OPVC CONTINUING PROJECT REPORT: 2014 **PROJECT YEAR:** 2 of 3

1. OPVC REPORT COVER PAGE

OPVC Project Number:

Project title: Increasing the Nutrient Use Efficiency of Snap Beans

PI Ed Peachey
OSU Department of Horticulture
541-740-6712
Ed.Peachey@oregonstate.edu
4017 Ag & Life Sciences Bldg.
Corvallis, OR 97331

Co-PI Dan Sullivan
OSU Crop and Soil Science
541-737-5715
Dan.Sullivan@oregonstate.edu
3017 Ag & Life Sciences Bldg.
Corvallis, OR 97331

Co-PI Aaron Heinrich
OSU Department of Horticulture
(541) 740-5750
heinriaa@oregonstate.edu
4017 Ag & Life Sciences Bldg.
Corvallis, OR 97331

Cooperators: Ernie Pearmine, Joe Fitts, Kenny Hendricks, Steve Kuedell, Justin Chambers, Peter Kenagy, and Mike Schrock

Total Project Request

Year 1: $12,733 Year 2: $14,109

2. EXECUTIVE SUMMARY

The overall objective of this multi-year project is to maximize nutrient use efficiency without compromising bean yield and quality. This year's project objectives were to: 1) evaluate crop response to P fertilizer at current soil P test levels in grower fields; 2) generate phosphorus (P) potassium (K), and nitrogen (N) nutrient budgets (fertilizer inputs vs. harvest removal); and 3) evaluate relationships among bean root rot disease, plant P uptake, biomass allocation (pods vs. leaves).

To evaluate P fertilizer response, paired field plots were set up at seven cooperator field locations in 2014, comparing pod yield for the grower P fertilizer rate vs. a zero P fertilizer control. When Bray P1 soil test levels were $\geq$ 55 ppm, no yield response to additional P fertilizer was observed. Yield was increased by P fertilization at one field site with a low P soil test value (34 ppm). Pooled data (2013 & 2014) indicates that significant savings in P fertilizer inputs could be attained by reducing P fertilizer rates to a minimal rate (30 lb P_2O_5 per acre) at sites with high soil test P (>55 ppm).

Nutrient uptake by bean plants was monitored at harvest time. Whole plant P uptake averaged 29 lb P_2O_5/A across 12 grower fields in 2013 & 2014. The range in P_2O_5 uptake was 21 to 41 lb/acre. Of total plant P uptake, approximately 45% was removed in pods at harvest, with the remainder left on the field in crop residue. Whole plant potassium uptake averaged 102 lb K_2O/acre (range 91 to 141 lb/acre). An average of 35% of whole plant K was removed in the harvested product (pods), while 65% remained in the field. The average grower K fertilizer rate was 75 lb K_2O /acre above the K fertilizer need predicted in an older OSU fertilizer guide (FG 28), suggesting that it may be possible to reduce K fertilizer rates without reducing crop yield and quality. Whole plant N uptake averaged 111 lb N/A (range 92-130) in 2014 and 140 lb N/A (range 110-172) in 2013. An average of 35% of whole plant N was removed in the harvested product (pods) while 65% remained in the field.

A preplant soil fumigation x P trial was conducted at the OSU Vegetable Research Farm in Corvallis (Bray P1 soil test = 99 ppm, a high value). The field was cropped to beans in 2011-13, resulting in high disease pressure in 2014. Gross pod yield was 4.8 tons/acre greater in fumigated plots compared to non-fumigated plots (12.6 vs. 7.8 ton/acre). Pod yields did not respond to P fertilizer application in fumigated or in non-fumigated treatments. This study suggests that longer rotations out of beans could significantly increase pod yield due to a decrease in bean root rot disease severity, and that P fertilizer rates do not need adjustment for fields with high soil test P and a high root rot potential.

Objectives

1. Continue to evaluate current OSU P fertilization recommendations for snap beans.
2. Generate a nutrient budget for N, P, and K for snap beans grown in Western Oregon.
3. Determine the relationships between bean root rot diseases, P uptake, biomass, pod yield, and allocation of growth between pods and foliage.

3. FULL REPORT

3a. Background

Oregon is the #2 snap bean producer in the US and grower's yields per acre are the highest of any other state (USDA NASS 2012). Despite the scale and importance of snap bean production, almost no research has been done on phosphorus (P) utilization over the past 30 years in the Willamette Valley (personal communication with John Hart, Emeritus professor, OSU Crop and Soils). As a result, P fertilization recommendations (OSU's Bush Beans: Western Oregon—West of Cascades Fertilizer Guide publication #FG 28) have not changed in decades even though much has changed during this period. We now have a better understanding of the factors that influence P availability. Also, during this period, soil P levels have steadily increased due to P fertilization in excess of what is removed in the harvested product. If soil P levels are already at or above the critical value for optimum growth, any addition of P beyond crop needs represents a potential economic loss as well as an increased risk for negative environmental losses. The overall objective of this project is to provide farmers with fertilizer rate recommendations that will allow them to maximize the nutrient use efficiency and yield while minimizing the potential for fertilizer losses.

