2018 -2019
Research Reports
for the
Oregon Processed Vegetable Commission

Oregon Processed Vegetable Commission Research Reports on 2018-2019 Funded Work

Research/Extension Progress Report for 2018-19 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 and Ed Peachey, OSU Department of Horticulture, 4017 ALS Bldg., Corvallis, OR 97331-7304

Cooperators: Various OPVC growers allowed placement of traps near their fields.

Funding History: 2016 $21,465, 2017 $20,154 2018 $20,392 (continuing)

Abstract:

Agricultural professionals in the Willamette Valley have come to depend on VegNet as a leading and reliable management tool. This regional program provides activity data for common insect pests of broccoli, cauliflower, sweet corn, and snap beans. Weekly reports are sent via email, and comparative analysis between sites and years can reveal 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. The regional nature of the service provides landscape-level comparisons, and allows producers to determine if there is a concern for their crop or location. Data has been collected in the same manner since 1996, which allows us to calculate and compare historical averages for each pest that is currently monitored. When pheromone traps detect an increased level of adult moths compared to historical averages, we use growing degree-day estimates and knowledge of the species' phenology to estimate timing of egg laying and the potential for subsequent crop damage by larvae. The program operates on an email subscription platform; each week between May and September, subscribers receive a summary of data trends and how they might affect vegetable crop production. Monitoring is an essential first step to integrated pest management (IPM), and the utility of having an insect pest monitoring network applies to a wide range of Ag industry professionals. Pest activity in 2018 varied by species. For instance, looper and corn earworm levels were notably low, but flea beetles and cucumber beetles were abundant.

Keywords: insect, monitoring, vegetable pests, IPM, Extension, newsletter, cutworm, looper

Objectives:

1. Continue operation of a regional pest monitoring and reporting network for damaging crop pests including black cutworm, variegated cutworm, diamondback moth, cabbage looper, 12-spot beetle and others.
2. Improve interpretation of long-term historical data for analysis, and work with cooperating researchers to better forecast pest outbreaks based on weather patterns, annual rainfall, and other macro environmental factors.
3. Manage an electronic agronomic platform as a visualization and reporting tool, and share with OPVC growers to gain access to trap count information and maps.

PROCEDURES:

Crop pest sampling tactics included pheromone traps and paper sticky traps, as well as soil samples and sweep netting. Monitoring locations were placed at processed vegetable field sites throughout the north and central Willamette Valley. Data collection occurred each week from April 23rd to September 17th. At each site, insects in wire mesh traps were killed to prevent re-capture of previously trapped specimens and pheromone lures were changed every 4 weeks. Sticky trap liners were changed and retained for follow-up examination if necessary. Trap catch data were tallied and analyzed by the program manager. Weekly reports were issued via an email marketing system to over 350 subscribers. Web traffic metrics (email opens, links clicked, etc.) of reports were monitored as a means of measuring impact of weekly content.

ACCOMPLISHMENTS:

OBJ. 1 - Regional pest monitoring and reporting -

Insect pest activity patterns tend to be cyclical. They can be influenced by annual weather patterns, host plant phenology, natural enemy levels, and many other factors. For some species, there is a clear pattern of number of generations, timing of peak flights, etc. Other pests seem to vary widely year-to-year and activity peaks may overlap, which makes analysis, and subsequent prediction of crop damage difficult.

Table 1 provides a summary of activity trends for each of the 10 pests monitored by VegNet. Corn earworm, cabbage looper, and alfalfa looper levels were much lower than average. This year's dramatic increase of yellowjacket wasps may have had an effect. Wasps are generalist predators and are often encountered in and around monitoring stations. However, they do not eat wings, so care was taken to continue to provide accurate counts based on wing pairs present in the traps.

Some of the complaints from growers this year were regarding flea beetles and 12-spottted cucumber beetles (rootworms). The 12-spots have been steadily increasing in the valley since 2014, possibly due to continual development and the green bridge effect (availability of host plants year-round). Flea beetles are not currently monitored by VegNet quantitatively, but we did make a few announcements about increased activity, and there is a pest profile about them located on the program blog.

Other commodities experienced intense pressure from armyworms this year, and we worked with Extension personnel to identify them and issue alerts. VegNet currently only monitors for bertha armyworm (*Mamestra configurata*), and although true armyworm (*Mythimna unipuncta*) is considered a grass specialist, it does feed on vegetables and forages if populations are high, which they probably were this year. Another species that may be worth tracking is the glassy cutworm (*Apamea devastator*). It was detected as a non-target in diamondback moth traps this year. It has a wide host range and overwinters as partially mature larvae, very similar to winter cutworm (*Noctua pronuba*).

Table 1. Summary of insect pest trends of 2018 compared to recent history. If applicable, prediction notes are provided.

Common and Latin name of insect	Crops affected	**2018** activity	Historic trends	Notes
Aphids (*M. persica,)*	varies by species	not monitored	not monitored since 2014	invasive species in Idaho feeds on wheat, cereals
Alfalfa looper (*Autographa californica)*	brassicas, snap beans, spinach	very low activity	unknown	
Armyworms (*Mamestra configurata, Apamea* spp., *Spodoptera praefica*)	brassicas, bell peppers, small grains, pastures, *	increase in non-target armyworms, other commodities had intense pressure	Bertha armyworm only species historically monitored by VN	may be related to rainfall in southern regions of N. America
Cabbage looper (*Trichoplusia ni*)	brassicas, snap beans, spinach	very low activity	2008 and 2017 were outbreak years, 2011 similar to 2018	predict normal levels 2019
Cabbage white butterfly (*Pieris rapae*)	brassicas	normal, average greatly influenced by 1 site in S. valley	2004 and 2011 outbreak years	
Corn earworm (*Helicoverpa zea*)	sweet corn, tomatoes, *	very low activity	2016-17 very similar to each other, above average	pattern consistent, good model for predictive estimates
Cutworm, black (*Agrotis ipsilon*)	sweet corn, snap beans, *	higher than normal in Apr-May but lower rest of season	2012-2015 saw huge increases vs. 1996-2011	
Cutworm, variegated (*Peridroma saucia*)	sweet corn, mint, *	very low activity, only detected in S. valley	unknown	
Diamondback moth (*Plutella xylostella*	brassicas	varied by field	2016 outbreak year	
Rootworm beetles (*Diabrotica undecimpunctata* and *D. virgifera*)	snap beans, sweet corn, squash, cucumbers, *	12-spot (12S) very abundant; Western corn rootworm established	12S steadily increasing since 2014	will likely be a problem again in early spring 2019

* = plus other, additional documented host plants. Many of the pests we monitor are generalist feeders

OBJ. 2 – Data interpretation and forecasting –

The strength of this program lies in its regional nature and the historical data sets that have developed over 20 years (1996-2016). However, managing this large of a dataset is no small task. In fact, there are over 41,000 data points. Assigning a date and GPS to each point would allow us to view possible spatial patterns. Additionally, basic statistics could be run on species of interest to test hypotheses like variance in date of first catch, relation to environmental factors, etc. We have made contact with other OSU researchers interested in pursuing a large-scale data analysis and have started to arrange data so that it is in a usable format, but much work remains to complete this objective.

An extensive literature search was done on migratory patterns of DBM, BCW, CEW, and others. It reveals that long range movement does affect populations, and some of the patterns are relevant for the PNW. The program manager published a few blog posts about migration concepts (https://wp.me/paiW4b-4Z and https://wp.me/paiW4b-2h). Air currents are one possible source to use when attempting to predict insect movement. Another is moisture. The level of rainfall each year in California can be useful in estimating armyworm pressure, for example.

OBJ. 3 – Exploration of software tools -

The 2018 budget included an allowance for a $285 electronic "agronomic platform" made by Spensa Technologies (http://spensatech.com/). For the majority of the field season, the mobile app was unreliable and therefore not used. The functionality was poor for Android devices. In theory, the concept seemed like it would be beneficial, but instead, we found it required an extra step because it was difficult to enter data from the field. The company has since been merged with DTN, and they have offered us a more complete package for a similar price. However, at this time, the 'prediction models' they offer are mainly for field corn and soybean pests. Another stated goal of Objective 3 was to offer data directly to OPVC growers, but we found it easiest to just notify them directly if an immediate problem was noted.

In general, it seems that automation of data is a current desire, at least from the view of some. A few years ago, we talked with representatives from Intel, and just a few weeks ago we were contacted by a startup from Portland, both interested in remote viewing/analysis of insect trap data.

IMPACTS;

Subscribers to the VegNet program immediately gain a competitive edge by receiving advance warning of potential pest problems as they occur. We like to think that "detection yields protection" if the program is used as intended – as one component of an IPM plan for processed vegetable growers. Reports during critical timing of certain pests (corn earworm at silking, black cutworm at planting, diamondback moth at button stage) are especially useful for growers and crop consultants.

Industry representatives (e.g. Valley Agronomics, CPS, Syngenta) account for a large portion of engaged subscribers. Not only are they reading reports, they are the only group who consistently clicks on links to learn more about the pests mentioned, read articles, etc (FIG.1). Built-in analytics of the email delivery platform have been very useful to learn more about how VegNet is being used.

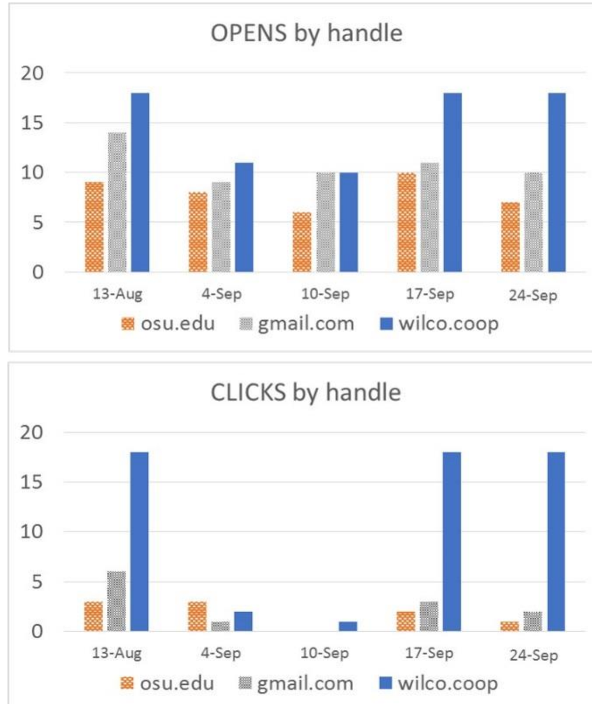

Figure 1 - A random selection of weeks in 2018 when crop consultant views and clicks of the pest report content greatly outnumbered other user groups.

RELATION TO OTHER RESEARCH / EXTENSION

Long-term monitoring of over 10 insect crop pests has yielded a robust dataset, and we are just beginning to realizing its true potential. In the near future we will be working with faculty in the Integrated Plant Protection Center at OSU to develop better predictive models for some of the common vegetable pests.

The Oregon Department of Agriculture plant health division contacted us mid-season to inquire about a collaborative effort to survey western corn rootworm (*Diabrotica virgifera*). An arrangement was reached that ODA would buy monitoring supplies and VegNet personnel would set and maintain the traps and report data. The survey was successful and encompassed 15 sites over 8 weeks, revealing that *D. virgifera* is widespread in western Oregon.

We have been strengthening relationships with existing as well as newly hired OSU Extension personnel (vegetable and specialty seed, field crop, small farms, dairy) in order to promote the VegNet program and work towards collaborative solutions to insect pest issues in Oregon.

OPVC CONTINUING PROJECT REPORT: YEAR 2018

1. OPVC REPORT COVER PAGE (maximum 2 pages)

OPVC Project Number:

Project Title: Broccoli Breeding, Evaluation

PI: James R. Myers
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Total Project Request (all years):
Year 1: $7,308 (breeding)
$4,648 (processing)
$11,956 (total)

Other funding sources: Western SARE

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.

Two yield trials were conducted in 2018. The first transplanted 8 June contained four released cultivars (Cascadia, Emerald Pride, Monflor, and Hancock). The second planted 7 August had four commercial checks and 16 experimental hybrids. Several new OSU inbreds (S471, S473, S474, S475, S480, S481, and S485) 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 usable floret (<2.5") proportion but did not find the relationship between broccoli type and proportion that we observed last year. In general as yield increased, floret size also increased. S471 does seem to combine well to produce high yields and has favorable quality attributes when combined with some older OSU inbreds. An observation trial with 26 advanced inbred lines, 4 segregating inbreds, 12 cytoplasmic male sterile lines in various stages of backcrossing to advanced inbreds, and 7 F1 hybrids with only enough seed for one replicate were grown and evaluated for horticultural traits in the field. Six isolation plots for hybrid seed production were established at the OSU Vegetable and Lewis Brown farms, with variable seed production with different hybrid combinations.

Cascadia had its first commercial testing in 2018 and overall, did not do well compared to commercial hybrids. A complementary Western SARE project to facilitate more efficient broccoli production was implemented, and will be reported separately.

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 and a Western SARE project in 2018 to automate broccoli harvest. 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 in 2016-17 and released it 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.

- Cascadia had similar yields to Emerald Pride and Monflor in the early summer trial, but performed poorly in the fall trial. Hancock had nearly double the yields of other hybrids in the spring trial and was the top yielder in the fall trial. However, Hancock has florets that are too large for processing as well as lacking in other processing attributes. Some OSU experimental broccoli hybrids have similar yields to existing commercial hybrids, but have more desirable characteristics for processing.
- While there were some shifts in floret:stem and usable (<2.5") floret proportions, they generally followed net yet ranking among hybrids.
- S471 is a new inbred to the program that continues 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 2017 growing season were grown from cuttings in the winter 2018 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 (Table 1). Plots were evaluated for percent blind (multiple shoots rather than a single head), head size, shape, firmness, exsertion, segmentation, uniformity, floret texture and color, and maturity.

Spring and fall replicated yield trials were established. The spring trial consisted of four commercial cultivars (including Cascadia) (Tables 2 & 3) while the fall trial had the four commercial hybrids along with 16 OSU experimental hybrids (Tables 4 & 5). The spring trial was transplanted 7 June while the fall trial was planted 7 August. They were arranged 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. In the fall trial, the proportion of florets > 2.5 inches was also determined. 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 on 8 November and was displayed at the PNVA meetings in Kennewick, WA on 15 November. 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.

Backcrossing of selected hybrids to place the nuclear genome in the Ogura and Arnund cytoplasmic male sterile (CMS) backgrounds continued (Table 1). 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 six isolation plots (three at the Vegetable Research Farm, and three 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 2017 to establish material for crossing and hybrid seed production in the greenhouse during the winter of 2017-2018. 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 2019 growing season. Most lines are highly inbred but a few are still segregating and showing significant variation in the field.

Observation Trials: The observation trial included 26 highly inbred lines, 4 lines still undergoing inbreeding and selection, and 12 Ogura cytoplasmic male sterility (CMS) lines at various stages of backcrossing to selected inbreds (Table 1). 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). Eleven inbreds received overall ratings of 7 or above (Table 1.). In addition, seven F1 hybrids for which there was not sufficient seed for replicated plots were grown for observation. All received overall scores of 7 or above, so we will attempt to make sufficient seed in 2019 of these hybrid combinations for replicated trials.

Yield Trial: The spring yield trial consisted of four commercial hybrids (Cascadia, Emerald Pride, Monflor and Hancock) (Table 2 & 3). Three of these have the exserted head trait, but vary for other traits. In terms of Net yield, Cascadia, Monflor and Emerald Pride were not significantly different, but were significantly lower yielding than Hancock. Emerald Pride had the most leaves on the stem (22%) followed by Monflor (20%) with Cascadia (12%) and Hancock (7%) having the least. Hancock had a significantly greater percent florets compared to the others. Cascadia had the best combination of quality traits followed by Emerald Pride. Of the commercial hybrids, Monflor has very deep branching and would require stems to be cut to a very long length to keep the head intact for floretting in the plant. Hancock has a high percentage of florets that are > 2.5" and would require recutting in the plant.

In the fall trial the same four commercial hybrids were grown along with 16 OSU experimental hybrids (Table 4 & 5). Hancock had the highest Net T/A at 6.0 but the differential was not as great compared to other hybrids, which ranged from 3.3 to 5.4 T/A. Most OSU experimental hybrid did not have yield significantly different from Monflor and Emerald Pride. Cascadia had the lowest net yield at 3.3 T/A. It had the highest leave percentage (10.6%) suggesting that it was cut at a younger stage than the others. Percent florets ranged from 59.2 to 77.1% while usable florets ranged from 42.3 to 56.2%. While Hancock had the highest percent florets, it had the second to lowest usable florets. Emerald pride ranked fourth from the bottom for usable florets while Cascadia was in the middle of the group and Monflor had the second highest percent usable florets (Table 4). On a T/A basis, Hancock had the second highest weight (following Monflor and Emerald Pride) of usable florets, while Cascadia had the lowest. A number of OSU experimental hybrids were not significantly different from Monflor and Hancock. The lesson learned is that overall head weight is more important than proportion of the head that is made up of florets.

A heavy aphid infestation was observed in this trial and number of heads with aphid damage was recorded. Significant differences in aphid infestation were observed (Table 5) with some of the lowest numbers being for the four commercial hybrids. Among experimentals, S474/S446 had relatively low numbers.

Hybrid Seed Production: Seed production from isolation plots was variable in 2018. This year, we started inbreds from cuttings in the greenhouse so that they were flowering immediately when transplanted to the field. We had excellent seed production in 2016 using this technique. The cross O446/S473 produced over 3000 seeds (table 6), while other cross combinations produced from 31 to 600 seed.

4. BUDGET DETAILS

Requested Budget	
1) Breeding (Myers)	
Salaries and benefits	
Faculty Research Assistant (Hort)	$2,526
OPE @ 66%	$1,659
Wages and benefits	
Student Wages	$1,290
OPE @ 10%	$129
Supplies	$300
Land use and greenhouse rental	$1,405
Total	$7,308
2) Processing (~~Radke~~ Yorgey)	
Salaries and benefits	
Faculty Research Assistant (FST)	$2,563
OPE @ 63%	$1,614
Wages and benefits	
Student Wages	$258
OPE @ 10%	$26
Supplies	$187
Total	$4,648
Grand Total	$11,956

BUDGET NARRATIVE

Salary and OPE is requested for a full time faculty research assistant in Horticulture who will commit approximately 6% FTE to broccoli breeding. The remainder of salary will come from other sources. For the faculty research assistant in FST, approximately 5% FTE will be required to process broccoli samples; the remainder of salary to come from other sources. $1,140 is requested for a summer undergraduate student to assist in plot maintenance and harvest operations. The FST FRA will also supervise an undergraduate student in broccoli processing. Undergraduate student OPE is 10%. 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. OSU breeding program broccoli observation trial for inbreds, CMS backcrosses and selected hybrids.

