at the Clair site may be as a result of the good seeding soil moisture conditions improving access of the seedlings to the higher levels of ammonium nitrogen associated with the urea. It has been demonstrated (Leyshon et al., 1980) that increased production is possible when nitrogen is maintained in the NH_4^+ form.

Seedling N Concentration

At the Kernen and Hagen sites entire seedlings were analyzed for N and P concentration. Increasing N rate resulted in a highly significant increase in seedling tissue N concentration at all placement positions at both sites (Table 7, Figure 19). This indicates that seedlings were accessing the N at all placement positions. At Hagen there was a highly significant form (rate) effect when N was seedplaced. This resulted in tissue N concentrations higher for AN than urea at all rates and indicates that at the drier Hagen site less of the urea N was available to the seedlings.

Seedling Phosphorus Concentration

At both the Kernen and Hagen sites, seedling P concentration was unaffected by N rate (Table 7, Figure 19). However, N form (rate) produced a highly significant effect at both locations when N was seedplaced. The effect of form (rate) was lower seedling P concentration with urea at all rates. This is a reflection of the lower uptake of N which occurred with seedplaced urea at both sites, although not significant at Kernen. The reduced uptake of N resulted in a corresponding lower uptake of P.

Seedling Nitrogen:Phosphorus Ratio

Increasing N rate had a significant effect of increasing seedling N:P ratio at all placements at both Kernen and Hagen (Table 7, Figure 20). These responses occur as a result of increasing N rate increasing seedling N concentration while seedling P concentration remained unaffected. The significant form (rate) effect for seedplaced N is also a reflection of the response obtained with seedling P concentration where seedplaced urea reduced seedling P concentration.

Total Nitrogen Yield

Increasing seedplaced N rate resulted in a decline in N yield at the Clair and Hagen locations (Table 6, Figure 21). This was accompanied by a form (rate) effect where urea produced a lower N yield than AN at all rates. The effect of urea was small but significant at Clair, however, it was highly significant at the dry Hagen site where increasing urea N rate resulted in a dramatic reduction in N yield.

When sidebanded 2.5 x 2.5 cm there was a N rate effect on total N yield at all locations. As N rate increased total N yield increased when the N was sidebanded. Only at the Hagen site was there a form (rate) effect as a result of lower N yields when urea was sidebanded. Again this is an indication of the reduced availability of the urea N at the drier location.

There was a small but significant rate response on total N yield at Watrous and Kernen when the N was sidebanded 5.0 x 5.0 cm. It is interesting that at both of these locations there was no significant effect of N rate on total N yield when N was seedplaced, but a significant effect when it was banded. This response to banded N, along with the nonsignificant effect of seedplaced N on weight per 10 seedlings at both sites (Table 7), is an indication that seed placement of N did not have the same impact on seedling stand establishment as occurred at the Clair and Hagen sites. This response was likely due to the soil type as both the Watrous and Kernen soils have a higher clay content with high cation exchange capacity which is capable of minimizing the effects of seedplaced N. Although the Hagen site also has a high soil clay content this could not completely compensate for the very low soil moisture conditions.

Total Phosphorus Yield

Increasing N rate had an effect on total P yield when N was seedplaced or sidebanded 2.5 x 2.5 cm at the Clair, Watrous and Hagen locations (Table 7, Figure 21). Total P yield declined with seedplaced N rates and were increased by sidebanding. At Clair and Hagen there were significant effects of form (rate) on P by yield when N was seedplaced with total P yield lower for AN than urea. The lack of many significant responses of N rate on P concentration and highly significant effects of N rate on total P yield are an indication that the differences are due more to the effects of dry matter yield rather than P concentration.

Table 6. 1986 Winter wheat seedling samples: Check plot means

	Clair	Watrous	Kernen	Hagen
Seedling number	210	219	260	227
Air dry weight	4.27	5.53	5.04	4.81
Weight per 10 seedlings	.206	.252	.189	.211
Gravimetric Moisture				
at Seeding	21.59	18.39	14.93	11.76
at Sampling	27.78	27.68	23.43	18.15
Soil type	Yorkton loam	Weyburn clay loam	Elston clay	Blaine Lake clay loam

Table 7. 1986 Fall Winter Wheat Seedlings:Level of Significance of Response

Variable		Clair		Watrous		Kernen		Hagen	
		Rate	Form(Rate)	Rate	Form(Rate)	Rate	Form(Rate)	Rate	Form(Rate)
Seedling number	A[1]	**	NS	**	NS	NS	NS	**	**
	B[2]	NS	NS	*	NS	NS	NS	NS	NS
	C[3]	NS	NS	NS	NS	NS	NS	NS	NS
Weight 10 seedlings	A	**	*	NS	**	NS	NS	**	**
	B	NS	NS	**	NS	*	NS	*	*
	C	NS	NS	NS	NS	NS	NS	NS	NS
Dry matter yield	A	**	*	**	*	NS	NS	**	**
	B	*	NS	**	NS	NS	NS	*	NS
	C	NS	NS	NS	NS	NS	NS	NS	NS
Leaf N concentration	A	**	NS	**	NS				
	B	**	NS	**	NS				
	C	*	NS	**	NS				
Leaf P concentration	A	NS	NS	*	NS				
	B	NS	NS	*	NS				
	C	NS	NS	NS	NS				
Leaf N:P ratio	A	**	NS	**	NS				
	B	*	NS	**	NS				
	C	*	NS	**	NS				
Crown N concentration	A	**	NS	NS	NS				
	B	*	NS	NS	NS				
	C	NS	NS	NS	NS				
Crown P concentration	A	NS	NS	NS	NS				
	B	NS	NS	NS	NS				
	C	NS	NS	NS	NS				
Crown N:P ratio	A	**	*	NS	NS				
	B	*	NS	NS	NS				
	C	NS	NS	NS	NS				
Seedling N concentration	A					**	NS	**	**
	B					**	NS	**	NS
	C					**	NS	**	NS
Seedling P concentration	A					NS	**	NS	**
	B					NS	NS	NS	NS
	C					NS	NS	NS	NS
Seedling N:P ratio	A					**	**	**	**
	B					**	NS	**	NS
	C					**	NS	*	NS
Total N yield	A	**	*	NS	NS	NS	NS	**	**
	B	**	NS	**	NS	**	NS	**	*
	C	NS	NS	*	NS	*	NS	NS	NS
Total P yield	A	**	*	**	NS	NS	NS	**	**
	B	**	NS	**	NS	NS	NS	*	NS
	C	NS	NS	NS	NS	NS	NS	NS	NS

[1]A represents seedplaced Nitrogen.
[2]B represents nitrogen sidebanded 2.5 x 2.5 cm.
[3]C represents nitrogen sidebanded 5.0 x 5.0 cm.
*:Significant (0.05); **:Significant (0.01); NS: Nonsignificant.

Summary and Conclusions

Although there was considerable variability over the 3 years this experiment was carried out, the data collected does indicate some common trends.

1. Seedplacement of nitrogen fertilizer resulted in reduced seedling establishment and seedling size. The only exceptions to this were associated with high clay content soils where the impact of the seedplaced nitrogen was minimized by high cation exchange capacities and where soil moisture at seeding and post-seeding precipitation were above normal. Long-term results would tend to indicate that soil moisture at seeding of winter wheat is usually low and stand establishment damage would be expected with seedplaced nitrogen.

2. When banded in the seedrow, urea had a greater negative effect on seedling establishment and seedling size than did ammonium nitrate.

3. Separation of the nitrogen fertilizer band as little as 2.5 cm (1 in) from the seedrow prevented any damage to seedling establishment and seedling size, and in most cases increased seedling size.

4. Increasing nitrogen rate had little or no effect on phosphorus uptake, resulting in an increased N:P ratio in seedling tissue.

5. Under favorable soil moisture conditions at seeding, nitrogen uptake occurred from bands placed as far as 11.4 cm (4.5 in) from the seedrow.

6. Soil moisture at seeding influence seedling response to nitrogen rate, form and placement to a greater degree than did postseeding precipitation. Good soil moisture at seeding reduced the impact of seedplaced nitrogen treatments and positively enhanced the effects of sidebanded nitrogen on seedling development. Seeding into dry soil with seedplaced nitrogen tended to increase the damaging effects of the nitrogen when precipitation does finally occur.

7. If nitrogen is going to be sidebanded in the fall it should be placed a minimum of 5.0 cm from the seedrow to eliminate any damaging effects on stand establishment.

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4. Fowler, D.B. and L.V. Gusta. 1978. Winter cereal production in Saskatchewan. Agric. Sci. Publ. No. 264, Extension Division, University of Saskatchewan, Saskatoon, Sask.
5. Harapiak, J.T., R.M.N. Kucey and D. Flaten. 1986. Nitrogen sources and placement in wheat production. In: Wheat production in Canada - A Review. Extension Division, University of Saskatchewan, Saskatoon, Sask.
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7. Thomas, R.L., R.W. Sheard and J.R. Meyer. 1967. Comparison of conventional and automated procedures for nitrogen, phosphorus and potassium analysis of plant material using a single digestions. Agron. J. 59: 240-243.