Current Oregon P fertilization recommendations (OSU's Bush Beans: Western Oregon—West of Cascades Fertilizer Guide publication #FG 28) are likely too high. By comparing the pod yield from unfertilized P plots in grower fields to the adjacent field (standard practice), we can evaluate OSU's recommendations based on yield and soil test P values. Both early and late plantings must be evaluated because temperature affects P availability. Research from California showed a 40 percent reduction in available P with a 20°F decrease in soil temperature (Johnstone et al., 2005). In western Oregon, the minimum soil temperature at the 4-inch depth increases approximately 20°F between mid-April and early July.

To increase P utilization and reduce fertilizer use on soils with high levels of P involves understanding plant uptake, removal in the harvested product, and how much is cycled back into the soil with incorporated residues. For example, under high soil test P (STP) conditions, the P fertilizer application could either be eliminated or reduced so that P applied is equal to either total P uptake or what is removed in the harvested product. This would reduce fertilizer use and reduce or slow down the increase in STP values. Although high STP will not have a negative effect on the crop (i.e. is not phytotoxic), high levels increase the risk of a negative environmental losses.

An important factor influencing the ability of snap beans to utilize soil nutrients is the presence of root diseases, which has not been well studied. Root rot is caused by several soil borne pathogens including fusarium, rhizoctonia, and pythium. They reduce bean yields when conditions are favorable for disease, especially when the interval between snap bean crops grown on the same site is short. With a less extensive root system, diseased plants are unable to access nutrients even though there may be sufficient nutrients for a plant with healthy roots to achieve maximum growth. Results from 2013 showed that there is a relationship between P uptake and root health, with increased uptake of fertilizer when roots were healthy. Therefore, anticipated disease severity for a particular site may need to be considered when developing fertilizer recommendations.

Through this research we will be able to provide growers with better fertilizer rate recommendations, and also provide information on the expected plant response to fertilizer rate depending on the anticipated level of root rot disease severity. This will allow farmers to maximize yield while potentially saving money and reducing the risk of negative environmental consequences.

3b. Objectives

1. Continue to evaluate current OSU P fertilization recommendations for snap beans. Current P recommendations have not been revised in 30+ yrs and recommendations appear high based on literature from other regions of the country.
2. Generate a nutrient budget for N, P, and K for snap beans grown in Western Oregon. By doing so, we can evaluate current fertilization practices and also provide recommendations for fertilizer rates to replace what is being removed in the harvested product yet maintain current soil test P and K levels.
3. Determine the relationships between bean root rot diseases, P uptake, biomass, pod yield, and allocation of growth between pods and foliage. If a high level of bean root rot is expected, higher P fertilizer rates may be necessary to overcome the smaller and weakened root system of the diseased plants.

3c. Significant findings

Phosphorus

- **In this study, no yield response to P fertilizer was observed when the soil test P (STP) level was ≥ 55 ppm Bray 1P.** This data set suggests that the current recommendations given in OSU's fertilizer guide *Bush beans: Western Oregon-west of Cascades (FG 28)* are excessive. When a field has an STP value ≥ 55 ppm Bray 1P, we recommend applying 15-30 lb P_2O_5/acre or even eliminating P fertilizer. **To be able to meet these low rates on high STP soils yet meet N fertilizer targets, shift away from low N, high P analysis fertilizers (i.e. 10-34-0) to higher N, lower P blends.**
- The average grower fertilizer P_20_5 application was 75 lb/A (range 30-158) in 2013 and 105 lb/A (range 50-158) in 2014. **If growers with STP ≥55 ppm applied only 30 lb P_2O_5/acre, they could reduce P applications on average by 63 lb** P_2O_5**/acre (range 6-129).** This P fertilizer rate would be more P than is being removed in the harvested product and would slow down the increase in or maintain soil test P levels in the soil.
- On average, total P_20_5 uptake in 12 grower fields over 2 field seasons using grower standard practices was 29 lb P205/A (range 21-41). The snap bean variety OSU 5630 was grown at 2/3rds of the test sites.
- **Of the total P uptake, approximately 45% was removed in the harvested product (pods) while 55% remained in the field.** The residue remaining in the field after harvest had a high N content (avg of 2.7%) and will break down rapidly, releasing N and P back into the soil.
- On average 1.48 lb P_2O_5/ton of pods was removed in the harvested product.