Entry	Days post trans-plant	Plants (no.)	Blind (no.)	Blind (%)	Exsert[z]	Head shape[y]	Branch depth[x]	Bead size[w]	Color[z]	Head Dia. (cm)	Head firm-ness[z]	Uniform -ity[z]	Over-all[z]	Notes
							Inbreds							
S442	70	17	2	11.8	6	6	3	m	5	10	3	3	3	Soft leafy heads
S445	70	14	2	14.3	8	6	7	f	5	17	7	7	7	Small florets
S446	72	18	4	22.2	7	7	5	m	7	17	7	7	7	
S454	68	19	3	15.8	7	6	7	m	7	16	5	7	7	
S462	68	18	1	5.6	7	5	7	m	5	16	6	3	5	Var. hd. size & florets
S463	70	14	3	21.4	6	7	5	m	7	13	9	7	7	
S465		16	0	0.0										Very late
S466	72	16	0	0.0	7	7	3	m	5	14	9	7	6	
S469	68	19	0	0.0	9	9	5	m	7	12	3	9	3	Incised leaves, wilty
S471	70	20	0	0.0	7	5	5	m	7	15	9	7	9	Highly segmented
S473	66	16	2	12.5	7	5	7	f	7	13	5	5	5	Some plants w/ alternaria
S474	70	18	1	5.6	7	7	5	m	5	13	7	7	5	
S475	70	19	1	5.3	7	5	7	f	7	16	9	7	7	Highly segmented w/ small florets
S479	70	15	1	6.7	7	4	9	f	5	16	7	9	7	1 blowout; leaves in head, highly segmented
S480	68	17	3	17.6	6	7	9	c	5	13	1	7	3	V. soft heads w/ coarse beads
S481	70	10	0	0.0	7	6	7	f	5	16	9	3	7	Leafy heads
S482		12	3	25.0										Very late
S483	70	19	0	0.0	8	5	5	f-m	7	14	8	9	8	
S484	70	11	0	0.0	8	4	7	f	7	20	7	9	6	Immat. Heads w/ yellowing uneven bead dev.
S485	68	19	1	5.3	9	7	9	f-m	7	17	7	3	6	Variable plants
S486	68	17	0	0.0	9	4	9	f	7	16	7	7	7	Highly segmented
S487	68	19	1	5.3	9	5	9	f-m	7	16	5	7	6	
S488	70	19	1	5.3	9	4	9	f	5	14	5	3	5	Variable
S490	68	14	0	0.0	9	4	9	m	7	21	7	7	7	Highly segmented & loose head
S491	70	19	0	0.0	7	6	7	f-m	9	19	9	3	7	Variable, small button heads

Entry	Days post trans-plant	Plants (no.)	Blind (no.)	Blind (%)	Exsert[z]	Head shape[y]	Branch depth[x]	Bead size[w]	Color[z]	Head Dia. (cm)	Head firm-ness[z]	Uniform -ity[z]	Over-all[z]	Notes
S492	68	14	1	7.1	9	7	5	f	7	19	7	5	7	
(S468/S446) -1-1-1	68	17	0	0.0	9	5	9	f	3	22	1	7	3	
(S468/S446) -1-1-2	68	18	5	27.8	var. 5-9	7	9	f	5	var.	1	1	3	Variable size
(S468/S446) -1-1-3	68	14	0	0.0	7	7	7	f	7	16	5	7	5	Heads may be too soft
(S468/S446) -1-2-1	70	24	3	12.5	8	7	5	f	3	14	9	3	3	Var. head size
Cytoplasmic Male Sterile backcrosses														
A463/S463	70	18	5	27.8	7	7	3	c	5	10	8	7	3	Smooth dome
O463-1*1	70	17	0	0.0	6	7	3	m-c	1	12	9	5	5	
O473-2*1	68	18	0	0.0	var.	4-7	9	f-m	-	var.	9	1	3	
O463-3*1	70	16	2	12.5	var.	7	7	m	3	10-18	9	3	5	
O463-4*1	70	5	0	0.0	5	7	5	m-c	5	13	9	5	5	Short plants
O473-3*1	72	15	0	0.0	7	7	5	m-c	5	12	9	1	5	
O473-4*1	70	18	1	5.6	7	6	9	f	5	19	5	3	5	
O454-1*1	66	20	2	10.0	7	6	9	m	5	18	7	5	5	
OS462-2*3	70	16	3	18.8	7	7	7	m-c	5	16	7	5	7	
O454-2*1	70	15	7	46.7	8	7	5	c	5	12	9	3	5	
O473-1*1	70	20	3	15.0	var.	var.	var.	var.	var.	var.	var.	var.	var.	
O462-1*3	64	18	0	0.0	var.	var.	var.	var.	var.	var.	var.	var.	var.	
F1 hybrids														
S462/S474	70	19	0	0.0	8	6	7	m	9	20	8	7	7	Lots of leaves, some button heads
S463/S473	66	18	2	11.1	7	5	9	m	5	18	9	7	8	
S473/S463	68	8	0	0.0	8	5	9	m	5	15	8	8	7	
S475/S463	70	20	2	10.0	6	7	3	m	9	17	9	8	9	
S471/S483	70	10	1	10.0	6	5	5	m	5	22	9	7	8	Highly segmented w/ loose heads
S483/S471	70	20	0	0.0	7	7	5	m	7	21	9	7	8	Florets may be too large
S473/S463	70	9	0	0.0	9	6	7	m	5	19	7	9	7	

[z]Scale of 1-9 where 1 = lowerst (worst) and 9 = highest (best); [y]Scale of 1-9 where <3 = concave, 5 = flat, 7 = moderate dome & 9 = extreme domed head; [x]Scale of 1-9 where 1 = shallow and 9 = deep branching; [w]vf = very fine, f = fine, m = medium & c = coarse beads.

Table 2. Field performance of four broccoli hybrids planted in a replicated processing yield trial on June 7th at the OSU Vegetable Research Farm.

Entry	Days to harvest	Total wt. (T/A)	Head wt. (T/A)	Leaf wt. (T/A)	Heads/A	Immature heads (%)	Net heads/A	Net T/A	Leaves (%)	Florets (%)	Floret wt. T/A
Cascadia	53	5.7	5.0	0.7	14,375	16.0	12,052	4.6	11.7	57.5	2.6
Emerald Pride	53	7.2	5.6	1.6	14,520	21.0	11,035	4.9	22.2	55.6	2.7
Hancock	61	10.0	9.3	0.7	15,682	14.0	13,504	8.9	7.1	70.9	6.3
Monflor	49	5.7	4.6	1.1	16,117	19.1	13,068	4.1	20.0	61.2	2.5
LSD 0.05	0	1.2	1.2	0.9	834	13.7	1,703	1.3	11.7	4.1	1.0

Table 3. Spring season processing broccoli trial at the OSU Vegetable Research Farm in 2018. Field observation data. See table 1 footnotes for an explanation of scales.

Entry	Plants (no.)	Blind (%)	Canopy ht. (in)	Head ht. (in)	Head dia. (cm)	Hollow stems (%)	Head Shape	Bead Size	Stem color	Exsert -ion	Seg- ment	Uniform -ity	Branch	Overall	Notes
Cascadia	29.5	3.4	25.3	22.3	14.4	92.5	7	m-c	7	7	7	3	3	7	
Em. Pride	29.3	5.2	26.3	22.5	17.6	27.5	4	m-c	5	5	3	3	3	5	
Hancock	30.0	4.2	26.0	19.3	13.9	87.5	5	m-c	3	7	5	5	1	3	Lg. lateral florets
Monflor	29.5	5.9	23.8	15.3	15.0	80.0	3	m-c	5	7	7	5	1	5	
LSD 0.05	0.9	4.2	1.2	1.3	1.4	28.0									

Table 4. Yield and yield component data from a fall trial of processing broccoli cultivars and experimental hybrids grown at the OSU Vegetable Research Farm in 2018.

Entry	Total T/A	Head wt. T/A	Heads/A	Young T/A	Young no./A	Cull wt. T/A	Cull no./A	Net T/A	Net no./A	Leaves (%)	Florets (%)	Usable florets (%)	Floret T/A	Usable floret T/A
S454/S475	4.7	4.5	15,682	0.02	290	0.0	0	4.5	15,391	2.4	67.1	56.2	3.0	2.5
Monflor	5.5	5.4	15,972	0.02	726	0.0	0	5.4	15,246	1.8	60.7	52.3	3.3	2.8
S471/S480	4.4	4.3	14,956	0.05	726	0.0	0	4.3	14,230	2.2	62.5	51.3	2.7	2.2
S474/S463	4.1	3.8	14,230	0.02	290	72.6	145	3.8	13,794	7.2	67.9	51.2	2.6	1.9
S471/S463	5.2	4.9	14,810	0.06	581	551.8	1,016	4.6	13,213	5.1	68.5	50.9	3.1	2.3
S471/S474	3.9	3.6	14,520	0.03	290	421.1	1,307	3.4	12,923	8.2	68.0	50.4	2.3	1.7
S471/S485	4.7	4.5	14,230	0.04	436	14.5	145	4.5	13,649	3.9	64.0	50.3	2.8	2.2
S454/S471	4.6	4.4	16,408	0.08	726	0.0	0	4.3	15,682	4.1	62.8	49.7	2.7	2.2
S454/S474	3.9	3.7	15,246	0.01	145	0.0	0	3.7	15,101	5.2	67.3	49.3	2.5	1.8
S471/S479	5.4	5.2	15,536	0.04	290	0.0	0	5.2	15,246	3.5	63.4	48.6	3.3	2.5
Cascadia	3.7	3.3	15,391	0.04	726	0.0	0	3.3	14,665	10.6	65.7	48.3	2.2	1.6
S471/S475	4.9	4.7	14,956	0.02	436	450.1	1,016	4.4	13,504	5.8	66.7	48.1	2.9	2.1
S471/S481	5.4	5.1	15,682	0.03	290	87.1	145	5.0	15,246	5.4	64.9	47.7	3.2	2.4
S454/S473	3.8	3.7	14,665	0.03	436	246.8	290	3.5	13,939	2.4	59.2	47.4	2.1	1.7
S474/S446	4.8	4.6	15,972	0.02	290	29.0	145	4.6	15,536	4.1	67.0	46.9	3.1	2.1
S471/S473	4.4	4.1	15,536	0.08	871	493.7	1,162	3.8	13,504	5.4	62.3	46.4	2.4	1.8
Em. Pride	6.0	5.5	16,988	0.08	871	43.6	145	5.4	15,972	8.8	61.1	46.2	3.3	2.5
S475/S446	5.0	4.8	14,810	0.04	581	58.1	145	4.7	14,084	5.0	62.7	45.8	3.0	2.2
Hancock	6.2	6.1	15,827	0.03	0	0.0	0	6.0	15,827	1.8	77.1	44.4	4.7	2.7
S471/S446	4.8	4.5	14,810	0.01	145	203.3	145	4.4	14,520	6.2	65.9	42.3	2.9	1.8
LSD 0.05	0.7	0.7	1,790	0.07	771	248.0	477	0.7	1,822	4.6	3.9	5.5	0.5	0.4

Table 5. Observation data from a fall trial of processing broccoli cultivars and experimental hybrids grown at the OSU Vegetable Research Farm in 2018. See table 1 footnotes for explanation of scales.

Entry	Blind (%)	Leaf ht. (in)	Head ht. (in)	Head shape	Color	Exsertion	Segment	Uniformity	Branch	Head dia. (cm)	Hollow stem (%)	Hollow stem Pr > |t|[z]	Heads w/ aphids (no./A)
Cascadia	1.5	22	20	7.0	3.3	6.5	4.3	4.0	4.0	12.2	38	0.08	0
Emerald Pride	1.5	22	16	4.0	4.0	4.5	3.8	4.0	3.0	15.6	8		0
Hancock	2.0	25	23	6.0	4.0	5.5	3.3	5.5	3.8	15.5	20	0.46	726
Monflor	0.5	25	17	4.8	5.0	5.0	8.3	5.0	5.0	15.1	49	0.02	0
S454/S471	1.3	24	22	5.3	4.5	7.0	5.5	3.8	4.0	14.2	70	0.00	726
S454/S473	3.5	26	23	4.3	4.0	6.0	5.3	4.3	4.8	14.0	48	0.02	290
S454/S474	2.3	25	23	6.8	3.8	7.0	5.0	4.0	5.0	13.2	60	0.00	1,597
S454/S475	2.0	24	24	6.0	3.0	8.0	6.0	5.5	4.3	14.6	43	0.04	1,016
S471/S446	0.3	22	19	6.5	4.0	5.5	3.8	4.0	4.8	14.3	25	0.30	1,016
S471/S463	2.0	23	22	7.0	3.5	6.8	3.5	5.3	3.8	15.7	45	0.03	1,016
S471/S473	2.0	27	24	4.8	4.5	6.5	6.5	3.8	4.3	14.1	28	0.24	3,194
S471/S474	3.3	21	21	5.8	3.8	7.5	7.0	4.0	5.3	13.4	5	0.88	4,937
S471/S475	3.5	23	22	5.3	4.0	7.3	8.0	3.8	4.3	14.6	23	0.37	4,792
S471/S479	2.0	24	22	4.8	4.0	6.3	6.5	4.0	5.0	14.4	68	0.00	1,742
S471/S480	2.3	26	24	4.8	4.5	7.0	6.5	5.0	4.8	14.4	35	0.10	1,016
S471/S481	1.5	23	22	6.5	3.3	6.0	4.8	4.8	4.8	14.4	38	0.08	1,452
S471/S485	2.0	26	24	6.0	4.8	6.3	5.8	4.0	4.0	14.3	58	0.00	1,016
S474/S446	1.0	23	21	7.0	3.5	7.0	4.3	4.0	4.0	13.7	50	0.01	436
S474/S463	3.8	23	22	7.0	3.3	6.0	4.8	4.0	4.5	13.3	18	0.55	2,323
S475/S446	1.0	27	22	6.8	4.0	5.0	4.3	4.5	4.3	14.1	53	0.01	2,033
LSD 0.05	1.7	2	2	0.7	0.6	0.9	1.1	0.6	1.1	1.2			1,844

[z]Probability of a > |t| for hypothesis: hybrid LS mean = Emerald Pride. Lines w/ Prob. < 0.05 are significantly different from Emerald Pride.

Table 6. Seed production from field isolation plots at the OSU Vegetable Research and Lewis Brown farms in 2018.

Hybrid	Seeds (no.)
0446 x S475	153
0446 x S475 (green)	139
0446 x S475	199
0446 x S473	3,377
0446 x S471	31
0446 x S462	600

OPVC CONTINUING PROJECT REPORT: PROJECT YEAR: *2018*

1. OPVC REPORT COVER PAGE (maximum 2 pages)

OPVC Project Number:

Project Title: Green Bean Breeding and Evaluation

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Total project request (all years):

Year 1:	$27,004 breeding
	$7,846 processing
	$34,850 total

Contributions from the OSU breeding program

Year 1: **$19,158**

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 2018, two yield and processing trials of OSU experimental advanced lines were conducted. The first had 8 check and experimental lines of the full sieve to whole bean pod size class, while the second consisted of 7 extra fine and small sieve checks and experimental lines. A third trial with 30 entries from commercial seed companies was also grown and evaluated. Two populations were evaluated for white mold disease in the field. One was of the cross Unidor/OSU5630 consisting of 184 lines; the second was a four-component nested association mapping population based with the common parent WMG904-20-4. In the early generation nursery, 1,378 plots of populations and lines at various stages of inbreeding were grown. In these nurseries, 454 plots were massed, 116 single plants were selected from individual plots and 55 populations were advanced by single pod descent. 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 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 three 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: 8 entries in a full sieve and whole bean pod size trial and 7 entries in an extra fine trial.
- Three advanced lines (OSU 6835, OSU 6993 and OSU 6996) continue to show the best combination of yield, quality and white mold resistance.
- Five extra fine snap bean lines 7046, 7047, 7048, 7049 and 7050 (B8407-49-1-1, B8408-30-1-1, B8408-41-1-1, B8408-43-1-1, and B8408-53-1-1 in the 2017 trial, respectively) were evaluated again in 2018.
- A trial with 30 commercial entries was also evaluated for yield, and quality.
- Of the 1,378 plots grown in the early generation nursery, 454 were harvested by massing all plants in the plot, 116 were harvested as single plants and 55 populations were advanced by single pod descent.
- White mold trials were conducted for two populations in the field. One was of the cross Unidor/OSU5630 consisting of 184 lines; the second was a four-component nested association mapping population based with the common parent WMG904-20-4.
- Populations varied in response to white mold disease with the Unidor population showing a normal distribution, while two of the four WMG 904-20-3 populations had the majority of individuals showing resistance.

3.d. METHODS

Varietal Development: The program made crosses among elite lines and the best white mold resistant lines during the winter of 2018 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: Recombinant inbred populations were evaluated for white mold resistance. Plots were established in a field with a history of severe white mold. At flowering, plots were watered daily for 30 minutes in the evening to increase leaf wetness duration. Plots were read at harvest maturity with data collected on percent incidence (proportion of plot infected) and severity (proportion of infection on individual plants using a 1 – 9 scale where 1 indicates no infection and 9 is most of the plant with symptoms). A disease severity index was calculated based on the geometric mean of incidence and severity.

Variety Trials: A replicated yield trial was planted 6 June with four four to full sieve checks (OR91G, OSU 5630, Sahara, and Cornell 501), two small sieve checks (Redon and Crockett), four4- to full sieve advanced lines, and five extra fine (two to three sieve) 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 8 November, 2018 and then displayed in a cutting at the PNVA meetings in Kennewick, WA on 15 November, 2018.

A trial of commercial entries was planted 19 June with four checks (OR91G, OSU 5630, Sahara, and Pierroton) and 26 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 1,378 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. In the early generation nurseries, 454 plots were massed, 116 single plants were selected from individual plots and 55 populations were advanced by single pod descent (bulking a single pod from each plant in the population). The 454 massed plots represent the next wave experimental lines advancing in the program to be funneled into replicated yield and disease trials. In 2019, we will begin yield and disease testing of these in 2019.

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) (Table 1). All experimental lines had been tested several times in the previous six years, and had been retained because they had the best combination of yield and white mold resistance. This trial matured during the hottest period of the summer, but showed relatively few problems indicative of heat damage. The checks OR 91G and OSU 5630 had unadjusted yields in the 12 – 13 T/A range as did Sahara. The experimental lines OSU 6771, 6835, OSU 6993 and OSU 6996 ranged in unadjusted yield from 10 - 12 T/A. These lines generally scored well in the raw product evaluation (Table 2) and the processed product sensory evaluation. They represent a continuum in terms of white mold resistance. OSU6993 is among the most resistant based on previous years' data but has the lowest yield potential of the group (Table 1) in part because it is a four sieve bean. 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 based on previous years' trial data.

