

THE EFFECT OF INOCULATION ON YIELDS OF GRAIN LEGUMES

R.P. Voroney¹, R.J. Rennie² and D.A. Rennie¹

¹Saskatchewan Institute of Pedology, University of Saskatchewan
Saskatoon, Sask., and

²Agriculture Canada, Research Station, Lethbridge, Alta.

A program to study the feasibility of including annual grain legumes (pulse crops) in the extended cropping system of the Innovative Acres Program was initiated in the spring of 1984 on five farms. The objective for the study was to quantify N₂ fixation and the yield of grain legumes as affected by rhizobial inoculation, legume cultivar and soil group.

Two common cultivars for each of the major grain legumes, lentils, field peas, and faba beans were tested in the program (Table 1). Cereal crops were included as non-fixing control plants for measurements of the amounts of N₂ fixed, barley for lentils and wheat for peas and faba beans.

The inoculate for faba beans Rhizobium leguminosarum Q and for peas and lentils Rhizobium leguminosarum C were obtained from the Nitragin Co., Milwaukee, Wis. The inoculum was in a granular form, rather than powder, for convenience of controlling application. An uninoculated control was included for each crop.

Grain legume field sites

Field sites were located in each soil zone (Table 2) on stubble fields. Spring soil test measurements showed mineral N contents to be generally low. Phosphate fertilizer (11-51-0) was broadcast on the plots at a rate of 50 kg P₂O₅ ha⁻¹ and incorporated using a rotovator prior to seeding.

Nodule evaluation

Nodulation was determined at anthesis by examination and counting the number of nodules on plant roots (Table 3). Inoculation greatly increased the numbers of nodules per plant. Furthermore, the nodules in the inoculated treatment were generally larger in size and pink coloured, indicative of active N₂ fixation, compared to those in the uninoculated treatment which were small and pale (inactive nodules).

Effect of seed inoculation on above-ground plant yields and N content

Inoculation increased yields of grain legumes at nearly all sites throughout the province (Table 4). Average yield increases were 24% for

lentils, 35% for peas, and 59% for faba beans with the more moist sites showing the highest yield increases. The nitrogen content of the lentils and peas was also directly related to available moisture and with inoculation increased by up to 40%.

N₂ Fixation by Grain Legumes

The amount of N fixed by grain legumes can be estimated by comparing the N yield in above ground material of the grain legumes to that of non-fixing control plants (Table 5). Nitrogen fixation estimated by the difference method with cereals as a control ranged from 6.3 to 26.1 kg N ha⁻¹ for lentils and from 4.3 to 72.0 kg N.ha⁻¹ for peas. However, the N in the cereal crop may over-estimate the uptake of soil N by the grain legume. This was evident for lentils at Aberdeen and Foam Lake and for fababeans at Foam Lake. Therefore, in these cases data from the uninoculated treatment may be a better control plant for determining uptake of soil N.

Table 1. Grain legumes and non-fixing control plants selected for the nitrogen fixation program.

Plant	Cultivar	Seeding rate (kg ha ⁻¹)	Maturity (days)
Lentils (<u>Lens culnaris</u>)	Eston Laird	38 80	100-106
Peas (<u>Pisum sativum</u>)	Trapper Tara	120 190	99-104
Faba beans (<u>Vicia faba</u>)	Aladin Outlook	168 150	108-110
Non-fixing control plants			
Barley (<u>Hordeum vulgare</u>)	Johnston	108	100
Wheat (<u>Triticum aestivum</u>)	Columbus	68	110

Table 2. Characteristics of the field sites selected for the grain legume study.

Cooperator (Location)	Soil characteristics		Macronutrient levels* (kg ha ⁻¹)				Available water** (cm)
	Association	Texture	N	P	K	S	
<u>Brown soil zone</u>							
Janis (Glenbain)	Ardill	Clay loam	24	12	370	84	17.4
<u>Dark Brown soil zone</u>							
McAllister (Regina)	Regina	Heavy Clay	30	11	630	>100	22.3
Kruger (Aberdeen)	Sutherland	Heavy Clay	21	25	550	10	25.0
<u>Black soil zone</u>							
Markusson (Foam Lake)	Yorkton	Loam	69	16	260	96	31.1
<u>Gray-Wooded soil zone</u>							
Russell (White Fox)	Whitewood	Loam	38	16	200	>160	--

* Spring soil test

** Change in soil moisture over the growing season + precipitation

Table 3. Root nodule evaluation at anthesis.

