EXAMINING THE NITROGEN FERTILIZER NEEDS OF DRY FIELD PEAS IN THE WILLAMETTE VALLEY

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Introduction

Dry field peas grown for seed are a valuable rotation crop that has expanded in acreage in the Willamette Valley in recent years. Although field peas have been produced extensively in the Pacific Northwest, they are a new crop for many Willamette Valley growers, and optimal management practices are still emerging. A fertilizer guide for field peas grown in western Oregon does not recommend application of any nitrogen (N) if nodulation is effective (Gardner et al., 2000). Effective nodulation occurs when there are sufficient and active populations of *Rhizobia* sp. bacteria, either from native populations or from successful inoculation. Despite the ability of peas to fix N through this association with Rhizobia bacteria, in-season N fertilizer application rates average around 60 lb N/acre in the Willamette Valley.

Studies from regions where field peas are more commonly grown (i.e., Canadian prairies, Dakotas, and Montana) have generally shown that in-season N fertilization is not necessary if field peas are successfully inoculated and starting N (soil + starter fertilizer) provides 10–15 lb total available N/acre (Jones and Olson-Rutz, 2018). Research from North Dakota has shown that 60–80% of the N found in a field pea is derived from N_2 fixation, with the remainder being derived from soil N sources (Franzen, 1998). Furthermore, it has been shown that high levels of available soil N (more than 50 lb/acre) reduce nodulation because the legume crop preferentially uses soil N and reduces utilization of "free N" from fixation.

Nearly all research conducted on dry field peas has been done in climates that are very different from the Willamette Valley, such as semiarid environments where soils carry over N from the previous crop. In the Willamette Valley, it is assumed that most NO_3-N present in the fall is leached and lost over winter.

A trial was conducted at three locations (Benton, Linn, and Polk counties) in 2016 to investigate the effect of in-season N rates on field pea yield and yield components (Sullivan, 2019). In that study, there was no effect of in-season N rate (0–120 lb/acre) on seed yield or yield components. Following harvest, higher residual soil N was observed at the higher N rate treatments (80 and 120 lb/acre), indicating that N was likely in excess of plant demand.

Results from a repeated study (2019) are presented in this report. Combined with the 2016 data, this work provides on-farm yield data across two growing seasons in the Willamette Valley. This work will help growers decide whether they can eliminate or reduce in-season N rates to reduce input costs and maximize the N_2 fixing abilities of field peas. In addition, nutrient accumulation data for macro- and micronutrients beyond N were also collected and will help guide growers in developing a pea fertility program.

Objectives:

- To demonstrate the effect of no in-season N fertilization on field pea growth and seed yield.
- To measure the effect of in-season N fertilizer rate on root nodulation, seed yield, and seed yield components.
- To develop recommendations for in-season N fertilizer use in field pea production based on research results and to disseminate this information to growers.

Table 1. Trial activities and dates completed at three field pea sites, 2019.

Activity	Linn	Benton	Marion
Preplant soil sample	Mar. 18	Mar. 25	Mar. 16
Fields planted	Mar. 21	Mar. 26	Mar.17
Flagged	Apr. 10	Apr. 11	Mar. 20
Grower fields fertilized	Apr. 17	Apr. 20	Apr.19
OSU trials fertilized	Apr. 23	Apr. 25	Apr. 24
Nodulation sampling	May 28	May 28	May 27
Swathed[1]	N/A	N/A	Jul. 13
Combined	Aug. 14	Aug. 12	Jul. 27
Postharvest soil sample	Aug. 19	Aug. 13	N/A[2]

[1]Linn and Benton county sites were direct combined.
[2]Plot flagging was removed at harvest, and postharvest soil samples could not be obtained.

Materials and Methods

Three trials were established in the spring of 2019 on growers' fields in Linn, Benton, and Marion counties (Table 1). Field peas were planted with grower equipment on March 17 (Marion), March 21 (Linn), and March 26 (Benton). The experiment was a randomized complete block design with four replications. Plots at the Linn and Marion sites were 0.13 acre, while Benton plots were 0.09 acre. Plot width was determined by grower harvest equipment. Preplant soil samples (0–6 inches) were taken at each site prior to planting and starter fertilizer application. Seed was not inoculated at any site. See Table 1 for field activity dates.

