

Field Pea Response to Nitrogen Fertilizer

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A trial to assess the response of field pea to varying levels of nitrogen (N) fertilizer was conducted at the NDSU Carrington Research Extension Center in 2004 and 2005 (Table 1). Plots measuring 10' x 25' were arranged in a randomized complete block design with four replicates. The center 5' of each plot was used for data collection. Individual plot N levels were brought up to 50, 75, 100, 125, 150, or 200 lbs total N / acre with a broadcast application of urea, which was incorporated prior to planting. The unfertilized check and treatments of 50 and 75 lbs total N / acre were sown both with and without inoculation with CellTech-C liquid inoculant. In addition, plots of 100 lbs total N were also sown with either 15 or 30 lbs (2004) or 30 lbs (2005) P₂O₅ broadcast as triple superphosphate and incorporated before planting. In response to interest by NDDP&L members in 2005, 10 lbs S / acre (potassium thiosulfate) was applied as a foliar spray to two replicates of the trial at the beginning bloom stage.

Table 1. Soil test and planting data for the field pea response to N fertilizer trial, NDSU Carrington.

	2004	2005
NO ₃ ⁻ -N (lbs/acre, 0-24")	15	20
P (ppm, Olson)	20	7
K (ppm)	219	158
pH	6.3	6.9
Organic Matter (%)	3.2	2.7
Salt	0.20/0.35	0.21 / 0.35
Cultivar	Integra	Integra
Planting Date	7 May	28 April

2004

Incremental increases in N level without inoculation and without additional P reduced nodulation and tended to delay maturity (Table 2). With the exception of the 150 lb N treatment, increasing N fertilizer numerically increased yield. Grain protein also increased with additional N. Seed inoculation at planting tended to increase yield at all three of the lowest N levels on a field with a history of field pea production (Tables 2 and 3). Although more data is needed to draw firm conclusions, these results suggest that there may be a benefit to applying starter fertilizer (bringing the soil N up to 50 lbs N / acre). The effects of added P fertilizer on yield were inconsistent (Table 2), but the soil test for P was in the "very high" range and a yield response would be surprising.

Table 2. Field pea response to soil nitrogen level, NDSU Carrington, 2004.

	Visual	Beginning	End	Physiological				Test	Seed	Seed
Treatment	Nodulation	Bloom	Bloom	Maturity	Lodging	Yield	Yield	Weight	Weight	Protein
(lbs total N/ac)	(1-9) ¹	(DAP) ²	(DAP)	(DAP)	(1-9) ³	(lbs/ac)	(bu/ac)	(lbs/bu)	(g/250)	(%)
15 lbs N	3.8	56.0	77.5	88.5	2.8	2831	47.2	64.6	69.9	18.4
15 N + Inoc	4.8	56.0	78.8	90.5	2.5	3265	54.4	64.9	70.4	18.6
50 N	5.5	56.3	78.0	91.3	2.3	3052	50.9	63.7	69.2	18.3
50 N + Inoc	4.3	56.3	79.3	91.3	2.0	3378	56.3	64.6	70.7	18.5
75 N	5.5	56.3	78.3	89.8	2.0	3113	51.9	64.8	70.5	18.8
75 N + Inoc	5.5	56.3	79.5	92.0	2.3	3221	53.7	64.2	73.3	19.1
100 N	6.0	56.0	79.3	91.5	2.3	3334	55.6	64.1	69.4	19.4
100 N + 15 P	6.8	56.3	79.0	91.0	1.8	3099	51.7	63.9	71.6	19.9
100 N + 30 P	6.3	56.3	79.5	91.3	1.8	3581	59.7	64.3	73.2	19.4
125 N	7.0	56.8	78.8	90.3	2.5	3393	56.6	64.1	70.0	20.0
150 N	7.0	56.8	79.5	91.5	2.8	3128	52.1	64.1	71.2	21.1
200 N	8.0	56.5	80.0	91.8	3.0	3525	58.7	64.1	70.3	21.6
Mean	5.9	56.3	78.9	90.9	2.3	3236	53.9	64.3	70.8	19.4
C.V. (%)	22.5	0.6	0.7	1.6	24.4	11.2	11.2	0.8	3.0	3.7
LSD (0.05)	1.9	0.5	0.8	NS	NS	NS	NS	NS	NS	1.1
LSD (0.01)	2.6	NS	1.0	NS	NS	NS	NS	NS	NS	1.4
¹ 1 = profuse, 9 = none			² Days after planting			³ 1 = erect, 9 = prostrate				

Table 3. Main effects of N rates with and without inoculation in the pea N response trial, NDSU Carrington, 2004.

