

# Oregon Processed Vegetable Commission Reports 2022

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**Reports**

**Research/Extension Progress Report for 2020-2021 Funded Projects**
**Progress Report for the Agricultural Research Foundation**
**Oregon Processed Vegetable Commission**

Title: Monitoring Soil Moisture and Temperature Impacts on Soilborne *Fusarium* Diseases in Processing Vegetable Cropping Systems

Project Leader(s):
Kristine Buckland, Ext. Horticulture Specialist & Assistant Professor,
OSU-North Willamette Research and Extension Center
15210 NE Miley Rd, Aurora, OR 97002
(503)506-0955

Cynthia M. Ocamb, Ext. Plant Pathology Specialist & Associate Professor,
OSU-Botany & Plant Pathology
4575 SW Research Way, Corvallis, OR 97333
(541)737-4020

Cooperator(s):
Three processed vegetable growers within the Willamette Valley

Funding History: Funds were awarded from OPVC in 2019 for $32,409, 2020 for $35,000, and $16,090 in 2021.

Abstract: Sweet corn and snap bean production, amongst other vegetable crops grown in the Willamette Valley of Oregon, are impacted by soilborne diseases caused by *Fusarium* species. The decline in sweet corn yields due to Fusarium crown and stalk node rot as well as root rot in snap bean and sweet corn are well documented in the valley. The widespread presence and increasing disease pressure from *Fusarium* in the soils of western Oregon compels growers to define optimum management practices in order to minimize the impact from *Fusarium* diseases. It may be possible to reduce *Fusarium* diseases and their associated losses in sweet corn and snap bean fields by connecting the physical properties of the soil environment (temperature and moisture) with the levels of *Fusarium* which could then be used to refine cropping practices such as irrigation or crop rotation. We hypothesize that the incidence of *Fusarium* root disease can be predicted by soilborne *Fusarium* populations, soil temperature, and soil moisture levels. Our objectives in this project are to 1) Evaluate the soil conditions as a predictor of *Fusarium* levels in the soil and 2) Evaluate the *Fusarium* disease incidence and severity of crops in monitored sweet corn and snap bean fields.

Key Words: *Fusarium*, sweet corn, snap bean, soil moisture, soil temperature

Objective(s):
**Objective 1:** Evaluate soil conditions (temperature and moisture) as predictors of *Fusarium* levels in the soil.

**Objective 2:** Evaluate *Fusarium* disease incidence and severity of crops in monitored sweet corn and snap bean fields.

Procedures:
**Objective 1.** Evaluate soil conditions (temperature and moisture) as predictors of *Fusarium* levels in the

soil.

*Soil monitoring was nearly continuous throughout all years of cropping and soil health data showed a wide range of microbial function indicators. The number of Fusarium colony forming units per gram of oven-dried soil were very high overall.*

Three commercial field sites (Table 1) were used for this study. The first field was cropped with snap beans in 2019 and subsequently planted in grass seed from late 2019 to present. The second field was cropped with sweet corn in 2019 and snap beans in 2020 and 2021, with the soil bare over winter. The third field was cropped with sweet corn in 2019, wheat in 2020, and sweet corn in 2021, with the soil bare and flooded over winter

**Table 1**. Rotation of crops in the three fields monitored during 2019-2021

| Year | Field 1 | Field 2 | Field 3 |
|---|---|---|---|
| 2019 | Snap bean | Sweet corn | Sweet corn |
| 2020 | Grass seed | Snap bean | Spring wheat |
| 2021 | Grass seed | Snap bean | Sweet corn |

We monitored soil temperature and soil moisture throughout the growing season from 2019 through 2021. Each field had two TDR-315 sensors installed at 6" below the soil surface. The probes were connected to data loggers located at recording stations within the fields, and set to take a reading every 30 minutes. Data were downloaded at regular intervals and used to describe overall field conditions throughout the season. Unfortunately, due to damaged and defective sensors, some data are missing, although replacement sensors were installed as problems were detected.

Comprehensive soil health testing results were accomplished for each field in 2020 and 2021. Physical, chemical, and biological soil characteristics were measured and some key indicators are reported in Table 2. Comparing the soil particle composition, we notice that Fields 1 and 2 are a similar mix of sand/silt/clay while Field 3 has significantly more clay, and due to both the clay levels as well as site location is likely to have increased periods of winter flooding and prolonged high soil moisture levels in the spring. The amount of potentially mineralizable nitrogen (PMN) was highly variable at the time of sampling and could be due to the effects from timing of sampling as well as the amount and quality of crop residue remaining near the soil surface. The final two soil tests listed for active carbon and respiration describe some aspects of microbial function in the soil. Active carbon is seen as a measure of readily available 'food' for microbes, whereas respiration reports the amount of $CO_2$ evolved from the soil in 24 hours which may indicate the size of the microbial population. We would expect a positive relationship between high active carbon, soil respiration and soils that have low disease (indicating perhaps a "disease-suppressive-soil").

**Table 2.** Soil health testing results

| Field | pH | Sand/Silt/Clay | Potentially Mineralizable Nitrogen (PMN) | Active Carbon | Respiration 24 hours |
|---|---|---|---|---|---|
| | | (%) | (ppm NO3-N at sample) | (ppm) | (µg CO2-C/g dry soil) |
| Field 1 | 5.5 | 32/48/20 | 14 | 514 | 54 |
| Field 2 | 6.3 | 38/40/22 | 16 | 234 | 21 |

| | | | | | |
|---|---|---|---|---|---|
| Field 3 | 6.5 | 18/58/24 | 40 | 321 | 37 |

*Fusarium* population levels in fields were determined in representative soil samples collected approximately every two weeks during the summer cropping months, and monthly thereafter (except for January-February 2020 and November-December 2021 after sensor stations were removed). Twenty 12-inch soil cores were collected in a systematic manner across each of four blocks in each field. Soil cores collected within each block were combined, bagged and returned to the lab. Soil samples were air-dried until the soil was dry enough to sieve. Three 10-gram subsamples were removed from each composite block soil collection for each field on each sampling date. Soil subsamples were evaluated for levels of *Fusarium* species by plating serial dilutions onto a *Fusarium*-selective medium. Two additional 10-gram subsamples per block for each date were oven-dried in tins placed at 100°C for 48 hours in order to determine the soil dry weights used for calculating the number of *Fusarium* colony forming units per gram of oven-dried soil. Processing and data collection are still under way for the rest of the 2021 sampling that occurred through October 2021.

We have included the colony forming units recovered from dilutions of $10^{-3}$ (Table 3) and $10^{-4}$ (Table 4) because means of the $10^{-3}$ dilutions have lower variance among the sample dates for the respective fields, but $10^{-4}$ dilutions' counts are more precise measurements of the higher levels of *Fusarium* CFUs in the soil samples. *Fusarium* numbers were very high overall (Table 3 and 4), especially in field #3 that underwent flooding conditions. Typically, *Fusarium* colony forming units per gram of oven-dried soil of bulk soil samples associated with diseased and disease-free crop fields are generally <10,000 and 2,000, respectively. The high numbers of *Fusarium* CFUs could explain the relatively severe disease that we observed in both sweet corn and snap bean during the 2019 growing season and in the subsequent crops rotated in 2020 and 2021.

**Table 3**. The number of *Fusarium* colonies that were obtained in $10^{-3}$ serial dilutions of soil samples collected on each date

| Date sampled | Field 1: Snap bean-2019/grass seed 2020 | Field 2: Sweet corn 2019/snap bean 2020 & 2021 | Field 3: Sweet corn 2019/spring wheat 2020/sweet corn 2021 |
|---|---|---|---|
| 11-Jul-19 | 34,503 | 68,437 | 228,125 |
| 25-Jul-19 | 60,597 | 49,568 | 237,195 |
| 8-Aug-19 | 65,861 | 66,486 | 226,837 |
| 22-Aug-19 | 76,385 | 89,381 | 181,899 |
| 5-Sep-19 | - | 98,240 | - |
| 19-Sep-19 | 141,493 | 85,799 | 239,748 |
| 3-Oct-19 | - | 95,588 | flooded |
| 3-Nov-19 | 174,556 | 111,411 | 253,846 |
| 5-Dec-19 | 131,765 | 99,410 | 175,000 |
| 18-Mar-20 | 91,159 | 67,890 | 228,667 |
| 20-Apr-20 | 131,579 | 125,444 | 227,653 |
| 18-May-20 | 54,294 | 133,750 | 18,018 |
| 25-Jun-20 | 46,687 | 77,295 | 124,374 |
| 8-Jul-20 | 98,281 | 42,388 | 179,532 |
| 23-Jul-20 | 79,508 | 75,942 | 175,275 |
| 19-Aug-20 | 150,999 | 56,372 | 164,354 |
| 3-Sep-20 | 127,108 | 57,787 | 93,333 |
| 24-Sep-20 | 82,477 | 45,846 | 131,502 |
| 22-Oct-20 | 59,327 | 22,222 | 134773 |
| 19-Nov-20 | 75,806 | 27,052 | flooded |
| 17-Dec-20 | 68,554 | 55,490 | flooded |
| 25-Jan-21 | 111,940 | 59,733 | flooded |
| 15-Feb-21 | 97,540 | 55,474 | flooded |
| 18-Mar-21 | 163,540 | 78,706 | 90,556 |

**Table 4**. The number of *Fusarium* colonies that were obtained in $10^{-4}$ serial dilutions of soil samples collected on each date

| Date sampled | Field 1: Snap bean-2019/grass seed 2020 | Field 2: Sweet corn 2019/snap bean 2020 & 2021 | Field 3: Sweet corn 2019/spring wheat 2020/sweet corn 2021 |
|---|---|---|---|
| 11-Jul-19 | 76,023 | 138,643 | 640,625 |
| 25-Jul-19 | 125,373 | 103,746 | 378,049 |
| 8-Aug-19 | 87,613 | 97,297 | 396,166 |
| 22-Aug-19 | 67,055 | 91,445 | 183,976 |
| 5-Sep-19 | - | 93,842 | - |
| 19-Sep-19 | 250,746 | 106,509 | 318,612 |
| 3-Oct-19 | - | 91,176 | flooded |
| 3-Nov-19 | 301,775 | 156,156 | 376,572 |
| 5-Dec-19 | 164,706 | 162,242 | 224,359 |
| 18-Mar-20 | 146,341 | 51,988 | 403,333 |
| 20-Apr-20 | 154,971 | 136,095 | 450,161 |
| 18-May-20 | 95,092 | 250,000 | 180,180 |
| 25-Jun-20 | 78,313 | 141,908 | 250,250 |
| 8-Jul-20 | 137,536 | 62,687 | 292,398 |
| 23-Jul-20 | 105,011 | 95,652 | 219,780 |
| 19-Aug-20 | 229,028 | 47,976 | 193,197 |
| 3-Sep-20 | 160,830 | 114,755 | 152,381 |
| 24-Sep-20 | 132,931 | 55,385 | 264,943 |
| 22-Oct-20 | 73,394 | 15,432 | 181,425 |
| 19-Nov-20 | 84,677 | 30,395 | flooded |
| 17-Dec-20 | 89,419 | 83,086 | flooded |
| 25-Jan-21 | 143,284 | 86,181 | flooded |
| 15-Feb-21 | 115,774 | 67,153 | flooded |
| 18-Mar-21 | 276,106 | 107,817 | 163,889 |

**Objective 2.** Evaluate *Fusarium* disease incidence and severity of crops in monitored sweet corn and snap bean fields.

*Fusarium rot of the roots of wheat, grass seed, and snap bean plants was present in the respective fields that were monitored during 2019-2021. Sweet corn exhibited a severe crown and stalk node rot rather than root rot, as was expected. Snap bean plants exhibited generally high levels of root rot and virtually all plants sampled had lesions on the lower stem before harvest. Rot of the adventitious root system of wheat and grass for seed was severe before harvest.*

Ten plants were carefully dug from each block (40 plants per field) from each of the monitored fields on each date of plant sampling. Plants were returned to the OSU campus where soil was washed from root balls in the laboratory. The incidence of rot and percentage of the affected underground portion of each plant with rot were determined in visual assessments conducted by Ocamb.

The grass seed plants that were planted in Field 1 (Table 5) following a snap bean crop exhibited severe root rot by the latter half of June in 2020. Samples were extremely difficult to collect in 2021 due to dry soil conditions but grass plants sampled in July had a similar level of severe root rot as was found during the prior season. The snap bean plants that were planted in Field 2 (Table 6) following the 2019 sweet corn crop exhibited root rot long before flowering in 2020; plants had 2 to 3 trifoliate leaves by 22 Jul and flower buds were developing by 5 Aug. Snap bean plants sampled in 2021 had similar levels of root rot severity and incidence of lower stem lesions as compared to the previous season. The sweet corn plants that were planted in Field 3 (Table 7) following the sweet corn-wheat rotation had the typical less severe rot of the adventitious roots, but exhibited a very high incidence of crown rot by late July. By the next sampling date two weeks later, the decay of the stalk nodes had progressed well up the stalk, averaging greater than three stalk nodes above the soil line. The take home is that sweet corn, snap bean, grass grown for seed crops, and spring wheat all show high levels of root and crown disease due to *Fusarium* spp. throughout the three years of investigations, reinforcing the findings of extremely high levels of soilborne *Fusarium* species in the three fields monitored.

**Table 5**. Field 1 disease ratings in 2019 (snap bean) and 2020-2021(grass seed)

| Date | Root rot (%) of snap bean plants |
|---|---|
| 11-Jul-19 | 51 |
| 25-Jul-19 | 60 |
| 8-Aug-19 | 52 |
| **Date** | **Root rot (%) of grass seed plants** |
| 24-Jun-20 | 62 |
| 8-Jul-20 | 80 |
| 10-Jul-21 | 79 |

**Table 6**. Field 2 disease ratings in 2019 (sweet corn) and 2020-2021 (snap bean)

| Date | Adventitious corn roots rot (%) | Mean # stalk nodes with rot | % incidence of crown rot |
|---|---|---|---|
| 11-Jul-19 | 0.4 | - | 98 |
| 25-Jul-19 | 4.1 | 0.2 | 95 |
| 8-Aug-19 | 10.9 | 2.5 | 95 |
| 22-Aug-19 | 15.6 | 2.7 | 100 |
| 5-Sep-19 | 8.9 | 2.6 | 100 |
| 19-Sep-19 | 17.3 | 2.6 | 98 |
| 3-Oct-19 | 22.6 | 2.6 | 100 |

| Date | Root rot (%) of snap bean plants | Incidence of lesions on stem base |
|---|---|---|
| 8-Jul-20 | 47 | 75 |
| 22-Jul-20 | 63 | 98 |
| 5-Aug-20 | 63 | 98 |
| 28-Jul-21 | 54 | 43 |
| 9-Aug-21 | 90 | 100 |

**Table 7**. Field 3 disease ratings in 2019 (sweet corn), 2020 (spring wheat), and 2021 (sweet corn)

| **Date** | **Adventitious corn roots rot (%)** | **Mean # stalk nodes with rot** | **% incidence of crown rot** |
|---|---|---|---|
| 25-Jun-19 | 4 | - | 100 |
| 11-Jul-19 | 5 | 2.3 | 100 |
| 25-Jul-19 | 4 | 3.5 | 100 |
| 8-Aug-19 | 9 | 3.9 | 100 |
| 22-Aug-19 | 24 | 3.4 | 100 |

| **Date** | **Primary root rot (%) of wheat** | **Overall wheat root rot (%)** | **Incidence of rot on wheat mesocotyl** | **Mean % mesocotyl with rot** |
|---|---|---|---|---|
| 24-Jun-20 | 17 | 11 | 23 | - |
| 8-Jul-20 | 94 | 56 | 100 | 64 |

| **Date** | **Adventitious corn roots rot (%)** | **Mean # stalk nodes with rot** | **% incidence of crown rot** |
|---|---|---|---|
| 28-Jul-21 | 2.5 | - | 100 |
| 9-Aug-21 | 11 | 3.6 | 100 |

<u>Accomplishments:</u>
As provided above, we were successfully able to both evaluate soil conditions (temperature and moisture) as predictors of *Fusarium* levels in the soil and also valuate *Fusarium* disease incidence and severity of crops in monitored sweet corn and snap bean fields. We continue to analyze the very large data set to explore these relationships further. An example of this continuing work is below and focuses on Field 3.

We are looking at different soil conditions such as minimum temperature and average temperature and moisture between sample dates to see if there this a correlation between any of these variables and the response we observed in both *Fusarium* CFU number and visible disease in the plant samples (Figure 1).

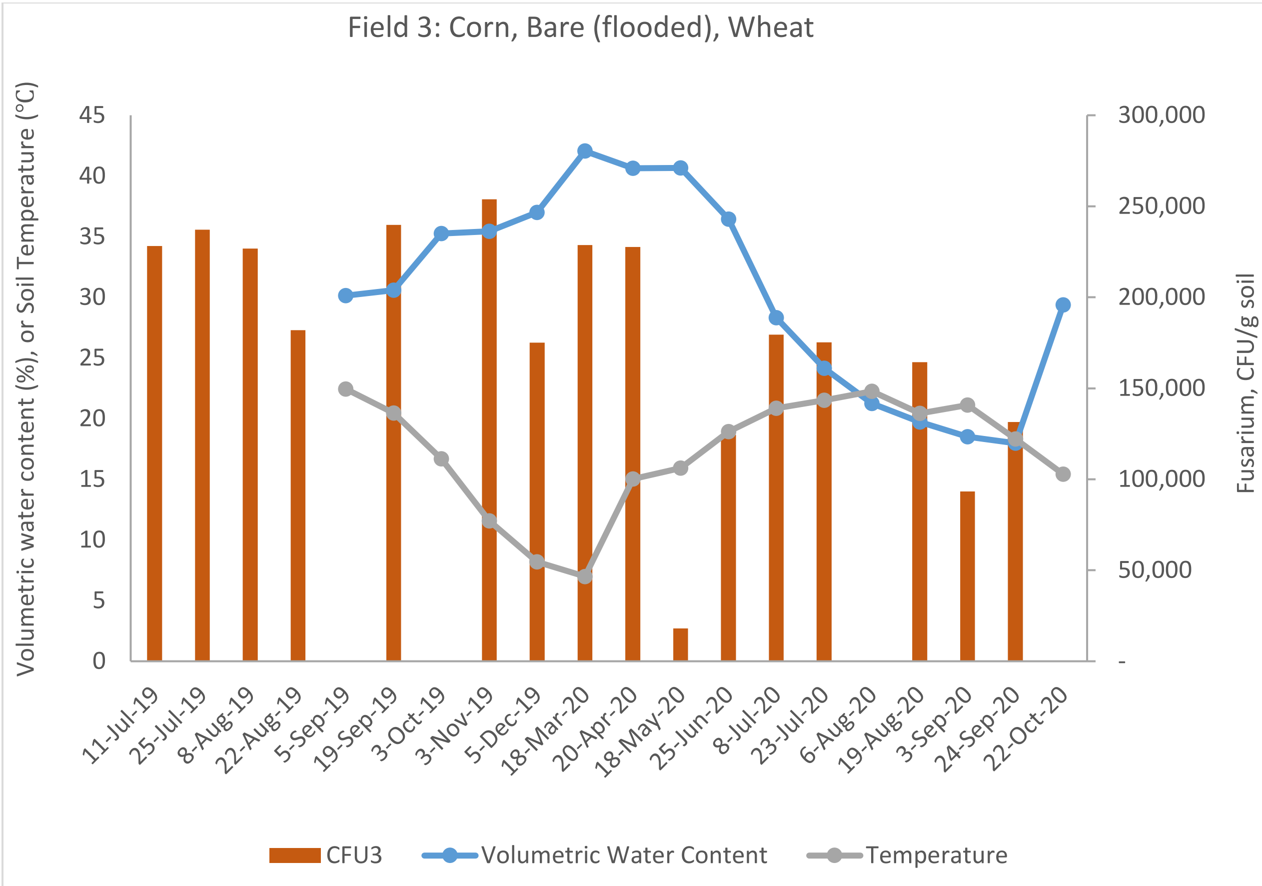


**Figure 1.** Soil temperature and moisture monthly averages as compared with soil *Fusarium* CFU counts for Field 3. Here we notice there appears to be a lag in decreased CFU counts following the minimum soil temperatures (March 18$^{th}$ observation).

