2017 - 2018
Research Reports
for
Oregon Processed Vegetable Commission

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Oregon Processed Vegetable Commission Research Reports on 2017-18 Funded Work

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OPVC CONTINUING PROJECT REPORT: YEAR 2017

1. OPVC REPORT COVER PAGE (maximum 2 pages)

OPVC Project Number:

Project Title: Broccoli Breeding and Evaluation

PI: James R. Myers
Organization: Oregon State University
Telephone: 541-737-3083
Email: james.myers@oregonstate.edu
Address: ALS 4017, Department of Horticulture
City/State/Zip: Corvallis, OR 97331

Total Project Request (all years):
Year 1: $7,068 (breeding)
$4,977 (processing)
$12,045 (total)

Other funding sources: none

2. EXECUTIVE SUMMARY (ABSTRACT): Processors need broccoli with better quality traits than what is available in cultivars developed for California and Mexico fresh markets. Farmers need to reduce labor costs of broccoli production by mechanizing harvest. Most contemporary commercially available cultivars are not suitable for either mechanical harvest or processing. The objective of the OSU broccoli breeding program is to develop broccoli varieties adapted to western Oregon with suitable quality and high yields. The program operates on a one year cycle where cuttings from the field are taken into the greenhouse in the fall where they are rooted and hand crossed and self-pollinated to produce seed for the next generation. Seed is harvested in May and June and used to plant trials for fall evaluation.

A yield trial consisting of seven experimental hybrids, two commercial checks and two commercial experimental hybrids were grown. Two new OSU inbreds (S471 and S473) were used in some hybrid combinations and these were among the best in terms of yield and quality Most OSU experimental broccoli hybrids had similar yields to existing commercial hybrids, but had more desirable characteristics for processing. We measured floret:stem ratio and generally found it to be higher in OSU experimental hybrids than commercial hybrids. These hybrids produce relatively more florets and less of the economically undesirable stem than commercial checks. S471 in particular appears to have very favorable attributes in its own right and combines well with some older OSU inbreds. An observation trial with 11 advanced inbred lines, 18 segregating inbreds and 12 cytoplasmic male sterile lines was grown and evaluated for horticultural traits in the field. Four isolation plots for hybrid seed production were established in the field, but seed production was poor mainly due to plants flowering during the heat of summer. In 2016, we contracted with P & R Seeds to scale up hybrid seed production of one hybrid (O446/S454) for eventual field production in Oregon. Seed of the inbreds (S446, S454 and O446) were increased by a grower in Chile in 2016 and hybrid seed production was happening in 2017 with a delivery date of winter, 2018. This work is also complementary to an ODA Specialty Crop Block Grant that was obtained in 2016 to develop a robotic harvesting system for direct harvest of broccoli for processing.

3. FULL REPORT (no maximum)

3.a. BACKGROUND

Mechanization has reduced labor costs in many crops, but broccoli and cauliflower remain relatively non-mechanized. Large labor crews are typically needed to harvest the crops. Cost and access to labor are the two biggest problems for broccoli harvest – cost in terms of wages to workers and access in that other crops such as blueberries need labor for harvest at the same time as broccoli. Some progress has been made towards mechanizing the process both in Europe and the U.S., but problems remain in creating a cost-competitive approach. The OPVC was awarded a USDA Specialty Crop Block Grant in 2016 to automate broccoli harvest through the addition of a robotics approach attached to existing prototype harvesters. While machinery is part of the equation, the other two parts are the broccoli plant (genotype) and the production system (environment). The OSU Vegetable Breeding Program has for many years, been working on cultivars that are suitable for mechanized harvest and with traits preferred by processors.

Most broccoli cultivars are not well suited for mechanical harvest. The two key factors in developing cultivars that are suitable are uniform heading and appropriate plant architecture. Most commercially available broccoli hybrids are high yielding but have short plants with heavy and poorly exserted heads. Short plants have high fiber in the portion of the stem subtending the head that must be used to achieve a normal-length cut. The lack of height as well as the high fiber makes them unsuitable for machine harvest.

In addition to direct harvest characteristics, processors need broccoli that makes a high quality pack. Florets and stems need to be dark green in color and should be uniform in color and shape; beads should be small, and retained during the blast freezing process. An added benefit to dark green color that we recently discovered is that darker color is associated with higher carotenoid (compounds such as pro-vitamin A) levels. Heat tolerance, and resistance to bacterial head rot, downy mildew, and club root is also desirable. Inbred lines from the Oregon State University breeding program have the genetic potential to create hybrids with greatly improved head exsertion and segmentation, better color, and low fiber. The OSU hybrids are suitable for machine harvest, and some inbreds possess some of the already discussed disease resistance characteristics.

Many OSU hybrids are high quality and have shown stable, high yields over several years and it appears now that the major limitation to achieving commercial seed production of hybrids is the scaling up of hybrid seed production using cytoplasmic male sterility or self-incompatibility. There is also a need to derive new inbreds with improved disease resistance. Using off-season production in Chile and with funds from the Specialty Crop Block Grant, we are producing large quantities of seed of the experimental hybrid O446 x S454. We plan to release this hybrid under the name 'Cascadia'.

3.b OBJECTIVES

1. Develop broccoli varieties adapted to western Oregon with suitable quality, high yields, and disease resistance including concentrated and uniform yield potential, large heads that are well exserted and have minimal leaf development on stems, firm, uniform florets of dark green color, and fine beads with short pedicels, which are retained after freezing.

2. Develop seed production systems using cytoplasmic male sterility (CMS) or self-incompatibility (SI) to produce field scale quantities of F_1 hybrid seed.

3. Scale up seed production to facilitate wider testing of OSU hybrids.

3.c. SIGNIFICANT FINDINGS.

- Most OSU experimental broccoli hybrids have similar yields to existing commercial hybrids, but have more desirable characteristics for processing.
- In general, the floret:stem ratio is higher in OSU experimental hybrids than commercial hybrids.
- S471 is a new inbred to the program and appears to have very favorable attributes in its own right and combines well with some older OSU inbreds.

3.d. METHODS. The broccoli breeding program follows a one year breeding cycle. Cuttings from hybrids and inbreds are brought from the field in the fall and rooted in the greenhouse. Upon flowering during the winter, inbreds are bud pollinated to self-pollinate them and crossed with other inbreds to produce inbreds and F_1 hybrids for testing.

We continued to derive new inbreds through 4 - 6 generations of self-pollination, and are using these on a small scale to produce F_1 hybrid seed for replicated yield trials. Inbreds lines saved from the 2016 growing season were grown from cuttings in the winter 2017 greenhouse. These were bud-pollinated to perpetuate the line, and crossed to other inbred lines to evaluate combining ability for F_1 hybrid production. Crossing efforts were focused on obtaining enough seed for replicated field trials of new hybrid combinations.

Transplants of inbreds and breeding lines are started from seed produced in the greenhouse and planted in the field. Inbreds and experimental hybrids and commercial hybrids were grown in an observation trial in the main fall planting in the field (Tables 1 & 2). Plots were evaluated for head size, shape, firmness, exsertion, segmentation, floret texture and color, maturity and head rot resistance (Table 3), and plants were selected in early generation plots.

A replicated main fall season yield trial of seven of the most promising OSU experimental hybrids, two commercial check hybrids and two commercial experimental hybrids was grown (Tables 4 & 5). These were transplanted 28 July into one row plots 30 feet in length and replicated four times with in-row spacing of 12 inches. In addition to observation data, yield data was obtained. Heads from the plots were trimmed to a 6.5 inch length and weighed, after which leaves were stripped from the heads and heads were again weighed. Leaf percent was calculated from this data. Heads were sorted for those that were judged too young and small for the floretting process in the plant, and those that were culls (mostly too mature). A set of 10 heads were evaluated for diameter and hollow stem, and a subset of five heads was floretted and florets and stems weighed separately. Floret and stem weight data was used to calculate a floret:stem ratio. Entries in the yield trial were taken to the OSU pilot processing plant for blanching and freezing. Frozen material was evaluated at the OSU winter cutting and was displayed at the PNVA meetings in Kennewick, WA in November, 2017. Data collected from the field included total number of plants and number that were “blind”, leaf and head height, head shape, bead size, stem color, exsertion, segmentation, uniformity, and branching. A ratio of head height:leaf height was calculated and a desirability score was derived by taking the geometric mean of many of the observation traits (see table 5 for details of calculations).

Backcrossing of selected hybrids to place the nuclear genome in the Ogura and Arnund cytoplasmic male sterile (CMS) backgrounds continued (Table 2). We focused mainly on the inbreds S454, S462, S463 and S473. Seed production of selected hybrid combinations using a fertile inbred as a male and a CMS inbred as a female were evaluated in the field using four isolation plots (three at the Vegetable Research Farm, one at the Lewis Brown Farm).

3.e. RESULTS & DISCUSSION *Greenhouse inbred and hybrid seed production:* Cuttings were taken from inbreds and breeding lines grown in the field in 2016 to establish material for crossing and hybrid seed production in the greenhouse during the winter of 2016-2017. Forty-nine selections were taken for rooting with most of these surviving to be potted for crossing. These will be bud pollinated by hand to self the inbreds and produce seed for the 2018 growing season. A list of the inbreds and breeding lines (along with pedigrees) with harvest instructions shown in Tables 1 & 2. Most lines are highly inbred but a few are still segregating and showing significant variation in the field.

Observation Trials: The observation trial included 11 highly inbred lines, 18 lines still undergoing inbreeding and selection, and 12 Ogura cytoplasmic male sterility (CMS) lines at various stages of backcrossing to selected inbreds (Table 3). These were evaluated at heading for various traits important to processing including number of blind plants, various head characteristics (color, bead size, segmentation) and plant characteristics (head exsertion, branching, uniformity and overall performance). Because of rains in October when heads were maturing, we were also able to rate the lines for head rot, and did observe and discarded several inbreds with head rot symptoms. We also made selections for cuttings for greenhouse production, and in part, selected single plants on the basis of reduced head rot. In all, one advanced generation inbred was discarded, 10 intermediate generation inbreds were eliminated, and one CMS inbred was discarded prior to collecting cuttings for greenhouse propagation.

Yield Trial: The yield trial consisted of seven experimental hybrids including Cascadia (labeled as S446 x S454 in tables 4 & 5), and the commercial checks 'Arcadia' and 'Emerald Pride'. Two additional commercial hybrids were supplied; 'Eastern Magic' from Sakata and 'Monflor' from Syngenta. Monflor was the earliest to mature in the trial. This hybrid is unusual in its degree of exsertion and segmentation. Arcadia was highest in net T/A yield followed by SS471 x S463 and Eastern Magic. S473 x S454 (a new hybrid combination) had the lowest yield and head size with most other experimental hybrids falling between these two extremes (Table 4, Fig. 2). Percent leaves in the head was highest for Eastern Magic, but was surprisingly low for other commercial check cultivars. In particular, Arcadia was late maturing and was past prime when harvested, which may account for the low percent leaf observed. In general, the OSU experimental lines had significantly higher floret:stem ratio compared to Eastern Magic and Emerald Pride (Table 4, Figs. 1 & 2). If head weight and floret weight were directly related in broccoli, we would expect to see a negative linear relationship between yield and floret weight. There was no discernable relationship between net T/A and floret:stem ratio (Fig. 2). In general, most OSU experimental hybrids have heads similar in weight to commercial hybrids, but a greater proportion of the head weight is in the more economically valuable florets (Fig. 1). Among new inbreds tested in hybrid combinations for the first time was S471. This inbred has many very favorable attributes (Table 3). It was derived from an open pollinated population that was bred and selected under organic production systems for many years as part of the Northern Organic Vegetable Improvement Collaborative project. It did not combine particularly well with S462, but when combined with S454 and S463, the hybrids performed very well. S461 x S471 had relatively high yield in the trial, while S471 x S454 had some of the best quality and all round favorable combination of field and processing traits.

Hybrid Seed Production: Seed production from isolation plots was low in 2017. This was mainly due to a very hot and dry July and August when plants were flowering. This year, we started inbreds from seed in the greenhouse with the intent to transplant to the field early in the season, but were delayed by rains during the spring. We had excellent seed production in 2016 with the main difference being that inbreds taken to the field were propagated from cuttings, not seeds. Plants grown from cuttings flower immediately, whereas those grown from seed have an extended vegetative period. In 2018, we plan to use cutting propagated plants for seed production as this allows flowering to occur when temperatures are optimal for seed development.

Off-season commercial seed production: In 2016, approximately 200 seeds each of S454, S446 and O446 seeds were provided to Peter Mes of P & R Seeds, who contracted with a custom seed production firm in Chile to first increase inbred lines, then to produce hybrid seed using the cross combination of O446 x S454. In 2016 the seeds were sown in small caged plots and hand pollinated to provide maximum yield of parent seed stock. Plants were sown in April, Transplanted in May, pollinated in November, with seed harvest in January (2017). A similar cycle of production occurred in 2017 with the inbreds being grown to produce F_1 hybrid seed of 'Cascadia'. Harvest of the F_1 hybrid seed is expected to occur in January of 2018 and we are anticipating approximately 20 kg of seed to be available. These seeds will be available for both small scale testing and large scale production in Oregon for the 2018 growing season.

4. BUDGET DETAILS

1) Breeding (Myers)

Salaries and benefits	
Faculty Research Assistant, field, full time	$2,345
OPE @ 70%	$1,641
Wages and benefits	
Student Wages	$1,230
OPE @ 12%	$148
Supplies	$300
Land use and greenhouse rental	$1,405
Total	$7,068

2) Processing (Yorgey)

Salaries and benefits	
Senior Faculty Research Assistant	$2,796
OPE @ 61.45%	$1,718
Wages and benefits	
Student Wages	$246
OPE @ 12%	$30
Supplies	$187
Total	$4,977
Grand Total	$12,045

BUDGET NARRATIVE

Salary and OPE is requested for a full time faculty research assistant who will commit approximately 6% FTE to broccoli breeding The remainder of salary will come from other sources. For the senior faculty research assistant, approximately 5% FTE will be required to process broccoli samples; the remainder of salary to come from other sources. $1,230 is requested for a summer undergraduate student to assist in plot maintenance and harvest operations. The SFRA will also supervise an undergraduate student in broccoli processing. Undergraduate student OPE is 12%. Funds for services and supplies includes $300 for field and greenhouse supplies ((fertilizer, pots, labels, stakes, tags, crossing supplies, envelopes, paper bags, etc.). Facilities user charges include land use rental (0.5 acre at $1,259 per acre = $630), and greenhouse rental ($1.55*500 sq. ft. = $775).

Table 1. Inbreds and breeding lines grown in the field at the OSU Vegetable Research Farm in 2016.

Line	Previous no.	Pedigree	Harvest
S411	88-76-4-1-2	HS179-1/S240-11-8	Mass
S442	91-203-2-3-1-1	S352/S240-11-8	Mass
S445	91-203-2-3-1-5	S352/S240-11-8	Mass
S446	91-203-2-3-2-1	S352/S240-11-8	Mass
S454	91-232-4-1-2-1	S233/Emerald City	Mass
S457	04-3-2-2-3	S454 /S387/S411/S446	Mass
S460	04-4-1-1-3	S411/S446/S454 /S387	Discard
S462	04-4-2-2-1	S411/S446/S454 /S387	Mass
S463	04-5-2-2-1	S454 /S446/USVL 089	Mass
S465	04-5-2-2-3	S454 /S446/USVL 089	Mass
S466	11-1-1-1-2	S446/S460	Mass
S469	11-2-1-1-1	S454/RS2	Mass
S471	09-1-1-3-1-2-2	OSU OP Selection	Mass
S473	09-1-3-1-1-1-1	OSU OP Selection	Mass
S474	09-1-1-3-1-1-1	OSU OP Selection	Mass
S475	09-1-1-3-1-1-2	OSU OP Selection	Mass
S479	(S446/S457)-1-1-2-3	S446/S457	Mass
S480	(S463/S446)-1-1-1-1	S463/S446	Mass
--	(S454/S445)-1-1-1-1	S454/S445	Discard
--	(S454/S445)-1-1-1-2	S454/S445	1 SP
--	(S454/S445)-1-1-1-3	S454/S445	Discard
--	(S454/S445)-1-1-1-4	S454/S445	Discard
--	(S454/RS2)-2-1-1-2-1	S545/RS2	Discard
--	(S454/RS2)-2-1-1-2-2	S545/RS2	1 SP
--	(S454/RS2)-2-1-1-2-4	S545/RS2	Discard
--	(S454/RS2)-2-1-1-2-6	S545/RS2	1 SP
--	(S458A/S446)-1-1-1-1	S458A/S446	1 SP
--	(S458A/S446)-1-1-1-2	S458A/S446	Discard
--	(S458A/S446)-1-1-1-3	S458A/S446	Discard
--	(S458A/S446)-1-1-2-1	S458A/S446	Discard
--	(S458A/S446)-1-1-2-2	S458A/S446	Discard
--	(S458A/S466)-1-3-1-1	S458A/S446	Discard
--	(S458A/S446)-1-3-1-2	S458A/S446	4 SP
--	(S458A/S446)-1-3-1-3	S458A/S446	3 SP
--	(S458A/S446)-1-3-1-4	S458A/S446	1 SP
--	(S468/S446)-1-2	S468/S446	1 SP

Table 2. Cytoplasmic male sterile broccoli inbreds grown at the OSU Vegetable Research Farm in 2017.

Line no.[z]	Pedigree	Harvest
A463/S463	(A411*3-1/S463)-2//S463	Mass
O462-1*3	O446*1-1/S462-1//S462///S462	5 Mass
O463-1*1	(O446*3/S446)-2/S463	Mass
O473-2*1	(O446*3/S446)-2/S473	Mass
O463-3*1	(O446*3/S446)-3/S463	Mass
O463-4*1	(O446*3/S446)-4/S463	Mass
O473-3*1	(O446*3/S446)-3/S473	Mass
O473-4*1	(O446*3/S446)-4/S473	Mass
O454-1*1	(O446*1-1/S462-1//S462)-1/S454	Mass
OS462-2*3	(O446*1-1/S462-2//S462)-1///S462	Mass
O454-2*1	(O446*1-1/S462-2//S463)-1/S454	Mass
O454-3*1	(O446*1-1/S462-2//S463)-1/S454	Mass
O465-1*2	(O446*1-1/S465)-2//S465	Discard
O465-2*2	(O446*1-1/S465)-2//S465	1 SP
O473-1*1	(O446*3/S446)-3//S473	Mass
O463-5*1	(O446*3/S446)-4/S463	Mass

[z]"A" indicates Arnund CMS background; "O" indicates Ogura CMS background.

Table 3. Observation trial of broccoli inbreds and early generation lines transplanted 7/28 and grown at the OSU Vegetable Research Farm in 2017.

Entry	Date	No. Plants	Exser -tion	Head shape	Branch depth	Bead size	Head color	Head dia. (cm)	Head firm- ness	Unifor- mity	Over -all	Notes
S445	Oct-14	24	7	5	7	f	5	18	7	7	7	Small florets highly segmented
S454	Oct-14	23	9	4	7	m	7	15	6	5	7	Head rot
S462	Oct-14	21	7	5	7	m	7	16	9	5	7	
S463	Oct-24	20	7	6	5	m	7	12	8	5	7	
S466	Oct-26	22	7	6	5	m	7	13	9	7	8	Fairly tall and leans.
S469	Oct-16	23	8	9	5	m	8	14	8	5	6	Small heads , leaners
S471	Oct-21	25	8	5	5	f	5	18	9	7	9	Very attractive. Large firm heads with fine beads. Holds well.
S473	Oct-16	21	9	3	9	f	7	20	5	7	5	Large loose deeply branched flat heads
S475	Oct-26	22	7	4	5	f	5	20	8	7	8	Leafy heads
S479	Oct-26	23	8	7	9	f	9	14	7	9	5	Nice broccoli but many tiny leaves in heads.
S480	Oct-26	22	7	6	7	c	7	15	3	8	5	Notes on glossy form. Mix of glossy dissected leaf type & waxy entire leaf type. Waxy removed.
(S454/RS2)-2-1-1-2-1	Oct-30	15	7	7	9	f	7	15	9	5	5	Many tiny leaves in heads and deeply branched.
(S454/RS2)-2-1-1-2-2	Oct-26	25	8	7	6	f-m	7	14	9	7	7	Many tiny leaves in head.
(S454/RS2)-2-1-1-2-4	Oct-26	23	7	8	7	f	7	15	9	8	5	Many tiny leaves in head.
(S454/RS2)-2-1-1-2-6	Oct-26	19	7	7	5	f	7	11	9	7	7	Most with many tiny leaves in head.
(S454/S445)-1-1-1-1	Oct-26	11	6	5	5	m	7	14	8	7	3	Much head rot
(S454/S445)-1-1-1-2	Oct-18	23	7	5	7	m	9	14	7	3	5	Earliest of set but significant head rot.
(S454/S445)-1-1-1-3	Oct-26	23	8	6	7	m	7	16	8	8	5	Lots of head rot

Table 3 (continued).

Entry	Date	No. Plants	Exser -tion	Head shape	Branch depth	Bead size	Head color	Head dia. (cm)	Head firm-ness	Unifor-mity	Over -all	Notes
(S454/S445)-1-1-1-4	Oct-24	17	8	7	7	m	7	13	5	9	5	Lots of head rot, soft heads.
(S458A/S446)-1-1-1-1	Oct-26	23	6	5	7	f	7	18	9	9	5	S446 habit highly segmented with small florets and large domed heads. Lots of head rot.
(S458A/S446)-1-1-1-2	Oct-26	24	6	4	5	f	5	21	9	8	3	Short but large heads. Many leaners and lodged.
(S458A/S446)-1-1-1-3	Oct-26	23	5	4	5	f	7	16	9	7	3	Many lodged in this and next plot. Lots of head rot.
(S458A/S446)-1-1-2-2	Oct-26	23	6	3	8	vf	7	19	9	5	3	Lots of lodging
(S458A/S446)-1-3-1-1	Oct-22	20	8	6	9	m	7	16	8	7	3	Lots of lodging
(S458A/S446)-1-3-1-2	Oct-18	22	8	6	3	f	5	15	9	7	8	Not so many leaners.
(S458A/S446)-1-3-1-3	Oct-18	24	7	6	7	f	9	17	7	5	8	
(S458A/S446)-1-3-1-4	Oct-18	22	7	5	7	f	3	18	5	8	7	
(S468/S446)-1-1	Oct-16	23	8	6	5	f	7	15	7	8	8	
O446*1-1/S462-1//S462///S462	Oct-16	22	8	6	7	m	7	16	5	7	8	CMS
(S468/S446)-1-2	Oct-16	8	7	7	7	f	7	13	7	7	8	
A463/S463	Oct-26	24	7	7	7	m	7	14	8	3	5	CMS
(O446*3/S446)-2/S463	Oct-26	25	7	6	8	m	5	14	7	7	6	CMS
(O446*3/S446)-2/S473	Oct-22	23	7	5	9	m	7	18	8	6	9	CMS
(O446*3/S446)-3/S463	Oct-26	23	8	6	5	mc	6	12	8	5	7	CMS
(O446*3/S446)-4/S463	Oct-26	11	8	8	7	m	7	16	7	5	7	CMS

Table 3 (continued).

Entry	Date	No. Plants	Exser -tion	Head shape	Branch depth	Bead size	Head color	Head dia. (cm)	Head firm-ness	Unifor-mity	Over -all	Notes
(O446*3/S446)-3/S473	Oct-16	24	7	6	7	f	7	15	7	5	6	CMS. Very tall plants
(O446*3/S446)-4/S473	Oct-18	24	7	5	7	f	5	12	6	5	6	CMS. Tall w/ softer heads
(O446*1-1/S462-1//S462)-1/S454	Oct-16	18	8	4	7	f	5	15	5	7	7	CMS
(O446*1-1/S462-2//S462)-1///S462	Oct-16	27	6	5	7	mc	7	13	6	8	5	CMS. A lot of leaners in this plot. large heads
(O446*1-1/S462-2//S463)-1/S454	Oct-15	20	8	5	7	m	9	14	5	9	6	CMS. Head rot.
(O446*1-1/S462-2//S463)-1/S454	Oct-16	3	7	5	5	m	3	?	8	9	8	CMS
S465*1-1/S465	Oct-26	24	5	6	7	c	7	12	9	7	5	Very late.
S465*1-2/S465	Oct-28	23	7	6	5	c	7	10	9	5	5	Identical to above but ck for CMS.

Table 4. Broccoli yield trial of experimental hybrids and commercial checks grown at the OSU Vegetable Research Farm in 2017 (transplanted 7/28).

Entry	Days to harvest	Total Wt. (T/A)	Total head wt. (T/A)	Leaf Wt. (T/A)	No. heads/ A	Head dia. (cm)	Hollow stem (%)	Young heads (no./A)	Young heads (T/A)	Cull heads (no./A)	Cull heads (T/A)	Net heads (no./A)	Net heads (T/A)	Leaf (%)	Floret : stem ratio
Arcadia	73	6.8	6.7	0.1	15,048	15.2	16.7	1,395	0.22	576	0.22	13,077	6.2	1.8	58.5
Eastern Magic	65	8.0	6.1	1.9	15,827	13.9	22.5	2,033	0.39	0	0.00	13,794	5.7	25.0	52.1
Emerald Pride	60	5.7	5.4	0.3	15,101	15.4	35.0	1,162	0.20	0	0.00	13,939	5.1	6.3	52.5
Monflor	55	4.8	4.5	0.3	14,520	13.6	60.0	2,178	0.28	145	0.04	12,197	4.2	5.4	56.0
S446 x S454	69	4.3	4.3	0.1	13,068	14.1	25.0	1,888	0.22	0	0.00	11,180	4.1	1.6	58.7
S446 x S462	73	5.4	5.4	0.0	13,649	14.2	62.5	290	0.04	145	0.03	13,213	5.3	0.7	59.5
S471 x S454	63	5.3	5.0	0.2	14,375	15.7	77.5	726	0.12	0	0.00	13,649	4.9	4.6	59.6
S471 x S462	63	4.0	3.7	0.3	14,084	14.0	35.0	2,033	0.32	0	0.00	12,052	3.4	8.9	60.7
S471 x S463	76	6.3	6.2	0.1	14,375	15.8	17.5	145	0.02	290	0.10	13,939	6.1	1.3	61.6
S473 x S454	63	4.1	3.9	0.1	13,504	13.7	37.5	2,033	0.37	436	0.13	11,035	3.4	3.4	62.0
S475 x S454	65	5.0	4.8	0.2	13,794	14.4	72.5	1,742	0.26	0	0.00	12,052	4.5	5.0	63.3
LSD 0.05	0	1.2	1.4	0.4	1,828	1.3	31.7	1,356	0.22	369	0.11	2,449	1.5	6.6	3.4

Table 5. Field notes from a broccoli yield trial grown at the OSU Vegetable Research Farm in 2017.

