THE NITROGEN AND PHOSPHORUS NUTRITION OF FABABEANS

J.M. Sadler
Department of Soil Science
University of Saskatchewan
Saskatoon, Saskatchewan

Introduction

Fababeans are a relatively new crop in the Canadian Prairies. The purpose of this study was to examine the effects of soil nitrogen (N) and phosphorus (P) fertility levels on dry matter production, and on the N and P nutrition of fababeans under prairie soil and climatic conditions. Of particular interest was the determination of the fababean's ability to symbiotically fix N under these conditions. Experiments were conducted on a single site with N and P fertilizers applied to provide a range of N and P fertility levels. Barley was grown as a comparative crop measure of the soil's N supplying power.

Methods and Materials

The site was 10 miles east of St. Louis, Saskatchewan (SE5-45-25-W2: Mr. Selma Njaa) on stubble land previously sown to barley. The soil was a deep black Orthic Chernozem belonging to the Hoey Association (Table 1). Soil test data indicated that the soil was low in plant available NO_3-N and P prior to seeding. Fertilizer recommendations based on soil test data for fababeans were 20 lb N and P_2O_5/acre. For barley, they were 45 lb N/acre and 35 lb P_2O_5/acre. Soil moisture conditions at seeding and during crop growth were excellent. Between seeding and harvest, 13.9 inches of rainfall were recorded at the site.

Table 1. Physical and chemical properties of the Hoey soil at seeding (average of 2 samples each consisting of 4 cores).

Depth (in.)	Texture	pH (sat. paste)	Cond. (mmhos/cm)	lb/acre $NaHCO_3$ extractable		
				NO_3-N	P	K
0-6	Clay loam	6.6	0.3	9	14	575
6-12	Clay loam	6.8	0.2	7	6	305
12-24	Silty clay	7.2	0.5	12	7	555

Crops were seeded on June 8, 1974 using a V belt, disc seeder with 9 inch row spacings and 28 foot row length. Nitrogen at 0, 25, 50 and 100 lb N/acre was broadcast as granular NH_4NO_3 (34-0-0) to the four adjacent main plots and rototilled in. Strips of ^{15}N-labelled NH_4NO_3 were included in the 25 and 50 lb N/acre main plots. Fababeans (Vicia faba var Diana) were slurry mixed with 'Nitragen' inoculum and seeded at 150 lb/acre. There were five seed placed fababean P treatments replicated five times (randomized complete block design) per N main plot. The two row P treatments were:

i) 0, 60 and 90 lb P_2O_5/acre applied as granular $NH_4H_2PO_4$ (11-55-0) to both rows, and

ii) 15 and 30 lb P_2O_5/acre with 11-55-0 in one row and ^{32}P-labelled $NH_4H_2PO_4$ (12-60-0) in the second for the determination of crop utilization of applied P.

Bonanza barley was seeded at 80 lb/acre with a single seed placed P treatment of 11-55-0 at 60 lb P_2O_5/acre. There were 5 two row barley replicates per N main plot.

One measure of symbiotic N fixation by fababeans was obtained in the field by the acetylene reduction method[1]. Determinations were carried out at weekly intervals from July 9 to harvest on the 0 and 50 lb N/acre - 60 lb P_2O_5/acre subplots.

Both crops were harvested between September 5 and 9 after the barley had matured. Fababean plants were 3.5 to 4 feet high. Bean pod formation was complete on the lower half of the plants but the pods had only just started to ripen. Above ground plant samples were dried at 60C and total and bean/grain dry matter yields determined. Duplicate subsamples of ground plant material were Kjeldahl digested for N and P analysis[2]. Dry ground fababean bean samples were assayed for ^{32}P activity by G.M. counting[3]. At seeding and harvest, soils were sampled down to 4 feet and all samples analyzed for $NaHCO_3$-extractable NO_3-N and soil moisture. Initial soil samples were also analyzed for $NaHCO_3$-extractable P and K, etc. (Table 1).

