Fertilizer Placement for Fababeans, Sunflowers, Rapeseed and Flax

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Introduction

The potential or maximum yield of a particular crop is largely associated with a certain minimum plant population, an adequate supply of available, accessible nutrients in the soil, adequate moisture and favorable climatic conditions. The minimum plant population required for maximum yield depends on the kind of crop and the climatic conditions influencing the growth of that crop as well as the soil fertility. Response to applied fertilizer nutrients is influenced by the effect the fertilizers have on plant populations and the availability of the nutrients placed in the soil to the crop. Maximum response to fertilizer nutrients should occur when they are placed in the soil in such a position that they will cause minimal damage to germination and seedling emergence and will be maximally available to the actively feeding roots of the particular crop.

An understanding of the relationships between plant population and yields of different crops, including morphological compensating features, and the effects of applied fertilizer nutrients and methods of application on germination and utilization of the applied nutrients is necessary in order to maximize the benefits of fertilizer use.

Plant Population and Yields

Cereals - Plants such as the cereal grains can compensate partially for a reduction in plant population by tillering. The contribution of the tillers to grain yield will depend on time at which tillering occurs and the availability of moisture and nutrients.

Sunflowers and fababeans - The amount of compensation for loss in stands through morphological changes is relatively small. In sunflowers, a reduction in plant numbers may result in an increase in size of heads under favorable conditions, while in fababeans, more pods may reach adequate stages of development and maturity during the growing period available.

Rapeseed and flax - Rapeseed plants, under favorable growing conditions, have the ability to alter substantially the extent of branching and pod size and distribution and are therefore not appreciably affected by changes in rates of seeding or plant populations within a relatively wide range. A reduction in plant population is generally associated with increased branching of individual plants and more pod formation lower on the plant. The effect of seeding rate with and without phosphate fertilizer on plant populations and pod formation of Torch rapeseed is shown in Figure 1. Flax reacts somewhat similarly to rape but has a much lower capacity for change.