Potassium

- On average total K_2O uptake in grower fields using grower standard practices was 102 lb K_2O/A (range 91-141) in 2014 and 111 lb K_2O/A (range 62-172) in 2013. **Of the total K_2O uptake, an average of 35% was removed in the harvested product (pods) while 65% remained in the field.**
- **Using the current OSU recommendations for beans (FG 28), K_2O rates could have been reduced on average by 75 lb K_2O/acre (range 40-94).**

Nitrogen

- On average total N uptake in grower fields under grower standard practices was 111 lb N/A (range 92-130) in 2014 and 140 lb N/A (range 110-172) in 2013. **Of the total N uptake, an average of 35% was removed in the harvested product (pods) while 65% remained in the field.** Due to a high N content of the foliage (avg of 2.7%) and warm fall soil temperatures, a significant fraction of the residue will rapidly mineralize (estimate of 15-30%) and be converted to nitrate. This nitrate will be subject to leaching with fall and winter rains unless a nitrate scavenging cover crop or fall crop is planted.

- Based on fertilizer N rates and preplant soil nitrate concentrations, we believe that there is the potential to reduce N fertilizer applications, but this study was not set up to address N rates. **Further research is needed to correlate preplant nitrate concentrations with crop response to N fertilizer rates.**

Root rot, yield, and P uptake

- Soil test P at the experimental site was 99 ppm Bray 1P. At this high level, no yield response to P fertilizer was observed, whether or not plots were fumigated. Therefore, the following findings will focus solely on the differences between fumigation treatments.
- Bean root rot disease severity in the fumigated plots was significantly less than in the non-fumigated plots. Due to the selectivity of the fumigant for fungi, root nodulation by *Rhizobium* bacteria was unaffected.
- **Due to healthier roots, gross pod yield was 4.8 tons/acre greater in the fumigated plots (12.6 vs. 7.8 ton/acre).**
- Although foliage yield was 89% greater in the fumigated plots compared to the non-fumigated plots, **the ratio of gross pods to total fresh biomass (pods and foliage) was similar (62 vs. 58% for the non-fumigated and fumigated plots, respectively)**. Despite the increase in foliage, harvesting the plants with a commercial harvester would likely not have been an issue (i.e., the plants were similar in size to those found in many commercial fields).
- **This study suggests that longer rotations between bean crops would significantly increase pod yield due to a decrease in bean root rot disease severity.**

3d. Methods

<u>Unreplicated P plots</u>

On seven commercial farms, growers excluded P applications at planting from a small area of their field (seeder width by ~30-40') and N and K were applied to these plots to replace the fertilizer that was excluded from these plots. To match grower N rates, ammonium sulfate was broadcast in the plot. If K was banded at seeding, KCl or K-K-Mag was banded approximately 3" from the seedline and 2" deep using a hand-push fertilizer applicator. Information for the 7 sites is given in Table 1 and 2. At harvest, three 6 ft. sections of row were harvested in the 'No-P' plots as well as outside the plot (grower standard practice or 'Grower' plot). Pods were stripped by hand. Stand, pod yield, and foliage weight were recorded. The beans were mechanically graded and then dried at 60C. The foliage was shredded using a 5 hp shredder (MTD model 242-645-000), from which a subsample was collected and dried in an oven at 60C. The dried foliage and pods were then ground using a Willey grinder and sent to Brookside Laboratories, Inc for nutrient analysis.

Table 1. Site information for unreplicated P plots.

						Grower fertilizer application		
Site	Location	Seeding date	Variety	Previous crop	Last bean planting	N	P_2O_5	K2O
					yrs prior	-------- *lb/acre* ----------		
1	Dever-Conner	29-Apr	OSU 5630	Wheat	~9	119	158	144
2	N. Albany	13-May	OSU 5630	Corn	2	75	50	30
3	Gervais	20-May	Tapia	Wheat	?	90	60	100
4	S. Corvallis	3-Jun	OSU 5630	Wheat	3 to 5	101	139	140
5	Independence	7-Jun	OSU 5630	Wheat	3	59	36	48
6	Stayton 1	13-Jun	OSU 5630	perennial rye	~3	47	159	82
7	Stayton 2	16-Jun	OSU 5630	perennial rye	~3	100	135	70
					average	**84**	**105**	**88**

Table 2. Soil characteristics for the unreplicated P plots and root rot and P uptake fumigation trial. Soil samples were taken at planting and therefore soil NO3+NH4 and K soil test levels may reflect the influence of broadcast and incorporated preplant fertilizers. All P was banded at planting.