Results and Discussion

a) Effects of different N fertility levels

Without N fertilizer, bean and total dry matter (D.M.) yields for fababeans (average for the 5 P levels) were 1510 and 7660 lb/acre respectively (Table 2). These yields increased by a maximum of 30 and 9% respectively as the N application increased to 100 lb N/acre. Fertilizer N application resulted in a small decrease in tissue N content from 5.7 to 5.5% for the beans and from 1.5 to 1.3% for the straw. At the same time bean and total N uptake progressively increased from 86 to 108 and from 175 to 188 lb N/acre, a

Table 2. Effect of applied nitrogen on dry matter production, and on nitrogen and phosphorus nutrition of fababeans (average for 5 levels of application and 5 replicates.

N applied lb/acre	Dry Matter		Plant Nitrogen				Plant Phosphorus			
	lb/acre		Tissue Content (%)		Uptake lb N/acre		Tissue Content (%)		Uptake lb P/acre	
	Beans	Total*	Beans	Straw	Beans	Total*	Beans	Straw	Beans	Total*
0	1510	7660	5.7	1.5	86	175	.68	.16	10.3	19.9
25	1650	8140	5.6	1.4	93	185	.67	.13	10.9	19.5
50	1760	8150	5.5	1.4	97	186	.66	.13	11.5	20.1
100	1960	8310	5.5	1.3	108	188	.61	.10	12.0	18.6

*Above ground material

Table 3. Effect of applied nitrogen on crop nitrogen uptake and residual soil NO_3-N† for fababeans and barley, and on fababean nitrogen fixation (lb/acre).

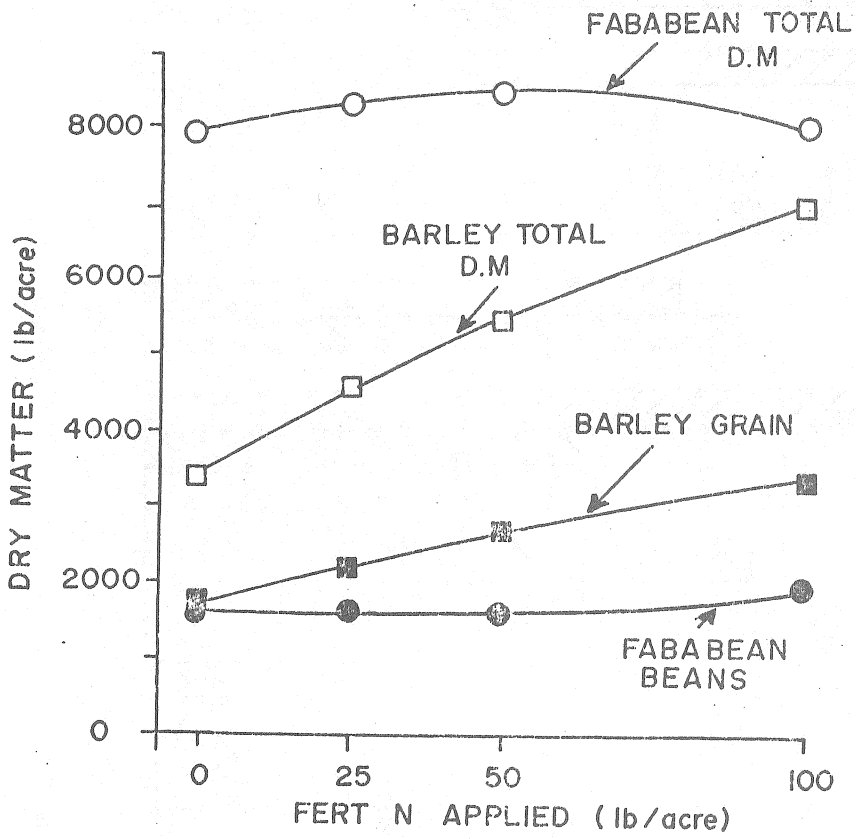
N applied lb N/acre	Fababeans*			Barley*			F'bean N Fix.	
	Crop N Uptake 1	Residual† Soil NO_3-N 2	Total 1 + 2 3	Crop N Uptake 4	Residual† Soil NO_3-N 5	Total 4 + 5 6	F'bean N-Bly. N (3-6)	Acetyl. Reduc.
0	173	15	188	37	21	58	130	61
25	189	12	201	49	27	76	125	ND
50	196	16	212	57	26	83	129	63
100	187	7	194	90	38	128	66	ND