Of the five experimental lines in the extra fine yield and quality trial, one (7049) had yield equivalent to Redon while the others were lower yielding (Table 1). OSU 7047 and 7049 had pod color equivalent to Redon, while the others had superior pod color (Table 2). Otherwise, all had acceptable processing characteristics. The lines varied in sieve size with size of pods maxing out in either 2 or 3 sieve categories, and in general had a broader sieve distribution than did Redon. These five lines should be trialed again in 2019. 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:
Seven 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. Yields ranged from about 5.3 – 13.6 T/A (unadjusted) (Table 4). OSU 5630 yielded 11 T/A with comparable yields for Huntington SB4738, SB4754, HS934, SV9203GV, CR-1639 and CR1745. Highest yielding in the trial was Pismo with 13.6 T/A (unadjusted). This was the second year for SV9203GV, a line with BBL attributes. Raw product evaluation notes are found in table 5 and seed size development at during successive harvests are in table 6.

White Mold Trial: Environmental conditions were favorable for white mold disease development in the recombinant inbred populations. Plot distributions are shown in Figs 1 & 2. Unidor/5630 population had 19 lines with DSI < 6. Cornell 501/WMG904-20-3 had 42 of 56 lines with DSI < 6, NY6020-4/WMG904-20-3 had 16 of 69, M0070/WMG904-20-3 had 12 of 60, and WMG904-20-3/A195 had 31 of 62 lines (Figs. 1 & 2). None of the nested association mapping populations showed a normal distribution as would be expected. Two (Cornell 501/WMG904-20-3 and WMG904-20-3/A195) were skewed towards resistance suggesting that the parents shared a number of complementary resistance genes whereas the other two populations showed approximately the same number of lines at all levels of resistance, suggesting low levels and fewer resistance genes. The white mold research discussed here is primarily funded by the National Sclerotinia Initiative but has direct applicability to the breeding program in breeding for resistance. In 2019 we will begin extracting resistant lines from these populations for testing for yield and processing attributes.

4. BUDGET DETAILS

1) Breeding (Myers)	
Salaries and benefits	
Faculty Research Assistant (Hort)	$15,997
OPE @ 66%	$10,507
Wages and benefits	
Student Wages	$0
OPE @10%	$0
Supplies	$500
Travel	$0
Land and greenhouse rental	$0
Total	**$27,004**
2) Processing Evaluation (~~Radke~~ Yorgey)	
Salaries and benefits	
Faculty Research Assistant (FST)	$3,000
OPE @ 63%	$1,890
Wages and benefits	
Student wages	$1,505
OPE (@ 10%	$151
Supplies	$1,300
Total	**$7,846**
Grand Total	**$34,850**
Contributions of the OSU breeding program	
Student Wages	$8,170
OPE @ 10%	$817
Supplies	$500
Travel	$86
Land and greenhouse rental	$9,586
Total	**$19,158**

BUDGET NARRATIVE

Request to OPVC: Salary and OPE is requested for a full time faculty research assistant in Horticulture who will commit 38% FTE to green bean breeding. A faculty research assistant in Food Science & Technology 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 $1,505 are requested for the processing program with 10% OPE. OPE for the FRA is 66% and that of the SFRA is 63%. $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 $8,170 are estimated for the breeding program with 10% 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. Performance of preliminary green bean lines, June 6 planting, Corvallis, 2018.[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]
Full sieve and whole beans												
91G	62	6	196.5	5.2	5.9	13.3	33.6	35.8	6.3	57.9	12.3	13.3
5630	63	6	200.0	4.7	6.8	13.2	36.3	34.6	4.4	61.0	13.4	14.8
Cornell 501	64	5	196.3	4.5	7.1	15.6	40.3	30.5	1.9	67.5	6.9	8.1
Sahara	63	4	197.3	4.8	8.6	26.5	46.7	13.4		86.6	13.0	13.0
6771	63	5	200.0	3.1	4.4	11.5	38.1	41.6	1.3	57.1	10.3	11.0
6835	63	6	195.7	4.7	6.3	12.6	31.9	39.4	5.1	55.5	11.6	12.2
6993	66	4	197.5	5.3	9.3	18.9	45.8	20.3	0.4	79.3	10.2	10.2
6996	66	6	195.3	4.1	4.5	9.9	35.1	44.2	2.1	53.7	11.0	12.7
Extra fine beans												
Redon	66	2	198.7	22.8	73.1	3.6	0.5			100.0	8.9	--
Crockett	66	3	200.0	10.8	25.3	55.6	8.3			100.0	10.8	--
7046	63	2	200.0	25.5	51.6	22.3	0.6			100.0	7.2	--
7047	64	2	195.0	11.3	49.4	35.1	4.2			100.0	7.6	--
7048	62	2	185.3	22.9	42.4	27.1	7.6			100.0	5.4	--
7049	63	2	199.8	9.9	35.1	42.4	12.6			100.0	8.8	--
7050	64	2	196.7	26.0	71.7	2.4				100.0	5.9	--
LSD 0.05			3.7								1.8	1.9

[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 2. Notes on preliminary green bean lines, June 6 planting, OSU Vegetable Research Farm, Corvallis, 2018.

								Flavor[z]			
Entry	**Harvest date**	**Obs. Sieve size**	**Pod Length (cm)**	**Pod Straight-ness[z]**	**Pod Cross Section[y]**	**Pod Smooth-ness[z]**	**Pod Color[x]**	**Sweet-ness**	**Astrin-gency**	**Perfumi-ness**	**Notes[w]**
5630	7-Aug	6	15.5	5	R	5	5	5	7	1	Very seedy 6 sv seedy 5 sv, moderate in 4 sv & beginning in 3 sv. 3 OTs: oval, strings, & blond pod.
91G	6-Aug	6	16	5	r	5	5	5	7	1	Seedy 6 sv moderately seedy 5 sv, mixed in 4 sv, 3 sv ok
Cornell 501	8-Aug	5	13	6	r-o	5	4	7	5	3	Oval tendency. Mixed seed to very seedy 5 & 6 sv, seedy 4 sv, 3 sv beginning.
Sahara	7-Aug	4	13	7	r	7	6	3	5	1	Seedy 5 sv, mod seedy 4 sv, 3 sv ok
6771	7-Aug	5	13	7	r	5	4	3	7	1	Seedy 6 sv, mixed mod-seedy 5 sv, mod seedy 4 sv, beg 3 sv. Seems short pods in this trial.
6835	7-Aug	6	17	5	r	5	5	5	7	1	Seedy 6 sv, mod seedy 5 sv, beg 4 sv, 3sv ok. Nice BBL bean
6993	10-Aug	5	12	7	r-cb	5	6	3	8	1	Seedy 6 sv, mod seedy 4 & 5 sv, 3 sv ok. Short but nicely colored bean.
6993	13-Aug										Seedy 6 sv, seedy to very seedy 5 sv, mixed seedy to moderately seedy 4 sv, beginning 3 sv.

Entry	Harvest date	Obs. Sieve size	Pod Length (cm)	Pod Straight-ness[z]	Pod Cross Section[y]	Pod Smooth-ness[z]	Pod Color[x]	Sweet-ness	Astrin-gency	Perfumi-ness	Notes[w]
6996	10-Aug	6	15.5	1	r-cb	7	4	5	7	1	Very curved pods in this trial. Only moderate seed development in 4, 5 & 6 sv; 3 sv ok.
6996	13-Aug										Mixed mod to seedy 6 sv, mod seedy 4 & 5 sv beginning in 3 sv.
Crockett	10-Aug	3	14	8	r	8	6	3	7	3	Shiny pods. Moderately seedy to seedy 4 sv, beginning in 3 & 4 sv. 4 sv may have happened because of early split set.
Redon	10-Aug	2	13	5	r	7	4	7	9	1	Tough skin. Very seedy 4 sv, mixed moderate to seedy 2 & 3 sv, 1 sv ok.
7046	6-Aug	2-3	13	7	r	7	5	5	7	1	Moderately seedy 3 sv 2 sv ok.
7046	7-Aug										Seedy 4 sv, mod seedy 3 sv, beg in 2 sv 1 sv ok. 4 sv lighter in color and may be a mix.
7047	8-Aug	2-3	11	7	r-o	7	4	7	9	1	Seems to have a mix of sizes and shapes w/ both round and oval types. Seedy to very seedy 4 sv, mixed in 3 sv, 2 sv ok.
7048	6-Aug	3	10	8	r/o	9	6	7	5	1	Appears to have lighter colored larger podded oval mix. All 4svs are of this type. 4sv seedy, 3 sv moderately seedy, 2 sv mixed, 1 sv ok.

Entry	Harvest date	Obs. Sieve size	Pod Length (cm)	Pod Straight-ness[z]	Pod Cross Section[y]	Pod Smooth-ness[z]	Pod Color[x]	Sweet-ness	Astrin-gency	Perfumi-ness	Notes[w]
7049	6-Aug	3	12	8	r	6	4	5	5	1	Nice looking 3 sv bean. Moderately seedy 3 & 4 sv, beginning in 2 sv, 1 sv ok.
7049	7-Aug										Very seedy 5 sv only a few pods), mixed seedy 4 sv, mod seedy 3 sv, 2 sv ok. Occasional blonde pod.
7050	8-Aug	2	13.5	7	r	5	5	7	9	1	Mixed mod to seedy 3 sv, beginning in 2 sv, 1 sv ok. Tough skin &n may be high fiber bean.

[z]Scale of 1 - 9 where 1 is least or worst and 9 is most or best. [y]Cross section: r = round, h = heart, cb = crease-back. [y]Scores based on a 1 - 9 scale with 9 darkest. Standard BBL color is rated as 5. [w]RC: reverse curve; sv: sieve; OT: off-type.

Table 3. Performance of commercial green bean varieties, June 19 planting, OSU Vegetable Research Farm, Corvallis, 2018.

					Percent Sieve Size[z]							Tons/Acre Sieve Size						
Entry	**Source**	**AV Stand**	**Sieve size**	**Days[x]**	**1**	**2**	**3**	**4**	**5**	**6**	**1-4**	**1**	**2**	**3**	**4**	**5**	**6**	**Graded Total[y]**
91G	OSU (ck)	200.0	6	**60**	8.3	8.3	14.0	32.6	30.6	6.2	63.2	0.7	0.7	1.2	2.7	2.6	0.5	8.4
91G				63	5.2	4.3	10.8	26.7	46.1	6.9	47.0	0.5	0.4	1.1	2.7	4.7	0.7	10.1
5630	OSU (ck)	200.0	6	60	9.9	10.5	18.8	33.1	22.7	5.0	72.4	0.8	0.8	1.5	2.6	1.8	0.4	7.9
5630				**63**	5.0	6.6	13.6	35.5	35.5	3.7	60.7	0.5	0.7	1.4	3.7	3.7	0.4	10.5
5630				64	3.2	5.6	9.5	23.8	48.4	9.5	42.1	0.3	0.6	1.0	2.6	5.3	1.0	11.0
Sahara	Harris Moran	200.0	4-5	60	4.1	6.2	23.3	58.0	8.3		91.7	0.3	0.5	2.0	4.9	0.7		8.4
Sahara				**63**	3.7	2.7	11.0	59.8	22.8		77.2	0.3	0.3	1.0	5.7	2.2		9.5
Sahara				65	2.2	1.7	5.6	58.4	31.2	0.9	68.0	0.2	0.2	0.6	5.9	3.1	0.1	10.1
Pierroton	Syngenta	200.0	2	61	34.8	64.0	1.2				100.0	2.5	4.6	0.1				7.1
Pierroton				**64**	22.0	76.9	1.1				100.0	1.7	6.1	0.1				7.9
Pierroton				66	13.3	76.9	9.8				100.0	1.0	5.8	0.7				7.5
Huntington	Syngenta	200.0	5	60	9.0	11.0	16.7	33.9	27.8	1.6	70.6	1.0	1.2	1.8	3.6	3.0	0.2	10.7
Huntington				**59**	3.9	5.1	10.2	26.0	47.6	7.1	45.3	0.4	0.6	1.1	2.9	5.3	0.8	11.1
Pismo	Syngenta	194.5	5	60	5.1	7.5	14.5	39.2	32.5	1.2	66.3	0.6	0.8	1.6	4.4	3.6	0.1	11.1
Pismo				**59**	3.8	4.5	8.6	25.1	52.6	5.5	41.9	0.5	0.6	1.1	3.2	6.7	0.7	12.7
SB4738	Syngenta	198.3	5	61	6.0	9.4	19.1	51.1	14.5		85.5	0.6	1.0	2.0	5.2	1.5		10.2
SB4738				**63**	5.0	5.4	11.5	46.7	30.3	1.1	68.6	0.6	0.6	1.3	5.3	3.4	0.1	11.4
SB4738				65	4.1	4.1	8.6	41.9	39.9	1.4	58.8	0.5	0.5	1.1	5.3	5.1	0.2	12.7
SB4748	Syngenta	200.0	5	63	4.6	6.6	12.2	42.9	33.2	0.5	66.3	0.4	0.6	1.0	3.7	2.8	0.0	8.5
SB4748				**64**	4.3	5.8	9.7	41.1	38.2	1.0	60.9	0.4	0.5	0.9	3.7	3.4	0.1	9.0
SB4748				65	2.4	5.3	10.1	39.9	41.3	1.0	57.7	0.2	0.5	0.9	3.6	3.7	0.1	9.1
SB4754	Syngenta	195.7	5	61	6.7	9.6	17.8	38.5	26.4	1.0	72.6	0.6	0.9	1.6	3.5	2.4	0.1	9.1
SB4754				**63**	5.3	5.7	11.0	28.8	46.6	2.7	50.8	0.6	0.7	1.3	3.3	5.4	0.3	11.5
SB4754				65	5.0	5.4	9.3	23.3	50.5	6.5	43.0	0.6	0.7	1.1	2.8	6.1	0.8	12.2
R202002	Syngenta	200.0	3	64	5.8	19.9	66.0	8.4			100.0	0.5	1.7	5.5	0.7			8.3
R202002				**66**	5.1	21.0	64.0	9.8			100.0	0.5	2.0	6.0	0.9			9.3
R202002				68	5.2	15.5	61.2	18.1			100.0	0.5	1.6	6.2	1.8			10.1

					Percent Sieve Size[z]							Tons/Acre Sieve Size						
Entry	Source	AV Stand	Sieve size	Days[x]	1	2	3	4	5	6	1-4	1	2	3	4	5	6	Graded Total[y]
HS934	Brotherton	200.0	3	63	8.6	27.0	59.0	5.4			100.0	0.8	2.6	5.7	0.5			9.7
HS934				**65**	8.6	18.5	63.8	9.1			100.0	0.9	1.9	6.4	0.9			10.1
HS934				67	4.2	14.1	65.4	16.3			100.0	0.5	1.6	7.5	1.9			11.5
BEX034	Brotherton	200.0	3	63	13.9	27.8	45.2	13.0			100.0	0.7	1.4	2.3	0.7			5.0
BEX034				**64**	15.6	21.3	49.2	13.9			100.0	0.8	1.1	2.6	0.7			5.3
BEX034				66	9.7	20.6	47.7	21.9			100.0	0.7	1.4	3.2	1.5			6.8
BEX057	Brotherton	200.0	3-4	63	6.5	10.2	30.6	47.3	5.4		94.6	0.5	0.8	2.5	3.8	0.4		8.1
BEX057				**65**	3.5	7.5	25.0	56.5	7.5		92.5	0.3	0.7	2.2	4.9	0.7		8.7
BEX057				67	2.0	4.8	16.1	59.4	17.7		82.3	0.2	0.5	1.7	6.4	1.9		10.8
BEX069	Brotherton	200.0	6	63	3.9	3.9	7.9	43.3	39.9	1.0	59.1	0.3	0.3	0.7	3.8	3.5	0.1	8.8
BEX069				**64**	3.3	3.8	7.0	31.5	52.1	2.3	45.5	0.3	0.3	0.7	2.9	4.8	0.2	9.3
BEX069				65	4.1	4.7	9.5	35.5	44.4	1.8	53.8	0.3	0.3	0.7	2.6	3.3	0.1	7.4
BEX070	Brotherton	200.0	4-5	64	3.3	6.5	20.0	61.4	8.8		91.2	0.3	0.6	1.9	5.7	0.8		9.4
BEX070				**66**	2.9	4.3	14.8	59.8	18.2		81.8	0.3	0.4	1.4	5.4	1.7		9.1
BEX070				67	3.7	3.7	13.2	57.9	21.5		78.5	0.4	0.4	1.4	6.1	2.3		10.5
BEX074	Brotherton	169.5	6	61	9.5	13.7	16.8	27.4	28.4	4.2	67.4	0.4	0.6	0.7	1.1	1.2	0.2	4.1
BEX074				**63**	6.9	8.6	13.8	22.4	34.5	13.8	51.7	0.3	0.4	0.7	1.1	1.7	0.7	5.1
BEX074				65	8.4	6.7	8.9	16.2	36.9	22.9	40.2	0.7	0.5	0.7	1.3	2.9	1.8	7.8
BEX138	Brotherton	200.0	4	64	4.8	6.6	25.1	52.0	11.5		88.5	0.5	0.7	2.5	5.1	1.1		9.9
BEX138				**65**	3.6	5.2	20.7	57.0	13.5		86.5	0.3	0.4	1.7	4.8	1.1		8.4
BEX138				67	3.0	4.6	16.2	59.9	16.2		83.8	0.3	0.4	1.4	5.1	1.4		8.6
BSCHB15	Brotherton	200.0	3-4	64	5.6	14.6	56.7	23.0	0.0		100.0	0.4	1.1	4.4	1.8	0.0		7.8
BSCHB15				**66**	6.4	12.7	48.0	31.8	1.2		98.8	0.5	1.0	3.6	2.4	0.1		7.5
BSCHB15				68	5.5	8.5	35.8	48.8	1.5		98.5	0.5	0.7	3.1	4.3	0.1		8.8
4624-3	Pureliine	200.0	6	63	6.0	6.0	11.4	27.1	45.2	4.2	50.6	0.4	0.4	0.8	2.0	3.3	0.3	7.2
4624-3				**65**	3.4	4.5	6.1	16.8	53.6	15.6	30.7	0.3	0.3	0.5	1.3	4.2	1.2	7.8
4624-3				67	3.0	3.5	5.5	14.9	54.2	18.9	26.9	0.3	0.3	0.5	1.3	4.7	1.7	8.8
1923	Pureliine	200.0	6	61	7.3	6.7	11.6	42.1	30.5	1.8	67.7	0.5	0.5	0.8	3.0	2.2	0.1	7.1
1923				**63**	5.0	4.5	7.2	23.9	52.3	7.2	40.5	0.5	0.4	0.7	2.3	5.1	0.7	9.7
4252	Pureliine	200.0	6	**64**	8.3	5.3	6.8	22.7	49.2	7.6	43.2	0.5	0.3	0.4	1.3	2.8	0.4	5.7
4252				65	4.8	5.6	8.1	21.8	50.0	9.7	40.3	0.3	0.3	0.4	1.2	2.7	0.5	5.4