Figure 1. 1985 COMBINED LOCATIONS SEEDLING NUMBER

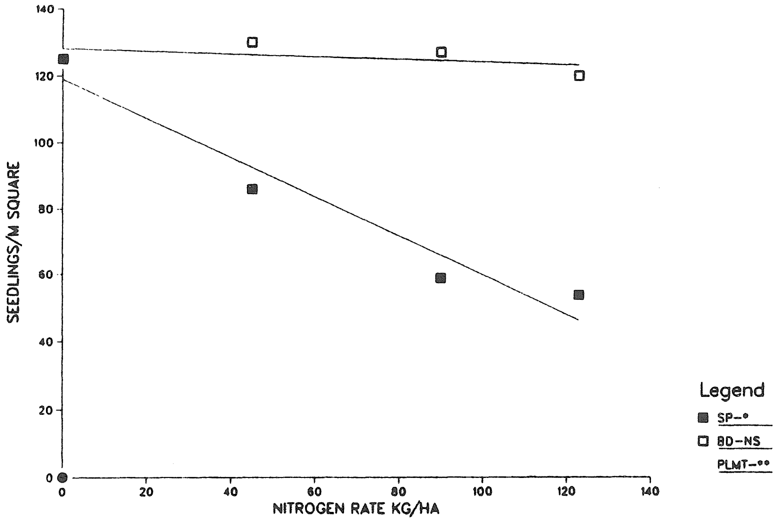


Figure 2. 1985 COMBINED LOCATIONS WEIGHT 10 SEEDLINGS

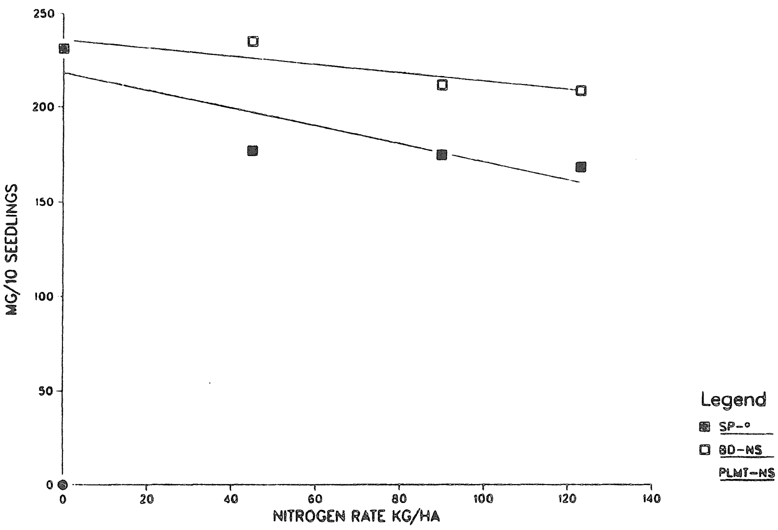


Figure 3. 1985 COMBINED LOCATIONS DRY MATTER YIELD

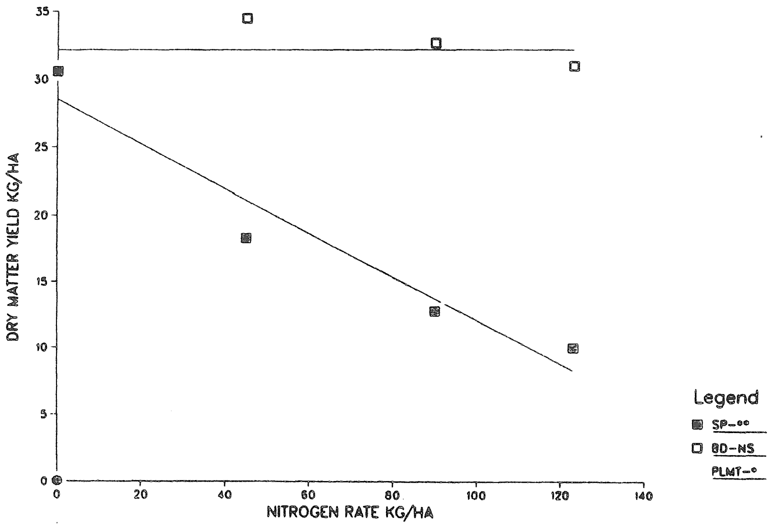


Figure 4. 1985 COMBINED LOCATIONS
SEEDLING NITROGEN AND PHOSPHORUS CONCENTRATION

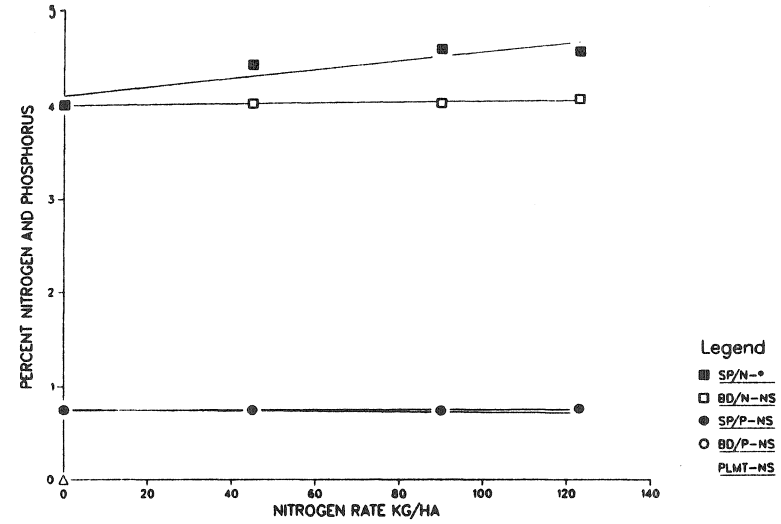
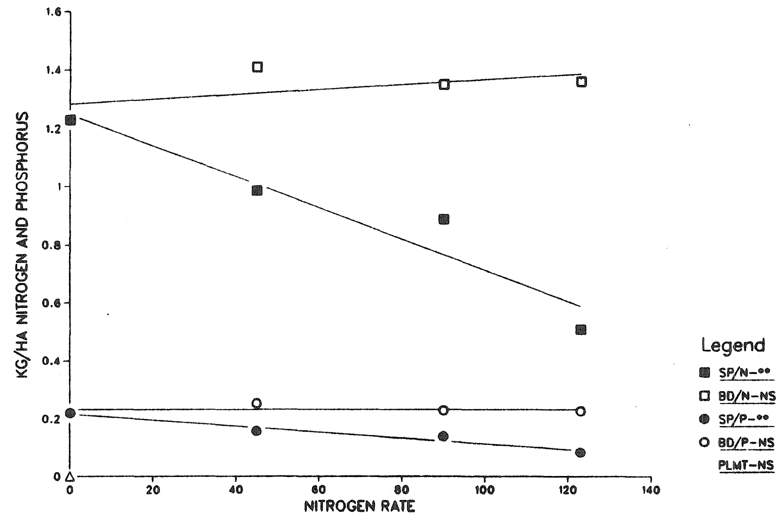


Figure 5. 1985 COMBINED LOCATIONS
SEEDLING NITROGEN AND PHOSPHORUS YIELD



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SEEDLING NUMBER

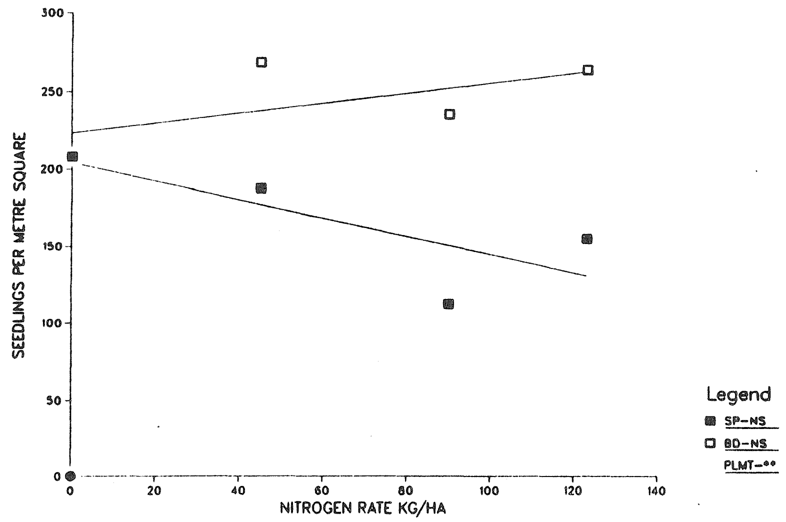
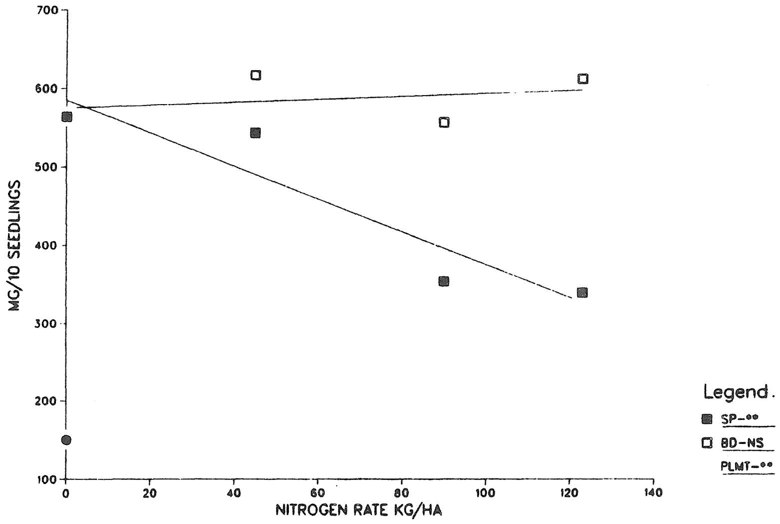


