Inoculation and Fertilization of Field Pea

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Summary

Peas are a legume capable of fixing nitrogen (N) biologically. However, a common practice among growers is to apply small amounts of "pop-up" or "starter" N and sometimes phosphorus (P) fertilizer with seed to enhance early-season growth of pea seedlings. Our objectives were to determine if yield or quality of peas are enhanced in low N- and P- soils by in-row and broadcast applications of N, P, and N+P fertilizer. To do this, inoculated and uninoculated peas were seeded in a randomized and replicated study at Carrington, Dickinson, and Minot in both 1999 and 2000. Different forms and/or amounts of N, P, and N+P fertilizer were applied. Reductions in pea plant stand generally occurred when >4 lb N is applied with seed as either MAP (11-52-0) or ammonium nitrate fertilizer. In-row applications of fertilizer did not enhance pea yield or quality compared with treatments where peas were inoculated properly with N-fixing bacteria just prior to planting. Applying N fertilizer did enhance pea yield or crude protein concentration in some environments compared with a treatment where uninoculated peas were grown. Food grade quality of peas was unaffected by applications of fertilizer. Results of this study do not support applications of N fertilizer to peas if the goal is to enhance yield or quality. Information generated by this study is included in a revised circular on fertilizer management of lentil and peas that will be published by the NDSU Extension Service. Results of this study also will be presented at the American Society of Agronomy's annual meeting in Charlotte, NC, in October, 2001, and will be submitted for publication consideration in the Canadian Journal of Plant Science.

Introduction

Pea is a legume that is capable of meeting a portion of its N needs biologically, as long as roots have been colonized by *Rhizobium leguminosarum,* a N-fixing bacteria. Production guides suggest that somewhere between 30% to 80% of a pea crop's N needs can be met through biological fixation (Ali-Khan and Zimmer, 1989; Bowren et al., 1986; Murray et al., 1979). The rest of the N must be provided from the soil or from fertilizer applications.

Soil N levels generally are adequate for optimum pea yield and quality, as long as biological N-fixation occurs. Lack of a yield response to N fertilizer confirmed that biological fixation was adequate for maximizing pea yield in temperate environments (Crozat et al., 1994). Broadcasted N fertilizer reduced pea yield as rates were increased from 0 to 180 lb/acre in soils already containing large amounts (> 135 lb/acre) of N (Gubbels, 1992).

Nitrogen fertilizer applications generally inhibit biological N-fixation by *R. leguminosarum*. Nitrogen-fixing nodules never formed on inoculated pea roots when 100 lb N/acre was broadcasted shortly after planting (Sosulski and Buchan, 1978). Reducing the N rate did inhibit nodule formation initially, but nodules developed later. The inhibitory effect of N fertilizer on nodule formation results from the fertilizer's contribution to the soil N pool. Bowren et al. (1986) concluded that nodule formation became inhibited as soil N levels approached 35 lb/acre, and were inhibited progressively as levels exceeded this amount. This suggests that N fertilizer applications will reduce biological N-fixation by *R. leguminosarum*, except where the amount of N applied as fertilizer plus that contained in the soil is less than 35 lb/acre.

Small N fertilizer applications have stimulated nodule formation on pea roots in some low N environments (Oghoghorie and Pate, 1971), as with other pulse crops (Kauskik et al., 1995). Bowren et al. (1986) suggested that applications of 10 to 20 lb N/acre enhanced pea seedling growth prior to nodule development in low N soils. Slinkard and Drew (1988) concurred with this recommendation, but warned that the N fertilizer should not be applied in-row. Musbach (1934) concluded that in-row applications of N fertilizer caused germination injury to peas, particularly in dry or coarse-textured soils. Seed yield and quality were reduced when fertilizer containing 13 lb N/acre was applied in-row compared to broadcasting.

In-row applications of fertilizers containing N caused germination injury to peas in central North Dakota (Franzen, 1998). No advantage in yield resulted from applying fertilizer with the seed compared with an unfertilized treatment. These data concur with results from experiments located in other regions of the state (Carr et al., 1998), and beg the question of why is this practice used in North Dakota. In some instances, in-row placement of N even reduced pea yield (Carr et al., 1998), suggesting that in-row fertilizer additions can be detrimental and should be discouraged.