† NO_3-N to 4 ft: harvest-seeding (38 lb N/acre)

* Same site - 60 lb P_2O_5/acre applied

ND - Not determined

Figure 1. Effect of nitrogen on dry matter production for fababeans and barley on the same site (60 lb P_2O_5/acre applied; average of 5 replicates).



20 and 7% increase respectively. Although N application also depressed tissue P content from 0.68% to 0.61% for the beans and from 0.16 to 0.10% for the straw. It had little effect on overall P uptake by fababeans.

At equal rates of applied P and without applied N, total D.M. production for fababeans at 7890 lb/acre was more than double that of the adjacent barley crop at 3360 lb/acre (Figure 1). However, with application of N at rates up to 100 lb/acre, barley D.M. production doubled to 6990 lb/acre, whereas there was less than a 7% increase for the fababeans. This data clearly shows that the unfertilized Hoey soil was deficient in plant available N for non-N fixing crops.

Symbiotic N fixation by the fababeans 5 weeks after seeding was less than 0.2 lb N/acre/day (Figure 2). It progressively increased to a maximum rate of about 2.0 lb N/acre/day 8 weeks later. Initially N fixation was higher

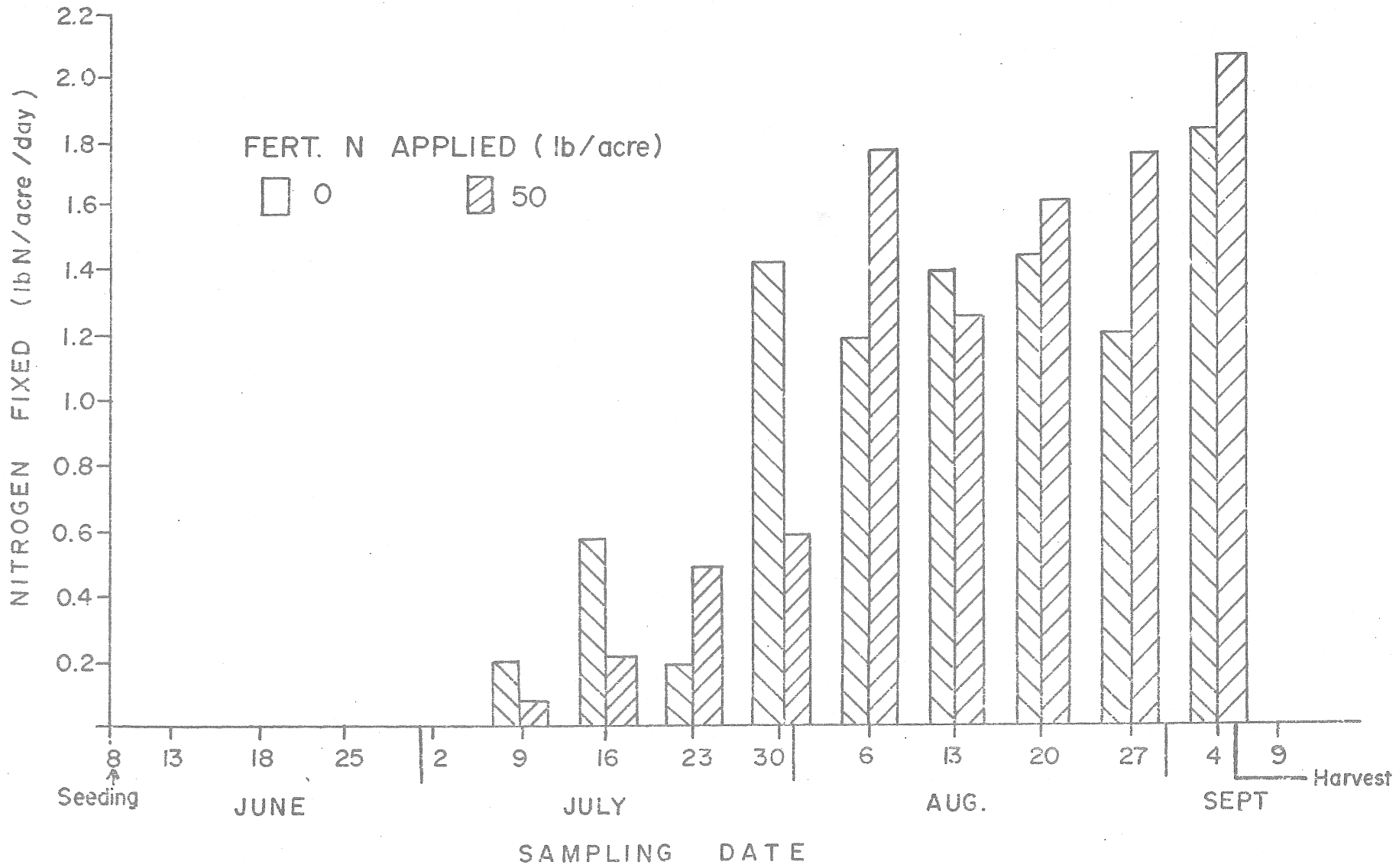


Figure 2. Seasonal pattern of nitrogen fixation in fababeans as affected by applied nitrogen--by acetylene reduction method (lb/acre/day).

with no applied N. This situation subsequently was reversed, with plants on the 50 lb N/acre plots showing higher rates of fixation. However, the sum of N fixed over the season as measured by acetylene reduction (Table 3), was similar for the 0 and 50 lb N/acre plots (61 and 63 lb N/acre).

Symbiotic N fixation was apparently not the only means whereby the fababean crop was able to more or less compensate for any N deficiency at the lower rates of N application. Despite the three fold increase in N uptake by barley in response to applied N (Table 3), residual NO_3-N in the top 4 feet of soil (difference in soil NO_3-N levels between seeding and harvest) was much higher under the barley crop, increasing with N application rate from 21 to 38 lb N/acre. This compares with 7 to 16 lb N/acre under fababeans. It suggests that fababeans were better able to exploit the soil and fertilizer N.