Figure 7. 1985 FLORAL
WEIGHT 10 SEEDLINGS



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DRY MATTER YIELD

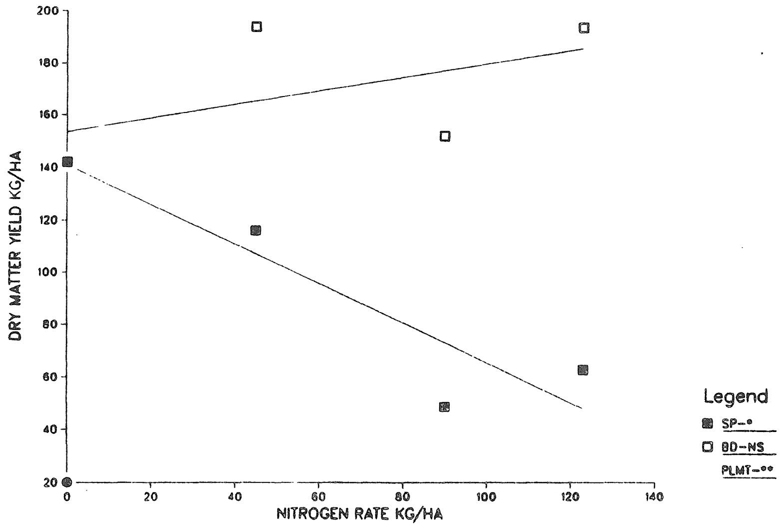


Figure 9. 1985 FLORAL
LEAF AND CROWN WEIGHT

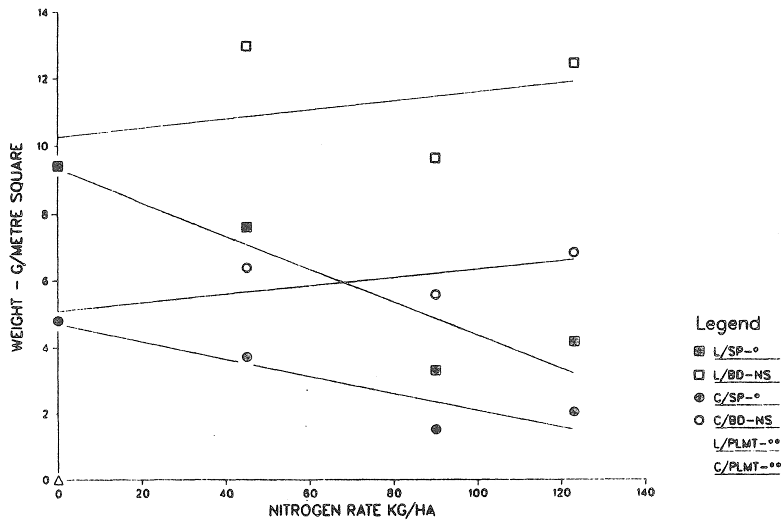


Figure 10. 1985 FLORAL
NITROGEN AND PHOSPHORUS YIELD

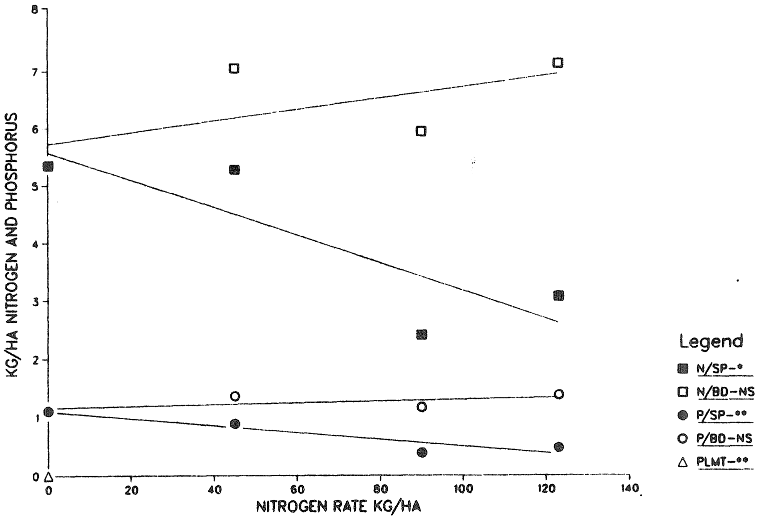


Figure 11. 1985 FLORAL
LEAF NITROGEN AND PHOSPHORUS CONCENTRATION

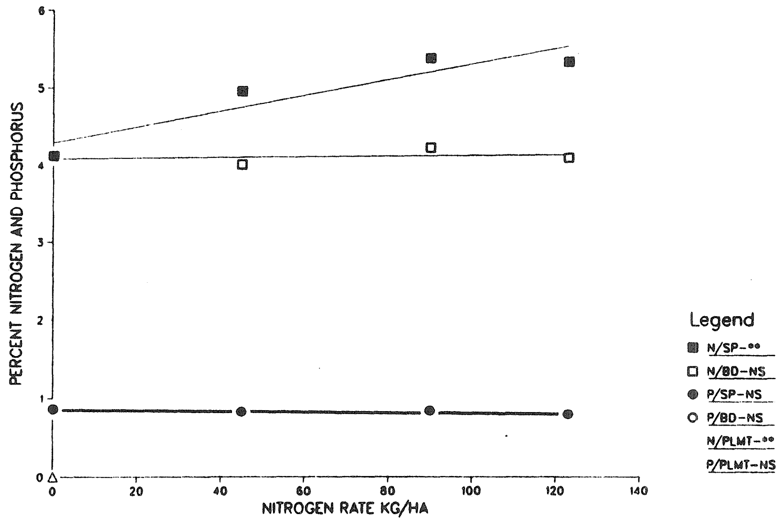
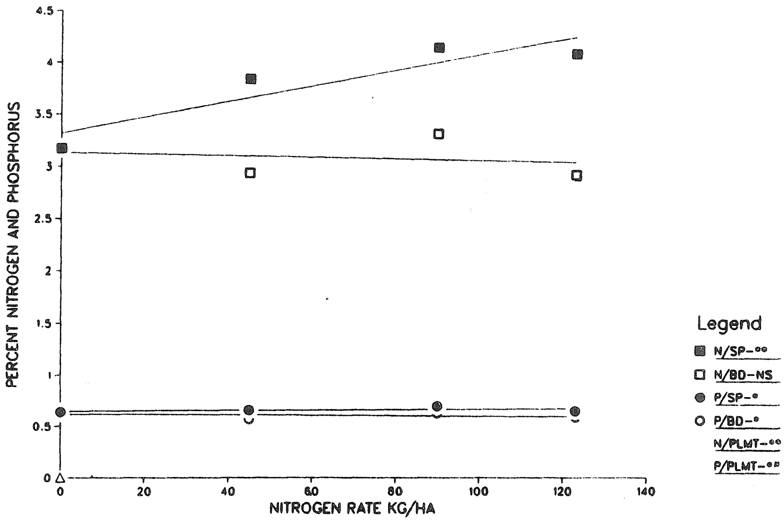
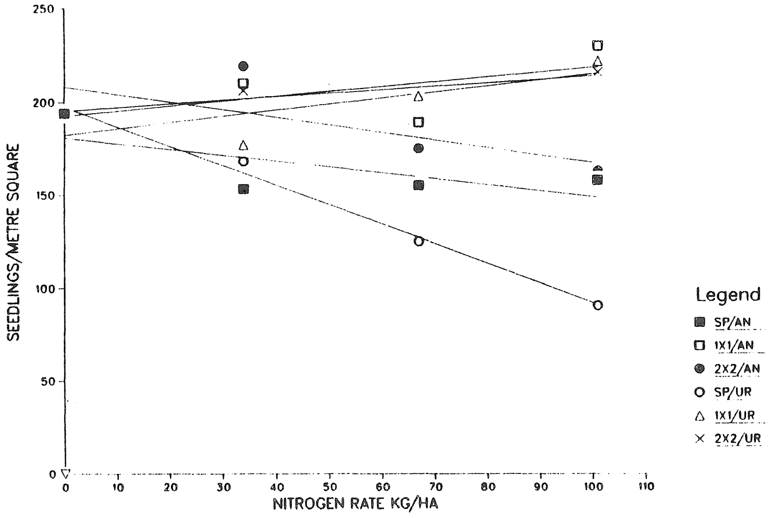


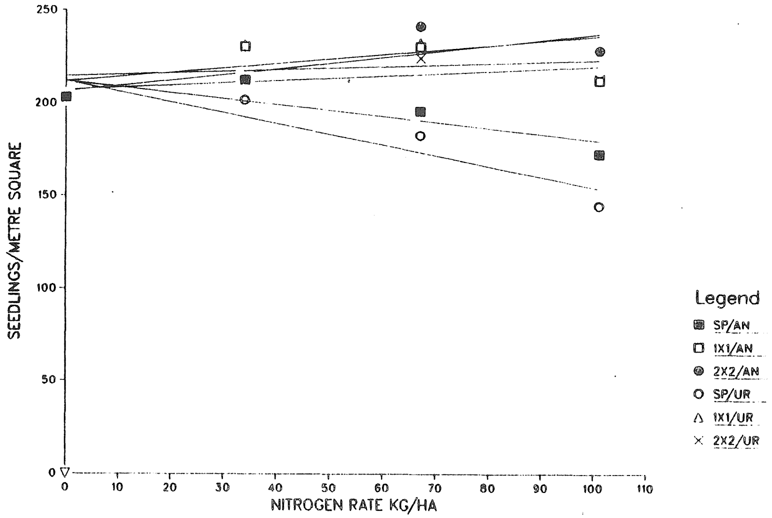
Figure 12. 1985 FLORAL
CROWN NITROGEN AND PHOSPHORUS CONCENTRATION



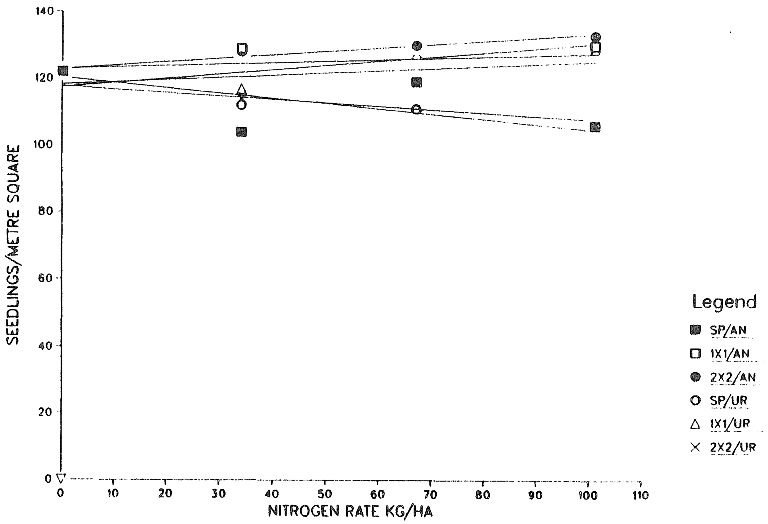
1986 WINTER WHEAT SEEDLINGS – CLAIR
SEEDLING NUMBER



1986 WINTER WHEAT SEEDLINGS – WATROUS
SEEDLING NUMBER



1986 WINTER WHEAT SEEDLINGS – KERNEN
SEEDLING NUMBER



1986 WINTER WHEAT SEEDLINGS – HAGEN
SEEDLING NUMBER

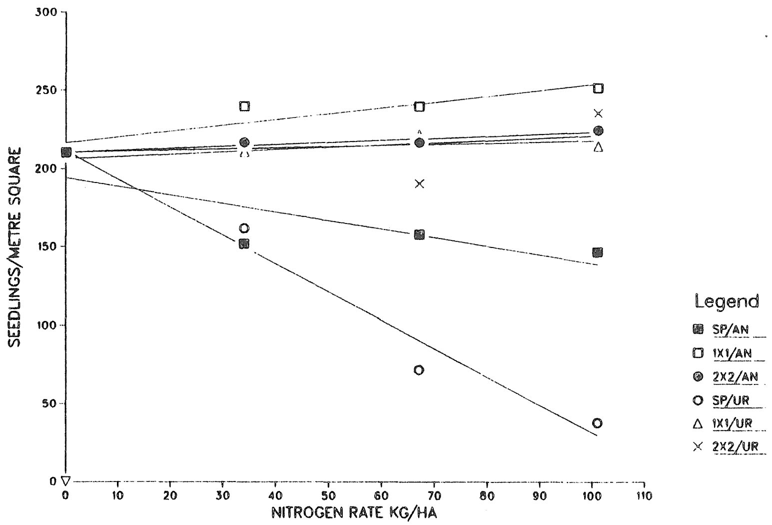


FIGURE 14.