Applications of fertilizers containing nutrients besides N have been shown to cause germination injury to peas when applied in-row. Musbach (1934) found that pea stands were reduced when ordinary superphosphate (0-20-0) was applied in-row, but concluded that the germination injury was warranted because of the increased vigor of the surviving plants. Seed yield was reduced when triple superphosphate (0-46-0) was applied at 40 and 60 lb P/acre in-row compared with banding fertilizer beside seed, but not at a 20 lb/acre rate (Gubbels, 1992). Stand reductions were associated with in-row applications of P at all three rates.

Applications of P-containing fertilizers with pea seed reduced plant stand in experiments in North Dakota. Pea stand was reduced by 15% from the in-row application of 5 lb/acre P as MAP compared with an unfertilized treatment in central North Dakota (Franzen, 1998). Plant stand was reduced by 34% from the in-row placement of 6 lb/acre of P as triple superphosphate in southwestern North Dakota (Carr et al., 1998). Seed yield and quality were not enhanced by in-row P additions at any location.

Peas require adequate amounts of P (Bowren et al., 1986; Slinkard and Drew, 1988), and yield and seed quality can be enhanced by P fertilizer in soils testing low in P (Pulung, 1994). Response to P fertilizer is variable even in low P soils, however, which may result from the confounding effect that different *R. leguminosarum* strains have on fertilizer response. An inoculant X fertilizer interaction occurred when single strain and multi-strain inoculants were compared (Sosulski and Buchan, 1978). Seed CP concentration was greater when a single *R. leguminosarum* strain was used to inoculate peas compared with a commercial multi-strain inoculant, and N fertilizer was applied. Differences in seed CP concentration were not detected between inoculant treatments when fertilizer was not applied.

Previous research suggests that complex factors govern the response of peas to N and P fertilizer applications. This is particularly true in regards to in-row fertilizer placement. Most research indicates that germination injury will result when N and P fertilizers are applied in-row, although exceptions exist. In some instances, seed yield and quality can be reduced. Environmental factors confound a consistent response to in-row placement of fertilizer, as do pea inoculant X fertilizer interactions. Development of consistent fertilizer recommendations for pea growers in North Dakota from previous experiments has been impossible because the experiments differed in experimental design and analyses. A multi-location experiment is needed to determine if in-row placement of N and P fertilizer enhances seed yield or quality under North Dakota growing conditions.

The objectives of this project were to determine if: (1) yield or quality of peas are enhanced by (i) in-row and (ii) broadcasted placement of N, P, and N + P fertilizers in low soil N and P environments, compared with an unfertilized, inoculated treatment; (2) a seed yield and quality response results from inoculating peas with different formulations of commercially available *R. leguminosarum* compared with a non-inoculated treatment; and (3) an inoculant formulation X fertilizer interaction exists for seed yield and quality.

Materials and Methods

Objective 1-3. An experiment was conducted at Carrington, Dickinson, and North Central (Minot) Research Extension Centers during 1999 and 2000. The experiment was located in a field that is low in N (< 30 lb/acre) and P (< 8 ppm Olsen P) at each location in each year, and where lentil and pea have not been grown for at least five years.

Seventeen treatments were included (Table 1). Fertilizers contained in the treatments were distributed from the Dickinson Research Extension Center (DREC) to other locations, as was pea. inoculants. A single supplier provided the pea inoculants during the experiment (Urbana Laboratories, St. Joseph, MO), and the same *R. leguminosarum* strains was provided in dry peat, liquid, and granular forms. The inoculants were stored in a dark, refrigerated environment until just prior to seeding, when they will be placed with peas.

Fertilizer was applied in all plots receiving 'broadcasted' fertilizer treatments using a small-plot planter. The peas were planted in a separate operation. Fertilizer was placed with peas during seeding in the same band in a single-pass in plots receiving 'with seed' fertilizer treatments. The green-cotyledon, pea cultivar Majoret was seeded at 325,000 pure live seed/acre at each location in both years.

Plots were arranged in a randomized complete block design with blocks replicated four times. Individual plot dimensions varied between sites but were a minimum of 4.5 ft by 20 ft. Plots were comprised of 7 to 9 rows, depending on the location.