		<u>Nodule Rating*</u>					
<u>Lentils</u>		<u>Peas</u>				<u>Faba beans</u>	
	I [†]	O [†]		I	O	I	O
Eston			Tara			Aladin	
Glenbain	2	1.3				Foam Lake	3 0.3
Regina	3	1.7	Regina	3	1	White Fox	3 1.3
Aberdeen	3	0.3	Foam Lake	3	0.7		
Foam Lake	2.5	1	White Fox	3	2.3		
						Outlook	
						Foam Lake	2.8 1.2
						White Fox	3 1.3
Laird			Trapper				
Glenbain	3	1.3					
Regina	3	2	Regina	1.8	2		
Aberdeen	3	0.7	Foam Lake	3	0.7		
Foam Lake	3	1	White Fox	3	2.3		

* Number of nodules

0 no nodules
 1 0-5 nodules
 2 6-49 nodules
 3 >50 nodules

Growth stage at sampling

Aberdeen }
 Foam Lake } mid-pod fill
 White Fox }
 Glenbain harvest maturity
 Regina late pod fill

[†]Inoculated

[†]Uninoculated

Table 4. Effect of seed inoculation of grain legumes on the above-ground plant yield and nitrogen content.

Location	Variety	Inoculated		Uninoculated	
		Plant yield (kg ha ⁻¹)	N content (%)	Plant yield (kg ha ⁻¹)	N content (%)
<u>Lentils</u>					
Glenbain	Eston	1400	2.03*	1260	1.44
	Laird	1373	2.06*	1190	1.65
Regina	Eston	1392	2.16	1307	1.91
	Laird	1359	1.75	1173	1.75
Aberdeen	Eston	2405*	2.55*	1338	1.45
	Laird	2218*	1.95*	1860	1.43
Foam Lake	Eston	3271*	2.47*	2797	1.73
	Laird	3832*	2.25*	2966	1.81
<u>Peas</u>					
Glenbain	Tara	2100	2.04	2040	1.97
	Trapper	1511*	2.08	1190	1.91
Regina	Tara	2213*	1.99	1471	1.84
	Trapper	1352	2.28*	1444	1.44
Foam Lake	Tara	5613*	2.33*	4611	1.97
	Trapper	4595	2.62*	4302	1.78
White Fox	Tara	2579*	2.30*	1270	1.74
	Trapper	2727*	2.42*	1534	1.57
<u>Faba beans</u>					
Foam Lake	Aladin	2360*	1.65	1363	1.78
	Outlook	1923	1.43	1881	1.64
White Fox	Aladin	1285*	2.94	834	2.70
	Outlook	1247*	2.26	709	2.31

* Significant response to inoculation (P < 0.10)

Table 5. Estimation of N₂ fixation by grain legumes.

Location	Variety	Above-ground		N ₂ fixed (kg ha ⁻¹)	
		N yield		Cereal control	Uninoculated control
		I	O		
Lentils					
Glenbain	Eston	28.5	18.1	7.6	10.4
	Laird	28.3	19.6	7.4	8.7
	barley	20.9			
Regina	Eston	30.1	25.0	13.7	5.1
	Laird	23.8	20.5	7.4	3.3
	barley	16.4			
Aberdeen	Eston	61.3	19.4	24.3	41.9
	Laird	43.3	26.6	6.3	16.7
	barley	37.0			
Foam Lake	Eston	80.8	48.4	20.7	32.4
	Laird	86.2	53.7	26.1	32.5
	barley	60.1			
Peas					
Glenbain	Tara	42.8	40.3	21.8	2.5
	Trapper	31.4	22.7	10.4	8.7
	wheat	21.0			
Regina	Tara	44.0	27.1	17.5	17.0
	Trapper	30.8	20.8	4.3	10.0
	wheat	26.5			
Foam Lake	Tara	130.8	90.8	72.0	39.9
	Trapper	120.4	76.6	61.7	43.8
	wheat	58.7			
White Fox	Tara	59.3	22.1	37.8	37.2
	Trapper	66.0	24.1	44.5	41.9
	wheat	21.5			
Faba beans					
Foam Lake	Aladin	38.9	24.3	0	14.7
	Outlook	27.5	30.8	0	0
	barley	60.1			
White Fox	Aladin	37.8	22.5	17.2	15.3
	Outlook	28.2	16.4	7.6	11.8
	barley	20.6			

I - inoculated; O - uninoculated