Entry	No. plant /plot	No. blind/ plot	Days to harvest	Leaf ht. (cm)	Head ht. (cm)	Ratio head ht.:leaf ht.	Head shape[z]	Bead size[y]	Stem color[x]	Exsert -ion[x]	Head segmenta -tion[x]	Plot uniform -ity[x]	Branch -ing[x]	Desira- bility score[w]
S446 x S462	30	2.8	73	66.3	69.5	1.05	4.8	3.0	7.0	9.0	8.0	7.3	3.0	6.1
S471 x S454	30	2.0	63	65.3	64.8	0.99	5.0	3.0	6.3	8.0	7.0	6.5	2.5	6.1
S475 x S454	29	2.5	65	63.5	60.8	0.96	4.3	2.5	7.3	7.5	7.3	6.5	3.0	5.8
S471 x S463	30	2.5	76	71.0	62.8	0.89	4.5	3.0	7.0	7.8	7.5	6.5	3.0	5.7
Arcadia	30	0.5	73	67.5	54.8	0.81	5.8	4.0	5.0	6.0	5.8	7.3	1.0	5.7
S446 x S454	29	2.8	69	65.3	63.3	0.98	6.0	3.0	6.5	7.3	7.0	5.0	3.0	5.7
S471 x S462	29	2.5	63	61.5	59.3	0.97	5.3	3.3	6.5	7.8	7.0	4.5	3.0	5.5
Monflor	30	2.0	55	65.0	54.0	0.83	2.5	3.0	7.0	7.0	8.5	6.0	1.5	5.5
S473 x S454	30	6.0	62	68.5	73.0	1.07	4.0	3.0	5.8	8.8	6.5	4.5	7.0	5.1
Emerald Pride	30	0.5	59	53.5	38.0	0.71	5.0	3.0	5.0	4.0	3.0	5.0	1.0	4.9
Eastern Magic	30	0.0	65	66.8	35.0	0.52	7.0	3.8	5.0	3.0	1.5	7.0	1.0	4.4
LSD 0.05	2	2.3	1	6.1	4.7	0.11	0.7	0.4	1.1	1.0	1.2	1.9	0.6	0.6

[z]Scale of 1 - 9 where 1 = concave, 3 = flat, 5 = slightly domed, 7 = moderately domed, 9 = highly domed; [y]Scale of 1 - 7 where 1 = very fine, 3 = fine to medium, 5 = medium to coarse, 7 = very coarse; [x]Scale of 1 - 9 where 1 = lighter/lower/worst and 9 = darkest/highest/best; [w]Geometric mean of inverse of ratio blind:total plants, inverse of days to harvest, head height, ratio head ht.:leaf ht., head shape, inverse of bead size, stem color, exsertion, segmentation, and uniformity.

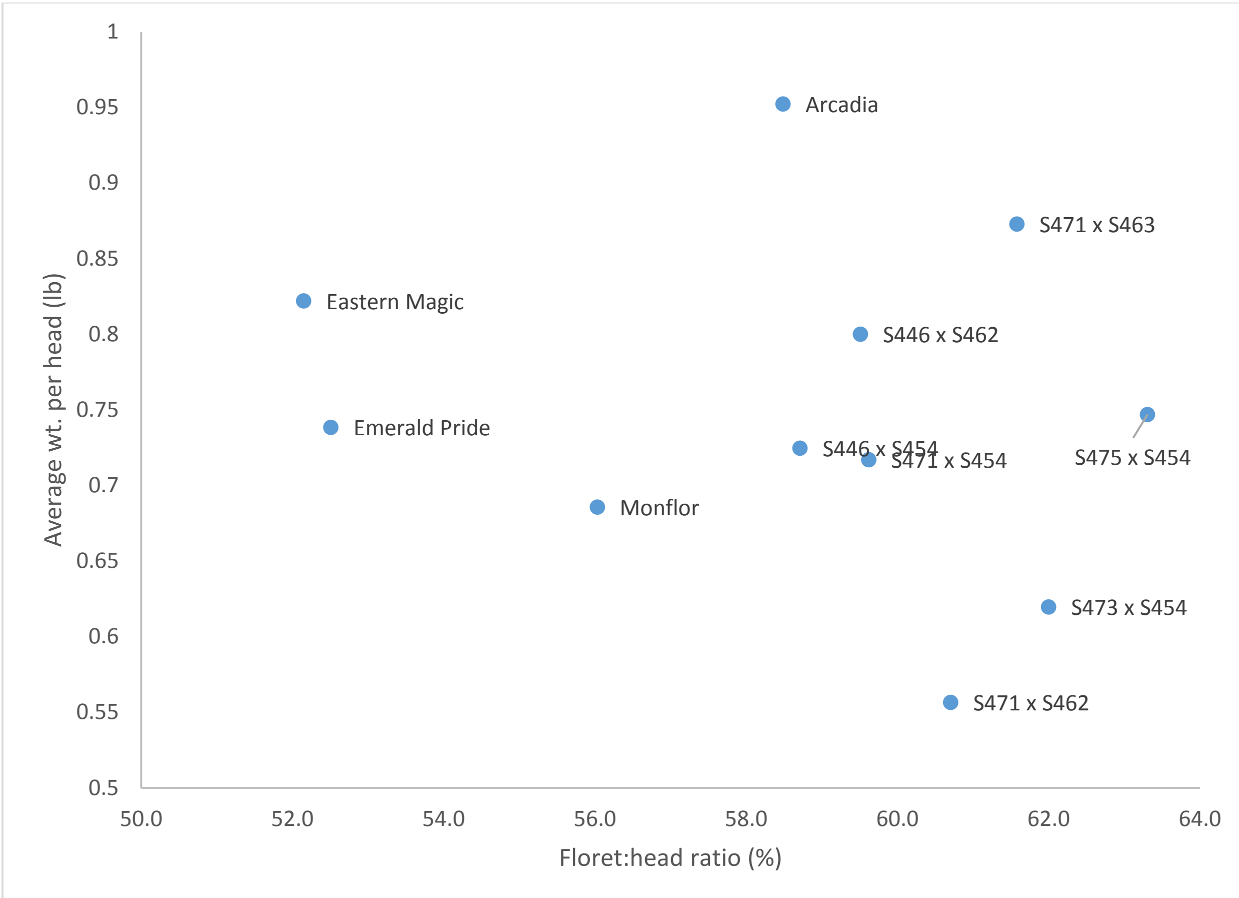

Figure 1. Floret:head ratio vs. weight per head of broccoli experimental hybrids and commercial cultivars grown in a yield trial at the OSU Vegetable Research Farm in 2017.

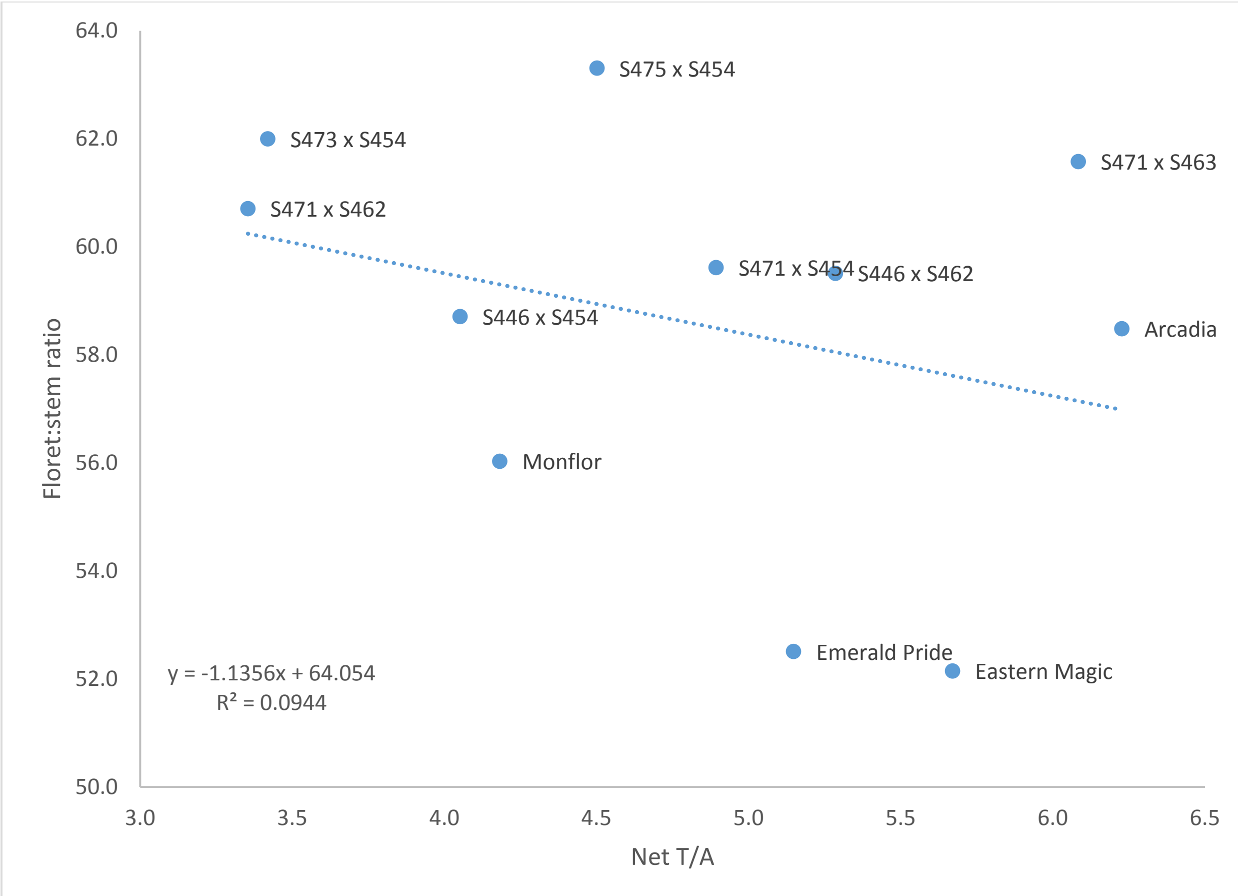

Figure 2. Net T/A yield vs. floret:stem ratio for broccoli experimental hybrids and commercial cultivars grown in a yield trial at the OSU Vegetable Research Farm in 2017.

OPVC CONTINUING PROJECT REPORT: PROJECT YEAR: *2017*

1. OPVC REPORT COVER PAGE (maximum 2 pages)

OPVC Project Number:

Project Title: Green Bean Breeding and Evaluation

PI: James R. Myers
Organization: Oregon State University
Telephone: 541-737-3083
Email: james.myers@oregonstate.edu
Address: ALS 4017, Department of Horticulture

City/State/Zip: Corvallis, OR 97331

Co-PI: Brian Yorgey
Telephone: 541-737-6496
Email: brian.yorgey@oregonstate.edu
Address: Wiegand Hall, Department of Food Science and Technology

Total project request (all years):

Year 1: $27,072 breeding
$7,501 processing
$34,573 total

Contributions from the OSU breeding program

Year 1: $18,896

Other funding sources: None

2. EXECUTIVE SUMMARY (ABSTRACT): Oregon is a major producer of processed green beans, and cultivars are needed that are adapted to western Oregon. The types that have traditionally been used are the bush blue lake (BBL) green beans with high yields, excellent processing quality. On the other hand, they need improvement in plant architecture, and disease resistance (especially to white mold and root rots). Further complicating the breeding process, BBL types are genetically isolated from other green beans. The primary objective of the OSU green bean breeding program is to develop high yielding and high quality BBL green beans with high levels of white mold resistance. In 2017, two yield and processing trials of OSU experimental advanced lines were conducted. The first had 19 check and experimental lines of the full sieve pod size class, while the second consisted of 15 extra fine and small sieve checks and experimental lines. A third trial with 21 entries from OSU and commercial seed companies was also grown and evaluated. Advanced breeding lines were evaluated for white mold disease. A nested association mapping population based with common parent WM904-20-4 was evaluated for white mold resistance in the field. A genome wide association study was conducted using two snap bean diversity panels (total of 376 cultivars) identified 146 significant associations with disease reaction distributed across the snap bean genome in 39 regions. Twenty-five new QTL were discovered. In the Unidor/OSU5630 recombinant inbred population, a single QTL for white mold resistance was identified on Pv03. In the early generation nursery, 1,688 plots of populations and lines at various stages of inbreeding were grown. In these nurseries, 176 plots were massed, 543 single plants were selected from individual plots and 59 populations were advanced by single pod descent. Six Unidor recombinant inbred populations in the F_5 with a total of 1,065 families was grown to produce seed for white mold

screening in 2018. Three advanced green bean lines (OSU 6835, OSU 6993, and OSU 6996) were found to possess the best combination of productivity, pod quality, and white mold resistance.

3. FULL REPORT (no maximum)

3.a. BACKGROUND Green beans grown for canning and freezing in the Willamette Valley contribute about $14 million to the Oregon state economy each year. The industry produces a high quality product with the unique flavor, color, and appearance based on the Bush Blue Lake (BBL) class of green beans. The growing environment in Western Oregon is different from any other green bean production area in the United States. Developing productive varieties that are adapted to this area requires the attention of a substantial breeding effort in Western Oregon. BBL green beans have higher yield potential than those typically bred for the Midwestern U.S. They also have unique flavor and quality characteristics that are hard to match. Another factor contributing to pod quality is that BBL beans typically have the lowest fiber pods (equivalent to Romano beans and much less than most Midwest and fresh market types). A tradeoff of the higher yields is that BBL beans allocate fewer resources to vegetative growth, which can compromise plant architecture and lead to lodging when pod loads are heavy. Lodging and low fiber content contributes to susceptibility to white and gray mold by BBL types.

White mold disease caused by *Sclerotinia sclerotiorum* is a pathogen of more than 400 species of plants including snap bean. Not only does it cause yield loss, but it can adversely affect pod quality and cause rejection of whole lots at the cannery if moldy pods in the lot exceeds 3%. The growing environment in western Oregon is favorable to disease development, especially during the fall when cooler and higher humidity conditions persist. The disease is mainly controlled by fungicide application, which requires precise timing and can be expensive especially if two sprays are required. Biological control also has potential but has not been implemented on a wide scale.

Genetic resistance is the most efficient means of achieving control of white mold disease. Incorporating resistance to white mold transfers the cost of controlling this disease from external inputs to that of the seed, thereby reducing costs to growers and improving quality in the processing plant. While partial resistance is known there are challenges to successful deployment. First, the genetic factors conditioning resistance generally have small individual effect and are strongly influenced by the environment (in this respect, white mold resistance shows many similarities to the genetic control of yield). A number of resistance factors are known but these are in different varieties, many of which are not snap beans. Our recent work involving meta-QTL analysis revealed 17 factors contributing to resistance distributed throughout the bean genome, and in new research, we found in a genome wide association study that 39 regions of the bean genome confer resistance in panels of 146 and 376 snap bean cultivars. We think that these factors are additive – the more resistance factors a bean variety has – the more resistant that variety will be. The challenge is in combining multiple sources of resistance from different genetic backgrounds into the same variety. Screening in the field is expensive and time-consuming so recombination is best facilitated by the use of molecular markers for selection. In addition to physiological resistance, avoidance traits such as maturity, growth habit, lodging, flower number and retention, and canopy porosity influence the overall level of resistance. This requires an approach to plant breeding that emphasizes field scale breeding using replicated plots along with marker assisted selection.

Our program has focused on using several resistance sources. These can be placed into two groups: resistance factors derived from common bean and resistance factors from the related species, scarlet runner bean. Of the common bean germplasm sources, NY 6020 is a snap bean developed by the snap bean breeding program at Cornell University. It has been well characterized genetically and we know that it has two relatively large resistance factors that have molecular markers for selection. This has been the primary focus of our white mold breeding program. Recently, we have screened additional snap bean lines and have discovered several which have useful levels of resistance. We have begun crossing to these to introgress from these resistance sources.

The NY 6020 derived lines are most advanced in the program and selections have been narrowed to four lines. With this particular form of resistance we have observed a negative correlation between disease resistance and yield. Lines with good white mold resistance generally yield 75 – 85% of susceptible check cultivars and we may ultimately determine that none of this material merits release. Our attention is turning now to some of the newly identified resistance sources. In particular, we have a number of crosses to the wax bean 'Unidor' which has shown good white mold resistance. Another parent that we are working with is WM904-20-3, a line we derived from crosses to scarlet runner bean. A third and potentially bountiful source of resistance genes is the dry bean A195. We have created populations from crosses to susceptible snap beans, and these need to be evaluated for resistance, increased, and placed into replicated yield trials. Additional crosses are in earlier generations, and need to be moved along the pipeline.

While the main focus of the program is on improving white mold resistance of the BBL types, other traits including yield, maturity, growth habit, pod size, shape and color, and processing characteristics need to be maintained or improved.

3.b OBJECTIVES

1. Breed improved Bush Blue Lake green bean varieties with:
    a. White and gray mold resistance
    b. Root rot resistance
    c. Improved plant architecture
    d. High economic yield
    e. Improved pod quality (including straightness, color, smoothness, texture, flavor and quality retention, and delayed seed size development)
    f. Tolerance to abiotic stresses

3.c. SIGNIFICANT FINDINGS

- Two yield trials were conducted: 19 entries in a full sieve size trial and 15 entries in an extra fine trial.
- Three advanced lines (OSU 6835, OSU 6993 and OSU 6996) were identified with the best combination of yield, quality and white mold resistance.
- Five extra fine snap bean lines (B8407-49-1-1, B8408-30-1-1, B8408-41-1-1, B8408-43-1-1, and B8408-53-1-1) were identified as having best combination of yield and quality.
- A trial with 21 commercial entries was also evaluated for yield, and quality.
- Of the 1,688 plots grown in the early generation nursery, 176 were harvested by massing all plants in the plot, 543 were harvested as single plants and 59 populations were advanced by single pod descent.
- White mold trials were conducted for the advanced full sieve experimental lines and a nested association mapping population with the common parent WM904-20-3.
- Most of the individuals in this population were resistant to white mold.
- Six Unidor recombinant inbred populations in the F_5 with a total of 1,065 families was grown to produce seed for white mold screening in 2018.

- A genome wide association study identified 146 significant associations with disease reaction distributed across the snap bean genome in 39 regions, 25 of which appear to be novel.

3.d. METHODS

Varietal Development: The program made crosses among elite lines and the best white mold resistant lines during the winter of 2017 and the F_1s were grown in the field. Breeding lines at various stages of development were evaluated in the field for selection and advancement. Pedigree and single seed descent breeding methods were used to advance and select early generation materials. Seed increase, roguing, and sub-line maintenance of the most promising lines continued. For cultivar maintenance, individual plants within each plot were assessed for presence of any off type variation (strings, oval pods, high fiber pods, off color pod, etc.) and these plants were removed from the plot prior to seed harvest.

Breeding for White Mold Resistance: Breeding lines in the preliminary yield trial were evaluated for white mold resistance. A natural infection occurred as plants were maturing, and plots were evaluated on remnant rows after harvest for processing had finished. Plots were rated for number of infected plants in the plot (incidence) and what proportion of plants was infected (severity).

A genome wide association mapping study (GWAS) was conducted using the Bean CAP Snap Bean Diversity Panel (SBDP) (n = 146) and the Snap bean Association Panel (SnAP) (n = 376). These had been evaluated in the field and greenhouse in previous years, and genotyping data had been collected. The analysis was conducted with FarmCPU. A nested association mapping (NAM) population with the common parent WM904-20-3 crossed to four different lines was screened for white mold resistance in the field. Populations were grown in a replicated trial at the Vegetable Research Farm. Normal cultural practices were used except beginning at flowering, plots were irrigated by solid set sprinklers for ½ hour in evenings to increase leaf wetness period and create conditions more favorable for disease development. Data on incidence (%) and severity (1 – 9 scale, 1 = no disease) was recorded. A disease severity index (DSI) was calculated based on the geometric mean of incidence and severity. The biparental population Unidor/OSU5630 was evaluated for disease in the field and greenhouse in previous years. In 2017, it was genotyped for SNPs and a genetic linkage map was constructed, and a QTL analysis performed.

Variety Trials: A replicated yield trial was planted 22 June with four checks (OR91G, OSU 5630, Sahara, and Cornell 501) and 15 advanced lines. These lines were mostly full sieve in size with the smallest podded line reaching maximum quality in the 4 to 5 sieve class. A second preliminary trial of extra fine (2 and 3 sieve size class) lines was grown. Pierroton and Crockett were used as checks to compare to 13 experimental lines. Plots consisted of a single 20-foot row from which 5-foot sections were harvested one or two times, two – three days apart. Lines were evaluated for growth habit, and yield. Graded samples were evaluated for pod smoothness, straightness, seed to pod ratio, and color and taste. Samples were processed and frozen for evaluation of the processed product. Samples were evaluated at the Food Science Pilot Plant 10 November, 2017 and then displayed in a cutting at the PNVA meetings in Kennewick, WA on 15 November, 2017.

A trial of commercial entries was planted 6 July with six checks (OR91G, OSU 5630, Sahara, Crockett, Pike and Pierroton) two OSU experimental lines, and 13 commercial entries from three companies. Plots consisted of a single 20-foot row from which 5-foot sections were harvested two or three times, two – three days apart. Lines were evaluated as described above and samples were processed and frozen for evaluation of the processed product. The commercial bean trial is not directly supported by OPVC, but solely through fees charged to commercial companies.

3.e. RESULTS & DISCUSSION

Varietal Development: In 2017, we grew 1,688 plots in the early generation nursery. Plots consisted of populations and lines at various stages of inbreeding. We also grew out the SnAP consisting of 376 snap bean cultivars to evaluate for various pod and disease traits. Six Unidor recombinant inbred populations in the F_5 with a total of 1,065 families was grown to produce seed for white mold screening in 2018. In the early generation nurseries, 176 plots were massed, 543 single plants were selected from individual plots and 59 populations were advanced by single pod descent (bulking a single pod from each plant in the population). The 543 single plants represent the next wave experimental lines advancing in the program to be funneled into replicated yield and disease trials. In 2018, these single plants will grow in in plots and massed to provide seed for testing in 2019 and beyond.

Yield Trials: The advanced line full sieve green bean yield and quality evaluation trial had two checks were that commercial bush blue lake cultivars (OR 91G, and OSU 5630), one small sieve check (Sahara), and one partially white mold resistant check (Cornell 501). All experimental lines had been tested two to several times in the previous six years, and had been retained because they had the best combination of yield and white mold resistance. In this trial, OR91G and OSU 5630 matured before pods could attain full size (Table 1-1, Fig. 1). Other lines in the trial seemed not to have this problem. Overall, unadjusted yields were on the moderate side with the highest being 11.1 T/A (OSU 6996) followed by 10.9 (Sahara). The lines that combined acceptable yields with other attributes included OSU 6835, OSU 6993 and OSU 6996. These lines generally scored well in the raw product evaluation (Table 2-1) and the processed product sensory evaluation. They represent a continuum in terms of white mold resistance. OSU6993 is among the most resistant (Table 7, Fig. 2) but has the lowest yield potential of the group (Table 1-1, Fig. 2). OSU 6996 is intermediate for both yield and white mold reaction, while OSU 6835 has the lowest resistance of the group but the highest yield potential. This ranking is apparent in previous years' reports as well. OSU 6835 is still significantly more resistant to white mold than either OR91G or OSU 5630 (Table 7).

Of the 13 experimental lines in the extra fine yield and quality trial, four (B8408-30-1-1, B8408-41-1-1, B8408-43-1-1, and B8408-53-1-1) have acceptable yield, quality and sensory characteristics (Tables 1-2 & 2-2; Fig. 3). The lines varied in sieve size with size of pods maxing out in either 2 or 3 sieve categories. One other line (B8407-49-1-1) had exceptional yields at 10.9 T/A (compared to 7.8 T/A for Redon) and good raw product scores but had off-flavors in the sensory evaluation. These five lines should be trialed again in 2018. The extra fine materials have not been tested for white mold resistance, but based on pedigree, are not expected to possess resistance to any significant degree.

Commercial Green Bean Trial:

Two commercial lines submitted for trial were full sieve (Table 3), but the other ranged from extra fine (2 sieve) types to whole bean (3 & 4 sieve) types. Overall, this trial was not particularly high yielding (Table 4) as all but the very earliest lines flowered and set pods during the hottest part of the summer. Highest yielding in the trial (but not significantly different from OSU 5630) was SV9203GV. This line also appeared to be BBL similar to a type in appearance and quality. Raw product evaluation notes are found in table 5 and seed size development at during successive harvests are in table 6. Figure 4 shows percent 1-3 sieve plotted against unadjusted T/A yield. In general, a moderate (r^2 = 0.49) relationship between higher yields associated with larger sieve size potential was observed.

White Mold Trial: Environmental conditions were favorable for white mold disease development at the end of the preliminary trial, and plots were rated (Table 7). OR 91G had about 58% incidence and a severity rating of 6.5. Partially resistant check Cornell 501 had 10% incidence and a severity score of 3.3. Six OSU advanced lines ranked lower in disease than Cornell 501 but the difference was not statistically significantly different.

The white mold research discussed below is primarily funded by the National Sclerotinia Initiative but has direct applicability to the breeding program in breeding for resistance. Four bi-parental populations were developed with one common parent WMG904-20-03 to create a nested association mapping (NAM) population (Table 8). This line combined the best common bean traits with white mold resistance introgressed from the *Phaseolus coccineus* accession PI 255956. The other parents in these populations also carry partial resistance to white mold. The task from previous years was to advance generations through single seed descent followed by seed increase of families to generate material for replicated trials. In the summer of 2017, the populations were screened for white mold reaction at OSU Vegetable Research Farm. The trials were planted using 3 m plots with 50 seed per plot surrounded by a border of the susceptible check, OSU 5630. The trials were placed in a field with a history of white mold disease to provide natural inoculation during the growing season. Plots were irrigated on a weekly basis with about 2.5 cm applied through solid-set overhead sprinklers. At flowering, plots were additionally irrigated in late afternoon or early evening for ~30 min on a daily basis to increase leaf wetness duration to create a more favorable microenvironment for disease development. Incidence and severity were measured as parameters of disease in three replicates arranged in a randomized complete block design. Incidence was measured as percentage of diseased plants within each plot. Severity was measured by observing diseased plants and rating symptoms using a 1 - 9 scale where 1 = No disease symptoms. Disease severity index (DSI) was calculated as the geometric mean of incidence and severity. The analysis of variance showed highly significant difference among families although all parents within the populations had some degree of partial resistance to white mold. Also highly significant differences were observed among the replications probably due to the large size of the population. Population distributions were skewed towards resistance for all crosses as would be expected for resistant x resistant combinations (Figure 5). WMG904-20-3 had the lowest incidence, severity and DSI compared with all others parents and the resistant check, G122 The next step is genotyping the NAM population to conduct GWAS. The DNA has been isolated at OSU/Center for Genome Research and Biocomputing. Also the NAM population should be screened to white mold reaction in the greenhouse using straw test and field for second year.

Table 8. Common bean nested association mapping recombinant inbred populations developed at OSU for analysis of white mold resistance. Populations are in the F_6 generation.

Population	Pedigree	No. of Families
B8351	Cornell501/WM904-20-3	56
B8359	NY6020-4/WM904-20-3	70
B8360	M0070/WM904-20-3	60
B8361	WM904-20-3/A195	62
Total		248

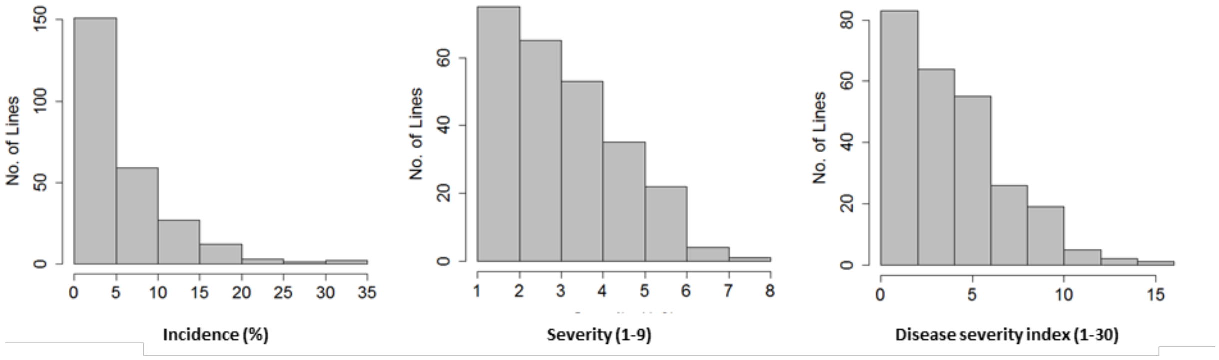

Figure 5. Distribution of WM904-20-3 derived bean RI nested association mapping population evaluated for white mold reaction (incidence, severity and disease severity index) in the field at the OSU Vegetable Research Farm in 2017.