Stand counts were made at 14 and 30 days after planting (DAP) by counting the number of plants in a 10.76 ft^2 (1 m^2) area from the center four rows of each plot. Ten plants were selected randomly and excavated at 30 DAP so that roots could be observed for evidence of N-fixation activity. The presence of abundant nodules that are pinkish-red in color was considered as evidence that N-fixation is occurring. The absence of nodules, or the presence of cream-colored nodules, was considered as evidence that *R. leguminosarum* are not fixing N effectively.

The experiment was managed at each location following acceptable agronomic procedure for optimum pea yield and quality. Upon reaching physiological maturity, a small-plot combine was be used to harvest peas. Seed yield and test weight will be determined for the entire plot; seed weight will be determined from a 250 seed sub-sample.

Sub-samples of peas from plots receiving each treatment were selected randomly from three blocks and analyzed for CP concentration by standard procedures at Chemical Laboratory Services, Jeffersonville, IN. Separate sub-samples were collected following the same procedure and evaluated for food grade quality at the Federal Grain Inspection Service facility located in Grand Forks.

Data within the experiment were analyzed using the ANOVA procedure available from SAS for each variable tested within each environment. A protected LSD was calculated for each variable where *F*-tests indicate that significant differences existed between treatments (P 0.05).

Demonstration plantings were done in two commercial fields in southwestern North Dakota in both 1999. A third location was identified in 1999 as were locations in 2000 but farmer-cooperators decided not to grow peas because of pea market prices. In the commercial fields where peas were grown, seed was inoculated and planted in side by side strips with peas in one strip receiving an N fertilizer application. Plant stands were determined by counting plants in a 10.76 ft^2 (1m^2) area at 10 locations randomly selected within each field. Seed yield was determined from within each strip once plants had reached physiological maturity. Seed weight and test weight were determined from sub-samples collected from both strips at each location.

Results and Discussion (Objectives 1-3)

Pea Plant Stand

Plant numbers never increased and sometimes were reduced by in-row applications of fertilizer (Table 2). In-row applications of 40 lb MAP/acre generally thinned plant stands within the same inoculant form (peat, liquid, granular) compared with the unfertilized treatment at Dickinson, and sometimes did at Carrington and Minot. Soils at Dickinson are coarse-textured (i.e., sandy loams and loamy sands) and surface soil-moisture deficits may develop prior to sowing. Soils at Minot and particularly Carrington are less likely to develop soil-moisture deficits prior to sowing.

Plant stand data from Dickinson suggest that stand reduction should be expected by an in-row application of 40 lb MAP/acre when peas are sown in coarse-textured soils, where dry conditions may develop (Table 2). Stand reduction sometimes may result from an in-row application of 40 lb MAP/acre in humid environments.

A dry and mild winter resulted in unusually dry soil conditions at Dickinson in 2000. An in-row application of only 20 lb MAP/acre reduced plant numbers compared to the unfertilized pea inoculated treatment, as did in-row applications of 13 lb/acre ammonium nitrate or 48 lb/acre triple superphosphate (Table 2). These data indicate that in-row applications of fertilizer should be avoided when pea is sown in dry environments.

Pea Root Nodule Size and Amount

Root nodule sizes were unaffected by in-row or broadcasted applications of fertilizer at either Carrington or Dickinson in 1999 (Table 3)[1]. Nodule sizes were not evaluated at Carrington in 2000[2]. Smaller nodules resulted when 235 lb/acre of ammonium nitrate was broadcasted prior to sowing peas at Dickinson in 2000 compared with inoculated treatments which did not include fertilizer, but nodule size was unaffected by other fertilizer treatments.

Fewer nodules occurred on pea roots when 235 lb/acre of ammonium nitrate was broadcasted prior to sowing peas at both Carrington and Dickinson (Table 3). Other fertilizer treatments failed to have affect nodule size consistently.

Experiments were placed in fields where peas had not been grown for 6 years and <30 lb soil nitrate-N occurred at both Carrington and Dickinson. The experiment at Dickinson was placed in a field where peas had never been grown in 2000. Uninoculated and unfertilized treatments were established prior to establishing other treatments. Still, nodules formed on pea roots that were uninoculated (Table 3).