Site	Location	Soil mapping	Est CEC	pH	Total N[1]	OM[2]	Bray I P	(NO3+NH4)-N	K[3]
			meq/100g		%	%	------------- *mg/kg soil*		-----------
1	Dever-Conner	Chehalis silty clay loam	32	5.8	0.12	2.3	64	14	182
2	N. Albany	Newberg loam	26	5.9	0.12	2.1	34	9[4]	70
3	Gervais	Cloquato silt loam	26	6.1	0.11	2.2	55	31	152
4	S. Corvallis	Chehalis silty clay loam	33	5.5	0.19	3.9	41	21	188
5	Independence	Cloquato gravelly silt loam	17	6.1	0.08	1.5	73	21	172
6	Stayton 1	Clackamas gravelly silt loam	18	5.6	0.26	5.0	69	31	241
7	Stayton 2	Clackamas gravelly loam	23	5.9	0.22	4.5	387	26[4]	417
Fumigated	Corvallis	Chehalis silty clay loam	27	6.3	NA	NA	99	12[4]	217

1-by combustion ; 2-estimated by 1.7 x total C (assumes soil OM contains 58% C); 3- Mehlich III extractable nutrients;

4- these sites received no preplant N fertilizer

Root rot and P uptake fumigation trial

This trial was conducted at the OSU Vegetable Research Farm in Corvallis on a soil mapped as a Chehalis silty clay loam. Soil characteristics are given in Table 2. At this site snap beans were continuously cropped for 3 years and the field had high bean root rot disease pressure. The experimental design was a split plot with the main plot as fumigation/no fumigation treatments and the subplots as P fertilizer treatments in a randomized complete block design. The plots were replicated 4 times and each subplot was 30’ in length.

On May 7 a commercial fumigation company applied the fumigant Tri-Clor EC (active ingredient chloropicrin, 94%) at a rate of 200 lb ai/acre (15.7 gal/A) in 11’ strips through the field. A plastic film was applied immediately behind the fumigant applicator. The plastic was cut open 16 days after application (DAA) to allow any remaining Tri-Clor to dissipate. The plastic was removed and the soil rotovated with a Kuhn power harrow 20 DAA.

On May 30 (20 DAA) snap beans var. OSU 5630 were seeded in 4 rows per plot at a rate of 174,000/A followed by a pre-emergent herbicide application of Dual Magnum. After planting, P fertilizer treatments of 0, 15, 30, and 60 lb P_2O_5/A were applied by banding approximately 3” from the seed line and 2” deep using a hand-push fertilizer applicator. N fertilizer in the form of ammonium sulfate was banded with the P fertilizer at a rate of 40 lb N/acre. Three weeks after planting, an additional 40 lb N/acre of ammonium sulfate was side-dressed. Seven weeks after planting, Topsin and Rovral fungicides were applied to control white and gray mold.

Bean pods were harvested on August 1 (63 days after planting from a 10 ft. section of one middle row in each plot. Plant stand, pod weight, and foliage weight were recorded. The beans were mechanically graded and then dried at 60C. The foliage was shredded in the field using a 5 hp shredder (MTD model 242-645-000), from which a subsample was collected and dried in an oven at 60C. The dried foliage and pods were then ground using a Willey grinder and sent to Brookside Laboratories, Inc for P tissue analysis.

3e. Results & Discussion

Unreplicated P plots (2013 and 2104)
(Note: Data from Site 6 in 2013 was removed from the 2013 averages used in this report because this site was an outlier and does not represent typical nutrient uptake for snap beans. The plants at this site were large with significant foliage but few pods. This field may have received too much nitrogen. See results from 2013 for more information about this site.)

Phosphorus
Soil test phosphorus (STP) levels were low (<50 ppm) to moderate (>50 and <75) at all sites except for site 7 which had an extremely high P level of 387 ppm (Table 2). Marketable pod yield (#1+#2) from the 'No P plots' (plots that received no P fertilizer) at all sites except for site 2 (N. Albany) were not different than the grower standard practice (Fig. 1). Site 2 had the lowest STP level of all sites (34 ppm). At sites 2 and 4 the difference in plant growth between the No P plot and the grower's field was dramatic (Fig. 2). Although there was no apparent difference in pod yield between 'No-P' and 'Grower' treatments for Site 4, the foliage in the 'Grower' plot was greater and had complete canopy closure (Fig. 2B). This resulted in a greater incidence of white mold in the 'Grower' treatments, whereas little or no white mold was found in the plots without P applied at planting.