		Beginning	End	Physiological				Test	Seed	Seed
Treatment	Nodulation	Bloom	Bloom	Maturity	Lodging	Yield	Yield	Weight	Weight	Protein
	(1-9) ¹	(DAP) ²	(DAP)	(DAP)	(1-9) ³	(lbs/ac)	(bu/ac)	(lbs/bu)	(g/250)	(%)
N Level (lbs total N/acre)										
15	4.3	56.0	78.1	89.5	2.6	3048	50.8	64.7	70.1	18.5
50	4.9	56.3	78.6	91.3	2.1	3215	53.6	64.1	70.0	18.4
75	5.5	56.3	78.9	90.9	2.1	3167	52.8	64.5	71.9	19.0
LSD (0.05)	NS	NS	0.6	1.4	NS	NS	NS	NS	NS	NS
LSD (0.01)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Inoculation										
- Inoculant	4.9	56.2	77.9	89.8	2.3	2999	50.0	64.4	69.9	18.5
+ Inoculant	4.8	56.2	79.2	91.3	2.3	3288	54.8	64.5	71.5	18.7
t-test (5%)	NS	NS	**	*	NS	NS	NS	NS	*	NS
¹ 1 = profuse, 9 = none			² Days after planting			³ 1 = erect, 9 = prostrate				
* and ** denote significant differences between means at P < 0.05 and P < 0.01, respectively										

2005

A statistically significant response to sulfur was observed for days to end bloom, days to physiological maturity, and plant height, but the differences were so small as to be inconsequential (Tables 4 and 5). All levels of N fertilizer reduced nodulation and lodging compared to the unfertilized, uninoculated check. When no N fertilizer was applied, the addition of sulfur improved nodulation without inoculation

and also improved the response to inoculation (Table 6). Seed treatment with QuikRoots significantly improved nodulation with no S fertilizer, but had no effect when S was applied. Although no other root data was collected, this may indicate that QuikRoots stimulated S absorption by increasing root mass or activity. Yield tended to increase as N rate increased, but no N fertilizer treatment yields were statistically ($P < 0.05$) superior to the inoculated, unfertilized check (Tables 4 and 5). Grain protein also tended to increase with total N levels of 100 lbs / acre and greater.

Table 4. Analysis of variance in the evaluation of field pea response to fertilizer and seed treatments, NDSU Carrington, 2005.

Source of Variation	Stand	Beginning Bloom	End Bloom	Physiological Maturity	Visual Nodulation	Plant Height	Lodging	Yield	Test Weight	Seed Weight	Grain Protein
Rep	0.3517	0.5000	<0.0001	0.0335	0.0903	0.0903	0.9723	0.5518	0.4531	0.3031	0.1414
S	0.1891	0.5000	<0.0001	0.0374	0.2952	0.0424	0.2697	0.8067	0.1516	0.4678	0.0432
Rep x S	0.4446	0.3282	1.0000	0.8809	0.5443	0.9748	<0.0001	0.3787	0.2657	0.0111	0.9331
N	0.9698	0.2370	0.4581	0.2516	<0.0001	0.5485	0.0008	0.0223	0.7278	0.2833	0.0337
N x S	0.8342	0.0872	0.4581	0.5351	0.0355	0.3022	0.0596	0.2998	0.6521	0.0147	0.6680

Table 5. Field pea response to fertilizer and seed treatments, NDSU Carrington, 2005.