Soil samples were taken prior to the start of the trial to determine the starting nutrient concentrations in all fields. Starting nitrate (NO_3^--N) ranged from 11 to 31 lb NO_3^--N/acre. Phosphorus (P) and potassium (K) levels varied quite widely among the sites (36.4–156.8 ppm P and 146–263 ppm K) but in all cases were sufficient for crop growth. Soil pH at the sites ranged from 5.6 to 6.4. A starter fertilizer was applied preplant or at planting at all sites (grower field and trial area). Application of starter N did not exceed 20 lb N/acre. In-season grower N application to the surrounding field was 60 lb N/acre.

At the four-leaf stage (V4), four fertilizer treatments (urea, 46-0-0) were applied at the following rates: 0, 40, 80, and 120 lb N/acre. Initial soil N levels were not used to adjust fertilizer rates; the same rate was applied at each site. Fertilizer was applied using an air-inducted Orbit Air spreader at the Benton site and using a manual spin spreader at the Marion and Linn sites.

Roots from each plot were sampled approximately 10 weeks after planting, and root nodulation was assessed visually according to the *Nodulation and Nitrogen Fixation Field Assessment Guide* published by the Saskatchewan Ministry of Agriculture (Risula, 2016). In this protocol, nodulation and N fixation potential of a legume plant are scored based on: (1) plant growth and vigor, (2) nodule color and abundance, and (3) nodule position. A score is then calculated corresponding to a rating of effective nodulation, less effective nodulation, or poor nodulation.

At harvest, two 1 ft^2 plant biomass samples were taken per plot. Biomass samples were separated into stems and pods, dried at 140°F, and analyzed separately. The stems were analyzed for total biomass and percent N concentration. Pods were processed to measure the number of pods/ft^2, peas/pod, and peas/ft^2. Harvest was performed with grower equipment and a weigh wagon. Seed yield was calculated based on the seed weights from individual plots. Postharvest soil samples (0–6 inches) were taken within 5 days of harvest from each plot to determine residual soil N.

In addition to yield and yield components, two 1 ft^2 biomass samples were taken from the 80 lb N/acre treatment on five dates during the growing season, roughly corresponding to the following: two-node stage (V2), eight-node stage (V8), onset of flowering (R1), green seed fill (R4), and harvest. In each case, whole plant biomass was weighed, ground, and analyzed for nutrient concentrations (N, P, K, Mg, S, B). Total nutrient quantities at each sampling time were calculated by multiplying the nutrient concentration by the biomass and extrapolating to a lb/acre basis. At harvest, total above-ground biomass was sampled from all treatments, partitioned into plant biomass and peas, and analyzed for the nutrient concentration as above.

Results and Discussion

At all sites and N rates, we observed effective nodulation, meaning the plants were green and vigorous and active pink nodules were present. At all sites, we observed a tendency of higher nodulation scores in the 0 N plots, but there was no significant difference in nodulation score among treatments. In the 2016 study, less effective nodulation was observed in the 80 and 120 lb N/acre treatments. An overall rating of less effective nodulation reflects a combination of lower number of pink or active nodules, reduced crown nodulation, and reduced vigor (Risula, 2016). This result follows the expectation that less nodulation will occur when N is readily available from fertilizer. It is possible that we did not see this effect in 2019 because of the timing of our N applications. In the 2019 growing season, N fertilizer was applied in late April, immediately after a period of high rainfall. Following application, there was a period of no rainfall that lasted nearly 3 weeks. This timing may have resulted in some ammonia volatilization and delayed fertilizer incorporation, thereby minimizing and delaying the impact of the fertilization treatments.

There were no differences in seed yield or plant samples taken at harvest (Table 2). A trend of increasing N content and N uptake was observed with increasing N rate, but this result was not significant. Among the seed yield components (pods/ft^2, peas/pod, and peas/ft^2), we observed no differences between the treatments. Similarly, in the 2016 trial, no differences in seed yield components were observed (data not shown). Relatively high residual postharvest soil N was observed among all treatments at the Linn and Benton sites, ranging from 39 to 51 lb/acre. A trend of increasing soil N with N fertilizer rate was observed at the Linn site, while no pattern was observed at the Benton site. In the 2016 trial, higher residual soil N was observed in the 80 and 120 lb N/acre fertilizer treatments relative to 0 N, indicating that N was in excess and was not completely taken up by the pea crop (data not shown).