Taking a similar approach, we are comparing the soil health indicators with disease measures. Two of the most responsive soil health indicators thus far have been active carbon (Figure 2) and total soil nitrogen (Figure 3). Across all monitored fields, the amount of active carbon and the total soil nitrogen percentage were both positively correlated with soilborne levels of *Fusarium*. While it is very early to make any conclusions, we continue to look at these indicators across several other fields and sample years to see if this trend remains, and if so, what might cause this response. This area of research can be very impactful for management strategies in the future.


**Figure 2.** Active carbon averages as compared with soil *Fusarium* CFU counts for all three fields. Here we notice a positive correlation with the active carbon at sampling (early spring) with the *Fusarium* CFU at the time of soil health sampling.

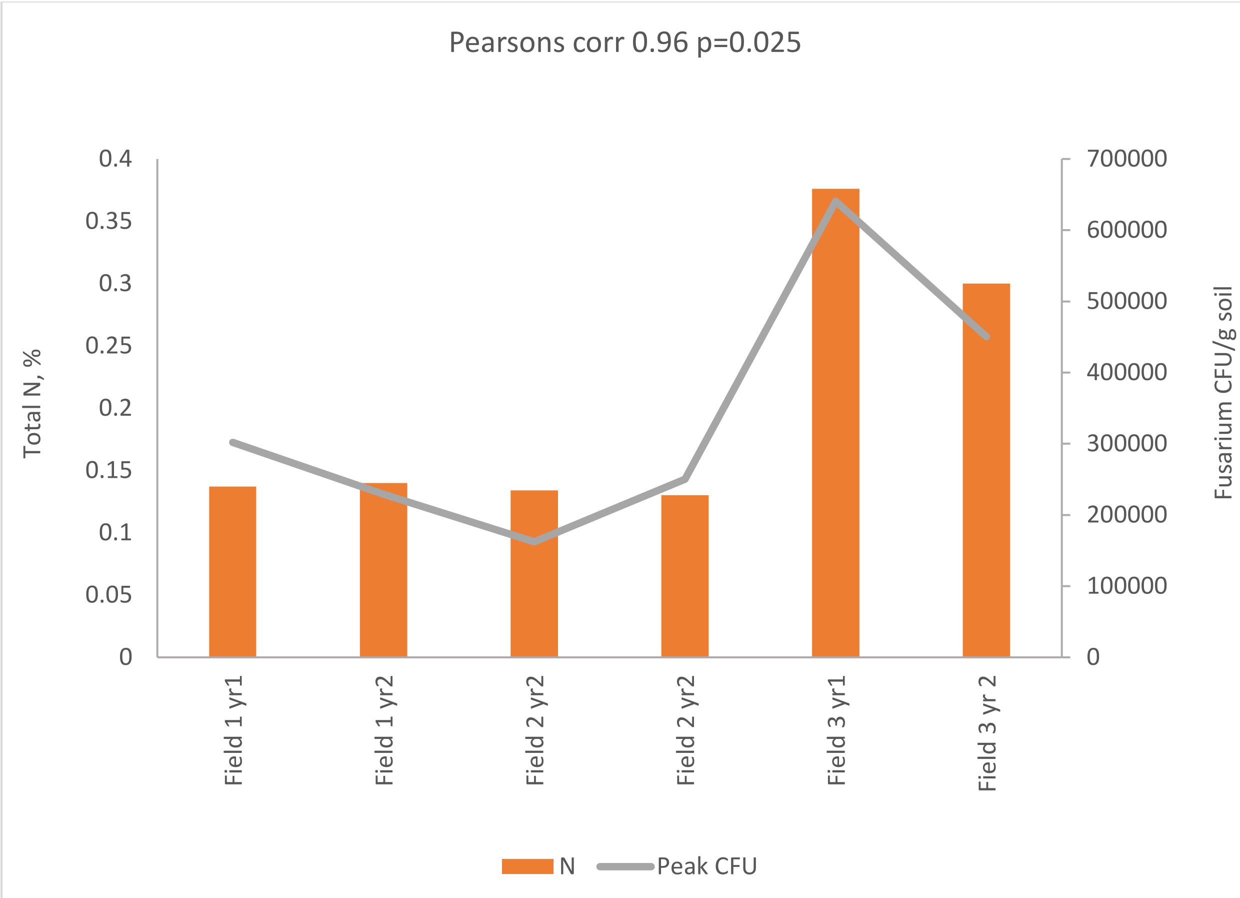


**Figure 3.** Total soil N percent averages as compared with soil *Fusarium* CFU counts for all three fields. Here we notice a positive correlation with percent nitrogen at sampling (early spring) with the *Fusarium* CFU at the time of soil health sampling.

Impacts: We anticipate that as data analysis progresses, and in coordination with data collected in similar studies within the specialty seed industry, we will identify potential conditions under which *Fusarium* populations will be higher and the potential risk for disease will be greater, posing an increased likelihood of crop loss. In the short term, we are preparing individualized reports for grower-cooperators with crop health observations and soil/soilborne descriptive data similar to that shared here.

This project has been presented at national conferences that brings awareness to the management challenges and fosters connection to further collaboration for a broader research effort to address the problem. In the longer term, these results will aid growers and field agronomists to adapt crop rotation, irrigation scheduling, and crop disease scouting intervals as needed to minimize crop losses.

Relation to Other Research: Both Buckland and Ocamb work across multiple industries and crop groups that can suffer losses to *Fusarium* and other soilborne pathogens. Often, growers that struggle with crop loss in processed vegetables also grow other crops susceptible to *Fusarium* disease losses and often struggle with other soilborne diseases. Therefore, we have recruited support from the Specialty Seed Growers of Western Oregon to monitor additional fields and are also actively working to secure federal grant funding to complete a replicated field trial that would test the impacts of soil health management strategies to mitigate soilborne disease presence (*Fusarium* and other pathogens). We are also actively working other researchers and growers to examine cropping system inputs such as tillage and crop rotation that might also impact soilborne disease incidence and severity. Our work will continue to look for funding opportunities to examine at a cropping systems level these interactions.

Acknowledgements: We would like to thank the Oregon Processing Vegetable commission for the support they provided as well as our three cooperating growers who allowed us to install equipment and sample throughout their fields. Also many thanks to Tim Flodquist, Mariah Dietrich, Taylor A. Bates, Alexandria S. Montgomery, Darby D. Bergl, Anna Ehlers, and Ann Rasmussen for their assistance with collection of weather monitoring data as well as plant and soil samples along with conducting the soil dilution series in 2021.

**OPVC CONTINUING PROJECT REPORT: PROJECT YEAR**: *2021*

**1. OPVC REPORT COVER PAGE (maximum 2 pages)**

**OPVC Project Number:**

**Project Title**: Green Bean Breeding and Evaluation

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

**City/State/Zip**: Corvallis, OR 97331

**Co-PI:** Zak Wiegand
**Telephone**: 541-737-6496
**Email**: Zak.Wiegand@oregonstate.edu
**Address**: Wiegand Hall, Department of Food Science and Technology

**Total project request (all years):**
Year 1: $31,070 breeding
$8,515 processing
**$39,584 total**

**Contributions from the OSU breeding program**
Year 1: **$20,163**

**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 which it means that it is difficult to introgress traits from other types of 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 2021, a yield and processing trial of 23 OSU experimental advanced lines and six check cultivars was conducted. Many of the experimental lines had high yields and good quality in 2020, but to narrow the field, they were retested using the greenhouse based straw test for white mold resistance. A second trial with 28 entries from commercial seed companies in addition to three checks and two OSU experimental lines were also grown and evaluated. Several commercial entries had BBL quality and high yields. In the greenhouse, 959 experimental lines were evaluated for white mold reaction using the straw test. Five-hundred eighty-nine lines (61%) had scores equal to four or less and were retained in the program; the remainder were dropped. A replicated trial with 27 OSU advanced experimental lines was planted in a white mold disease nursery at the Vegetable Research Farm. Disease incidence and severity was low for white mold, but we did see a significant infection with gray mold and incidence and severity scores were obtained for both diseases.

## 3. FULL REPORT

**3.a. BACKGROUND** Green beans grown for processing in the Willamette Valley contribute significantly to the Oregon state economy each year ($20.6 million in 2020). 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. From genetic studies we have conducted, Blue Lake green beans form a distinct gene pool compared to other snap beans. Furthermore, the growing environment in Western Oregon is unlike any other green bean production area in the United States, and the OSU BBL cultivars have been bred for this environment for more than half a century. Developing productive varieties that are adapted to Western Oregon requires a dedicated breeding effort. BBL green beans have higher yield potential than those bred for the Midwestern U.S. A factor contributing to BBL pod quality is that these types typically have very low fiber pods. 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 have the potential to cause heavy yield loss, but it can adversely affect pod quality and cause rejection of whole lots at the processing plant if moldy pods in the lot exceeds 3%. The growing environment in western Oregon is favorable to disease development, especially during cooler and moist conditions that may occur anytime during the growing season. The disease is mainly controlled by fungicide application, which requires precise timing and can be expensive especially if two sprays are used. Biological control also has potential but is expensive has not been implemented on a wide scale. If genetic variation exists, resistance is usually the most efficient means of achieving control of any disease, as the costs associated with control of that disease are internalized in the cost of the seed. White mold disease resistance is no exception to this principle.

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 work supported by the USDA National Sclerotinia Initiative involving meta-QTL analysis revealed that there are 17 factors contributing to resistance distributed throughout the bean genome. More recently, we conducted a genome wide association study (GWAS) and identified 39 regions of the bean genome that harbor resistance. These resistance factors can be combined in the same variety which 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 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 are only beginning to understand what resistance factors they possess, and have begun crossing to these to introgress from these resistance sources.

From the scarlet runner derived materials, we have several snap bean germplasm lines that have significant levels of resistance. WMG904-20-3 resistance was recently characterized in a recombinant inbred population where we found a major factor for resistance residing on common bean linkage group

8. We are using these newly identified resistance sources in our breeding program. These include 'Unidor', 'Cornell 501' and 'Idaho Refugee'. We have advanced lines with the latter two in evaluation and our work to incorporate resistance from Unidor is currently at earlier generations. These need further evaluation for resistance, yield and quality. 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 mold resistance
    b. Improved plant architecture
    c. High economic yield
    d. Improved pod quality (including straightness, color, smoothness, texture, flavor and quality retention, and delayed seed size development)
    e. Tolerance to abiotic stresses

**3.c. SIGNIFICANT FINDINGS**

- A yield trial of 23 OSU experimental lines and six checks revealed many that showed high yields and good quality. These lines had also performed well in 2020 yield and processing trials, and in white mold trials in 2019.
- Six experimental lines again had high yields and good quality and are promising lines to consider for release.
- A trial with 28 commercial entries, three checks and two OSU experimental lines was also evaluated for yield, quality and pods were frozen for processing evaluation. One commercial entry was a wax bean, the remainder were green beans of different types. Several lines showed BBL characteristics and out yielded OSU5630.
- We experienced a second year of little white mold disease in the field. Incidence was higher than in 2020 and in addition, there was significant incidence of gray mold.

**3.d. METHODS**

*Breeding for White Mold Resistance:* Because of the overriding need for white mold resistant snap bean cultivars, breeding for white mold resistance continues to be the primary objective of the breeding program.

The focus in 2021 was to evaluate advanced lines that are potentially resistant to white mold. We screened 989 experimental lines in intermediate generations and 30 advanced lines with the greenhouse-based straw test. In the field, we planted 27 advanced experimental lines along with two susceptible and two partially resistant check cultivars into a randomized complete block design with 3 reps for evaluating white mold reaction in the field. At flowering, the plots were given a short (30 min.) irrigation every evening to create conditions conducive to disease development.

*Varietal Development:* The program continued with crosses among elite lines and the best white mold resistant lines. Pedigree and single seed descent breeding methods were used to advance and select early generation materials. While the emphasis was on breeding for white mold resistance, we also continued to incorporate improved plant architecture and conduct yield and processing trials of the best lines. We placed 9 of the 23 lines identified in 2019 and 2020 as having high yields, white mold resistance and acceptable quality, along with two check cultivars in a replicated yield trial to evaluate yield and quality. An additional 20 advanced lines were included in this trial along with six check cultivars. The yield and quality trial consisted of three reps arranged in a randomized complete block design and planted into 20 ft. single row plots with 30" row spacing. The trial was planted May 15. Five-foot sections of each plot were harvested up to three times to obtain data on graded yield and raw product evaluation. Lines were also evaluated for growth habit and graded samples were evaluated for pod smoothness, straightness, seed to pod ratio, and color. Those that met expectations in the raw product evaluation were frozen for evaluation of the processed product.

We also conducted a second trial of commercial snap bean lines and cultivars. It was planted June 15 in a similar manner to the first trial, except six reps were planted, of which four were harvested for evaluation. Otherwise the harvest and evaluation procedures were the same.

A sample display was conducted Dec. 1 at the OSU Pilot Plant where panelists evaluated snap bean samples for quality attributes. Due to Covid 19 restrictions, access to the evaluation was limited to OSU faculty, staff and students. Data collected from panelists is being compiled and analyzed. We plan to hold a sample display in late winter 2021 at Oregon Processed Vegetable Growers meeting where growers, processors and seedsmen will be invited to take part.

*Advanced Lines:* Seed increase, roguing, and sub-line maintenance of the historical releases continued. Seed quality of OSU advanced lines will be quantified using germination damage tests that are standard in the industry. In short, seeds are dropped onto a steel plate, and then subjected to cold (10°C) germination tests.

**3.e. RESULTS & DISCUSSION**

*Varietal Development*: In 2021, we grew 877 plots in the early generation nursery. Plots consisted of populations and lines at various stages of inbreeding. In the early generation nurseries, there were 250 advanced lines, the remainder being populations at various stages of advance.

*Yield Trials*: For the first trial (Table 1), most experimental entries fell into the 5 to 6 (full) sieve classes (50-60% 1-4 sieve) with two lines judged to be more of a 4 or 4-5 sieve bean (Table 2). Maturities ranges from 76 to 83 days, reflecting a cool spring despite the heat dome of early June. This high temperature event came before lines in the trial were in flower, so had negligible effect on yields, although it might have contributed to the delay in maturities. OR5630 was moderately high yielding with 9.9 T/A (10.5 T/A adjusted) with three experimental lines with yields significantly higher than the check. Our 4-sieve check, Savanah had a yield of 7.8 T/A which was significantly lower than OSU5630. We calculated pod filling efficiency, which is yield divided by days to harvest and gives an estimate of rate of gain in yield per day. It essentially paralleled yield *per se* supporting the idea that highest yielding genotypes are those with the most rapid photosynthate accumulation.

None of the experimental lines had oval pods and only one had a tendency towards heart-shaped pod cross-section. Pods of three lines appeared to be slightly lighter green in color compared to OSU5630, but all pods will need to be evaluated after processing (Table 3). Seed development by sieve size and harvest date is shown in table 4. Most lines showed typical BBL full seed development by the time of harvest. Quality and flavor data from the sample display is shown in table 5. This was a non-blind evaluation so there may be some bias to evaluations as shown by the high score for OSU5630 checks. Among experimental lines, OSU7248 OSU7273and OSU7290 received relatively high ratings.

*Commercial Green Bean Trial*: This trial had 28 commercial entries, three check cultivars and two OSU experimental full sieve types (Table 6). Six commercial lines submitted for trial were 5- or full-sieve, but the other ranged from extra fine (2 sieve) types to whole bean (3 & 4 sieve) types. One entry was a wax bean while the remainder were green beans. Overall yields were similar to slightly lower in this trial compared to the first in the season, ranging from about 4.7 – 11.5 T/A at prime harvest (Table 7). We found in this trial that we were often surprised by how rapidly the beans were maturity – perhaps due to high temperatures moving the trial along. OSU 5630 yielded 9.8 T/A with no other lines showing significantly higher yields. Among the highest yielding commercial lines were the RR lines from Pure Line Seeds (Table 8). Raw product quality for most was acceptable although several had pod color too light to blend with BBL types (Table 9). Seed size development notes during successive harvests are in table 10.

*White Mold Trial:* In the winter 2021 greenhouse, 959 experimental lines were evaluated for white mold reaction using the straw test (Figure 1). Five-hundred eighty-nine lines (61%) had scores equal to four or less and were retained in the program; the remainder were dropped. A field trial of advanced lines planted mid-summer was timed to mature during the fall when temperatures moderate and leaf wetness periods increase. In the past two decades, we have consistently achieved conditions conducive to disease development, whereas other times during the season may be hit and miss. In 2020, trial maturation coincided with the extreme dry conditions that led to wildfires and heavy smoke in the valley, and no white mold symptoms developed. In 2021, fall conditions were again warm and dry, but transitioned to cool and rainy, which allowed some disease development, but not as fully as desired. We conducted one field trial evaluation of advanced experimental lines and obtained some data on both white mold and gray mold incidence (Table 11). Over the years, we have observed that white mold may have a suppressive effect on gray mold, because in trials where white mold incidence is low, there is often a higher than normal incidence of gray mold. In addition to the field screening, we also tested advance lines with the straw test in the winter greenhouse to obtain severity scores for white mold (Table 12). Of the six advanced lines of greatest interest, three showed moderately high levels of resistance (two not significantly different from NY6020-4) and three appeared to be more similar to the susceptible check.

Advanced lines for release: Table 13 summarizes three years of yield data along with disease reaction for nine advanced lines that show the most promise for release. These have all been shown to have acceptable quality. OSU7318 is a consistently high yielding line with excellent quality, but while it appears to be more resistant to white mold, is among the worst performers for this group of advanced lines. OSU7199 has a high average yield, but performance has been variable across years. It does, however, have very good white mold resistance. Another line of interest is OSU7066 with relative high yield and very good white mold reaction. We are currently scaling up production of these and other lines for potential release to seed companies.

**4. BUDGET DETAILS**

| **1) Breeding (Myers)** | |
|---|---|
| | |
| **Salaries and benefits** | |
| Faculty Research Assistant | $17,462 |
| OPE @ 75.4% | $13,107 |
| **Wages and benefits** | |
| Student Wages | $0 |
| OPE @10% | $0 |
| **Supplies** | $500 |
| **Travel** | $0 |
| **Land and greenhouse rental** | $0 |
| | |
| **Total** | $31,070 |

| | |
|---|---|
| | |
| **2) Processing Evaluation (Wiegand)** | |
| | |
| **Salaries and benefits** | |
| Faculty Research Assistant | $3,242 |
| OPE @ 61.59% | $1,997 |
| **Wages and benefits** | |
| Student wages | $1,780 |
| OPE @ 10% | $196 |
| **Supplies** | $1,300 |
| | |
| Total | $8,515 |
| | |
| **Grand Total** | **$39,584** |

| **Contributions of the OSU breeding program** | |
|---|---|
| | |
| Student Wages | $9,500 |
| OPE @ 10% | $950 |
| Supplies | $500 |
| Travel | $93 |
| Land and greenhouse rental | $9,120 |
| Total | $20,163 |

**BUDGET NARRATIVE**

**Request to OPVC:**
Salary and OPE is requested for a full-time faculty research assistant who will commit 40% FTE to green bean breeding. OPE is 71.3%. A Food Science and Technology faculty research assistant will commit approximately 0.05 FTE to processing of entries from green bean trials; the remainder of salary to come from other sources. Undergraduate student wages of $1,780 are requested for the processing program with 10% OPE. $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 $9,120 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, $93 is estimated. Land use rental at the OSU Vegetable Research Farm consists of five acres at $1,390 per acre and greenhouse rental of 2,123 $ft^2$ at $1.55 per square foot.