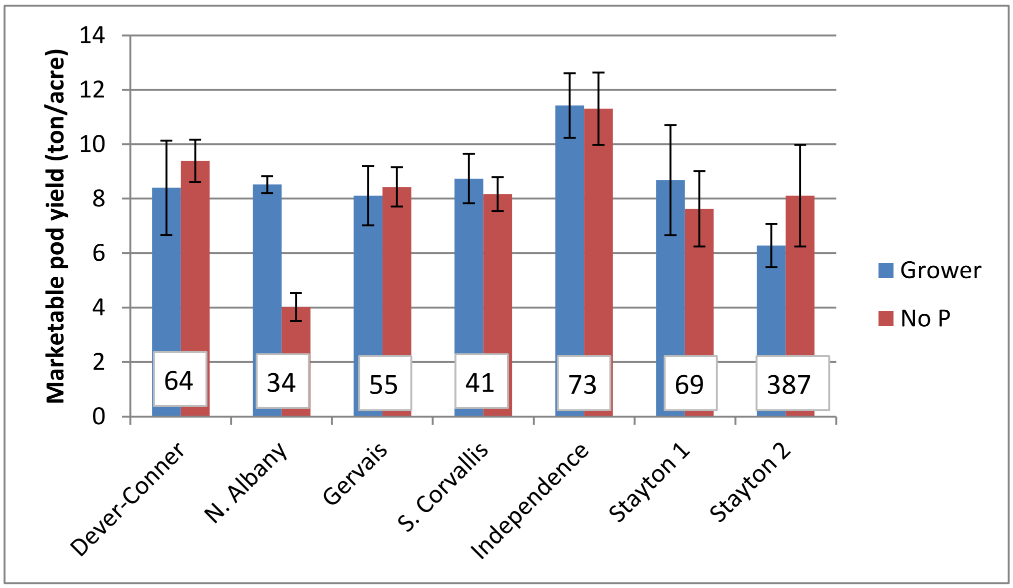

Figure 1. Marketable pod yield (#1 and #2's) from a plot in each grower field receiving no P fertilizer (No P) compared to the surrounding field that received the grower standard P rate (Grower). Error bars represent the SE of 3 subsamples (not true replicates). Values in boxes represent the pre-plant soil test Bray 1 P level in ppm.

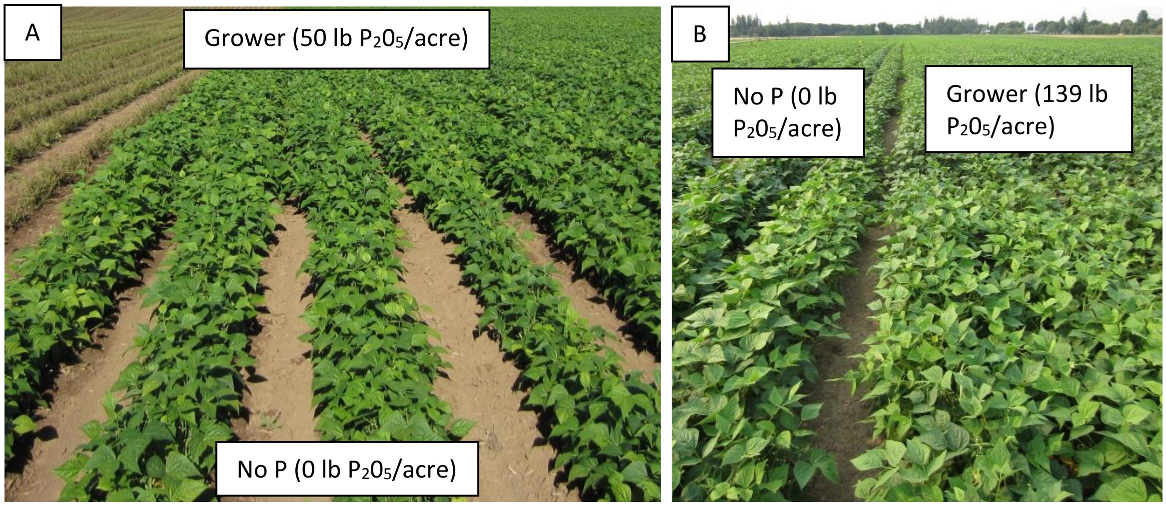

Figure 2. Difference in bean growth at harvest between No P and Grower treatment for A) site 2 (N. Albany) with a soil test P (STP) of 34 ppm Bray 1P and B) site 4 (S. Corvallis) with a soil test P (STP) of 41 ppm Bray 1P. At site B there was no significant difference in pod yield (Fig. 1), but there was significantly less white mold in the No P plot because the canopy never closed, allowing for more air movement that reduced moisture in the canopy.

Total P_2O_5 uptake in aboveground biomass (foliage + pods) is given in Figure 3. Average P_2O_5 uptake for the Grower and No P treatments across all sites was 27 (range 21-33) and 23 (range 14-32) lb P_2O_5 /acre, respectively. This is lower than last year (2013) when the Grower plots averaged 32 (range 25-41) lb P_2O_5 /acre. Because foliage and pod dry matter yields were similar in each year, the difference is due to lower tissue P in 2014 (Table 3). This may be due to lab analysis variability and may not reflect true differences in actual tissue P between years.