Genome wide association study (GWAS) was conducted to detect markers significantly associated with white mold resistance in a panel of snap bean cultivars. The objectives of the present study were: 1) to verify previously reported QTLs detected in other populations and studies, 2) to detect novel QTLs associated with white mold resistance and 3) to identify new sources of resistance to this disease in common bean, with particular emphasis on snap bean. Two populations of snap bean were used in this study: BeanCAP (Coordinated Agriculture Project) Snap Bean Diversity Panel (SBDP) (n= 137) and the Snap Bean Association Panel (SnAP) consists of 376 cultivars and breeding lines. The BeanCAP was phenotyped for white mold reaction in the field in 2012 and 2013, while the SnAP was screened for white mold reaction in greenhouse only using the seedling straw test. The population was genotyped using genotyping by sequencing (GBS) for which 40,023 SNPs were generated. GWAS was analyzed using the R package FarmCPU. One-hundred forty-six significant SNPs associated with white mold reaction were detected on all 11 common bean chromosomes. Twenty significant SNPs were detected by the seedling straw test while 126 significant SNPs were detected in one or both years. The 146 significant SNPs could be grouped into 39 regions distributed across all chromosomes. The regions overlapped with 13 previously identified QTLs (WM1.1, WM2.2, WM3.1, WM3.3, WM5.5, WM6.1, WM6.2, WM7.1, WM7.4, WM7.5, WM8.1, WM8.3 and WM9.3) identified in bi-parental populations. In addition, the associations found in the present study overlapped with 13 significant markers that were associated with white mold resistance detected by GWAS in a dry bean panel. Twenty-five associations were unique to this study. NY6020-5 and Unidor were the most outstanding snap bean cultivars in the field tests for both years while Homestyle and Top Crop were the most resistant snap beam cultivars in straw test.

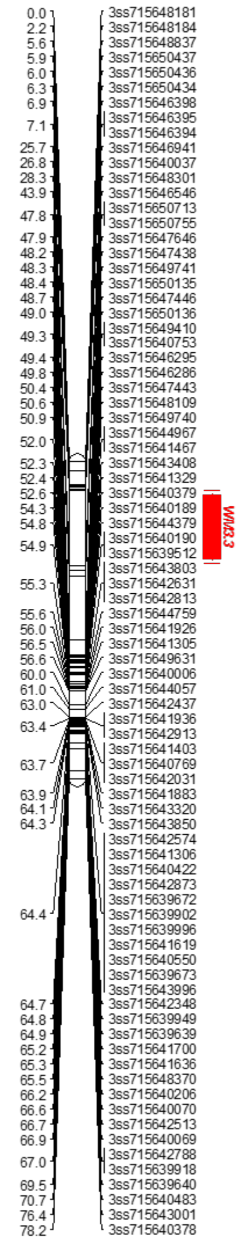

Figure 6. Linkage map of Pv03 from the Unidor/OSU5630 RI population (n = 190) showing the position of the WM3.3 QTL. Bar representing the QTL is positioned in reference to the physical chromosome, not the SNP markers. SNP names are shown to the right and corresponding cM distance is shown to the left of the chromosome.

In a preliminary trial to investigate the resistance carried by Unidor, the population Unidor/OSU5630 (n=190, F4:5) was phenotyped using seedling straw test in 2016 and genotyped in 2017 using Illumina iSelect 6K SNPchip. A linkage map of 1,296 SNPs was constructed using Joinmap 4.1. Quantitative trait loci analysis was conducted implementing multiple QTL mapping (MQM) using MapQTL6. One significant QTL (LOD = 3.11) associated with white mold resistance was detected on Pv03 at 15.1 cM (Fig. 6). The QTL was located at about 1.07 to 2.57Mb on the physical map. The QTL explained 7.2% of the phenotypic variation with additive effect of -0.31.

4. BUDGET DETAILS

1) Breeding (Myers)	
Salaries and benefits	
Faculty Research Assistant	$15,631
OPE @ 70%	$10,942
Wages and benefits	
Student Wages	$0
OPE @12%	$0
Supplies	$500
Travel	$0
Land and greenhouse rental	$0
Total	$27,072

2) Processing Evaluation (Yorgey)	
Salaries and benefits	
Senior Faculty Research Assistant	$2,800
OPE @ 61.45%	$1,721
Wages and benefits	
Student wages	$1,500
OPE (@ 12%	$180
Supplies	$1,300
Total	$7,501
Grand Total	**$34,573**

Contributions of the OSU breeding program	
Student Wages	$7,790
OPE @ 12%	$935
Supplies	$500
Travel	$86
Land and greenhouse rental	$9,586
Total	**$18,896**

BUDGET NARRATIVE

Request to OPVC: Salary and OPE is requested for a full time faculty research assistant who will commit 40% FTE to green bean breeding. A senior faculty research assistant will commit approximately 0.05 FTE to processing of entries from green bean trials; the remainder of salary to come from other sources. Undergraduate student wages of $1,500 are requested for the processing program with 12% OPE. OPE for the FRA is 70% and that of the SFRA is 61.45%. $500 is requested for materials and supplies for field work (includes stakes, tags, envelopes, paper bags, etc.)

Contributions of the Vegetable Breeding Program: Undergraduate student wages of $7,790 are estimated for the breeding program with 12% OPE. An additional $500 is required to cover field and greenhouse materials and supplies expenses (fertilizer, pots, labels, stakes, tags, & crossing supplies). To cover transport of samples from the farm to campus for processing, $86 is estimated. Land use rental at the OSU Vegetable Research Farm consists of five acres at $1,259 per acre and greenhouse rental of 2,123 ft^2 at $1.55 per square foot.

Table 1-1. Performance of green bean lines in a preliminary yield trial, Jun 22 planting, OSU Vegetable Research Farm in 2017.[z]

Line	Days to Harvest	Est. Sieve Size	Stand	Percent Sieve Size[y] 1.0	2.0	3.0	4.0	5.0	6.0	%1-4 Sieve	Av Tons/Acre	Av Adj Tons/Acre[x]
91G	57	6	196.0	9.4	13.0	19.6	33.3	22.5	2.2	75.4	6.3	7.9
5630	57	6	154.0	7.7	9.7	21.0	39.0	20.5	2.1	77.4	8.6	11.0
Cornell 501	59	5	194.5	8.3	13.0	25.9	39.8	13.0	0.0	87.0	4.9	6.7
Sahara	57	4-5	195.0	5.8	13.2	32.6	45.5	2.9	0.0	97.1	10.9	10.9
6771	59	6	184.5	6.9	10.3	16.6	35.2	29.7	1.4	69.0	6.7	7.9
6827	62	6	183.3	11.5	14.9	18.4	17.2	20.7	17.2	62.1	4.4	5.0
6835	61	6	184.3	4.4	5.7	13.1	28.8	44.5	3.5	52.0	10.7	10.9
6870	57	6	195.8	2.5	4.9	10.3	26.1	45.8	10.3	43.8	9.3	8.7
6893	64	6	198.0	6.7	9.7	12.7	26.1	34.3	10.4	55.2	6.1	6.4
6900	59	5	191.5	7.5	8.2	15.0	38.8	29.3	1.4	69.4	6.6	7.9
6909	57	6	187.3	2.1	7.0	15.5	38.7	33.1	3.5	63.4	6.7	7.6
6925	63	6	195.3	8.1	9.1	14.0	25.8	35.5	7.5	57.0	8.5	9.0
6938	61	6	194.8	5.9	7.0	8.6	18.8	44.6	15.1	40.3	8.1	7.3
6965	59	4	164.8	7.3	11.8	29.1	48.2	3.6	0.0	96.4	5.1	5.1
6980	64	5	192.8	15.1	18.3	20.4	24.7	18.3	3.2	78.5	4.4	5.6
6986	67	6	133.8	11.2	13.6	20.8	27.2	21.6	5.6	72.8	5.7	7.0
6992	62	4-5	144.3	9.4	12.0	22.2	41.9	14.5	0.0	85.5	5.4	7.3
6993	64	6	184.5	5.7	9.6	17.2	35.7	26.8	5.1	68.2	7.2	8.5
6996	64	6+	191.8	3.3	4.9	8.1	20.3	42.3	21.1	36.6	11.1	9.6
LSD 0.05			24.6								2.4	2.8

[z]Mean of 3 replications; subplots of 5' were harvested from 18' plots in rows 30" apart. [y]Percent calculated as % of total of 1-6 sieve beans. [x]Tons/Acre adjusted to 50% 1-4 sieve for full and 5 sieve beans; yields for smaller sieve lines were not adjusted.

Table 1-2. Performance of preliminary extra fine green bean lines, Jun 22 planting, Corvallis, 2017.[z]

Line	Days to Harvest	Est. Sieve Size	Stand	Percent sieve size 1.0	2.0	3.0	4.0	%1-2 Sieve	Av Tons/Acre
Crockett	64	3	193.3	7.9	16.7	49.4	25.1	24.7	10.8
Redon	61	2	198.3	30.6	64.7	4.7	0.0	95.3	7.8
B8407-14-1-1	61	2-3	192.5	23.8	52.5	23.8	0.0	76.2	5.7
B8407-49-1-1	67	2-3	197.5	10.3	45.5	42.6	1.7	55.8	10.9
B8407-49-2-1	61	2-3	197.8	20.6	47.8	29.4	2.2	68.4	6.3
B8408-30-1-1	61	2-3	192.5	12.9	49.0	37.1	1.0	61.9	9.5
B8408-41-1-1	62	2-3	197.8	18.0	57.5	22.8	1.8	75.4	7.7
B8408-43-1-1	59	3	200.0	13.2	36.6	47.3	2.9	49.8	9.3
B8408-53-1-1	63	2	194.3	23.4	70.1	6.5	0.0	93.5	7.1
B8408-59-1-1	59	2	193.8	31.4	50.0	17.6	1.0	81.4	4.7
B8408-67-1-1	61	2-3	193.3	16.2	50.6	31.8	1.3	66.9	6.8
B8408-71-1-1	57	2-3	175.3	24.0	48.8	26.4	0.8	72.9	5.9
B8408-74-1-1	57	3	198.3	21.0	42.8	34.1	2.2	63.8	6.4
B8408-76-1-1	61	2	124.3	21.0	36.2	40.6	2.2	57.2	6.4
B8408-8-1-1	59	2	193.5	19.4	66.7	12.9	1.1	86.0	8.5
LSD 0.05			16.6						1.8

Table 2-1. Notes on preliminary green bean lines, June 22 planting, OSU Vegetable Research Farm, Corvallis, 2017.

Entry	Pod Length (cm)	Pod Straight-ness[z]	Pod Cross Section	Pod Smooth-ness[z]	Pod Color[y]	Flavor[z] Sweet-ness	Flavor[z] Astrin-gency	Flavor[z] Perfumi-ness	Notes[w]
91G	15.5	5	round	5	5	5	7	1	Seedy 5 & 6 sv, moderately seedy 4 sv beginning in 3 sv. Variety is maturing without sizing up. Poor stand in 1st rep. Stringy off-type.
5630	14.5	5	round	7	5	5	7	1	Good yield but appears to be maturing without sizing up. Seedy 5 & 6 sv, moderately seedy 3 & 4 sv. Blond and oval off types.
Cornell 501	13.5	5	flat-round	4	3	7	5	3	Needs to be rogued for flats. Seedy 5 sv, moderately seedy 4 sv, beginning in 3 sv.
Sahara	14.5	8	round	8	6	3	3	1	Tough skin. Moderately seedy 5 sv, mixed in 4 sv, beginning in 3 sv.
6771	14.0	7	round	7	4	7	7	1	Mixed moderate to seedy 5 sv, moderately seedy 4 sv, beginning in 3sv.
6827	15.0	--	heart-round	3	5	7	7	1	Seems to be a mix of early hooked heart type and a later full sieve straight round podded type. Mixed seed development in all sieve sizes.
6835	17.0	3	heart-round	3	5	3	7	1	Oval-heart in smaller sieves becoming heart-round in 5 & 6 sv. Moderate seed development in 6 sv, beginning in 4 & 5 sv. 3 sv ok.

Table 2-1. (continued).

Entry	Pod Length (cm)	Pod Straight-ness[z]	Pod Cross Section	Pod Smooth-ness[z]	Pod Color[y]	Flavor[z] Sweet-ness	Astrin-gency	Perfumi-ness	Notes[w]
6870	15.0	5	round	5	4	3	7	1	Only moderate seed development in 6 sv, beginning in 5 sv, 3 & 4 sv very small. Strong RC but light two tone color.
6893	11.0	7	round	1	6	7	7	1	Tall stiff plant w/ little WM in the plot. Short bumpy pods - many polywogs and tendency to break during picking. Very seedy 6 sv, seedy 5 sv, moderately seedy 4 sv, 3 sv. Ok. A few strings and ovals.
6900	13.0	5	heart	5	5	7	7	1	Oval tendency. Seedy to very seed 5 sv, moderately seedy 4 sv, beginning in 3 sv.
6909	14.5	7	round	--	4	5	5	1	EZ pick type. WM on stems. Mixed seeds in 6 sv, moderate in 4 & 5 sv, beginning in 3 sv. Line somewhat variable for pod color, length and straightness, and EZ pick trait.
6925	13.0	3	round	3	5	5	7	1	About 80% stringy pods. Large leggy plant in the field with moderate levels of WM that affected yield. Hard to pick - breaks in clusters. Seedy to very seedy 6 sv, seedy 5 sv, moderately seedy 4 sv, mixed 3 sv.

Table 2-1. (continued).

Entry	Pod Length (cm)	Pod Straight-ness[z]	Pod Cross Section	Pod Smooth-ness[z]	Pod Color[y]	Flavor[z] Sweet-ness	Flavor[z] Astrin-gency	Flavor[z] Perfumi-ness	Notes[w]
6938	11.4	5	oval	5	5	7	8	1	Line has unique growth habit - single erect stem, with raceme held high. Resembles adzuki bean habit. Oval and stringy. Excellent flavor. Seedy 6 sv, moderately seedy 5 sv, beginning in 4 sv, 3 sv ok.
6965	13.0	8	round	8	6	7	7	1	Mixed moderate to seedy 5 sv, moderately seedy 4 sv, beginning in 3sv.
6980	12.0	3	round	5	5	3	5	1	Short pods with strong RC - a lot of battering in the grader. Plants somewhat leggy in the field with little WM. EZ pick type. Moderate seed dev in 5 - 6 sv beginning in 3 & 4 sv.
6986	14.0	5	heart	5	5	3	7	1	Leggy plants in the field with thick basal stems and very little white mold. Rep 3 very late - many flowers but few immature pods. Moderately seedy 5 & 6 sv, mixed beginning to moderate in 3 & 4 sv.

Table 2-1. (continued).

Entry	Pod Length (cm)	Pod Straight-ness[z]	Pod Cross Section	Pod Smooth-ness[z]	Pod Color[y]	Flavor[z] Sweet-ness	Astrin-gency	Perfumi-ness	Notes[w]
6992	13.0	5	round	7	5	7	5	1	Moderately seedy 5 sv, mixed beginning to moderately seedy 4 sv beginning in 3 sv. Stand problems in the field may have led to problems with yield and accurately judging maturity.
6993	12.5	7	round	5	6	7	7	1	Slight RC on fairly short pods. Moderately seedy 5 & 6 sv, beginning in 3 & 4 sv.
6996	15.0	5	round	5	4-5	7	7	1	May be too light when blanched. Otherwise, a nice bean with good yields. Mixed moderate to seedy 6 sv, moderately seedy 5 sv, 3 & 4 sv ok.

[z]Scale of 1 - 9 where 1 is least or worst and 9 is most or best. [y]Scores based on a 1 - 9 scale with 9 darkest. Standard BBL color is rated as 5. [w]RC: reverse curve; sv: sieve.

Table 2-2. Notes on experimental extra fine green bean lines grown in a preliminary yield trial, June 22 planting, OSU Vegetable Research Farm, Corvallis, 2017.

Entry	Pod Length (cm)	Pod Straight-ness[z]	Pod Cross Section	Pod Smooth-ness[z]	Pod Color[y]	Flavor[z]			Notes[w]
						Sweet-ness	Astrin-gency	Perfumi-ness	
Crockett	14.5	7	round	8	7	5	7	3	Long slender dark green pods. Moderately seedy 4 - 5 sv beginning in 3 sv, 2 sv ok.
Redon	13.5	4	round	7	4	7	7	5	Tough pods, straight pods in lower sieve sizes but curly 3 sv. Moderately seedy 3 sv, beginning in 2 sv, 1 sv ok.
B8407-14-1-1	11.0	4	heart	7	5	5	7	1	Strong RC. Moderately seedy 3 sv, beginning in 2 sv.
B8407-49-1-1	12.5	5	round	7	5	9	5	1	Strong RC. Very seedy 4 sv, mixed moderate to seedy 3 sv, moderately seedy 2 sv, beginning in 1 sv. Significant WM in the field.
B8407-49-2-1	12.0	5	heart-oval	5	5	7	7	1	Very mixed lot - variable in size, length, color, cross section. Seedy 4 sv, moderately seedy 2 & 3 sv. Ok in 1 sv.
B8408-30-1-1	12.0	8	heart	7	4	7	5	5	Tough skin. Relatively short but straight pods. Plants with concentrated set and some white mold. Seedy 4 sv, moderately seedy 3 sv beginning in 1 & 2 sv. Overall very nice bean. Color lighter than 5630 but darker than Redon.

Table 2-2. (continued).

Entry	Pod Length (cm)	Pod Straight-ness[z]	Pod Cross Section	Pod Smooth-ness[z]	Pod Color[y]	Flavor[z] Sweet-ness	Astrin-gency	Perfumi-ness	Notes[w]
B8408-41-1-1	11.5	7	round	5	5	5	7	3	Seedy to very seedy 4 sv, moderately seedy 2 & 3 sv, 1 sv ok. Attractive bean.
B8408-43-1-1	13.0	5	round	7	5	5	7	1	Tough skin. More of a 3 sv bean than 2sv. Very nice with good yields. Mixed moderately seedy to seedy in 4 sv, beginning in 3 sv, 1 & 2 sv ok.
B8408-53-1-1	12.5	7	round	9	5	5	7	1	Tough skin. Very nice extra fine - concentrated set in the field. Good color. Moderately seedy in 3 sv, beginning in 2 sv, 1 sv ok.
B8408-59-1-1	12.5	7	heart	5	5	7	5	1	Very BBL flavor but with tough skin. Seedy 4 sv, moderately seedy 3 sv, beginning in 1 & 2 sv.
B8408-67-1-1	11.0	8	round	8	5	5	7	1	Short straight bean that should flow well in processing plant. Seedy 3 & 4 sv, mixed beginning to moderately seedy 2 sv, 1 sv ok.
B8408-71-1-1	11.5	5	heart	9	4	7	7	3	Very indeterminate in the field. Pods have strong RC. Seedy 4 sv, moderately seedy 2 & 3 sv, 1 sv ok.

Table 2-2. (continued).

Entry	Pod Length (cm)	Pod Straight-ness^z^	Pod Cross Section	Pod Smooth-ness^z^	Pod Color^y^	Flavor^z^ Sweet-ness	Astrin-gency	Perfumi-ness	Notes^w^
B8408-74-1-1	12.0	7	heart	9	4	2	8	3	Tough skin. Color matches 4-6 sv of 91G but is lighter than corresponding sieve sizes (1-4) of 91G. In the field, this line produces large bush with few pods and very indeterminate - still flowering. Slight amount of white mold developing on pods.
B8408-76-1-1	12.0	3	round	7	5	5	7	1	Extreme reverse curve which makes very curly pods. Skin not tough. Rather indeterminate in the field. Mixed beginning to moderately seedy 4 sv, beginning in 2 & 3 sv, 1 sv ok. Moderate levels of WM.
B8408-8-1-1	11.0	7	heart	7	4	7	7	1	Good yields, but pod cross section shape and color are concerns. Tender skin. Seedy 4 sv, moderately seedy 3 sv beginning in 2 sv, 1 sv ok.

[z]Scale of 1 - 9 where 1 is least or worst and 9 is most or best. [y]Scores based on a 1 - 9 scale with 9 darkest. Standard BBL color is rated as 5. [w]RC: reverse curve; sv: sieve.

Table 3. Performance of commercial green bean varieties, July 6 planting, OSU Vegetable Research Farm, Corvallis, 2017.

Variety	Source	AV Stand	Sieve size	Days	Percent Sieve Size[z]							Tons/Acre Sieve Size						Graded Total[y]
					1	2	3	4	5	6	1-4	1	2	3	4	5	6	
91G	OSU (ck)	200			11.4	10.5	15.2	38.1	21.9	2.9	75.2	0.5	0.5	0.7	1.7	1.0	0.1	4.6
91G*			6	59	6.6	6	9.9	25.2	43.7	8.6	47.7	0.4	0.4	0.7	1.7	2.9	0.6	6.6
91G					3.8	3.8	7.1	16.9	49.2	19.1	31.7	0.3	0.3	0.6	1.4	3.9	1.5	8.0
5630	OSU (ck)				19	19	26.2	26.2	9.5		90.5	0.3	0.3	0.5	0.5	0.2		1.8
5630					9.1	10.9	19.1	39.1	20	1.8	78.2	0.4	0.5	0.9	1.9	1.0	0.1	4.8
5630*		186.5	6	59	6.7	7.3	12.7	29.3	40.7	3.3	56	0.4	0.5	0.8	1.9	2.7	0.2	6.5
Sahara*	Harris Moran (ck)	198.8	4	59	5.4	7.7	26.9	53.8	6.2		93.8	0.3	0.4	1.5	3.0	0.3		5.7
Sahara					4.5	3.8	17.3	63.2	11.3		88.7	0.3	0.2	1.0	3.7	0.7		5.8
Crockett*	Harris Moran (ck)	197.3	3-4	61	7.9	16.5	48	27.6			100	0.4	0.9	2.7	1.5			5.5
Pike	Harris Moran (ck)				20.3	20.3	33.3	26.1			100	0.6	0.6	1.0	0.8			3.0
Pike*		185.8	3	59	9.1	16.4	38.2	36.4			100	0.4	0.8	1.8	1.7			4.8
Pike					6.3	11	39.4	41.7	1.6		98.4	0.3	0.6	2.2	2.3	0.1		5.5
Pierroton	Syngenta (ck)	192.3			46.3	50.7	3	0			100	1.4	1.5	0.1	0.0			2.9
Pierroton*			2	59	38.2	60.5	1.3	0			100	1.3	2.0	0.0	0.0			3.3
Pierroton					28	69.5	2.4	0			100	1.0	2.5	0.1	0.0			3.6
6771	OSU	189.3			8	17.3	29.3	41.3	4		96	0.3	0.6	1.0	1.4	0.1		3.3
6771*			5	59	3.4	4.3	12.1	44.8	35.3		64.7	0.2	0.2	0.6	2.3	1.8		5.1
6771					1.7	2.5	5.9	35.6	52.5	1.7	45.8	0.1	0.1	0.3	1.8	2.7	0.1	5.1
6827	OSU	194.5			17.9	20.5	28.2	28.2	5.1		94.9	0.3	0.3	0.5	0.5	0.1		1.7
6827*			5	59	11.3	12.7	18.3	32.4	21.1	4.2	74.6	0.3	0.4	0.6	1.0	0.7	0.1	3.1
6827					9.5	7.6	10.5	23.8	39	9.5	51.4	0.4	0.3	0.5	1.1	1.8	0.4	4.6
HB15	Brotherton				30.6	57.1	12.2				100	0.7	1.2	0.3				2.1

Table 3. (continued).

Variety	Source	AV Stand	Sieve size	Days	Percent Sieve Size[z] 1	2	3	4	5	6	4-Jan	Tons/Acre Sieve Size 1	2	3	4	5	6	Graded Total[y]
HB15*		192.5	3	61	11.5	20.2	50	18.3			100	0.5	0.9	2.3	0.8			4.5
HS934	Brotherton				28.6	49.2	20.6	1.6			100	0.8	1.4	0.6				2.7
HS934*		199.5	2-3	59	15	33	48	4			100	0.7	1.4	2.1	0.2			4.4
HS934					8.3	27.5	56.7	7.5			100	0.4	1.4	3.0	0.4			5.2
BSC26	Brotherton				57.7	30.8	11.5				100	0.7	0.3	0.1				1.1
BSC26*		199.5	2	59	34	35.8	24.5	5.7			100	0.8	0.8	0.6	0.1			2.3
BSC26					16.7	26.2	41.7	15.5			100	0.6	1.0	1.5	0.6			3.7
F/Carlo*	Brotherton				15.6	17.2	21.9	25	17.2	3.1	79.7	0.4	0.5	0.6	0.7	0.5	0.1	2.8
F/Carlo		158.5	6	61	8.8	10.8	12.7	26.5	31.4	9.8	58.8	0.4	0.5	0.6	1.2	1.4	0.4	4.4
BEX138	Brotherton				17.1	29	38.1	14.5	1.3		98.7	0.6	1.0	1.3	0.5			3.3
BEX138*		187.3	3-4	59	9.1	16.2	38.4	34.3	2		98	0.4	0.7	1.7	1.5	0.1		4.3
BEX138					4.8	10.5	37.9	44.4	2.4		97.6	0.3	0.6	2.0	2.4	0.1		5.4
PSL4921	Pureline				20.3	32.2	37.3	10.2			100	0.5	0.8	1.0	0.3			2.6
PSL4921*		197.3	3	59	12.4	19.1	41.6	27			100	0.5	0.7	1.6	1.0			3.9
PSL4921					7.1	15.3	50	26.5	1		99	0.3	0.7	2.1	1.1			4.3
Angigua*	Pureline	195.5	4	57	23.1	23.1	30.8	20	3.1		96.9	0.7	0.7	0.9	0.6	0.1		2.8
Angigua					9.1	12.4	24.8	50.4	3.3		96.7	0.5	0.7	1.3	2.7	0.2		5.3
PLS6017	Pureline				18.5	22.2	35.2	20.4	3.7		96.3	0.4	0.5	0.8	0.5	0.1		2.4
PLS6017*		131.5	4	59	8.9	10	20	52.2	8.9		91.1	0.3	0.4	0.8	2.0	0.3		3.9
PLS6017					4.6	5.4	14.6	51.5	23.1	0.8	76.2	0.3	0.3	0.8	2.9	1.3		5.7
PLS5519	Pureline				10.4	19.5	27.3	35.1	7.8		92.2	0.3	0.7	0.9	1.2	0.3		3.4
PLS5519*		199.3	4	57	6.4	10.6	33	43.6	6.4		93.6	0.3	0.4	1.4	1.8	0.3		4.1
PLS5519					5.6	6.5	17.6	50	18.5	1.9	79.6	0.3	0.3	0.8	2.4	0.9	0.1	4.7
SV1286GW	Seminis				38.5	42.3	19.2				100	0.4	0.5	0.2				1.1
SV1286GW*		192.3	2	59	24.3	37.8	32.4	5.4			100	0.4	0.6	0.5	0.1			1.6

Table 3. (continued).