**Table 1. Experimental green bean lines and check cultivars grown in a yield and processing evaluation trial at the OSU Vegetable Research Farm in 2021. Highlighted lines are those of particular interest for release.**

| No. | Line | Pedigree | Predominant sieve size |
|---|---|---|---|
| 1 | Cornell501 | (check) | 5 |
| 2 | NY6020-4 | (check) | 5 |
| 3 | OSU5630 | (check) | 5-6 |
| 4 | Sahara | (check) | 4 |
| 5 | Pierroton | (check) | 2 |
| 6 | Redon | (check) | 2 |
| 7 | OSU7066 | 5630/Cornell 501 | 6 |
| 8 | OSU7069 | 5630/Cornell 501 | 6 |
| 9 | OSU7152 | 5630/6771 | 6 |
| 10 | OSU7187 | 6443/6772 | 6 |
| 11 | OSU7199 | 6792/6443 | 6 |
| 12 | OSU7208 | 6792/6443 | 6 |
| 13 | OSU7221 | 6794/5630 | 6 |
| 14 | OSU7226 | 6794/5630 | 5-6 |
| 15 | OSU7248 | 6443/6794 | 6 |
| 16 | OSU7261 | ID Refugee/6443 | 5 |
| 17 | OSU7273 | 5630/6771 | 6 |
| 18 | OSU7281 | 5630/6771 | 6 |
| 19 | OSU7290 | 5630/6771 | 6 |
| 20 | OSU7292 | 5630/6771 | 4-5 |
| 21 | OSU7300 | 5630/6771 | 6 |
| 22 | OSU7305 | 5630/6771 | 5 |
| 23 | OSU7306 | 5630/6771 | 5-6 |
| 24 | OSU7318 | 5630/6771 | 6 |
| 25 | OSU7322 | 5630/6792 | 5 |
| 26 | OSU7340 | 6792/5630 | 4 |
| 27 | OSU7341 | 6792/5630 | 6 |
| 28 | OSU7347 | 6793/5630 | 5 |
| 29 | OSU7048 | Banga/5600 | 2-3 |

**Table 2. Yield, yield parameters and sieve size categories for OSU experimental green bean lines grown in a trial planted May 15 at the OSU Vegetable Research Farm in 2021.[z] Color coding: red indicates large while blue indicates relatively small numbers.**

| Entry | Date processed | Harvest (DAP) | Plant stand (No./A) | Ton/A | Adjusted Ton/A | Pod filling efficiency (lb/A/da) | Sieve category (%)[y] % 1-4 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OSU5630 | x | 76 | 193,600 | 9.9 | 10.5 | 261.4 | 55.6 | 3.1 | 15.4 | 29.0 | 29.0 | 40.7 | 3.7 |
| OSU5630 | | 79 | | | | | 40.9 | 1.0 | 8.9 | 27.6 | 27.6 | 49.3 | 9.9 |
| Sahara | x | 76 | 164,241 | 7.8 | 7.8 | 204.8 | 82.0 | 3.1 | 16.4 | 56.3 | 56.3 | 18.0 | 0.0 |
| Pierroton | x | 79 | 157,135 | 5.9 | 5.9 | 148.5 | 100.0 | 29.8 | 70.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| Redon | x | 79 | 192,313 | 5.6 | 5.6 | 142.6 | 100.0 | 22.8 | 69.6 | 7.6 | 0.0 | 0.0 | 0.0 |
| OSU7066 | x | 79 | 190,047 | 11.2 | 10.5 | 283.8 | 43.5 | 2.3 | 5.6 | 11.3 | 24.3 | 38.4 | 18.1 |
| OSU7069 | x | 76 | 164,560 | 8.2 | 9.8 | 217.0 | 68.7 | 5.2 | 11.2 | 18.7 | 33.6 | 28.4 | 3.0 |
| OSU7152 | x | 76 | 179,399 | 5.6 | 6.0 | 148.3 | 56.7 | 4.4 | 7.8 | 12.2 | 32.2 | 37.8 | 5.6 |
| OSU7199 | x | 83 | 166,177 | 9.9 | 8.5 | 239.3 | 35.3 | 2.6 | 5.2 | 9.2 | 18.3 | 30.7 | 34.0 |
| OSU7208 | x | 83 | 192,632 | 8.4 | 8.7 | 201.5 | 54.5 | 4.9 | 7.7 | 14.0 | 28.0 | 30.1 | 15.4 |
| OSU7221 | x | 81 | 186,175 | 8.0 | 6.9 | 196.5 | 36.9 | 3.1 | 6.2 | 10.8 | 16.9 | 33.8 | 29.2 |
| OSU7226 | x | 79 | 179,399 | 8.2 | 8.1 | 207.3 | 49.3 | 2.9 | 6.5 | 12.3 | 27.5 | 42.0 | 8.7 |
| OSU7248 | x | 81 | 165,209 | 6.7 | 7.7 | 166.3 | 64.9 | 9.0 | 18.0 | 17.1 | 20.7 | 22.5 | 12.6 |
| OSU7261 | x | 80 | 176,495 | 10.3 | 7.9 | 257.0 | 26.9 | 1.2 | 2.4 | 5.4 | 18.0 | 56.9 | 16.2 |
| OSU7273 | x | 79 | 171,985 | 13.1 | 12.0 | 330.8 | 42.2 | 1.8 | 4.1 | 10.1 | 26.1 | 49.5 | 8.3 |
| OSU7281 | x | 79 | 175,857 | 10.6 | 8.2 | 269.1 | 27.5 | 1.2 | 4.1 | 8.2 | 14.0 | 46.8 | 25.7 |
| OSU7290 | x | 80 | 188,111 | 13.3 | 11.4 | 332.5 | 35.7 | 1.5 | 3.5 | 6.5 | 24.1 | 54.3 | 10.1 |
| OSU7292 | x | 76 | 188,441 | 7.6 | 7.7 | 198.7 | 52.0 | 4.9 | 6.5 | 9.8 | 30.9 | 43.9 | 4.1 |
| OSU7300 | | 76 | | | | | 71.4 | 8.7 | 11.1 | 16.7 | 34.9 | 28.6 | 0.0 |
| OSU7300 | x | 79 | 189,728 | 10.0 | 9.5 | 252.9 | 44.7 | 2.5 | 5.0 | 11.8 | 25.5 | 46.0 | 9.3 |
| OSU7305 | x | 79 | 190,377 | 12.7 | 12.8 | 320.5 | 51.5 | 1.9 | 5.3 | 13.1 | 31.1 | 41.7 | 6.8 |
| OSU7306 | x | 76 | 190,047 | 10.2 | 12.0 | 267.5 | 67.8 | 10.0 | 8.9 | 15.0 | 33.9 | 30.0 | 2.2 |
| OSU7318 | x | 79 | 177,793 | 12.0 | 11.0 | 304.4 | 41.7 | 2.0 | 3.9 | 8.8 | 27.0 | 52.0 | 6.4 |

| Entry | Date pro- cessed | Harvest (DAP) | Plant stand (No./A) | Ton/A | Ad- justed Ton/A | Pod filling efficiency (lb/A/da) | Sieve category (%)[y] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | % 1-4 | 1 | 2 | 3 | 4 | 5 | 6 |
| OSU7318 | | 80 | | | | | 36.1 | 2.3 | 3.2 | 5.9 | 24.7 | 57.5 | 6.4 |
| OSU7322 | x | 80 | 180,048 | 10.9 | 10.4 | 271.5 | 45.4 | 2.2 | 5.4 | 10.8 | 27.0 | 48.6 | 5.9 |
| OSU7340 | x | 81 | 193,600 | 8.8 | 8.8 | 218.0 | 81.7 | 7.0 | 9.9 | 22.5 | 42.3 | 18.3 | 0.0 |
| OSU7341 | x | 79 | 189,728 | 10.6 | 8.1 | 267.6 | 26.6 | 0.6 | 2.3 | 6.4 | 17.3 | 45.7 | 27.7 |
| OSU7347 | x | 80 | 184,569 | 9.5 | 8.8 | 238.1 | 42.3 | 2.6 | 6.4 | 9.6 | 23.7 | 48.7 | 9.0 |
| OSU7048 | x | 80 | 152,295 | 6.4 | 6.4 | 161.2 | 100.0 | 12.6 | 56.8 | 27.0 | 3.6 | 0.0 | 0.0 |
| LSD 0.05 | | | 26,951 | 2.5 | 2.4 | 63.8 | | | | | | | |

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

**Table 3. Pod quality parameters, flavor and notes on green bean lines and cultivars grown in a trial planted May 15 at the OSU Vegetable Research Farm in 2021.**

| | Pod | | | | | | | Flavor[z] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Entry | Harvest (DAP) | Mainsieve size | Length (cm) | Straightness[z] | Cross-section shape[y] | Smoothness[z] | Color[x] | Sweetness | Astringency | Perfuminess | Notes[w] |
| **OSU5630** | 76 | 5-6 | 15 | 5 | r | 5 | 5 | 7 | 7 | 1 | Some blanks & polywogs oval mix |
| **OSU5630** | 79 | | | | | | | | | | Very seedy 6 sv but other svs good quality |
| **Sahara** | 76 | 4 | 14 | 6 | r | 9 | 7 | 3 | 7 | 1 | Some blanks & polywogs; |
| **Pierroton** | 79 | 2 | 12 | 9 | r | 7 | 4 | 7 | 9 | 3 | Has held up well in the heat |
| **Redon** | 79 | 2 | 14 | 7 | r | 9 | 3 | 7 | 9 | 3 | |
| **OSU7048** | 80 | 2-3 | 11 | 9 | r | 7 | 6 | 7 | 9 | 3 | Nice appearance and has held up well in the heat |
| **OSU7066** | 79 | 6 | 17 | 5 | r-cb | 5 | 5 | 7 | 7 | 1 | Flats in 3 & 4 sv |
| **OSU7069** | 76 | 5 | 13 | 7 | h-r | 7 | 5 | 8 | 7 | 1 | Medium length 5 sv; 6 sv very seedy |
| **OSU7152** | 76 | 6 | 17 | 6 | r-cb | 7 | 7 | 7 | 7 | 1 | Long attractive pods. Slow seed development |
| **OSU7199** | 83 | 6 | 15 | 5 | r | 5 | 5 | 5 | 5 | 1 | Seems to have a split in 6 sv - some w/ little seed dev., others w/ a lot; upright in the field but doesn't have the pods to drag it down |
| **OSU7208** | 83 | 6 | 16 | 5 | r | 5 | 5 | 7 | 7 | 1 | Easy picker, but low yield & late, split in 6 sv. |
| **OSU7221** | 81 | 6 | 18 | 7 | r | 9 | 5 | 5 | 7 | 1 | Extraordinarily long pods - up to 20 cm - too long for snippers? Probably a split set in this one |

| | Pod | | | | | | Flavor[z] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Entry | Harvest (DAP) | Mainsieve size | Length (cm) | Straightness[z] | Cross-section shape[y] | Smoothness[z] | Color[x] | Sweetness | Astringency | Perfuminess | Notes[w] |
| **OSU7226** | 79 | 5 | 14 | 5 | r-cb | 3 | 3 | 7 | 7 | 1 | Short pods, low yield & light color - discard |
| **OSU7248** | 81 | 6 | 13 | 5 | r | 5 | 5 | 7 | 7 | 1 | Strong RC. This line is either very in-determinate or bad split set |
| **OSU7261** | 80 | 5 | 14 | 7 | r-cb | 5 | 6 | 7 | 7 | 1 | Short pods many w/ blanks, poly-wogs. |
| **OSU7273** | 79 | 6 | 16 | 5 | r | 7 | 5 | 7 | 5 | 1 | Some blanking |
| **OSU7281** | 79 | 6 | 15 | 5 | r-cb | 5 | 5 | 7 | 9 | 1 | Some blanking; could have been har-vested 7/30 |
| **OSU7290** | 80 | 6 | 15 | 7 | r | 7 | 5 | 7 | 9 | 1 | Dark green interior gel; some blank-ing but otherwise of good quality |
| **OSU7292** | 76 | 5-6 | 12 | 7 | r-cb | 3 | 4 | 5 | 5 | 1 | Short bean that tends to become bumpy |
| **OSU7300** | 76 | 5-6 | 15 | 6 | r | 7 | 5 | 7 | 5 | 1 | Seems to be split set w/ 6 sv v seedy but 5 sv only moderately seedy |
| **OSU7300** | 79 | | | | | | | | | | |
| **OSU7305** | 79 | 6 | 15 | 5 | r | 7 | 5 | 7 | 7 | 1 | Some blanking in 6 sv |
| **OSU7306** | 76 | 6 | 15 | 5 | h-r | 7 | 5 | 7 | 7 | 1 | Double split set in small sv & in 6 sv. 6 sv -ranges from mod - v seedy. Flat mix |
| **OSU7318** | 79 | 5 | 17 | 5 | r-cb | 7 | 7 | 7 | 7 | 1 | Unknown yield problem in 2nd rep. excellent quality even w/ low grade |
| **OSU7318** | 80 | | | | | | | | | | Still good quality |

| Entry | Pod | | | | | | | Flavor[z] | | | Notes[w] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Harvest (DAP) | Mainsieve size | Length (cm) | Straightness[z] | Cross-section shape[y] | Smoothness[z] | Color[x] | Sweetness | Astringency | Perfuminess | |
| **OSU7322** | 80 | 6 | 14 | 5 | r | 5 | 3 | 7 | 7 | 1 | Good quality bean but too light. |
| **OSU7340** | 81 | 4 | 15 | 7 | r-cb | 7 | 5 | 9 | 7 | 1 | Hard to pick & detaches in clusters. Hard to pull -strong roots w/ large & deep taproot. Long straight attractive pods |
| **OSU7341** | 79 | 6 | 14 | 3 | r | 5 | 4 | 7 | 7 | 1 | Short pods, variable color-lots of 2-tone pods, should have been har-vested 7/30 |
| **OSU7347** | 80 | 6 | 12 | 7 | r-cb | 7 | 6 | 7 | 7 | 1 | Pods are short in this trial. Some blanking & polywogs |

[z]Scale of 1 - 9 where 1 is least or worst and 9 is most or best. [y]Scores based on a 1 - 9 scale with 9 darkest. Standard BBL color is rated as 5. [x]r = round, cb = creaseback, h = heart and o =oval. [w]Abbreviations: sv = sieve, dev = development, RC = reverse curve, v = very.

**Table 4. Seed development in different sieve sizes on day of harvest for experimental and check snap bean lines grown in a trial planted May 15 at the OSU Vegetable Research Farm in 2021.**

| Entry | Harvest days after planting | Sieve size[z] 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|
| OSU5630 | 76 | 8 | 6 | 4 | 2 | | |
| OSU5630 | 79 | 9 | 7 | 5 | 3 | | |
| Sahara | 76 | | 5 | 3 | 1 | | |
| Pierroton | 79 | | | | 5 | 3 | 1 |
| Redon | 79 | | | | 5 | 3 | 1 |
| OSU7048 | 80 | | | 9 | 5 | 3 | 2 |
| OSU7066 | 79 | 7 | 6 | 3 | 2 | | |
| OSU7069 | 76 | 9 | 7 | 5 | 2 | | |
| OSU7152 | 76 | 6 | 4 | 2 | 2 | | |
| OSU7199 | 83 | 9-7 | 6 | 4 | 2 | | |
| OSU7208 | 83 | 7 | 5 | 3 | 1 | | |
| OSU7221 | 81 | 8 | 7 | 5 | 3 | | |
| OSU7226 | 79 | 8 | 7 | 5 | 3 | | |
| OSU7248 | 81 | 9 | 7 | 5 | 2 | | |
| OSU7261 | 80 | 8 | 7 | 5 | 2 | | |
| OSU7273 | 79 | 9 | 8 | 5 | 3 | | |
| OSU7281 | 79 | 8 | 6 | 4 | 2 | | |
| OSU7290 | 80 | 9 | 8 | 6 | 4 | | |
| OSU7292 | 76 | 7 | 5 | 3 | 1 | | |
| OSU7300 | 76 | 7 | 5 | 3 | 2 | | |
| OSU7300 | 79 | 7 | 7 | 5 | 2 | | |
| OSU7305 | 79 | 9 | 8 | 5 | 3 | | |
| OSU7306 | 76 | 7 | 5 | 3 | 2 | | |
| OSU7318 | 79 | 8 | 6 | 5 | 3 | | |
| OSU7318 | 80 | | | | | | |
| OSU7322 | 80 | 8 | 7 | 5 | 2 | | |
| OSU7340 | 81 | | 8 | 7 | 5 | | |
| OSU7341 | 79 | 9 | 8 | 6 | 3 | | |
| OSU7347 | 80 | 8 | 7 | 5 | 3 | | |

[z]Scale of 1 - 9 for seed development where 1 = none, 3 = beginning, 5 = moderate, 7 = becoming seedy & 9 = very seedy.

**Table 5. Average scores for processed (frozen samples of the OSU green bean breeding lines evaluated in a sample display, Dec. 1 2021 at the OSU Pilot Plant.**

| | Average Score | | | | % Count (Overall) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Line | Color | Fla-vor | Sweet-ness | Over-all | Worst (1) | 2% | 3% | 4% | Best (5) |
| OSU5630 | 4.1 | 3.4 | 2.9 | 3.6 | 0% | 13% | 13% | 75% | 0% |
| Sahara | 3.9 | 3.2 | 3.1 | 3.3 | 0% | 19% | 38% | 44% | 0% |
| Pierroton | 3.8 | 2.9 | 2.4 | 3.0 | 0% | 31% | 25% | 31% | 0% |
| Redon | 3.1 | 2.7 | 2.3 | 2.7 | 6% | 38% | 31% | 19% | 0% |
| OSU7066 | 4.0 | 3.4 | 3.1 | 3.4 | 0% | 6% | 38% | 44% | 0% |
| OSU7069 | 4.2 | 3.4 | 3.1 | 3.3 | 0% | 13% | 44% | 25% | 6% |
| OSU7152 | 4.0 | 3.2 | 3.5 | 3.2 | 0% | 13% | 44% | 25% | 0% |
| OSU7199 | 3.8 | 3.0 | 2.8 | 3.1 | 6% | 13% | 44% | 25% | 6% |
| OSU7208 | 3.5 | 2.9 | 2.8 | 3.0 | 13% | 6% | 50% | 19% | 6% |
| OSU7221 | 3.9 | 3.0 | 2.7 | 3.1 | 0% | 25% | 25% | 38% | 0% |
| OSU7226 | 3.4 | 3.0 | 2.7 | 3.1 | 6% | 13% | 25% | 31% | 0% |
| OSU7248 | 3.8 | 3.4 | 3.0 | 3.4 | 0% | 0% | 56% | 19% | 6% |
| OSU7261 | 4.2 | 3.4 | 2.9 | 3.2 | 0% | 19% | 56% | 13% | 13% |
| OSU7273 | 3.9 | 3.3 | 2.9 | 3.4 | 0% | 0% | 63% | 25% | 6% |
| OSU7281 | 3.8 | 3.1 | 2.8 | 3.1 | 6% | 13% | 38% | 31% | 0% |
| OSU7290 | 3.5 | 3.5 | 3.2 | 3.6 | 0% | 6% | 38% | 38% | 13% |
| OSU7292 | 3.7 | 3.5 | 3.0 | 3.3 | 0% | 19% | 25% | 31% | 6% |
| OSU7300 | 3.8 | 2.9 | 2.5 | 3.2 | 6% | 13% | 25% | 38% | 0% |
| OSU7305 | 3.6 | 3.2 | 2.6 | 3.2 | 0% | 13% | 44% | 25% | 0% |
| OSU7306 | 3.7 | 3.2 | 3.2 | 3.0 | 13% | 13% | 19% | 38% | 0% |
| OSU7318 | 4.4 | 2.9 | 2.9 | 3.2 | 0% | 31% | 13% | 38% | 6% |
| OSU7322 | 3.5 | 2.9 | 3.2 | 3.1 | 0% | 31% | 25% | 13% | 13% |
| OSU7340 | 3.5 | 2.6 | 2.2 | 2.5 | 13% | 25% | 38% | 6% | 0% |
| OSU7341 | 3.6 | 3.1 | 2.7 | 3.0 | 6% | 25% | 25% | 25% | 6% |
| OSU7347 | 4.4 | 3.6 | 3.0 | 3.5 | 0% | 6% | 25% | 44% | 0% |
| OSU7048 | 3.8 | 3.0 | 2.5 | 2.9 | 6% | 25% | 25% | 31% | 0% |