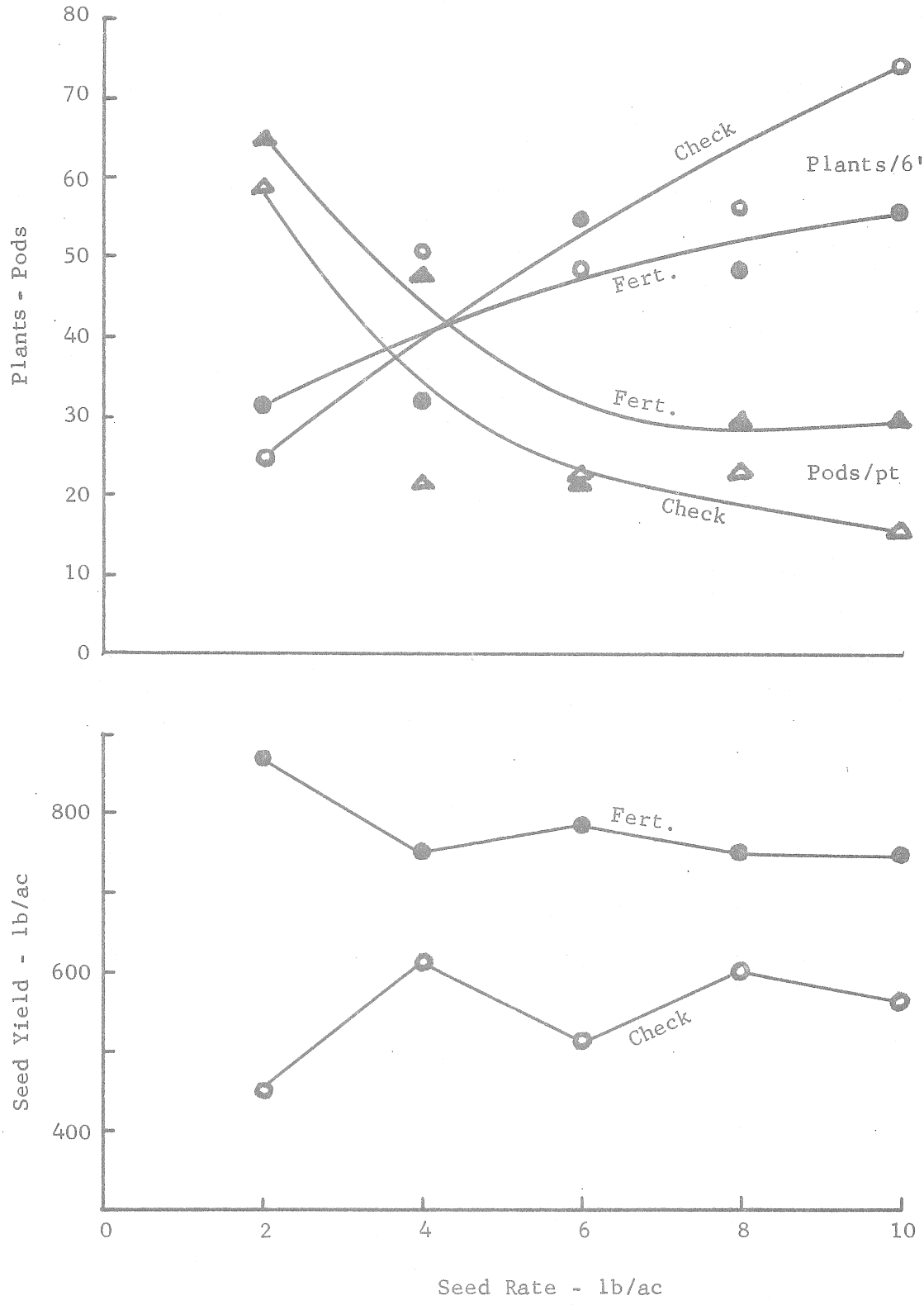

Figure 1. Effect of seeding rate and phosphate fertilizer on plant population, pod formation and yield of Torch rapeseed.

Effects of Fertilizer Placement on Germination and Nutrient Availability

Only nitrogen and phosphorus will be discussed in this report.

Nitrogen - Although there are considerable differences in the tolerance of various crops to seed-placed nitrogen during germination and seedling emergence stages, high rates of nitrogen placed in contact with the seed at high rates are detrimental to most crops. With crops such as rapeseed, sunflowers and flax, severe depression in germination and emergence may result even at relatively low rates of applied nitrogen (Nyborg, 1961; Molberg, 1961). Urea is generally more harmful than such forms as ammonium nitrate or ammonium sulphate. Nitrogen fertilizers are quite soluble and highly mobile in moist soils, and therefore, placement with or close to the seed is not required to facilitate uptake for crops such as rapeseed, sunflowers or flax.

Phosphorus - Although phosphate is generally less harmful than nitrogen when applied with the seed, some crops such as rapeseed, flax and sunflowers are quite sensitive to phosphate fertilizers when applied with the seed even at recommended rates under certain soil conditions. Phosphate fertilizers are relatively immobile when placed in the soil, and therefore, maximum availability to field crops depends on placing the phosphate with or close to the seed.

Methods and Materials

Nitrogen and phosphate fertilizers were applied at several rates on fallow and stubble for rapeseed, sunflowers and fababeans. To study the effect of placement, nitrogen was (1) placed with the seed, (2) broadcast and incorporated before seeding, and (3) side-banded 2.5 cm below and to the side of the seed. Phosphate was either (1) placed with the seed, or (2) side-banded. Ammonium nitrate (A.N.) and urea were used as sources of nitrogen, and phosphorus was applied as monoammonium phosphate (MAP), 11-55-0.

Results and Discussion

Nitrogen source, rate and placement

Rapeseed - Under dryland conditions on Scott loam, the application with the seed of both A.N. and urea at 22 kg N/ha or more significantly reduced emergence and plant populations. Urea was slightly more harmful than A.N. at equal rates of N. Urea at 44 kg N and A.N. at 89 and 134 kg N/ha reduced plant populations by more than 70%. Both carriers broadcast and incorporated were the least harmful. Under irrigation, only seed-applied urea at 44 kg N or more significantly reduced stands to just below 50%. On Waseca loam, significant reductions in plant populations resulted only when urea or A.N. were applied with the seed at rates of 89 and 134 kg N/ha. Effects on plant populations are shown in Figure 2.