Variety	Source	AV Stand	Sieve size	Days	Percent Sieve Size^z^ 1	2	3	4	5	6	4-Jan	Tons/Acre Sieve Size 1	2	3	4	5	6	Graded Total^y^
SV1286GW					15.2	39.1	37	8.7			100	0.3	0.8	0.7	0.2			2.0
SV9203GV	Seminis				9	12.8	19.2	41	16.7	1.3	82.1	0.3	0.4	0.7	1.4	0.6	0.0	3.4
SV9203GV*		175	6	57	4.8	6	12.6	35.3	37.7	3.6	58.7	0.3	0.4	0.9	2.6	2.7	0.3	7.3
SV9203GV					3.1	3.1	7.2	27.4	54.3	4.9	40.8	0.3	0.3	0.7	2.7	5.3	0.5	9.7
SV0579GG*	Seminis	199	4	61	6.3	7.9	27.6	55.1	3.1		96.9	0.3	0.4	1.5	3.0	0.2		5.5
SVGG2053	Seminis				16.7	27.4	40.5	15.5			100	0.6	1.0	1.5	0.6			3.7
SVGG2053*		200	4	59	7.9	12.7	33.3	44.4	1.6		98.4	0.4	0.7	1.8	2.4	0.1		5.5
SVGG2053					5	6.4	27.9	58.6	2.1		97.9	0.3	0.4	1.7	3.6	0.1		6.1

[z]Percent calculated as % of total of 1-6 sieve beans. [y]Total tons/acre of the graded beans, including sieve sizes 1-6. *Harvested for processing.

Table 4. Statistical comparison of yields of commercial green bean lines, Corvallis, 2017[z].

Cultivar	Sieve size	T/A Unadjusted	T/A Adjusted[y]
Sahara	4	6.1	6.1
Crockett	3-4	5.8	5.8
Pike	3	5.0	5.0
Pierroton	2	3.7	3.7
OSU 5630	6	6.8	7.2
91G	6	6.9	6.7
OSU 6771	5	5.2	6.0
6827	5	3.4	4.3
HB15	3	4.8	4.8
HS934	2-3	4.8	4.8
BSC26	2	2.5	2.5
F/Carlo	6	4.6	5.0
BEX138	3-4	4.5	4.5
PLS4921	3	4.3	4.3
Antigua	4	3.2	3.2
PLS6017	4	4.3	4.3
PLS5519	4	4.5	4.5
SV1286GW	2	1.9	1.9
SV9203GV	6	7.7	8.2
SV0579GG	4	5.8	5.8
SVGG2053	4	5.9	5.9
LSD 0.05		1.5	1.6

[z]Based on one selected harvest for each variety (marked with * in Table 3), which was usually the harvest closest to optimal based on that variety's intended use (50% 1-4 sieve for full sieve). Yields are field yields of 1-6 sieve beans. [y]Five and six sieve beans were adjusted to 50% 1-4 sieve; all others were unadjusted.

Table 5. Notes on July 6 commercial bean trial, OSU Vegetable Research Farm, Corvallis, Oregon, 2017.

Line	Pod Length (cm)	Pod Straight-ness[z]	Pod Cross Section	Pod Smooth-ness[z]	Pod Color[y]	Flavor[z] Sweet-ness	Astrin-gency	Perfumi-ness	Notes[x]
91G	17.0	5	round	5	5	7	7	1	Short & junky 3 sv.
OSU 5630	14.0	5	round	5	5	7	7	1	
Sahara	13.0	8	round	9	6	5	7	1	
Crockett	12.0	8	round	9	7	7	5	1	
Pike	12.0	8	round	9	6	7	5	1	
Pierroton	12.0	7	round	7	5	7	7	1	
OSU 6771	12.0	5	round	7	5	5	7	1	Short pods particularly in 3 & 4 sv
OSU 6827	15.0	5	round	7	5	7	7	1	Retains long pods despite heat - very few polywogs. RC.
HB15	15.5	7	round	7	4	7	5	1	Long slender bean.
HS934	11.0	8	round	7	4	5	5	3	Holds up well in heat.
BSC26	12.5	6	heart-round	9	5	7	7	1	Holds up well in heat.
F/Carlo	15.5	5	round-creaseback	7	5	3	8	1	Severe battering in grader, very small white flakes on pods - cuticle wax?
BEX138	12.5	7	heart-round	7	4	7	3	5	Long spurs. Somewhat variable pod color.
PSL4921	12.5	7	heart	7	3	7	7	3	Lots of blanks.
Antigua	11.0	7	round	7	5	5	7	1	Tough skin - seems like a large jump in seed dev from 4 to 5 sv.

Table 5. (continued).

Line	Pod Length (cm)	Pod Straight-ness^z	Pod Cross Section	Pod Smooth-ness^z	Pod Color^y	Flavor^z Sweet-ness	Astrin-gency	Perfumi-ness	Notes^x
PLS6017	13.0	5	heart-slight oval	7	6	5	7	1	Tough skin.
PLS5519	13.0	8	round	9	6	3	7	1	Yields reduced by heat. Otherwise nice looking bean.
SV1286GW	11.5	5	round	9	5	3	5	1	Tough skin.
SV9203GV	14.5	5	round-heart	5	5	7	5	1	This line was earliest in the trial and may have avoided the heat that depressed yields and pod quality of other lines.
SV0579GG	12.5	5	round	7	7	5	5	1	Pc type w/ very uniform pod color. Short and junky pods in 3 & 4 sv from heat.
SVGG2053	14.0	8	round	9	5	5	9	1	Shiny pods in upper sieves.

^{z}Scale of 1 - 9 where 1 is least or worst and 9 is most or best. ^{y}Scores based on a 1 - 9 scale with 9 darkest. Standard BBL color is rated as 5.
^{x}Pc = persistent color, RC = reverse curve, sv = sieve.

Table 6. Seed development in green bean pods across harvest dates for the July 6 commercial bean trial, OSU Vegetable Research Farm, Corvallis, Oregon, 2017.

	Sieve		Seed development (sieve size)[y]					
Entry	size	DTM[z]	6	5	4	3	2	1
91G (ck)	6	57	7	7	5	3		
91G (ck)	6	59	9	8	5	3		
91G (ck)	6	61	9	7	5	3		
F/Carlo	6	59	6	5	3	1		
F/Carlo	6	61	7	7	3	3		
OR 5630 (ck)	6	57	7	5	3	3		
OR 5630 (ck)	6	59	9	8	5	3		
SV0579GG	6	61		7	5	3		
SV9203GV	6	57	7	7	5	3		
SV9203GV	6	59	9	9	7	5		
6771	5	57		7	5	3		
6771	5	59	9	6	5	3		
6771	5	61	7	7	6	3		
6827	5	57		5	3	1		
6827	5	59	7	6	3	3		
6827	5	61	7	7	6	4		
Antigua	4	57		7	5	3		
Antigua	4	59		7	5	3		
PLS5519	4	56		7	6	3	3	
PLS5519	4	57		6	5	3		
PLS5519	4	59	8	7	6	5		
PLS6017	4	57		5	3	3		
PLS6017	4	59	9	7	5	3		
PLS6017	4	61	9	8	5	3		
Sahara	4	59		7	6	3		
Sahara	4	61		8	7	5		
SVGG2053	4	57			3	3		
SVGG2053	4	59		5	4	3		
SVGG2053	4	61		9	6	5		
BEX138	4	57		5	3	3	1	
BEX138	4	59		7	5	5	3	
BEX138	4	61		7	6	5		
Crockett (ck)	4	61			5	3	1	
HB15	3	59			6	3	3	

Table 6. (continued).

	Sieve		Seed development (sieve size)[y]					
Entry	**size**	**DTM**[z]	**6**	**5**	**4**	**3**	**2**	**1**
HB15	3	61		7	5	5	4	
Pike (ck)	3	57			5	5	3	
Pike (ck)	3	59		7	6	5	3	
Pike (ck)	3	61		8	8	6	3	
PSL4921	3	57			5	3	1	1
PSL4921	3	59			8	5	3	
PSL4921	3	61		9	7	6	5	
HS934	3	57			5	5	3	1
HS934	3	59			7	5	3	3
HS934	3	61			7	5	4	
BSC26	2	57				5	3	1
BSC26	2	59			5	5	3	1
BSC26	2	61			6	5	3	
Pierroton (ck)	2	57				5	3	1
Pierroton (ck)	2	59				7	6	5
Pierroton (ck)	2	61				9	9	5
SV1286GW	2	57				3	3	1
SV1286GW	2	59			5	3	3	1
SV1286GW	2	61			7	6	6	

[z]DTM = days to maturity. [y]Scale of 1 - 9 where 1 = no seed development, 3 = seed development beginning, 5 = moderate seed development, 7 = significant seed development, and 9 = seed physiologically mature.

Table 7. White mold incidence and severity in a green bean yield trial of experimental lines grown at the OSU Vegetable Research Farm in 2017.

Line	Incidence (%)	Severity[z]
OSU6992	1.3	1.3
OSU6986	1.5	1.3
OSU6938	1.8	1.5
OSU6993	2.3	1.5
OSU6827	2.5	1.8
OSU6965	4.0	2.5
OSU6771	5.3	2.8
Sahara	5.5	3.0
OSU6893	8.0	3.3
Cornell 501	9.8	3.3
OSU6900	12.5	3.8
OSU6996	13.0	3.8
OSU6925	13.3	4.0
OSU6909	14.3	4.3
OSU6870	20.0	4.5
OSU6835	20.3	5.0
OSU6980	20.3	5.3
OSU5630	40.0	5.5
OR91G	57.5	6.5
LSD 0.05	18.5	2.2

[z]Scale of 1 - 9 where 1 = least and 9 = most severe.

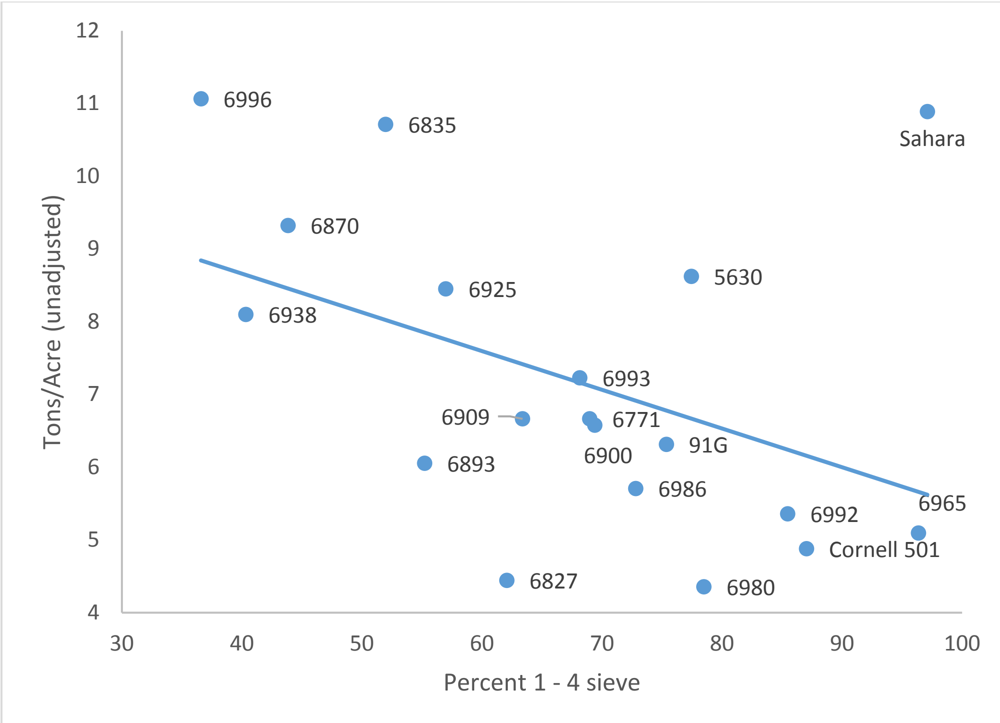

Figure 1. Percent 1-4 sieve vs. unadjusted T/A for experimental snap bean lines and check cultivars grown at the OSU Vegetable Research Farm in 2017.

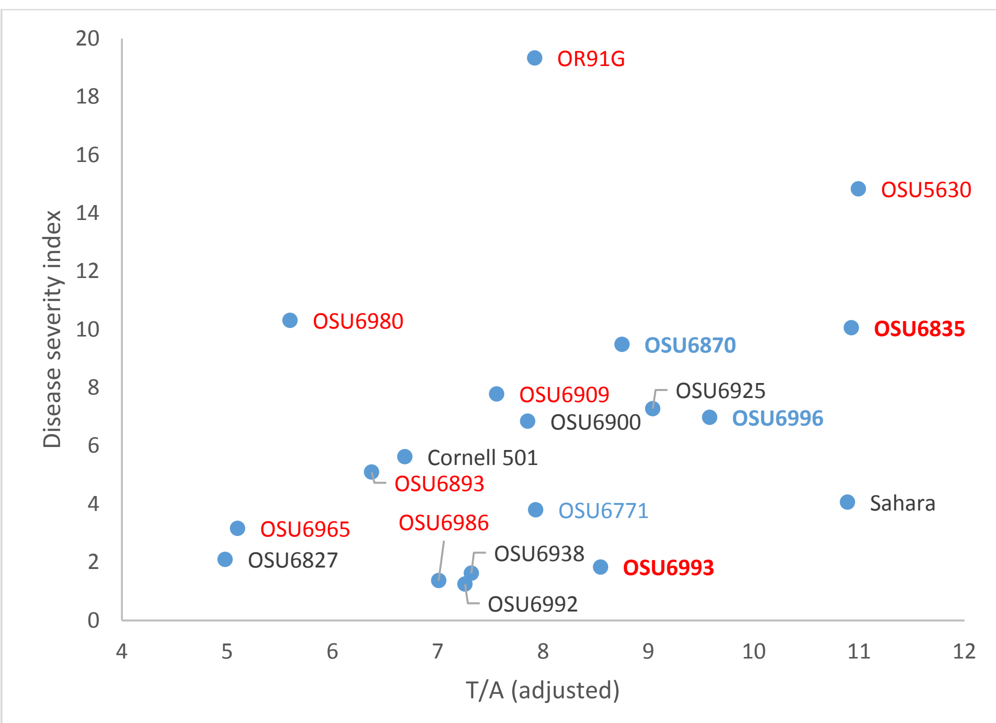

Figure 2. Adjusted T/A yield vs. disease severity index (geometric mean of incidence and severity) for white mold in an evaluation of advanced green bean lines grow in at the OSU Vegetable Research Farm in 2017. Entry names in red have very good sensory evaluations while those of entries in blue were rated good. Those in black were either not evaluated or were ranked as poor.

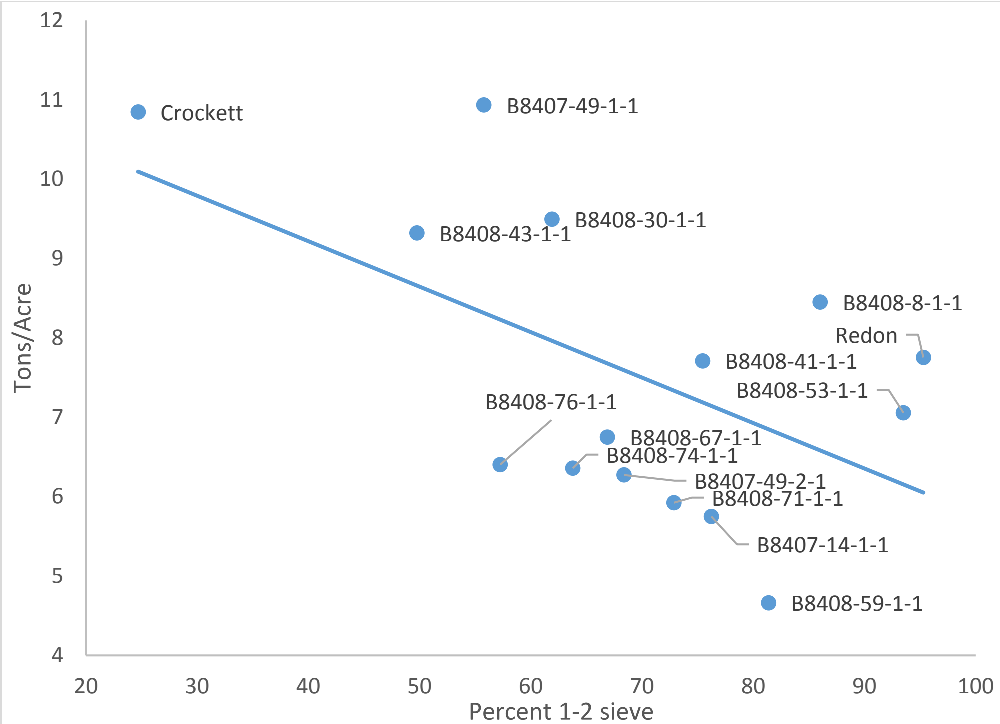

Figure 3. Percent 1-2 sieve size vs. T/A of extra fine experimental snap bean lines and check cultivars grown in a yield trial at the OSU Vegetable Research Farm in 2017.

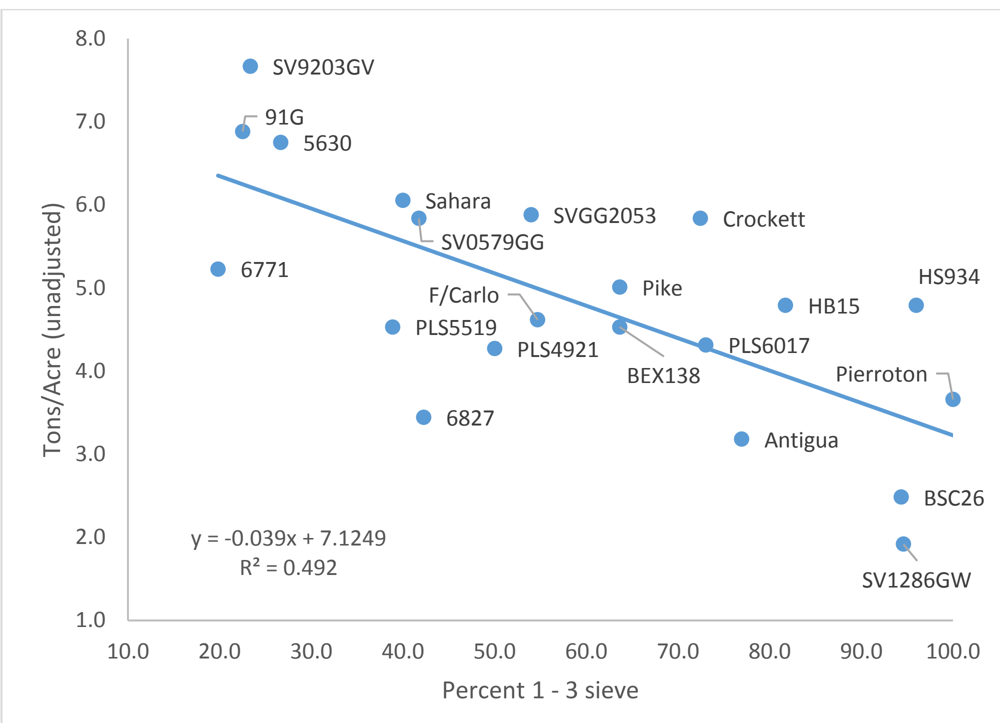

Figure 4. Percent 1-3 sieve size vs. unadjusted T/A for commercial snap bean cultivars grown in a yield trial at the OSU Vegetable Research Farm in 2017.

Research Progress Report for 2017-18 Funded Projects

Agricultural Research Foundation

and the

Oregon Processed Vegetable Commission

Title: Interseeding of Cover Crops to Improve Cover Crop Establishment and Performance in Sweet Corn

Project Leader(s):

PI: Ed Peachey
Organization: Oregon State University
Telephone: 541-740-6712
Email: ed.peachey@oregonstate.edu

Co-PI: Dan Sullivan
Organization: Oregon State University
Telephone: 541-737-5715
Email: dan.sullivan@hort.oregonstate.edu

Other project participants: Ryan Clark, Olsen Farms, Suver; Scott Setniker, Setniker Farms, Independence; Ernie Pearmine, Pearmine Farms, Gervais; Jeff Ediger, Ediger Farms, Dayton; and Scott Zielinski, Windsor Island Farms, Salem; Laura Masterson, 47 Ave Farms, Grand Island; Eric Horning, Horning Farms, Monroe; and Andrew Donaldson, Horticulture Dept. OSU.

Funding History: 2016: $12,870 2017: $12,870

Abstract:

Cover crop establishment for producers of processed vegetables in the Willamette Valley of western Oregon can be a challenge, depending on fall weather and the when winter rains arrive. A potential improvement is to interseed a cover crop into corn or other vegetable crops before the vegetable crop canopy becomes too competitive. Interseeding cover crops introduces additional weed management challenges, however, and the tradeoffs must be thoroughly understood before this strategy is adapted. Research and demonstration trials of 2017 were located at several sites in western OR and highlights are summarized below.

- A cover crop of triticale and crimson clover produced adequate biomass when interseeded at V4 and V6 and did not interfere with corn growth and yield.
- In sweet corn near Monroe, interseeded winter wheat survived corn harvest well and reduced soil sediment losses during November rains.
- In an organic sweet corn field near Macksburg, corn yield may have been slightly reduced by the presence of a common vetch crop that was interseeded at V7-8.
- In a sweet corn field near Mollala, all cover crop treatments except tall fescue tolerated Outlook applied PPS at 12 oz/A, but not 21 oz/A.
- Cereal rye and Cayuse oats established well in organic processing squash, but may have reduced yield because of competition with the crop or damage during interseeding.
- Tall fescue failed to establish adequately in a conventional sweet corn field of 30 acres near Windsor Island Rd.
- In a replicated trial, row orientation and the competitiveness of the corn variety affected cover crop drymatter accumulation.
- Weed control with 4-HPPD herbicides was poor when applied to sweet corn at V6, and the addition of Basagran made little improvement.
- Red and crimson clover were differentially affected by the 4-HPPD herbicides in a trial that evaluated several herbicides for carryover and potential to damage 15 interseeded cover crop species.

Key Words: cover crop, interseeding, relay planting, herbicide, carryover.

Objectives:

1. Measure the effect of sweet corn variety, cover crop species, and time of POST herbicide application on cover crop growth and survival and competition with the corn crop.
2. Begin creating a decision-making model that helps growers determine whether interseeding is appropriate for a particular planting date or variety.
3. Measure efficacy of topyralate in sweet corn and compare with other HPPD inhibitors such as tembotrione (Laudis) and topramezone (Impact) to determine whether these herbicides are compatible with interseeding objectives.

Procedures and Accomplishments:

Objective 1. Measure the effect of sweet corn variety, cover crop species, and time of POST herbicide application on cover crop growth and survival and competition with the corn crop.

Research Farm Site (Tables 1 and 2)

Sweet corn Var. 4927 was planted on June 20 at 28,000/A. Preemergence herbicides and chlorpyrifos were not applied in 2017. Plots were cultivated on July 8, and a mix of triticale (Var. 099) and crimson clover (Nitrocoat) at 80 and 15 lbs/A, respectively were interseeded with the high clearance drill on July 10 at V4, followed by a broadcast application of Impact (3/4 oz/A) and Basagran (1 pt/A) on July 11. V6 treatments were interseeded on July 1 followed by Impact and Basagran on July 19. V8 treatments were interseeded on July 24, followed by a directed application of Impact and Basagran under the canopy the same day. Urea was applied with a hand push spreader at 80 lbs N/A (determined by PSNT test) on July 21. Corn growth and soil moisture were measured throughout the summer. Cover crop biomass was collected just before corn was harvested on September 8. Corn was harvested by hand from 20 ft of row in each plot. The entire plot was machine harvested on September 11 to simulate commercial harvest after the yield estimate was taken. Fall cover crops were planted in designated plots on Sept 28 and cover crop biomass was measured again on December 6.

Triticale emergence was much less when interseeded at V8 that on V4 or V6. Clover emergence was best when broadcast rather than drilled. Corn growth and competition with the cover crop was unaffected by the cover crop treatments at midseason. Corn yield was unaffected by cover crop, also, with the exception that average ear wt may have been reduced in the V4 planting. Cover crop production (dry wt) was greatest in the V4 treatment.

On farm demonstrations

Monroe, conventional sweet corn (Table 3, Figure 1). Sweet corn var. Jubilee super sweet was planted on June 1. Impact herbicide (without atrazine) was applied on June 26 to the entire field to control weeds. Cover crops were interseeded on July 6 at V6 to 7 at approximately 490 GDD (Base 50 for Jubilee sweet corn). Cover crops were seeded into plots 150 by 20 ft with two replications in a randomized block. At the time of interseeding, the corn was at V6-7, was 19.7 in tall, had a stand density of 20,100 plants/A, and had a LAI reading of 0.88. Cover crop and corn yield were estimated on September 12, before commercial harvest. Corn was machine harvested on September 17. On Oct 10, small areas adjacent to Block 2 were tilled to 4 in. with a tractor powered rototiller to simulate conventional planting of cover crops. The grower direct-seeded winter wheat and radish to the entire field on October 27. Forage winter wheat (var. Cleada) was seeded into the conventional tillage plots on Nov 7. Water collectors (11 ft sq) were installed on Nov. 6 in the four treatment types with three replications in a non-randomized design so that the effect of cover crop and tillage system on soil and nutrient loss can be measured.

Triticale var. 2700 provided the most cover crop drymatter, followed by winter wheat. Yield was highly variable among plots and the variability was not related to competition from the cover crop. Sediment losses from the winter wheat plot were less than from the conventionally tilled and direct-seeded plots, but similar to losses from the fallow plot.

Cramer Rd., Molalla, organic sweet corn. Common vetch was interseeded into corn on July 19 that averaged 22 inches tall at V6, had a LAI of 0.86 and a corn stand of 17,500 plants/A. Plots were 1130 ft by 20 ft wide (~ ½ A) and seeded at 40 or 60 lbs/A and two depths. Corn was machine harvested and yield of the entire plot was compared to yield of the adjacent field. Common vetch emerged well and continued to survive though the growing season, despite a very competitive corn crop.

No differences in biomass were noted among the four planting depths and seeding rates. Yield as determined by grade tickets from the cannery indicated that corn yield might have been suppressed slightly by the presence of the cover crop. The area planted to common vetch yielded 11.51, and the adjacent area that was not interseeded yielded 12.18 t/A. Harvest and failing after the harvest to control weed seed production damaged the vetch, but as of December 15 the vetch was still surviving well.

Barnards Rd., Molalla, conventional sweet corn (Table 4). Sweet corn var. Jubilee Super Sweet was planted on June 6. Outlook herbicide treatments were applied on June 9 to 4 blocks that were 80 x 50 ft. The design was for demonstration purposes and cover crop were planted in strip 250 x 20 feet and unreplicated. Cover crops were interseeded on July 11 in 200 by 20 foot strips that transversed the herbicide blocks. Impact (1 oz/A) and Basagran (1 pt/A) were applied to the entire plot after cover crops were seeded. Corn was harvested from 20 ft of row in each plot on September 13 and cover crop biomass harvested 2 -7.5 ft sq areas in each plot.

All cover crop treatments tolerated Outlook applied at 12 oz/A, but not 21 oz/A when applied approximately 5 weeks before planting. Fescue was injured by all rates of Outlook. We were not able to track cover crop survival during the winter because the plot was inadvertently used for a staging area during harvest and was destroyed.

Gervais, organic squash (Table 5). Cereal rye (110 lbs/A), oats (100 lbs/A), and red clover (20 lbs/A) were seeded into a Golden delicious squash field on 13-Jul after the final cultivation. The three cover crops were interseeded in demonstration plots that were 1250 x 20 ft (approximately 0.6 A). The crop had begun to 'run' at the time of interseeding and a few runners were damaged during interseeding. Squash was harvested on 5-Oct from a 120 ft sq area in each plot and cover crops from a 6 sq foot area.