**Table 6. Commercial snap bean lines and checks grown in a yield trial at the OSU Vegetable Research Farm in 2021.**

| No. | Entry | Source | Predominant sieve size |
|---|---|---|---|
| 1 | OSU5630 | OSU/check | 6 |
| 2 | Sahara | HM/check | 4-5 |
| 3 | Crockett | HM/check | 3 |
| 4 | R201149 | Syngenta | 2-3 |
| 5 | SB4734 | Syngenta | 4 |
| 6 | SB4735 | Syngenta | 4-5 |
| 7 | SB4739 | Syngenta | 4-5 |
| 8 | SB4766 | Syngenta | 4-5 |
| 9 | SB4794 | Syngenta | 3-4 |
| 10 | SB4829 | Syngenta | 4 |
| 11 | Pike | Syngenta | 3-4 |
| 12 | Outlaw | Syngenta | 4 |
| 13 | SV 1136GF | Semnis | 5 |
| 14 | SVGG 1312 | Semnis | 5 |
| 15 | SVGV 2089 | Semnis | 4-5 |
| 16 | SVGG 2097 | Semnis | 4 |
| 17 | Competitor | Semnis | 5-6 |
| 18 | Affirmed | Semnis | 3 |
| 19 | BEX028 | BSC | 3 |
| 20 | BSC897 | BSC | 3-4 |
| 21 | Jackson | BSC | 3-4 |
| 22 | World Cup | BSC | 4-5 |
| 23 | Cosmos | BSC | 4-5 |
| 24 | RR 3005 | PLS | 6 |
| 25 | RR 3006 | PLS | 4 |
| 26 | RR 3009 | PLS | 6 |
| 27 | RR 3011 | PLS | 4-5 |
| 28 | RR 3015 | PLS | 5 |
| 29 | GSVB17 | Seneca | 4-5 |
| 30 | GVS B59 | Seneca | 4 |
| 31 | GVSWB1 | Seneca | 4-5 |
| 32 | OSU 7199 | OSU | 6 |
| 33 | OSU 7347 | OSU | 5 |

**Table 7. Yield and maturity of commercial green bean lines in a yield trial planted June 15 at the OSU Vegetable Research Farm, Corvallis, 2021[z]. Second picking for all entries was considered to be the prime harvest and was sent for processing.**

| Entry | Stand (no./A) | Days to harvest | T/A | Days to harvest | T/A | Days to harvest | T/A | Days to harvest | T/A | T/A (ad-justed)[y] |
|---|---|---|---|---|---|---|---|---|---|---|
| Affirmed | 166,738 | 63 | 8.8 | 65 | 8.3 | 67 | 9.5 | 65 | 8.3 | 8.3 |
| BEX028 | 189,002 | 64 | 6.2 | 66 | 6.1 | | | 64 | 6.2 | 6.2 |
| BSC897 | 183,436 | 64 | 6.9 | 66 | 7.3 | | | 64 | 6.9 | 6.9 |
| Competitor | 184,162 | 59 | 9.1 | 62 | 11.5 | | | 62 | 11.5 | 9.6 |
| Cosmos | 188,276 | 62 | 6.5 | 64 | 6.8 | 66 | 7.5 | 64 | 6.8 | 5.2 |
| Crockett | 163,592 | 62 | 6.0 | 64 | 7.2 | 66 | 8.4 | 64 | 7.2 | 7.2 |
| GSVB17 | 193,600 | 62 | 7.0 | 64 | 8.1 | | | 62 | 7.0 | 6.6 |
| GVS B59 | 193,600 | 62 | 9.4 | 64 | 8.5 | | | 62 | 9.4 | 8.2 |
| GVSWB1 | 193,358 | 63 | 5.2 | 65 | 5.3 | 67 | 6.1 | 63 | 5.2 | 5.2 |
| Jackson | 164,802 | 63 | 4.7 | 65 | 4.7 | 67 | 6.3 | 63 | 4.7 | 4.7 |
| OSU 7199 | 182,710 | 64 | 5.2 | 66 | 8.5 | | | 64 | 5.2 | 5.0 |
| OSU 7347 | 193,600 | 63 | 7.8 | 65 | 9.2 | | | 63 | 7.8 | 7.9 |
| OSU5630 | 191,664 | 62 | 9.8 | 63 | 9.6 | 64 | 9.1 | 62 | 9.8 | 9.8 |
| Outlaw | 193,600 | 63 | 7.1 | 65 | 7.7 | 67 | 7.6 | 65 | 7.7 | 7.7 |
| Pike | 165,528 | 62 | 5.8 | 64 | 7.1 | 66 | 8.9 | 64 | 7.1 | 7.1 |
| R201149 | 190,696 | 62 | 4.7 | 64 | 5.5 | 66 | 5.8 | 62 | 4.7 | 4.7 |
| RR 3005 | 186,340 | 62 | 10.5 | | | | | 62 | 10.5 | 8.4 |
| RR 3006 | 180,532 | 62 | 9.8 | | | | | 62 | 9.8 | 8.6 |
| RR 3009 | 176,418 | 59 | 7.4 | 62 | 10.5 | 64 | 12.0 | 62 | 10.5 | 11.6 |
| RR 3011 | 185,856 | 59 | 11.2 | 62 | 13.1 | | | 59 | 11.2 | 11.2 |
| RR 3015 | 176,660 | 62 | 10.8 | 64 | 10.2 | | | 62 | 10.8 | 11.6 |
| SB4734 | 166,980 | 62 | 7.3 | 64 | 7.7 | | | 62 | 7.3 | 5.4 |
| SB4735 | 193,600 | 62 | 7.3 | 64 | 8.4 | | | 62 | 8.4 | 7.3 |
| SB4739 | 171,820 | 63 | 10.4 | 65 | 11.2 | 67 | 9.3 | 65 | 10.4 | 7.3 |
| SB4766 | 177,870 | 63 | 8.3 | 65 | 8.2 | | | 63 | 8.3 | 10.5 |
| SB4794 | 190,212 | 63 | 8.9 | 65 | 9.1 | | | 63 | 8.9 | 8.0 |
| SB4829 | 181,742 | 62 | 9.1 | 64 | 9.9 | 66 | 9.8 | 62 | 9.9 | 8.9 |
| SV 1136GF | 192,148 | 62 | 7.0 | 64 | 7.1 | | | 64 | 7.0 | 10.1 |
| SVGG 1312 | 162,382 | 62 | 7.4 | 64 | 7.4 | | | 62 | 7.4 | 7.0 |
| SVGG 2097 | 192,632 | 62 | 5.6 | 64 | 5.4 | | | 62 | 5.4 | 7.4 |
| SVGV 2089 | 165,770 | 62 | 4.2 | 64 | 4.9 | 66 | 7.1 | 64 | 4.9 | 5.4 |
| Sahara | 184,404 | 62 | 5.4 | 64 | 6.3 | 66 | 6.2 | 64 | 5.4 | 4.8 |
| World Cup | 192,148 | 62 | 7.1 | 64 | 7.1 | 66 | 7.3 | 62 | 7.1 | 8.3 |
| LSD 0.05 | 16,444 | | 2.0 | | 2.0 | | | | 2.0 | 1.9 |

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

**Table 8. Grades of commercial green bean lines in a yield trial planted June 15 OSU Vegetable Research Farm, Corvallis, 2021.[z]**

| | | | Sieve size | | | | | | | | Sieve sizez | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Entry** | **Proc** | **Date** | **1** | **2** | **3** | **4** | **5** | **6** | **1-4** | **Total** | **1-4** | **1** | **2** | **3** | **4** | **5** | **6** |
| | | | T/A | | | | | | | | % | | | | | | |
| Affirmed | | 63 | 0.3 | 0.5 | 2.0 | 5.0 | 0.7 | 0.0 | 7.8 | 8.5 | 91.3 | 3.6 | 6.2 | 23.1 | 58.5 | 8.7 | 0.0 |
| Affirmed | x | 65 | 0.2 | 0.2 | 1.4 | 5.4 | 0.7 | 0.0 | 7.2 | 7.9 | 91.2 | 2.8 | 2.8 | 17.1 | 68.5 | 8.8 | 0.0 |
| Affirmed | | 67 | 0.1 | 0.2 | 0.5 | 5.1 | 3.4 | 0.0 | 5.8 | 9.2 | 63.0 | 0.9 | 1.9 | 5.2 | 55.0 | 37.0 | 0.0 |
| BEX028 | x | 64 | 0.3 | 1.0 | 3.7 | 0.9 | 0.0 | | 6.0 | 6.0 | 100.0 | 5.8 | 16.7 | 62.3 | 15.2 | 0.0 | |
| BEX028 | | 66 | 0.3 | 0.7 | 3.1 | 1.7 | 0.0 | | 5.8 | 5.8 | 100.0 | 4.5 | 12.8 | 54.1 | 28.6 | 0.0 | |
| BSC897 | x | 64 | 0.3 | 0.7 | 2.8 | 2.7 | | | 6.4 | 6.6 | 98.0 | 4.0 | 10.6 | 42.4 | 41.1 | | |
| BSC897 | | 66 | 0.2 | 0.4 | 2.4 | 3.7 | | | 6.8 | 6.8 | 99.4 | 2.5 | 6.4 | 35.7 | 54.8 | | |
| Competitor | | 59 | 0.3 | 0.4 | 1.0 | 3.4 | 3.2 | | 5.2 | 8.5 | 61.5 | 4.1 | 5.1 | 11.8 | 40.5 | 37.9 | |
| Competitor | x | 62 | 0.3 | 0.3 | 0.6 | 2.4 | 6.8 | | 3.7 | 11.1 | 33.5 | 3.1 | 3.1 | 5.5 | 21.7 | 61.0 | |
| Cosmos | | 62 | 0.1 | 0.3 | 0.5 | 2.0 | 2.8 | | 2.8 | 6.1 | 46.8 | 2.2 | 4.3 | 7.9 | 32.4 | 46.0 | |
| Cosmos | x | 64 | 0.1 | 0.1 | 0.3 | 1.2 | 3.6 | | 1.7 | 6.6 | 26.3 | 1.3 | 2.0 | 4.6 | 18.4 | 53.9 | |
| Crockett | | 62 | 0.3 | 1.2 | 3.1 | 1.0 | 0.0 | | 5.6 | 5.6 | 100.0 | 6.2 | 20.9 | 55.8 | 17.1 | 0.0 | |
| Crockett | x | 64 | 0.3 | 0.9 | 3.9 | 1.7 | 0.0 | | 6.8 | 6.8 | 100.0 | 4.5 | 13.4 | 57.3 | 24.8 | 0.0 | |
| GSVB17 | x | 62 | 0.2 | 0.3 | 0.6 | 2.0 | 3.6 | 0.2 | 3.0 | 6.8 | 44.6 | 2.5 | 4.5 | 8.9 | 28.7 | 52.9 | 2.5 |
| GSVB17 | | 64 | 0.2 | 0.3 | 0.6 | 1.9 | 4.6 | 0.3 | 2.9 | 7.9 | 37.0 | 2.2 | 3.3 | 7.2 | 24.3 | 58.6 | 4.4 |
| GVS B59 | x | 62 | 0.0 | 0.2 | 0.5 | 2.7 | 5.0 | 0.9 | 3.4 | 9.2 | 36.8 | 0.5 | 2.4 | 5.2 | 28.8 | 53.8 | 9.4 |
| GVS B59 | | 64 | 0.0 | 0.2 | 0.5 | 2.3 | 4.5 | 1.3 | 3.0 | 8.8 | 34.2 | 0.5 | 2.0 | 5.4 | 26.2 | 51.5 | 14.4 |
| GVSWB1 | x | 63 | 0.1 | 0.4 | 1.6 | 2.6 | 0.2 | 0.0 | 4.7 | 4.9 | 95.5 | 2.7 | 8.0 | 32.1 | 52.7 | 4.5 | 0.0 |
| GVSWB1 | | 65 | 0.1 | 0.3 | 1.0 | 3.0 | 0.3 | 0.0 | 4.4 | 4.7 | 92.6 | 1.9 | 5.6 | 20.4 | 64.8 | 7.4 | 0.0 |
| Jackson | x | 63 | 0.1 | 0.2 | 0.7 | 2.6 | 0.8 | 0.0 | 3.6 | 4.4 | 81.2 | 3.0 | 4.0 | 14.9 | 59.4 | 18.8 | 0.0 |
| Jackson | | 65 | 0.1 | 0.1 | 0.7 | 2.8 | 0.7 | 0.0 | 3.7 | 4.4 | 85.0 | 3.0 | 3.0 | 15.0 | 64.0 | 15.0 | 0.0 |
| OSU 7199 | x | 64 | 0.3 | 0.3 | 0.5 | 1.2 | 2.0 | | 2.2 | 4.7 | 46.8 | 5.5 | 5.5 | 11.0 | 24.8 | 41.3 | |
| OSU 7199 | | 66 | 0.2 | 0.4 | 0.7 | 1.2 | 3.1 | | 2.5 | 7.9 | 31.3 | 2.7 | 4.9 | 8.8 | 14.8 | 39.0 | |
| OSU 7347 | x | 63 | 0.1 | 0.3 | 0.7 | 2.6 | 3.6 | | 3.8 | 7.4 | 50.9 | 1.8 | 4.1 | 9.9 | 35.1 | 48.0 | |
| OSU 7347 | | 65 | 0.2 | 0.3 | 0.7 | 2.9 | 4.6 | | 4.2 | 8.9 | 47.1 | 2.5 | 3.9 | 7.8 | 32.8 | 52.0 | |
| OSU5630 | x | 62 | 0.3 | 0.4 | 0.8 | 3.2 | 4.4 | 0.2 | 4.8 | 9.4 | 50.9 | 3.7 | 4.2 | 8.8 | 34.3 | 47.2 | 1.9 |
| OSU5630 | | 63 | 0.3 | 0.4 | 0.8 | 3.8 | 3.7 | 0.1 | 5.4 | 9.3 | 58.7 | 3.8 | 4.7 | 8.9 | 41.3 | 40.4 | 0.9 |

| | | | | | | Sieve size | | | | | | | | Sieve sizez | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Entry | Proc | Date | 1 | 2 | 3 | 4 | 5 | 6 | 1-4 | Total | 1-4 | 1 | 2 | 3 | 4 | 5 | 6 |
| Outlaw | | 63 | 0.2 | 0.3 | 1.0 | 4.5 | 0.7 | 0.0 | 5.9 | 6.5 | 90.0 | 2.7 | 4.0 | 14.7 | 68.7 | 10.0 | 0.0 |
| Outlaw | x | 65 | 0.2 | 0.2 | 0.8 | 4.9 | 1.2 | 0.0 | 6.1 | 7.3 | 83.9 | 3.0 | 3.0 | 10.7 | 67.3 | 16.1 | 0.0 |
| Pike | | 62 | 0.4 | 1.0 | 2.4 | 1.6 | 0.0 | | 5.4 | 5.4 | 100.0 | 8.1 | 17.7 | 45.2 | 29.0 | 0.0 | |
| Pike | x | 64 | 0.3 | 0.7 | 2.9 | 2.7 | 0.0 | | 6.7 | 6.7 | 100.0 | 4.6 | 11.1 | 43.1 | 41.2 | 0.0 | |
| Pike | | 66 | 0.2 | 0.5 | 3.0 | 4.7 | 0.0 | | 8.3 | 8.4 | 99.5 | 2.6 | 5.7 | 35.4 | 55.7 | 0.5 | |
| R201149 | x | 62 | 0.5 | 2.0 | 1.7 | 0.1 | | | 4.4 | 4.4 | 100.0 | 12.0 | 46.0 | 40.0 | 2.0 | | |
| R201149 | | 64 | 0.4 | 1.7 | 2.9 | 0.2 | | | 5.2 | 5.2 | 100.0 | 7.6 | 33.6 | 55.5 | 3.4 | | |
| R201149 | | 66 | 0.3 | 1.4 | 3.6 | 0.3 | 0.0 | | 5.5 | 5.5 | 100.0 | 4.7 | 24.4 | 64.6 | 6.3 | 0.0 | |
| RR 3005 | x | 62 | 0.3 | 0.3 | 0.7 | 1.8 | | | 3.0 | 10.1 | 30.3 | 2.6 | 3.0 | 6.5 | 18.2 | | |
| RR 3006 | x | 62 | 0.2 | 0.3 | 0.7 | 2.5 | 5.1 | 0.9 | 3.6 | 9.6 | 37.3 | 1.8 | 2.7 | 6.8 | 25.9 | 53.6 | 9.1 |
| RR 3009 | | 59 | 0.4 | 0.7 | 1.5 | 3.4 | 1.0 | 0.0 | 6.0 | 7.0 | 85.6 | 6.3 | 9.4 | 21.9 | 48.1 | 14.4 | 0.0 |
| RR 3011 | x | 59 | 0.5 | 0.8 | 1.8 | 1.7 | 2.5 | | 4.8 | 7.4 | 64.7 | 7.1 | 10.6 | 24.7 | 22.4 | 34.1 | |
| RR 3011 | | 62 | 0.5 | 0.7 | 1.3 | 4.8 | 5.1 | 0.3 | 7.3 | 12.7 | 57.4 | 3.8 | 5.8 | 10.0 | 37.8 | 39.9 | 2.7 |
| RR 3015 | x | 62 | 0.5 | 0.6 | 0.8 | 3.9 | 3.6 | 0.6 | 5.8 | 10.0 | 58.1 | 4.8 | 6.1 | 7.9 | 39.3 | 35.8 | 6.1 |
| RR 3015 | | 64 | 0.4 | 0.6 | 1.0 | 4.1 | 3.1 | 0.3 | 6.1 | 9.5 | 64.4 | 4.1 | 6.4 | 11.0 | 42.9 | 32.4 | 3.2 |
| Sahara | x | 62 | 0.3 | 0.3 | 0.8 | 3.3 | 0.5 | 0.0 | 4.6 | 5.1 | 90.6 | 5.1 | 6.0 | 15.4 | 64.1 | 9.4 | 0.0 |
| Sahara | | 64 | 0.3 | 0.3 | 0.9 | 3.8 | 0.8 | 0.0 | 5.2 | 6.0 | 87.0 | 4.3 | 4.3 | 15.2 | 63.0 | 13.0 | 0.0 |
| SB4734 | x | 62 | 0.2 | 0.6 | 2.0 | 4.0 | 0.0 | | 6.8 | 6.8 | 99.4 | 3.2 | 8.3 | 29.3 | 58.6 | 0.6 | |
| SB4734 | | 64 | 0.2 | 0.4 | 1.9 | 4.6 | 0.2 | | 7.1 | 7.3 | 97.6 | 2.4 | 5.4 | 26.3 | 63.5 | 2.4 | |
| SB4735 | | 63 | 0.3 | 0.4 | 1.8 | 4.3 | 0.2 | | 6.8 | 7.0 | 96.9 | 3.7 | 6.2 | 25.5 | 61.5 | 3.1 | |
| SB4735 | x | 65 | 0.2 | 0.3 | 1.2 | 5.6 | 0.9 | | 7.3 | 8.1 | 89.3 | 2.1 | 3.2 | 15.0 | 69.0 | 10.7 | |
| SB4735 | | 67 | 0.2 | 0.3 | 1.1 | 6.0 | 1.2 | | 7.5 | 8.8 | 86.1 | 2.0 | 3.0 | 12.4 | 68.7 | 13.9 | |
| SB4739 | x | 63 | 0.3 | 0.5 | 1.0 | 3.3 | 4.5 | 0.3 | 5.1 | 9.9 | 50.9 | 3.1 | 4.8 | 10.1 | 32.9 | 45.6 | 3.5 |
| SB4739 | | 65 | 0.3 | 0.4 | 0.9 | 2.9 | 5.9 | 0.2 | 4.5 | 10.7 | 42.4 | 2.9 | 4.1 | 8.2 | 27.3 | 55.5 | 2.0 |
| SB4766 | x | 63 | 0.1 | 0.2 | 0.6 | 2.7 | 4.2 | | 3.6 | 7.8 | 46.1 | 1.7 | 2.8 | 7.3 | 34.3 | 53.9 | |
| SB4766 | | 65 | 0.2 | 0.2 | 0.3 | 2.4 | 4.7 | | 3.0 | 7.7 | 39.2 | 2.3 | 2.3 | 4.0 | 30.7 | 60.8 | |
| SB4794 | x | 62 | 0.3 | 0.6 | 2.6 | 4.9 | 0.3 | | 8.4 | 8.7 | 96.0 | 4.0 | 6.5 | 29.5 | 56.0 | 4.0 | |
| SB4794 | | 64 | 0.3 | 0.4 | 1.8 | 5.4 | 0.9 | | 7.9 | 8.8 | 90.0 | 3.0 | 5.0 | 20.9 | 61.2 | 10.0 | |
| SB4794 | | 66 | 0.2 | 0.3 | 1.7 | 6.0 | 1.5 | | 8.2 | 9.7 | 84.7 | 1.8 | 2.7 | 18.0 | 62.2 | 15.3 | |