Pea plant nutrient uptake was correlated to biomass growth. At the Marion site, nutrient accumulation was most rapid through the end of May for N, K, Mg, and S (Figure 1). The other sites were direct combined, and plants matured in the field for approximately a month longer. At these sites, plants seemed to accumulate nutrients most rapidly in July. This difference is likely a combination of variety difference, drought stress (which seemed to be more severe at the Marion site), and a longer growth period at the Benton and Linn sites.

Table 2. Field pea biomass, stem and pod characteristics, nodule ratings, yield, and postharvest soil sample results, 2019.[1]

	------ Postharvest plant biomass ------								
N rate	Total N concentration	Biomass	N uptake	Nodulation rating	Pod/ft^2	Peas/pod	Peas/ft^2	Yield	Postharvest soil N
	(%)	(lb/a)	(lb/a)		(no.)	(no.)	(no.)	(lb/a)	(lb/a)
0	1.13	5,600	61	Effective	65	4.1	270	3,351	40
40	1.18	5,762	65	Effective	69	4.1	281	3,330	39
80	1.21	6,421	76	Effective	75	4.7	334	3,265	51
120	1.23	5,932	71	Effective	70	4.6	312	3,355	49

[1]Results are averaged across three locations in the Willamette Valley (Marion, Linn, and Benton counties) under four N fertilization rate treatments.