Differences in crop N uptake plus residual soil NO_3-N at harvest between fababeans and barley at equal rates of applied P were taken at an alternate measure of symbiotic N fixation (Table 3). This data indicates that N fixation was unaffected by N applications of up to 50 lb N/acre, averaging 128 lb N/acre. However, application at the 100 lb N/acre rate caused a 50% reduction in N fixation. Comparison of the 2 sets of N fixation data showed that the acetylene reduction method probably under-estimated fababean N fixation by at least 50%. This agrees with other data. The ^{15}N data when available should provide additional information concerning the extent to which fababean N requirements are supplied by soil N, fertilizer N and by symbiotic N fixation.

b) Effects of different P fertility levels

Without P fertilizer, bean and total D.M. yields for fababeans (average for 4 N levels) were 1790 and 7780 lb/acre (Table 4). Application of P resulted in a slight decrease in bean D.M. production but an increase of up to 7% in total D.M. Application of P had no effect on tissue N content. Tissue P content, on the other hand, progressively increased with P application from 0.62 to 0.69% in the beans and from 0.12 to 0.15% in the straw. The net result was a 21% increase in total P uptake from 17.9 to 21.7 lb P/acre. Phosphorus 'A' values were similar for the 15 and 30 lb P_2O_5/acre rates averaging 108 and 120 lb P/acre (Table 5). Corresponding values for fababean use of applied P, calculated for the above ground plant material, were 17.1 and 14.6%. Data in this table confirms the previous statement that N application had little effect on overall P uptake by fababeans.