| | | | Sieve size | | | | | | | | Sieve size[z] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Entry** | **Proc** | **Date** | **1** | **2** | **3** | **4** | **5** | **6** | **1-4** | **Total** | **1-4** | **1** | **2** | **3** | **4** | **5** | **6** |
| SB4829 | | 62 | 0.3 | 0.4 | 0.7 | 4.3 | 3.0 | | 5.7 | 8.8 | 65.3 | 4.0 | 5.0 | 7.9 | 48.5 | 34.7 | |
| SB4829 | x | 64 | 0.3 | 0.4 | 0.7 | 3.5 | 4.5 | | 4.9 | 9.4 | 52.3 | 3.7 | 4.2 | 7.4 | 37.0 | 47.7 | |
| SV 1136GF | x | 62 | 0.3 | 0.4 | 0.9 | 3.6 | 1.7 | | 5.1 | 6.8 | 74.5 | 3.8 | 5.7 | 12.7 | 52.2 | 25.5 | |
| SV 1136GF | | 64 | 0.2 | 0.4 | 0.8 | 3.3 | 1.9 | 0.1 | 4.7 | 6.7 | 69.9 | 3.3 | 5.9 | 11.8 | 49.0 | 28.8 | 1.3 |
| SVGG 1312 | x | 62 | 0.3 | 0.5 | 1.1 | 3.7 | 1.7 | | 5.6 | 7.2 | 77.1 | 4.2 | 6.6 | 15.1 | 51.2 | 22.9 | |
| SVGG 1312 | | 64 | 0.2 | 0.3 | 0.9 | 3.7 | 2.0 | | 5.1 | 7.1 | 72.4 | 3.1 | 4.9 | 12.3 | 52.1 | 27.6 | |
| SVGG 2097 | | 62 | 0.2 | 0.3 | 1.0 | 3.0 | 0.7 | | 4.5 | 5.2 | 86.7 | 4.2 | 6.7 | 18.3 | 57.5 | 13.3 | |
| SVGG 2097 | x | 64 | 0.2 | 0.3 | 1.0 | 2.7 | 1.0 | | 4.1 | 5.2 | 79.8 | 3.4 | 5.0 | 18.5 | 52.9 | 20.2 | |
| SVGG 2097 | | 66 | 0.2 | 0.2 | 0.7 | 4.1 | 1.4 | | 5.1 | 6.5 | 78.7 | 2.7 | 3.3 | 10.7 | 62.0 | 21.3 | |
| SVGV 2089 | | 62 | 0.1 | 0.3 | 0.7 | 1.8 | 1.1 | 0.1 | 2.9 | 4.1 | 71.3 | 3.2 | 6.4 | 17.0 | 44.7 | 26.6 | 2.1 |
| SVGV 2089 | x | 64 | 0.1 | 0.2 | 0.4 | 1.7 | 2.3 | 0.2 | 2.4 | 4.8 | 48.6 | 1.8 | 3.6 | 9.0 | 34.2 | 47.7 | 3.6 |
| SVGV 2089 | | 66 | 0.1 | 0.2 | 0.3 | 1.7 | 3.0 | 0.7 | 2.2 | 5.8 | 37.3 | 1.5 | 3.0 | 4.5 | 28.4 | 50.7 | 11.9 |
| World Cup | x | 62 | 0.3 | 0.3 | 0.9 | 2.7 | 2.1 | 0.0 | 4.3 | 6.4 | 66.7 | 4.1 | 5.4 | 14.3 | 42.9 | 32.7 | 0.7 |
| World Cup | | 64 | 0.2 | 0.3 | 0.7 | 3.0 | 2.7 | 0.1 | 4.1 | 6.8 | 59.6 | 2.6 | 3.8 | 9.6 | 43.6 | 39.1 | 1.3 |
| World Cup | | 66 | 0.1 | 0.2 | 0.5 | 2.5 | 3.7 | 0.2 | 3.3 | 7.1 | 46.0 | 1.2 | 2.5 | 6.7 | 35.6 | 51.5 | 2.5 |

[z]Percent calculated as % of total of 1-6 sieve beans. “X” in Proc column indicates harvest that was sent for processing.

**Table 9. Notes on a commercial green bean yield trial planted Jun 15 at the OSU Vegetable Research Farm, Corvallis, 2021. See Table 3 for an explanation of pod cross section shape.**

| Entry | DAP | Sieve size | Pod: Length (cm) | Pod: Straightness[z] | Pod: Cross-sectional shape | Pod: Smoothness[z] | Pod: Color[y] | Flavor[z]: Sweetness | Flavor[z]: Astringency | Flavor[z]: Perfuminess | Notes[x] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **OSU5630** | 62 | 5-6 | 15 | 5 | r | 5 | 5 | 5 | 7 | 1 | Not showing any heat damage to pods ; becoming seedy before pods developed. |
| **OSU5630** | 63 | | | | | | | | | | |
| **OSU5630** | 64 | | | | | | | | | | Becoming pithy |
| **Sahara** | 62 | 4 | 12 | 3 | r | 9 | 6 | 7 | 7 | 1 | Strongly curved in all sv sizes prob due to heat; mixed seed dev in 3 & 4 sv |
| **Sahara** | 64 | | | | | | | | | | Becoming seedy & pithy |
| **Crockett** | 62 | 3-4 | 12 | 9 | r | 9 | 7 | 7 | 3 | 1 | Tough skin; some pod constrictions, ace pods |
| **Crockett** | 64 | | | | | | | | | | Slow seed dev but becoming pithy |
| **Crockett** | 66 | | | | | | | | | | $ flat off type, still excellent quality |
| **Affirmed** | 63 | 4 | 15 | 7 | r | 7 | 5 | 7 | 7 | 1 | Ace & pc pods. Pea seed weevil oviposit marks more visible on pc types. Generally, a nice bean. Mixed seed dev in all sv sizes. |
| **Affirmed** | 65 | | | | | | | | | | Still good quality, short & junky 3 sv |
| **Affirmed** | 67 | | | | | | | | | | Not too seedy but starting to become pithy |
| **BEX028** | 64 | 3-4 | 16 | 7 | r | 7 | 5 | 7 | 5 | 3 | Tough skin |

| Entry | DAP | Sieve size | Pod | | | | | Flavor[z] | | | Notes[x] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Length (cm) | Straight-ness[z] | Cross-sec-tional shape | Smooth-ness[z] | Col-or[y] | Sweet-ness | Astrin-gency | Per-fumi-ness | |
| **BEX028** | 66 | | | | | | | | | | $ ovals, seedy & becoming pithy |
| **BSC897** | 64 | 3-4 | 14 | 7 | oval-round | 7 | 3 | 7 | 7 | 1 | Ace pods, long slender bean, oval mix, mixed sv sz in 3 sv |
| **BSC897** | 66 | | | | | | | | | | Many oval podded plants in plots |
| **Competitor** | 59 | | 5-6 | 15 | 5 | ht | 5 | 5 | | | |
| **Competitor** | 62 | 6 | 14 | 5 | R | 5 | 5 | 5 | 7 | 1 | Larger sv missed the heat, lots of blanking in 3 & 4 sv |
| **Cosmos** | 62 | 6 | 15 | 5 | r-cb | 7 | 3 | 8 | 7 | 1 | Var seed dev in 6 sv, some blanking in 3 sv, grading low but still good quality |
| **Cosmos** | 64 | | | | | | | | | | Yet good quality, var. seed dev w/in 5 & 6 sv; oval mix |
| **Cosmos** | 66 | | | | | | | | | | Still good quality although grading very low |
| **GSVB17** | 62 | 5 | 14 | 3 | r-cb | 7 | 3 | 7 | 7 | 1 | Still good quality even though grading low, short & junky 3 sv |
| **GSVB17** | 64 | | | | | | | | | | |
| **GVS B59** | 62 | 6 | 12 | 5 | cb | 5 | 3 | 7 | 7 | 3 | Short fat pods w/ some blanking in 3, 4 & 5 sv, graded low but still good quality, may have v conc set. |

| Entry | DAP | Sieve size | Pod | | | | | | Flavor[z] | | | Notes[x] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Length (cm) | Straight-ness[z] | Cross-sec-tional shape | Smooth-ness[z] | Col-or[y] | | Sweet-ness | Astrin-gency | Per-fumi-ness | |
| **GVS B59** | 64 | | | | | | | | | | | Very strongly creaseback to the point, not sure they grade accurately |
| **GVSWB1** | 63 | 4 | 14 | 7 | r | 5 | 5 | | 7 | 7 | 1 | Wax bean. Some blanking in smaller sieves; 2 sv some-what greenish |
| **GVSWB1** | 67 | | | | | | | | | | | Still good quality but becom-ing seedy |
| **Jackson** | 63 | 4-5 | 14 | 8 | r | 9 | 6 | | 7 | 7 | 1 | Nice pods but stunted plants & low yield. Var seed sz w/in 4 & 5 sv |
| **Jackson** | 65 | | | | | | | | | | | Still good quality but variable seed dev in 5 sv |
| **Jackson** | 67 | | | | | | | | | | | Very seedy |
| **OSU 7199** | 64 | 6 | 17 | 6 | h | 4 | 6 | | 3 | 5 | 1 | Long pods w/ good color, sl, off flavor |
| **OSU 7199** | 66 | | | | | | | | | | | Strong RC; still, good quality, pick Monday |
| **OSU 7347** | 63 | 5 | 11 | 8 | r | 7 | 6 | | 7 | 7 | 1 | Short pods in this trial, some-what round seeds |
| **OSU 7347** | 65 | | | | | | | | | | | Becoming seedy |
| **Outlaw** | 63 | 4 | 13 | 8 | r | 9 | 8 | | 3 | 5 | 1 | Ace pods |
| **Outlaw** | 65 | | | | | | | | | | | Becoming seedy |
| **Outlaw** | 67 | | | | | | | | | | | Seedy & becoming pithy |
| **Pike** | 62 | | | | | | | | | | | Good stage for 1st pick |

| Entry | DAP | Sieve size | Pod: Length (cm) | Pod: Straight-ness[z] | Pod: Cross-sec-tional shape | Pod: Smooth-ness[z] | Pod: Col-or[y] | Flavor[z]: Sweet-ness | Flavor[z]: Astrin-gency | Flavor[z]: Per-fumi-ness | Notes[x] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pike** | 64 | 3-4 | 16 | 8 | r | 7 | 7 | 7 | 3 | 1 | Short pods & blanks in 3 sv, slow seed dev |
| **Pike** | 66 | | | | | | | | | | Becoming pithy but not seedy |
| **R201149** | 62 | 2-3 | 15 | 7 | r | 9 | 6 | 7 | 7 | 1 | Partial strings, long slender shiny (ace) pods |
| **R201149** | 64 | | | | | | | | | | Becoming seedy |
| **R201149** | 66 | | | | | | | | | | Seedy & becoming pithy |
| **RR 3005** | 62 | 6 | 15 | 6 | cb | 3 | 5 | 7 | 7 | 1 | BBL type, blanking in 3 & 4 sv |
| **RR 3006** | 62 | 6 | 15 | 4 | r-cb | 5 | 5 | 7 | 7 | 3 | A bit fibrous; junky 3 sv; grad-ing low but quality still good |
| **RR 3009** | 59 | 6 | 17.5 | 6 | cb | 6 | 7 | | | | |
| **RR 3009** | 62 | 6 | 15 | 6 | r-cb | 5 | 5 | 5 | 7 | 1 | Seems to have held up well in heat, but seed dev is pro-gressing rapidly |
| **RR 3009** | 64 | | | | | | | | | | Very seedy |
| **RR 3011** | 59 | 4-5 | 14.5 | 4 | cb | 5 | 8 | | | | |
| **RR 3011** | 62 | 5 | 15 | 4 | r-cb | 5 | 5 | 7 | 7 | 1 | Becoming very seedy |
| **RR 3011** | | | | | | | | | | | |
| **RR 3015** | 62 | 6 | 16 | 4 | cb | 5 | 5 | 7 | 5 | 1 | Some blanking in 3 sv |
| **RR 3015** | 64 | | | | | | | | | | Almost mature seed but pods still succulent and green |
| **SB4734** | 62 | 4 | 14 | 7 | r | 9 | 7 | 7 | 5 | 5 | Tough skin & fibrous, rela-tively straight, ex color; has ace |
| **SB4734** | 64 | | | | | | | | | | Becoming pithy |

| Entry | DAP | Sieve size | Pod | | | | | | Flavor[z] | | | Notes[x] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Length (cm) | Straight-ness[z] | Cross-sectional shape | Smooth-ness[z] | Color[y] | | Sweet-ness | Astrin-gency | Per-fumi-ness | |
| **SB4735** | 63 | 4 | 14 | 7 | r | 7 | 7 | | 7 | 7 | 1 | Ace pods, generally nice-looking bean |
| **SB4735** | 65 | | | | | | | | | | | Still of good quality |
| **SB4735** | 67 | | | | | | | | | | | Becoming pithy, hard to pick in the field - pods & stems more brittle than pod abscision point |
| **SB4739** | 63 | 6 | 16 | 7 | r | 9 | 6 | | 7 | 5 | 1 | Ace pods, generally nice-looking bean w/ good yield |
| **SB4739** | 65 | | | | | | | | | | | Becoming seedy |
| **SB4766** | 63 | 5 | 14 | 8 | r | 9 | 6 | | 7 | 7 | 1 | Short pods in 3 sv, some w/ blanks; var seed dev in 3 & 4 sv |
| **SB4766** | 65 | | | | | | | | | | | Very seedy |
| **SB4794** | 62 | 4 | 15 | 5 | r-cb | 7 | 6 | | 9 | 3 | 1 | Strings bottom suture; ace pods; some pithy pods in 4 & 5 sv |
| **SB4794** | 64 | | | | | | | | | | | pc type, shows pea seed weevil marks, becoming seedy |
| **SB4794** | 66 | | | | | | | | | | | Becoming pithy |
| **SB4829** | 62 | 4-5 | 13 | 7 | r | 7 | 6 | | 7 | 5 | 1 | Not terribly seedy but becoming pithy & a bit fibrous & stringy |
| **SB4829** | 64 | | | | | | | | | | | A few 6 sv but not enough to weigh |

| Entry | DAP | Sieve size | Pod | | | | | | Flavor[z] | | | Notes[x] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Length (cm) | Straightness[z] | Cross-sectional shape | Smoothness[z] | Color[y] | | Sweetness | Astringency | Perfuminess | |
| **SV 1136GF** | 62 | 4-5 | 14 | 7 | r-cb | 7 | 5 | | 8 | 5 | 1 | Mix seed dev in 3 & 5 sv, short 3 & 4 sv |
| **SV 1136GF** | 64 | | | | | | | | | | | Quality ok but becoming seedy |
| **SVGG 1312** | 62 | 4 | 14 | 4 | oval-round | 7 | 7 | | 7 | 7 | 1 | Ace pods; oval tendency, nice 2 sv; |
| **SVGG 1312** | 64 | | | | | | | | | | | Slow seed dev |
| **SVGG 2097** | 62 | 4 | 14 | 6 | r | 7 | 6 | | 5 | 7 | 5 | |
| **SVGG 2097** | 64 | | | | | | | | | | | Slow seed dev. blanks & polywogs in 3 sv |
| **SVGG 2097** | 66 | | | | | | | | | | | Still decent quality although 5 sv becoming seedy |
| **SVGV 2089** | 62 | 4-5 | 15 | 4 | r-cb | 6 | 4 | | 7 | 7 | 1 | A few blanks in 3 & 4 sv |
| **SVGV 2089** | 64 | | | | | | | | | | | Becoming seedy but still good quality; junky 3 & 4 sv |
| **SVGV 2089** | 66 | | | | | | | | | | | 3 sv mostly polywogs; quality ok & not too seedy |
| **World Cup** | 62 | 5 | 15 | 6 | r | 7 | 5 | | 7 | 7 | 1 | Round seed, ace pods |
| **World Cup** | 64 | | | | | | | | | | | |
| **World Cup** | 66 | | | | | | | | | | | Still good quality |

[z]Scale of 1 - 9 where 1 is least or worst and 9 is most or best. [y]Scores based on a 1 - 9 scale with 9 darkest. Standard BBL color is rated as 5. [x]Abbreviations: sv = sieve, sz = size, $ = segregating, Ace = shiny pods, pc = persistent color, conc = concentrated, RC = reverse curve, BBL = bush blue lake, CB = creaseback, WM = white mold.

**Table 10. Seed development of lines in snap bean yield trial planted June 15 and grown at the Vegetable Research Farm in 2021. Red highlighting indicates high values of the scale while blue indicates low values.**

| | | Seed development in sieve size:[z] | | | | | |
|---|---|---|---|---|---|---|---|
| **Entry** | **DAP** | **6** | **5** | **4** | **3** | **2** | **1** |
| OSU5630 | 62 | 8 | 7 | 6 | 3 | | |
| OSU5630 | 63 | 9 | 9 | 5 | 4 | | |
| OSU5630 | 64 | 9 | 9 | 7 | 5 | | |
| Sahara | 62 | | 7 | 5 | 3 | | |
| Sahara | 64 | | 9 | 7 | 7 | | |
| Crockett | 62 | | | 4 | 2 | 1 | |
| Crockett | 64 | | | 5 | 3 | 2 | |
| Crockett | 66 | | | 7 | 5 | 3 | |
| Affirmed | 63 | | 5 | 4 | 3 | | |
| Affirmed | 65 | | 5 | 4 | 2 | | |
| Affirmed | 67 | | 7 | 5 | 2 | | |
| BEX028 | 64 | | | 5 | 4 | 2 | |
| BEX028 | 66 | | | 8 | 7 | 5 | |
| BSC897 | 64 | | 6 | 4 | 3 | 2 | |
| BSC897 | 66 | | 8 | 7 | 5 | | |
| Competitor | 59 | 5 | 5 | 2 | 1 | | |
| Competitor | 62 | 8 | 8 | 6 | 4 | | |
| Cosmos | 62 | 6 | 5 | 3 | 2 | | |
| Cosmos | 64 | 7 | 5 | 3 | 2 | | |
| Cosmos | 66 | 7 | 7 | 5 | 3 | | |
| GSVB17 | 62 | 7 | 6 | 4 | 2 | | |
| GSVB17 | 64 | 9 | 8 | 4 | 2 | | |
| GVS B59 | 62 | 7 | 6 | 5 | 2 | | |
| GVS B59 | 64 | 9 | 8 | 8 | 7 | | |
| GVSWB1 | 63 | | 6 | 4 | 3 | 2 | |
| GVSWB1 | 67 | | 8 | 7 | 3 | | |
| Jackson | 63 | | 5 | 5 | 3 | | |
| Jackson | 65 | | 6 | 4 | 3 | | |
| Jackson | 67 | | 9 | 8 | 7 | | |
| OSU 7199 | 64 | 8 | 6 | 4 | 2 | | |
| OSU 7199 | 66 | 8 | 7 | 6 | 4 | | |
| OSU 7347 | 63 | 8 | 6 | 5 | 3 | | |
| OSU 7347 | 65 | 9 | 8 | 7 | 3 | | |
| Outlaw | 65 | | 7 | 7 | 5 | | |
| Outlaw | 67 | | 9 | 8 | 7 | | |
| Pike | 64 | | | 3 | 3 | 2 | |
| Pike | 66 | | 7 | 7 | 6 | 2 | |
| R201149 | 62 | | | 5 | 5 | 3 | 2 |

| Entry | DAP | Seed development in sieve size:[z] 6 | 5 | 4 | 3 | 2 | 1 |
|---|---|---|---|---|---|---|---|
| R201149 | 64 | | | 7 | 5 | 5 | |
| R201149 | 66 | | | 8 | 8 | 5 | |
| RR 3005 | 62 | 8 | 8 | 5 | 3 | | |
| RR 3006 | 62 | 7 | 6 | 3 | 2 | | |
| RR 3009 | 59 | 5 | 5 | 3 | | | |
| RR 3009 | 62 | 7 | 7 | 6 | 3 | | |
| RR 3009 | 64 | 9 | 9 | 7 | 7 | | |
| RR 3011 | 59 | 5 | 5 | 3 | 1 | | |
| RR 3011 | 62 | 9 | 9 | 7 | 5 | | |
| RR 3015 | 62 | 7 | 6 | 5 | 4 | | |
| RR 3015 | 64 | 9 | 9 | 7 | 5 | | |
| SB4734 | 62 | | 7 | 5 | 3 | 1 | |
| SB4734 | 64 | | 9 | 7 | 5 | | |
| SB4735 | 63 | | 4 | 4 | 3 | 1 | |
| SB4735 | 65 | | 6 | 5 | 3 | | |
| SB4735 | 67 | | 7 | 5 | 4 | | |
| SB4739 | 63 | 7 | 5 | 3 | 2 | | |
| SB4739 | 65 | 8 | 8 | 5 | 4 | | |
| SB4766 | 63 | | 8 | 7 | 5 | | |
| SB4766 | 65 | | 9 | 7 | 5 | | |
| SB4794 | 62 | | 7 | 4 | 3 | 1 | |
| SB4794 | 64 | | 5 | 4 | 3 | | |
| SB4794 | 66 | | 9 | 7 | 5 | | |
| SB4829 | 62 | | 7 | 6 | 3 | | |
| SB4829 | 64 | 9 | 8 | 6 | 3 | | |
| SV 1136GF | 62 | | 7 | 4 | 3 | | |
| SV 1136GF | 64 | | 8 | 6 | 5 | 3 | |
| SVGG 1312 | 62 | | 5 | 4 | 2 | | |
| SVGG 1312 | 64 | | 5 | 3 | 2 | | |
| SVGG 2097 | 62 | | 5 | 3 | 2 | | |
| SVGG 2097 | 64 | | 5 | 4 | 2 | | |
| SVGG 2097 | 66 | | 8 | 6 | 4 | | |
| SVGV 2089 | 62 | 5 | 4 | 3 | 2 | | |
| SVGV 2089 | 64 | 7 | 6 | 5 | 2 | | |
| SVGV 2089 | 66 | 8 | 7 | 5 | 3 | | |
| World Cup | 62 | 7 | 6 | 5 | 2 | | |
| World Cup | 64 | 7 | 6 | 4 | 3 | | |
| World Cup | 66 | 8 | 8 | 7 | 5 | | |

[z]Scale of 1-9 where 1 = no development, 3 = seed development beginning, 5 = moderate seed development, 7 = seedy appearance, 9 = very seedy appearance.