Entry	Source	AV Stand	Sieve size	Days[x]	Percent Sieve Size[z] 1	2	3	4	5	6	1-4	Tons/Acre Sieve Size 1	2	3	4	5	6	Graded Total[y]
7396	Pureliine	200.0	3	63	17.3	42.9	10.2	10.2			100.0	0.7	1.3	1.8	0.4			4.3
7396				**65**	9.0	21.4	48.3	21.4			100.0	0.6	1.4	3.0	1.4			6.3
7396				67	7.7	18.4	47.8	25.1	1.0		99.0	0.7	1.7	4.3	2.3	0.1		9.0
Synfony	Pureliine	200.0	2-3	64	7.4	49.1	43.5				100.0	0.7	4.6	4.1				9.4
Synfony				**65**	6.9	48.4	44.7				100.0	0.6	4.0	3.7				8.2
Synfony				67	5.0	42.5	50.0	2.5			100.0	0.5	4.4	5.2	0.3			10.5
Affirmed	Seminis	200.0	4	64	8.3	14.5	28.5	44.6	4.1		95.9	0.7	1.2	2.4	3.7	0.3		8.4
Affirmed				**66**	5.4	9.0	22.3	52.4	10.8		89.2	0.4	0.7	1.6	3.8	0.8		7.2
Affirmed				68	3.5	4.4	12.7	56.1	22.8	0.4	76.8	0.3	0.4	1.3	5.6	2.3	0.0	9.9
SV9203GV	Seminis	200.0	6	65	7.0	9.6	21.8	47.2	14.4		85.6	0.7	1.0	2.2	4.7	1.4		10.0
SV9203GV				**67**	5.0	6.2	14.7	55.0	19.0		81.0	0.6	0.7	1.7	6.2	2.1		11.2
SV9203GV				70	3.6	3.6	8.6	46.4	37.1	0.7	62.3	0.5	0.5	1.1	6.1	4.9	0.1	13.2
SVGG2053	Seminis	200.0	4	64	5.2	7.3	21.9	58.9	6.8		93.2	0.4	0.6	1.8	4.9	0.6		8.4
SVGG2053				**66**	4.2	4.2	14.7	65.4	11.5		88.5	0.3	0.3	1.2	5.4	1.0		8.3
SVGG2053				68	3.7	4.6	12.4	61.8	17.5		82.5	0.3	0.4	1.2	5.8	1.7		9.5
CR-1535	Crites	175.3	4-5	64	3.6	4.1	9.7	48.2	33.8	0.5	65.6	0.3	0.3	0.8	4.1	2.9	0.0	8.5
CR-1535				**66**	3.2	4.2	9.5	43.4	39.7		60.3	0.3	0.3	0.8	3.6	3.3		8.2
CR-1535				68	3.5	3.0	5.2	28.3	54.3	5.7	40.0	0.3	0.3	0.5	2.8	5.4	0.6	10.0
CR-1639	Crites	156.8	6	**61**	3.3	3.3	5.7	22.1	53.7	11.9	34.4	0.3	0.3	0.6	2.4	5.7	1.3	10.6
CR-1639				63	2.7	2.3	3.4	14.9	55.2	21.5	23.4	0.3	0.3	0.4	1.7	6.3	2.4	11.4
CR-1745	Crites	193.0	5	61	3.6	4.5	13.9	48.4	28.7	0.9	70.4	0.3	0.4	1.4	4.7	2.8	0.1	9.7
CR-1745				**63**	3.6	3.6	6.7	35.7	47.3	3.1	49.6	0.3	0.3	0.7	3.5	4.6	0.3	9.8
CR-1745				64	1.6	2.7	6.3	30.9	56.6	2.0	41.4	0.2	0.3	0.7	3.4	6.3	0.2	11.2
CR-1747	Crites	199.5	4	60	6.9	13.8	35.6	40.0	3.8		96.3	0.5	1.0	2.5	2.8	0.3		7.0
CR-1747				**63**	3.9	4.9	20.4	63.1	7.8		92.2	0.3	0.4	1.8	5.7	0.7		9.0
CR-1747				65	2.7	4.9	15.7	68.2	8.5		91.5	0.3	0.5	1.5	6.6	0.8		9.7

[z]Percent calculated as % of total of 1-6 sieve beans. [y]Total tons/acre of the graded beans, including sieve sizes 1-6. [x]Bold indicates date harvested for processing.

Table 4. Statistical comparison of yields of commercial green bean lines, June 19 planting, Corvallis, 2018[z].

Entry	Sieve size	T/A Unadjusted	T/A Adjusted[y]
91G	6	9.0	10.2
5630	6	11.0	12.2
Sahara	4-5	9.8	9.8
Pierroton	2	8.4	8.4
Huntington	6	11.5	11.0
Pismo	5	13.6	12.5
SB4738	5	11.7	13.9
SB4748	5	9.5	10.6
SB4754	5	11.6	11.7
R202002	3	9.6	9.6
HS934	3	10.6	10.6
BEX034	3	5.6	5.6
BSCHB15	3-4	7.8	7.8
BEX057	3-4	9.2	9.2
BEX069	6	9.8	9.4
BEX070	4-5	9.5	9.5
BEX074	6	5.3	5.4
BEX138	4	8.8	8.8
4624-3	6	8.1	6.5
4252	6	6.3	5.9
1923	6	9.9	9.0
7396	3	6.5	6.5
Synfony	2-3	8.7	8.7
Affirmed	4	7.5	7.5
SV9203GV	6	11.9	15.6
SVGG2053	4	8.7	8.7
CR-1535	4-5	8.7	8.7
CR-1639	6	10.9	9.2
CR-1745	5	10.1	10.1
CR-1747	4	9.4	9.4
LSD 0.05		2.9	2.0

[z]Based on one selected harvest for each variety (marked in bold on 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]Full sieve beans were adjusted to 50% 1-4 sieve; all others were unadjusted.

Table 5. Notes on June 19 planting commercial bean trial, OSU Vegetable Research Farm, Corvallis, Oregon, 2018.

Entry	Days[x]	Sieve size	Pod length (cm)	Pod straight-ness[z]	Pod cross Section[y]	Pod smooth-ness[z]	Pod color[x]	Sweet-ness	Astrin-gency	Perfumi-ness	Notes[w]
91G	**60**	6	15.5	5	r-cb	5	5	5	7	1	
91G	63										
5630	60	6	15	5	r	5	5	5	7	1	Some junky pods & polywogs
5630	**63**										Blanks & polywogs
5630	64										
Sahara	60	4-5	13.5	6	r	7	6	5	5	7	Some fishooks & polywogs
Sahara	**63**										Split in smaller sieves
Sahara	65										6 sv becoming pithy
Pierroton	61	2	12.5	5	r	9	5	7	9	1	
Pierroton	**64**										
Pierroton	66										ONE plot of HS934 mixed with Pierroton resulting in over estimate of 3 sv.
Huntington	60	6	14	5	r-cb	7	4	7	7	1	Non nod
Huntington	**59**										Still high quality pods; lots of flowers
Pismo	**59**	5	14	7	r-cb	7	4	7	5	1	Does not nodulate in field
Pismo											
SB4738	61	5	14	7	r	7	6	3	5	1	
SB4738	**63**										Very BBL like w/ good color
SB4738	65										becoming pithy in 5 & 6 sv
SB4748	63	5	13	7	r	7	4	7	5	1	Some flats in 3 sv; 6 sv is oval
SB4748	**64**										
SB4748	65										Becoming pithy in 6 sv
SB4754	61	5	13	7	r	7	5	5	7	1	Non nod
SB4754	**63**										A longer podded Huntington
SB4754	65										Becoming pithy in 5 & 6 sv
R202002	64	3	12.5	7	r	7	4	7	7	3	
R202002	**66**										A few twisted pods
R202002	68										A lot curved

Entry	Days[x]	Sieve size	Pod length (cm)	Pod straight-ness[z]	Pod cross Section[y]	Pod smooth-ness[z]	Pod color[x]	Sweet-ness	Astrin-gency	Perfumi-ness	Notes[w]
HS934	63	3	13	7	r-h	7	5	7	9	1	
HS934	**65**										Most 1 sv usable
HS934	67										Pithy in 4 sv & becoming pithy in 3 sv
BEX034	63	3	14.5	5	r	9	5	7	5	1	Long slender shiny bean
BEX034	**64**										
BEX034	66										
BEX057	63	3-4	12.5	7	r-cb	9	4	7	7	1	Shiny pods in larger sieve sizes.
BEX057	**65**										
BEX057	67										Some very pithy pods in 5 sv
BEX069	63	6	17	5	cb	5	3	7	7	1	
BEX069	**64**										
BEX069	65										Many fewer 5 sv in this harvest
BEX070	64	4-5	14.5	6	r	5	3	7	3	7	
BEX070	**66**										Becoming bumpy in 5 sv
BEX070	67										
BEX074	61	6	15	5	r-cb	7	5	5	7	1	Seems more susceptible to herbicide damage
BEX074	**63**										Low yields a combination of split set and Herbicide damage. Slow seed development
BEX074	65										
BEX138	64	4	13.5	5	o-r	9	4	5	3	1	Oval mix
BEX138	**65**										
BEX138	67										
BSCHB15	64	3-4	14	7	r	7	4	7	7	3	
BSCHB15	**66**										Rather indeterminate bean - could be used as either a 3 or 4 sv
BSCHB15	68										Light color
4624-3	63	6	14	5	r-cb	8	4	7	5	5	Lots of polywogs in smaller sieves
4624-3	**65**										Still high quality pods
4624-3	67										This line seems to hold very well

Entry	Days[x]	Sieve size	Pod length (cm)	Pod straight-ness[z]	Pod cross Section[y]	Pod smooth-ness[z]	Pod color[x]	Sweet-ness	Astrin-gency	Perfumi-ness	Notes[w]
1923	61	6	16.5	6	r	9	4	7	7	1	Exceptionally long slender bean; possibly pc?
1923	**63**										Very little battering in the grader despite Such long pods
4252	**64**	6	15.5	4	r	7	3	7	7	1	Severe split set which probably causes this line to grade low without much seed development.
4252	65										
7396	63	3	13	6	h	7	4	7	7	1	
7396	**65**										
7396	67										
Synfony	64	2-3	11.5	7	r	5	4	7	7	7	
Synfony	**65**										
Synfony	67										
Affirmed	64	4	14.5	7	r	9	6	7	3	1	Tough skin; a very pretty dark green shiny bean
Affirmed	**66**										
Affirmed	68										Dark, attractive
SV9203GV	65	6	13.5	7	r-cb	9	5	7	5	1	Smooth shiny pc type
SV9203GV	**67**										
SV9203GV	70										
SVGG2053	64	4	13	6	r	9	6	7	5	3	Very attractive shiny dark green bean
SVGG2053	**66**										
SVGG2053	68										Very dark
CR-1535	64	4-5	13.5	5	r	7	5	7	7	1	
CR-1535	**66**										
CR-1535	68										Lots of curved, fragrant smell, some polywogs

Entry	Days[x]	Sieve size	Pod length (cm)	Pod straight-ness[z]	Pod cross Section[y]	Pod smooth-ness[z]	Pod color[x]	Sweet-ness	Astrin-gency	Perfumi-ness	Notes[w]
CR-1639	**61**										Lots of RC pods; strongly crease back which is affecting grade
CR-1639	63										Slow seed development; beginning to show some pithiness in 6 sv
CR-1745	61	5	15	7	r-cb	8	5	7	7	1	Polywogs in 3 sv
CR-1745	**63**										Little battering in grader
CR-1745	64										Long spurs; junky 3 sv
CR-1747	60	4	13.5	7	o-h-r	5	3	5	9	3	Oval mix
CR-1747	**63**										
CR-1747	65										Becoming pithy in 5 sv

[z]Scale of 1 - 9 where 1 is least or worst and 9 is most or best. [y]r = round, cb = crease back, h = heart & o = oval. [x]Scores based on a 1 - 9 scale with 9 darkest. Standard BBL color is rated as 5. [w]RC = reverse curve, pc = persistent color, nod = nodulating, sv = sieve.

Table 6. Seed development in green bean pods across harvest dates for the June 19 commercial bean trial, OSU Vegetable Research Farm, Corvallis, Oregon, 2018.

Entry	Sieve size	Days[z]	Seed development in sieve class[y] 6	5	4	3	2	1
91G	6	**60**	7	5	3	1		
91G		63	8	7	4	3		
5630	6	60	8	5	5	1		
5630		**63**	9	8	5	3		
5630		64	9	8	6	4		
Sahara	4-5	60		5	5	3	1	
Sahara		**63**		7	5	4		
Sahara		65	9	9	9	6		
Pierroton	2	61				5	3	1
Pierroton		**64**				7	4	3
Pierroton		66				9	7	5
Huntington	5	60	5	3	1	1		
Huntington		**59**	7	7	5	3		
Pismo	5	**59**	7	5	5	1		
SB4738	5	61		5	3	3		
SB4738		**63**	7	6	5	3		
SB4738		65	9	7	7	5		
SB4748	5	63	7	5	5	3		
SB4748		**64**	9	7	5	3		
SB4748		65	9	7	5	3		
SB4754	5	61	5	3	3	1		
SB4754		**63**	7	7	5	3		
SB4754		65	9	7	5	3		
R202002	3	64			8	5	3	
R202002		**66**			8	5	4	
R202002		68			9	6	4	
HS934	3	63			5	3	1	
HS934		**65**			6	5	3	
HS934		67			7	7	5	
BEX034	3	63			7	5	3	
BEX034		**64**			7	6	3	
BEX034		66			7	5	4	
BEX057	3-4	63		5	4	3	1	
BEX057		**65**		7	6	3		
BEX057		67		9	8	5	3	
BEX069	6	63	7	7	5	3		
BEX069		**64**	9	8	6	4		
BEX069		65	9	9	7	4		

Entry	Sieve size	Days[z]	Seed development in sieve class[y]					
			6	5	4	3	2	1
BEX070	4-5	64		6	5	3		
BEX070		**66**		9	6	4		
BEX070		67	9	7	7	5		
BEX074	6	61	5	4	3	1		
BEX074		**63**	5	5	3	1		
BEX074		65	5	5	5	3		
BEX138	4	64		8	5	5		
BEX138		**65**		7	6	5		
BEX138		67		8	8	5		
BSCHB15	3-4	64			5	3	1	
BSCHB15		**66**		7	7	5	3	
BSCHB15		68		6	5	4	3	
4624-3	6	63	7	5	3	1		
4624-3		**65**	7	5	5	3		
4624-3		67	9	7	2			
1923	6	61	7	6	3	3		
1923		**63**	9	7	6	3		
4252	6	**64**	7	5	3	3		
4252		65	7	6	5	3		
7396	3	63			6	6	3	
7396		**65**			7	6	5	
7396		67		9	9	7	3	
Synfony	2-3	64				7	6	4
Synfony		**65**				7	6	3
Synfony		67			9	7	6	5
Affirmed	4	64		5	2	3	1	
Affirmed		**66**		7	5	3		
Affirmed		68	5	5	6	4	3	
SV9203GV	6	65		5	3	2		
SV9203GV		**67**	7	5	5	3		
SV9203GV		70	9	8	6	5		
SVGG2053	4	64		5	4	3		
SVGG2053		**66**		7	6	4		
SVGG2053		68		8	5	4		
CR-1535	4-5	64	6	5	5	1		
CR-1535		**66**		7	6	3		
CR-1535		68	8	7	5	3		
CR-1639	6	**61**	5	5	5	1		
CR-1639		63	7	6	5	3		
CR-1745	5	61	7	5	3	1		
CR-1745		**63**	9	7	5	3		
CR-1745		64	9	7	6	3		

			Seed development in sieve class[y]					
Entry	Sieve size	Days[z]	6	5	4	3	2	1
CR-1747	4	60		5	3	1	1	
CR-1747		**63**		6	6	3		
CR-1747		65		8	7	6		

[z]Days to maturity; bolded number is day cultivar was selected for processing. [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.

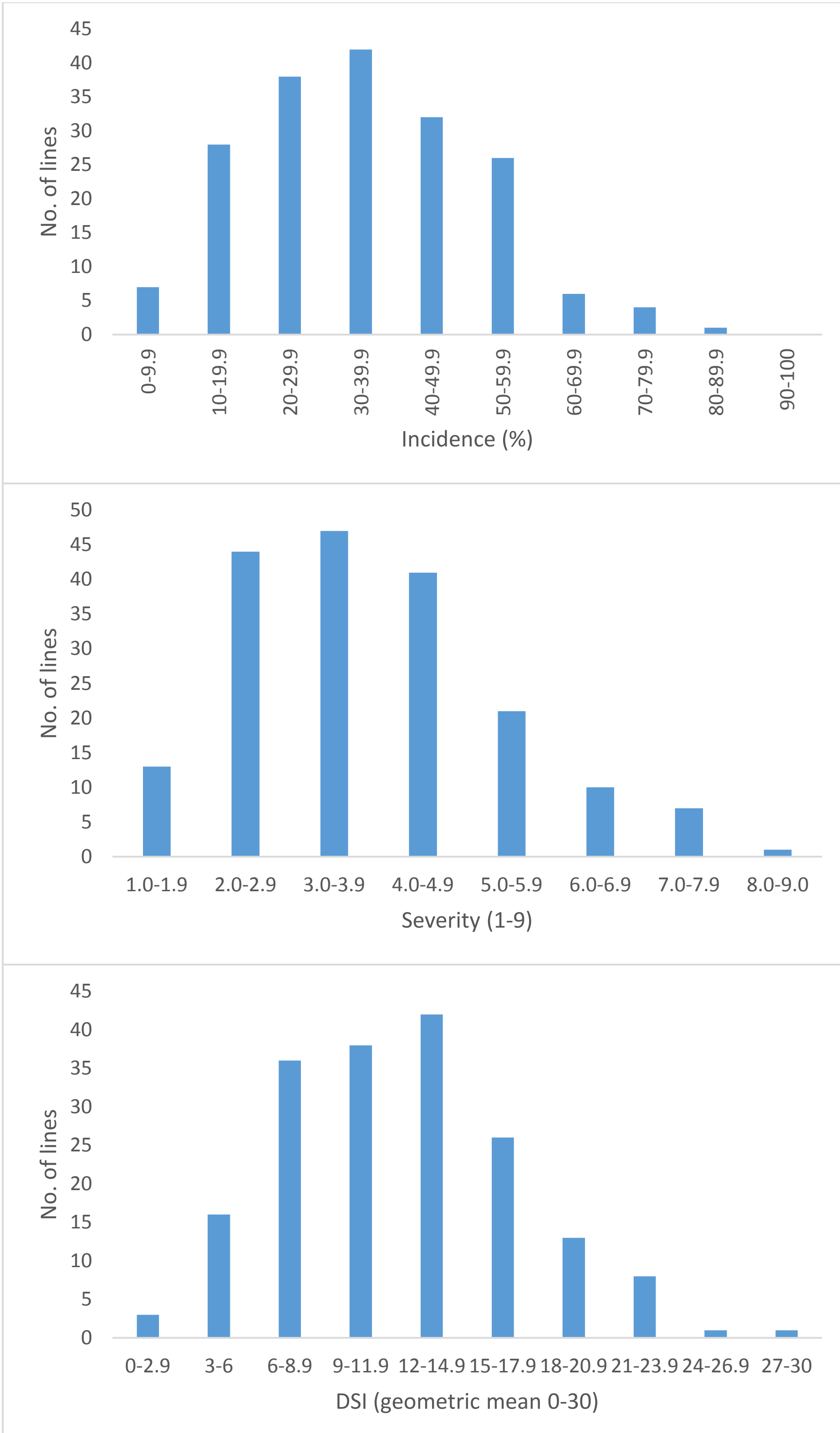

Figure 1. Performance of the Unidor/OSU5630 (B8323) recombinant inbred population (n = 184) evaluated for white mold reaction at the OSU Vegetable Research Farm in 2018. Incidence (top, 0-100% of plot infected); Severity (middle, scale of 1-9 where 9 = most of plants in plot affected) and disease severity index (DSI, bottom, geometric mean of incidence and severity).