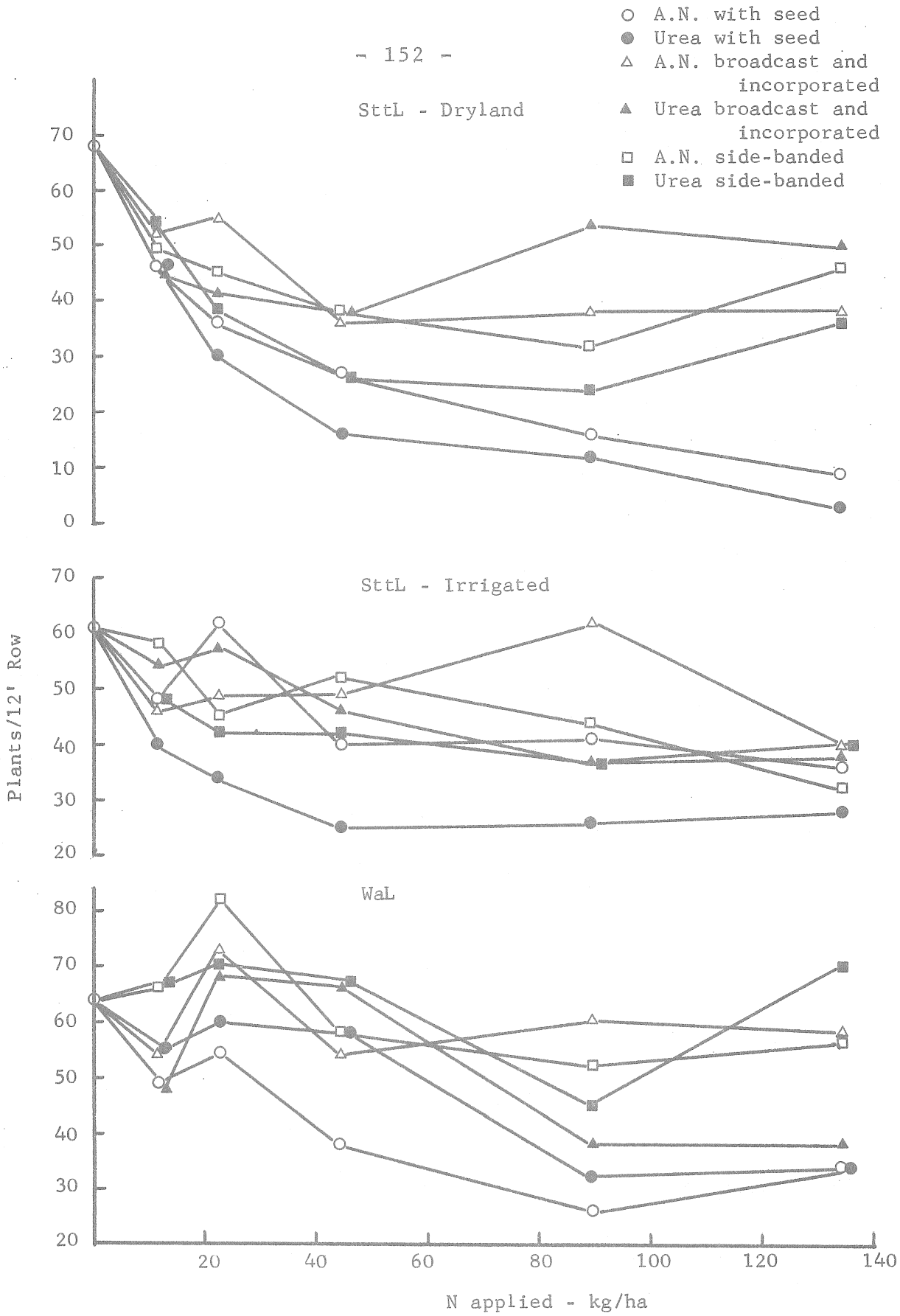

Figure 2. The effect of nitrogen source, rate and placement on plant populations of Torch rapeseed.

Under dryland conditions on Scott loam with 100 kg N/ha of available NO_3-N at seeding time, a significant yield increase was obtained only from broadcast applications of urea and A.N. at 44 kg N or more per ha. When applied at 44 kg N/ha with the seed, both N forms reduced yields below the check, and the reductions were large and significant at the 89 and 134 kg N rates. Under irrigation on Scott loam and on the Waseca loam, all treatments increased yields above the check, even though certain treatments had sharply reduced plant populations as indicated above. The strong response to the applied N more than compensated for the harmful effects on germination. Largest yield increases resulted from the broadcast-incorporated N treatments on all sites. Yield data are given in Table 1.