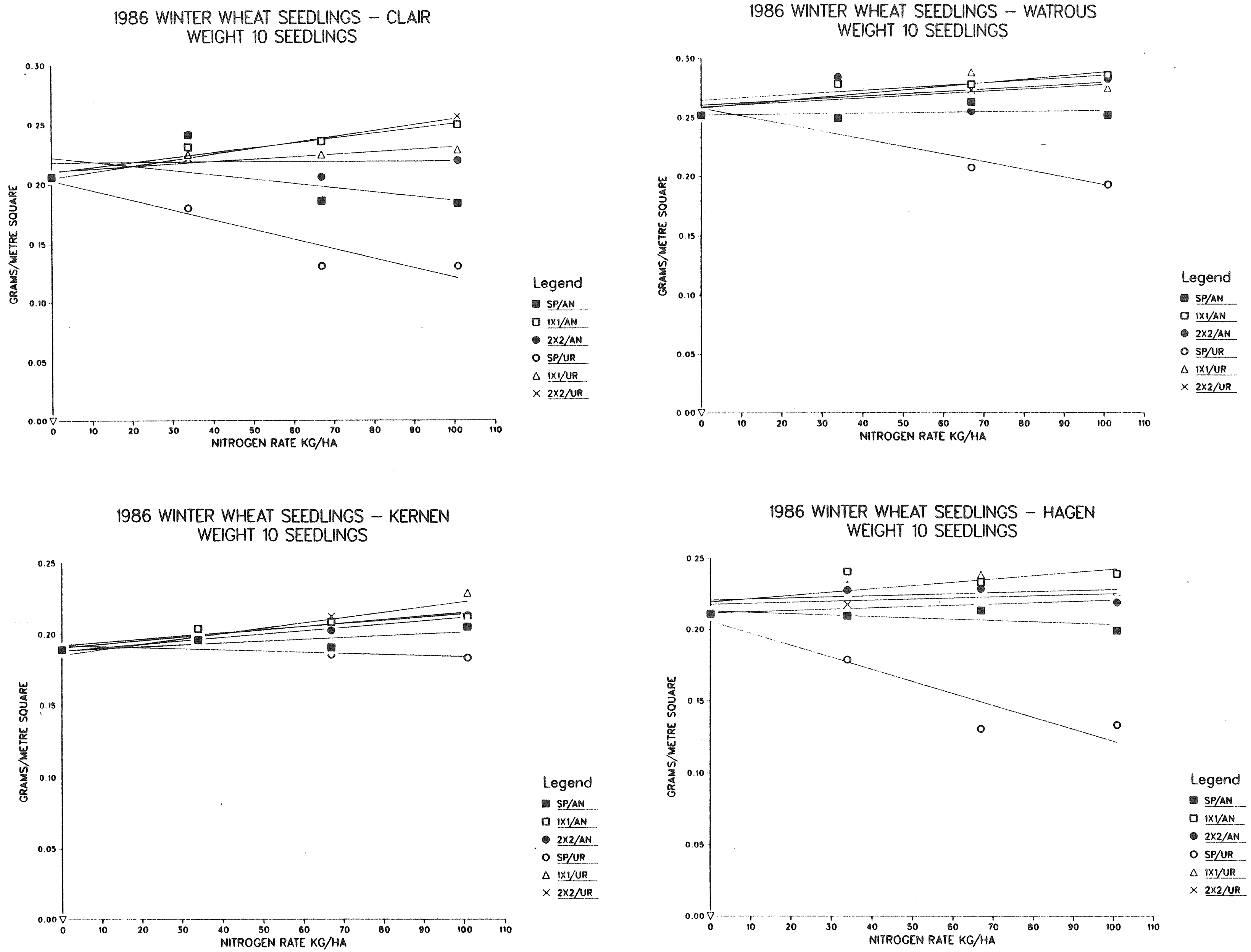
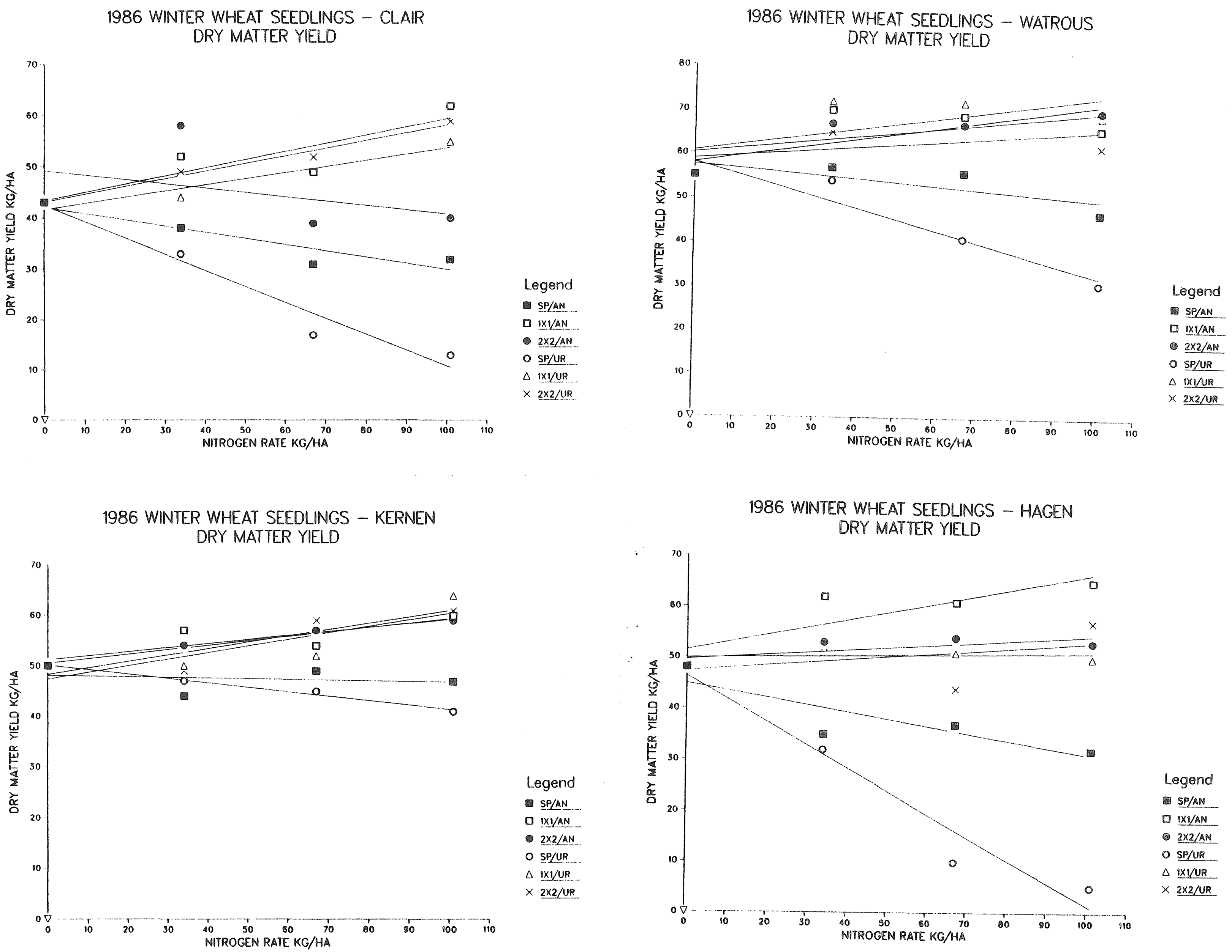
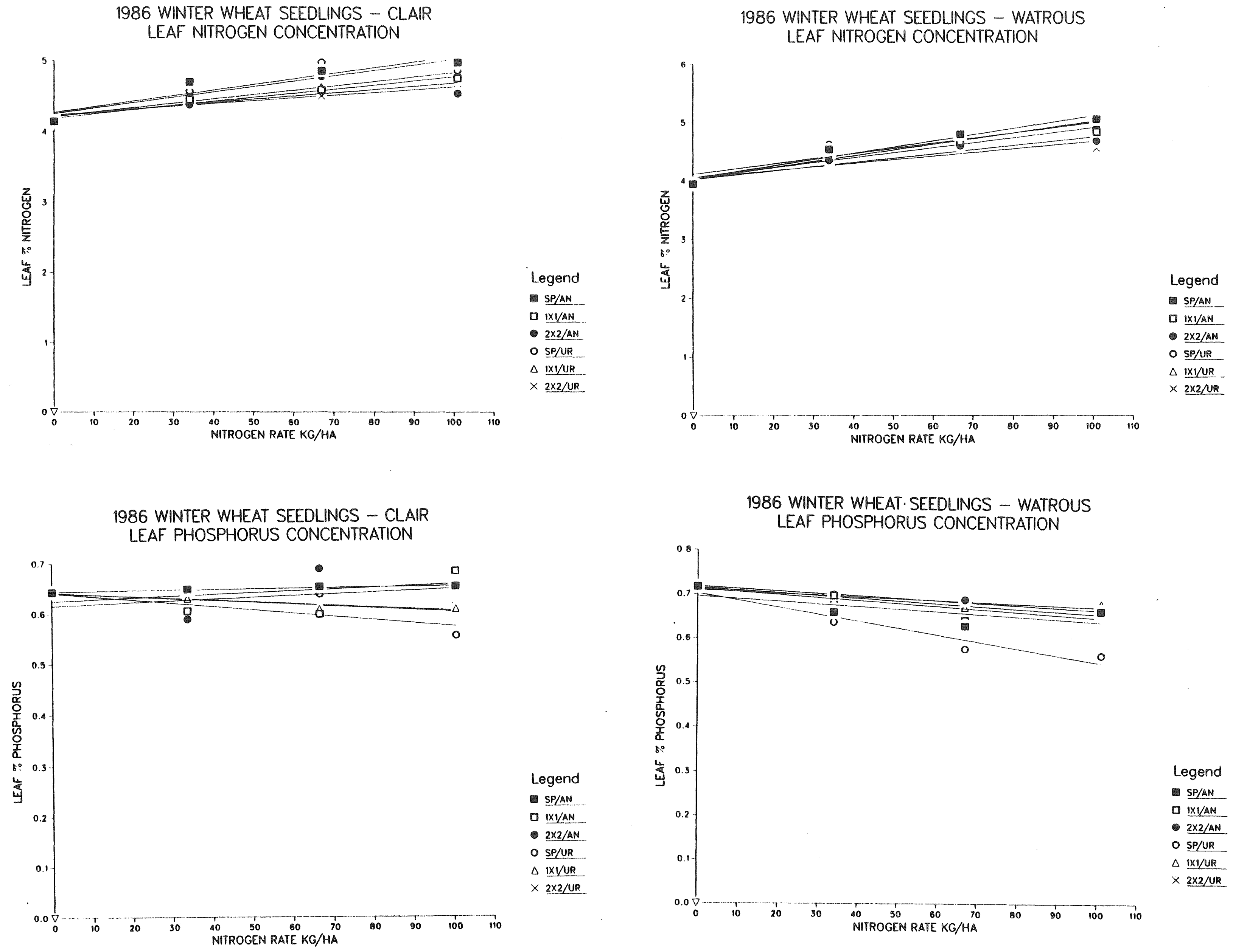

1986 WINTER WHEAT SEEDLINGS – CLAIR
WEIGHT 10 SEEDLINGS
GRAMS/METRE SQUARE
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – WATROUS
WEIGHT 10 SEEDLINGS
GRAMS/METRE SQUARE
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – KERNEN
WEIGHT 10 SEEDLINGS
GRAMS/METRE SQUARE
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – HAGEN
WEIGHT 10 SEEDLINGS
GRAMS/METRE SQUARE
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR

FIGURE 15.



1986 WINTER WHEAT SEEDLINGS – CLAIR
DRY MATTER YIELD
1986 WINTER WHEAT SEEDLINGS – WATROUS
DRY MATTER YIELD
1986 WINTER WHEAT SEEDLINGS – KERNEN
DRY MATTER YIELD
1986 WINTER WHEAT SEEDLINGS – HAGEN
DRY MATTER YIELD
DRY MATTER YIELD KG/HA
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR

FIGURE 16.


1986 WINTER WHEAT SEEDLINGS – CLAIR
LEAF NITROGEN CONCENTRATION
LEAF % NITROGEN
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – WATROUS
LEAF NITROGEN CONCENTRATION
LEAF % NITROGEN
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – CLAIR
LEAF PHOSPHORUS CONCENTRATION
LEAF % PHOSPHORUS
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – WATROUS
LEAF PHOSPHORUS CONCENTRATION
LEAF % PHOSPHORUS
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR

FIGYRE 17.