**Table 11. Incidence and severity for white mold and gray mold in a field trial at the OSU Vegetable Research Farm in 2021.**

| | White mold | | Gray Mold | |
|---|---|---|---|---|
| **Line** | **Incidence (%)** | **Severity[z]** | **Incidence (%)** | **Severity+** |
| 7066 | 0.0 | 1.0 | 0.0 | 1.0 |
| 7069 | 0.0 | 1.0 | 0.0 | 1.0 |
| 7152 | 1.7 | 1.7 | 0.0 | 1.0 |
| 7182 | 0.0 | 1.0 | 1.7 | 2.0 |
| 7199 | 0.0 | 1.0 | 0.7 | 1.3 |
| 7208 | 0.0 | 1.0 | 1.7 | 2.3 |
| 7221 | 3.3 | 2.3 | 0.0 | 1.0 |
| 7226 | 0.0 | 1.0 | 0.0 | 1.0 |
| 7235 | 0.0 | 1.0 | 3.3 | 2.3 |
| 7248 | 0.0 | 1.0 | 0.0 | 1.0 |
| 7260 | 0.0 | 1.0 | 0.0 | 1.0 |
| 7261 | 0.0 | 1.0 | 0.0 | 1.0 |
| 7273 | 0.0 | 1.0 | 0.0 | 1.0 |
| 7276 | 0.0 | 1.0 | 0.0 | 1.0 |
| 7279 | 0.0 | 1.0 | 0.0 | 1.0 |
| 7281 | 0.7 | 2.3 | 0.0 | 1.0 |
| 7290 | 0.0 | 1.0 | 0.7 | 1.3 |
| 7292 | 0.0 | 1.0 | 0.7 | 1.7 |
| 7300 | 0.0 | 1.0 | 0.0 | 1.0 |
| 7305 | 0.0 | 1.0 | 0.0 | 1.0 |
| 7306 | 0.0 | 1.0 | 2.3 | 2.0 |
| 7312 | 0.0 | 1.0 | 0.7 | 1.3 |
| 7318 | 0.0 | 1.0 | 0.0 | 1.0 |
| 7322 | 0.7 | 2.7 | 0.0 | 1.0 |
| 7340 | 0.0 | 1.0 | 0.0 | 1.0 |
| 7341 | 1.3 | 3.3 | 0.0 | 1.0 |
| 7347 | 3.3 | 2.3 | 0.3 | 1.3 |
| 91G | 0.0 | 1.0 | 18.3 | 3.0 |
| Cornell | 0.0 | 1.0 | 3.3 | 2.3 |
| NY6020 | 0.0 | 1.0 | 0.7 | 1.7 |

[z]1 - 9 scale where 1 = low severity.

**Table12. White mold severity scores for OSU experimental advanced green bean lines grown in the green house and evaluated with the straw test in 2021. Scale of 1 - 9 where 1 = resistant and 9 = highly susceptible.**

| Line | Severity score |
|---|---|
| **NY6020-4** | 3.8 |
| 7199 | 4.4 |
| 7066 | 4.8 |
| 7187 | 4.8 |
| 7221 | 4.9 |
| 7322 | 5.4 |
| Cornell 501 | 5.6 |
| 7261 | 6.0 |
| 7276 | 6.1 |
| 7290 | 6.2 |
| 7208 | 6.3 |
| 7306 | 6.3 |
| 7069 | 6.3 |
| 7226 | 6.3 |
| 7341 | 6.3 |
| 7281 | 6.4 |
| 7248 | 6.5 |
| 7300 | 6.6 |
| 7305 | 6.6 |
| 7312 | 6.6 |
| 7182 | 6.8 |
| 7292 | 6.8 |
| 7347 | 6.8 |
| 7279 | 6.9 |
| 7273 | 7.0 |
| 7235 | 7.2 |
| 7340 | 7.2 |
| 7260 | 7.6 |
| 7318 | 7.6 |
| OR91G | 7.7 |
| 7152 | 8.0 |
| OSU5630 | 8.2 |
| LSD 0.05 | 1.1 |

**Table 13. Field productivity and disease resistance parameters for advanced green bean lines grown at the OSU Vegetable Research Farm in 2019 - 2021.**

| | | | | Yield T/A | | | | Yield - % of check | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Entry | Pedigree | Days to harvest | Sieve size[z] | 2019 | 2020 | 2021 | Average | % OSU5630 | % Saraha | % Pier-roton | % 1-4[z] | White mold DSI[y] | Straw test DS[x] |
| OSU5630 (ck) | 5402/91G | 70 | 5.5 | 10 | 13.4 | 9.9 | 11.1 | 100 | 138 | 245 | 53.2 | 14.6 | 8.2 |
| Sahara (ck) | | 69 | 4.0 | 6.1 | 10.3 | 7.8 | 8.1 | 73 | 100 | 178 | 95.1 | 15 | -- |
| OSU7066 | 5630/Cornell 501 | 67 | 6.0 | 11.6 | 7.5 | 11.2 | 10.1 | 91 | 125 | 223 | 54.9 | 1.7 | 4.8 |
| OSU7187 | 6443/6772 | 73 | 6.0 | 11.4 | 9.6 | -- | 10.5 | 95 | 130 | 232 | 48 | 5.6 | 4.8 |
| OSU7199 | 6792/6443 | 74 | 6.0 | 15.8 | 11.9 | 9.9 | 12.5 | 113 | 155 | 276 | 43.8 | -- | 4.4 |
| OSU7261 | ID Refugee/6443 | 73 | 5.0 | -- | 11.2 | 10.3 | 10.8 | 97 | 133 | 237 | 58.3 | 3.6 | 6.0 |
| OSU7281 | 5630/6771 | 69 | 6.0 | 14.5 | 10.9 | 10.6 | 12.0 | 108 | 149 | 265 | 48.3 | 2.4 | 6.4 |
| OSU7318 | 5630/6771 | 70 | 6.0 | 16.6 | 13 | 12 | 13.9 | 125 | 172 | 306 | 54.7 | 6.1 | 7.6 |
| OSU7340 | 6792/5630 | 70 | 4.0 | 10.8 | 10.3 | 8.8 | 10.0 | 90 | 124 | 220 | 93.3 | 1.7 | 7.2 |
| OSU7347 | 6793/5630 | 73 | 5.0 | 13.4 | 12 | 9.5 | 11.6 | 105 | 144 | 257 | 41.1 | 2.8 | 6.8 |
| OSU7048 | Banga/5600 | 64.5 | 2.5 | 5.6 | 6 | 6.4 | 6.0 | 54 | 74 | 132 | 100 | -- | -- |
| Pierroton (ck) | | 62 | 2.0 | 4 | 3.7 | 5.9 | 4.5 | 41 | 56 | 100 | 100 | -- | -- |
| LSD 0.05 | | | | 2.8 | 2.1 | 2.5 | | | | | | | |

**[z]Sieve size is the predominant to maximum sieve size (grades 1 – 6) that is characteristic of the line. [y]White mold DSI (disease severity index) is the geometric mean of percent incidence and severity (scale of 1-10). DSI ranges from 0 to 30 with lower numbers being more resistant. Anything with a DSI <10 shows some resistance. Data is from 2019 and Resistant checks had DSI of 1.0 (Cornell 501) and 4.3 (NY6020-4). [x]Straw test disease severity score conducted in the 2021 greenhouse, scale of 1 - 9 with 1 = resistant. Cornell 501 had a DS or 5.6 and NY6020-4 was 3.8.**

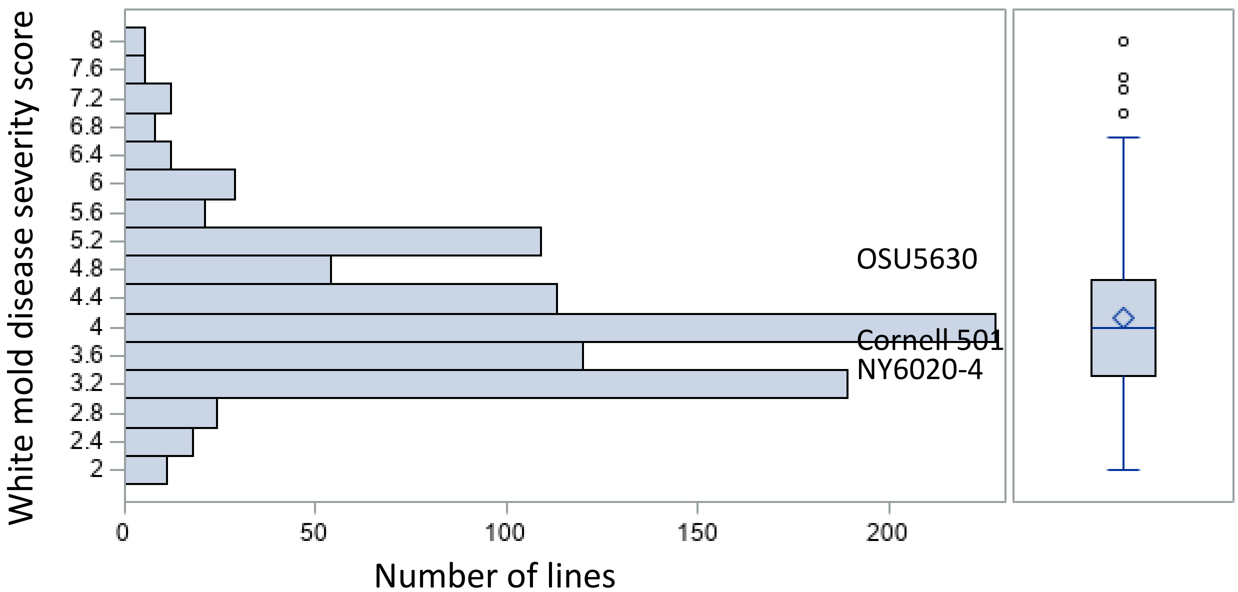


**Figure 1.** Distribution of 959 green bean experimental lines tested for white mold resistance using the straw test performed in the OSU greenhouses in 2021. Two resistant checks (Cornell 501 and NY6020-4) and one susceptible check (OSU5630) are positioned on the graph based on their mean (N = 9) severity score.

**1. PROJECT YEAR**: *2021*

**Project Title**: Broccoli Breeding and Evaluation

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

**Co-PI:** Zak Wiegand
**Telephone**: 541-737-6496
**Email**: Zak.Wiegand@oregonstate.edu
**Address**: Wiegand Hall, Department of Food Science and Technology

**Total project request (all years):**
**Year 1**: **$8,315 (breeding)**
**$5,696 (processing)**
**$14,012 (total)**

**Other funding sources: None**

## 2. EXECUTIVE SUMMARY (ABSTRACT):

Oregon has the climate and infrastructure to produce high quality broccoli for processing. The main constraints are high labor costs and buffering against environmental perturbations. We have been breeding broccoli to be better adapted to mechanical harvest as well as selecting for traits that improve processing quality. The objectives of this project are to breed high yielding broccoli cultivars with excellent processing quality and field productivity that includes exserted, large and firm heads with reduced leaves about the head. Processing traits include segmented heads with uniformly colored, small florets with fine beads and short pedicles. In 2021, we grew the breeding nursery and a replicated yield trial. The yield trial consisted of eight experimental hybrids and two commercial check cultivars and four commercial hybrids that have shown stable performance in heat stress trials. The broccoli plots were planted into field with a recently incorporated cover crop and as a result of the nitrogen tie-up, yields were extremely low. While differing in total yields, all hybrids had similar net yields. OSU experimental lines had reduced leafage around heads and a greater recovery of small (<2.5 in.) florets. Our observation nurseries consisted of 17 inbred lines, 14 F1 hybrids for which we had too little seed to plant in replicated trials, 21 early generation lines, and 11 CMS backcross lines.

## 3. FULL REPORT

### 3.a. BACKGROUND

Oregon has a climate favorable for summer production of broccoli with relatively mild temperatures and a long growing season. The challenges facing broccoli growers are the cost of production and buffering against climate perturbations. The challenges facing processors are finding cultivars with the desired quality and ease of processing characteristics along with productivity. Mechanization has reduced labor costs in many crops, but Cole crop harvest remains relatively non-mechanized. Large labor crews are typically needed to harvest broccoli and cost and access to labor are the two main 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. The industry is progressing towards mechanization but problems remain in developing systems that achieve efficiency in the field and deliver quality product to the processing plant. One difficult aspect of mechanical harvest in particular appears to be the removal of leaves from around the head.

The three pieces that have to be joined to achieve efficient mechanization are the production system, the harvest equipment, and the plant genetics. Our program focuses on the plant genetics. The OSU broccoli breeding program has worked for over 25 years to develop cultivars that have architectural traits that make the cultivar more amenable to machine harvest.

The two key factors for developing cultivars suitable to machine harvest 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 a challenge for machine harvest.

In the processing plant, traits that would increase the efficiency of the process include reducing leaves around the head and minimizing large floret size. Historically, leaves around the head have been removed by the harvester when harvested by hand. Leaf removal by machine has proved more difficult with the result that heads coming into the plant carry too much vegetative matter, resulting in the rejection of lots. Florets larger than 2½ inches have to be recut, which decreases processing efficiency; plants with small florets would be preferred over those with high yields but large florets. Emphasis for most commercial hybrids has been on large, dense heads on short-stature plants. As a result, these have many large leaves around the head, and achieve high head weight by producing larger florets. These are traits that are amenable to breeding and our exserted head materials already have fewer leaves and smaller florets with the main challenge with these hybrids being achieving high levels of productivity in this architectural package. Other quality traits needed in a processing broccoli include florets and stems that are uniformly dark green in color and shape; and beads that are small and retained during the blast freezing process.

Disease resistances that are desirable include bacterial head rot, downy mildew, and club root resistances. 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, but to bring these into commercial production, cytoplasmic male sterility needs to be backcrossed into inbreds used as the female in crosses. There is also a need to derive new inbreds with improved disease resistance.

**3.b OBJECTIVES**

1. Breed broccoli cultivars with excellent processing quality and field productivity.
    a. Field traits include exserted heads with reduced leaves about the head on lodging resistant plants. Hybrids should be high yielding with large and firm heads.
    b. Processing traits include segmented heads that produce uniformly colored florets that are dark green in color with fine beads and short pedicles. Florets should be <2½" in size.
2. Screen OSU inbreds and hybrids for heat tolerance and stability.
3. Develop seed production systems using cytoplasmic male sterility (CMS) to produce field scale quantities of $F_1$ hybrid seed.

### 3.c. SIGNIFICANT FINDINGS

- Broccoli plots were planted into a field with a recently incorporated cover crop and as a result of the nitrogen tie-up, yields were extremely low (top yield 2.9 T/A with a single destructive harvest).
- OSU experimental lines had reduced leafage around heads and a greater recovery of small (<2.5 in.) florets. They also showed better quality traits such as dark green stems and florets.
- Among the four commercial lines tested, Castle Dome had highest yield and good floret recovery.

### 3.d. METHODS

We continued to derive new inbreds and use these on a small scale to produce $F_1$ hybrid seed for replicated yield trials. Inbreds saved from the 2020 fall trials were grown from cuttings in the greenhouse. During the winter of 2021, these were bud-pollinated to perpetuate the line, and crossed to other inbred lines to produce seeds for field evaluation of combining ability for $F_1$ hybrid production. Crossing efforts focused on obtaining enough seed for replicated field trials of new hybrid combinations. Our breeding cycle is set up for fall production in the field, but where sufficient seed is available, we trial hybrids in the spring as well. New inbreds obtained from selections of a random-mated mass selected population originally developed under organic production systems, where cuttings have been brought into the greenhouse for self-pollination. Approximately five or more generations of selfing are required to develop homozygous inbreds.

Inbreds and experimental hybrids and commercial hybrids were grown in the 2021 main fall planting in the field in a single replicate observation trial, and hybrids alone in a replicated yield and quality evaluation trial (Tables 1a & 1b). Plots were evaluated for head size, shape, and exsertion, segmentation, floret texture and color, maturity and disease resistance (Tables 2a & 2b).

A replicated yield trial was conducted in the fall. Eight of the most promising OSU experimental hybrids and two check cultivars were planted along with four commercial hybrids that had shown stable performance in heat stress trials. Of the checks, Emerald Pride is the industry standard, Cascadia is a recent release from the OSU breeding program. Hybrids were transplanted in one-row plots 30 feet in length and replicated four times with a one-foot in-row spacing. In addition to observation data, yield data was obtained. Entries in the yield trials were taken to the OSU pilot processing plant for blanching and freezing. Frozen material was evaluated at the OSU winter cutting and will be displayed in 2021 at Oregon Processed Vegetable Grower winter meetings and growers, processors and seed company representatives will be invited to evaluate these.

Backcrossing of selected hybrids to place the nuclear genome in the Ogura cytoplasmic male sterile (CMS) background continued. We crossed to develop CMS forms of S454, S462, S463, S471 and S473. Seed production of selected hybrid combinations using a fertile inbred as a male and a CMS inbred as a female was to be evaluated in the field using isolation plots.

### 3.e. RESULTS & DISCUSSION

*Greenhouse inbred and hybrid seed production:* Cuttings were taken from inbreds and breeding lines grown in the field in 2020 to establish material for crossing and hybrid seed production in the greenhouse during the winter of 2020-2021. Sixty-two selections were taken for rooting with most of these surviving to be potted for crossing. These were bud pollinated by hand to self the inbreds and produce seed for the 2021 growing season. Most lines are highly inbred but a few are still segregating and showing significant variation in the field. The process was repeated at the end of the 2021 growing season where cuttings of 65 lines were collected and brought into the greenhouse for rooting in November.