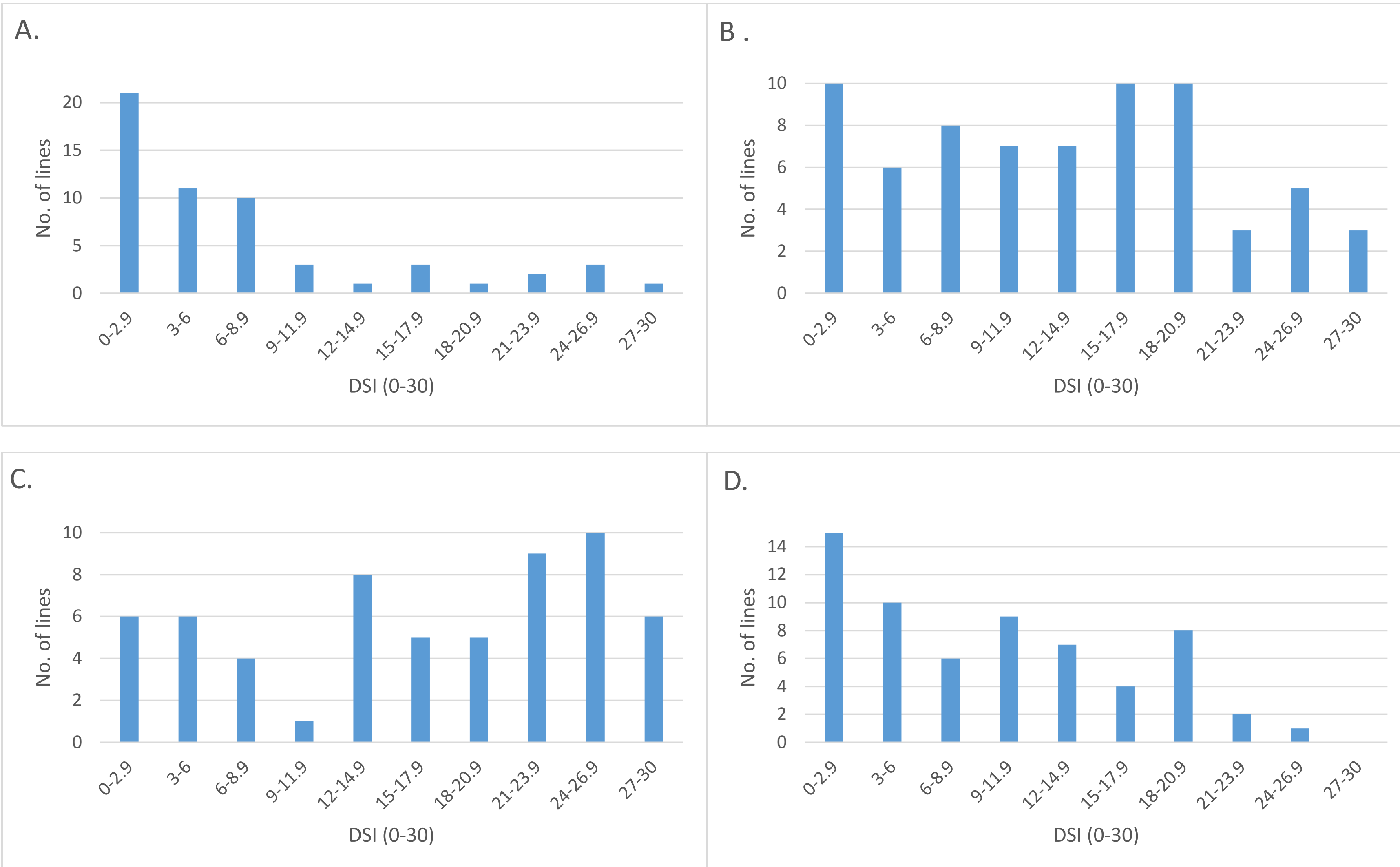

Figure 2. Performance of nested recombinant inbred populations with WMG904-20-3 as common parent, when evaluated for white mold reaction at the OSU Vegetable Research Farm in 2018. A. B8351 (Cornell 501/WMG904-20-3), B. B8359 (NY6020-4/WMG904-20-3), C. B8360 (M0070/WMG904-20-3), and D. B8361 (WMG904-20-3/A195).

Research/Extension Progress Report for 2018-19 Funded Projects

Progress Report for the Agricultural Research Foundation
Oregon Processed Vegetable Commission

Title: Effect of Preemergence Herbicide on Broccoli Yield and Uniformity When Transplanted With a Tape System

Project leader: Ed Peachey, OSU Vegetable Extension, Weed Science, Horticulture Department, ALS 4045, Oregon State University, Ed.Peachey@oregonstate.edu, 541-740-6712

Funding history: $4,305 (2018-19 only)

Abstract: A field trial tested whether a tape transplanting system compromised crop tolerance to herbicides compared to hand transplanting. Goal, Spartan, Chateau, Prowl, and bicyclopyrone herbicides were applied to plots before broccoli (var. Cascadia, exerted head type) was either transplanted using a tape system, or was planted by hand with a drop tube transplanter. Severe phytotoxicity and stunting were noted with Chateau and bicyclopyrone herbicides 2 weeks after transplanting. Herbicide effects on growth were not consistent among the planting systems. Injury from Chateau herbicide was less severe with the tape transplanting system than with the hand planting. Broccoli yield was influenced by the herbicide applied; Chateau and bicyclopyrone treatments produced very little broccoli, while the Goal, Spartan, and Prowl treatments had comparable yields, but with slightly lower yield than the untreated check plots. All treatments except the hand transplant Prowl plots yielded less than the checks. Overall, yield of plots that were tape transplanted were less than the hand transplanted plots for the first harvest, but after the third harvest yield was greater in the tape transplanted plots.

Key words: weed control, herbicides, tape transplanting, sulfentrazone, flumioxazin, pendimethalin, oxyfluorfen.

Objective Measure the effect of transplanting system and preemergence herbicide on broccoli growth and yield.

Procedures

A trial was set at the Vegetable Research farm to examine factors that may improve yield, head uniformity, and weed control in transplanted broccoli. Factors examined in the trial included transplanting system (tube vs tape) and pre-transplant herbicide. Broccoli var. Cascadia was seeded into 2" plant trays or into tape transplant cells in the greenhouse on 24-Apr, 2018. When transplants were adequate size and hardened off, field plots were prepared and starter fertilizer applied to three rows 26" wide in beds 78"wide with our Gaspardo precision seeder. Herbicides were broadcast before transplanting with rates listed in Table 1 and applied on 17-May (one day before transplanting) from 7:15 to 8 AM with air and 2" soil temperatures at 58 and 59F, respectively, wind from the SW at 0.8 to 2.0 MPH, and 69% RH. Herbicides were applied with a 4-nozzle boom equipped with XR-8003 nozzles delivering 20 gal/A. The boom was powered with a CO_2 backpack sprayer at 25 PSI. In-row spacing for the 2" transplants was 12" and 6" for the tape system. A hand-pull tape transplanter (Fig. 1) was used to deliver one plant per 6" in designated plots. A hand held drop-tube transplanter was used to insert transplants into the soil in standard plots. After initial weed evaluations, the plots were hand-weeded to reduce the impact on broccoli yield. Broccoli heads were harvested three times from 10 ft of row and head size and wt measured.

Accomplishments

Severe phytotoxicity and stunting were noted with Chateau and bicyclopyrone herbicides two weeks after transplanting. Herbicide effects on growth were not consistent among the planting systems. Injury from Chateau herbicide was less severe with the tape transplanting system than with the conventional planting. Weed control was exceptional for all of the herbicides.

Broccoli yield was influenced by the herbicide applied (Table 2, Figure 2). Chateau and bicyclopyrone treatments produced very little broccoli, while the Goal, Spartan, and Prowl yields were comparable. All treatments except the hand transplant in Prowl plots yielded less than the checks. Yield of plots that were tape transplanted were less than the hand planted plots for the first harvest, but after the third harvest yield was greater in the tape transplanted plots than the drop-tube plots. This was likely due to size differences between the two types of transplants initially. Plants of the tape system were much smaller.

Fig. 1. Equipment used to plant broccoli seeded into plant tape.

Table 1. Effect of herbicide and transplanting system on early growth and weed control (n=3).

	Transplant system	Herbicide	Rate	Crop growth				Weed control			
				Phyto		Stunting		Pig-weed	Night-shade	Shepherds purse	Composite rating
				1-Jun	10-Jun	1-Jun	10-Jun				
				0-10		--------- % ---------		--------------------------%------------------------			
1	Hand	Goal 4F	2.0 pt	1.7	1.0	17	13	100	100	100	100
2	Hand	Prowl H_2O	2.0 pt	0.0	0.7	3	23	100	95	100	97
3	Hand	Bicyclopyrone	2.5 oz	6.7	9.3	37	92	100	90	100	93
4	Hand	Chateau	4.0 oz	8.7	9.7	70	100	100	100	100	100
5	Hand	Spartan	6.0 oz	6.3	2.3	50	53	100	100	100	99
6	Hand	Untreated	-	0.0	0.0	0	0	0	0	0	0
1	Tape	Goal 4F	2.0 pt	1.0	1.7	7	27	100	100	100	100
2	Tape	Prowl H_2O	2.0 pt	0.7	1.0	2	30	98	98	98	96
3	Tape	Bicyclopyrone	2.5 oz	5.0	8.0	40	87	98	95	97	98
4	Tape	Chateau	4.0 oz	4.7	3.7	43	68	100	100	100	100
5	Tape	Spartan	6.0 oz	4.0	2.0	30	47	100	99	100	99
6	Tape	Untreated	-	0.3	0.0	0	7	0	0	0	0
	FPLSD(0.05)			2.9	3.2	23	25	2	6	3	3
	ANOVA										
	Herbicide			<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
	Transplant system			0.004	0.02	0.01	0.50	0.18	0.29	0.20	0.13
	Herbicide x transplant system			0.02	0.001	0.10	0.05	0.58	0.66	0.55	0.02

Table 2 Effect of herbicide and transplanting system on broccoli yield (n=3).

	Transplant system	Herbicide	Rate	Harvest 20-Jul		Harvest 23-Jul		Harvest 27-Jul		Total no. heads	Yield	Avg. head wt.
				head no.	wt	head no.	wt	head no.	wt			
				no./plot	*lb*	*no./plot*	*lb*	*no./plot*	*lb*	*no/plot*	*tons/A*	*lb*
1	Hand	Goal 4F	2.0 pt	2.7	1.1	3.0	1.7	2.3	0.9	8.0	8.1	1.0
2	Hand	Prowl H2O	2.0 pt	2.7	1.1	4.3	3.5	0.7	0.3	7.7	10.9	1.4
3	Hand	Bicyclopyrone	2.5 oz	0.0	0.0	0.0	0.0	0.3	0.2	0.3	0.5	0.5
4	Hand	Chateau	4.0 oz	0.0	0.0	0.0	0.0	1.7	1.2	1.7	2.7	0.5
5	Hand	Spartan	6.0 oz	0.3	0.1	3.0	2.1	4.0	1.7	7.3	8.7	1.2
6	Hand	Untreated	-	1.7	0.6	6.7	3.9	1.0	0.4	9.3	10.8	1.2
1	Tape	Goal 4F	2.0 pt	1.0	0.7	4.7	2.0	2.7	1.2	8.3	8.7	1.1
2	Tape	Prowl H2O	2.0 pt	2.0	0.8	3.0	1.9	3.0	1.5	8.0	9.2	1.1
3	Tape	Bicyclopyrone	2.5 oz	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	Tape	Chateau	4.0 oz	0.7	0.2	0.7	0.3	1.0	0.5	2.3	2.4	0.3
5	Tape	Spartan	6.0 oz	1.0	0.4	1.7	1.1	3.7	2.4	6.3	8.7	1.4
6	Tape	Untreated	-	2.3	0.9	5.7	3.4	2.0	1.3	10.0	12.2	1.2
	FPLSD (0.05)			ns	ns	3.2	2.2	ns	Ns	3.8	8.0	8.1
	ANOVA											
	Herbicide			0.0051	0.0005	0.0002	0.0005	0.0053	0.0073	<.0001	<.0001	<.0001
	Transplant system			0.0012	0.0001	0.7424	0.6511	<.0001	<.0001	0.2965	0.1863	0.0768
	Herbicide x transplant system			0.0561	0.0092	0.6347	0.6304	0.307	0.1772	0.1643	0.2104	0.2686

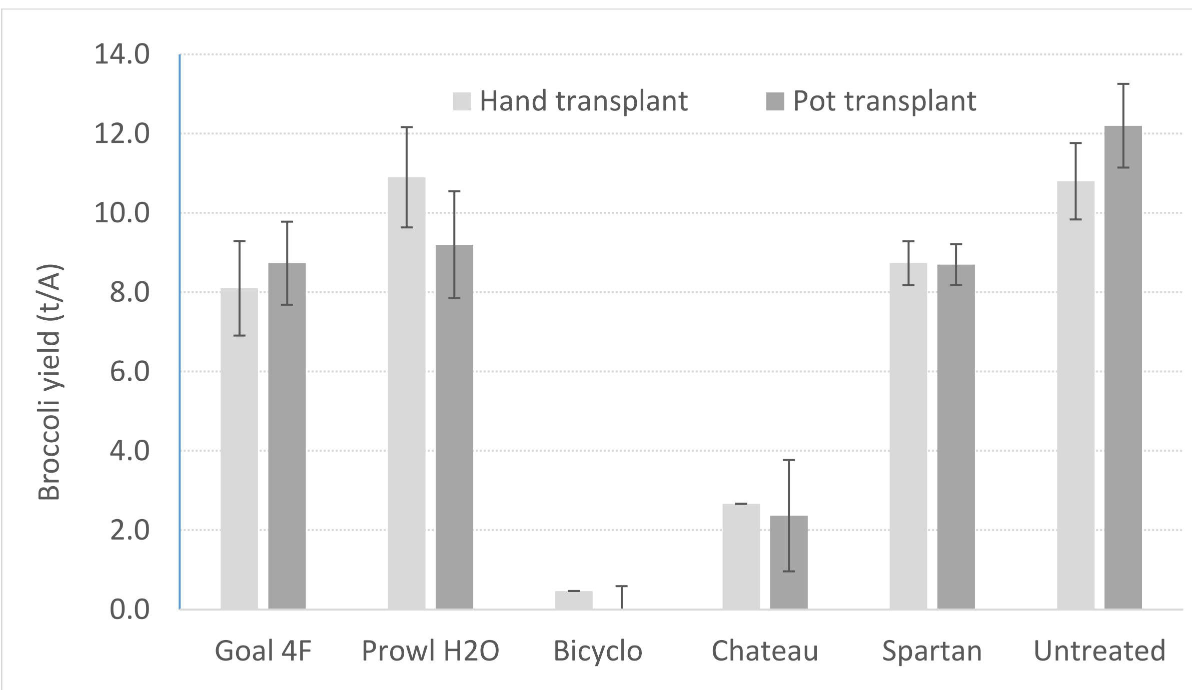

Figure 2. Effect of transplanting system and herbicide on broccoli yield, 2018.

Impacts

The fate of broccoli production in the Willamette Valley hinges on whether the current production system can be retooled to facilitate mechanical planting and harvesting. These phases of current production are labor intensive, and given projected market trends, labor will become less available and costs will continue to rise. The tradeoff between direct-seeding and transplanting is labor upfront in transplanting costs or labor costs later for thinning and hoeing.

Weed control in direct-seed brassicas is also less reliable with currently labeled herbicides. The OPVC is currently supporting projects that are developing image-sensing software and exserted head varieties that will improve the potential to move to mechanical harvest. Another piece to the puzzle would be improvement of planting systems that reduce not only the labor required, but facilitate head uniformity and lessen the troubles associated with weed control in direct-seed systems.

Emerging technologies in vegetables include tape transplanting systems that have the potential to greatly reduce labor costs. It is unclear how the exserted heard varieties developed by the OSU vegetable breeding program of OSU will perform in tape transplanting systems. Also unknown is whether Goal herbicide is suited for tape transplanting of brassicas and whether this system will allow other herbicide such as Prowl (pendimethalin) or Spartan (sulfentrazone) to be applied before transplanting. We tested Prowl herbicide in cooperation with the IR-4 program and demonstrated good crop safety with Pre-transplant applications in cole crops, yet when the label was issued, the use pattern was confined to post-directed sprays (avoiding the growing point of the plant) to mitigate potential crop injury. There may be potential to use Prowl with the tape-transplanting system because like most with transplant machines the soil is moved aside during planting. The tape transplanting system also positions a membrane between the roots of the transplant and the treated soil, potentially improving crop safety. If crop safety is improved with the tape transplanting system, low rates of Prowl and Goal applied together (lower rates than currently used) would greatly improve the spectrum and longevity of weed control in brassica crops. More work is required to determine whether Spartan may also be useful in broccoli production.