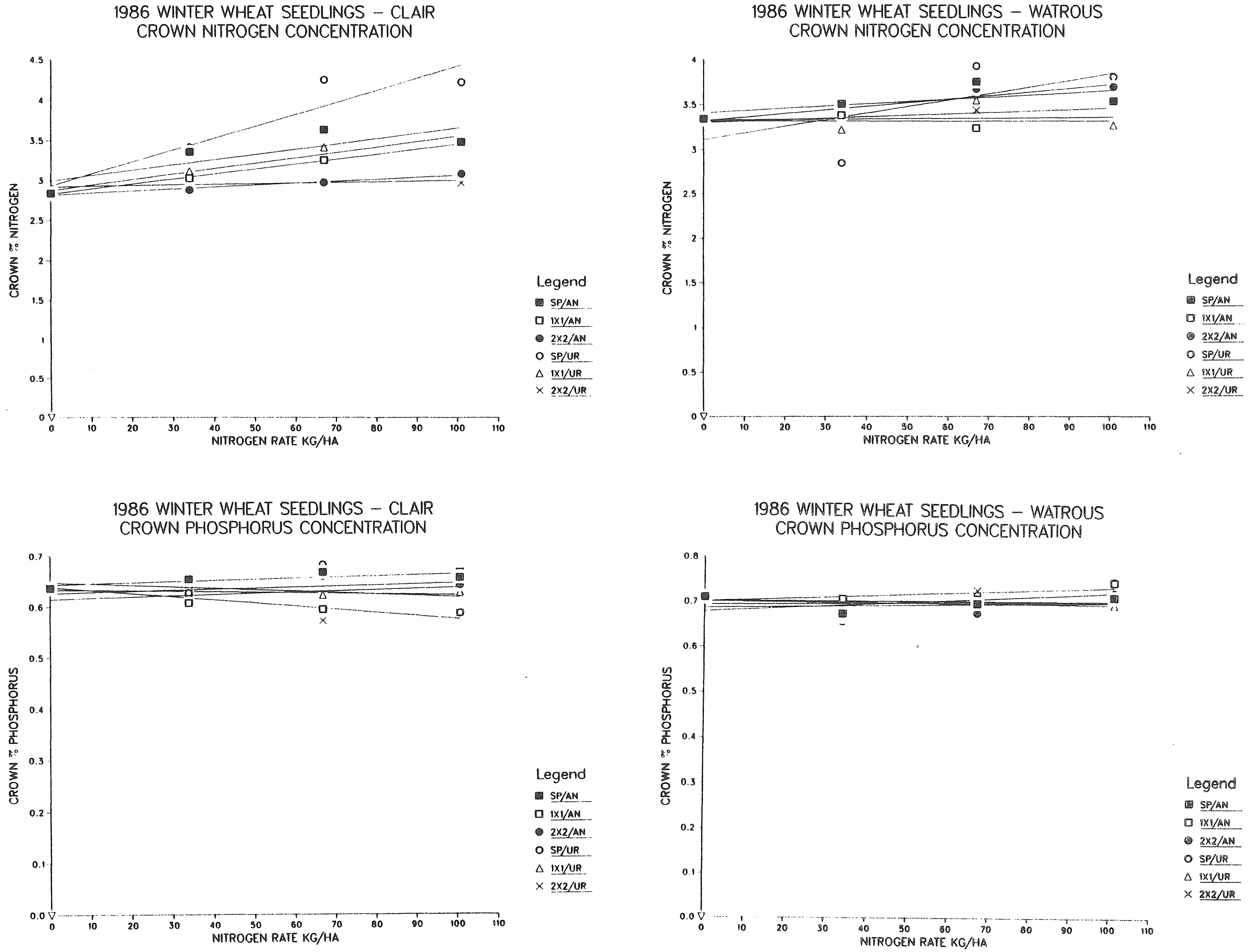

1986 WINTER WHEAT SEEDLINGS – CLAIR
CROWN NITROGEN CONCENTRATION
CROWN % NITROGEN
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – WATROUS
CROWN NITROGEN CONCENTRATION
CROWN % NITROGEN
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – CLAIR
CROWN PHOSPHORUS CONCENTRATION
CROWN % PHOSPHORUS
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – WATROUS
CROWN PHOSPHORUS CONCENTRATION
CROWN % PHOSPHORUS
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR

FIGURE 18.

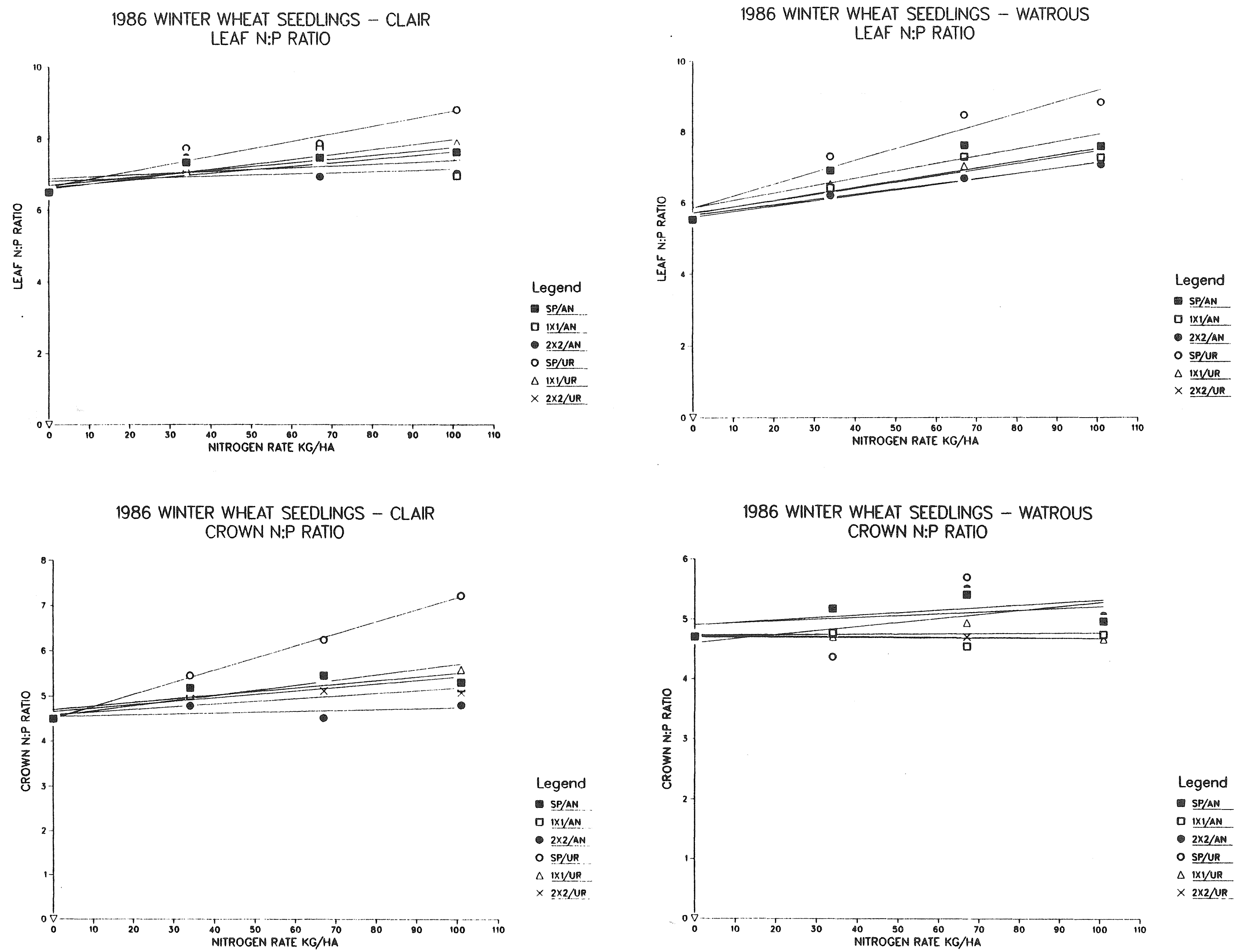
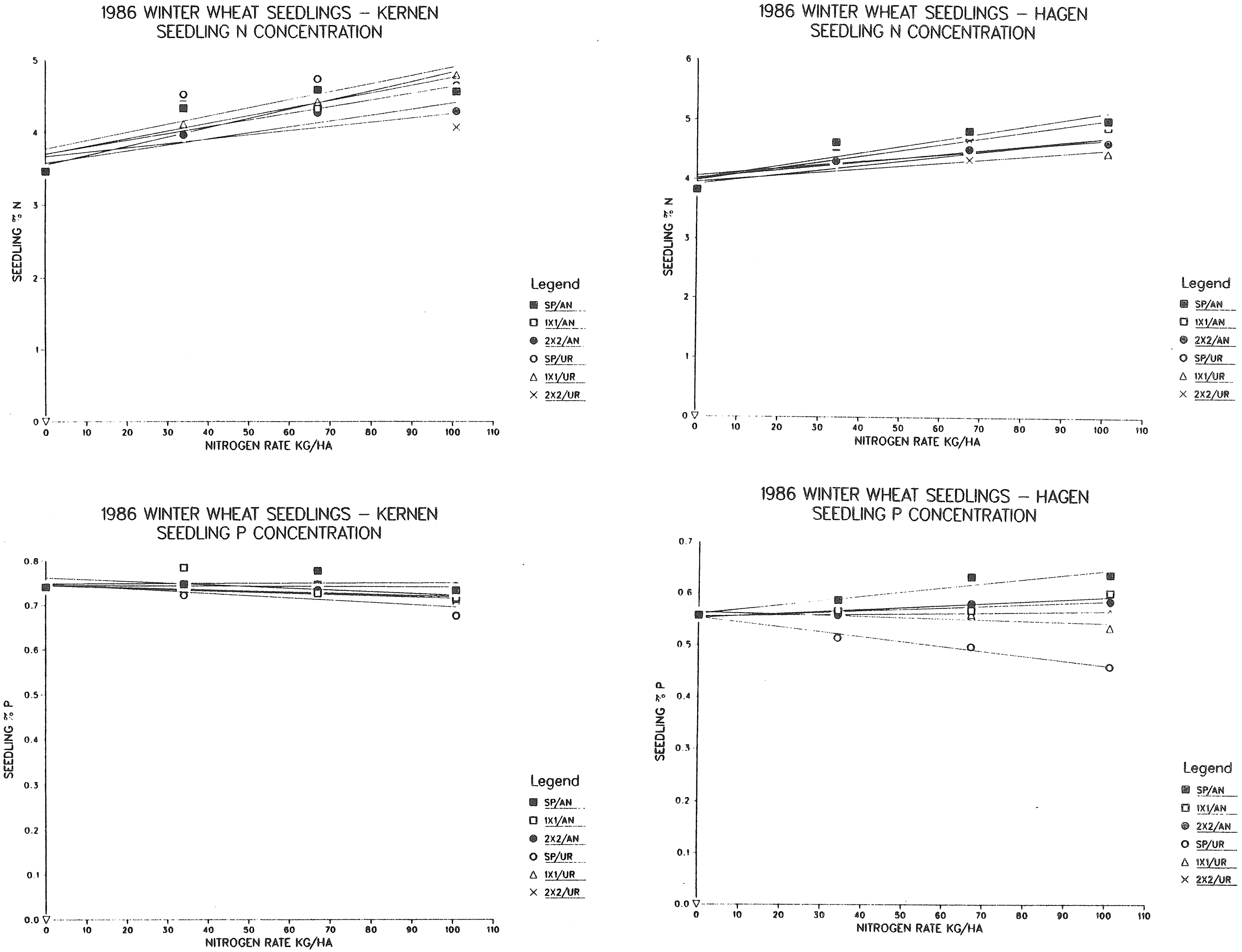
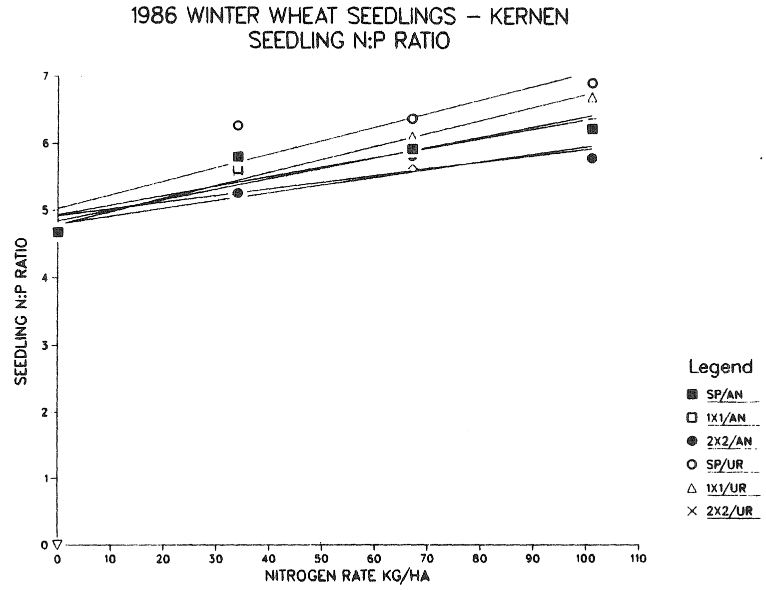