Table 1. The Effects of Nitrogen Source, Rate and Placement on Yields of Rapeseed Grown on Stubble - 1974

N[1] kg/ha		Seed Yield - q/ha								
		SttL - Dry			SttL - Irrig			WaL		
		W	BR	S	W	BR	S	W	BR	S
11.2	A.N.	12.6	13.3	12.8	17.4	20.0	17.3	9.8	8.7	8.0
	Urea	12.4	13.2	12.7	16.2	19.1	17.4	10.2	8.7	7.6
22.4	A.N.	13.8	15.1	14.5	19.6	21.1	18.1	9.1	9.7	8.7
	Urea	11.9	13.8	13.5	18.9	20.0	17.0	9.5	11.3	8.6
44.8	A.N.	11.2	18.2	15.0	21.4	20.6	19.8	9.8	12.6	10.2
	Urea	9.7	15.0	13.6	19.2	21.0	18.3	11.6	12.0	10.0
89.6	A.N.	8.3	14.8	13.9	23.3	23.6	19.1	13.5	15.6	12.4
	Urea	7.2	15.3	13.4	22.3	25.0	20.3	14.7	15.3	12.5
134.5	A.N.	7.6	16.7	14.4	21.7	25.6	21.8	12.0	15.3	15.0
	Urea	4.9	15.1	11.2	19.9	23.7	23.3	15.1	16.4	13.7
44.8[2]	A.N.	11.8	13.9	12.9	17.9	16.8	17.0	9.2	10.2	10.1
	Urea	8.8	13.0	11.7	17.3	18.0	15.2	10.6	10.6	9.8
Check			12.1			14.7			5.8	
Mean[3]	A.N.	10.7	15.6	14.1	20.7	22.2	19.2	10.8	12.4	10.9
	Urea	9.2	14.5	12.9	19.3	21.8	19.3	12.2	12.7	10.5
LSD 5%			2.7			3.1			2.6	
Soil test - kg/ha										
N	0-60 cm		100			30			31	
P	0-15 cm		29			29			31	

[1]44.8 kg P_2O_5/ha applied with all rates of N.
[2]No P_2O_5 applied.
[3]Only treatments with P_2O_5 averaged.
W - with seed; BR - broadcast and incorporated; S - side-banded.

Nitrogen applied at high rates depressed rapeseed oil content. On Scott loam under dryland conditions, drilling the N with the seed caused a substantially greater reduction in oil percentage than broadcasting or side-banding of the N (Figure 3). Under irrigation on Waseca loam, seed oil contents were similar for different N placement methods.