Table 4. Effect of applied phosphorus on dry matter production and on nitrogen and phosphorus nutrition of fababeans (average for 4 levels of application and 5 replicates).

P applied lb P_2O_5/ acre	Dry Matter		Plant Nitrogen				Plant Phosphorus			
	lb/acre		Tissue Content (%)		Uptake lb N/acre		Tissue Content (%)		Uptake lb P/acre	
	Beans	Total*	Beans	Straw	Beans	Total*	Beans	Straw	Beans	Total*
0	1790	7780	5.6	1.4	100	183	.62	.12	11.0	17.9
15†	1750	8050	5.6	1.3	97	182	.63	.12	10.9	18.4
30†	1680	8010	5.6	1.4	94	179	.65	.13	11.0	18.9
60	1690	8180	5.6	1.4	95	186	.68	.14	11.4	20.7
90	1690	8340	5.6	1.4	95	188	.69	.15	11.7	21.7

*Above ground material

†P treatments receiving crystalline ^{32}P-labelled $NH_4H_2PO_4$ (12-60-0)

Table 5. Phosphorus 'A' values and % crop use of applied phosphorus for fababeans (average of 5 replicates).

N treatment (lb N/acre)	P treatment (lb P_2O_5/acre)		
	15	30	Average
'A' values (lb P/acre)			
0	99	126	113
25	99	107	103
50	139	144	141
100	93	104	99
Average	108	120	114
% crop use of applied P (above ground material)			
0	18.4	13.0	15.9
25	18.1	16.5	17.3
50	15.0	13.1	14.1
100	16.7	15.0	15.9
Average	17.1	14.6	15.9

Although the Hoey soil was apparently low in available P at the outset of the experiment (Table 1), fababean response to applied P on this site was small. This may have been partly due to the unusually wet soil conditions throughout the growing season. Olsen et al.[4] have shown that inorganic P availability frequently increases with increasing soil moisture content due to increased mobility of the P ions in soil solution. Field studies conducted by the Soil Science Department in 1973[5] indicated that in more normal prairie summers, fababeans grown on soils low in available P would respond well to seed placed or side banded P provided that the crop had access to an adequate supply of N from the soil or from N fixation.

Conclusions

1) In the Prairie Black Soil zone, properly inoculated fababeans, given adequate soil moisture and P fertility levels, have the capability of fixing appreciable quantities of atmospheric N--probably in excess of 130 lb N/acre/season.

2) Moderate applications of inorganic N (50 lb N/acre or less) on an initially N deficient soil should have a beneficial effect on fababean dry matter and protein yield without adversely affecting N fixation.

3) The effect of the soil P fertility level on fababean yield is unclear at this stage. Indications are that fababeans grown on P deficient soils under normal prairie climatic conditions will probably respond to applied inorganic P provided that the crop has an adequate supply of N, either from the soil, fertilizer or via symbiotic N fixation.

References

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3) RENNIE, D.A. and PAUL, E.A. 1971. Isotope Methodology and Techniques in Soil-Plant Nutrition and Plant Physiology. Sask. Inst. of Pedology Publ. No. 76, p. 5.

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DISCUSSION

Question: You mentioned dissatisfaction over the acetylene reduction method for measuring nitrogen fixation - why are you displeased?

Answer: We found it very difficult to obtain an accurate correlation between what we had detected by an alternative method of measurement and by the acetylene reduction technique.

Comment: In Alberta, research has indicated the nitrogen fixing power of Rhizobium was reduced when even 30 lbs. of nitrogen was added to the soil.