1986 WINTER WHEAT SEEDLINGS – CLAIR
LEAF N:P RATIO
LEAF N:P RATIO
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – WATROUS
LEAF N:P RATIO
LEAF N:P RATIO
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – CLAIR
CROWN N:P RATIO
CROWN N:P RATIO
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – WATROUS
CROWN N:P RATIO
CROWN N:P RATIO
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR

FIGURE 19.



1986 WINTER WHEAT SEEDLINGS – KERNEN
SEEDLING N CONCENTRATION
SEEDLING % N
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – HAGEN
SEEDLING N CONCENTRATION
SEEDLING % N
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – KERNEN
SEEDLING P CONCENTRATION
SEEDLING % P
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – HAGEN
SEEDLING P CONCENTRATION
SEEDLING % P
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR

FIGURE 20.


1986 WINTER WHEAT SEEDLINGS – KERNEN
SEEDLING N:P RATIO
SEEDLING N:P RATIO
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR

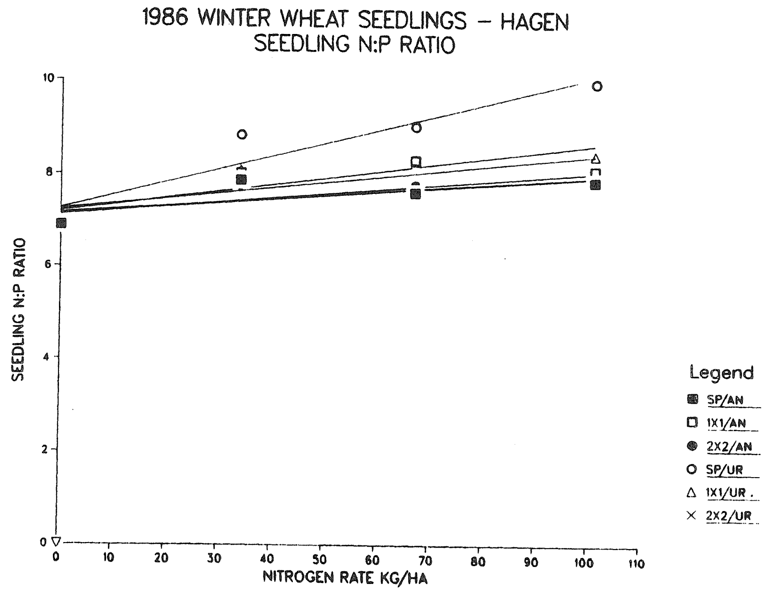

1986 WINTER WHEAT SEEDLINGS – HAGEN
SEEDLING N:P RATIO
SEEDLING N:P RATIO
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR

FIGURE 21.

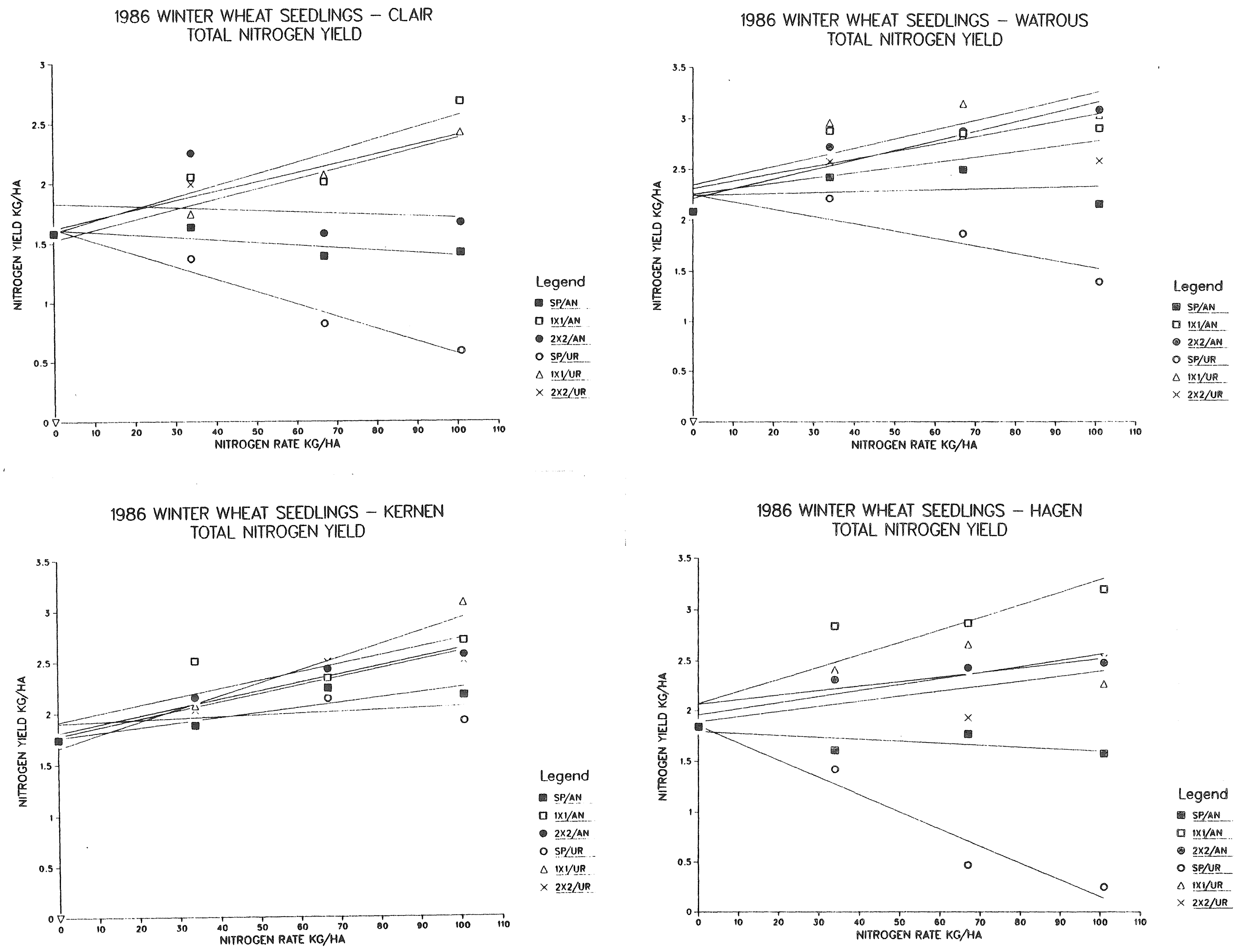
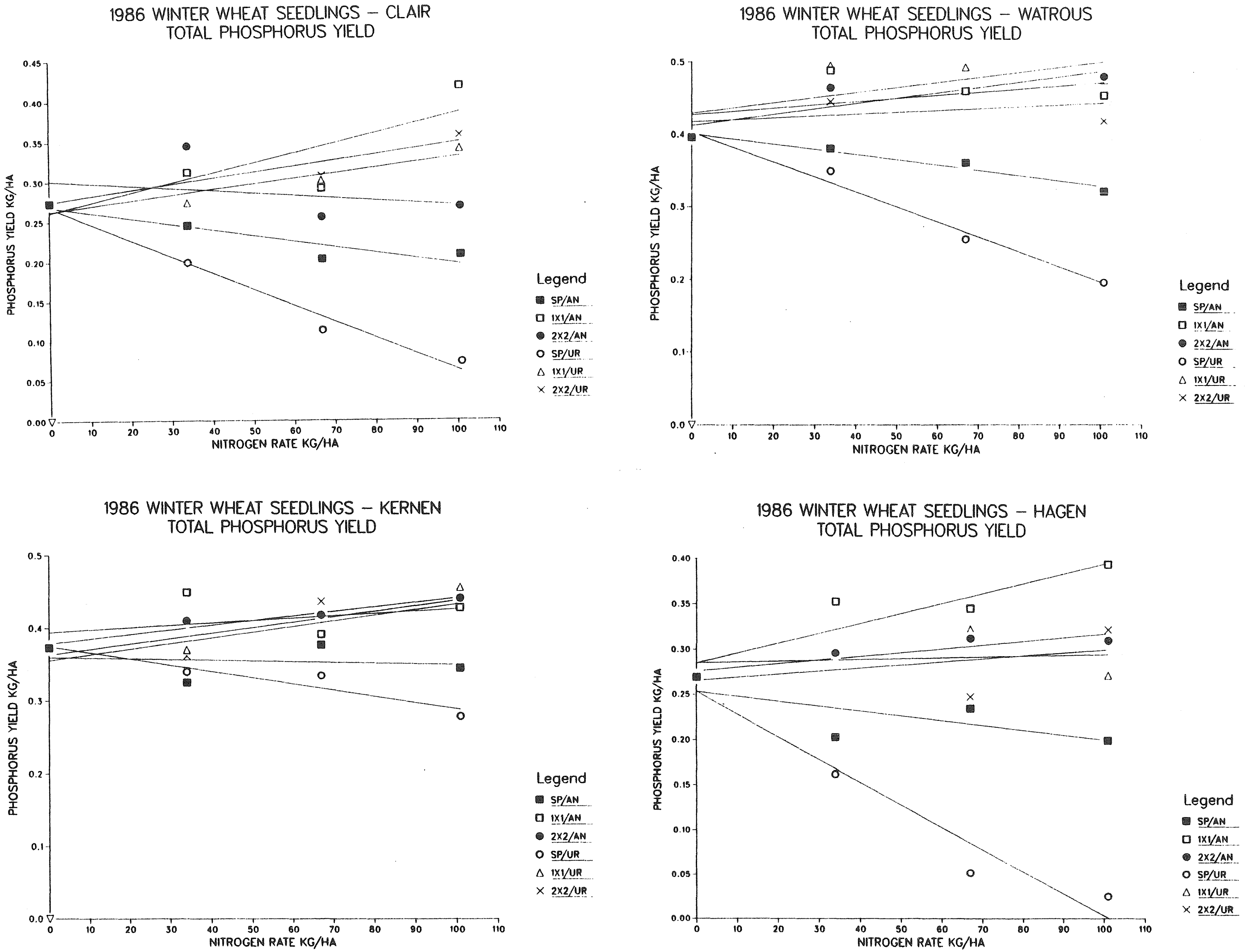

1986 WINTER WHEAT SEEDLINGS – CLAIR
TOTAL NITROGEN YIELD
NITROGEN YIELD KG/HA
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – WATROUS
TOTAL NITROGEN YIELD
NITROGEN YIELD KG/HA
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – KERNEN
TOTAL NITROGEN YIELD
NITROGEN YIELD KG/HA
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – HAGEN
TOTAL NITROGEN YIELD
NITROGEN YIELD KG/HA
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR

FIGURE 22.


