Effect of Source, Rate and Placement of Nitrogen for Wheat and Rapeseed on Stubble

H. Ukrainetz
Research Station
Agriculture Canada
Saskatoon, Saskatchewan

Introduction

The primary limiting factors for cereal grain and rapeseed production on stubble land in Western Canada are nutrient and moisture availability. Weeds are generally a greater problem in crop production on stubble than on fallow, but relatively effective weed control methods are becoming available to minimize the weed competition factor. The problem of seedbed preparation for satisfactory seeding in heavy stubble can generally be overcome by thorough chopping and spreading of straw when combining and by pre-seeding tillage.

In the more northern areas of Saskatchewan where moisture conditions are quite favorable for stubble cropping, there is a good potential for producing relatively high yields of cereals and rapeseed crops with adequate inputs of fertilizer nutrients where required. Urea is rapidly becoming a major form of fertilizer nitrogen, and a more thorough assessment of its effectiveness in comparison to such forms as ammonium nitrate is required.

Methods and Materials

In 1973, fertilizer test plots were located on Sceptre heavy clay (ScHvC) at Kindersley, Scott loam (SttL) at Scott, Waseca loam (WaL) at Lashburn, Waitville loam (WvL) at Glaslyn and Loon River loam (LnL) at Loon Lake. Some properties of the soils used in this study are given in Table 1. Soil samples were taken from the plot areas in spring prior to seeding for moisture determination and chemical analyses. Urea and ammonium nitrate (AN) were applied with the seed, broadcast and incorporated before seeding and side-banded 3/4 inch below and to the side of the seed at rates of 0, 10, 20, 40, 80 and 120 lb N/acre. With-seed and side-band placement were done with a specially-constructed, double-disc opener, self-powered plot seeder. Phosphate was applied with the seed at 40 lb P_2O_5/acre alone and with each rate of N. An additional 40 lb rate of N was applied without P to determine the effect of P on response to N. Treatments were randomized and replicated four times. Neepawa wheat was used as the test crop at all locations, and Torch rapeseed was also seeded at Lashburn.

The effect of the fertilizer treatments on germination and plant stands was determined by taking plant counts on two replicates of all treatments at the time of heading. Plant counts were not taken on the rapeseed plots, although visual observations were made. At maturity, the two

Table 1. Some soil characteristics of the plots used in the fertilizer study.

Soil	Zone	Texture	pH	% O.M.	C.E.C. meq/ 100 g	Available Nutrients* lb/ac NO_3-N	P
Sceptre heavy clay	Brown	HvC	7.9	2.6	41	24	20
Scott loam	Dark brown	L	5.2	4.7	18	40 D	13 D
						28 I	9 I
Waseca loam	Black	L	6.8			40	14
Waitville loam	Grey	L	6.0	3.5	14	126	20
Loon River loam	Grey	L	6.8	2.3	11	20	13

* Sampled just prior to seeding in the spring, 1973. NO_3-N on basis of 0- to 24-inch depth, $NaHCO_3$-ext P on 0- to 6-inch depth. D - dryland, I - irrigated.

center rows of each plot were cut at ground level for grain and straw yield determination and for analysis. Protein contents in wheat and rapeseed were determined by the Kjeldahl method, and oil content of rapeseed was determined on whole seed samples by the NMR method. Soil samples were taken from the check and 120 lb N broadcast treatment plots after crops were harvested to determine levels and movement of residual fertilier N.