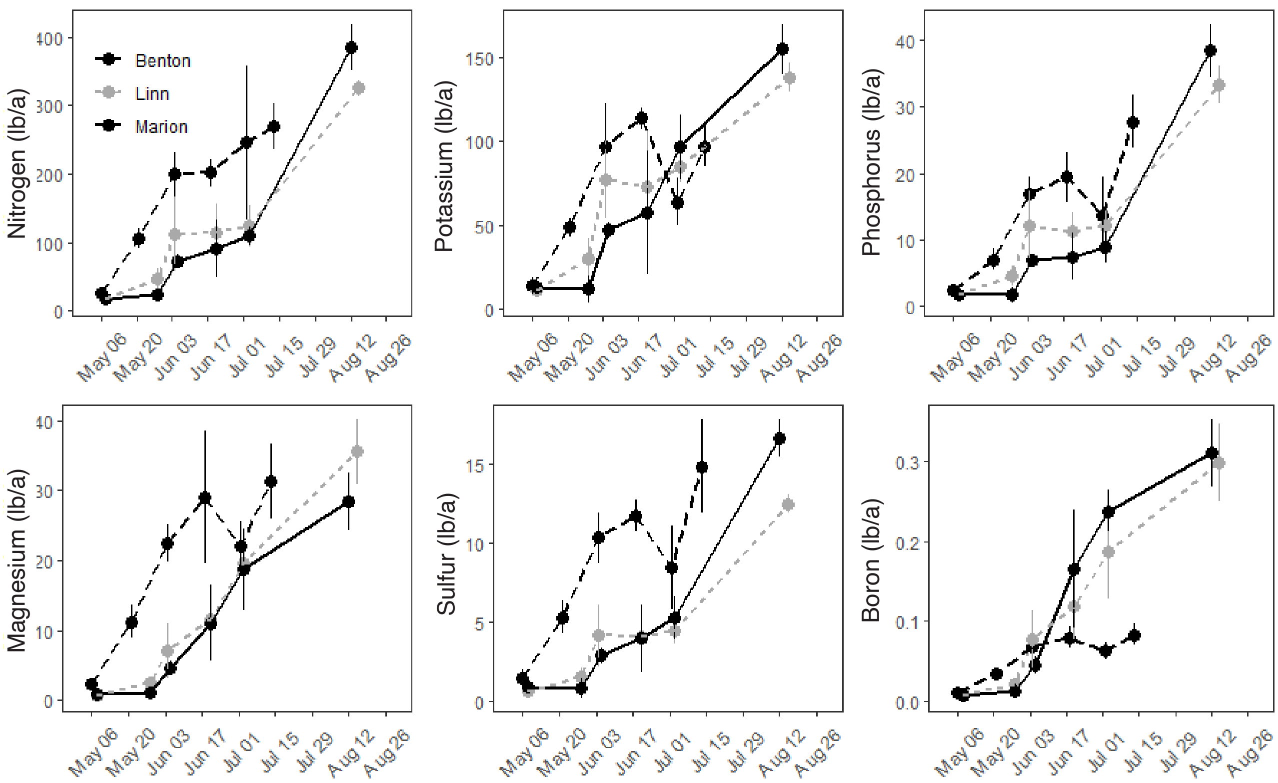

Figure 1. N, K, P, Mg, S, and B uptake throughout the growing season in the 80 lb N/acre treatment (n = 4). Nutrient uptake was calculated by multiplying plant biomass by nutrient concentration.

Table 3. Total nutrient uptake in postharvest plant biomass and peas.[1]

Portion of plant	N rate	N	P	Mg	K	Ca	S	B
		(lb/a)						
Plant biomass	0	61.4 (19.1)	3.9 (1.5)	19.3 (3.4)	54.9 (18.6)	144.3 (35.9)	3.8 (1.2)	0.1 (0.1)
Plant biomass	40	65.2 (18.4)	4.1 (1.1)	19.9 (7.0)	58.6 (18.9)	155.8 (54.3)	3.9 (1.5)	0.2 (0.1)
Plant biomass	80	76.2 (16.1)	4.7 (1.6)	23.7 (4.9)	68.0 (17.5)	177.6 (53.2)	4.4 (1.1)	0.2 (0.1)
Plant biomass	120	71.1 (18.7)	4.1 (1.3)	21.6 (6.7)	59.8 (19.2)	149.3 (46.7)	4.1 (1.6)	0.2 (0.1)
Peas	0	207.9 (71.9)	24.5 (7.6)	6.5 (2.1)	52.5 (19.2)	5.5 (2.2)	8.6 (1.9)	0.04 (0.03)
Peas	40	200.8 (65.3)	24.6 (7.7)	6.4 (2.0)	51.3 (16.4)	5.4 (2.4)	9.0 (2.9)	0.04 (0.02)
Peas	80	250.5 (61.4)	28.4 (6.0)	7.7 (1.8)	61.1 (16.5)	6.2 (2.2)	10.5 (2.3)	0.05 (0.02)
Peas	120	200.4 (50.4)	24.8 (8.7)	6.2 (1.7)	50.4 (17.9)	5.1 (1.8)	8.4 (2.1)	0.04 (0.02)

[1]Results were averaged across all three sites with the standard deviation in (). Biomass nutrients were left on the field, while pea nutrients were removed with harvest.

Plant biomass from all treatments was analyzed for nutrient concentration at harvest (Table 3). If fertilizer application practices are designed to maintain soil fertility, the average nutrient load removed with the peas can be used to guide total fertilization rates. One exception is N; because peas fix N, a large portion of N will come from the atmosphere. On average, peas removed 26 lb P/acre, 7 lb Mg/acre, 54 lb K/acre, 9 lb S/acre, and 0.04 lb B/acre (Table 3).

As in the first year of this trial (2016), seed yields were not increased by N fertilizer rate (Table 4). These data confirm previous findings demonstrating that in-season N fertilizer is not needed to obtain maximum seed yield in field pea crops grown in the Willamette Valley. Given the variability we observed in starting soil NO_3^- concentrations, a starter fertilizer with some N is still recommended but should not exceed 20 lb N/a.

Table 4. Yield results of three field pea trials in Benton, Linn, and Marion counties under different N rates as compared to grower field average, 2019.[1]

	Yield		
Treatment	Benton	Linn	Marion
(lb N/a)		(lb/a)	
0	2,564	4,374	3,115
40	2,781	4,252	2,957
80	2,575	4,406	2,815
120	2,675	4,483	2,908
Trial average	2,649	4,379	2,949
Grower field average	3,348	4,700	2,213
Grower fertilizer rate	60 lb N/a	60 lb N/a	60 lb N/a

[1]Grower fertilizer rates included. No differences between treatments within a field or between treatments summarized across sites were observed.

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