Squash yield was likely reduced by competition from the oats and possibly damage by from the planter. Cereal rye increased yield variability between plots but did not appear to reduce yield. The cereal rye survived the mechanical harvest best.

Windsor Island Rd, sweet corn. Tall fescue was interseeded into a 30 acre planting of sweet corn at a rate of 15 lbs/A. In contrast to 2016, fescue establishment was very poor and the plot was terminated after the corn was harvested.

Table 1. Effect of interseeding time and POST herbicide on cover crop and corn growth, Vegetable Research farm, 2017.

	Cover crop planting system	Cover crop	Rate	Sweet corn growth state when cover crops were interseeded	Date cover crops seeded	Post herbicide (topramezone 3 oz/A)	Triticale emergence (4-Aug)	Clover emergence (4-Aug)	Leaf area index (LAI)	Corn height
							no/3 ft	*no/3 ft*		*inches*
1	Interseed + POST	Cr. Clover + Triticale	15:80 lbs/A	V4	10-Jul	V4[1]	39	20	4.3	75
2	Interseed + POST	Cr. Clover + Triticale	15:80 lbs/A	V6	17-Jul	V6[1]	17	26	4.5	73
3	Interseed + POST	Cr. Clover + Triticale	15:80 lbs/A	V8	24-Jul	V8[2]	7	8	4.1	73
4	Interseed, No POST	Cr. Clover + Triticale	15:80 lbs/A	V4	10-Jul	N	30	2	5.3	73
5	Interseed, No POST	Cr. Clover + Triticale	15:80 lbs/A	V6	17-Jul	N	21	18	4.3	75
6	Interseed, No POST	Cr. Clover + Triticale	15:80 lbs/A	V8	24-Jul	N	4	7	5.2	74
7	Broadcast + POST	Cr. Clover + Triticale	15:80 lbs/A	V4	10-Jul	V4[1]	40	31	5.1	76
8	Broadcast + POST	Cr. Clover + Triticale	15:80 lbs/A	V6	17-Jul	V6[1]	18	26	5.0	75
9	Broadcast + POST	Cr. Clover + Triticale	15:80 lbs/A	V8	24-Jul	V8[2]	5	17	5.3	73
10	Direct-seeded	Cr. Clover + Triticale	15:80 lbs/A	After ear harvest	28-Sept	V6[2]	-	-	4.7	76
11	Conventional	Cr. Clover + Triticale	15:80 lbs/A	After ear harvest	28-Sept	V6[2]	-	-	5.2	74
12	Checks (POST all V8)	None			-	V6[2]	-	-	5.1	75
	FPLSD (0.05)						*15*	*19*	*ns*	*ns*

[1] Impact (3/4 oz/A) + Basagran (1 pt/A)
[2] Directed application

Table 2. Effect of interseeding method, time, and POST herbicides on corn yield, Vegetable Research farm, 2017.

	Cover crop planting system	Cover crop	Sweet corn growth stage @ inter-seeding	Corn and Cover Crop Yield (7 Sept)					
				Plant stand	Ear number	Ear yield	Avg. Ear wt.	Cover crop dry wt.	Weed dry wt.
				no/A	*no/A*	*tons/A*	*lb/ear*	*lb/A*	*lbs/A*
1	Interseed + POST	Cr. clover + Triticale	V4	23813	27007	11.8	0.87	904	467
2	Interseed + POST	Cr. clover + Triticale	V6	22651	27298	9.8	0.70	666	0
3	Interseed + POST	Cr. clover + Triticale	V8	21780	23813	9.7	0.81	614	774
4	Interseed, No POST	Cr. clover + Triticale	V4	20619	27588	11.1	0.81	697	764
5	Interseed, No POST	Cr. clover + Triticale	V6	21490	24684	10.9	0.89	243	1234
6	Interseed, No POST	Cr. clover + Triticale	V8	22070	25555	10.9	0.85	209	1381
7	Broadcast + POST	Cr. clover + Triticale	V4	22361	29621	12.6	0.84	769	546
8	Broadcast + POST	Cr. clover + Triticale	V6	21199	26717	11.2	0.85	733	283
9	Broadcast + POST	Cr. clover + Triticale	V8	22070	22651	10.3	0.90	656	214
10	Direct-seed	Cr. clover + Triticale	After harvest	21490	26717	10.4	0.78	0	420
11	Conventional	Cr. clover + Triticale	After harvest	23522	26136	11.5	0.89	0	423
12	Fallow	None		21199	25845	11.2	0.87	0	215
	FPLSD (0.05)			*ns*	*ns*	*ns*	*0.04*	*384*	*609*

Table 3. Effect of interseeded cover crop treatments on corn yield and cover crop drymatter accumulation, Monroe.

	Cover crop treatment	Ear yield	Corn yield	Cover crop drymatter
		no/A	*t/A*	*lbs/A*
1	Triticale 099	20000	8.6	429
2	Triticale 2700	21800	8.6	1068
3	W. Wheat	26100	10.6	748
4	Check	12000	8.3	0
5	Cayuse oat	25700	10.4	493
	FPLSD (0.05)	*ns*	*ns*	*600*

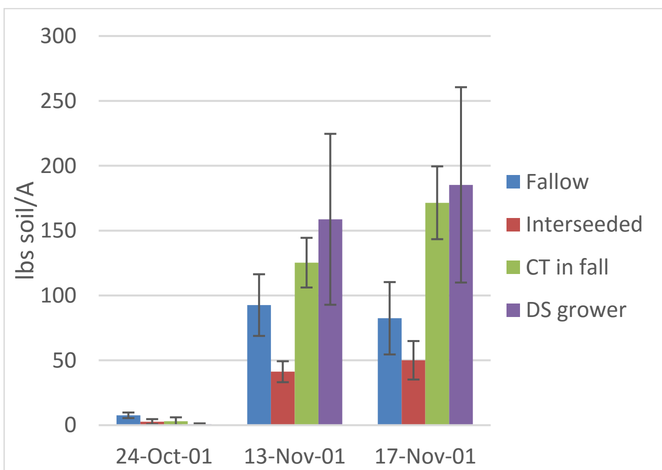

Figure 1. Soil loss from plots from Oct 24-Nov 17, 2017. Monroe (± SE)

Table 4. Effect of PRE herbicide on survival and growth of interseeded cover crops, Barnards Rd, 2017 (n=2).

Cover crop treatment	Cover crop rate	Outlook herbicide rate	Ear harvest	Yield	Average ear wt.	Cover crop drymatter
	Lb/A	*oz/A*	*No./A*	*t/A*	*lbs*	*lbs/A*
Comm. vetch	60	12	22200	10.3	0.93	185
Comm. vetch	60	16	23500	9.8	0.83	105
Comm. vetch	60	21	20000	9.1	0.90	67
Comm. vetch	60	0	22700	9.5	0.84	125
Oats + comm. vetch	60+15	12 oz	21800	9.3	0.85	853
Oats + comm. vetch	60+15	16 oz	24000	10.7	0.90	1176
Oats + comm. vetch	60+15	21 oz	23500	10.8	0.92	240
Oats + comm. vetch	60+15	0	20500	9.3	0.91	1051
Triticale + cr. clover	60+15	12 oz	26600	11.5	0.87	853
Triticale + cr. clover	60+15	16 oz	-	-	-	-
Triticale + cr. clover	60+15	21 oz	24400	11.2	0.92	268
Triticale + cr. clover	60+15	0	27000	10.4	0.77	1648
Fescue	15	12 oz	26600	11.2	0.84	0
Fescue	15	16 oz	-	-	-	13
Fescue	15	21 oz	22200	11.2	1.01	0
Fescue	15	0	24000	10.5	0.87	32
FPLSD (0.05)			*2100*	*1.2*	*0.04*	*647*

Table 5. Squash and cover crop yield in interseeded plots, Gervais, Oct 5, 2017 (n=3).

Cover crop	Squash yield			Cover crop drymatter	Weed drymatter
	Tons/A	*No. fruit/plot*	*Avg. wt/fruit*	*lbs/A*	*lbs/A*
Red clover	22.9	11.0	10.8	489	0
Oats	18.3	10.0	9.5	2308	91
Cereal rye	24.3	11.0	11.4	995	40
No cover crop	25.1	11.0	11.8	0	1956
FPLSD (0.1)	*ns*	*ns*	*1.8*	*733*	*478*

Objective 2. Begin creating a decision-making model that helps growers determine whether interseeding is appropriate for a particular planting date or variety..

Row orientation x Variety x Topping. Two sweet corn varieties, Coho and Spring Treat, were planted on June 26 in two 40'x40' row orientations, east-west and north-south, in a split plot design. Within each plot, divided Coho and Spring Treat subplots were split 20' x 40'. Within each variety block, a topping treatment was applied, further splitting plots into 10' x 40', resulting in an Orientation x Variety x Topping treatment of eight plots with four replications. A two-way cover crop mix of cayuse oats (60 lbs/A) and common vetch (30lbs/A) was interseeded in all plots at the V5-V6 growth stage, using the Coho as reference. The topping treatment was applied the Spring Treat on August 23 and to the Coho on September 6. Spring Treat ear harvest and cover crop biomass sampling occurred on September 8. Coho harvest and cover crop biomass sampling occurred on-September 17.

Cover crop emergence was higher overall in Spring Treat, which most likely was due to smaller overall stature of the corn, leading to lower light interception by the sweet corn. Topping produced higher cover crop biomass in both row orientations in Coho. Within Spring Treat, topping had no real effect, most likely due to the smaller stature and lower overall biomass, as biomass was the highest by comparison. Cover crop biomass in North-South orientations produced higher cover crop biomass, apart from Spring Treat East-West treatments. Weed populations were small and exhibited no real competitive effect on the cover crop.

Table 6. Effect of row orientation and topping on cover crop drymatter, Corvallis.

Variety	Topping	Row Direction	Plant Stand	Ears	Ear Yield	Cover Crop dry wt.	Weed dry wt.
			no/A	no/A	tons/A	lb/A	lb/A
Coho	Topped	E/W	20255	17424	6.0	74	16
	Topped	N/S	21562	19820	6.7	124	37
	Topped	Averaged over direction	20909	18622	6.3	61	8
Coho	Untopped	E/W	20473	23087	8.3	48	0
	Untopped	N/S	19166	18513	6.2	62	0
	Untopped	Averaged over direction	19820	20800	7.2	36	1
Spring Treat	Topped	E/W	20909	18731	6.3	241	50
	Topped	N/S	22216	20691	5.2	284	91
	Topped	Averaged over direction	21562	19711	5.8	201	34
Spring Treat	Untopped	E/W	23087	21562	7.5	166	20
	Untopped	N/S	21998	20255	7.3	125	5
	Untopped	Averaged over direction	22542	20909	7.4	208	19

3. Measure efficacy and carryover of topyralate and other HPPD and preemergent herbicides in sweet corn to determine potential for use in interseeding programs.

<u>HPPD herbicide efficacy (Table 7).</u> Sweet corn was planted on June 20. POST herbicide treatments were applied on July 11 to plots that were 25 x 10 ft and replicated 4 times in a randomized complete block design. The corn was 18.8 inches tall with a plant population of 14,000/A that produced a LAI reading at the soil surface of 0.08 at the time of the herbicide application. Poor stand and uneven growth contributed to the low LAI reading. Cover crops were interseeded the same day and included triticale (50 lbs/A), common vetch (30 bs/A), and red and crimson clover at 10 lbs/A each.

Cover crop emergence was extremely poor for unknown reasons and produced little if any biomass by the time corn was harvested. Weed control was fair to poor at mid-season, probably because of the late application of the HPPD herbicides and omission of atrazine in the tankmix. Tankmixes with Basagran improved weed control slightly. Corn growth was reduced in many of the treatments, in part due to competition from weeds present as demonstrated by the crop growth reduction in the untreated check plot of 43%. There was very little improvement in crop yield compared to the untreated plot.

Carryover of postemergence herbicides (Table 8). The field was tilled and designated herbicides applied on May 20, 14 days before cover crops were seeded. All treatments were applied with a 5-nozzle boom sprayer to 10 x 80 ft main plots at the vegetable research farm. A second set of herbicide treatments was applied on May 27, 7 days before cover were seeded. Cover crops were planted on 3-June in strips perpendicular to the main herbicide plots and designated herbicides applied the following day. Emergence counts were made 2 and 4 weeks after planting along with an overall cover growth rating.

Results were as expected with exceptions. Laudis and Impact caused significant damage to red clover. Crimson clover was very tolerant to Laudis, whereas Impact caused significant damage to crimson clover. All of the legumes appeared to be tolerant to tolpyralate, which is surprising given the residual broadleaf control that has been noted in previous trials.

Table 7. Efficacy of triazine-less POST herbicide treatments on weed control and corn yield, Wheatland, 2017.

	Treatment[a]	Timing		Corn growth reduction	Weed control (9-Aug)				Corn Harvest			
					Pig-weed	Hairy nightshade	Nut-sedge	Total	Ear count	Ear yield	Avg. ear wt.	Weed control
				%	%				#/A	t/A	lbs	%
1	Laudis	V6	3 oz	23	78	71	43	68	16300	6.4	0.75	46
2	Laudis +	V6	3 oz	20	68	91	81	84	17600	6.6	0.75	54
	Basagran	V6	1 pt									
3	Impact +	V6	1 oz	40	90	71	25	80	22200	8.5	0.76	74
4	Impact+	V6	1 oz	23	91	79	43	88	18700	7.7	0.84	73
	Basagran	V6	1 pt									
5	Tolpyralate	V6	1 oz	28	95	58	38	80	16100	6.3	0.74	48
6	Tolpyralate+	V6	1 oz	18	94	90	53	90	20500	8.0	0.79	89
	Basagran	V6	1 pt									
7	Bicyclopyrone	V6	1.8 oz	20	93	55	43	73	20500	8.3	0.81	66
8	Bicyclopyrone	V6	1.8 oz	29	85	88	50	88	19600	8.1	0.83	55
	Basagran	V6	1 pt									
9	Callisto	V6	3 oz	33	56	73	33	63	19200	8.0	0.84	55
10	Callisto	V6	3 oz	30	78	93	88	80	20000	7.8	0.78	61
	Basagran	V6	1 pt									
11	Check			43	-	-	-	-	16300	6.8	0.78	51
12	Outlook	V6	16 oz	35	94	80	43	89	20000	7.7	0.77	76
	Impact	V6	1 oz									
13	Grower treatment			0	-	-	-	-	23200	10.2	0.89	-
	FPLSD (0.05)			*Ns*	*17*	*23*	*ns*	*19*	*ns*	*ns*	*ns*	*ns*

[a] MSO and UAN applied to all treatments except Callisto with COC.

Table 8. Herbicide residual effects on cover crop species, Veg Res Farm, Corvallis, 2017.

	Herbicide	Days before planting that herbicide was applied	Rate per acre	Cereal rye	Triticale	Red clover	Crimson clover	Cayuse spring oat	Spring barley	Tall fescue	Sudangrass	Annual ryegrass	Per. ryegrass	Common vetch	Buckwheat	Phacelia	Berseem clover	Spring wheat
				cover crop growth rating (10 is best; 0=no emergence)														
1	Atrazine	14	1 pt	9.0	10.0	0.0	0.7	9.7	10.0	10.0	10.0	10.0	7.7	9.0	4.7	2.7	1.0	5.7
2	Laudis	7	3 oz	10.0	10.0	0.0	9.0	9.7	10.0	10.0	10.0	10.0	10.0	9.0	10.0	6.7	6.7	6.7
3	Laudis	0	3 oz	9.7	10.0	0.0	9.0	10.0	10.0	9.7	9.0	10.0	9.3	5.0	9.0	4.0	2.7	6.7
4	Impact	7	1 oz	9.7	10.0	1.7	1.7	10.0	10.0	10.0	10.0	10.0	10.0	7.0	8.7	8.3	7.3	6.7
5	Impact	0	1 oz	9.7	10.0	2.0	4.0	10.0	10.0	10.0	10.0	10.0	10.0	7.7	10.0	3.7	5.0	6.7
6	Outlook	14	12 oz	6.7	8.3	3.3	3.7	8.0	8.7	0.0	3.0	0.7	0.3	7.3	6.3	4.0	2.7	6.3
7	Dual Mag	14	16 oz	1.3	2.7	5.7	6.3	6.3	6.3	0.0	2.3	0.3	0.3	5.3	7.7	5.0	3.3	5.0
8	Reflex	14	8 oz	8.3	8.3	8.3	7.0	7.3	8.3	9.0	2.0	10.0	10.0	7.3	5.7	8.7	9.3	5.7
9	Tolpyralate	7	1 oz	9.7	10.0	9.3	7.3	10.0	10.0	8.3	8.3	10.0	10.0	7.7	7.3	7.3	3.0	5.7
	FPLSD (0.05)			2.9	2.1	2.9	2.9	2.3	1.2	1.9	2.0	0.4	2.3	4.2	2.5	4.6	5.8	ns

Impacts:

Interseeding of cover crops is not a new concept for producers of processed vegetables in Oregon. Annual ryegrass has been successfully seeded with corn for decades. Cropping systems evolve, however, and now annual ryegrass is not suitable because of its weedy nature and potential to affect production of other crops in the rotation. This research demonstrates that interseeding may improve profitability and sustainability of production in certain situations. Of most interest by the cooperators is the potential to establish tall fescue in sweet corn, potentially eliminating one year in the rotation cycle and improving pest management options.

Relation to Other Research:

These projects complement many of the other research projects that are underway in processed vegetable production. We continually strive to provide relevant information to producers that will reduce cost or improve the cost per unit of efficacy that a technology provides.

Research Progress Report for 2017-18 Funded Projects for the
Agricultural Research Foundation
and the
Oregon Processed Vegetable Commission

Title: Weed Control in Snap Beans: Tolerance to Flame Weeding and Organic Herbicides, and Improved Efficacy of Reflex

Project Leader(s):
PI: Ed Peachey
Organization: Oregon State University
Telephone: 541-740-6712
Email: ed.peachey@oregonstate.edu

Funding History: 2016: $6,940 2017: $7,910

Abstract. Nonchemical weed control strategies other than cultivation are in short supply in dicot crops such as snap beans, particularly strategies that target weeds within the seed row. One option is the use of flame weeding in stale seedbeds, a common practice in low input and organic systems. Seedbeds are prepared but weeds encouraged to emerge before the crop is planted, then removed with flame before the crop emerges. Flame weeding is routinely used in corn, but the window of opportunity is less in snap beans because of potential damage to the hypocotyl and growing point in young bean seedlings. A second set of studies was designed to determine what Reflex herbicide use patterns most effectively control lambsquarters, a weed that is often missed in snap bean weed control programs.

Both flame and organic herbicides reduced yield compared to the untreated check. Flaming improved weed control in the row better than organic herbicides, but not as well as conventional herbicides. Even when irrigation and/or rain are not expected, growers may benefit by applying Reflex post plant surface, especially in situations where the application can be delayed and a few weeds have emerged before the crop has emerged.

Key words: stale seedbed, flaming, organic herbicides, fomesafen

Objectives:

1. Compare flame weeding and Suppress herbicide for snap bean crop safety and weed control in stale seedbed systems.
2. Determine conditions that reduce the efficacy of Reflex applied PRE and POST Plant surface and allow lambsquarters to escape.

Procedures and accomplishments

Objective 1. Compare flame weeding and Suppress herbicide for snap bean crop safety and weed control in stale seedbed systems.

This study was conducted at OSU's Vegetable Research Farm in Corvallis on a Chehalis silty clay loam soil. The field was tilled on June 27, irrigated with ½ in water, then designated plots (Dual Magnum + Reflex, and the Tilled check) again on July 9 before planting. On July 10, snap beans (var. 5630) were planted 1.5 in deep with fertilizer (325 lb/acre of 12-10-10) banded next to the seed row into the stale seed bed and tilled treatments. Dual Magnum and Reflex were applied to treatment 18 (see Table 1 for a list of treatments). The flaming and organic herbicide treatments were applied on 15-Jul in the early morning (cracking) or late afternoon (hypocotyl) at the following emergence stages: 1) Crack (soil surface in row beginning to lift with a few hypocotyls showing), and 2) Hypocotyl showing (an average emergence of 5.3% of hypocotyls visible from seed that was planted) (Table 1). The number of snap bean seedlings that had emerged were counted before each application, and the number of damaged seedlings counted 7 days after treatment. Raptor and Basagran herbicides were applied to the entire trial on July 29 to beans in the 2nd trifoliate. All plots were cultivated multiple times to eliminate weed pressure. Hand hoeing was used to remove escapes. Poast herbicide was applied between rows where barnyardgrass escaped the herbicide sprays. Snap beans

Results (Table 2). Injury to snap bean seedlings was highly variable and inconsistent with original hypotheses. Injury was visible on many treatments but did not always reduce yield. Flaming reduced plant stand when applied after cracking, but did not increase the number of severely injured seedlings, probably because a few plants were killed during the flaming operation. Weed density was reduced by most treatments compared to the stale seedbed reference. Overall, flaming more effectively killed weeds than the organic herbicides. The application rate for the organic herbicides was 20 GPA, and later experiments indicated that 40 GPA or greater significantly enhance weed control. Crop yield differed statistically between treatments, but primarily because the greatest yield was in the untreated check plot, which yielded 10.4 tons/A. Yield of the organic herbicide treatments was less than the untreated check. Suppress herbicide appeared to cause more damage to crop yield than Avenger Opti. Flame treatments overall had the lowest yields, and the cause of this is unclear (Figure 1). Even flame treatments applied before snap beans emerged (cracking) reduced yield by as much as 26%. The only difference between these flame treatments and the untreated check was one additional pass through with the tractor. The Dual Magnum + Reflex treatment also reduced snap bean yield by 17%.

Table 1. Herbicide and flaming application data, Vegetable Research Farm, Corvallis.

Date	07/11/17	07/14/17	07/15/17	07/15/17	07/15/17	07/15/17	7/29/17
Treatment	Dual Magnum 16 oz + Reflex 8 oz	Glyphosate	Suppress and Avenger @ crack	Flame	Flame	Suppress and avenger	Raptor 4 oz + Basagran 16 oz + 0.5% NIS
Timing	PPS	PRE	Crack	Crack	Hypocotyl	Hypocotyl	2nd trifoliate
Crop emergence	-	Very early crack	Very early crack, 3 hypocotyl visible per 40 ft of row on average	Very early crack, 3 hypocotyl visible per 40 ft of row on average	See data	See data	None
Time	5:45 AM	7pm	8-8:45 AM	9:50 - 10:30 AM	6:30-7:15 PM	7:40-8:30 PM	9-10 AM
Soil moisture	Dry	Wet	Damp	Dry to damp	Dry	Dry	Dry
Wind direction	NE	NE	0	0	W	W	NE
Wind speed	0-3	2-5	0	0	1-6	1-6	2-4
Nozzle size	5-XR8003	5-XR8003	5-XR8003	-	-	5-XR8003	6-XR8002
Pressure (PSI)	25	25	25	20	20	25	25
Delivery rate (GPA/BTU)	20	20	20	45,000 BTU/A	90,000 BTU/A	20	20
Air temp	65	78	60	65	74	74	70
RH (%)	52	38	68	54	47	47	60

Table 2. Crop injury following propane flaming or Suppress herbicide application at crook to snap beans planted into a stale seedbed system (Fig. 1).

	Herbicide/Flaming	Snap bean growth stage when treatment applied	Rate	Date, Time, Days after planting	Plant stand 21-Jul	Crop injury (21-Jul, 7 days after treatment)			Weed density	Crop Yield (11-Sept)				
						Light but visible damage to seedlings	Severe damage to seedlings	Total seedlings injured	In row	Plant stand	Plant biomass	Ratio of pods to biomass	Pod yield	Grade
					No/A	*-------- %*	*of seedlings damaged*	*-------*	*no/ m sq.*	*no./A*	*t/A*	*-*	*t/A*	*% 1-4*
Flame applied to stale seedbeds														
1	Suppress (9%) fb	Crack fb	20 GPA	15-Jul 9 AM (5)	155400	4.4	4.7	9.1	6.0	153500	18.4	0.40	8.1	60
	Flaming	Hypocotyl	5 GPA	15-Jul 8 PM (5)										
2	Flaming fb	Crack fb	5 GPA	15-Jul 9 AM (5)	168400	7.5	4.7	12.2	7.8	151400	17.8	0.42	8.1	69
	Suppress (9%)	Hypocotyl	20 GPA	15-Jul 8 PM (5)										
3	Flaming	Crack	5 GPA	15-Jul 9 AM (5)	172800	2.5	2.3	4.8	3.5	155700	18.2	0.39	8.2	64
4	Flaming	Crack	10 GPA	15-Jul 9 AM (5)	165500	1.7	0.0	1.7	3.3	160600	18.2	0.37	7.4	67
5	Flaming	Hypocotyl	5 GPA	15-Jul 8 PM (5)	174200	8.4	4.9	13.3	5.5	138300	16.1	0.44	7.6	67
6	Flaming	Hypocotyl	10 GPA	15-Jul 8 PM (5)	151000	4.8	3.8	8.6	4.0	143000	18.0	0.40	7.9	66
Herbicide applied to stale seeds (excluding Trs. 16-18).														
7	Suppress (9%) + UAN 2.5 % + MSO 1%	Hypocotyl	20 GPA	15-Jul 8 PM (5)	159700	1.0	3.7	4.6	6.5	145400	17.9	0.42	8.0	63
8	Suppress (9%)	Crack	20 GPA	15-Jul 9 AM (5)	168400	3.6	3.5	7.1	9.0	185100	20.0	0.43	9.4	59
9	Suppress (9%)	Hypocotyl	20 GPA	15-Jul 8 PM (5)	158300	7.2	2.4	9.6	0.0	156800	19.3	0.44	9.2	62
10	Suppress (18%)	Crack	20 GPA	15-Jul 9 AM (5)	193100	0.9	2.3	3.3	10.8	156800	19.4	0.42	8.8	63
11	Suppress (18%)	Hypocotyl	20 GPA	15-Jul 8 PM (5)	196000	11.5	2.3	13.8	11.3	150800	17.7	0.40	7.8	66
12	Avenger Opti (7%)	Crack	20 GPA	15-Jul 9 AM (5)	151000	4.9	1.1	6.0	4.0	161700	18.2	0.42	8.1	63
13	Avenger opti (7%)	Hypocotyl	20 GPA	15-Jul 8 PM (5)	164100	2.7	5.3	8.0	8.0	139900	18.6	0.47	9.2	61
14	Avenger opti (14%)	Crack	20 GPA	15-Jul 9 AM (5)	181500	3.4	0.9	4.2	6.0	147000	17.3	0.50	8.7	66
15	Avenger opti (14%)	Hypocotyl	20 GPA	15-Jul 8 PM (5)	167000	1.7	2.9	4.6	14.8	180000	18.8	0.44	8.9	62
16	Tilled, none				168400	1.9	0.0	1.9	13.5	157900	20.6	0.48	10.4	61
17	Tilled, glyphosate	Early crack	1 lb ae/A	14-Jul 7 PM (4)	178600	1.7	3.7	5.4	4.8	154600	18.1	0.44	8.5	69
18	Tilled, Dual + Reflex	PPS	1pt + 1 pt	11-Jul 7 PM (1)	171300	1.9	0.8	2.8	0.8	142100	18.6	0.43	8.6	66
19	Stale seed bed reference					-	-	-	21.2	-	-	-	-	
	FPLSD (0.05)				27500	7.2	ns	ns	16.1	ns	2.1	ns	1.4	5

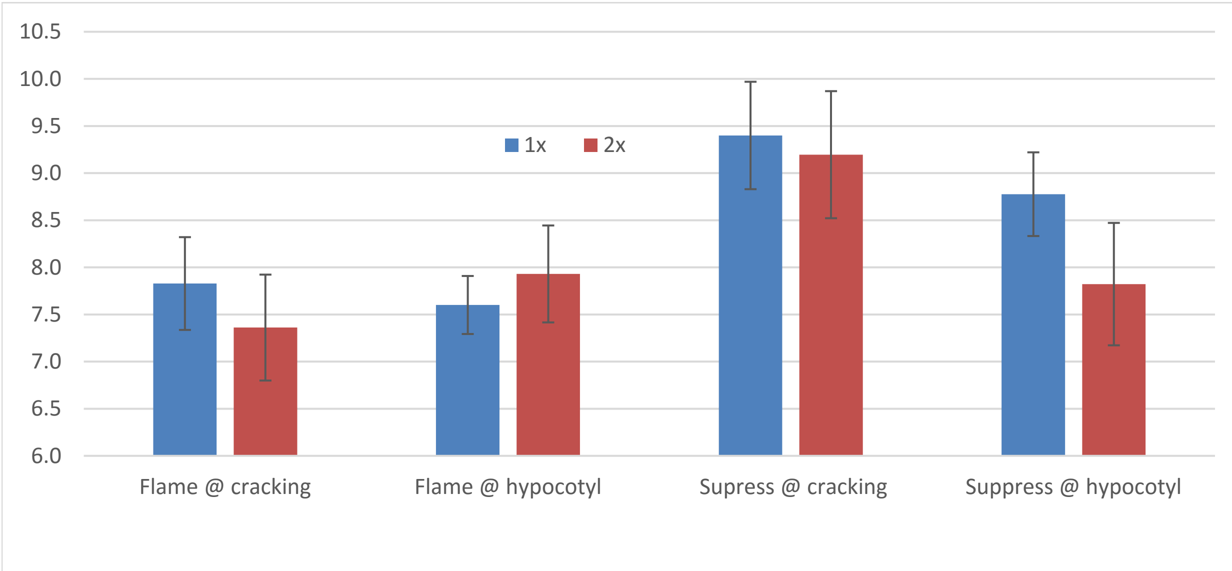

Figure 1. Effect of flaming and organic herbicides on yield of snap beans (+ SE, n=4).