Results and Discussion

Germination and emergence

The surface soil (seedbed) dried out rapidly following seeding at Scott, Glaslyn and Loon Lake. At Scott, irrigation water was not applied until after crop emergence. As a result, at these locations, the seed and fertilizer remained in relatively dry soil (less than 50% AC) from the time of seeding until after most of the plants had emerged. Soil moisture reserves were only fair at all locations at the time of seeding. Plant populations determined at heading time are given in Table 2. On Scott loam under dryland conditions, urea applied with the seed at 40 lb N/acre reduced plant stands slightly, and further substantial reductions resulted from the 80 and 120 lb rates. Following water application on the irrigated plots on SttL, additional plants emerged, and only the 120 N urea application with the seed resulted in significant reduction in plant stands. On the Sceptre soil, a slight decrease in plant population resulted only from urea applied with the seed at 120 lb N/acre. Urea drilled with the seed at 80 and 120 lb N/acre reduced plant populations substantially on WaL, and stands were severely thinned by these treatments on the grey WvL. On the grey LnL, urea with the seed was detrimental even at the 40 lb N rate. On all soils, AN applied with the seed did not appear to be detrimental to germination even at the 120 lb N rate. With urea, broadcast application had little or no effect on germination, drilling with the seed was most detrimental and side-banding was intermediate. It would appear that a 3/4-inch separation of seed and fertilizer was not sufficient to completely overcome the harmful effects of urea at the highest rates of N. Application of 40 lb N with the seed, particularly urea, without phosphate, depressed germination more than with added phosphate. Except for the urea treatments placed with the seed, N applications tended to increase plant populations above the check level.

Plant populations of rapeseed on WaL at Lashburn were also noticeably reduced by urea placed with the seed at rates of 40 lb N/acre or more, but subsequent strong response to N by remaining plants tended to compensate for the reduced stands.

The detrimental effects of seed-placed urea appeared to be most closely related to soil C.E.C. although no C.E.C. data is available to verify this relationship for the WaL soil.

Yields

Available N and P at seeding time were in the low to medium range on all soils, and therefore, a response to fertilizers was expected. Wheat grain yields for SttL and ScHvC are shown in Figure 1 and for WaL, WvL and LnL in Figure 2. On the SttL under dryland conditions, yields of wheat were relatively low, and response to applied N was small, undoubtedly related to the high moisture stress during the growing season. Urea and AN placed with the seed produced the lowest yields; a significant reduction in yield resulted from urea at 80 and 120 lb N/acre. Under irrigation, a good response to N was obtained with highest yields resulting from the broadcast applications of urea and AN. Urea placed with the seed produced lowest yields and did not significantly increase yields above the check. Response to N was strongest up to the 40 lb N rate and tended to level off at higher rates. On ScHvC, a strong response to N was also obtained up to the 40 lb N rate with a leveling off at higher rates. There were no significant differences due to method of N placement except for urea placed with the seed at 80 and 120 lb N. These latter treatments produced yields significantly higher than the check but lower than the other treatments. On the WaL soil, wheat yields continued to increase as rates of N increased up to 120 lb/acre with the exception of urea at 80 and 120 lb N applied with the seed. These latter treatments depressed yields below the check level. Highest yields were obtained from the urea and AN broadcast treatments with increases of more than 100% at the highest N rates. A strong response to N was also obtained on the grey WvL soil. There were no significant differences between methods of placement of AN, and broadcast urea was equal in effectiveness. A marked depression in yields resulted from urea at 80 and 120 lb N with seed, and urea side-banded 3/4 inch away from the seed produced the second lowest yields at N rates in excess of 20 lb/acre. Although the grey LnL soil was low in available N at seeding, yield increases from applied N were relatively small. Urea with the seed was yield-depressing at rates as low as 20 lb N/acre, and at the 120 lb N rate, yields were reduced to just over 5 bu/acre. Urea side-banded at 80 and 120 lb N also produced poor results. Highest yields were obtained from broadcast AN. Heavy rains caused some damage to the crop through lodging and erosion at a late stage of growth, probably accounting in part for the variable yields and relatively low increases from N.

The response of Torch rapeseed to N applications on the WaL soil, shown in Figure 3, was most striking. The most effective treatments were urea and AN broadcast and incorporated before seeding. AN produced the highest yields, but differences between urea and AN were not statistically significant. The strong response to N masked the harmful effects of seed-placed urea on germination, and there was no marked depression in yield even with the 120 lb N rate.

The yields of wheat and rapeseed were consistently and substantially higher on all soils when phosphate was applied in addition to N as compared to N applications alone. Data for rapeseed on WaL are given in Table 3. These results emphasize the importance of providing adequate phosphate in order to maximize response to N.