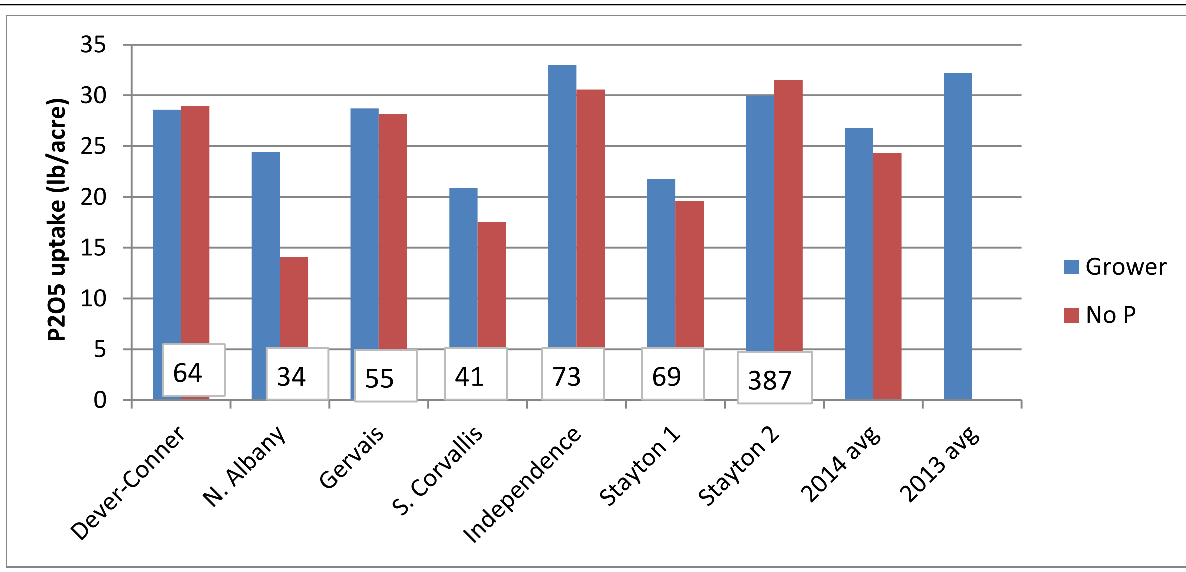

Figure 3. P2O5 uptake in aboveground biomass from a plot in each grower field receiving no P fertilizer (No P) compared to the surrounding field that received the grower standard P rate (Grower). Values in boxes represent the pre-plant soil test Bray 1 P level in ppm. For 2013 there was no uptake data for the No P plots.

Of the total P uptake, an average of approximately 48% (range 36-60) was removed in the harvested pods while the remaining 52% was cycled back into the soil (Table 4). This is slightly greater than the 41% removed in the harvested product from the 2013 plots. The residue remaining in the field after harvest had a high N content (Table 3) and will break down rapidly, releasing P back into the soil. **This residue P will contribute to the soil phosphorus pool that will be available to future crops and that will maintain or continue to increase soil test P levels.**

Table 3. P and N tissue concentrations from the 'Grower' treatment. The 'No-P' plots were excluded because there was little or no difference between the treatments.

Site	Location	% P		% N	
		Foliage	Pods	Foliage	Pods
1	Dever-Conner	0.22	0.39	2.1	2.9
2	N. Albany	0.22	0.38	2.3	2.7
3	Gervais	0.21	0.36	1.9	2.7
4	S. Corvallis	0.17	0.31	2.5	2.5
5	Independence	0.26	0.41	2.7	3.1
6	Stayton 1	0.15	0.27	2.4	2.8
7	Stayton 2	0.27	0.48	2.8	3.5
	2014 avg	0.21	0.37	2.4	2.9
	2013 avg	0.26	0.42	3.0	3.1

Table 4. P2O5 uptake in foliage and pods.

Site	Location	Foliage		Pods		Total		P removed with pods	
		Grower	No P	Grower	No P	Grower	No P	Grower	No P
		------------------------------ *lb P_2O_5/acre*					---------------------------------	% of total	
1	Dever-Conner	16	15	13	14	29	29	44	49
2	N. Albany	11	8	13	7	24	14	53	46
3	Gervais	17	16	12	12	29	28	42	43
4	S. Corvallis	10	8	11	10	21	18	51	55
5	Independence	17	15	16	16	33	31	49	52
6	Stayton 1	9	8	13	11	22	20	60	57
7	Stayton 2	19	19	11	12	30	32	36	38
	2014 avg	14	13	13	12	27	24	48	49
	2013 avg	19	NA	13	NA	32	NA	41	NA

Based on our limited data set, the critical soil test P value (the soil test P value at which a yield response to P fertilizer is unlikely) is approximately 55 ppm. The University of Idaho Extension publication, "Southern Idaho Fertilizer Guide: Beans" (CIS 1189) published in 2012, recommends that no P fertilizer should be applied when Bray 1 P is ≥30 ppm for dry bean production. However, based on our data set, this level is insufficient to obtain maximum pod yield for snap beans grown in western Oregon.