Treatment	Stand (plants/acre)	Beginning Bloom (DAP) ¹	End Bloom (DAP)	Physiological Maturity (DAP)	Visual Nodulation (1-9) ²	Plant Height (cm)	Lodging (1-9) ³	Yield (bu/ac)	Test Weight (lb/bu)	Seed Weight (g/250)	Grain Protein (%)	
<i>Sulfur (lbs/acre)</i>												
0	253,000	57.8	70.4	86.1	7.3	74.1	4.0	48.5	63.0	61.1	23.7	
10	276,000	57.6	70.0	85.4	7.0	73.5	6.1	48.1	62.3	59.5	24.1	
<i>t-test</i>	NS	NS	**	*	NS	*	NS	NS	NS	NS	*	
<i>Total N (lbs/acre) / Seed Treatment</i>												
20	267,000	57.3	69.5	85.3	5.8	71.8	6.5	39.0	62.3	60.9	23.6	
20+Inoculant	244,000	57.3	70.3	85.3	5.0	69.8	5.8	47.8	62.7	59.7	23.7	
20+QuikRoots	280,000	57.5	70.0	85.0	4.5	72.8	5.8	48.5	62.5	59.7	23.3	
50	256,000	57.5	70.3	86.0	5.8	77.3	4.8	48.5	62.8	61.4	22.7	
50+Inoculant	262,000	57.5	70.3	85.5	7.0	74.5	4.8	47.0	62.9	60.4	22.5	
75	270,000	57.8	70.3	86.5	8.5	75.8	4.8	44.4	63.0	60.9	23.5	
75+Inoculant	265,000	57.8	70.3	85.5	8.0	74.3	5.0	47.2	62.5	61.0	23.6	
100	266,000	57.5	70.0	85.8	8.0	71.5	4.8	48.2	62.4	57.5	24.0	
100+P	269,000	57.8	70.3	85.3	8.3	73.3	4.8	53.5	62.6	59.7	24.6	
125	257,000	57.8	70.5	86.5	8.3	73.8	4.3	50.8	62.9	61.7	24.2	
150	268,000	58.0	70.5	86.3	8.5	75.0	4.5	54.8	62.7	60.1	25.1	
200	269,000	58.5	70.5	86.5	8.5	76.3	4.8	50.4	62.9	60.5	25.8	
LSD (0.05)	NS	NS	NS	NS	---	NS	0.9	7.3	---	NS	1.8	
LSD (0.01)	NS	NS	NS	NS	---	NS	1.2	NS	---	NS	NS	
Overall Mean	265,000	57.7	70.2	85.8	7.2	73.8	5.0	48.3	62.7	60.3	23.9	
C.V. (%)	12.0	1.0	0.8	1.1	13.1	6.1	11.6	10.3	0.9	3.2	5.0	
¹ Days after planting		² 1 = profuse, 9 = none			³ 1 = erect, 9 = prostrate			⁴ denotes significant N x S interaction				
* and ** denote significant differences between S treatments at $P < 0.05$ and $P < 0.01$, respectively												

Table 6. Statistically significant interactions in the field pea response to fertilizer and seed treatments trial, NDSU Carrington, 2005.

N Treatment	Visual Nodulation		Test Weight	
	0 lbs S/acre	10 lbs S/acre	0 lbs S/acre	10 lbs S/acre
20N	6.5	5.0	62.4	62.1
50N	6.0	5.5	63.3	62.3
75N	8.5	8.5	63.4	62.7
100N	8.0	8.0	63.2	61.5
125N	8.0	8.5	63.0	62.7
150N	8.0	9.0	63.4	62.1
200N	8.5	8.5	63.2	62.5
20N+QRroots	3.5	5.5	62.9	62.0
20N+Inoc	7.0	3.0	63.0	62.3
50N+Inoc	7.5	6.5	62.9	62.8
75N+Inoc	8.0	8.0	63.0	62.0
100N+P	8.5	8.0	62.7	62.6
LSD (0.05)		2.0		1.2

2-year Combined Analysis

A combined analysis was performed on the parameters measured in both years of the project. All parameters except yield varied significantly with year (Tables 7 and 8). Increasing the N fertilizer rate increased the days to beginning bloom, end bloom, and physiological maturity, but the differences were not great. Lodging was reduced by N fertilization, possibly due to increased stem strength. Across years, nodulation was reduced with increasing levels of N, but inoculation had no effect on fields with a previous history of field pea production. All treatments with N fertilizer and / or inoculation increased yield over the unfertilized / uninoculated check. However, the data indicate no yield advantage of high N fertilization over only inoculation. On the other hand, although not statistically significant ($P < 0.05$), all N rates above 100 lbs / acre resulted in numerically higher yields (2.6-3.5 bushels / acre) than with only inoculation. This may or may not be a real difference and the lack of statistical significance suggests that it is not. If it is, the attractiveness of this potential yield increase will obviously depend upon the value of the grain, the price of N, and application costs.

Table 7. Analysis of variance in the evaluation of field pea response to N fertilizer and inoculation, NDSU Carrington, 2004-2005.