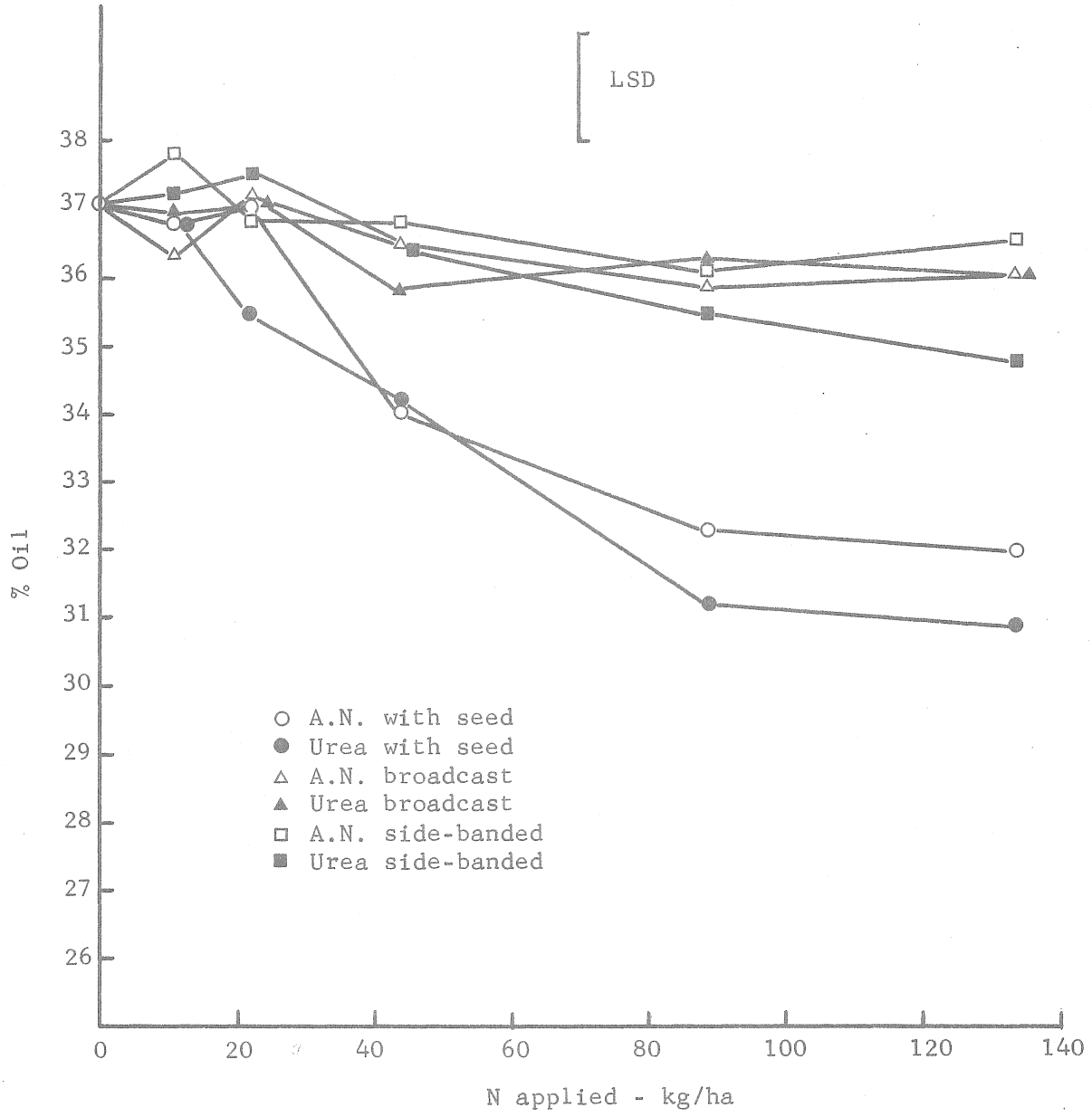

Figure 3. The effect of nitrogen source, rate and placement on oil content of Torch rapeseed.

On Scott loam, both dryland and irrigated, protein contents were only slightly increased at the high rates of N, and there were no significant differences between methods of N placement. However, on the Waseca loam where the seed protein content was increased 6% at the 134 kg rate of N, broadcasting with incorporation was the most effective placement method (Table 2).

Table 2. The Effect of Nitrogen Source, Rate and Placement on Protein Content of Torch Rapeseed on Waseca Loam - 1974

N[1] kg/ha		% Protein in Seed[2] W	BR	S
11.2	A.N.	18.2	18.1	18.0
	Urea	18.1	18.1	18.1
22.4	A.N.	18.1	18.4	18.1
	Urea	18.6	18.8	18.1
44.8	A.N.	18.9	20.5	20.0
	Urea	19.6	21.1	19.8
89.6	A.N.	21.9	24.6	22.6
	Urea	22.8	24.9	22.1
134.5	A.N.	23.5	25.0	23.8
	Urea	24.0	25.2	23.3
0-44.8	P_2O_5		18.4	
Check			18.9	
Mean	A.N.	20.1	21.3	20.5
	Urea	20.6	21.6	20.3
LSD 5%			1.4	

[1]44.8 kg P_2O_5/ha applied with N.
[2]Whole seed basis.
W - with seed; BR - broadcast and incorporated before seeding; S - side-banded.

Fababeans and sunflowers - Germination and emergence of both crops on Scott loam were severely depressed when N was applied with the seed at 44 kg/ha or more. Sunflower stands were reduced slightly at the 22 kg N rate, and this crop appears to be generally more sensitive to seed-placed N than fababeans. Yields were significantly lowered when N at 89 and 134 kg/ha was applied with the seed, but no harmful effects were observed when the N was broadcast and incorporated before seeding. Nitrogen did not depress yields of fababeans except when germination was reduced.