Crop quality

Grain protein determinations were completed for wheat on the LnL site, and rapeseed samples from the WaL were analyzed for protein and oil content. Results are presented in Figure 4. Wheat grain protein contents increased almost linearly with increasing rate of N with broadcast urea and AN being most effective at the highest rates of N. Protein contents were increased by more than 3% at the 120 lb N rate. Protein contents of Torch rapeseed were also sharply increased by N at rates of 40 to 120 lb/acre. Broadcast applications of urea and AN resulted in the highest protein contents. At the 10 lb N rates, protein percentages decreased from the check level and were restored by the 20 lb N treatment. This corresponds with the sharp rise in seed yields from the initial increments of N. The increased protein contents resulting from the higher rates of N were associated with significant decreases in seed oil percentages.

Residual N in soil from fertilizer treatments

Analysis of soil samples taken after crops were harvested showed that some residual N had moved down to 30 inches on irrigated SttL, on WvL wheat plots and under rapeseed on WaL. Residual NO_3-N remained above the 18-inch depth in the other plots. There was an apparent small loss of urea N from the WvL soil,and a substantial loss from the LnL, probably through volatilization of ammonia. Significant loss of NH_3 from incorporated urea in the LnL was demonstrated by a simple incubation experiment in the laboratory.

Conclusions

At high rates of N application, urea and AN were most effective for wheat and rapeseed when broadcast and incorporated before seeding. When applied in this way, the two sources of N were not significantly different in effect on yields and quality of the crops. Ammonium nitrate appears to be a more efficient form of N for wheat on the grey LnL soil because of the potential losses of urea N through ammonia volatilization.

Table 2. Effect of nitrogen fertilizer treatments on plant populations of wheat sown on stubble on several soil types - 1973.

Fertilizer treatment		Plants per 12 feet of row											
		Scott loam Dryland		Scott loam Irrigated		ScHvC		WaL		WvL		LnL	
N	P_2O_5	AN	Urea	AN	Urea	AN	Urea	AN	Urea	AN	Urea	AN	Urea
10 W	40	73	70	86	64	98	86	85	74	64	66	87	80
10 BR	40	74	70	91	86	88	92	84	92	77	78	88	81
10 S	40	68	68	86	92	93	97	88	82	74	76	80	94
20 W	40	68	74	77	84	88	88	73	78	86	78	74	82
20 BR	40	81	84	85	80	92	92	84	92	90	84	77	88
20 S	40	86	77	83	83	90	94	87	87	86	86	77	83
40 W	40	75	62	81	86	90	86	88	90	89	92	76	61
40 BR	40	74	69	86	96	82	82	102	96	96	102	82	72
40 S	40	74	77	92	80	78	80	84	86	85	82	71	74
80 W	40	76	51	84	77	96	90	99	64	76	37	67	54
80 BR	40	80	79	77	80	98	92	104	87	88	88	68	76
80 S	40	82	63	77	76	108	110	76	87	86	80	84	68
120 W	40	78	35	84	35	106	76	89	46	90	37	92	42
120 BR	40	76	78	84	93	95	95	79	84	90	95	72	85
120 S	40	70	78	90	89	92	90	82	74	90	70	92	65
40 W	0	69	60	76	78	91	76	80	74	74	82	73	62
40 BR	0	64	68	76	86	90	92	78	88	73	78	79	72
40 S	0	70	62	86	94	92	91	97	92	76	82	74	90
Check		66		58		80		72		69		84	