Research/Extension Progress Report for 2018-19 Funded Projects
Progress Report for the Agricultural Research Foundation
Oregon Processed Vegetable Commission

Title: Evaluating Tolpyralate Herbicide and Rotational Strategies to Economize Sweet Corn Production

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Abstract

Two on-farm studies compared Shieldex with Impact, Laudis and other herbicides for weed control, efficacy, and crop safety in sweet corn. Overall weed control was exceptional for all three of the 4-HPPD herbicides applied at V4 to sweet corn. Crop injury was minimal but elevated slightly when tankmixed with Basagran. The main advantage of Shieldex is the cost of $8.10/A.

Work continued to find ways to improve cover crop establishment in late planted sweet corn. Interseeded tall fescue (V6) did not establish sufficiently in an 11 acre field near Salem and the grower terminated the crop. Interseeded common vetch and red clover established well in two organic sweet corn plantings. And a cover crop of triticale in sweet corn may have reduced nitrate concentrations in soil water compared to a plot without cover crop.

Similar to herbicide carryover studies of the last two years, large differences were noted in cover crop response to the 4-HPPD herbicide of Impact, Laudis, and Shieldex. In general, red clover, crimson clover, peas, common vetch and phacelia were the most sensitive to these herbicides. Crimson clover was more tolerant than red clover. Both crimson clover and red clover appeared to be more sensitive to Shieldex than Laudis or Impact. Peas were more tolerant to Shieldex than Impact and Laudis.

Key Words: interseeding, relay planting, topramezone, tembotrione, tolpyralate

Objectives:

1. Measure efficacy of topyralate in sweet corn and compare with other HPPD inhibitors such as tembotrione (Laudis) and topramezone (Impact) with and without atrazine and other tankmixes to improve efficacy.
2. Determine potential of interseeding to improve cover crop performance.
3. Assess potential carryover of tolpyralate and other PRE and POST herbicides on establishment of cover crops.

Objective 1. Measure efficacy of topyralate in sweet corn and compare with other HPPD inhibitors such as tembotrione (Laudis) and topramezone (Impact) with and without atrazine and other tankmixes to improve efficacy.

Procedures: Two demonstration and research trials were located on farms in the Willamette Valley to compare Laudis, Impact, and Shieldex herbicides for postemergent control in sweet corn. Herbicides were applied to plots and each treatment replicated three times. Plots were 30 to 40 feet long and 10 ft. wide (4 rows). Weed and crop injury evaluations were made approximately 2 weeks after treatments were applied, and again at harvest. Corn was harvested by hand from 20 ft of row in each plot. Field days were held at each site.

Accomplishments

Stayton. Overall weed control was exceptional across all three of the 4-HPPD herbicides applied at V4 to the sweet corn variety Cash (Table 2). Crop injury was minimal but elevated slightly when tankmixed with Basagran. Dual Magnum and Outlook provided little if any control of volunteer squash and caused substantial injury to the corn. When Dual Magnum or Outlook was tank mixed with Zidua PPI or PRE corn growth was reduced from 18 to 25%, but with only a slight improvement in weed control. The intent of the Zidua treatments was to look for alternative grass control products, particularly for annual ryegrass. The annual ryegrass density in this field was inadequate for a robust evaluation. Corn yield at this site was low on average with the largest yield of 8.5 t/A coming from Tr. 25 (Shieldex + Outlook applied at V4, Table 3). Treatments that included Impact and Laudis applied at V4 tended to yield lower the Shieldex. All of the 4-HPPD herbicides provided exceptional weed control, whether applied alone or tankmixed with Basagran or atrazine. The main advantage of Shieldex is the cost of $8.10/A that controlled all weeds when applied alone at V4 and still yielded 8.3 t/A.

Junction City. Similar to the Stayton site, weed control was very good with the 4-HPPD herbicides (Table 5), with one exception. Common purslane is very tolerant to the 4-HHPD herbicides, and this species was not controlled at this site. Even with the addition of Basagran, control of purslane was only moderate. Laudis appeared to be the weakest of the 4-HPPD herbicides for control of purslane when applied alone. Preemergence treatments were largely ineffective because neither rainfall nor irrigation was available to incorporate the herbicides before weeds emerged. Ear yield was as expected for Super Sweet Jubilee at this planting date (Table 6). Tankmixes with Basagran appeared to suppress yield. Impact alone yielded best even though it only provided 92% weed control.

Table 1. Herbicide application data for the Stayton trial.

Date	2-Jun, 2018	6-Jun, 2018	20-Jun, 2018	30-Jun, 2018
Crop stage	-	Planted 6-4	V2	V4-5
Weeds and growth stage				Lambsquarters up to 6” tall Nightshade and pigweed <4” tall
Herbicide/treatment	PPI	PRE	EPOST	V4
Application timing	PPI	PRE	V2	V4-5
Start/end time	11-11:45	6-6:45	12:15-12:45PM	8-9:30
Air temp/soil temp (2")/surface	73/82/95	59/52/52	85/84/95	70/76/76
Rel humidity	46%	74%	55%	74%
Wind direction/velocity	N 1.6-6	0	S 2-5	WNW 2-5
Cloud cover	0%	80%	20%	0
Soil moisture	0	Very dry, incredibly cloddy, and very rocky in spots	Wet irrigated 6-19	irrigated 2 days ago, damp
Plant moisture	-	-	Dry	Dew on corn and weeds
Sprayer/PSI	BP CO2/25	BP CO2/25	BP CO2/25	BP CO2/25
Mix size	2100	2100	2100	2100
Gallons H20/acre	20	20	20	20
Nozzle type	5-XR8003	5-XR8003	5-XR8003	5-XR8003
Nozzle spacing and height	20/20	20/20	20/20	20/18 above corn
Soil Inc. method/implement	Vibrashank	Irrigation 0.5 in after planting; rainfall 1 to 1.5 in 6/8-10	-	-

Table 2. Weed control in sweet corn, Stayton, 2018

	Treatment	Timing	Product rate	Total cost	Adjuvant	Crop injury (30-Jun) Phyto	Crop injury (30-Jun) Stunting	Crop injury (17-Jul) Phyto	Crop injury (17-Jul) Stunting	Weed control (17-Jul) Pig-weed	Lambs-quarters	Night-shade	Wild proso millet	Volunteer squash	Smart-weed	Overall
						0-10	*%*	*0-10*	*%*	----------	----------	----------	%	----------	----------	----------
Comparison of 4-HPPD herbicides																
1	Laudis	V4	3 oz	$ 15.30	MSO+UAN	0	3	0	7	100	100	100	100	100	100	100
2	Laudis	V4	3 oz	$ 15.30	COC	0	7	0	3	100	100	100	100	100	100	100
	Basagran	V4	2 pt	$ 13.75												
3	Laudis	V4	3 oz	$ 15.30	MSO+UAN	0	0	0	0	67	100	100	100	98	70	100
	Atrazine	V4	2 pts	$ 4.15												
4	Impact	V4	1 oz	$ 19.83	MSO+UAN	0	0	0	3	100	100	100	100	100	100	100
5	Impact	V4	1 oz	$ 19.83	COC	0	0	0	0	100	100	100	100	100	100	100
	Basagran	V4	2 pt	$ 13.75												
6	Impact	V4	1 oz	$ 19.83	MSO+UAN	0	0	0	3	100	100	100	100	100	100	100
	Atrazine	V4	2 pt	$ 4.15												
7	Shieldex	V4	1 oz	$ 8.10	MSO+UAN	0	3	0	0	100	100	100	100	100	100	100
8	Shieldex	V4	1 oz	$ 8.10	COC	0	0	0	0	100	100	99	100	100	100	100
	Basagran	V4	2 pt	$ 13.75												
9	Shieldex	V4	1 oz	$ 8.10	MSO+UAN	0	3	0	3	100	100	100	100	100	100	100
	Atrazine	V4	2 pt	$ 4.15	MSO+UAN											
10	Check					0	0	0	0	0	0	0	0	0	0	0
Dual Mag vs Outlook																
11	Outlook	PRE	13 oz	$13.81	-	0	12	0	10	100	48	77	100	67	67	67
12	Dual Magnum	PRE	16 oz	$11.70	-	0	5	0	0	100	73	37	100	0	33	58
13	Dual Magnum	PPI	16 oz	$11.70	-	0	20	0	33	100	87	87	100	0	97	82
	Outlook	PRE	13 oz	$13.81												

Cont'd

Table 2. Weed control in sweet corn, Stayton, 2018

Treatment	Timing	Product rate	Total cost	Adjuvant	Crop injury (30-Jun)		Crop injury (17-Jul)		Weed control (17-Jul)						
					Phyto	Stunting	Phyto	Stunting	Pig-weed	Lambs-quarters	Night-shade	Wild proso millet	Volunteer squash	Smart-weed	Overall
					0-10	*%*	*0-10*	*%*	------- % -------						
Zidua															
14 Dual Magnum	PPI	16 oz	$11.70	-	0	13	0	18	100	80	87	100	33	58	82
Zidua	PPI	3 oz	$28.84												
15 Dual Magnum	PRE	16 oz	$11.70	-	0	15	0	23	100	93	98	100	0	77	55
Zidua	PRE	3 oz	$28.84												
16 Outlook	PRE	13 oz	$13.81	-	0	13	0	25	100	97	97	100	33	67	94
Zidua	PRE	3 oz	$28.84												
17 Zidua	PRE	3 oz	$28.84	-	0	7	0	22	100	100	82	100	33	67	77
18 Anthem (Zidua + fluthiacet)	V2	9 oz	$40.01	-	0	12	0	15	100	90	85	67	67	0	73
Misc.															
19 Dual Magnum	PRE	1 pt	$11.70	-	0	17	0	8	100	97	96	100	100	100	96
Callisto	PRE	7.7 oz	$9.69												
20 Outlook	PRE	13 oz	$17.00	-	0	15	0	18	100	100	100	100	100	100	100
Callisto	PRE	7.7 oz	$9.69												
21 Outlook	V2	13 oz	$13.81	MSO+UAN	0	8	0	0	100	100	97	100	100	100	97
Impact	V2	1 oz	$19.83												
22 Atrazine	V4	2 pts	$4.15	COC	0	0	0	3	100	98	100	67	100	67	100
23 Dual Magnum	PPI	16 oz	$11.70		0	12	0	8	100	100	100	100	100	100	100
Atrazine	PPI	2 pt	$4.15												
24 Shieldex	V2	1 oz	$8.10	MSO+UAN	0	15	0	7	100	100	98	97	100	100	96
Outlook	V2	13 oz	$13.81												
25 Shieldex	V4	1 oz	$8.10	MSO+UAN	0	3	0	7	100	100	100	100	98	100	99
Outlook	V4	13 oz	$13.81												
FPLSD (0.05)					*-*	*9*	*-*	*15*	*19*	*17*	*18*	*27*	*46*	*46*	*19*

Table 3. Sweet corn yield, Stayton, 2018.

	Treatment	Timing	Product rate	Total cost	Adjuvant	Ear no	Ear yield	Avg. ear wt	Weed control
						20 ft of row	*t/A*	*lb/ear*	*%*
Comparison of 4-HPPD herbicides									
1	Laudis	V4	3 oz	$ 15.30	MSO+UAN	24.0	8.6	0.83	100
2	Laudis	V4	3 oz	$ 15.30	COC	20.3	7.6	0.86	100
	Basagran	V4	2 pt	$ 13.75					
3	Laudis	V4	3 oz	$ 15.30	MSO+UAN	19.0	7.4	0.90	100
	Atrazine	V4	2 pts	$ 4.15					
4	Impact	V4	1 oz	$ 19.83	MSO+UAN	18.7	7.3	0.93	100
5	Impact	V4	1 oz	$ 19.83	COC	21.3	7.6	0.84	100
	Basagran	V4	2 pt	$ 13.75					
6	Impact	V4	1 oz	$ 19.83	MSO+UAN	20.0	7.7	0.88	99
	Atrazine	V4	2 pt	$ 4.15					
7	Shieldex	V4	1 oz	$ 8.10	MSO+UAN	22.0	8.3	0.87	99
8	Shieldex	V4	1 oz	$ 8.10	COC	21.0	8.0	0.87	100
	Basagran	V4	2 pt	$ 13.75					
9	Shieldex	V4	1 oz	$ 8.10	MSO+UAN	21.3	8.5	0.92	100
	Atrazine	V4	2 pt	$ 4.15	MSO+UAN				
10	Check					6.0	1.3	0.51	0
Dual Mag vs Outlook									
11	Outlook	PRE	13 oz	$13.81	-	12.0	4.4	0.79	68
12	Dual Magnum	PRE	16 oz	$11.70	-	17.3	5.8	0.76	83
13	Dual Magnum	PPI	16 oz	$11.70	-	20.3	7.5	0.87	73
	Outlook	PRE	13 oz	$13.81					
Zidua									
14	Dual Magnum	PPI	16 oz	$11.70	-	22.0	7.9	0.83	88
	Zidua	PPI	3 oz	$28.84					
15	Dual Magnum	PRE	16 oz	$11.70	-	20.0	7.4	0.86	95
	Zidua	PRE	3 oz	$28.84					
16	Outlook	PRE	13 oz	$13.81	-	20.7	8.2	0.92	95
	Zidua	PRE	3 oz	$28.84					
17	Zidua	PRE	3 oz	$28.84	-	23.3	8.0	0.80	79
18	Anthem (Zidua + fluthiacet)	V2	9 oz	$40.01	-	20.0	7.6	0.87	75
Misc.									
19	Dual Magnum	PRE	1 pt	$11.70	-	21.0	7.8	0.85	95
	Callisto	PRE	7.7 oz	$9.69					
20	Outlook	PRE	13 oz	$17.00	-	17.3	6.3	0.83	99
	Callisto	PRE	7.7 oz	$9.69					
21	Outlook	V2	13 oz	$13.81	MSO+UAN	19.7	6.8	0.80	98
	Impact	V2	1 oz	$19.83					
22	Atrazine	V4	2 pts	$4.15	COC	21.7	8.3	0.87	99
23	Dual Magnum	PPI	16 oz	$11.70	-	21.3	8.3	0.94	93
	Atrazine	PPI	2 pt	$4.15					
24	Shieldex	V2	1 oz	$8.00	MSO+UAN	20.0	8.3	0.96	98
	Outlook	V2	13 oz	$13.81					
25	Shieldex	V4	1 oz	$8.00	MSO+UAN	21.7	8.7	0.92	100
	Outlook	V4	13 oz	$13.81					
FPLSD (0.05)						*6.9*	*2.1*	*0.14*	*14*

Table 4. Herbicide application data for Junction City site.

Date	Wednesday, June 20, 2018	Monday, July 09, 2018
Crop stage	Planted 18-Jun	V3-4
Weeds and growth stage	-	
Pigweed	-	<4 tall
Lambsquarters	-	<2 tall
Hairy nightshade	-	<1 tall
Barnyardgrass	-	2-8 leaves
Crabgrass	-	<2 in dia
Herbicide/treatment	PRE	POST
Application timing	PRE	V3-4
Start/end time	3:30-4:15 PM	10:20-11:20 AM
Air temp/soil temp (2")/surface	81/96/103	71/64/65
Rel humidity	54%	71%
Wind direction/velocity	S 3-7	0
Cloud cover	20%	100%
Soil moisture	Dry	Wet, irrigated day before
Plant moisture	-	Wet from light mist earlier
Sprayer/PSI	$BPCO_2$/20	$BPCO_2$/20
Mix size	2100 mls	2100 mls
Gallons H20/acre	30	30
Nozzle type	5-XR8003	5-XR8003
Nozzle spacing and height	20/20	20/20

Table 5. Crop injury and weed control, Junction City, 2018

Treatment		Timing	Date	Adjuvant	Product sate	Cost/A	Crop injury (18-Jul)		Weed control (18-Jul, before V6 treatments were applied)					
							Phyto	Stunting	Pigweed	H. night-shade	C. purslane	Barnyard-grass	Witch grass	Overall rating
Postemergent							*0-10*	*%*	------------------- *%* -------------------					
1	Laudis	V4	9-Jul	MSO+UAN	3 oz	$ 15.30	0.0	0	88	99	33	96	96	92
2	Laudis	V4	9-Jul	COC	3 oz	$ 15.30	0.7	0	95	100	83	95	95	93
	Basagran	V4	9-Jul		2 Pt	$ 13.75								
3	Laudis	V4	9-Jul	MSO+UAN	3 oz	$ 15.30	0.0	0	100	100	100	100	100	98
	Atrazine	V4	9-Jul		2 pts	$ 4.15								
4	Impact	V4	9-Jul	MSO+UAN	1 oz	$ 19.83	0.0	0	96	98	97	94	94	95
5	Impact	V4	9-Jul	COC	1 oz	$ 19.83	2.0	8	95	99	100	88	88	90
	Basagran	V4	9-Jul		2 pt	$ 13.75								
6	Impact	V4	9-Jul	MSO+UAN	1 oz	$ 19.83	0.0	0	99	100	100	98	98	98
	Atrazine	V4	9-Jul		2 pt	$ 4.15								
7	Shieldex	V4	9-Jul	MSO+UAN	1 Oz	$ 8.10	0.0	0	98	100	97	97	97	95
8	Shieldex	V4	9-Jul	COC	1 Oz	$ 8.10	2.3	10	92	99	100	93	93	92
	Basagran	V4	9-Jul		2 Pt	$ 13.75								
9	Shieldex	V4	9-Jul	MSO+UAN	1 Oz	$ 8.10	1.3	8	98	100	100	98	98	97
	Atrazine	V4	9-Jul		2 Pt	$ 4.15								
Preemergent														
10	Outlook	PRE	20-Jun	-	16 oz	$ 16.96	0.0	0	43	50	33	33	33	43
	Atrazine	PRE	20-Jun	-	1 pt	$ 4.15								
11	Acuron	PRE	20-Jun	-	2.5 qts	$ 38.75	0.0	0	83	93	67	85	85	80
12	Acuron Flexi	PRE	20-Jun	-	2 qts	-	0.0	0	68	78	70	86	86	75
PRE + POST														
13	Dual Magnum	PRE	20-Jun	-	1 Pt	$ 11.70	*0.0*	*3*	*27*	*0*	*67*	*40*	*47*	*37*
	Zidua	PRE	20-Jun	-	1.5 oz	$ 14.42								
	Shieldex	V6	19-Jul	MSO+UAN	1 oz	$ 8.10								
14	Outlook	PRE	20-Jun	-	13 oz	$ 13.78	*0.0*	*7*	*42*	*13*	*100*	*47*	*47*	*37*
	Zidua	PRE	20-Jun	-	1.5 oz	$ 14.42								
	Shieldex	V6	19-Jul	MSO+UAN	1 oz	$ 8.10								
15	Zidua	PRE	20-Jun	-	3 oz	$ 28.84	*0.0*	*0*	*47*	*0*	*100*	*53*	*53*	*30*
	Shieldex	V6	19-Jul	MSO+UAN	1 oz	$ 8.10								
16	Shieldex	V6	19-Jul	MSO+UAN	1 oz	$ 8.10	-	-	-	-	-	-	-	-
FPLSD (0.05)							*0.7*	*6.7*	*31*	*24*	*54*	*27*	*24*	*12*

Table 6. Sweet corn yield, Junction City, 2018.