Phosphorus

Rapeseed - Although fertilizer recommendations for rapeseed generally emphasize precautions against applying high rates of N with the seed to avoid damage during germination, there is considerable evidence to show seed-placed phosphate fertilizers may also be harmful under certain conditions (Nyborg, 1961; Ukrainetz, et al. 1975). Furthermore, the

utilization of applied phosphate may be markedly influenced by placement method. Table 3 shows the effects of applying phosphate fertilizer at several rates with the seed and side-banded on emergence of rapeseed at two soil moisture levels in the growth chamber.

Table 3. Effect of Phosphate Fertilizer on Germination of Rapeseed

P_2O_5 kg/ha*		Emergence - 10 days % of Check (0 P_2O_5) F.C.	50% A.C.
11	with seed	96	74
22	with seed	54	46
44	with seed	16	12
11	1.25 cm to side	100	92
22	1.25 cm to side	100	100
44	1.25 cm to side	100	100

F.C. - field capacity moisture; 50% A.C. - 50% of available capacity.
*Applied as MAP, 11-48-0.

Data in Table 4 show effects of phosphate fertilizers on rapeseed plant populations under field conditions.

Table 4. Effect of Phosphate Fertilizer Rate and Placement on Plant Populations of Torch Rapeseed

P_2O_5* kg/ha		Plants/3.66 m Row SttL (Irrigated)	WaL	WvL
11.2	W	42	44	26
11.2	S	62	72	28
22.4	W	40	54	32
22.4	S	81	68	32
44.8	W	48	50	22
44.8	S	76	64	35
67.3	W	30	38	32
67.3	S	66	70	34
89.7	W	24	23	32
89.7	S	66	56	30
Check		78	60	27
LSD 5%		33	15	N.S.

*Applied as 11-55-0 monoammonium phosphate.

It should be noted that part of the detrimental effect at the highest rates of P may have been due to the nitrogen component of the fertilizer used. However, side-banding produced better stands even at the lowest rates of fertilizer. On two of the three soils, plant populations were significantly decreased by the seed-placed fertilizer. At the 89.7 kg

P_2O_5 rate, the reduction was more than 50%. Plant count data are not available for the dryland Scott loam, but observations during the growing season showed a marked reduction in plants in the rows when phosphate was applied with the seed even at relatively low rates (22 kg P_2O_5/ha). Yield data given in Table 5 show that side-banding of the MAP fertilizer was more effective than placement with the seed for all rates on all soils.

Table 5. Effects of Phosphate Rate and Placement on Yields of Rapeseed

P_2O_5* kg/ha		1974 Yields - q/ha				3-Year Average - q/ha		
		SttL				SttL		
		Dry.	Irrig.	WaL	WvL	Dry.	Irrig.	WaL
11.2	W	10.9	10.2	15.4	13.0	11.0	15.8	12.4
	S	11.6	14.8	16.6	19.5	11.2	16.3	13.0
22.4	W	9.8	12.6	16.7	13.9	9.1	16.2	14.2
	S	12.4	14.1	17.4	18.2	10.1	15.7	13.3
44.8	W	9.7	16.0	18.6	14.8	9.9	15.5	14.3
	S	13.8	17.0	18.4	23.4	12.4	17.3	15.2
67.3	W	9.0	15.8	17.5	12.7	10.3	16.2	13.8
	S	15.4	18.3	19.1	23.7	13.2	17.0	14.2
89.7	W	9.1	13.6	19.9	9.7	8.5	14.6	13.2
	S	15.0	17.9	19.3	18.5	14.0	19.6	15.3
Check		9.9	11.2	14.3	14.0	7.7	15.5	11.7
LSD 5%		3.1	4.1	2.7	4.2			
Soil Test - kg/ha								
N	0-60 cm	154	106	139	123			
P	0-15 cm	27	26	16	29			
K	0-15 cm	645	778	705	425			

*Applied as MAP, 11-55-0.

The data for the Waitville loam (WvL) suggest that side-banding improved the uptake and utilization of the applied phosphate. The three-year yield data also show the more favorable response to side-banded phosphate. Phosphate fertilizer had little or no effect on protein content of rapeseed, and in instances where high rates of phosphate lowered rapeseed oil content, side-banding of the fertilizer eliminated this effect.