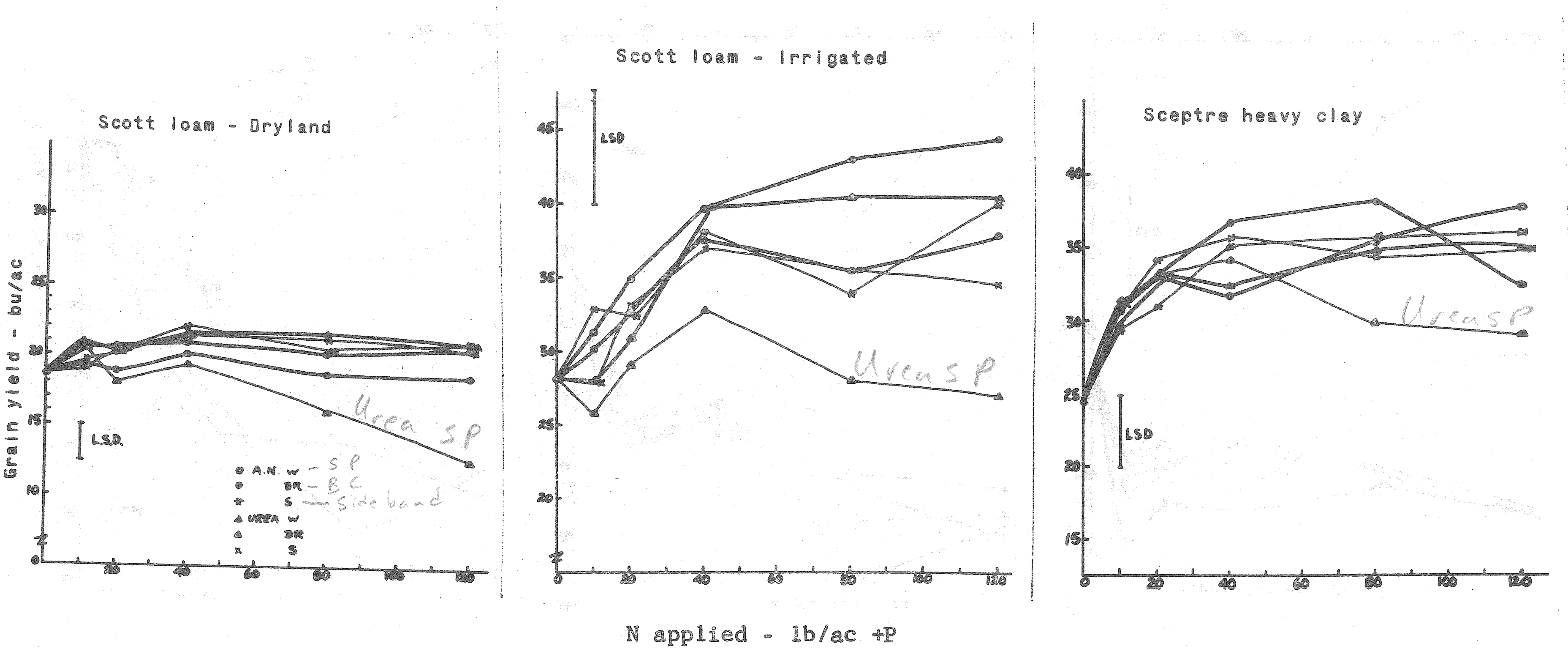

Figure 1. Effect of N source, rate and placement method on stubble wheat yields, 1973.