Source of Variation	Beginning Bloom	End Bloom	Physiological Maturity	Visual Nodulation	Lodging	Yield	Test Weight	Seed Weight	Grain Protein
Rep	0.0235	0.3402	0.3806	0.3144	0.2754	0.4835	0.5933	0.7994	0.0367
Year	<0.0001	<0.0001	0.0127	0.0106	0.0196	0.3306	0.0110	0.0070	0.0014
Rep x Year	0.8076	0.2289	0.1812	0.3226	<0.0001	<0.0001	0.0006	0.0001	0.6821
N	0.0055	<0.0001	0.0442	<0.0001	0.0003	0.0060	0.1421	0.3304	<0.0001
N x Year	0.7932	0.0092	0.1290	0.1432	0.0078	0.5634	0.1842	0.6415	0.6732

Table 8. Combined 2-year field pea response to N fertilizer and inoculation, NDSU Carrington, 2004-2005.

	Beginning	End	Physiological	Visual			Test	Seed	Grain
Treatment	Bloom	Bloom	Maturity	Nodulation	Lodging	Yield	Weight	Weight	Protein
	(DAP) ¹	(DAP)	(DAP)	(1-9) ²	(1-9) ³	(bu/ac)	(lb/bu)	(g/250)	(%)
Year									
2004	53.3	75.9	87.8	5.7	2.4	53.7	64.3	70.5	22.3
2005	57.7	70.2	85.9	7.3	5.0	47.8	62.7	60.4	23.9
t-test	**	**	*	*	*	NS	*	**	**
Total N (lbs/acre)									
15/20	55.1	72.0	85.4	4.8	4.6	43.1	63.4	65.4	22.4
15/20+Inoculant	55.1	73.0	86.4	4.9	4.1	51.1	63.8	65.1	22.5
50	55.4	72.6	87.1	5.6	3.5	49.7	63.2	65.3	21.9
50+Inoculant	55.4	73.3	86.9	5.6	3.4	51.6	63.7	65.6	21.9
75	55.5	72.8	86.6	7.0	3.4	48.2	63.9	65.7	22.6
75+Inoculant	55.5	73.4	87.3	6.8	3.6	50.4	63.3	67.2	22.8
100	55.3	73.1	87.1	7.0	3.5	51.9	63.2	63.5	23.2
125	55.8	73.1	86.9	7.6	3.4	53.7	63.5	65.8	23.6
150	55.9	73.5	87.4	7.8	3.6	53.5	63.4	65.6	24.7
200	56.0	73.8	87.6	8.3	3.9	54.6	63.5	65.4	25.3
LSD (0.05)	0.5	0.6	1.3	1.2	0.6	5.5	NS	NS	0.9
LSD (0.01)	0.7	0.8	NS	1.6	0.8	7.3	NS	NS	1.2
Overall Mean	55.5	73.1	86.9	6.5	3.7	50.8	63.5	65.5	23.1
C.V. (%)	0.9	0.7	1.4	17.6	15.0	10.7	0.8	3.6	3.7
¹ Days after planting ² 1 = profuse, 9 = none ³ 1 = erect, 9 = prostrate ⁴ denotes significant N x S interaction * and ** denote significant differences between S treatments at P<0.05 and P<0.01, respectively									

Significant interactions were observed between year and N treatment for days to end bloom and lodging (Table 9). This statistical significance indicates that the response of these parameters to N was different (either in magnitude or in direction) in the two years. In the cool growing season of 2004, days to end bloom increased by 2.5 days from the lowest to the highest N level, while the difference was only one day in 2005. Lodging in 2005 was reduced with all applications of N fertilizer, but that was not the case in 2004.

Table 9. Statistically significant interactions in the field pea response to N fertilizer and inoculation, NDSU Carrington, 2004-2005.

Total N (lbs/acre)	Days to End Bloom		Lodging	
	2004	2005	2004	2005
15/20	74.5	69.5	2.8	6.5
15/20 + Inoculant	75.8	70.3	2.5	5.8
50	75.0	70.3	2.3	4.8
50 + Inoculant	76.3	70.3	2.0	4.8
75	75.3	70.3	2.0	4.8
75 + Inoculant	76.5	70.3	2.3	5.0
100	76.3	70.0	2.3	4.8
125	75.8	70.5	2.5	4.3
150	76.5	70.5	2.8	4.5
200	77.0	70.5	3.0	4.8
LSD (0.05)		0.8		0.8
LSD (0.01)		1.1		1.1