Fababeans and sunflowers - Fababeans and sunflowers were grown on Scott loam low in available P. Fababeans tolerated seed-placed phosphate up to 89 kg P_2O_5/ha with no significant effect on germination or plant populations under field conditions on Scott loam. Sunflowers, however, were quite sensitive to ammonium phosphate placed with the seed, and stands were thinned quite severely by application of 22 kg P_2O_5 or more per ha. Effects of phosphate rate and placement on emergence of sunflowers in a growth chamber is shown in Table 6. Yields of fababeans were similar for seed-placed and side-banded P treatments at all rates on fallow in 1974, and a strong response to applied P was obtained up to

Table 6. The Effect of Ammonium Phosphate Fertilizer on Emergence of Sunflowers at 10 Days in a Loam Soil at 50% Field Capacity Moisture

P_2O_5 kg/ha		Emergence % of Check*
11	with seed	92
11	banded 1.25 cm to side	92
22	with seed	68
22	banded 1.25 cm to side	100
33	with seed	61
33	banded 1.25 cm to side	103
44	with seed	61
44	banded 1.25 cm to side	92
55	with seed	24
55	banded 1.25 cm to side	98

*Mean of two replicates.

the 89 kg P_2O_5 rate. On stubble, the 89 kg P_2O_5 rate side-banded resulted in highest yield. Seed yields of sunflowers grown on fallow were severely depressed by placing phosphate fertilizer with the seed, but side-banding raised the yields sharply with response up to the 89 kg P_2O_5 rate. Two-year average yields for fababeans and sunflowers on Scott loam, showing effects of phosphate placement, are shown in Table 7.

Table 7. Effect of Phosphate on Yields of Fababeans and Sunflowers on Scott Loam Fallow - Two-Year Average (1973-74)

P_2O_5* kg/ha		Seed Yield - q/ha	
		Fababeans	Sunflowers
22.4	W	1847	576
22.4	S	1688	837
44.8	W	1866	605
44.8	S	1995	891
89.6	W	2105	390
89.6	S	2164	1036
Check		1281	416

*22.4 kg N/ha broadcast on all plots.

In 1974 on fallow, all rates of seed-placed P (22 to 89 kg P_2O_5/ha) depressed oil content below check level, but oil contents were raised substantially above the check level when the phosphate was side-banded.

Flax - Flax has a low tolerance to fertilizers (N or P) placed with the seed (Nyborg, 1961; Molberg, 1961). Much of the research with flax carried out in Western Canada has shown this crop to be relatively unresponsive to phosphate application, and phosphate fertilizers are generally not recommended even on soil low in available P. However, methods of fertilizer placement were not given sufficient attention in

previous studies, and therefore, the significance of phosphate placement was largely overlooked. Earlier work by Nyborg and Hennig (1969) showed that yields of flax were increased most by phosphate when the phosphate source was applied directly below the seed. More recent studies by Bailey (1974) in Manitoba showed striking increases in yields of flax in response to phosphate placed directly below the seed with the flax responding to relatively high rates of applied P on both calcareous and noncalcareous soils. On the calcareous soil, flax failed to respond to P when applied with the seed. Figure 4 shows results from Bailey's work on two soil types.

Conclusions and Implications for Research

The data and discussion presented show that, where severe nutrient deficiencies exist and under favorable growing conditions, the responses of crops such as rape may partially or completely mask the harmful effects of fertilizers placed in contact with the seed. For rapeseed, broadcasting of nitrogen before seeding, even at relatively low rates preferably with incorporation, is as effective as any other placement method, and therefore, there is no need to place damaging amounts of N with the seed. Fababeans tolerate relatively high rates of phosphate placed with the seed, but for sunflowers and flax, both N and P should be placed separate from the seed to maximize response to the applied fertilizers. In the case of flax, not only is separate banding of the P necessary to avoid seed injury, but also the position of the P relative to the seed appears to be critical from the standpoint of uptake and utilization. Phosphate placement may also be an important factor in the use of applied P by rape and sunflowers.

It is obvious that more research is required into placement of phosphorus and possibly other nutrients for certain crops in order to determine the most efficient fertilizer practices.