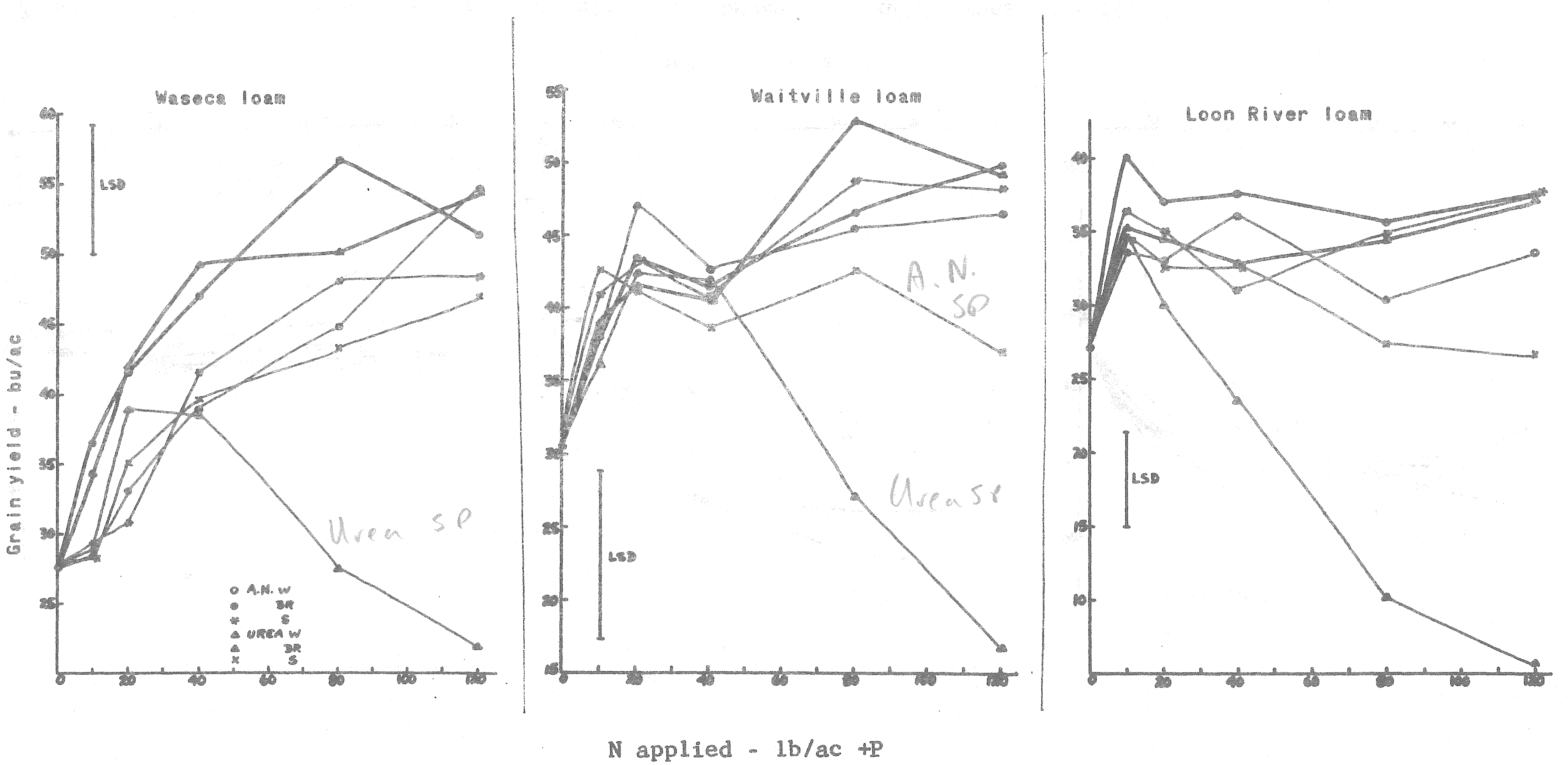

Figure 2. Effect of N source, rate and placement method on stubble wheat yields, 1973.

Table 3. Response of rapeseed on stubble on Waseca loam to nitrogen applied alone and with phosphate - 1973.

Fertilizer (lb/ac)		Seed yield (lb/ac)	
N	P_2O_5	AN	Urea
0	40	788	
40 W	0	862	733
40 BR	0	1038	940
40 S	0	851	925
40 W	40	1123	1168
40 BR	40	1422	1206
40 S	40	1120	1254
Check		749	
LSD 5%		233	
Soil available N (0-24")		40	
P (0-6")		14	

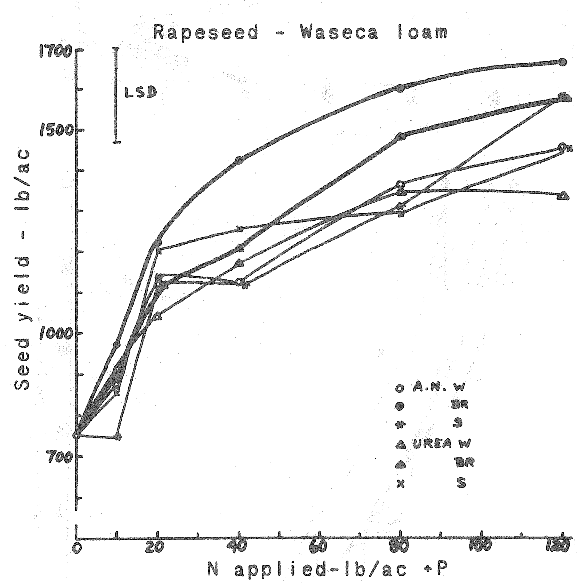

Figure 3. Effect of N source, rate and placement method on yields of Torch rape on stubble - Waseca loam, 1973.