1986 WINTER WHEAT SEEDLINGS – CLAIR
TOTAL PHOSPHORUS YIELD
PHOSPHORUS YIELD KG/HA
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – WATROUS
TOTAL PHOSPHORUS YIELD
PHOSPHORUS YIELD KG/HA
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – KERNEN
TOTAL PHOSPHORUS YIELD
PHOSPHORUS YIELD KG/HA
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR
1986 WINTER WHEAT SEEDLINGS – HAGEN
TOTAL PHOSPHORUS YIELD
PHOSPHORUS YIELD KG/HA
NITROGEN RATE KG/HA
Legend
SP/AN
1X1/AN
2X2/AN
SP/UR
1X1/UR
2X2/UR

EFFECT OF LIQUID NITROGEN FERTILIZER APPLIED TO WINTER WHEAT FOLIAGE AT THREE GROWTH STAGES ON YIELD AND PROTEIN

L. Townley-Smith
Agriculture Canada Research Station
Melfort, Saskatchewan

ABSTRACT

Urea-ammonium nitrate liquid fertilizer was applied at 0, 5, 10, 15 and 20 kg N ha^{-1} to winter wheat at full emergence of the flag leaf, half emergence of the head and full emergence of the head. Growth stage had no effect on the responses. Grain yield and grain N yield showed linear response to applied N with slopes of 3 and 0.12 kg ha^{-1} N respectively. Nitrogen concentrations in the grain and straw showed a quadratic response. The N concentration of the grain was increased from 19.2 to 21.3 g kg^{-1} and the protein from 11.1 to 11.7%.

INTRODUCTION

Winter wheat has a high grain yield relative to protein yield. In Saskatchewan the protein concentration of the grain is, except in dry years, often below 11% (Fowler 1986). The occurrence of piebald kernals increases as protein concentration decreases, leading to a reduction in grade. Addition of N fertilizer to the soil is not an economical method to increase protein (Fowler 1986).

Nitrogen, in the form of urea, ammonium nitrate and mixtures of urea and ammonium nitrate has been experimentally applied to the leaves of crop plants to increase yield and protein concentration. Garcia and Hanway (1976) showed the foliar application of urea in soybean increased yield. Foliar applications of urea increased the protein cncentration of rice from 7.1 to 11.4% (Thom et al. 1981). Urea-ammonium nitrate increased the seed protein of barley from 7.8 to 11.0% (Turley and Ching 1986). Ammonium nitrate applied to soil at a rate of 34 kg N ha^{-1} increased protein in wheat from 12 to 13.4%

while the same rate applied as a foliar spray increased it to 14.8% (Alkier et al. 1972). In winter wheat, 50 kg ha^{-1} increased the protein concentration from 10.9 to 12.6% while top dressing 100 kg ha^{-1} increased it to only 11.5% (Altman et al. 1983). Foliar application of urea increased both yield and protein concentration of winter wheat in India (Sadaphal and Das 1966).

The objective of this experiment was to determine the response of winter wheat to foliar application of nitrogen at three stages of development.

METHODS

Norstar winter wheat (Triticum aestivum cv. 'Norstar') was seeded with barley in the spring of 1985. The stand in the spring of 1986 was fair, with some delay in development where windrows had lain the previous fall. Wild oat populations were high where the stand development was delayed. Both N and P fertility were low. Ammonium nitrate at a rate of 50 kg N ha^{-1} was broadcast in the spring.

Liquid N fertilizer (urea-ammonium nitrate, 28-0-0) was applied to the crop at full emergence of the flag leaf, head half emerged from the boot and at full emergence of the head. Five rates, 0, 5, 10, 15 and 20 kg N ha^{-1}, were applied at each growth stage in equal volumes of water using a 2 m wind shielded plot sprayer. The split plot experiment, with growth stage in the main plots and rate of N in the subplot factor, had four replicates.

The 2 by 5 m plots were harvested with a plot combine at crop maturity to determine grain yield. Grain and straw N concentration were measured by micro-kjeldahl digestion followed by colorimetric determination with a Technicon auto-analyser. Grain nitrogen yield was determined arithmetically from the yield and N concentration. The data were analysed by analysis of variance and significant N rate effects were further analysed by regression.

RESULTS AND DISCUSSION

Grain yields averaged 1200 kg ha^{-1} which are low for winter wheat. Fowler (1986) reported yields in this range from locations with poor moisture conditions. Although growing season rainfall was near average, there was no effective rain, greater than 5 mm, from May 15 until July 9. There was no response to growth stage or the stage x fertilizer interaction. Grain yield showed a linear response to foliar nitrogen (r^2 = 0.806) (Figure 1). The slope is approximately 3.1 while Fowler (1986) showed a slope near 7 with 50 to 70 kg of available N and spring application to the soil.

Grain N concentration showed a quadratic response to the applied N (r^2 = 0.945) (Figure 2). There was no response to growth stage or the stage x fertilizer interaction. The fertilizer raised the grain N concentration from 19.2 to 21.3 g kg^{-1} and the crude protein from 11.1 to 11.7%. The maximum grain N concentration occurred at approximately 15 kg N ha^{-1}. Sadaphal and Das (1966) showed a linear response of protein to foliar application of urea over a similar range of rates in a more productive environment in India.

Grain N yield also showed a linear response to N rate (r^2 = 0.801) (Figure 3) but no response to growth stage or the stage x fertilizer interaction. Approximately 12% of the applied N was recovered in the grain. The response is about half of the response reported by Fowler for soil plus fertilizer N (1986).

Straw N concentration also showed a quadratic response to N rate (r^2 = 0.891) (Figure 4) but not to growth stage or the stage x fertilizer interaction. The peak occurred near 12 kg ha^{-1}. Straw N yield and recovery was not available as straw yields were not measured.