*Yield Trial:* In the fall trial, four commercial hybrids and two checks were grown along with eight OSU experimental hybrids (Table 1a & 1b). Because of low overall yields, few differences were observed among hybrids. The data continues to support the observation that heavier heads produce more florets and that yield in some broccoli cultivars has been achieved by increasing floret size rather than floret number. Observation notes from the yield trial revealed large differences in head and canopy height (Table 2a) with commercial hybrids being significantly shorter than the OSU experimental lines. Another trait that appears to be important in producing high yielding heads is a short branch length. Eiffel demonstrated this trait (Table 2a), and we are evaluating this trait in our inbred lines. Because of the small plant size, we did not observe any hollow stem, so data on this trait is not reported. Most OSU hybrids showed a domed head shape, acceptable bead size and floret segmentation (Table 2b).

*Observation Trials:* The observation trial included 17 highly inbred lines (Table 3), 14 $F_1$ hybrids for which we had too little seed to plant in replicated trials (Table 4), 21 lines still undergoing inbreeding and selection (Table 5), and 11 cytoplasmic male sterility (CMS) lines at various stages of backcrossing to selected inbreds (Table 6). 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). Twelve inbreds received overall ratings of 7 or above (Table 3). Among F1 hybrids in the observation trial, nine received overall ratings of 7 or above (Table 4).

Sensory analysis: Results from the evaluation of processed broccoli samples is shown in Table 7. This was a non-blind test, which may have influenced why Emerald Pride was rated best overall. Several experimental hybrids and commercial cultivars had relatively high ratings.

**4. BUDGET DETAILS**

| **1) Breeding (Myers)** | |
|---|---|
| | |
| Salaries and benefits | |
| Faculty Research Assistant, field, 0.06 FTE | $2,619 |
| OPE @ 75.4% | $1,966 |
| Wages and benefits | |
| Student Wages ($12.50/hr, 15 hr/wk, 8 wks | $1,500 |
| OPE @ 10% | $150 |
| Supplies | $300 |
| Land use and greenhouse rental | $1,780 |
| | |
| Total | $8,315 |

| | |
|---|---|
| | |

| **2) Processing (Wiegand)** | |
|---|---|
| | |
| Salaries and benefits | |
| Faculty Research Assistant | $3,242 |
| OPE @ 61.59% | $1,997 |
| Wages and benefits | |
| Student Wages | $246 |
| OPE @ 10% | $25 |
| Supplies | $187 |
| | |
| Total | $5,696 |
| | |
| Grand Total | $14,012 |

**BUDGET NARRATIVE**

Salary and OPE is requested for a full-time faculty research assistant who will commit approximately 6% FTE to broccoli breeding OPE for FRA is 75.4%. The remainder of salary will come from other sources. For the Food Science & Technology faculty research assistant, approximately 5% FTE will be required to process broccoli samples; the remainder of salary to come from other sources. $1,500 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 $1,390 per acre = $695), and greenhouse rental ($1.55*500 sq. ft. = $775).

**Table 1a.**Yield and yield parameters from a yield trial of OSU experimental broccoli hybrids and checks planted at the OSU Vegetable Research Farm in 2021. Columns following a trait indicate statistically significant differences from the check hybrids Cascadia (Cas) and Emerald Pride (EP). ns = not significantly different, * = significantly different at $p \le 0.05$, ** = significantly different at $p \le 0.01$, and *** = significantly different at $p \le 0.001$. ns below a trait column indicates no significant differences for the trait.

| Hybrid | Total head wt. T/A | Cas | EP | Total no. heads/A | Cas | EP | Immature heads no./A | Cas | EP | Immature heads T/A | Cas | EP | Cull no. heads/A | Cas | EP | Cull heads T/A | Cas | EP | Net no. heads/A | Cas | EP | Net heads T/A | Cas | EP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Asteroid | 2.3 | | | 23.8 | | | 581 | | ** | 0.1 | | ** | 2,468 | | | 0.4 | | | 10,745 | * | | 1.8 | | |
| Cascadia | 1.9 | | * | 23.0 | | | 1,307 | | * | 0.1 | | * | 4,356 | | * | 0.5 | | | 7,696 | | | 1.3 | | * |
| Castle Dome | 3.7 | *** | ** | 25.8 | | | 1,888 | | | 0.2 | | | 2,468 | | | 0.6 | | | 10,600 | * | | 2.9 | *** | * |
| Eiffel | 1.7 | | | 19.8 | | | 145 | | ** | 0.0 | | *** | 3,920 | | * | 0.6 | | | 7,405 | | | 1.1 | | ** |
| EP X S481 | 3.2 | *** | | 27.0 | | | 726 | | ** | 0.1 | | ** | 3,485 | | | 0.5 | | | 11,471 | * | | 2.7 | *** | |
| Emerald Pride | 2.7 | * | | 22.3 | | | 2,904 | * | | 0.3 | * | | 774 | * | | 0.2 | | | 9,293 | | | 2.2 | * | |
| Lieutenant | 3.6 | *** | * | 28.3 | * | * | 1,742 | | | 0.2 | | | 3,485 | | | 0.9 | * | ** | 11,180 | * | | 2.5 | *** | |
| S469 X S486 | 2.5 | | | 24.3 | | | 1,452 | | | 0.1 | | * | 2,904 | | | 0.4 | | | 9,728 | | | 2.0 | * | |
| S471 X S481 | 1.6 | | ** | 23.0 | | | 968 | | * | 0.1 | | ** | 5,614 | | ** | 0.5 | | | 6,776 | | | 1.0 | | ** |
| S471 X S488 | 1.4 | | ** | 17.5 | * | * | 290 | | ** | 0.0 | | *** | 3,920 | | * | 0.4 | | | 5,953 | | | 1.0 | | ** |
| S479 X S481 | 1.3 | | *** | 19.0 | | | 290 | | ** | 0.0 | | *** | 5,082 | | ** | 0.4 | | | 5,663 | | * | 0.8 | | *** |
| S479 X S486 | 1.8 | | * | 24.0 | | | 1,162 | | * | 0.1 | | * | 4,356 | | * | 0.4 | | | 8,422 | | | 1.3 | | * |
| S479 X S487 | 1.9 | | * | 22.8 | | | 290 | | ** | 0.0 | | *** | 5,663 | | ** | 0.7 | | * | 7,260 | | | 1.2 | | ** |
| S479 X S488 | 1.6 | | ** | 21.0 | | | 1,597 | | | 0.1 | | ** | 4,356 | | * | 0.5 | | | 6,244 | | * | 1.0 | | ** |

**Table 1b.** Plant, leaf and head characteristics from a yield trial of OSU experimental broccoli hybrids and checks planted at the OSU Vegetable Research Farm in 2021. Columns following a trait indicate statistically significant differences from the check hybrids Cascadia (Cas) and Emerald Pride (EP). ns = not significantly different, * = significantly different at $p \le 0.05$, ** = significantly different at $p \le 0.01$, and *** = significantly different at $p \le 0.001$. ns below a trait column indicates no significant differences for the trait.

| Hybrid | Days to harvest | Cas | EP | Head dia. (cm)[z] | Cas | EP | Leaves (%)[y] | Cas | EP | Florets (%)[x] | Cas | EP | Small florets (%)[w] | Cas | EP | Aphid infested heads (%) | Cas | EP | Total wt. T/A | Cas | EP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Asteroid | 74 | *** | *** | 10.9 | | | 13.5 | * | | 62.5 | | ** | 81.0 | | | 24.1 | | | 2.6 | | |
| Cascadia | 79 | | *** | 11.0 | | | 5.1 | | *** | 63.1 | | ** | 92.1 | | | 32.2 | | * | 2.0 | | ** |
| Castle Dome | 67 | *** | *** | 12.6 | * | | 10.3 | | ** | 58.8 | | | 87.8 | | | 19.2 | | | 4.2 | *** | |
| Eiffel | 74 | *** | *** | 9.1 | ** | ** | 16.0 | | | 68.9 | * | *** | 66.5 | * | | 44.4 | | *** | 2.0 | | *** |
| EP X S481 | 73 | *** | | 11.3 | | | 2.8 | | *** | 53.5 | * | | 95.2 | | | 20.8 | | | 3.3 | ** | |
| Emerald Pride | 73 | *** | | 11.5 | | | 21.5 | *** | | 54.5 | ** | | 88.3 | | | 6.0 | * | | 3.5 | ** | |
| Lieutenant | 73 | *** | | 11.0 | | | 16.9 | ** | | 56.8 | * | | 47.9 | *** | ** | 14.8 | | | 4.4 | *** | * |
| S469 X S486 | 70 | *** | *** | 11.9 | | | 6.2 | | ** | 64.2 | | ** | 89.1 | | | 20.6 | | | 2.7 | | |
| S471 X S481 | 77 | *** | *** | 9.4 | * | ** | 14.4 | * | | 56.6 | * | | 84.2 | | | 42.5 | | ** | 1.9 | | *** |
| S471 X S488 | 79 | * | *** | 10.6 | | | 8.8 | | ** | 59.3 | | | 85.4 | | | 37.3 | | ** | 1.5 | | *** |
| S479 X S481 | 79 | * | *** | 10.2 | | | 9.8 | | * | 53.0 | *** | | 72.2 | | | 44.7 | | *** | 1.4 | | *** |
| S479 X S486 | 77 | *** | *** | 10.7 | | | 9.3 | | ** | 58.0 | | | 93.4 | | | 31.9 | | | 2.0 | | *** |
| S479 X S487 | 74 | *** | *** | 9.8 | | * | 6.2 | | ** | 58.6 | | | 85.8 | | | 51.1 | * | *** | 2.0 | | *** |
| S479 X S488 | 74 | *** | *** | 9.4 | * | ** | 11.0 | | * | 57.1 | * | | 87.5 | | | 49.1 | | *** | 1.8 | | *** |

[z]Mean of 10 heads per rep. [y]Percent by weight of leaves attached to head after trimming to 6.5 in. [x]Percent of head that is florets by weight. [w]Percent of head that is florets <2.5 in. in diameter.

**Table 2a.** Observation notes of plant characteristics on a yield trial of OSU experimental broccoli hybrids and checks planted at the OSU Vegetable Research Farm in 2021. Columns following a trait indicate statistically significant differences from the check hybrids Cascadia (Cas) and Emerald Pride (EP). ns = not significantly different, * = significantly different at $p \leq 0.05$, ** = significantly different at $p \leq 0.01$, and *** = significantly different at $p \leq 0.001$. ns below a trait column indicates no significant differences for the trait.

| Hybrid | Plants/A (no)[z] | Head dia. (cm) | Cas | EP | Head ht. (cm) | Cas | EP | Canopy ht. (cm) | Cas | EP | Exsertion[y] | Cas | EP | Branch depth[x] | Cas | EP | Stem color[w] | Cas | EP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Asteroid | 16,262 | 12.3 | | | 38 | *** | | 45 | * | | 5.0 | *** | | 3.0 | *** | | 6.0 | * | * |
| Cascadia | 16,553 | 13.5 | | | 59 | | *** | 53 | | ** | 7.8 | | *** | 6.5 | | *** | 7.0 | | *** |
| Castle Dome | 16,553 | 15.3 | | * | 35 | *** | | 40 | *** | | 5.5 | *** | | 5.5 | | * | 5.0 | *** | |
| Eiffel | 15,827 | 11.5 | | | 50 | *** | *** | 59 | | *** | 7.3 | | *** | 1.5 | *** | * | 4.5 | *** | |
| EP X S481 | 17,279 | 12.5 | | | 54 | * | *** | 52 | | ** | 7.5 | | *** | 7.5 | | *** | 7.0 | | *** |
| Emerald Pride | 16,456 | 12.7 | | | 37 | *** | | 42 | ** | | 5.0 | *** | | 3.7 | *** | | 5.0 | *** | |
| Lieutenant | 17,279 | 12.8 | | | 34 | *** | | 48 | | | 4.0 | *** | * | 3.5 | *** | | 3.0 | *** | *** |
| S469 X S486 | 16,988 | 13.0 | | | 67 | ** | *** | 54 | | ** | 8.8 | * | *** | 9.0 | ** | *** | 7.0 | | *** |
| S471 X S481 | 16,408 | 12.0 | | | 57 | | *** | 53 | | ** | 8.5 | | *** | 5.0 | * | | 7.0 | | *** |
| S471 X S488 | 17,134 | 12.8 | | | 62 | | *** | 54 | | ** | 9.0 | ** | *** | 5.0 | * | | 7.0 | | *** |
| S479 X S481 | 16,408 | 11.8 | | | 59 | | *** | 53 | | ** | 8.0 | | *** | 5.5 | | * | 7.0 | | *** |
| S479 X S486 | 17,134 | 12.8 | | | 60 | | *** | 53 | | ** | 9.0 | ** | *** | 6.5 | | *** | 7.0 | | *** |
| S479 X S487 | 17,134 | 12.5 | | | 65 | * | *** | 56 | | *** | 9.0 | ** | *** | 8.0 | * | *** | 8.3 | ** | *** |
| S479 X S488 | 17,279 | 12.5 | | | 63 | | *** | 54 | | ** | 8.8 | * | *** | 7.5 | | *** | 6.0 | * | * |

[z]Trial was transplanted on Aug. 9 into 30 ft. rows spaces 30 in. apart. Plant spacing within row was 1 ft. [y]Scale of 1 - 9 where 1 is least and 9 is most head exsertion above canopy. [x]Branching depth on a 1 - 9 scale where less depth is preferred. [w]Scale of 1 - 9 where 1 is lighter and 9 is very dark green.

**Table 2b.** Observation notes of head characteristics of a yield trial of OSU experimental broccoli hybrids and checks planted at the OSU Vegetable Research Farm in 2021. Columns following a trait indicate statistically significant differences from the check hybrids Cascadia (Cas) and Emerald Pride (EP). ns = not significantly different, * = significantly different at $p \leq 0.05$, ** = significantly different at $p \leq 0.01$, and *** = significantly different at $p \leq 0.001$. ns below a trait column indicates no significant differences for the trait

| Hybrid | Head shape[z] | Cas | EP | Bead size[y] | Cas | EP | Head firmness[x] | Cas | EP | Uniformity[w] | Cas | EP | Segmentation[v] | Cas | EP | Overall[w] | Cas | EP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Asteroid | 5.3 | | | 3.5 | ** | ** | 7.0 | | | 5.5 | | | 3.8 | *** | | 7.0 | | *** |
| Cascadia | 4.8 | | | 5.5 | | | 7.0 | | | 5.0 | | | 7.3 | | *** | 7.3 | | *** |
| Castle Dome | 4.5 | | | 7.0 | * | | 4.5 | ** | * | 3.5 | | * | 3.0 | *** | | 5.0 | *** | |
| Eiffel | 5.8 | | * | 3.0 | *** | ** | 9.0 | * | ** | 3.5 | | * | 3.0 | *** | | 7.0 | | *** |
| EP X S481 | 4.3 | | | 5.0 | | | 6.0 | | | 4.5 | | | 7.8 | | *** | 7.0 | | *** |
| Emerald Pride | 4.3 | | | 5.7 | | | 6.3 | | | 5.7 | | | 3.0 | *** | | 5.0 | *** | |
| Lieutenant | 5.3 | | | 7.0 | * | | 5.5 | | | 5.5 | | | 2.5 | *** | | 3.5 | *** | *** |
| S469 X S486 | 4.8 | | | 3.0 | *** | ** | 4.5 | ** | * | 4.0 | | | 8.3 | | *** | 7.0 | | *** |
| S471 X S481 | 6.0 | * | ** | 3.0 | *** | ** | 7.3 | | | 5.0 | | | 8.3 | | *** | 6.5 | | ** |
| S471 X S488 | 5.3 | | | 5.5 | | | 7.0 | | | 4.5 | | | 8.3 | | *** | 7.5 | | *** |
| S479 X S481 | 5.5 | | | 3.0 | *** | ** | 7.5 | | | 3.0 | * | ** | 9.0 | ** | *** | 7.0 | | *** |
| S479 X S486 | 6.5 | ** | ** | 3.0 | *** | ** | 6.3 | | | 4.5 | | | 8.3 | | *** | 7.0 | | *** |
| S479 X S487 | 6.0 | * | ** | 3.0 | *** | ** | 6.8 | | | 3.0 | * | ** | 8.0 | | *** | 7.3 | | *** |
| S479 X S488 | 6.3 | ** | ** | 3.5 | ** | ** | 6.3 | | | 3.0 | * | ** | 7.3 | | *** | 6.8 | | *** |

[z]Scale of 1 - 9 where 1 is convext head, 5 is a flat head and 9 is an extreme domed head. [y]Scale of 1 - 9 where 1 is coarse, 5 is medium and 9 is very fine bead size. [x]Scale of 1 - 9 where 1 is soft and 9 is very fiirm head. [w]Scale of 1 - 9 where 1 is least and 9 is best. [v]Scale of 1 - 9 where 1 is smooth dome, 5 is segmented but touching florets and 9 is separated florets.

**Table 3. Field observation data for experimental broccoli inbred lines grown at the OSU Vegetable Research Farm in 2021[z].**

| Entry | Date evaluated | No. plants | No. blind[y] | Head ht. (cm) | Canopy ht. (cm) | Exsertion[x] | Head shape[w] | Segmentation[v] | Branch depth[u] | Bead size[t] | Color[s] | Head dia. (cm) | Head firmness[r] | Head uniformity[q] | Overall[q] | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S446 | 28-Oct | 11 | 0 | 54 | 60 | 5 | 6 | 3 | 5 | 1 | 7 | 11 | 7 | 3 | 5 | Head dia good indicator of maturity; hvy aphids; head rot |
| S466 | 28-Oct | 3 | 0 | 50 | 56 | 5 | 6 | 3 | 3 | 1 | 7 | 10 | 7 | 5 | 5 | Immature head |
| S454 | 28-Oct | 11 | 0 | 50 | 48 | 7 | 4 | 7 | 5 | 2 | 9 | 16 | 5 | 3 | 7 | Var mat |
| S462 | 28-Oct | 11 | 0 | 70 | 58 | 9 | 8 | 9 | 7 | 1.5 | 7 | 10 | 5 | 3 | 7 | Loose heads |
| S463 | 28-Oct | 7 | 0 | 55 | 48 | 8 | 7 | 7 | 3 | 1 | 9 | 10 | 8 | 3 | 7 | Rosetting |
| S465 | 10-Nov | 11 | 1 | 45 | 50 | 7 | 6 | 5 | 5 | 1 | 7 | 10 | 7 | 5 | 7 | V late |
| S469 | 28-Oct | 14 | 0 | 65 | 57 | 9 | 7 | 9 | 5 | 1.5 | 9 | 12 | 5 | 3 | 7 | |
| S471 | 28-Oct | 14 | 1 | 56 | 51 | 8 | 4 | 8 | 3 | 1.5 | 8 | 16 | 9 | 3 | 9 | |
| S473 | 28-Oct | 11 | 2 | 60 | 58 | 8 | 4 | 7 | 5 | 1.5 | 9 | 12 | 3 | 3 | 3 | 1 plt w/ leaf spots |
| S475 | 28-Oct | 14 | 0 | 50 | 50 | 7 | 6 | 5 | 3 | 2 | 8 | 8 | 5 | 3 | 5 | |
| S475-1G | 28-Oct | 2 | 0 | | | | | | | | | | | | | Glossy leaves but otherwise similar to S475 |
| S479 | 28-Oct | 14 | 0 | 51 | 48 | 8 | 7 | 8 | 5 | 1 | 9 | 13 | 7 | 3 | 7 | Small uneven florets |
| S481 | 28-Oct | 8 | 0 | 55 | 62 | 7 | 7 | 8 | 3 | 1 | 7 | 10 | 9 | 3 | 7 | Small heads |
| S483 | 28-Oct | 10 | 0 | 45 | 45 | 6 | 4 | 8 | 5 | 1.5 | 7 | 15 | 7 | 3 | 8 | Head rot beginning |
| S486 | 28-Oct | 12 | 0 | 65 | 55 | 9 | 5 | 9 | 7 | 1.5 | 9 | 20 | 8 | 3 | 9 | Loose heads; stunted plants (6) |
| S487 | 28-Oct | 14 | 0 | 62 | 52 | 9 | 5 | 9 | 5 | 1.5 | 8 | 12 | 5 | 3 | 7 | |
| S488 | 28-Oct | 14 | 0 | 63 | 58 | 9 | 5 | 9 | 3 | 1 | 7 | 10 | 8 | 3 | 8 | |

[z]Trial was transplanted on Aug. 9 into 30 ft. rows spaces 30 in. apart. Plant spacing within row was 1 ft. [y]Number of plants per plot that failed to form a single central head. [x]Scale of 1 - 9 where 1 is least and 9 is most head exsertion above canopy.[w]Scale of 1 - 9 where 1 is convex head, 5 is a flat head and 9 is an extreme domed head. [v]Scale of 1 - 9 where 1 is smooth dome, 5 is segmented but touching florets and 9 is separated florets. [u]Branching depth on a 1 - 9 scale where less depth is preferred. [t]Scale of 1 - 9 where 1 is coarse, 5 is medium and 9 is very fine bead size.[s]Scale of 1 - 9 where 1 is lighter and 9 is very dark green. [r]Scale of 1 - 9 where 1 is soft and 9 is very fiirm head. [q]Scale of 1 - 9 where 1 is least and 9 is best.