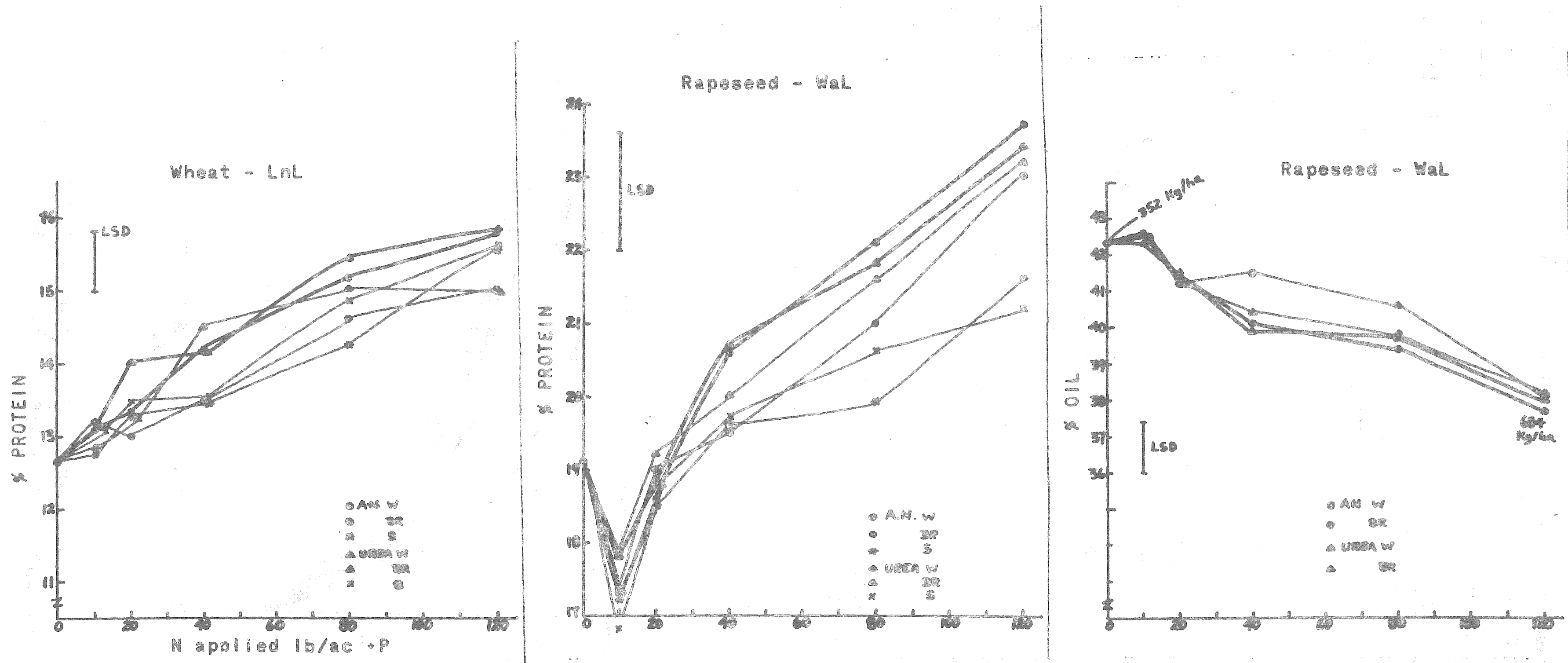

Figure 4. Effect of N source, rate and placement method on protein content in wheat and protein and oil content in rapeseed, 1973.