These results also demonstrate that the P fertilizer recommendations in OSU's fertilizer guide for snap beans (FG 28: Bush beans Western Oregon-west of the Cascades) are too high (Fig. 4). This data has not been updated in 30 yrs and does not reflect current production practices, cultivars, and fertilizers. Based on our data set, when soil test P (STP) is ≥55 ppm, P fertilizer can be eliminated without resulting in a yield loss. But, making recommendations for STP values below 60 ppm is a challenge because most fields in row crops have high STP values, the result of years of high application rates of P fertilizers in excess of what is removed in the harvested product.

If the soil test for P is (ppm)	Apply this amount of phosphate (P_2O_5) (lb/a)
0–15	120–150
15–60	90–120
over 60	60–90

Figure 4. P fertilizer recommendations from OSU's fertilizer guide for snap beans (FG 28: Bush beans) Western Oregon-west of the Cascades)

This data set shows the potential for significant fertilizer P savings. Although there were no significant yield responses for fields with a STP value ≥55 ppm, farmers applied an average of 110 lb P_2O_5 on these fields. Because P levels may vary within a field, growers with STP levels ≥55 ppm could apply 15-30 lb P_2O_5/acre as insurance against under-fertilizing a "weak spot" in the field. By doing so, P fertilizer use could be dramatically cut back. Also, by applying 15-30 lb P_2O_5/acre, this rate will cover what is removed in the harvested pods and will maintain current STP levels. To accomplish this, growers will need to use lower P analysis fertilizers and move away from fertilizers such as 10-34-0. **In this study, if growers with STP ≥55 ppm applied only 30 lb P_2O_5/acre, they could on average reduce P applications by 80 lb P_2O_5/acre (range 6-129).**

Nitrogen

On average total N uptake in 7 grower fields using grower standard practices was 111 lb N/A (range 92-130) (Table 5). **Of the total N uptake, an average of 39% was removed in the harvested product (pods) while 61% remained in the field.** Due to a high N content of the foliage (Table 3. avg of 2.4%) and warm summer/early fall soil temperatures, a large fraction of the residue will rapidly mineralize (~20-30% based on OSU's Cover Crop Calculator) and be converted to nitrate. This nitrate will be subject to leaching with fall and winter rains unless an N scavenging cover crop is planted. Nitrogen fertilizer applications averaged 84 lb N/A (range 47-119). Biological N fixation and soil N mineralization supplied the difference between total N uptake (111 lb N/A) and N fertilizer applications (84 lb/A). There is need for more research to determine if N fertilizer rates can be cut back based on at-planting nitrate soil tests.

Table 5. Nitrogen uptake in aboveground biomass (foliage and pods).

Site	Location	Foliage	Pods	Total	Residue N returned to soil
		------------	*lb N/A*	-----------	*%*
1	Dever-Conner	67	40	107	63
2	N. Albany	53	40	93	57
3	Gervais	63	39	103	62
4	S. Corvallis	65	38	103	63
5	Independence	76	54	130	59
6	Stayton 1	61	58	120	51
7	Stayton 2	87	34	121	72
	2014 avg	68	43	111	61
	2013 avg	98	42	140	70

Potassium

On average total K2O uptake in 7 grower fields using grower standard practices was 102 lb K2O/A (range 91-141 lbs/A) (Table 6). **Of the total K2O uptake, an average of 38% was removed in the harvested product (pods) while 62% remained in the field.** Based on soil test K levels at these fields and the rates at which farmers are apply K fertilizers, there is an opportunity to reduce K rates. Potassium usually does not get as much attention as N and P because K containing fertilizers are relatively cheap and K does not pose an environmental concern. Generally when soil test K levels are ≥ 150 ppm, the probability of a yield increase with the addition of K fertilizers is low. In our study 6 of 7 sites had >150 ppm, yet they field received an average of 97 lb K2O/acre (Table 1). Based on current recommendation (Fig. 5), 3 sites could have eliminated K fertilizer, and the remaining 3 could have reduced rates to 40-60 lb K2O/acre. **Using the current OSU recommendations, K2O rates could have been reduced on average by 75 lb K2O/acre (range 40-94).**

Table 6. Potassium uptake in aboveground biomass (foliage and pods).

Site	Location	Foliage	Pods	Total	Residue K2O returned to soil
		-------	*lb K2O/A*	-------	*%*
1	Dever-Conner	66	34	100	66
2	N. Albany	27	29	56	48
3	Gervais	59	32	91	65
4	S. Corvallis	58	36	94	62
5	Independence	69	47	116	59
6	Stayton 1	69	46	115	60
7	Stayton 2	108	33	141	76
	2014 avg	65	37	102	62
	2013 avg	87	38	124	70

If the soil test for K is (ppm)	Apply this amount of potash (K_2O) (lb/a)
0–75	90–120
75–150	60–90
150–200	40–60
over 200	0

Figure 5. K fertilizer recommendations from OSU's fertilizer guide for snap beans (FG 28: Bush beans Western Oregon-west of the Cascades)

Root rot, yield, and P uptake

The STP level at the fumigation field site was 99 ppm. As a result of the high soil test P, no yield response to the P fertilizer was observed for both the fumigated or non-fumigated treatments. Therefore, the following discussion centers only on the effect of fumigation on bean yield, and not the effect of the P fertilizer.