Objective 2. Determine conditions that reduce the efficacy of Reflex applied PRE and POST Plant surface and allow lambsquarters to escape.

Treatments were applied to snap bean plantings at sites near Stayton, Suver, and Jefferson. Data from the Suver site are not reported because adequate weed populations did not materialize. Reflex, Dual Magnum, and Reflex + Dual Magnum herbicide treatments were applied after planting with a CO_2 backpack sprayer delivering 20 GPA through a boom with 5- XR8003 nozzles. Plots were 25 ft long by 10 ft wide and each treatment replicated three times. Snap beans were hand-harvested from 10 ft of row and graded.

Stayton (Table 3). Snap beans were planted on 23-May and the field rolled after planting. All treatments were applied 3 days later over beans that were near to emergence and to plots that had a few visible weed seedlings (see photo to right). Irrigation was not applied to activate the Reflex herbicide, but approximately 0.05 inches of rain fell within 7 days after the PRE herbicide application. Raptor and Basagran were applied on 24-Jun, just after bloom initiated (1%) to reduce competition from surviving weeds. Beans were harvested on 21-July.

Figure. Seedlings that emerged before Reflex herbicide was applied.

Pigweed was by far the dominate weed at this site and was poorly controlled with Dual Magnum alone. Reflex controlled pigweed better than Dual Magnum. Reflex plus Dual Magnum at 1 pt/A provided the best weed control. Despite the fact that irrigation was not used to activate the herbicide, the small amount of rain received after the PRE application (0.05 in) was apparently sufficient to activate the Reflex herbicide. Weed seedlings were noted when PRE herbicide were applied. Perhaps good soil moisture and overall good pigweed seedling emergence after planting was the cause of the good weed control with Reflex. This effect has not been observed in prior research, and should encourage growers to use Reflex in very weedy situations even if the proper amount of irrigation is not available after planting.

Jefferson (Table 4). Snap beans were planted into very wet soil on 22-Jun. Reflex and Dual PRE treatments were applied on 23-Jun. Irrigation followed within 3 days of application with more than ½ inch of water. Basagran (1 qt/A)+COC was applied to the entire plot on 14-Jul to minimize the effect of surviving weeds on crop yield.

Lambsquarters was the primary species present, and control was good to exceptional with Reflex 3 weeks after planting. Reflex plus Dual Magnum controlled nearly all lambsquarters. The estimate of crop yield varied widely from plot to plot and within treatments. Reflex 1 pt/A provided very good weed control with very little injury to the crop. The tankmix of Dual Magnum at 1 pt/A and Reflex 1 pt/A caused significant injury to the crop and may have reduced yield.

Table 3. Effect of Reflex herbicide timing and tank mix on weed control and snap bean yield, Stayton, 2016.

	Herbicide	Product rate	Timing	Rate	Crop injury	Weed (pigweed) control			Harvest (28-Jul)			
					6-Jun	6-Jun	4-Jul	21-Jul	Plant stand	Bio-mass	Pod wt	Grade
		pts/A		*lbs ai/A*	*%*	---------- % -------------			*no./A*	*t/A*	*t/A*	*%1-4*
1	Reflex	½ pt	Del PRE 5/26	0.125	0	72	43	70	10300	9.7	4.7	96%
2	Reflex	1 Pt	Del PRE 5/26	0.25	0	73	47	65	11900	12.4	6.9	99%
3	Reflex+ Dual Magnum	½ Pt 1 Pt	Del PRE 5/26 Del PRE 5/26	0.125 0.95	0	85	63	77	9880	10.2	5.4	91%
4	Reflex+ Dual Magnum	1 Pt 1 Pt	Del PRE 5/26 Del PRE 5/26	0.25 0.95	0	85	82	88	10100	13.2	6.4	96%
5	Dual Magnum	1 Pt	Del PRE 5/26	0.95	0	47	47	57	8500	6.5	2.8	96%
6	Check		-		0	0	0	7	14700	7.7	3.4	82%
						34	32	37	3800	3.8	2.5	-

Table 4. Effect of Reflex rate and tankmix partner on crop growth and weed control, Jefferson, 2017.

	Herbicide	Product rate	Timing	Rate	Crop injury (stunting)	Weed control (15-Jul)	Weed control (26-Aug)			Harvest (26-Aug)			
					15-Jul	Lambs-quarters	Pig-weed	Lambs-quarters	Over-all	Plant stand	Plant bio-mass	Pod yield	Grade
		pt/A		lbs ai/A	%	%	------------------ % ------------------			no./A	t/A	t/A	%
1	Reflex	1/2 pt	PRE	0.125	0	91	67	95	83	107100	12.5	6.2	49
2	Reflex	1 pt	PRE	0.25	7	98	100	97	98	108000	14.7	6.6	47
3	Reflex Dual Magnum	1/2 pt 1 pt	PRE PRE	0.125 0.95	10	100	100	97	99	111600	12.5	5.6	64
4	Reflex Dual Magnum	1 pt 1 pt	PRE PRE	0.25 0.95	23	100	100	100	100	119800	10.1	5.0	47
5	Dual Magnum	1 pt	PRE	0.95	7	68	100	65	89	109808	10.4	5.2	57
6	Check		-		0	0	0	0	0	104400	10.5	5.2	53
	FPLSD (0.05)				*21*	*24*	*42*	*40*	*21*	*ns*	*ns*	*ns*	*ns*

Impacts:

Flame weeding and organic herbicides. Weeds still present many challenges to producers of snap beans, particularly in organic systems. Many weed control practices damage crops, including cultivation, flaming, or conventional herbicides, and the tradeoffs between weed control and crop injury are not always clear. The flaming study was designed to eliminate the effect of surviving weeds on crop yield so that the impact of flaming on crop yield would be clearer. Both flame and organic herbicides reduced yield compared to the untreated check. Flaming improved weed control in the row better than organic herbicides, but not as well as conventional herbicides. The Reflex herbicide study was designed to determine what use patterns most effectively control lambsquarters, a weed that is often missed. This study added one more piece of critical information to the weed control puzzle when using Reflex. Even when irrigation and rain is not expected, growers may benefit by applying Reflex post plant surface, especially in situations where the application can be delayed and a few weeds have emerged.

Relation to Other Research:

These projects complement many of the other research projects that are underway. We continually strive to provide relevant information to producers that will reduce cost or improve the cost per unit of efficacy that a technology provides.

Research/Extension Progress Report for 2017-18 Funded Projects
Progress Report for the Agricultural Research Foundation
Oregon Processed Vegetable Commission

Title: Monitoring and Reporting Insect Pests in Cole Crops and Sweet Corn (VegNet)

Project Leaders:

Jessica Green
Organization: OSU
Telephone: 541-737-5456
Email:jessica.green@oregonstate.edu
Address: 4017 ALS Bldg., OSU
City/State/Zip: Corvallis, OR 97331-7304

Ed Peachey
Organization: OSU
Telephone: 541-740-6712
Email:ed.peachey@oregonstate.edu
Address: 4017 ALS Bldg., OSU
City/State/Zip: Corvallis, OR 97331-7304

Cooperators:

Thomas Barnett, Mike Christensen, Dickman Farms, Fessler Farms, Randy Hopson, Kendal Johnson, Peter Kenagy, Pearmine Farms, Frank Pitcher, Stahlbush Island Farms

Funding History:

YEAR	**2017**	2016	2015
A. SALARIES/BENEFITS			
RA Salary (0.25-0.35% FTE)	$8,735	$10,224	$9,927
RA benefits (~60%)	$5,504	$6,441	$6,254
B. WAGES/BENEFITS			
TECH ($10-11/hr)	$3,200	$2,400	$2,400
TECH benefits (8%)	$256	$192	$192
C. EQUIPMENT		n/a	
D. SUPPLIES	$620	$768	$1,375
E. TRAVEL	$1,839	$1,440	$1,440
Total request to OPVC	$20,154	$21,465	$21,588

ABSTRACT:
Pest monitoring is often the first component to integrated pest management (IPM). The VegNet program is a leading and reliable IPM tool. This monitoring and reporting system provides weekly reports of activity data for common insect pests of snap bean, cauliflower, broccoli, and sweet corn. Data have been collected in the Willamette Valley since 1996, which allows us to calculate historical averages for each pest that is currently monitored. When pheromone traps detect an increased level of adult moths compared to historical norms, we consider that to be a 'flight', which give predictions of egg laying timing and the potential for subsequent crop damage. Weekly reports are sent via email, and comparative analysis between sites and years can reveal landscape-level trends that directly affect pest management priorities. Growers and crop consultants then use the data to maintain or intensify field scouting efforts and make informed spray decisions. This year, a blog site was established and program visibility was increased by national research meetings and print media coverage. Notable pest trends for 2017 include: cabbage looper outbreak; continued abundance of cucumber beetles and black cutworm; and valley-wide armyworm contamination.

Keywords: Vegetable IPM – pheromone traps – corn earworm – black cutworm – cabbage looper

OBJECTIVES

1. Monitor standard and emerging insect pests that affect processed vegetable growers. Provide weekly data reports and issue pest alerts to provide advance warning of potential outbreaks.
2. Improve reporting by using data visualization tools.
3. Extend monitoring to 26 weeks.
4. Continue to evaluate insecticide efficacy of diamondback moth and potential resistance to commonly used insecticides.
5. Expand invasive pest monitoring to include Brown Marmorated Stink Bug and European Pepper Moth.

PROCEDURES

Monitoring in 2017 began April 17th and ran through Sept. 29th in an effort to encompass emergence and activity of major vegetable pest cycles from planting through harvest. Passive sampling tactics including pheromone traps and paper sticky traps were placed at processed vegetable field sites throughout the central Willamette Valley. Traps were checked weekly and lures were changed every 4 weeks. At each collection, insects in wire mesh traps were killed to prevent re-capture of previously trapped specimens. Active sampling tactics (sweep netting, leaf pulls along transects, etc.) were performed as needed.

Weekly newsletters were sent via MailChimp. Static maps were developed using Arc-GIS and posted as clickable links from weekly newsletters. A variety of data visualization tools were utilized this year, in an attempt to determine which methods are preferred by program users throughout the season. Measurable metrics included page views and 'clicks', and were determined by built-in analytics of WordPress and Mailchimp, respectively.

ACCOMPLISHMENTS

Program Info and Reporting (Objectives 1 and 2)

VegNet has a strong and loyal user network, and the subscriber base has grown by 28% since 2014. There has been a small but important shift in the age of program users. A demographic survey was sent to subscriber lists at the beginning of the 2015 and 2017 seasons. People under 34 years old comprised 17% of this year's survey respondents, versus 11% in 2015. There has also been an increase in users aged 55 and up. One of the challenges facing VegNet is how best to serve the priorities of processed vegetable producers as well as other program users (FIG. 1).

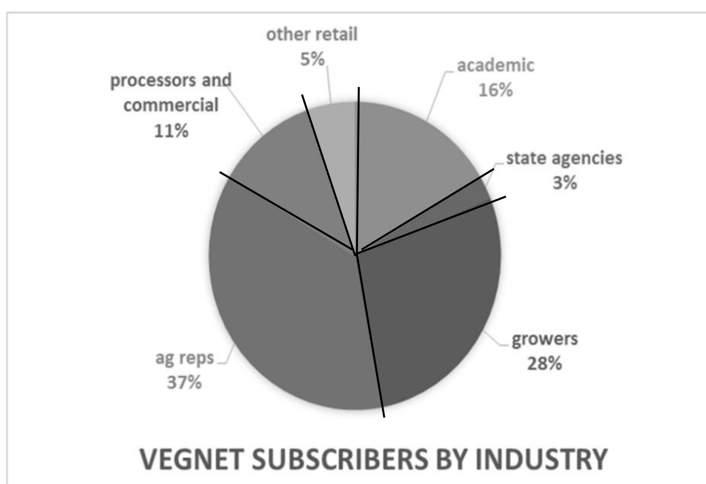

Figure 1. Due to a new email marketing platform, we can estimate which demographic groups are utilizing the program. This graph represents email addresses with obvious handles (e.g. @wilco.coop), which are 45% of the current subscriber list.

Graphics and videos summarizing pest patterns were appreciated by program users (as measured by click rates), but the most preferred mode of viewing data has been and continues to be, data tables (FIG. 2a). This standard form of reporting is familiar to most users, and allows cooperating growers to quickly access trap counts for their location and see how they compare to the regional average. A blog page was developed to teach prospective users how to read and interpret data tables, and it has 51 views to date.

	VEGNET 2017							
	Week of July 24th, 2017 Willamette Valley, OR							
Insects per day*	AURO	MCKE	MTAG	BRKS	ALBN	CVRO	MNRO1	MNRO2
BCW	0.20	0.00	0.57	n/a	0.25	1.80	0.29	0.57
WAW	0.00	0.00	0.14	n/a	0.00	0.20	0.29	0.71
CEW	0.20	n/a	n/a	n/a	0.0 | 0.3	0.20	0.71	0.86
PHX	0.00	n/a	n/a	n/a	0.0 | 0.1	0.00	0.00	0.00
WCR	0.00	n/a	n/a	n/a	0.00	4.20	0.43	1.14
12S-YST	8.60	n/a	n/a	n/a	1.50	14.60	2.88	3.63
12S-SN	0.63	n/a	n/a	n/a	n/a	n/a	n/a	2.00
CL	n/a	n/a	36.14	52.00	17.25	15.20	n/a	n/a
AL	n/a	n/a	1.71	0.43	0.00	0.00	n/a	n/a
DBM	20.00	n/a	n/a	n/a	21.00	16.50	n/a	n/a
BAW	0.00	0.14	0.00	0.00	n/a	0.00	n/a	n/a
VCW	1.00	0.57	0.29	0.29	n/a	0.00	n/a	n/a
CWB*	3.00	0.00	0.00	0.00	0.00	1.00	n/a	n/a

Willamette Valley 7day Ave Week of JULY 24

Insects per day*	15Yr Ave	2016	2017	Note
BCW	0.74	0.91	0.53	Normal risk
WAW	n/a	1.02	0.19	Unknown
CEW	0.36	11.03	0.38	Normal risk
PHX	0.09	0.00	0.02	Normal risk
12S	1.47	7.75	6.24	*Alert*
CL	16.08	37.80	30.15	*Above Normal*
AL	1.28	0.60	0.54	Normal risk
DBM	11.52	4.19	19.17	*Alert*
BAW	0.17	0.09	0.03	Normal risk
VCW	0.80	0.23	0.43	Normal risk
CWB*	4.98	0.00	0.67	Normal risk

VegNet Key

BCW = Black Cutworm Moths	WAW = Western Yellowstriped Armyworm
CEW = Corn Earworm Moths	PHX = False Corn Earworm Moths
12S = 12 Spot Beetles	SCB = Striped Cucumber Beetles
CL = Cabbage Looper Moths	AL = Alfalfa Looper Moths
DBM = Diamondback Moths	CWB = Cabbage Butterflies/2 min scan
BAW = Bertha Armyworm Moths	VCW = Varigated Cutworm Moths
n/a = not available	WCR = Western Corn Rootworm

* Values reported are pests per day, except CWB and SN, which are temporal snapshots

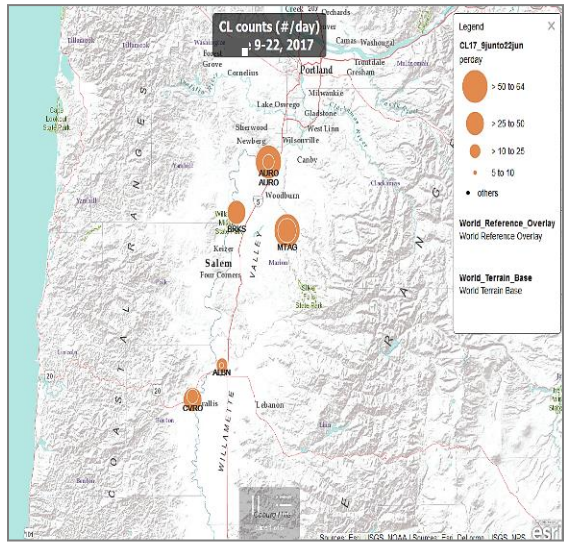

Figure 2. Each year, a large amount of activity data is gathered, and we are exploring potential ways to make the most of the information. Despite the seemingly convenient map structure (b., right), data tables (a., left) continue to be the most widely-viewed format to disseminate weekly trap counts of pests.

According to a pre-season survey, program users were supportive of the idea to visualize trap count data on a static map. Visualizing insect data per site might help to relate population dynamics in landscape scale, and could better inform why changes in regional pest trends are occurring. The map seen above (FIG. 2b) was the only one produced in 2017, but it took a lot of behind the scenes work to produce it. We now have the framework set up, and the program manager is working on integrating historical data of a few key species to make the maps more useful. That said, traffic to the map page was monitored as a means of measuring how many people would be interested in the new format, and it received only 9 views, less than 5% of people who opened that week's report.

Pest Activity Patterns (Objectives 1 and 3)

Black Cutworm – BCW has been steadily increasing since 2013, and trap counts were above average for nearly half of this season (11 of the 24 monitored weeks in 2017). Deploying traps earlier in the year did not enhance detection, as we suspected it might. Instead, activity was shifted towards later in the year, with 2 evident peaks (FIG. 3). Counts were more aligned with the 1997 outbreak, and were about 4 times greater than historical averages. We have found that moth abundance does not always correlate with damage in the field. If sweet corn can get planted early enough, it may escape BCW pressure.

Corn Earworm – CEW can reach high numbers, but is usually not a concern for processed vegetable growers because most feeding occurs at the tip of the ear, which is cut off during processing. Historically, there is just one peak of activity, corresponding with silking, late in the season. However, over the past couple of years, we have seen a small but important increase in moths at the beginning of the season (FIG. 4, mid to late June). Because CEW has an extremely wide host range, this could be a concern for pepper and tomato producers.

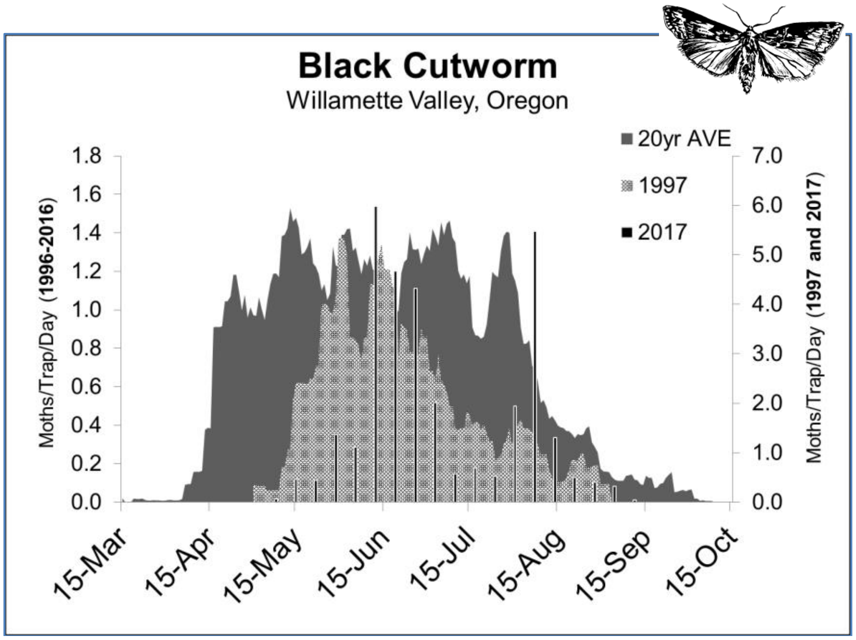

Figure 3. Black cutworm trap counts of 2017 (bars) were about 4 times higher than the 20 year average.

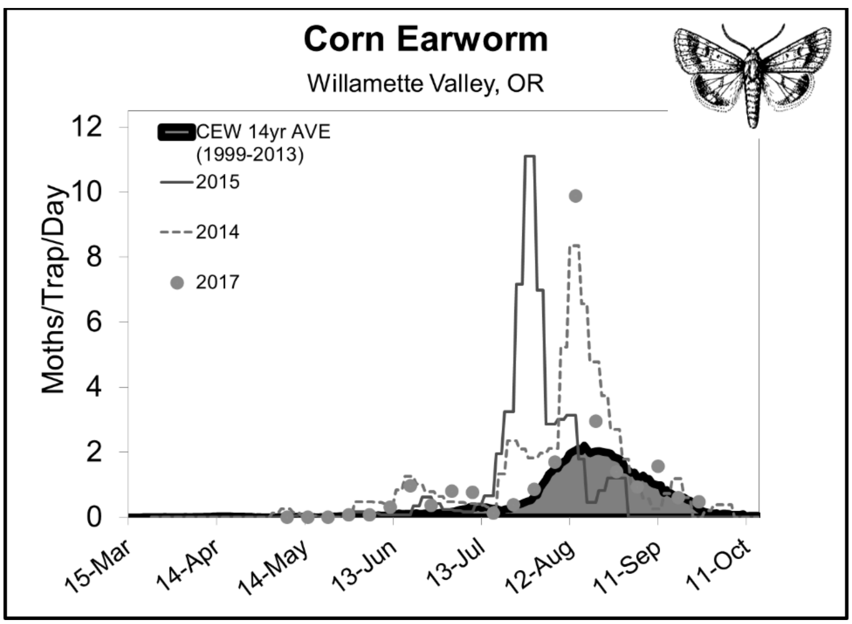

Figure 4. Corn earworm is a highly migratory, polyphagous species. The main flight peak coincides with corn silking, which can vary by year.

Cabbage Looper – CL levels in 2017 qualified for designation as 'outbreak', a term we rarely use. As with any pest, some years are worse than others, but at one site in late July, there were 2028 moths in the trap, which is 25 times more than the same site and week last year. One problem is that CL is one of the few moths we monitor for that are known to successfully overwinter in this region; the development threshold is 50°F, and there is no diapause in this species. The year of the last significant CL outbreak of this magnitude was in 2008 (FIG. 5).

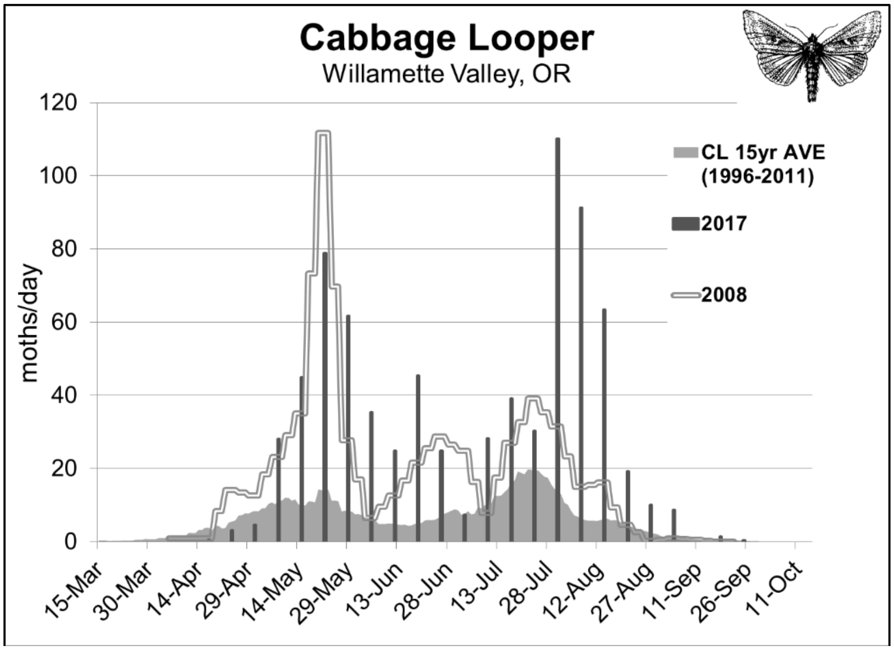

Figure 5. There are multiple generations of cabbage looper per year, and this was the 'worst' year since 2008.

Western Spotted Cucumber Beetle (12-Spots) – 12S activity has increased dramatically in the Willamette Valley, and although trap counts are nearly 5 times what they used to be (FIG. 6), the pattern has remained relatively consistent for the past few years.

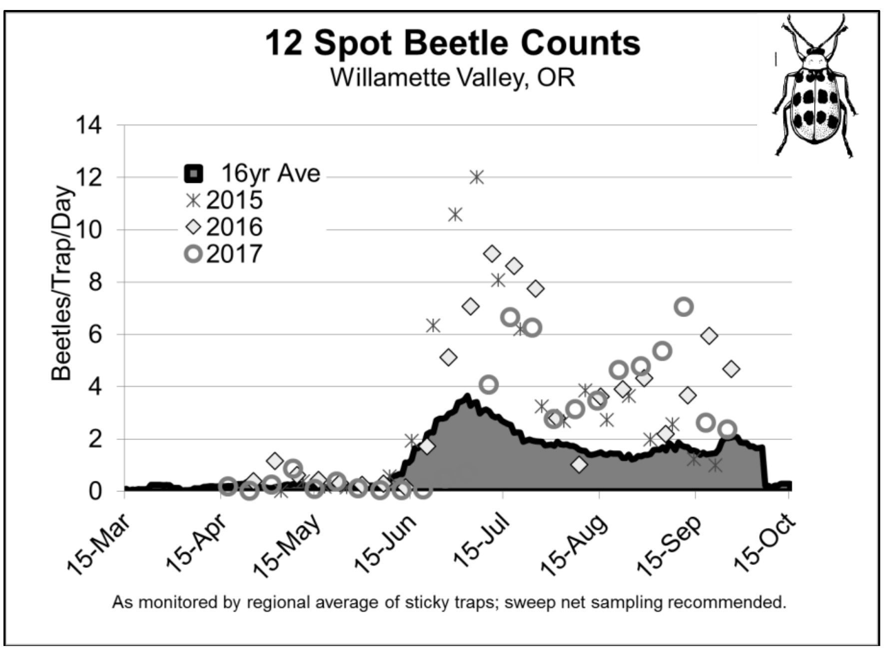

Figure 6. Monitoring late-season activity of western spotted cucumber beetles can better inform growers about pest pressure the following year.