We are unable to explain how peas appeared to develop functioning nodules on roots when uninoculated seed was sown in a field where peas were not grown previously or had not been for several years. However, uninoculated soybean has also developed nodules on roots in fields where soybean have not been grown (data not presented).

Seed Yield

Pea yield never was increased by an in-row application of MAP at either 20 or 40 lb/acre (Table 4). Pea yield was unaffected by any N fertilizer application when seed was inoculated with the same *R. leguminosarum* form (peat-based, liquid, granular), except at Minot in 2000. Yield was less when MAP was applied in-row at 40 lb/acre and seed was supplied with a granular inoculant. These data do not support the hypothesis that applications of starter N-fertilizer will enhance the yield of peas in low-N soils, as long as peas are inoculated.

Yield generally was not increased by supplying *R. leguminosarum* inoculant to peas compared with sowing uninoculated peas (Table 4) . Exceptions occurred in 2000 at Carrington, where yield was lower for the uninoculated, unfertilized treatment than other treatments, and at Minot, where yield for the uninoculated, unfertilized treatment was less than a treatment in which ammonium nitrate was applied in-row at 13 lb/acre to peas supplied with a peat-based inoculant. These data suggest that yield increases may not result even when seed is inoculated properly and peas are sown in some low-N (<30 lb/acre) environments, compared with sowing uninoculated seed.

Grain Protein

In-row applications of MAP at either 20 or 40 lb/acre did not enhance the protein concentration of seed compared with forgoing any fertilizer when peas received the same inoculant form (Table 4). Some of the other in-row fertilizer treatments affected the crude protein concentration of peas, but consistent trends did not occur. For example, crude protein increased from an in-row application of ammonium nitrate at 13 lb/acre at Carrington in 1999, but declined in 2000. These data suggest that protein concentration of peas generally is unaffected by applications of fertilizer when inoculant is provided with seed.

Seed protein concentration generally was enhanced when inoculant was supplied prior to sowing peas compared with the uninoculated, unfertilized treatment at both Carrington and Dickinson in 2000 (Table 4). A similar enhancement in seed protein concentration did not occur at either location in 1999.

Test Weight, Seed Weight, and Food Grade

An in-row application of MAP at 40 lb/acre did not enhance test weight, seed weight, or food grade at any sort in either year (Tables 4-5). Other fertilizer treatments as well as supplying inoculant did not enhance test weight, seed weight, or food grade of peas compared with the uninoculated, unfertilized treatment.

On-Farm Demonstrations

Results of on-farm demonstrations were disappointing. No differences between treatments occurred for pea plant stand, seed yield, or seed quality in either field (data not provided). Problems encountered in establishing pea plants in one field and applying N fertilizer in the other field may account for a lack of difference resulting from N fertilizer on pea plant stand.

Acknowledgments

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1 Nodule development was not evaluated at the Minot location in either 1999 or 2000.
2 A nodule score incorporating both size and amount evaluations were determined at Carrington in 2000.

Table 1. Treatments of an experiment located at Carrington, Dickinson, and North Central Research/Extension Centers during 1999 and 2000.

------------------------------- Treatment -------------------------------	-- lb N/P_2O_5 applied per acre --
0 inoculant + 0 fertilizer	0/0
Dry peat inoculant + 0 fertilizer	0/0
Dry peat inoculant + 20 lbs/acre 11-52-0 [with seed]	2/10
Dry peat inoculant + 40 lbs/acre 11-52-0 [with seed]	4/21
Dry peat inoculant + 48 lbs/acre 0-45-0 [with seed]	0/21
Dry peat inoculant + 48 lb/acre 0-45-0 [broadcasted]	0/21
Dry peat inoculant + 13 lbs/acre 34-0-0 [with seed]	4/0
Dry peat inoculant + 40 lbs/acre 11-52-0 [broadcasted]	4/21
Liquid inoculant + 0 fertilizer	0/0
Liquid inoculant + 40 lbs/acre 11-52-0 [with seed]	4/21

Liquid inoculant + 40 lbs/acre 11-52-0 [broadcasted]	4/21
Liquid inoculant + 48 lbs/acre 0-45-0 [broadcasted]	0/21
Granular + 0 fertilizer	0/0
Granular + 40 lbs/acre 11-52-0 [with seed]	4/21
Granular + 40 lbs/acre 11-52-0 [broadcasted]	4/21
Granular + 48 lbs/acre 0-45-0 [broadcasted]	0/21
0 inoculant + 235 lbs/acre 34-0-0 [broadcasted]	80/0

Table 2. Pea plant counts at approximately 17 (First) and 26 (Second) days after planting at several locations in North Dakota during 1999 and 2000.