Treatment			Timing	Product rate		Corn yield (14-Sept)			Weed control at harvest (14-Sept)			
						Ear no.	Ear yield	Avg. ear wt	Crabgrass	Pigweed	C. lambs-quarters	Overall
						no./20 ft row	*tons*	*lb*	---------- % ----------			
1	Laudis		V4	3	Oz	32	9.3	0.66	98	98	100	98
2	Laudis	+	V4	3	Oz	33	9.5	0.66	97	93	100	95
	Basagran		V4	1	Qt							
3	Laudis	+	V4	3	Oz	33	9.9	0.69	90	77	100	83
	Atrazine		V4	1	Qt							
4	Impact		V4	1	Oz	34	10.1	0.68	88	96	98	93
5	Impact	+	V4	1	Oz	30	8.4	0.64	70	93	98	77
	Basagran		V4	1	Qt							
6	Impact	+	V4	1	Oz	31	9.2	0.67	94	100	100	96
	Atrazine		V4	1	Qt							
7	Shieldex		V4	1	Oz	32	9.6	0.69	90	100	100	92
8	Shieldex	+	V4	1	Oz	30	8.4	0.65	85	93	100	90
	Basagran		V4	1	Qt							
9	Shieldex	+	V4	1	Oz	34	8.9	0.62	98	100	100	98
	Atrazine		V4	1	Qt							
10	Outlook		PRE	16	Oz	28	7.5	0.62	58	13	33	7
	Atrazine		PRE	1	pt							
11	Acuron		PRE	2.5	qts	30	9.7	0.73	92	73	100	78
12	Acuron Flexi		PRE	2	qts	26	7.8	0.68	99	75	97	75
13	Dual Magnum		PRE	1	pt	31	9.4	0.70	98	99	100	98
	Zidua		PRE	1.5	oz							
	Shieldex		V6	1	oz							
14	Outlook		PRE	13	oz	31	7.5	0.56	99	100	100	99
	Zidua		PRE	1.5	oz							
	Shieldex		V6	1	oz							
15	Zidua		PRE	3	oz	27	7.7	0.66	100	96	100	98
	Shieldex		V6	1	oz							
16	Shieldex		V6	1	oz	30	7.5	0.57	88	62	67	62
FPLSD (0.05)						*ns*	*2.0*	*0.89*	*ns*	*31*	*33*	*28*

Objective 2. Determine potential of interseeding to improve cover crop performance.

2.1. On farm interseeding experiments. Work continued to find ways to improve cover crop establishment in late planted sweet corn. In the third year of on-farm trials, tall fescue was interseeded at approximately V6 into an 11 A field of sweet corn north of Salem. The seeding rate was increased to 20 lbs/A in an attempt to improve cover crop density. The fescue established better in 2018 than the previous year, but some areas of the field were nearly devoid of cover crop. Another issue was a substantial population of annual bluegrass that permeated the field. The grower terminated the crop in the fall.

At another site near Molalla, a field of approximately 11 A was interseeded with common vetch. The remainder of the field was tilled and planted to common vetch conventionally. Interseeding improved vetch biomass accumulation, but also encouraged more weeds, primarily chickweed. However, the competition from the chickweed in the conventional planting will probably keep further cover crop biomass accumulation in the spring very low (Table 7).

At a third site near Gervais, red clover was interseeded into sweet corn at V7-8 prior to last cultivation. Clover established very well despite substantial competition from pigweed (Table 7, Fig. 1). The clover was seeded with the high clearance interseeder, and then rototilled.

Figure 1. Clover establishment in organic sweet corn at Gervais, Dec 12, 2018.

Table 7. Cover crop dry-matter collected from on-farm trials.

Site	Cover crop	Cover crop	Weeds	Total	Total N
		------------------------lb/A-------------------			
Molalla	Interseeded	344	1611	1611	
	Conventional	36	912	912	
Gervais	Interseeded	71	83	83	

2.2. Effect of corn variety, row orientation, and topping on cover crop growth. At the OSU research farm, work continued for a 2nd year to evaluate the effect of row orientation, corn variety, and topping on cover crop growth. A cover crop of triticale was interseeded into two varieties of sweet corn, one extremely competitive (Coho), and one less competitive (Spring Treat). Cover crop biomass was greatest in the Spring Treat corn variety, as expected (Table 8). The effect of row orientation and topping on cover crop growth was much less than the effect of corn variety, but data did indicate slight trends that a north-south row orientation is less competitive with the cover crop than an east-west row orientation. A small effect of topping may also have been noted, but was inconsistent across the varieties and row orientations.

Table 8. Effect of row orientation, corn variety, and topping on cover crop biomass when sweet corn was harvested in 2017 and 2018.

Year	Orientation	Cultivar	Cover Crop Biomass	
			Topped	Untopped
			----------------- *lb/A* -----------------------	
2017	EW	Coho	90	45
	NS	Coho	36	36
	EW	Spring Treat	204	120
	NS	Spring treat	200	197
2018	EW	Coho	78c[a]	71c
	NS	Coho	147bc	118bc
	EW	Bodacious	135bc	168bc
	NS	Bodacious	131bc	118bc
	EW	Spring Treat	361a	197ab
	NS	Spring Treat	269ab	352a

[a] *Means followed by the same letter within the same year do not differ (P=0.05).*

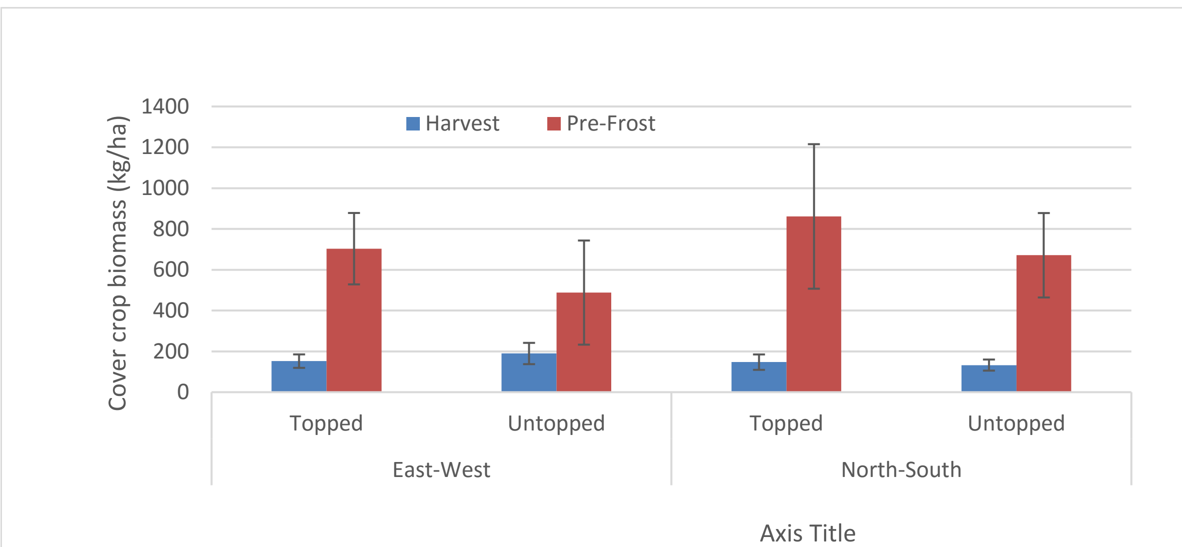

Figure 1. Effect of row orientation and topping on cover crop yield at corn harvest and in December, 2018 (SE, n=4)

<u>2.3. Effect of interseeding on nitrate concentrations in soil water.</u> In a third experiment sweet corn (Pacer, SH_2) was planted for the third continuous year on the same plot and nitrate concentrations in soil water monitored throughout the year. One half of the 2.5 acre field was interseeded with triticale at V6 while the other half was not planted to a cover crop and kept nearly weed free throughout the winter. Triticale establishment was good after planting at V6, and survival after harvest was acceptable despite exceptional growth of the corn that yielded from 14.9 to 16.7 tons/A. Sweet corn was harvested

with a commercial picker. Hand samples were taken from the field to estimate yield and indicated that the cover crop reduced yield by about 10% (Table 9). Nitrate concentrations in the soil appeared to be influenced by the presence of the cover crop (Figure 2).

Table 9. Effect of interseeding on sweet corn yield, Vegetable Research Farm, Corvallis, 2018.

Plot	Obs	Ears harvested	Ear Yield	Ear dia.	Avg. ear length	Tip fill
		no./sample	*t/A*	*in.*	*in.*	*%*
No cover crop	6	39	16.7	2.1	10.1	97
Interseeded with triticale	6	32	14.9	2.1	10.2	96
*FPLSD **(0.15)***		*0.06*	*1.7*	*ns*	*ns*	*ns*

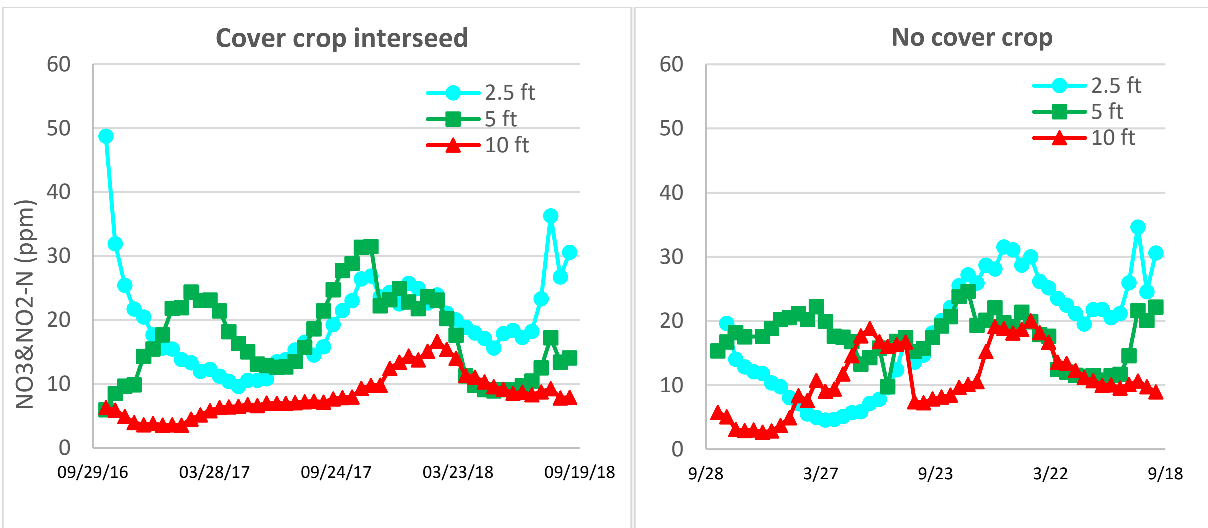

Figure 2. Effect of cover crop interseed on nitrate concentration in soil water, 2016 through 2018.

Objective 3. Assess potential carryover of tolpyralate and other PRE and POST herbicides on establishment of interseeded fescue and other potential interseeding crops.

Interseeding in conventional corn systems will only be possible if strategies are available to control weeds. Glyphosate is commonly used in glyphosate tolerant corn, but this is not an option for most sweet corn produced in the Willamette Valley. The 4-HPPD herbicides such as Shieldex may be useful for weed control in interseeding systems, but cover crop safety must be demonstrated and understood before these herbicides can be used in concert with interseeding.

The field was ripped, disked and rototilled with a vertical tine tiller before planting. Herbicides were applied 14 or 7 days before planting (DBP), or shortly after planting (0 DBP). Cover crops were planted on 20-Jun, and irrigated with approximately ½ inch of water the next day. Herbicides were applied with

CO_2 backpack sprayer with a 5-nozzle, 8.3 foot long boom. The resulting plots were 10 by 10 ft. Seedling emergence was counted from 3 ft of the middle row of each plot on 10-Jul. Crop growth also was rated on 10-Jul on a scale of 0-10, with a rating of 10 as the best growth and a rating of 0 if the crop was dead or had not emerged.

Results. As in past studies, large differences were noted in cover crop response to the 4-HPPD herbicide of Impact, Laudis, and Shieldex (Table 12, Figure 4). In general, red clover, crimson clover, peas, common vetch and phacelia were the most sensitive to these herbicides. Crimson clover was more tolerant than red clover. Both crimson clover and red clover appeared to be more sensitive to Shieldex than laudis or Impact. Peas were more tolerant to Shieldex than Impact and Laudis.

Table 11. Herbicide application data for herbicide carryover study on cover crops, 2018.

Date	June 13, 2018	June 20, 2018	June 27, 2018
Herbicide/treatment	Atrazine @ 1 pint/A Outlook @ 12 oz/A Dual Magnum @ 16 oz/A	Laudis @ 3oz/A Impact @ 1oz/A Shieldex @ 1 oz/A	Laudis @ 3oz/A Impact @ 1oz/A Shieldex @ 1 oz/A
Application timing	PRE:14 days before planting	PRE: 7 days before planting	PRE: 0 days before planting
Start/end time	6:30 - 8:00 AM	6:45-7:40 AM	6:00-7:15 AM
Air temp/soil temp (2")/surface	57 F/61F/57F	74F/68F/75F	60F/ 62F/64 F
Rel humidity	75%	61%	81%
Wind direction/velocity	SW 1.1 mph	SE 0.3	West 3.1
Cloud cover	Cloudy	Clear	Clear
Soil moisture	< Field capacity	< Field capacity	< Field capacity
Plant moisture	N/A	N/A	N/A
Sprayer/PSI	Backpack @ 30 psi	Backpack @ 30 psi	Backpack @ 30 psi
Mix size	3 gallons	3 gallons	3 gallons
Gallons H20/acre	20 gal/A	20 gal/A	20 gal/A
Nozzle type	8002	8003	8003
Nozzle spacing and height	20" @ 3'	20" @ 3'	20" @ 3'
Soil inc. method	N/A	N/A	N/A

Table 12. Cover crop tolerance to common herbicides that might interfere with interseeding efforts. Yellow cells = moderate risk of injury; orange cells = high risk of injury.

Herbicide	Days before planting	Product Rate	Rye	Triticale	Spring oat (Cayuse)	Spring wheat (Cleda)	Spring barley (Steptoe)	Red clover	Crimson clover	Ann ryegrass	Tall fescue	Buckwheat	Pea	Phacelia	Radish	Sudan grass	Common vetch
Cover crop stand			*No. plants per 3 feet of row*														
Atrazine	14	1 pt	65	49	102	95	101	7	7	43	30	14	12	11	33	183	23
Dual Mag	14	16 oz	18	16	46	28	69	1	25	0	21	4	12	2	23	53	14
Outlook	14	12 oz	15	18	45	46	78	1	17	0	18	7	11	2	23	28	15
Impact	0	1 oz	80	56	81	102	93	44	41	71	37	11	7	45	55	206	11
Impact	7	1 oz	67	47	75	93	89	53	60	78	71	13	8	65	51	90	29
Laudis	0	3 oz	47	45	99	99	94	19	55	96	47	13	3	55	48	78	7
Laudis	7	3 oz	91	61	71	117	94	29	50	66	76	20	9	57	49	221	20
Shieldex	0	1 oz	75	49	92	107	102	16	27	114	58	10	10	18	47	241	18
Shieldex	7	1 oz	63	51	92	65	97	44	41	70	72	15	18	29	41	201	16
Not treated	-		88	53	99	105	105	57	42	75	80	18	6	32	39	243	16
FPLSD (0.05)			39	17	22	45	32	44	31	43	53	10	8	33	29	110	14
Crop injury			*Growth rating (10=best; 0=dead)*														
Atrazine	14	1 pt	10	10	9	9	8	0	2	7	4	6	5	1	7	10	4
Dual Mag	14	16 oz	4	2	3	4	4	0	2	0	0	4	5	1	7	4	5
Outlook	14	12 oz	5	3	5	5	4	0	2	0	0	4	6	0	7	5	7
Impact	0	1 oz	10	10	9	10	10	3	8	9	7	6	3	6	10	10	4
Impact	7	1 oz	10	10	10	9	10	6	9	10	10	8	7	9	9	10	9
Laudis	0	3 oz	8	9	10	10	10	3	8	9	8	9	2	5	8	8	3
Laudis	7	3 oz	10	10	9	10	10	5	9	9	7	7	8	8	9	10	9
Shieldex	0	1 oz	10	10	10	10	10	1	5	8	8	9	8	4	10	10	5
Shieldex	7	1 oz	10	9	10	10	10	6	7	9	10	8	10	7	9	10	9
Not treated	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FPLSD (0.05)			*2*	*1*	*2*	*2*	*2*	*4*	*3*	*2*	*2*	*4*	*4*	*3*	*2*	*3*	*4*

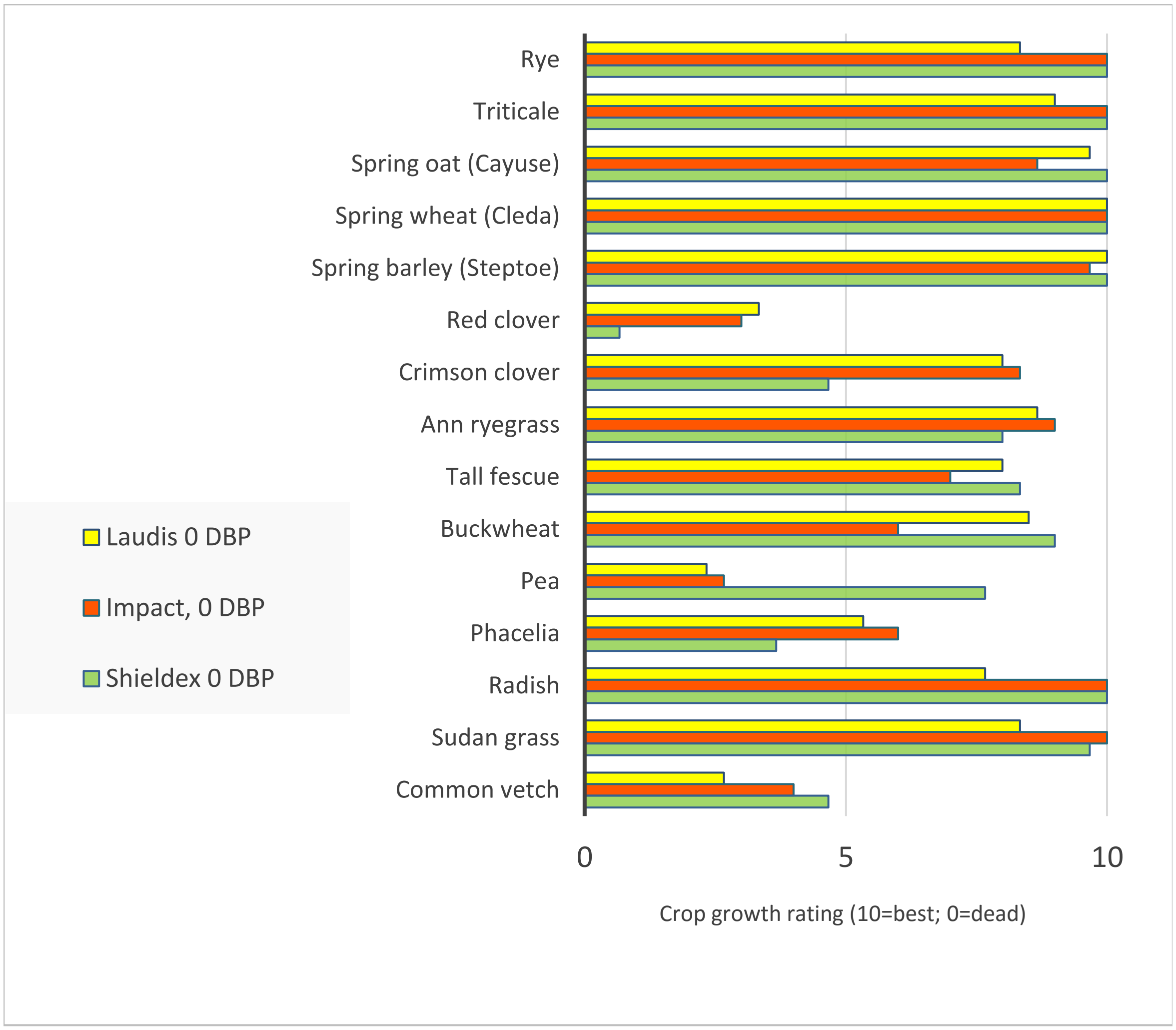

Figure 4. Cover crop tolerance to herbicides applied PRE (0 days before planting).