Supplemental Results (Objectives 4 and 5)

Each year, we try to incorporate small, side projects in addition to regular monitoring. Topics studied this year included:

Diamondback Moth - Because of their high reproductive capacity, DBM is very prone to developing insecticide resistance (IR), which is why it is one of the hardest crucifer pests to manage. Based on per-site variability and reports from cooperating growers, there is cause to suspect that IR is occurring in diamondback moth populations of the Willamette Valley. We screened 3 chemistries to compare efficacy on diamondback and cabbage looper: Mustang Maxx, a commonly used pyrethroid that works on contact as a nerve toxin; Radiant, a nerve inhibitor and stomach poison, derived from a bacterium, which works on contact and by ingestion; and Exirel/Verimark - a diamide that has some contact activity, but is most effective through ingestion, and is labeled for use as a foliar spray or soil application, depending on the pest. Responses to leaf-dip assays, as measured by mortality, varied between sites (TBL. 1), but confirmed that Mustang Maxx and Radiant as less effective on DBM than they are on cabbage loopers. However, we have only been able to test 86 larvae total.

Table 1. Percent mortality of lepidoptera larvae to common insecticides used by regional brassica growers (2016-17). It is our eventual aim to test 6+ products from different mode-of-action groups, as designated by the International Resistance Action Committee (IRAC).

IRAC GROUP	Active ingredient	Population	% mortality – DIAMONDBACK [a]	% mortality – LOOPER [a]
3A	z-cypermethrin (Mustang Maxx)	MTAG	33	100
		STLU	33	100
		CVRO	40	100
		BRKS	83	---
5	spinetoram (Radiant)	MTAG	33	100
		STLU	33	100
		CVRO	40	100
		BRKS	100	---
28	cyantraniliprole (Exirel/Verimark)	BRKS	67	---

Most insecticide mortality assays suggest evaluation at 72 hours, but group 5 insecticides can take up to 96 hours to act on larvae. In this trial, the spinosad-treated dishes were monitored at 72 hours and again at 96 hours, values reported are at 96 hours.

Brown Marmorated Stink Bug - After reviewing OSU Extension publication EM9138, it was determined that field monitoring for BMSB cannot be accomplished by trapping alone. It must be used in combination with beat-sheet sampling and visual counts, both of which are very time consuming. Furthermore, because the pheromone used in trapping is an aggregation pheromone, placing a trap near crop edges may have the unintended effect of increasing crop damage, because not every BMSB that is attracted will enter the trap (Wiman et al. 2016).

Other New Invasives –Japanese Beetle, European Pepper Moth, Swede Midge, and Vegetable Weevil all have been mentioned as potential concerns for stakeholders and producers. In short, these cannot be adequately studied with limited resources for personnel, and may be beyond the scope of VegNet. For example, there is now a full-blown effort by OSU and ODA to trap and detect Japanese Beetle.

IMPACTS

Agricultural professionals in the Willamette Valley have come to depend on VegNet as a reliable IPM tool. Regional monitoring can be used to estimate populations of many pests and how patterns change over time. Because of historical data sets that have developed over 20 years (1996-2016), we are able to detect that corn earworms are arriving earlier, for instance. From an applied management perspective, we like to think that “detection equals protection”, and that VegNet users gain a competitive edge by being informed.

Another benefit of VegNet is that it provides a front-line resource, not only for growers and crop consultants, but for Extension and research programs at OSU. For instance, when an armyworm outbreak occurred in grass seed and forage fields this summer, we worked with OSU-EXT personnel to positively identify the main species and spread the word through our extensive network. The new faculty hire for vegetable crop extension sought our expertise so that she can pursue and recommend a management strategy for cabbage maggot. In 2016, OSU Small Farms faculty requested training on how to monitor for certain pests so that they could incorporate the knowledge into their own IPM modules.

RELATION TO OTHER RESEARCH

Although VegNet is considered a stand-alone program, the data collected often provide the basis for other IPM trials that are of broad interest to fresh market vegetable growers, home gardeners, etc. Some examples include: cabbage maggot insecticide efficacy, the PNW Insect Management Handbook, and an upcoming publication on cutworm and armyworm species commonly found in this area.

Research/Extension Progress Report for 2017-18 Funded Projects
Progress Report for the Agricultural Research Foundation Oregon
Processed Vegetable Commission

Title: Providing organic nutrient management guidance to processed vegetable growers (2017)

Project Leader(s): Dan Sullivan, OSU Dept. of Crop and Soil Science, 541-737-5715, Dan.Sullivan@oregonstate.edu

Cooperator(s): Thomas Barnett, Denny Hopper, Matt Cook, Steve Koch, Jim Bronec, GreenSpring Farms, Earnie Pearmine. All cooperators in Willamette Valley.

Funding History: Year 1 (2016): $24,020. Year 2 (2017; this year): $23,997.

Abstract:

The goal of this project is to assist growers in matching N supply from soil and from organic fertilizers to meet crop demand, minimize nutrient loss to the environment and reduce fertilizer costs, and achieve crop yield targets. Project objectives are to: 1) Quantify the rate and timing of plant-available nitrogen (N) from soil organic matter, 2) Evaluate the potential for midseason on-farm soil nitrate testing to guide N management decisions, and 3) Evaluate sidedress organic N fertilizer application, at a rate determined by midseason soil nitrate testing, as a method to efficiently meet crop N need. Objective 1: Across soils, N mineralized during the first six weeks of incubation averaged 35 ppm (123 lb N per acre-ft) at 72 ^{o}F (22^{o}C) in the laboratory and 31 ppm (109 lb per acre-ft) in buried bags in the field (average soil temp 70^{o}F (21^{o}C); June 15 to July 27). Nitrate-N supplied by mineralization (0-12 inch soil depth) in six weeks in the field was equivalent to 2% of the soil total N present in soil organic matter. Objective 2: On-farm monitoring confirmed the utility of in-season monitoring of soil nitrate-N. Corn N uptake was maximized when mid-season soil nitrate-N exceeded 25 ppm. Objective 3: A replicated experiment demonstrated that relatively low rates of organic N fertilizer application were sufficient for broccoli in a field with a midseason soil nitrate-N analysis of 21 ppm (0-12 inches). A midseason soil nitrate-N of 21 ppm NO3-N is not unusual. Grower fields monitored (Objective 2) averaged 21 ppm NO3-N at midseason. Nitrogen use efficiency by the broccoli crop was greater with sidedress organic fertilizer (37% of N applied) vs. preplant organic fertilizer (20% of N applied). Further research is needed to integrate these tools (N min prediction, in-season nitrate tests, and sidedress organic fertilizer application).

Key Words: nitrogen mineralization, organic vegetable production, nitrate-nitrogen, soil testing

Objective(s):

Goal: Assist growers in matching N supply from soil and organic fertilizers to meet crop demand, minimize environmental losses and fertilizer costs, and achieve yield targets.

- Objective 1. Quantify the rate and timing of soil N supply (i.e., N mineralization) of organically managed fields.

- Objective 2. Evaluate the potential for targeted nitrate sampling over the growing season and plant sampling at harvest as a tool to evaluate and modify on-farm nutrient management programs.

- Objective 3. Evaluate the potential of organic fertilizers applied midseason at a rate determined by a pre-sidedress nitrate test (PSNT) to meet crop N needs (**new for 2017**)

Impacts: This project provides local data on the quantity and rate of plant-available N release from soil organic matter for Willamette Valley soils used for processed vegetable production. Improved predictions of N mineralization rate are critical for reducing “insurance” preplant organic fertilizer applications. Greater efficiency in N management reduces production cost and reduces loss of N to groundwater.

Relation to Other Research: This research contributes to the development of OSU Extension nutrient management guides and online tools developed specifically for Oregon growers.

Procedures

Objective 1: Cumulative N supplied by mineralization. Quantify the rate and timing of soil N supply (i.e., N mineralization) of organically managed fields.

The amount and timing of N supplied from soil N mineralization was estimated by incubating soil from collected from grower fields (Table 1.1). Bulk soil (0-12 in depth) was collected 21-Apr to 5-May at 10 grower field sites. All soil samples were collected prior to organic fertilizer application. Cover crop biomass and its N concentration were measured at three field sites (C, HB, and HCC) prior to plowdown. After collection, soils were refrigerated until the start of field and laboratory incubations (15-June).

The soil was stored at 40°F (4.5 °C) from time of collection until the incubation experiments were initiated (15-Jun). Soil was collected from an additional field site (B) on 9-Jun. Soil for all incubations was prepared for incubation by sieving through a 9.8 mm screen, which was then placed in 4-mm low density polyethylene (LDPE; Wagner Packaging Solution, Salt lake City, UT) tube shaped bags. One end of the bag was sealed with kitchen bag sealer machine. Then, the sieved soil was added in 3-inch increments, packed with rapid vertical shaking, and repeated until the bag contained 12 in. of packed soil. After filling, bags were sealed to prevent moisture exchange. Soils were subsampled to determine moisture, initial mineral N concentration, pH, total C and N, and nutrients (Table 1.2).

Buried bag incubation. Bags were buried in a sweet corn field at the OSU Vegetable Research Farm, which allowed us to incubate the soil under field temperature conditions, but at constant moisture. Using a 1.75" mud auger (AMS, Inc. American Falls, ID), 12 inch holes were hand dug in the seedline of recently emerged corn, and then the bags were placed in each hole. Soil temperature was monitored using Hobo pendant dataloggers with sensors at 3, 6, 9 and 12 inches.

Buried bags were harvested from the field at three week intervals (0, 3, 6, 9, and 12 weeks after the start of incubation). At each harvest, soil-filled bags were removed from the field and mixed before obtaining a subsample for analysis of nitrate-N and moisture. Soil from three field buried bags was composited into a single sample for analysis. Soil was extracted with 2M KCl for nitrate analysis. Nitrate-N was determined by a contract laboratory (Brookside Laboratories, New Bremen, OH). Soil nitrate-N was expressed on a soil dry weight basis (ppm; mg N/kg).

Soil incubations in the laboratory. A composite soil sample from each field site (Table 1.1) was incubated at 22 and 35°C in the laboratory in Ziploc storage bags. At three week intervals (0, 3, 6, 9, and 12 weeks after the start of incubation), a subsample was collected from each bag for nitrate-N and moisture analysis.

Objective 2. On-farm N monitoring. Evaluate the potential for targeted nitrate sampling over the growing season and plant sampling at harvest as a tool to evaluate and modify on-farm nutrient management programs.

Nitrate monitoring. Fields were divided into three sampling replications, and were sampled along a transect pattern. Sampling schedule: Initial soil was sampled from grower's fields 0-7 days from planting date; V4-V6 soil was sampled 0-7 days from the sixth leaf emergence, or around grower PSNT sampling; final soil was sampled 0-7 days from grower harvest.

For each replication, six 0.75 inch diameter soil cores were collected at 0-12 inch depth (between row), mixed, and a subsample was used for KCl extraction for nitrate + ammonium-N analysis by Brookside Labs (New Bremen, OH). For the final collection, soil was collected at both 0-12 and 12-24 inch depths. If soil was not extracted on the day of collection, it was frozen until processing.

Whole plant corn N uptake**.** Fields were divided into three sampling replications, and were sampled along a transect pattern. Whole plant biomass was collected 0-7 days from grower harvest. Nine plants were collected for each replication (cut 1 to 3 inches above ground level), weighed, then composited and shredded with a wood chipper. A thoroughly mixed subsample of biomass was taken from each shredded composite, weighed, and dried at 130 ^{o}F for five days. Dry matter was weighed and recorded. Subsamples of biomass were taken and sent to Brookside Laboratory (New Bremen, OH) for total N analysis (by combustion). Biomass was multiplied by the N concentration in the biomass to determine whole plant N uptake.

Corn stalk nitrate-N**.** Fields were divided into three sampling replications, and were sampled along a transect pattern. Corn stalks were collected 0-7 days from grower harvest. Nine plants were selected within each replication. Corn stalks were cut 6 inches above ground level and 12 to 14 inches above ground level giving a 6 to 8 inch stalk. Samples were composited and sent to Brookside Laboratory (New Bremen, OH) for nitrate-N analysis.

Objective 3. Sidedressing organic fertilizer. Evaluate the potential of organic fertilizers applied midseason at a rate determined by a pre-sidedress nitrate test (PSNT) to meet crop N needs (new for 2017).

Sidedress N application rates were informed by calibrations of the PSNT test for sweet corn (OSU EM 9010). Because broccoli takes up more N than sweet corn, the recommended sidedress N rate for 21 ppm from the sweet corn guide (100 lb urea-N/acre; OSU EM 9010) was increased to 120 lb N per acre. The recommended PSNT N application rate for feather meal was adjusted upward for feather meal to account for its lower N availability. We assumed that 75% of the total N in feather meal becomes plant-available in the short term, so urea-N applied at 120 lb N/acre is roughly equivalent to 160 lb total N per acre as feather meal. Sidedress N application rates lower and higher than the N rate recommended by PSNT were included. So, PSNT N application rates were 60, 120 and 180 lb N/acre for urea, and 80, 160, and 240 lb N/acre for feather meal.

Calendar of site management and data collection, 2017:

7/7/17. Preplant. A composite soil sample (0-12 inches) was collected for routine nutrient analysis. Preplant organic fertilizer treatments were weighed out and then applied by hand. After application, fertilizer was lightly incorporated with a metal rake. Plot size was 9x30 ft. Preplant N rate (lb N/plot): 1.4 lbs N of urea, 1.9 lbs N of feather, 2.8 lbs N of chicken.

7/8/17. Broccoli (var. Emerald Pride) was seeded (3 seeds per foot in 26 inch wide beds). Starter N (40 lb N/acre) was applied to all treatments except the zero N control (Treatment 1) with a Gaspardo. Starter fertilizer supplied 20 lbs P2O5 and 20 lbs K2O per acre in a band 2 x 2 inches from the seed row. Devrinol was applied after planting at 2 lbs/A.

7/9/17 to 8/3/2017. Sevin insecticide was applied on July 21 to control flea beetles. Thiamethoxam (75SG) 1.66 oz/A + Bt (Deliver) 1 lb/A was applied Aug 2-3 to control 12 spot, flea beetles, and loopers.

8/14/17. Soil sampled prior to sidedress N fertilizer application (pre-sidedress nitrate test; PSNT). 0-12 inch depth, between rows. Soil cores were collected away from the at-seeding fertilizer incorporation line.

8/18/17. Sidedress urea treatments were applied with a Planet Jr. Spreader, shanked in at 1 to 3 inch depth (6 inches from row). Feather meal was applied in a furrow made by a hoe, 1 to 3 inch depth (6 inches from row. After feather meal was applied, the furrow was covered with soil.

10/3/17. Broccoli head harvest. Heads were harvested, counted, measured, and weighed.

10/3/17. Whole broccoli plant was harvested for determination of dry biomass and N uptake from selected treatments. Treatments chosen had the same fresh weight head yield at harvest (ton/acre yield not different at P=0.05). Treatments sampled (N applied preplant/starter/sidedress): feather meal (0/40/80), feather meal (300/40/0), Urea (0/40/60), and compared to treatments that did not receive any sidedress N application: Urea (0/40/0), Check (0/0/0). Biomass samples from three plants per plot were ground wet with a chipper, subsampled for moisture and dry matter, and sent to laboratory for N analysis.

10/3/17. Postharvest soil nitrate-N. Each plot was sampled (0-12 inch depth) within the row and between the seed row. Within the row: 6 cores in an alternating pattern in all three rows in plot. Between row: a total of 9 cores were collected from a transect perpendicular to the row: 4 to 6 inches away from the plant, 10 to 12 inches from the plant, and 16 to 18 inches from the plant, thereby capturing any gradient in N distribution across the row. Preplant and sidedress feather meal treatments only (Trt 3 and 10) were sampled in-row at three depths (0 to 12, 12 to 24, and 24 to 36 inch depths). Three cores were collected and composited per plot.

Accomplishments

Note: Tables and Figures follow Accomplishments for each Objective.

Objective 1. Quantify the rate and timing of soil N supply (i.e., N mineralization) of organically managed fields.

Soils used in the study represented ten field locations (Table 1.1). Soil organic matter ranged from 2.4 to 4.6 % (avg. 3.3%; Table 1.2). Soil surface textures were silt loam or silty clay loam.

Three incubations were conducted: 22°C (lab), buried bag (field) and 35°C (lab). Soil temperatures in the field where buried bag incubations were conducted averaged 70.6 °F (21.4 °C), very close to that of the lab incubation (Figure 1.1). The accumulation of nitrate (ppm) was expressed in units of ppm N and in units of ppm N per day (Figure 1.2; Table 1.3). One ppm is equivalent to approximately 3.5 lb/acre-ft, assuming a soil bulk density of 81 lb/cubic foot (1.3 g per cm^3). The first six weeks of incubation time (mid-June through July) corresponds roughly to first half of a growing season for sweet corn. Because only one bag of soil was incubated from each field site at each temperature, comparisons are not possible among soils. Instead, we focus on averages across soils (n=10; Table 1.3).

At the start of incubations, soil samples collected from Apr. 21 to May 1, and held under refrigeration had nitrate-N concentrations less than 4 ppm (very low; Table 1.3). The rate of N mineralization in in all three incubations (Lab 22C, Lab 35C, and buried bags in field) decreased with incubation time (Figure 1.2). Across soils, N mineralized during the first six weeks of incubation averaged 35 ppm (123 lb

N/acre-ft) at 22°C in the lab, 31 ppm (109 lb/acre-ft) in the buried bags in the field, and 49 ppm (171 lb N/acre-ft) at 35°C in the lab (Table 1.3). Across the first six weeks of incubation, the rate of nitrate-N accumulation per day averaged 0.8 ppm N per day (2.9 lb N/acre-ft/day) at 22°C (lab) and 0.7 ppm N per day (2.6 lb N/acre-ft/day) for soils incubated in buried bags in the field.

Table 1.1. Site information. Bulk soil collected from sites for Objective 1 (incubations). Fields monitored for Objective 2 (on-farm monitoring).

Site ID	**Location**	**Soil mapping and texture**	**2017 Crop**	**2016 crop**	**Bulk soil collected (Objective 1; incubations)**
B	Canby	Dayton/Aloha/Woodburn sil	org sw corn	fallow/volunteer clover	9-Jun
BA	Aurora	Amity/Concord/Dayton sil	org sw corn	caulifower	21-Apr
C	Dever-Conner	Colquato sil/Chehalis sicl	org eincorn	org eincorn	21-Apr
GSAR	S. Corvallis	Veboort sicl	org sw corn	snap beans	1-May
GSFR	Philomath	Coburg sicl/Dayton sil	org sw corn	fallow/pasture	1-May
HB	Mollala	Concord/Alpha sil	org sw corn	org sw corn	21-Apr
HC	Mollala	Malabon/Salem sicl	org sw corn	org sw corn	21-Apr
HCR	Canby	Woodburn sil	org sw corn	org sw corn	21-Apr
KCR	Mollala	Alpha/Concord sil	org sw corn	triticale/cauliflower	5-May
KLE	Aurora	Alpha/Amity/Woodburn sil	org sw corn	pumpkins	5-May
P	Brooks	Chehalis/McBee sicl	org sw corn	squash	21-Apr

sil= silt loam and sicl= silty clay loam

Table 1.2. Preplant soil tests, 0-12 inches. Soils used in incubations (Objective 1) and for on-farm monitoring.

Site ID	pH	C	OM	Total N	C:N	Bray P1	K	Ca	Mg	Sum cations	B
	in water	%	%	%	ratio	ppm	ppm	meq/100g	meq/100g	meq/100g	ppm
BARNETT	6.4	2.7	4.6	0.22	12.4	226	408	14.0	2.7	17.9	0.6
COOK	6.2	1.6	2.8	0.16	10.1	108	356	17.4	4.8	23.3	0.7
GSAR	6.6	2.1	3.6	0.20	10.7	52	207	15.1	3.2	18.9	0.6
GSF	5.9	3.1	5.3	0.25	12.5	12	124	19.3	4.7	24.6	0.7
HOPPER B	6.1	1.9	3.1	0.15	12.3	165	142	7.3	0.9	8.7	0.5
HOPPERCC	6.0	2.0	3.4	0.16	12.4	95	262	13.0	1.6	15.3	0.5
HOPPERCR	5.8	1.4	2.4	0.11	12.9	249	179	6.7	1.4	8.6	0.5
KOCH CR	6.2	2.0	3.4	0.19	10.6	242	293	8.5	1.9	11.3	0.7
KOCH LE	6.2	1.4	2.4	0.13	10.8	224	249	7.7	1.9	10.4	0.5
PEARMINE	6.8	1.4	2.4	0.15	9.5	109	200	16.1	4.3	21.1	0.8

pH (1:1; soil:water), C and N by combustion with direct determination of C in combusted gas, organic matter (OM) estimated as %C x 1.7, P by Bray P1 extraction method, cations and B by Mehlich 3 extraction method.

Table 1.3. Nitrate-N accumulated in soil during incubation in the lab at 22C (left), in the buried bags at the OSU vegetable research farm field site (middle), and in the lab at 35C (right).

	All Week 0	Lab 22C Week 3	Lab 22C Week 6	Field Week 3	Field Week 6	Lab 35C Week 3	Lab 35C Week 6
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
BARNETT	0.4	23	40	18	26	37	49
COOK	8.7	23	32	22	33	36	50
GSAR	2.3	42	51	21	24	65	63
GSFR	3.1	23	42	21	22	36	64
HOPPER B	0.5	18	33	28	25	32	42
HOPPERCC	1.2	15	22	14	30	55	67
HOPPERCR	0.6	27	23	13	43	3	43
KOCH CR	1.6	14	41	16	35	39	43
KOCH LE	1.5	21	48	23	29	41	24
PEARMINE	0.3	10	19	12	43	30	42
BRONEC	7.3			4	43		
average	2	22	35	19	31	37	49
ppm NO3-N/day		0.9	0.6	0.8	0.6	1.7	0.5

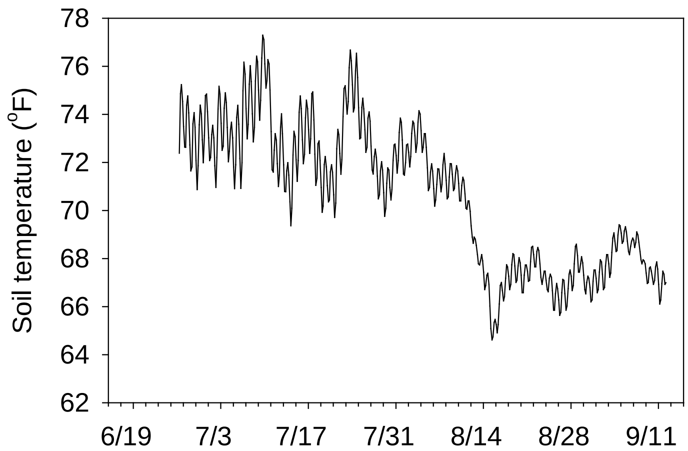

Figure 1.1. Soil temperature (0-12 inch depth) at soil N mineralization field experiment.. Average of 4 sensor measurements, placed at depths of approximately 3, 6, 9 and 12 inches. Average soil temperature was 70.6 °F OSU Vegetable Research Farm, 2017.

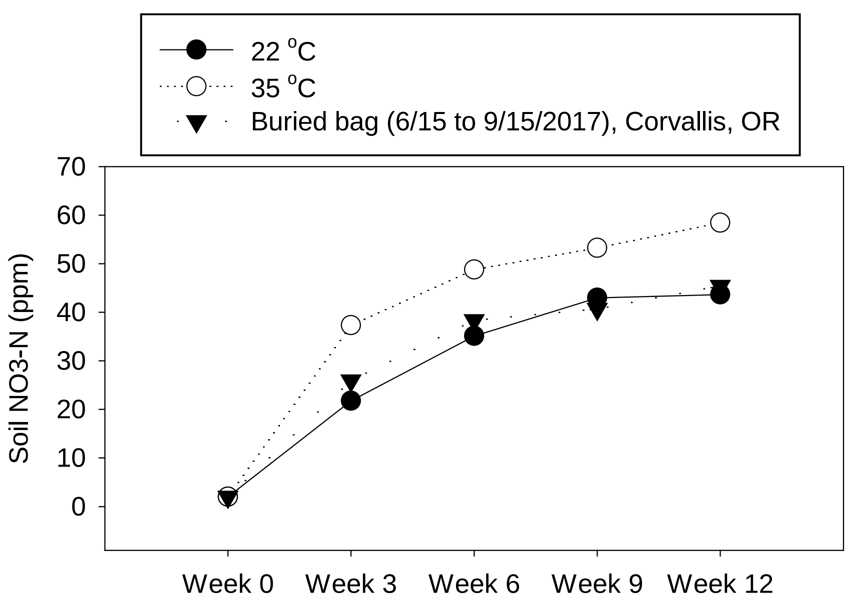

Figure 1.2. Accumulation of nitrate-N during incubation of soils from organically managed sweet corn fields. Soil incubated in buried bags (0-12 inch depth) in the field and in Ziploc bags at 22 and 35 oC) in the laboratory. Each data point is the average of 10 soil samples.

Objective 2. On-farm N monitoring. Evaluate the potential for targeted nitrate sampling over the growing season and plant sampling at harvest as a tool to evaluate and modify on-farm nutrient management programs.

Soil test levels for pH, P and K (Table 1.2) were adequate at most grower fields, suggesting that only N input was needed to meet corn ear yield targets. Soil pH was in the optimum range (6.0+) for soil N mineralization (mineralization slows when pH is less than 5.5). Suggested soil pH for sweet corn is above 5.8 (OSU Sweet Corn Nutrient Management Guide). Soil test P and K was generally adequate to support optimum crop yields (P > 50 ppm, K > 200 ppm), with a few exceptions. Bray soil test P was greater than 50 ppm at all locations except GSFR, indicating adequate P for sweet corn. Seven of 10 sites had soil test K above 200 ppm, indicating adequate K for crop production. Soil test K was between 120 and 180 ppm at three sites, indicating a small possibility of crop response to K fertilization. Soil pH was greater than 6.0 at all locations, adequate for sweet corn. We did not compile grower records of fertilization for these fields.

Three grower fields (C, HB, and HCC) had winter cover crops (mostly cereals) that were incorporated in spring. We measured biomass and total N concentrations (1.2 to 2.1%) in the cover crops just prior to termination. Total N input by cover crop biomass was 53, 72 and 73 lb N/acre. But because of high C:N ratio present in biomass (low total N %), estimated plant-available N contribution from cover crops was small (estimated at 3 to 17 lb N/acre, using the OSU Organic Fertilizer and Cover Crop Calculator; Appendix Table C). Previous crops (2016) included corn (HB, HCC, HCR), einkorn [C], brassicas (BA, KCR) snap beans (GSAR), and squash (KLE, P) and fallow/pasture (B, GSFR).