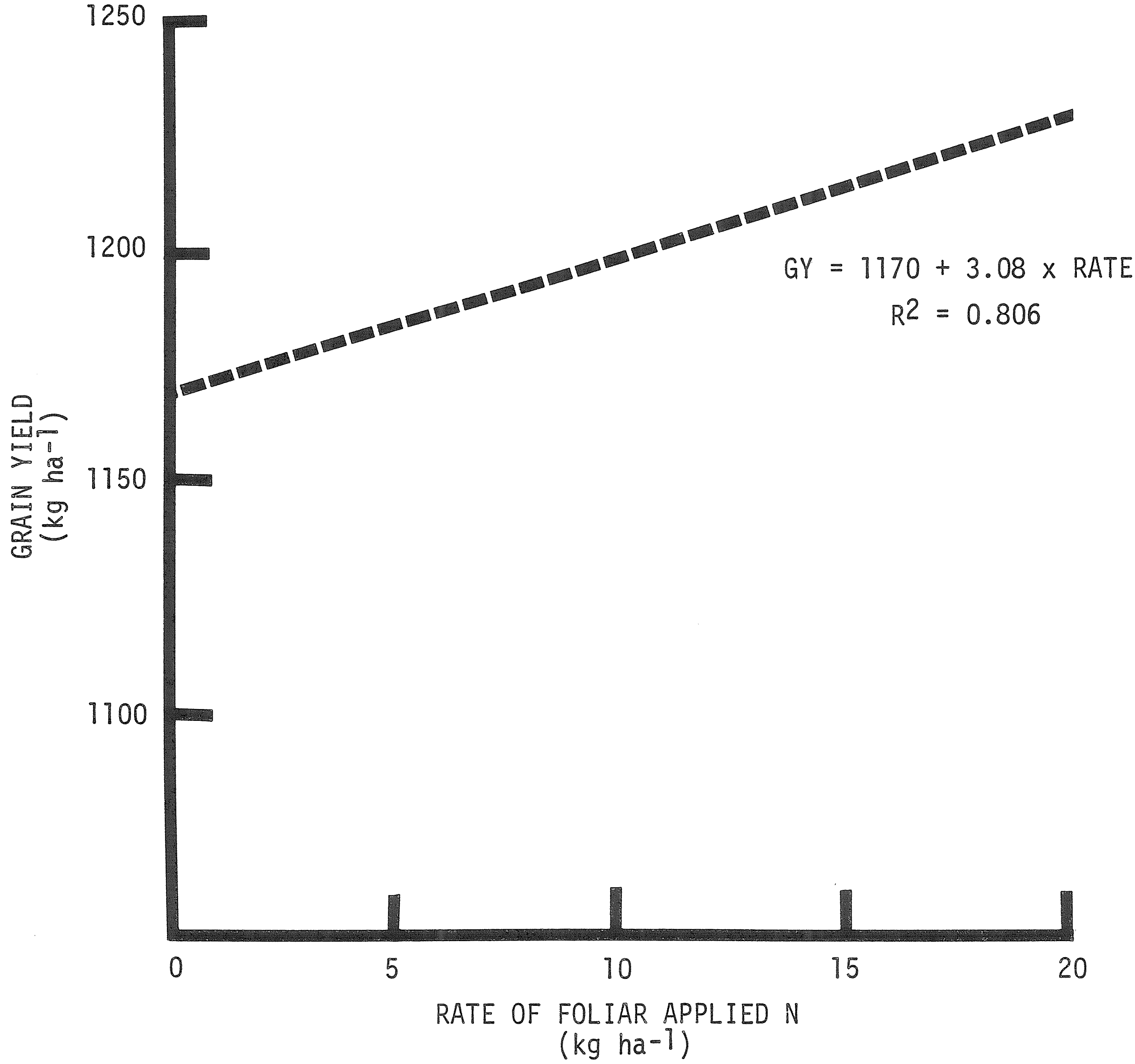


Fig. 1. Response of grain yield to foliar applied nitrogen

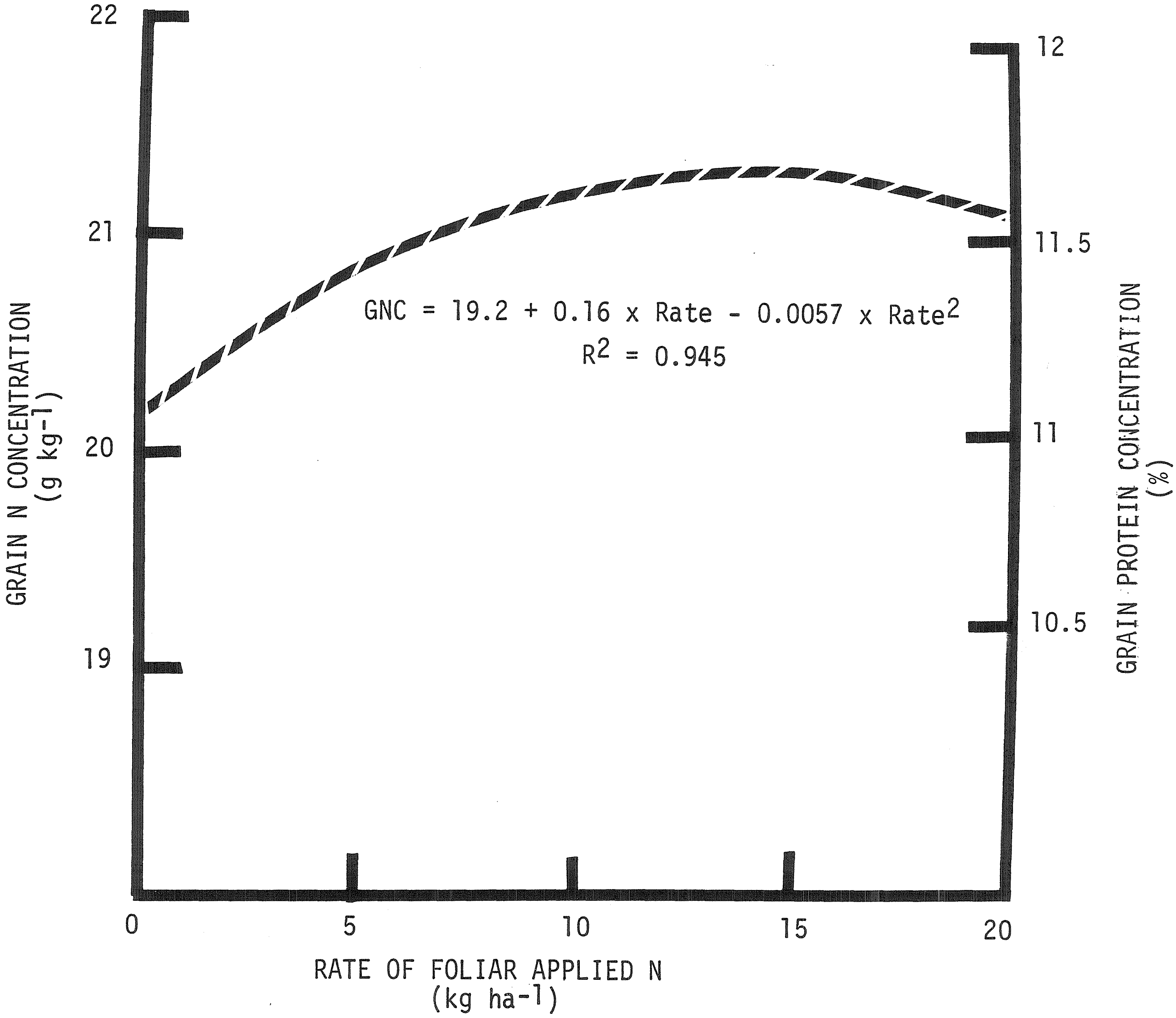


Fig. 2. Response of grain nitrogen and protein concentration to rate of foliar applied nitrogen

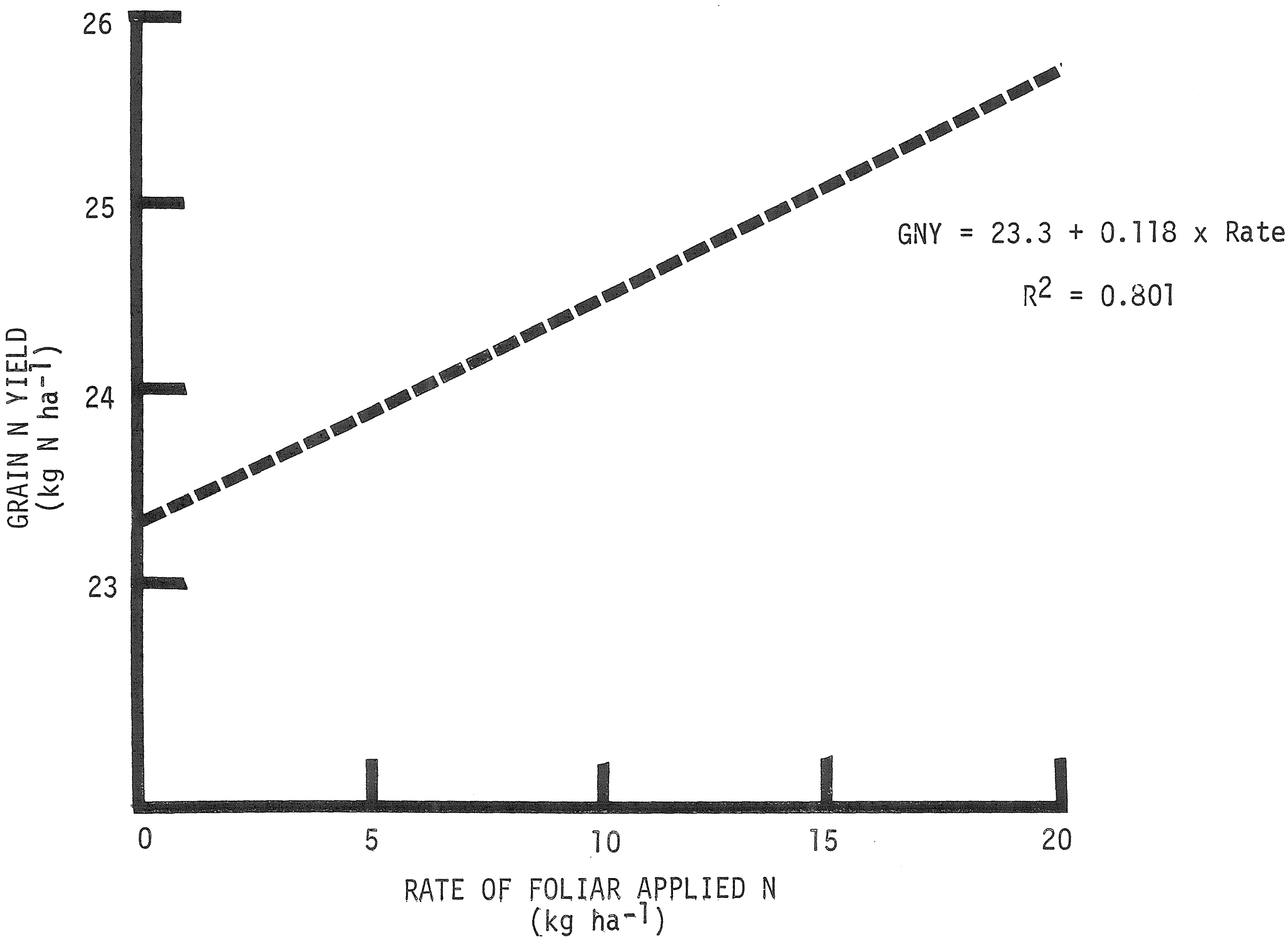


Fig. 3. Response of grain nitrogen yield to rate of foliar applied nitrogen

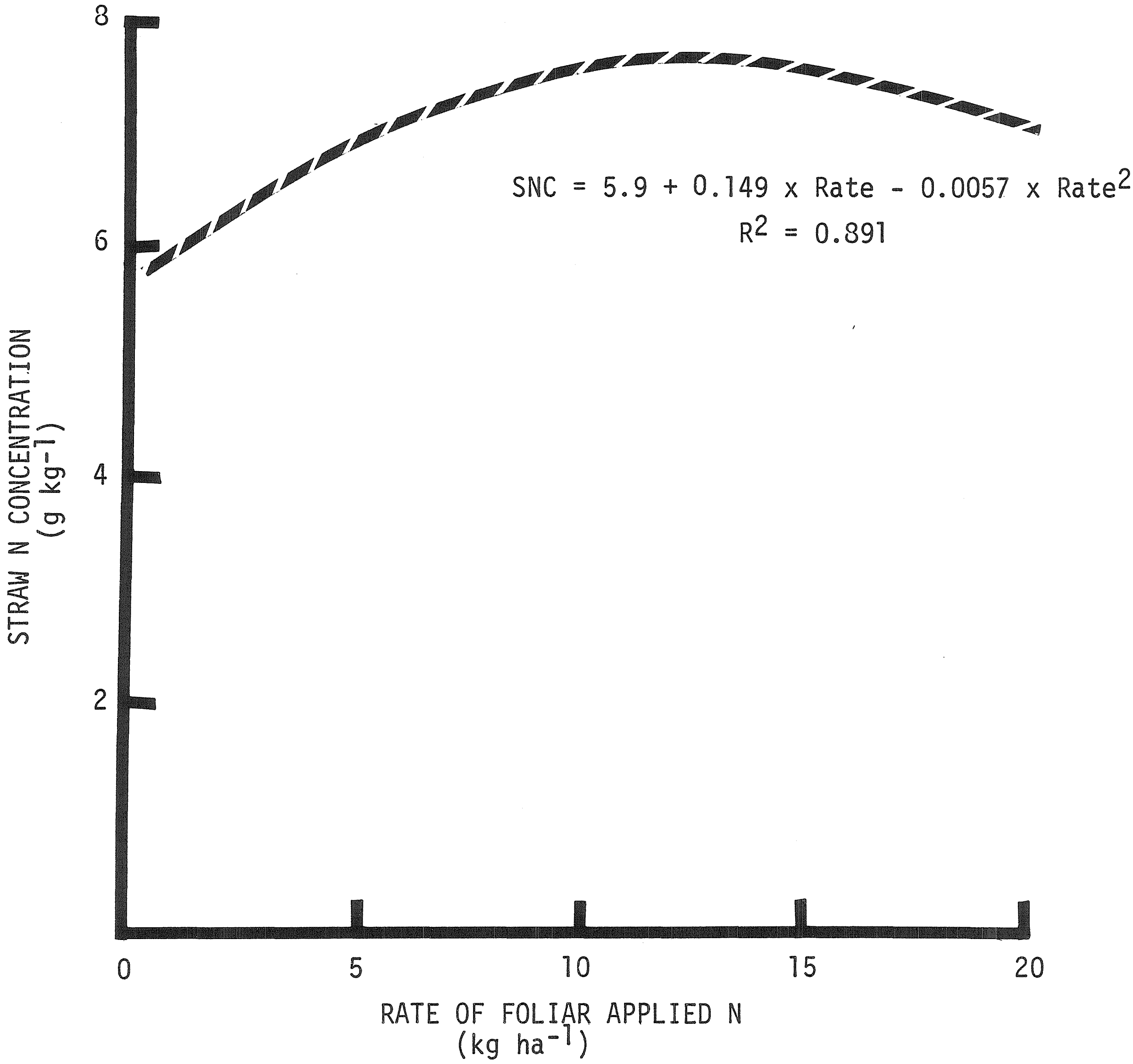


Fig. 4. Response of straw nitrogen concentration to rate of foliar applied nitrogen