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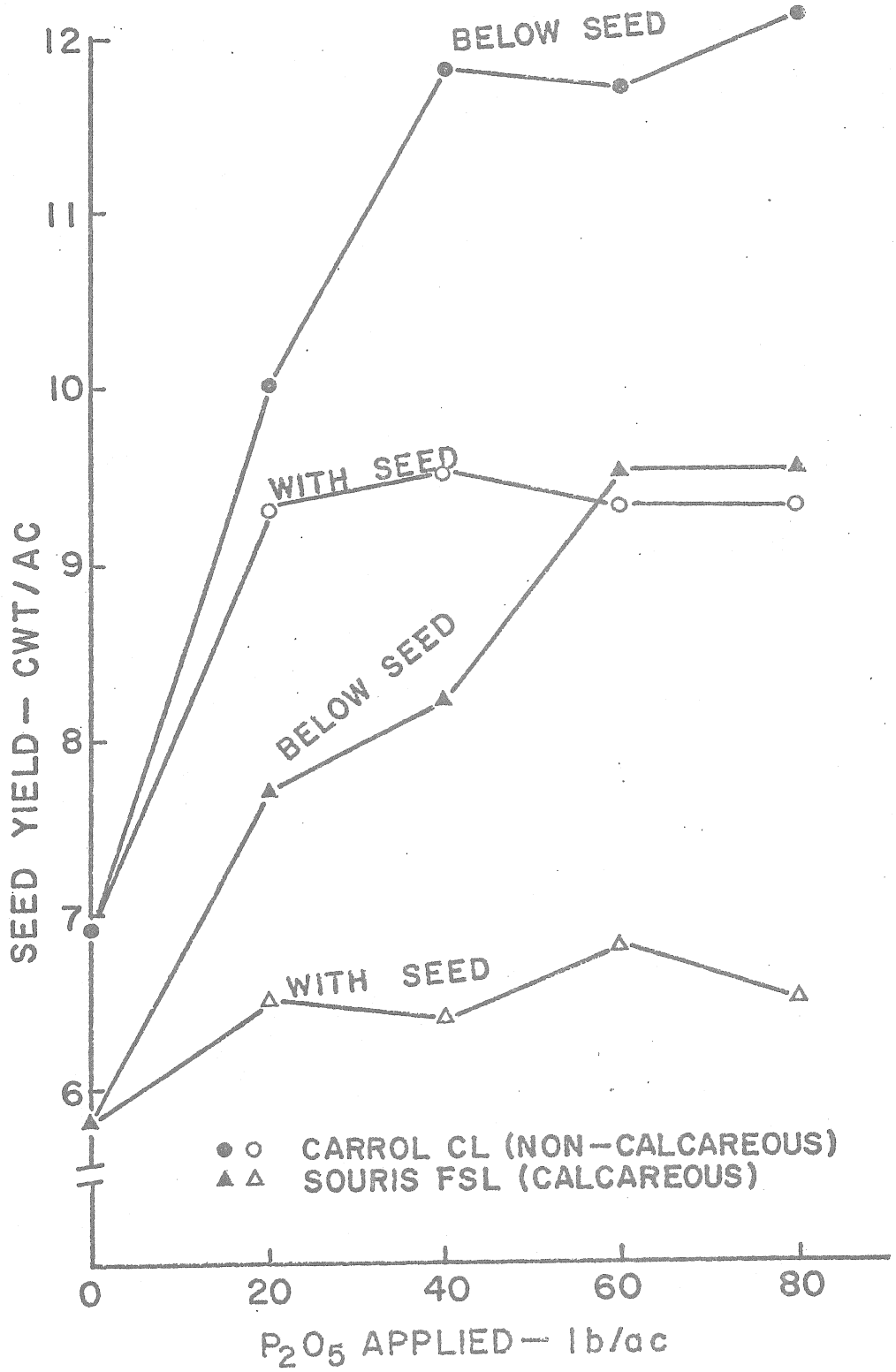

Figure 4. Effect of phosphate placed with and below the seed on yields of flax on two soils in Manitoba.

DISCUSSION

Question: How far was phosphate placed below the seed? (for Flax)

Answer: Thought it was 1" directly below seed.

Comment: It would be interesting to discover if any similarity exists between side banded phosphate and residual phosphate.