Midseason soil nitrate-N (near V6 growth stage; Jun 29-30 and July 11-13 sample dates) was a good predictor of corn N uptake (Figure 2.1). Aboveground N uptake by corn averaged 168 lb N/acre (range 113 to 207 lb N/acre). Corn in fields where midseason soil NO3-N was greater than 20- 25 ppm had biomass N uptake of 200 lb N/acre. When midseason soil nitrate-N was below 20 ppm, corn biomass N uptake was reduced. Fields with midseason NO3-N of 10 to 15 ppm had corn N uptake of approximately 110 to 140 lb/acre.

The midseason soil nitrate test results of our trial are in agreement with calibration data collected for the pre-sidedress soil nitrate test (PSNT; OSU EM 9165, 2017, p. 19). EM 9165 predicts that when midseason soil NO3-N (0-12 in) exceeds 25-30 ppm, the crop may not benefit from additional N supplied at V-4 to V-6 growth stage.

Corn stalk nitrate-N was a new measurement evaluated for the first time in our project in 2017 (Table 2.2). Trials specifically designed to calibrate the end-of-season stalk nitrate test have not been performed in Oregon (OSU Nutrient Mgmt. Guide EM9010, sweet corn, p. 18). Corn stalk nitrate was a rough indicator of corn biomass N uptake (Figure 2.2). Corn stalk nitrate-N was less than 100 ppm at four grower fields (HB, HCR, KLE, and P) where corn N uptake was less than 160 lb/acre. Corn stalk nitrate ranged from 1400 to 2700 ppm at fields where corn biomass N uptake was greater (190 to 210 lb/acre; B, BA, HCC, and KCR).

Preplant soil test values for soil organic matter and soil total N were positively correlated with corn biomass N uptake (Figure 2.3). Soils with organic matter of less than 3% had corn biomass N uptake of 110 to 140 lb N/acre. Soils with greater than 3.5% organic matter had biomass N uptake of 180 to 210 lb/acre. The positive correlation between soil organic matter and crop N uptake observed in this study is unusual. In previous trials with sweet corn, soil organic matter and soil total N were not strongly correlated with crop N uptake (Sullivan et al., OVPC nitrogen trials, 2011-13).

Midseason soil nitrate-N (0-12 in) was relatively stable across Jun 29-30 to July 11-30 sampling dates (Table 2.3; Figure 2.4; Appendix Table D). Five fields (C, GSFR, HB, HCR, P) had midseason soil nitrate < 20 ppm, suggesting that crop yield may have been limited by N supply, or that some of the nitrate-N had moved below the 0-12 inch sampling depth. Two fields (B and KCR) had soil nitrate-N above 28 ppm during midseason testing, suggesting that soil N supply was equal to, or greater than crop N need.

Late season soil nitrate-N within 7 days of ear harvest) was very low at all sites in samples from 0-12 in depth (< 8 ppm NO3-N) and 12-24 inch depth (< 4 ppm NO3-N). The goal of late-season soil nitrate testing is to identify fields where more N was supplied than could be utilized by the crop. Late-season soil nitrate interpretations have not been specifically developed for vegetable crops. For most crops, soil nitrate should be less than 10 to 15 ppm (0-to 12-inch soil depth) near the time of crop harvest.

In general, the soil N mineralization data collected for Objective 1 is consistent with the N monitoring data collected from grower fields in Objective 2 (Table 2.4). Both datasets suggest that 1) N provided by mineralization is capable of supplying most of the N needed by a sweet corn crop, and 2) a midseason soil nitrate test (0-12 inches) is a good indicator of N supply from all sources (e.g. soil N mineralization, manure, cover crop). Soil N mineralized in six weeks in the field (0-12 inches; Table 1.3) averaged 31 ppm nitrate-N, demonstrating the capability of soil N mineralization in supplying timely plant-available N for a corn crop. Nitrate-N supplied by mineralization (0-12 inch depth) in six weeks in the field (Figure 1.2; Table 1.3) was equivalent to 2% of the soil total N (range 1 to 3%) present in soil organic matter.

Table 2.1. Whole plant crop N uptake measured prior to ear harvest.

Site ID	Whole plant N	Whole plant biomass	Plant population*	Calculated crop N uptake
	% N in DM	dry ton/acre	plants/acre	lb N/acre
B	2.11	4.8	18000	203
BA	1.37	7.5	22000	207
HB	1.51	5.2	18000	158
HCC	1.65	5.7	22000	188
HCR	1.46	4.4	18000	129
KLE	0.91	7.7	22000	140
KCR	1.54	6.6	18000	202
P	1.15	4.9	22000	113

*Typical plant population for organic sweet corn is 20,000 to 22,000 per acre. Lower plant populations noted visually at fields listed with 18,000 plant population.

Table 2.2. Nitrate-N in corn stalks near date of ear harvest.

Site ID	Rep 1	Rep 2	Rep 3	Average
B	4871	449	692	2004
BA	2346	1714	229	1430
HB	76	40	93	70
HCC	444	2384	5393	2740
HCR	14	36	26	25
KLE	14	18	18	17
KCR	3124	3009	809	2314
P	16	15	20	17

Table 2.3. Soil nitrate-N values from grower fields. 0-12 inch sampling depth during season, 12-24 inch depth near ear harvest time. Samples collected between rows.

					Site							
Date Sampled	Dates	B	BA	Cook	GSAR	GSFR	HB	HCC	HCR	KCR	KLE	P
					ppm NO3-N (0-12 inches)							
Week 0	Jun 9-16	43	17	1			10	13	7	18	24	18
Week 2	Jun 29-30	41	24	**2**			**18**	23	**14**	28	37	**13**
Week 4	July 11-13	34	20		22	**9**	**14**	20	**8**	41	25	**19**
Week 6	July 27	52					20	21	16	39		
Week 8+ (near harvest)		8	8	5			4	2		4	2	
						ppm NO3-N (12-24 inches)						
Week 8+ (near harvest)	Aug 11- Sep 26	2	4				1	1	2	1		

Values in bold <20 ppm near PSNT sample time (4 to 6 leaf stage)

Table 2.4. Summary of 2017 measurements to estimate nitrogen availability in organically managed soils. Objectives 1 and 2.

Measurement	Avg.	Std Dev	Min	Max
	Preplant soil test			
Soil OM (%)	3.3	1.0	2.4	5.3
Soil total N (%)	0.17	0.04	0.11	0.25
Soil total N (lb/acre-ft)	6020	1492	3850	8750
	Soil incubation to assess N mineralization (Objective 1)			
Soil NO3-N, Lab 22C, Week 6 (lb/acre-ft)	123	39	66	178
Soil NO3-N, Field buried bags, Week 6 (lb/acre-ft)	109	26	79	151
Soil NO3-N, Lab 35C, Week 6 (lb/acre-ft)	171	45	84	233
Rate of soil N mineralization, Lab 22C/Field Avg, Week 6 (lb/acre/day)	2.8	0.3	2.2	3.2
	On-Farm N Monitoring (Objective 2)			
Soil NO3-N, Jun 29-30 (ppm, 0-12 in)	22	12	2	41
Soil NO3-N, July 11-13, (ppm, 0-12 in)	21	10	8	41
Corn N uptake (lb/acre)	168	37	113	207
Whole plant corn N (% in DM)	1.5	0.4	0.9	2.1
Corn Stalk NO3-N (ppm)	1077	1174	17	2740

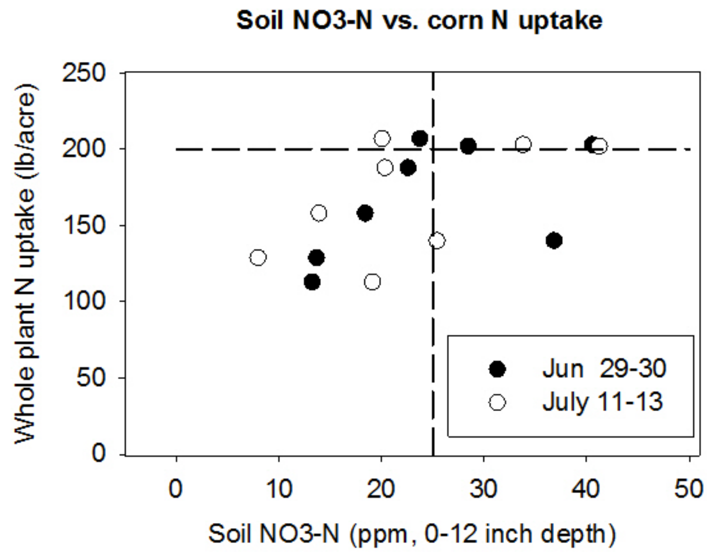

Figure 2.1. Midseason soil NO3-N (0-12 in) vs. corn biomass N uptake at harvest. Vertical dashed line represents typical threshold for interpretation of midseason soil nitrate test. When soil NO3-N is greater than 25to 30 ppm, minimal or no N input at sidedress time is needed to achieve maximum ear yield.

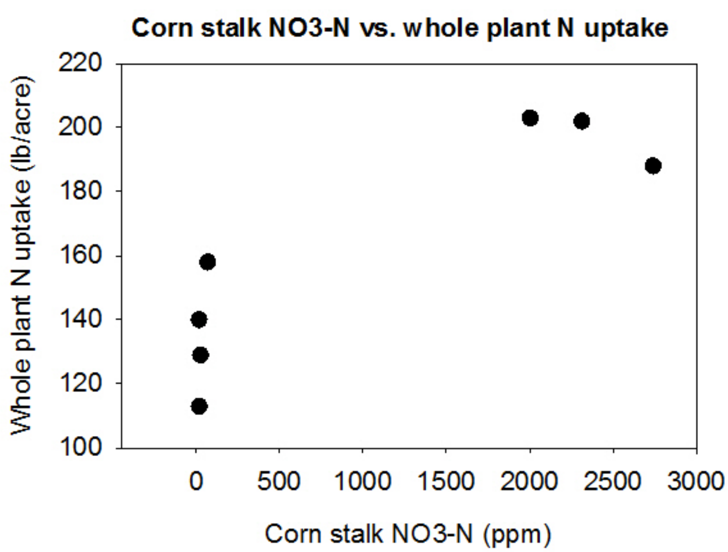

Figure 2.2. Corn stalk NO3-N vs. whole plant biomass N uptake. Both measurements taken on same day, within 7 days of ear harvest.

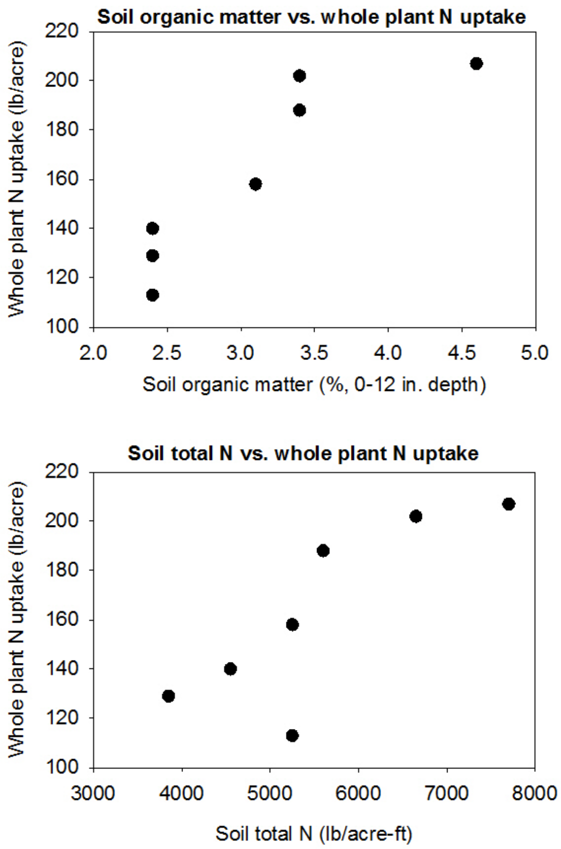

Figure 2.3. Whole plant N uptake at harvest vs. soil organic matter percentage (top) and soil total N (below). The amount of N in corn biomass at harvest averaged about 3 percent of the N present in soil organic matter.

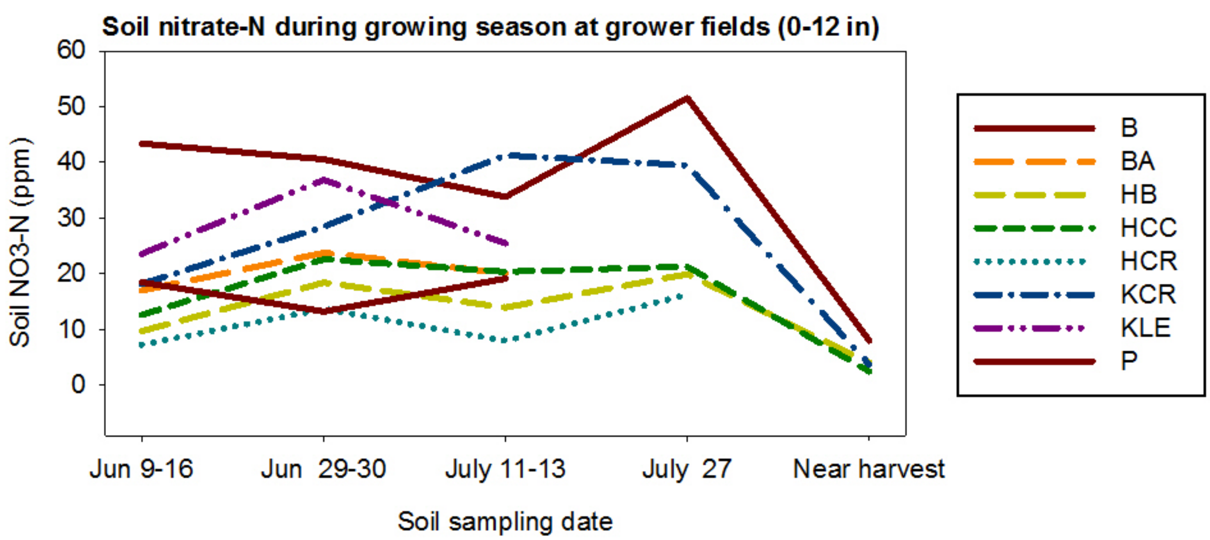

Figure 2.4. Soil nitrate-N (0-12 in.) in grower fields. Site B is top solid line. Other solid line is Site P.

Objective 3. Sidedressing organic fertilizer. Evaluate the potential of organic fertilizers applied midseason at a rate determined by a pre-sidedress nitrate test (PSNT) to meet crop N needs (new for 2017).

This experiment was designed to evaluate crop response and yield benefit of sidedress organic fertilizer application vs. the traditional preplant organic fertilizer application. The major benefit of side-dress N application (instead of preplant application) is that the N rate can be adjusted based on an in-season (PSNT) soil nitrate test. Urea (non-organic fertilizer) was included in the experimental design in order to determine the relative efficacy of the sidedress organic fertilizer relative to the efficacy of urea (conventional fertilizer with known N release properties).

Broccoli (var. Emerald Pride) was seeded July 7 and harvested October 3 at the OSU Vegetable Research Farm. Three seeds per foot of row were seeded, and later thinned to one plant per foot of row. Sidedress N application rates (applied August 18 when broccoli had 4 to 6 true leaves were informed by in-field (pre-sidedress) soil nitrate testing (August 14). At PSNT time, soil nitrate-N (0-12 inches) averaged 21 ppm. Three rates of sidedress N application were included for urea and feather meal because the PSNT has not been specifically calibrated for broccoli. Based on PSNT, N application rates were 60, 120 and 180 lb N/acre for urea, and 80, 160, and 240 lb N/acre for feather meal.

Yields and head weight were increased by N fertilization (Table 3.1). Broccoli yields ranged from 6.7 ton/acre for the zero N control to 10 ton/acre with fertilization. The N applied as starter (at seeding) did not affect yield or head size. Preplant urea at a high rate (225 lb N/acre) did not increase yield vs. the zero N treatment, likely because of seedling damage from excessive soluble salts. Yields and head size were not statistically different ($P = 0.05$) for sidedress feather meal vs. preplant feather meal or for preplant pelleted chicken manure. All sidedress rates of urea and feather meal resulted in similar broccoli yield and head size.

This trial demonstrated that relatively low rates of organic N fertilizer application were sufficient for broccoli in a field with a pre-sidedress N analysis of 21 ppm (0-12 inches). A PSNT value of 21 ppm NO3-N is not unusual. Grower fields monitored (Objective 2) averaged 21 ppm NO3-N at midseason.

Whole plant broccoli N uptake at harvest was measured for selected treatments (Table 3.2). Whole plant N uptake was 181 to 191 lb N/acre with zero sidedress N applied. Crop N uptake was 250 lb N/acre with preplant feather meal. No statistical differences were present in broccoli N uptake between the high rate of feather meal applied preplant, and any of the sidedress urea or sidedress feather meal treatments.

Nitrogen use efficiency by the crop [(increase in crop N uptake due to fertilization)/N rate applied x 100] was greater with sidedress vs. preplant feather meal. Nitrogen use efficiency for 80 lb sidedress N as feather meal was 37% vs. 20% for preplant N as feather meal.

Table 3.1. Effect of N source, rate and timing of application on broccoli yield and head size. Objective 3. OSU Vegetable Research Farm.

Treatment					Harvest		
Trt.	Fertilizer	Preplant	Starter N	Sidedress N	Head count	Yield	Head weight
		lb N/ac[a]	lb N/ac[b]	lb N/ac[c]	heads/plot	ton/acre	lb
1	None	0	0	0	18.0	6.7	0.737
2	Urea	0	40	0	16.8	7.2	0.858
3	Feather	0	40	80	17.8	9.1	1.023
4	Feather	0	40	160	18.5	9.0	0.979
5	Feather	0	40	240	19.0	8.5	0.897
6	Urea	0	40	60	19.5	9.4	1.001
7	Urea	0	40	120	19.3	10.0	1.045
8	Urea	0	40	180	17.3	10.4	1.204
9	Urea	225	40	0	17.0	7.1	0.836
10	Feather	300	40	0	18.8	9.2	0.979
11	Chicken	450	40	0	19.5	9.3	0.974
FPLSD.05					Not significant	1.86	0.223

a Broadcast organic fertilizer rates designed to apply equivalent of 225 lb plant-available N (same as urea)

b Starter fertilizer contains mix of mono-ammonium phosphate and ammonium sulfate

c Sidedress N fertilizer rates based on pre-sidedress soil nitrate test (PSNT), averaging 21 ppm NO3-N.

Table 3.2. Effect of N source, rate and timing of application on whole plant broccoli dry matter and N uptake. Objective 3. OSU Vegetable Research Farm.

Treatment									
Trt.	Fertilizer	Preplant	Starter N	Sidedress N	Whole plant harvest				
					Broccoli whole plant biomass (dry ton/acre)				
		lb N/acre	lb N/acre	lb N/acre	Rep 1	Rep 2	Rep 3	Rep 4	Avg.
1	None	0	0	0	3.0	3.2	2.6	2.8	2.9
2	Urea	0	40	0	2.9	2.8	2.4	3.2	2.8
3	Feather	0	40	80	3.0	3.4	2.4	3.5	3.1
6	Urea	0	40	60	2.6	3.6	4.2	3.6	3.5
10	Feather	300	40	0	3.2	4.5	2.2	4.4	3.6
								Trt. P value	0.28
								CV (%)	19
					Broccoli N (% in DW)				
					Rep 1	Rep 2	Rep 3	Rep 4	Avg.
1	None	0	0	0	3.28	2.78	3.33	3.80	3.30
2	Urea	0	40	0	3.59	3.43	3.16	2.68	3.22
3	Feather	0	40	80	4.02	3.27	3.32	3.73	3.59
6	Urea	0	40	60	3.64	3.78	3.58	3.05	3.51
10	Feather	300	40	0	3.65	3.18	3.89	3.40	3.53
								P value	0.55
								CV (%)	10
					Broccoli N uptake (lb N/acre)				
					Rep 1	Rep 2	Rep 3	Rep 4	Avg.
1	None	0	0	0	198	178	173	215	191
2	Urea	0	40	0	207	193	154	170	181
3	Feather	0	40	80	243	220	158	264	221
6	Urea	0	40	60	189	271	298	223	245
10	Feather	300	40	0	234	288	175	302	250
								P value	0.12
								CV (%)	19

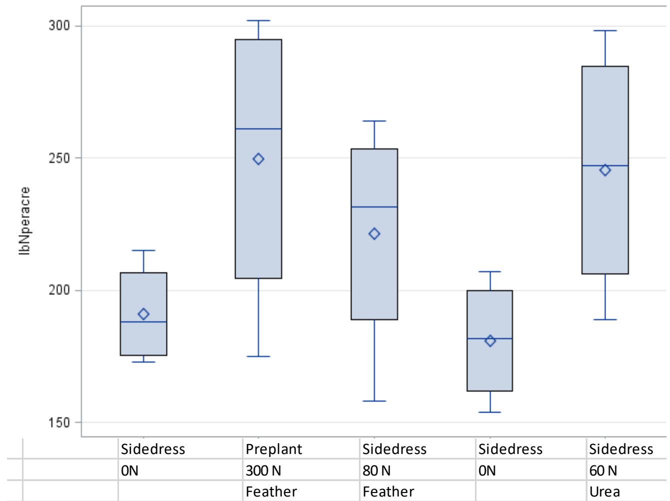

Figure 3.1. Effect of N source (none, feather meal, or urea) and timing (preplant or sidedress) on whole plant broccoli N uptake at harvest (lb N per acre; Y axis) at harvest. Diamonds are treatment means. Level of significance (P value) among treatment means = 0.12.

Appendix Table A. Plant-available nitrate-N mineralized in soil in units of lb/acre-ft and lb/acre/day. Far right column is average of 22C (lab) and field incubation. Objective 1 (Nmin).

Site ID	Soil OM	Soil Total N	Soil Total N	Incubation Lab 22C Week 6 N min	Incubation Field Week 6 N min	Incubation Lab 35C Week 6 N min		Incubation 22 C and Field Week 6 N min
	%	%	lb/acre-ft	lb/acre-ft	lb/acre-ft	lb/acre-ft		lb/acre/d
BA	4.6	0.22	7700	138	91	170		2.7
C	2.8	0.16	5600	112	116	176		2.7
GSAR	3.6	0.2	7000	178	83	219		3.1
GSFR	5.3	0.25	8750	146	79	225		2.7
HB	3.1	0.15	5250	117	89	148		2.5
HC	3.4	0.16	5600	78	107	233		2.2
HCR	2.4	0.11	3850	81	151	152		2.8
KCR	3.4	0.19	6650	142	123	151		3.2
KLE	2.4	0.13	4550	169	102	84		3.2
P	2.4	0.15	5250	66	151	148		2.6
B								
	Avg	0.17	6020	123	109	171		2.8
	Median	0.16	5600	128	104	161		2.7

Soil total C and N determined by Brookside Laboratories, New Bremen, OH.
Organic matter (OM) percentage estimated as %C x 1.7.
Nmin in incubations in lab and in field = NO3-N (ppm) at Week 6 (42 days)
Nmin (lb/acre) = (ppm N; Week 6)/1,000,000) x 3.5 million lb soil/acre
Nmin (% of total N) = (Nmin; lb/acre)/(soil total N; lb/acre) x 100
Nmin (lb/acre/d) = N min (lb/acre)/42 days.

Appendix Table B. Plant-available nitrate-N mineralized in soil expressed as a percentage of soil total N (0-12 inches). Far right column is average of 22C (lab) and field incubation. Objective 1 (Nmin).

Site ID	Soil OM	Soil Total N	Incubation Lab 22C Week 6 N min	Incubation Field Week 6 N min	Incubation Lab 35C Week 6 N min		Incubation 22 C and Field Week 6 N min
	%	%	% of total N	% of total N	% of total N		% of total N
BA	4.6	0.22	1.8	1.2	2.2		1.5
C	2.8	0.16	2.0	2.1	3.1		2.0
GSAR	3.6	0.2	2.5	1.2	3.1		1.9
GSFR	5.3	0.25	1.7	0.9	2.6		1.3
HB	3.1	0.15	2.2	1.7	2.8		2.0
HC	3.4	0.16	1.4	1.9	4.2		1.6
HCR	2.4	0.11	2.1	3.9	3.9		3.0
KCR	3.4	0.19	2.1	1.9	2.3		2.0
KLE	2.4	0.13	3.7	2.2	1.9		3.0
P	2.4	0.15	1.3	2.9	2.8		2.1
B							
Average		0.17	2.1	2.0	2.9		2.0
Median		0.16	2.1	1.9	2.8		2.0

Soil total C and N determined by Brookside Laboratories, New Bremen, OH.
Organic matter (OM) percentage estimated as %C x 1.7.
Nmin in incubations in lab and in field = NO3-N (ppm) at Week 6
Nmin (lb/acre) = (ppm N; Week 6)/1,000,000) x 3.5 million lb soil/acre
Nmin (% of total N) = (Nmin; lb/acre)/(soil total N; lb/acre) x 100

Appendix Table C. Total N and estimated plant-available N in cover crops prior to termination. Cover crop samples collected April, 2017. Objective 2, Monitoring N in grower fields.

		Total N	**Total N**	**Est Nmin**	**Est N min[a]**
Site ID	**Rep**	**%N in DW**	**lb/acre**	**% of total N**	**lb/acre**
C	1	1.4	73	10	7
	2	1.2	41	4	2
	3	1.1	45	4	2
	Ave	1.2	53	6	3
HB	1	2.8	98	36	35
	2	1.9	76	20	15
	3	1.6	42	13	6
	Ave	2.1	72	23	17
HCC	1	1.6	81	14	11
	2	1.5	75	13	10
	3	1.7	63	17	11
	Ave	1.6	73	15	11

[a] Estimated plant-available N mineralized from cover crop estimated by OSU Organic Fertilizer and Cover Crop Calculator

Appendix Table D. Soil nitrate-N at grower field sites. 0-12 inches. Objective 2.

Site	Date Sampled	Rep 1	Rep 2	Rep 3	Avg.	Std Dev.
			NO3-N (ppm)			
B	16-Jun	69	53	9	43	31
	30-Jun	45	42	35	41	5
	13-Jul	50	33	18	34	16
	27-Jul	71	43	41	52	17
	26-Sep	9	7	8	8	1
BA	9-Jun	17	21	13	17	4
	29-Jun	28	22	21	24	4
	13-Jul	15	18	27	20	6
	31-Aug	8	8	8	8	0
C	16-Jun	1	1	1	1	0
	29-Jun	3	2	1	2	1
	11-Aug	4	5	6	5	1
HB	9-Jun	11	8	10	10	1
	29-Jun	20	17	19	18	2
	11-Jul	18	12	12	14	4
	27-Jul	21	15	23	20	4
	5-Sep	4	4	4	4	0
HCC	9-Jun	12	12	14	13	1
	30-Jun	26	21	21	23	3
	13-Jul	23	20	19	20	2
	27-Jul	20	24	20	21	2
	19-Sep	2	2	3	2	0
HCR	9-Jun	9	11	2	7	5
	29-Jun	15	14	13	14	1
	13-Jul	10	7	6	8	2
	27-Jul	11	20	18	16	5
KCR	9-Jun	19	19	17	18	1
	29-Jun	36	25	24	28	7
	11-Jul	58	26	40	41	16
	27-Jul	41	39	38	39	2
	13-Sep	3	4	4	4	0
KLE	9-Jun	29	30	12	24	10
	29-Jun	42	33	36	37	5
	11-Jul	12	30	35	25	12
	31-Aug	2	3	2	2	0
P	9-Jun	12	27	17	18	7
	29-Jun	12	14	13	13	1
	11-Jul	20	9	28	19	10