			Carrington				Dickinson				Minot			
Inoculant		Application	1999		2000		1999		2000		1999		2000	
form	Rate/fertilizer	Method	First	Second	First	Second	First	Second	First	Second	First	Second	First	Second
	--- lb/acre ---													
Liquid	--	--	7.8	7.9	5.5	5.7	6.6	7.3	7.1	6.7	6.4	--	--	--
Liquid	40 lb MAP	broadcast	7.3	7.5	6.4	6.5	6.6	7.4	6.7	6.4	5.1	--	--	--
Liquid	40 lb MAP	with seed	5.8	6.4	5.3	5.9	5.6	6.2	4.9	5.2	4.4	--	--	--
Liquid	48 lb TSP	broadcast	6.7	6.6	5.9	6.4	6.1	6.6	7.0	6.7	--	--	--	--
Granular	--	--	7.6	7.7	6.4	6.6	6.5	6.9	6.9	6.9	4.3	--	--	--
Granular	40 lb MAP	broadcast	7.0	7.0	5.8	5.6	6.7	7.5	6.7	6.4	4.6	--	--	--
Granular	40 lb MAP	with seed	6.1	7.0	6.1	6.1	5.7	6.5	4.4	4.3	3.8	--	--	--
Granular	48 lb TSP	broadcast	7.2	6.9	6.2	6.7	7.2	8.0	6.8	6.2	--	--	--	--
Peat	--	--	7.2	7.0	6.0	6.0	6.2	6.7	6.6	6.3	5.1	--	--	--
Peat	40 lb MAP	broadcast	6.6	7.2	5.9	5.9	6.1	7.2	6.8	6.2	4.9	--	--	--
Peat	20 lb MAP	with seed	6.8	7.0	6.1	6.4	5.9	7.0	5.9	5.8	4.2	--	--	--
Peat	40 lb MAP	with seed	6.1	6.8	5.7	5.9	5.5	5.8	4.6	4.2	4.3	--	--	--
Peat	13 lb AMN	with seed	6.5	7.0	4.9	5.0	6.7	7.4	5.1	5.1	4.6	--	--	--
Peat	48 lb TSP	with seed	6.5	6.4	5.9	6.4	6.5	7.4	6.1	5.8	3.7	--	--	--
Peat	48 lb TSP	broadcast	6.8	6.7	6.9	7.0	6.6	7.6	6.9	6.7	4.7	--	--	--
--	--	--	7.4	7.2	5.5	5.5	6.8	7.5	6.7	6.6	4.5	--	--	--
--	235 lb	broadcast	7.3	7.2	5.9	5.7	5.6	6.7	6.4	6.5	4.4	--	--	--
Mean			6.9	7.0	5.9	6.1	6.3	7.1	6.2	6.0	4.6	--	--	--
CV%			11.2	12.5	16.1	15.3	14.4	12.2	8.8	10.2	21	--	--	--

CV%			11.2	[illegible]	[illegible]	[illegible]	14.4	12.2	[illegible]	[illegible]	21			
LSD .05			1.1	NS	NS	NS	NS	0.6	0.8	0.9	1.3	--	--	-

Table 3. Root nodule development for peas at Carrington (Carr) and Dickinson (Dck), North Dakota, in 1999 (99) and 2000 (00).