Impacts

This project is continuing to explore strategies to reduce the cost of production of sweet corn. Shieldex is the first new herbicide to be approved that will improve efficacy and substantially reduce cost of production. Interseeding of cover crops will become more reliable with data from this study and as we continue to refine strategies. Producers also will be able to confidently plan crop rotations based on data from the herbicide carryover studies of the last 3 years.

Research/Extension Progress Report for 2018-19 Funded Projects

Progress Report for the Agricultural Research Foundation
Oregon Processed Vegetable Commission

Title: Tolerance of Snap Beans to Flame Weeding

Project leader: Ed Peachey, OSU Vegetable Extension, Weed Science, Horticulture Department, ALS 4045, Oregon State University, Ed.Peachey@oregonstate.edu, 541-740-6712

Funding history:
Year 1: 2015-16 $6,940 YEAR 2: 2016-17 $7,910 Year 3: 2017-18 $5,562 (complete)

Abstract Previous research demonstrated that there is a small window of opportunity to flame weed over the row in snap beans without causing a yield reduction. This trial confirmed this observation. Careful planning is needed if flame weeding is to be successfully used. Flame weeding was applied to snap beans in a stale seedbed system to evaluate weed control and crop tolerance. Flame weeding at soil crack caused little if any injury at either rate of propane. Flaming with 11 to 13% of seedlings visible (Tr. 2 and 6, respectively) injured 19% of the seedlings when propane was applied at 5 GPA and 38% when applied at 10 GPA. Snap bean yield was reduced in the 10 GPA treatment by 9%. Flame applied when 40 to 49% of the seedlings had emerged and when 28 to 38 of the cotyledons had oriented vertically, on the other hand, injured from 48 to 61 % of the seedlings and reduced yield by 27%. Snap bean yield followed a nearly linear response to the percentage of bean seedlings that were exposed when flame was applied. Weed control in the crop row did not differ substantially after flaming. The main factor contributing to this outcome was that the John Deere Max Emerge planter did a very good job of disrupting weed seedlings when the beans were planted, and because soil temperatures were relatively high, snap beans emerged before another full flush of weeds appeared. Two organically approved herbicides were tested in this trial and were applied when 60 to 65% of the seedlings were visible and 52 to 58 % of the cotyledons had unfolded and separated from the soil. Crop yield was reduced by 17 to 21% compared to the stale seedbed only treatment.

Key words Flaming, weed control, organic herbicides, s-metolachlor, fomesafen, d-limonene, capric acid, caprylic acid.

Objective Measure the effect of flame weeding on snap bean growth and yield.

Procedures

The field was tilled on 5-Jun, first by ripping, then disking and then vertical tine rototilling to appropriate soil conditions for snap beans. The field was irrigated 1.5 hrs (0.6 in) after tillage to encourage a flush of weeds. Snap beans var. 5630 were planted on 14-Jun at 1 inch deep at 193,000 seeds/A. Plots were 35 ft long by 10 feet wide (4 rows on 30 in). Fertilizer (325 lb/A 12-10-10) was banded next to the row at planting. Dual Magnum (1 pt/A) and Reflex (1 pt/A) herbicides were applied to specified treatments on 15-Jun, followed by 1 hr of irrigation (0.4 in). Flame treatments were applied on 19 and 20-Jun with one (5 GPA) or two nozzles (10 GPA) set at 20 PSI and delivering 186,000 BTU/nozzle/hr to a 10 inch band over the seed row. All treatments were replicated 4 times. Raptor and Basagran herbicides were applied on 3-Jul to control all remaining weeds, and Basagran was applied again on 16-Jul to control squash volunteers and a few


Figure 1. Flamer used in study with two propane nozzles for each row.

remaining weeds in the row. Plots were cultivated twice before row closure and hand hoed several times to remove all weeds. Snap beans were harvested from 8 ft of row on 16-Aug and graded.

Accomplishments

Previous research demonstrated that there is a small window of opportunity to flame weed over the row in snap beans without causing a yield reduction. This trial again demonstrated this to be true. Careful planning is needed if flame weeding is to be successfully used.

Flaming at cracking (Tr. 1 and Tr. 5, 1 to 2% of seedlings visible, Table 2) caused very little visible injury to emerging snap beans and did not reduce stand (Table 3). Flaming with 11 to 13% of seedlings visible (Tr. 2 and 6, respectively) injured 19% of the seedlings when propane was applied at 5 GPA and 38% when applied at 10 GPA. Snap bean yield was reduced in the 10 GPA treatment by 9%. Flame applied when 40 to 49% of the seedlings had emerged and when 36 to 28% of the cotyledons had separated from the soil (Tr. 4 and Tr. 8, Table 2), on the other hand, injured from 48 to 61 % of the seedlings, and 14 to 16 % of those seedlings were seriously injured (Table 3). Snap bean yield followed a nearly linear response to the percentage of seedlings that were exposed when flame was applied. Additionally, the 10 GPA rate consistently reduced crop yield compared to the 5 GPA rate (Figure 2).

One anomaly in the yield data was the lower than expected yield in Tr. 1 and Tr. 5 when snap beans were flamed at soil crack, compared to Tr. 2 and Tr. 6 with 11 to 13% of the seedlings were visible. Only 1 to 2% of the snap beans were visible and none of the hypocotyls or cotyledons had extended beyond the soil surface. The only difference between these treatments other than the growth stage of the beans was the time of day of the application. Treatments 1 and 5 were applied at the end of a hot and dry day, whereas Tr. 2 and 6 were applied early the next morning when soil temperatures were nearly 20 F lower than the previous day (Table 1). We speculate that this difference in soil environment may have influenced crop tolerance to flaming.

Weed control in the crop row did not differ substantially after flaming. The main factor contributing to this outcome was that the John Deere Max Emerge planter did a very good job of disrupting weed seedlings when the beans were planted, and because soil temperatures were relatively high, snap beans emerged before another full flush of weeds appeared.

Two organically approved herbicides were tested in this trial and were applied when 60 to 65% of the seedlings were visible and 52 to 58 % of the cotyledons had unfolded (Table 2). Crop yield was reduced by 17 to 21% compared to the stale seedbed only treatment (Tr. 13, Table 3) with a maximum 23% percent reduction in weed density.

An interesting outcome of this trial, with results similar to 2017, was that we were able to demonstrate that stale seedbeds have a yield cost compared to conventional tillage. The conventionally tilled treatment without flaming or herbicides provided the largest yield of 11.0 t/A, nearly a 10% yield increase compared to the stale seedbed control plots. This may simply be because of poorer seed to soil contact when planting into stale seedbeds.

Impacts

Nonchemical weed control strategies are in short supply in dicotyledonous 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 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. Monocot crops such as corn and grass weeds are very tolerant to flame weeding because the growing point remains protected beneath the soil for the early part of the growing season.

Data from this trial suggest that even though snap beans are moderately tolerant to flame weeding at cracking, flame weeding may cause severe crop yield reductions of 30% if the seedlings are visible and approximately 10 to 20 % of those hypocotyls have oriented vertically and separated from the soil. Additionally, crop tolerance also may depend on soil temperatures at the time when flame is applied, and yield may be suppressed even though crop injury is not obvious. Weed control will depend on the condition of the stale seedbed and how fast weeds are emerging relative to the crop. There was no obvious advantage of the organic herbicides Suppress and Avenger Opti over flaming.

Table 1. Treatment application data.

	Dual Mag 16 oz/A + Reflex 16 o/A (conventional tillage treatments)	Glyphosate 1 qt/A (all plots)	Flame1	Flame2	Flame 3	Flame 4	Suppress or Avenger Opti	Raptor 4 oz + Basagran 16 oz + 0.5% NIS	Basagran 1 qt + 1% COC
Date	6/15/18	6/18/18	6/19/18	6/20/18	6/20/18	6/20/18	6/21/18	7/3/18	7/16/18
Time	7-7:15 PM	5-5:15 PM	5-5:30 PM	8-8:30 AM	1:30 -2 PM	6:45-7:15 PM	8- 8:15 PM	12-1 PM	6-7 AM
Soil moisture	Damp	Dry	Very dry	Very dry	Very dry	Very dry	Very dry	Very dry	Damp
Wind direction and speed	NE 0-2	W 2-5	NE 2-6	S 0-3	W 3-10	W 4-8	0	NE 3-8	0-1
Nozzle no. and size	5-XR8003	5-XR8003	-	-	-	-	5-XR8003	5-XR8003	5-XR8003
Pressure (PSI)	25	25	20	20	20	20	25	25	25
Delivery rate (GPA applied to 10 inch band)	20	20	5 or 10	5 or 10	5 or 10	5 or 10	40	20	20
Bean growth stage at application	One day after planting	Very early crack, no seedlings visible	------------------------- see Table 3 below --------------------------					1st trifoliate	2nd trifoliate
Temp (air/2 in./surface)	59/69/66	81/93/91	88/90/98	75/72/74	84/69/79	76/78/78	63/66/66	72/	60/
Plant moisture	None	Weeds dry, no plants	Dry	Dry	Dry	Dry	Dry	Dry	Heavy dew
RH (%)	72	47	40	60	74	51	63	40	86

Table 2. Targeted seedling emergence when stale seedbed treatments were applied.

Treatment		Propane rate (gal/A in 10 inch band)	Targeted seedling emergence	Snap bean seedling growth stage		
				Visible seedling	Hypocotyl unfolded	Cotyledon upright
			%	*----------------- % emergence at each growth stage-----*		
1	Flame	5	5	2	1	0
2	Flame	5	10	13	9	4
3	Flame	5	15	27	21	11
4	Flame	5	25	49	41	36
5	Flame	10	5	1	0	0
6	Flame	10	10	11	7	4
7	Flame	10	15	32	28	20
8	Flame	10	25	40	34	28
9	Suppress	-	15	60	56	52
10	Avenger	-	15	65	62	58
FPLSD (0.05)				*9*	*9*	*8*

Table 3. Effect of flame, herbicide, and planting system on crop injury and weed control in the bean row.

Flame or herbicide treatment		Propane or Herbicide rate	Crop stand and injury (2-Jul)					In-row weed control (3-Jul)	
			Stand	Severe injury	Visible injury	Total injured	Percent injured	Total survival in row	Between row density
		(Propane: gal/A applied to 10 inch band; herbicide #/A)	*------------------no/5 ft-------------*				*%*	*---------no./ m sq.--------*	
1	Flame	5	42	1	2	3	8	17	97
2	Flame	5	47	3	6	9	19	20	128
3	Flame	5	32	4	6	10	32	19	89
4	Flame	5	37	16	5	21	61	26	66
5	Flame	10	46	1	1	1	3	17	118
6	Flame	10	37	6	2	8	36	17	93
7	Flame	10	42	10	9	19	47	17	79
8	Flame	10	39	14	5	19	48	16	93
9	Suppress	9% solution, 40 GPA	39	11	8	20	51	16	59
10	Avenger Opti	9% solution, 40 GPA	47	7	14	21	44	25	64
11	Tilled seedbed	Dual Magnum (1 pt) + Cobra (12 oz)	43	2	2	3	7	0	0
12	Tilled seedbed check	Untreated	40	3	3	6	14	20	42
13	Stale seedbed check	Untreated	39	2	2	4	10	28	104
14	Stale seedbed check	Glyphosate before crop emergence (1 qt)	43	2	2	4	11	20	10
FPLSD (0.05)			*8*	*5*	*5*	*7*	*26*	*ns*	*13*

Table 4. Flame and herbicide effects on snap bean yield, 2018.

Flame or herbicide treatment		Propane or Herbicide rate	Growth stage at treatment	Plant stand	Pod yield	Grade
		(Propane: gal/A applied to 10 inch band; herbicide #/A)	*% at each stage*	*no/8 ft or row*	*t/A*	*% 1-4 sieve*
1	Flame	5	2, 1, 0 [a]	60	9.6	50
2	Flame	5	13, 9 ,4	70	10.4	49
3	Flame	5	27, 21, 11	53	8.4	50
4	Flame	5	49, 41, 36	55	7.6	54
5	Flame	10	1, 0, 0	69	8.5	46
6	Flame	10	11, 7, 4	62	9.2	50
7	Flame	10	32, 28, 20	48	7.9	50
8	Flame	10	40, 34, 28	53	6.5	57
9	Suppress	9% solution, 40 GPA	60, 56, 52	61	8.0	51
10	Avenger Opti	9% solution, 40 GPA	65, 62, 58	65	8.4	54
11	Tilled seedbed	Dual Magnum (1 pt) + Cobra (12 oz)	0	64	10.5	47
12	Tilled seedbed check	Untreated	0	72	11.0	44
13	Stale seedbed check	Untreated	0	64	10.1	52
14	Stale seedbed check	Glyphosate before crop emergence (1 qt)	0	68	10.4	49
FPLSD (0.05)				*15*	*1.7*	*7*

[a] *Percent emergence at treatment (seedlings visible - hypocotyl unfolded - cotyledons separated from soil or open)*

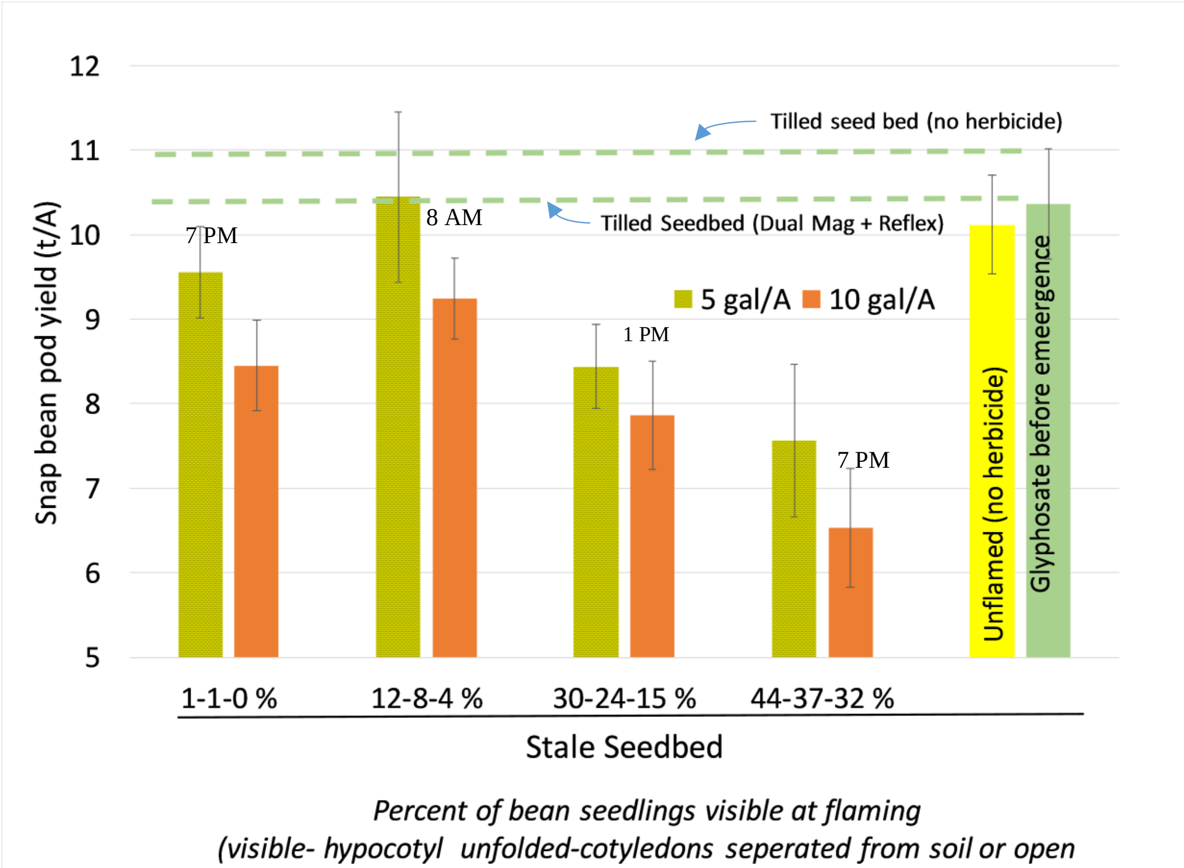

Figure 2. Effect of flaming rate, timing, and tillage treatments on snap bean yield.