Although fumigation did not completely eliminate bean root rot diseases, it significantly reduced disease severity (Table 7 and Fig. 6). The fumigant did not affect root nodulation because chloropicrin is most effective on fungi and does not affect the bacteria responsible for root nodulation. In general, the roots in both treatments were firm (when squeezed between fingers they did not collapse under moderate to high pressure), but the amount of discoloration and "corkiness" (Fig. 6B) were greater in the non-fumigated treatment.

The difference in root rot disease severity had a significant effect on plant growth (Fig. 7 and Table 7). Pod and foliage yield in the fumigated plots was 61% and 90% greater, respectively, than the non-fumigated plots. That translated into a 4.8 ton/acre difference in gross pod yield between treatments. Although there was more foliage in the fumigated plots, the ratio of pods to total aboveground fresh biomass was not much greater than the non-fumigated plots (62% vs. 58% for non-fumigated and fumigated, respectively). For comparison, the ratio of pods to total fresh biomass was 51% in the unreplicated P plots, which was lower than in our research plots. Growth was also faster in the fumigated plots resulting in less #1 grade pods (1-4) (Table 7) at harvest. If the fumigated plots were harvested 1 to 2 days earlier, the grade would have been similar. The plant size and extra foliage were not so great that a commercial harvester would have issues with the extra foliage.

If the price of #1 grade pods was $250/ton, the beans in the fumigated plot would have generated $300/acre more than the beans with higher root rot. However, if the fumigated plot were harvested 1 to 2 days earlier and had the same grade, the beans in the fumigated plot would have generated $580/acre more than the non-fumigated plot.

Tissue P and P uptake are given in Table 8. Total P uptake was 17 and 27 lb P_2O_5/acre for the non-fumigated and fumigated treatments, respectively. Due to the higher P requirement for the plants with a healthier root system, when soil test P levels are lower (<50 ppm), higher P fertilizer application rates may be necessary to maximize yield when a low level of bean root rot is expected.

Table 7. Harvest characteristics for plots that were fumigated or received no fumigation. All differences between treatments for each parameter are statistically significant at P<0.001.

Treatment	Pods yield (gross)	Foliage (fresh)	#1 Grade (sieve 1-4)	#1 grade pod yield (sieve 1-4)	Pods: total fresh biomass	Root rot rating
	----------*ton/acre*--------		*%*	*ton/acre*	*%*	*% hypocotyl discolored*
Non-fumigated	7.8	4.9	47.1	3.6	62	88
Fumigated	12.6	9.3	36.8	4.8	58	55

Figure 6. A) Fumigated beans (top) and non-fumigated beans (bottom) and B) non-fumigated bean root (left) and fumigated root (right). Although the roots in the non-fumigated beans had good laterals and most of the hypocotyls were solid (did not collapse under moderate to high pressure), the hypocotyl of the non-fumigated plants had more discoloration and “corkiness”.

Figure 7. Non-fumigated plants (left) and fumigated plants (right) on July 20 (51 days after planting). The canopy in the non-fumigated plots did not completely close by harvest.

Table 8. Tissue P and P uptake in plants at harvest for plots that were fumigated and non-fumigated. All differences between treatments for each parameter are statistically significant at P<0.01 or greater except for tissue P in the pods.

Treatment	P (foliage)	P (pods)	P (foliage)	P (pods)	Total P uptake
	% of DM		*------------ lbs P_2O_5/A ----------------*		
Non-fumigated	0.16	0.32	7	10	17
Fumigated	0.15	0.31	11	16	27

4. BUDGET DETAILS

Budget

Expenses		Year 1	Year 2
Salary and benefits	Aaron Heinrich (FRA)	6750	5000
	OPE (67%)	3470	3350
Wage and benefits	Summer labor ($11/hr for 120 hrs)	900	1320
	OPE (8%)	72	141
Equipment:	Data loggers	200	0
Supplies	Fertilizer	40	100
Travel	To and from field sites	300	520
Plot fees	Land rental OSU Veg farm (1A @ $1385/A)	0	1385
Other	Commercial fumigation	-	1500
	Complete soil analysis (11*$13/sample)	-	143
	NPK plant tissue (30*$11/sample)	-	330
	P only plant tissue (64*$5/sample)	-	320
	2013 lab analysis	1001	-
	Total:	**$12,733**	**$14,109**