			Nodule								
	Fertilizer		**Size[1]**				**Amount[2]**				**Score[3]**
Inoculant	Amount &	Application	**Carr**		**Dck**		**Carr**		**Dck**		**Carr**
Form	Material	Method	99	00	99	00	99	00	99	00	00
Liquid	--	--	5	--	3	5	6	--	4	5	4
Liquid	40 lb MAP	broadcast	6	--	4	3	5	--	5	3	4
Liquid	40 lb MAP	with seed	6	--	4	4	6	--	5	5	4
Liquid	48 lb TSP	broadcast	5	--	3	5	5	--	5	4	4
Granular	--	--	6	--	5	4	6	--	5	5	6
Granular	40 lb MAP	broadcast	6	--	5	5	6	--	5	5	6
Granular	40 lb MAP	with seed	5	--	5	5	6	--	5	6	7
Granular	48 lb TSP	broadcast	6	--	5	4	6	--	5	5	6
Peat	--	--	6	--	5	5	6	--	5	5	5
Peat	40 lb MAP	broadcast	6	--	3	5	7	--	4	4	5
Peat	20 lb MAP	with seed	6	--	4	4	7	--	5	5	5
Peat	40 lb MAP	with seed	6	--	4	4	4	--	5	4	4
Peat	13 lb AMN	with seed	6	--	4	4	5	--	5	5	5
Peat	48 lb TSP	with seed	6	--	4	3	6	--	5	4	5
Peat	48 lb TSP	broadcast	6	--	5	4	7	--	5	5	6
--	--	--	6	--	4	4	6	--	5	2	2
--	235 lb AMN	broadcast	5	--	2	1	3	--	3	1	1
Mean			6	--	4	4	6	--	5	4	5
CV%			23.2	--	16	28.7	28.6	--	9.5	23.0	38.7
LSD .05			NS	--	NS	2	2	--	1	1	2

[1] 1=small, 9=large

[2] 1=none 9=>15/plant

[3] score combining size and amount

Table 4. Seed yield, protein concentration, and test weight for peas at Carrington, Dickinson, and Minot, North Dakota, during 1999 and 2000.																				
			Yield						**Protein**				**Test Weight**					
Inoculant	Rate &	Application	**Carr**		**Dck**		**Minot**		**Carr**		**Dck**		**Carr**		**Dck**		**Minot**	
Form	Fertilizer	Method	99	00	99	00	99	00	99	00	99	00	99	00	99	00	99	00
Liquid	--	--	66.7	58.3	29.7	36.7	30.0	41.7	26.1	24.7	26.5	25.2	64.1	63.6	67.0	66.8	62.1	64.0
Liquid	40 lb	broadca	72.8	62.3	35.5	40.5	25.5	43.1	26.2	24.1	27.3	25.9	64.1	64.0	66.8	66.9	62.1	64.7
Liquid	40 lb	with	72.3	61.3	29.5	40.0	25.6	38.9	25.9	25.0	28.0	25.8	63.6	63.6	66.7	66.3	62.2	63.9
Liquid	48 lb	broadca	74.0	58.2	29.9	40.3	25.5	41.5	26.0	24.1	27.6	25.9	64.5	63.4	66.5	67.3	61.7	64.2
Granula	--	--	70.5	58.0	30.9	41.0	25.9	42.2	25.8	24.8	28.0	25.7	64.5	63.7	66.8	66.6	62.1	64.6
Granula	40 lb	broadca	69.9	59.2	26.3	41.4	26.0	40.0	26.1	24.1	26.9	24.6	64.2	63.7	66.5	66.8	62.3	65.1
Granula	40 lb	with	74.0	60.4	33.8	41.0	21.7	35.5	25.8	25.1	27.7	25.6	65.2	63.7	66.5	66.3	62.3	64.9
Granula	48 lb	broadca	71.2	61.2	32.2	38.1	27.1	42.0	26.1	24.2	26.4	24.1	64.9	64.0	66.4	66.5	62.2	64.0
Peat	--	--	68.8	55.9	27.6	38.8	25.9	39.7	25.9	25.4	26.8	25.0	64.4	63.5	66.3	66.9	61.9	65.5
Peat	40 lb	broadca	70.7	59.1	30.7	39.3	27.3	43.3	26.2	24.8	27.9	26.6	64.4	63.5	66.8	66.6	62.1	65.2
Peat	20 lb	with	70.2	60.7	30.5	42.0	26.5	36.6	25.7	25.4	28.1	25.1	63.8	63.7	66.8	67.4	62.1	65.4
Peat	40 lb	with	74.5	61.0	30.0	38.7	26.4	37.7	26.4	25.1	27.2	25.2	64.5	63.8	66.8	66.9	62.0	65.2
Peat	13 lb	with	68.0	57.5	28.1	35.5	25.3	44.2	26.8	24.1	28.0	25.3	64.1	63.7	65.8	66.6	61.9	64.5
Peat	48 lb	with	71.8	60.4	29.2	37.9	28.4	39.3	25.6	25.0	27.7	24.8	64.3	63.3	66.3	66.6	62.4	65.3
Peat	48 lb	broadca	72.6	63.8	32.5	39.7	25.5	38.5	25.7	24.9	27.3	24.8	63.8	63.8	66.4	66.8	62.3	65.4
--	--	--	70.7	47.4	31.6	35.7	26.0	38.5	26.0	22.8	27.4	23.1	64.5	64.1	66.8	66.4	61.7	65.5
--	235 lb	broadca	70.9	60.9	28.5	36.1	26.8	46.1	25.6	23.5	26.7	24.0	64.0	63.6	67.5	67.1	62.0	63.8
Mean			71.2	59.2	30.4	39.0	26.2	40.5	26.0	24.5	27.4	25.1	64.3	63.7	66.6	66.8	62.1	64.8
CV%			4.5	8.2	14.8	9.7	12.0	9.1	1.1	2.1	2.9	3.6	8.1	0.8	1.1	0.9	0.5	0.4
LSD			NS	6.9	NS	NS	NS	5.3	0.5	0.7	NS	1.5	NS	NS	NS	NS	NS	NS

Table 5. Seed Weight and Grade for peas at Carrington, Dickinson, and Minot, North Dakota, during 1999 and 2000.							
			Seed Weight			**Grade**	
			Carrington	**Dickinson**	**Minot**	**Carrington**	**Dickinson**

Inoculate	Fertilizer	Application	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
Liquid	--	--	2,049	1,743	1,919	1,803	2,762	2,144	3.7	1.0	2.3	1.6
Liquid	40 lb	broadcast	1,957	1,822	1,961	1,791	2,747	2,139	3.3	1.0	2.7	1.0
Liquid	40 lb	with seed	1,927	1,782	2,018	1,745	2,646	2,125	3.3	1.0	3.0	1.3
Liquid	48 lb TSP	broadcast	1,947	1,785	1,902	1,743	2,620	2,161	3.0	1.0	3.0	2.3
Granular	--	--	1,954	1,807	1,944	1,762	2,571	2,110	3.0	1.0	3.7	1.3
Granular	40 lb	broadcast	1,984	1,746	1,969	1,802	2,829	2,070	3.3	1.0	4.0	1.6
Granular	40 lb	with seed	1,950	1,813	1,952	1,754	2,706	2,088	3.7	1.0	2.7	1.3
Granular	48 lb TSP	broadcast	1,937	1,799	1,911	1,790	2,717	2,105	3.3	1.0	3.7	1.3
Peat	--	--	1,964	1,704	1,922	1,819	2,710	2,127	3.7	1.0	3.7	1.6
Peat	40 lb	broadcast	2,041	1,757	1,967	1,773	2,612	2,154	4.0	1.0	3.0	1.6
Peat	20 lb	with seed	1,950	1,831	1,945	1,776	2,580	2,138	3.0	1.0	3.0	1.6
Peat	40 lb	with seed	1,957	1,782	1,967	1,758	2,578	2,105	3.0	1.0	3.3	1.6
Peat	13 lb	with seed	1,998	1,799	1,970	1,809	2,683	2,120	3.0	1.0	3.0	1.0
Peat	48 lb TSP	with seed	1,947	1,779	1,999	1,757	2,740	2,146	3.7	1.3	3.3	1.3
Peat	48 lb TSP	broadcast	1,970	1,876	1,964	1,781	2,480	2,094	3.3	1.3	3.0	1.0
--	--	--	1,920	1,741	1,947	1,807	2,719	2,211	2.7	1.3	2.0	1.6
--	235 lb	broadcast	1,947	1,876	1,950	1,824	2,710	2,262	4.0	1.0	3.0	1.6
Mean			1965	1791	1953	1782	2671	2135	3.4	1.1	3.1	1.4
CV%			3.7	5.6	3.9	2.4	5.8	2.8	25.7	22.9	44.4	39.3
LSD .05			NS	NS	NS	NS	NS	NS	NS	NS	NS	NS