**Table 4.** Experimental broccoli hybrids for which there was not enough seed for replicated trials, grown at the OSU Vegetable Research Farm in 2021.

| Entry | Date evaluated | No. plants | No. blind[y] | Head ht. (cm) | Canopy ht. (cm) | Exsertion[x] | Head shape[w] | Segmentation[v] | Branch depth[u] | Bead size[t] | Color[s] | Head dia. (cm) | Head firmness[r] | Head uniformity[q] | Overall[q] | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S469 X S487 | 1-Nov | 12 | 0 | 83 | 70 | 9 | 8 | 7 | 9 | 2 | 9 | 15 | 7 | 7 | 7 | |
| S471 X S463 | 1-Nov | 14 | 0 | 55 | 57 | 7 | 7 | 5 | 5 | 2 | 5 | 17 | 8 | 7 | 9 | Robust good veg frame |
| S475 X S463 | 1-Nov | 11 | 0 | 61 | 55 | 8 | 7 | 5 | 7 | 2 | 9 | 18 | 7 | 7 | 9 | Robust & vigorous, some leaners |
| S475 X S481 | 1-Nov | 11 | 0 | 61 | 58 | 7 | 7 | 7 | 5 | 2 | 9 | 13 | 7 | 5 | 8 | Leaners |
| S475 X S487 | 1-Nov | 14 | 0 | 66 | 60 | 9 | 7 | 7 | 5 | 1 | 9 | 14 | 7 | 5 | 7 | |
| S475 X S488 | 10-Nov | 1 | 0 | 65 | 50 | 9 | 6 | 7 | 5 | 2 | 7 | 14 | 5 | 5 | 5 | |
| S479 X S481 | 1-Nov | 12 | 0 | 60 | 59 | 7 | 7 | 5 | 3 | 1 | 7 | 14 | 8 | 7 | 9 | |
| S479 X S486 | 1-Nov | 14 | 0 | 57 | 49 | 7 | 7 | 7 | 5 | 1 | 7 | 15 | 7 | 5 | 7 | Leaners |
| S479 X S488 | 1-Nov | 14 | 0 | 63 | 61 | 7 | 7 | 7 | 3 | 1 | 9 | 13 | 9 | 5 | 9 | Leafy heads |
| EP X S471 | 1-Nov | 14 | 0 | 55 | 55 | 6 | 6 | 1 | 5 | 3 | 5 | 16 | 5 | 5 | 5 | |
| EP X S475 | 1-Nov | 1 | 0 | 55 | 53 | 7 | 5 | 6 | 5 | 2 | 9 | 15 | 7 | 3 | 5 | |
| EP X S481 | 1-Nov | 15 | 0 | 57 | 68 | 5 | 7 | 2 | 7 | 2 | 9 | 17 | 9 | 3 | 7 | |
| EP X S483 | 1-Nov | 15 | 0 | 53 | 55 | 5 | 4 | 3 | 5 | 2 | 7 | 17 | 7 | 3 | 5 | |
| S475-1G X S471 | 1-Nov | 15 | 0 | 54 | 54 | 7 | 7 | 3 | 3 | 1.5 | 7 | 10 | 9 | 5 | 7 | Not glossy |

[z]Trial was transplanted on Aug. 9 into 30 ft. rows spaces 30 in. apart. Plant spacing within row was 1 ft. [y]Number of plants per plot that failed to form a single central head. [x]Scale of 1 - 9 where 1 is least and 9 is most head exsertion above canopy.[w]Scale of 1 - 9 where 1 is convext head, 5 is a flat head and 9 is an extreme domed head. [v]Scale of 1 - 9 where 1 is smooth dome, 5 is segmented but touching florets and 9 is separated florets. [u]Branching depth on a 1 - 9 scale where less depth is preferred. [t]Scale of 1 - 9 where 1 is coarse, 5 is medium and 9 is very fine bead size.[s]Scale of 1 - 9 where 1 is lighter and 9 is very dark green. [r]Scale of 1 - 9 where 1 is soft and 9 is very fiirm head. [q]Scale of 1 - 9 where 1 is least and 9 is best.

**Table 5.** Early generation experimental broccoli lines undergoing selfing to homozygosity in a breeding nursery grown at the OSU Vegetable Research Farm in 2021.

| Entry | Date evaluated | No. plants | No. blind[y] | Head ht. (cm) | Canopy ht. (cm) | Exsertion[x] | Head shape[w] | Segmentation[v] | Branch depth[u] | Bead size[t] | Color[s] | Head dia. (cm) | Head firmness[r] | Head uniformity[q] | Overall[q] | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (S471/S483)-1-1 | 28-Oct | 12 | 0 | 57 | 52 | 8 | 7 | 5 | 5 | 1 | 5 | 7 | 9 | 3 | 5 | Small heads |
| (S471/S483)-1-2 | 28-Oct | 13 | 0 | 61 | 56 | 8 | 7 | 8 | 5 | 1 | 5 | 12 | 8 | 3 | 8 | Good veg frame despite low fert |
| (S473/S463)-2 | 28-Oct | 14 | 0 | 66 | 61 | 9 | 5 | 7 | 7 | 2 | 9 | 15 | 5 | 3 | 8 | |
| (S463/S473)-1-1 | 28-Oct | 11 | | | | | | | | | | | | | | Still young |
| (S463/S473)-1-2 | 28-Oct | 18 | 1 | 66 | 58 | 9 | 6 | 7 | 5 | 1 | 7 | 13 | 5 | 3 | 7 | |
| (S471/S483)-1-4 | 28-Oct | 12 | 0 | 50 | 43 | 8 | 6 | 8 | 3 | 1.5 | 7 | 13 | 9 | 3 | 9 | V nice broccoli |
| (S473/S463)-1 | 28-Oct | 14 | 0 | 56 | 54 | 9 | 4 | 8 | 7 | 1 | 5 | 13 | 7 | 3 | 7 | Uneven florets; some lodging |
| (S475/S463)-1-1-1 | 28-Oct | 9 | 0 | 46 | 41 | 7 | 6 | 7 | 5 | 1.5 | 7 | 13 | 5 | 3 | 5 | |
| (S475/S463)-1-1-2 | 28-Oct | 13 | 0 | 43 | 37 | 7 | 5 | 5 | 3 | 2 | 3 | 15 | 8 | 3 | 5 | Resembles Emerald Pride |
| (S475/S463)-1-1-3 | 28-Oct | 15 | 0 | 57 | 51 | 7 | 5 | 7 | 5 | 1 | 7 | 13 | 3 | 3 | 3 | Loose heads small florets |
| (S475/S463)-1-1-4 | 28-Oct | 15 | 0 | 50 | 46 | 7 | 5 | 8 | 5 | 1 | 7 | 19 | 9 | 3 | 7 | Loose heads |
| (S475/S463)-1-1-5 | 28-Oct | 14 | 1 | 55 | 51 | 7 | 4 | 7 | 7 | 1 | 8 | 18 | 9 | 3 | 8 | |
| (S475/S463)-1-1-6 | 1-Nov | 15 | 0 | 41 | 41 | 5 | 4 | 9 | 5 | 1 | 7 | 11 | 9 | 3 | 5 | |
| (S475/S463)-1-1-7 | 1-Nov | 14 | 0 | 42 | 44 | 5 | 5 | 7 | 3 | 1 | 5 | 12 | 9 | 5 | 7 | |
| (S475/S463)-2-1-1 | 1-Nov | 14 | 0 | 53 | 48 | 7 | 7 | 5 | 5 | 1 | 9 | 10 | 9 | 3 | 7 | Small heads |
| (S475/S463)-3-1-1 | 1-Nov | 13 | 0 | 62 | 57 | 9 | 6 | 9 | 9 | 1 | 7 | 13 | 9 | 5 | 7 | |
| (S483/S471)-2-1-1 | 1-Nov | 14 | 0 | 59 | 47 | 9 | 7 | 9 | 7 | 1 | 9 | 11 | 5 | 5 | 5 | |
| (S471/S486)-1 | 1-Nov | 12 | 0 | 61 | 51 | 9 | 5 | 9 | 9 | 1 | 9 | 15 | 9 | 5 | 7 | Loose heads |
| (S471/S490)-1 | 1-Nov | 13 | 0 | 53 | 45 | 7 | 5 | 3 | 5 | 2 | 7 | 13 | 5 | 3 | 5 | |
| (S471/S492)-1 | 1-Nov | 11 | 0 | 57 | 57 | 7 | 7 | 5 | 3 | 1 | 5 | 10 | 9 | 3 | 7 | Late |
| (S475/S486)-1 | 1-Nov | 10 | 0 | 62 | 57 | 7 | 5 | 7 | 5 | 2 | 9 | 15 | 5 | 5 | 5 | Head rot |

[z]Trial was transplanted on Aug. 9 into 30 ft. rows spaces 30 in. apart. Plant spacing within row was 1 ft. [y]Number of plants per plot that failed to form a single central head. [x]Scale of 1 - 9 where 1 is least and 9 is most head exsertion above canopy.[w]Scale of 1 - 9 where 1 is convext head, 5 is a flat head and 9 is an extreme domed head. [v]Scale of 1 - 9 where 1 is smooth dome, 5 is segmented but touching florets and 9 is separated florets. [u]Branching depth on a 1 - 9 scale where less depth is preferred. [t]Scale of 1 - 9 where 1 is coarse, 5 is medium and 9 is very fine bead size.[s]Scale of 1 - 9 where 1 is lighter and 9 is very dark green. [r]Scale of 1 - 9 where 1 is soft and 9 is very fiirm head. [q]Scale of 1 - 9 where 1 is least and 9 is best.

**Table 6.** Status of backcrossing experimental broccoli inbreds into an Arnund A prefix) or Ogura (O prefix) cytoplasmic male sterile background, grown at the OSU Vegetable Research Farm in 2021. Evaluated Nov. 1, 2021.

| Line | No. plants | No. blind[y] | Head ht. (cm) | Canopy ht. (cm) | Exsertion[x] | Head shape[w] | Segmentation[v] | Branch depth[u] | Bead size[t] | Color[s] | Head dia. (cm) | Head firmness[r] | Head uniformity[q] | Overall[q] | No. of back-crosses |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (A463/S463) | 15 | 0 | 56 | 54 | 7 | 7 | 3 | 5 | 1 | 9 | 12 | 9 | 5 | 5 | many |
| O446 | 15 | 0 | 67 | 65 | 8 | 7 | 3 | 3 | 2 | 7 | 10 | 9 | 3 | 7 | many |
| O446*2-1/S462-1/S454 | 14 | 0 | 62 | 57 | 8 | 4 | 5 | 7 | 2 | 9 | 12 | 7 | 5 | 7 | 2 |
| O454-1*3 | 13 | 0 | 65 | 55 | 9 | 5 | 5 | 7 | 2 | 5 | 12 | 7 | 5 | 7 | 4 |
| O454-2*3 | 14 | 0 | 70 | 55 | 9 | 6 | 3 | 5 | 1 | 5 | 10 | 3 | 3 | 5 | 4 |
| O463-1*3 | 13 | 0 | 60 | 57 | 8 | 7 | 5 | 7 | 1 | 9 | 12 | 7 | 5 | 7 | 4 |
| O463-4*4 | 12 | 0 | 53 | 46 | 7 | 8 | 1 | 3 | 2 | 7 | 10 | 7 | 5 | 5 | 5 |
| O473-1*3 | 8 | 0 | 53 | 53 | 5 | 5 | 5 | 5 | 1 | 9 | 10 | 7 | 3 | 5 | 4 |
| O473-2*3 | 10 | 0 | 53 | 57 | 7 | 5 | 3 | 7 | 1 | 9 | 10 | 5 | 3 | 5 | 4 |
| O473-3*3 | 9 | 0 | 50 | 50 | 5 | 5 | 5 | 5 | 1 | 3 | 10 | 5 | 3 | 5 | 4 |
| OS473-1*3-2/S471 | 11 | 0 | 49 | 45 | 7 | 7 | 3 | 5 | 1 | 7 | 11 | 7 | 3 | 7 | 3 |

[z]Trial was transplanted on Aug. 9 into 30 ft. rows spaces 30 in. apart. Plant spacing within row was 1 ft. [y]Number of plants per plot that failed to form a single central head. [x]Scale of 1 - 9 where 1 is least and 9 is most head exsertion above canopy. [w]Scale of 1 - 9 where 1 is convex head, 5 is a flat head and 9 is an extreme domed head. [v]Scale of 1 - 9 where 1 is smooth dome, 5 is segmented but touching florets and 9 is separated florets. [u]Branching depth on a 1 - 9 scale where less depth is preferred. [t]Scale of 1 - 9 where 1 is coarse, 5 is medium and 9 is very fine bead size.[s]Scale of 1 - 9 where 1 is lighter and 9 is very dark green. [r]Scale of 1 - 9 where 1 is soft and 9 is very firm head. [q]Scale of 1 - 9 where 1 is least and 9 is best.

**Table 7. Average scores for sensory evaluation of processed (frozen) broccoli samples evaluated at the OSU Pilot Plant Dec. 1, 2021.**

| | Average Score | | | | % Count (Overall) | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Line** | **Color** | **Flavor** | **Sweet-ness** | **Over-all** | **Worst (1)** | **2%** | **3%** | **4%** | **Best (5)** |
| S469 X S486 | 3.3 | 1.9 | 1.6 | 2.1 | 29% | 50% | 7% | 14% | 0% |
| S471 X S481 | 4.0 | 3.3 | 2.4 | 3.2 | 0% | 29% | 14% | 50% | 0% |
| S471 X S488 | 3.6 | 2.8 | 2.3 | 3.0 | 7% | 14% | 50% | 29% | 0% |
| S479 X S481 | 3.4 | 2.6 | 2.5 | 2.8 | 7% | 36% | 36% | 14% | 7% |
| S479 X S486 | 3.8 | 3.0 | 2.8 | 3.2 | 0% | 29% | 29% | 29% | 7% |
| S479 X S487 | 3.5 | 2.5 | 2.2 | 2.5 | 21% | 29% | 14% | 29% | 0% |
| S479 X S488 | 4.2 | 3.0 | 2.7 | 3.0 | 7% | 21% | 36% | 21% | 7% |
| EP X S481 | 4.0 | 3.2 | 3.0 | 3.3 | 0% | 14% | 50% | 29% | 7% |
| Emerald Pride | 3.7 | 4.1 | 3.6 | 3.6 | 0% | 14% | 14% | 57% | 7% |
| Eiffel | 2.6 | 2.1 | 2.3 | 2.3 | 21% | 29% | 29% | 7% | 0% |
| Cascadia | 4.3 | 3.4 | 2.8 | 3.5 | 7% | 0% | 36% | 50% | 7% |
| Lieutenant | 3.2 | 3.4 | 3.3 | 3.2 | 7% | 14% | 36% | 29% | 7% |
| Asteroid | 4.2 | 3.6 | 3.1 | 3.2 | 0% | 21% | 36% | 36% | 0% |
| Castle Dome | 2.5 | 2.9 | 2.8 | 2.6 | 14% | 29% | 36% | 7% | 7% |

# Research Progress Report for 2021-2022 Funded Projects

for the
Agricultural Research Foundation
Oregon Processed Vegetable Commission

Title: Seed Corn Maggot Control in Snap Beans and Sweet Corn Without Chlorpyrifos (Lorsban)

Project Leader(s): Ed Peachey, Horticulture Department, OSU

Funding History: $8,917 (2021)

Abstract: Chlorpyrifos (Lorsban) seed treatments for control of seed corn maggot in snap beans and sweet corn will soon vanish. One potential replacement insecticide is spinosad. The toxicologic profile of this insecticide is very favorable and spinosad provides protection to snap beans similar to chlorpyrifos, at least in NY tests (Nault 2007). Efficacy has yet to be demonstrated in Oregon and around the country. Spinosad is also approved for organic use in some crops, and in the case of organically grown snap beans, the benefit would be immense. One shortcoming of spinosad is cost, but low rates coupled with other seed treatment insecticides such as thiamethoxam may be a strategy to make spinosad a practical solution, even in conventional snap bean production.

Efficacy of spinosad seed treatments as a standalone and as a supplement for control of seed corn maggot (SCM) was tested at 5 snap bean sites and 2 sweet corn sites in the Willamette Valley from early May through late July in 2021. Seed was treated with Entrust, Tracer, or Regard, depending on seed source and rate required for the trials. Although damage from seed corn maggot was highly variable, important trends emerged. In all trials, there was some evidence that spinosad reduced damage to snap beans from seed corn maggot. The variety Pierroton had very poor emergence in 4 of the 5 snap bean trials, apparently unrelated to seed corn maggot damage. At the site with the most SCM damage (Keizer), the most effective seed treatment was Regard and reduced the presence of seed corn maggots on roots by 90%. Similarly, treatments that included spinosad plus thiamethoxam nearly eliminated SCM. In Exp 4 with much better emergence of Pierroton, Entrust and Regard seed treatment reduced damage from SCM by an average of 60%. Maggot damage in the 2 sweet corn trials was low and no effect of spinosad treatment on maggot damage was recorded.

Key Words: Chlorpyrifos, *Delia platura*, seed corn maggot, spinosad, spinosyn, bifenthrin, thiamethoxam, Regard, Entrust, Tracer

Objective(s): Test efficacy of spinosad and bifenthrin for control of seed corn maggot in snap beans and sweet corn, and demonstrate crop safety for these insecticides.

## Procedures:

**Snap beans**. Efficacy of spinosad for control of seed corn maggot in snap beans was tested at five sites in the Willamette Valley. Snap bean seed was treated with spinosad (*Entrust* @ 0.125 mg ai/seed and *Tracer* @ 0.25 mg ai/seed). For the 2 sites at the OSU vegetable Research farm (Exp 1 and 2), fresh dairy manure was vigorously rototilled into the soil at a rate of ~5 tons/A fresh wt before snap beans were planted. Exps 3, 4 and 5 were located on grower fields in both conventional (Keizer and Monroe) and organically (Macksburg) managed fields. Seeds (200 in each plot row) were planted with a hand-push belt planter with 2 rows per plot, then blood meal applied over the seed row at 2 cups per 20 row ft in a 2-inch band to further encourage seed corn maggot damage. Plots were replicated three or four times. Snap bean emergence was counted in the entire plot and vigor rated. Stand counts were made before the trifoliate leaf expanded in a 3 ft length of row with poor emergence, then seedlings counted and excavated to assess root maggot damage.

**Sweet corn** var. 1477 was planted at sites in Corvallis and Macksburg as described for snap beans in Exp 1 and 2 with the exception that 40 seeds were planted per row in each plot. Plots were replicated three times. At the V1-V2 stage (first true leaf), plant stand was counted and plant vigor rated. At the V4-V5 stage, stand establishment including percentage of "runts" was rated including another plant vigor assessment. Three ft of row was dug up that did not establish well during the V1 assessment, and damage due to seed corn maggot was assessed.

## Accomplishments:

**Snap beans (Tables 1 to 5).** In Exp 1, there was little if any evidence from stand counts, vigor ratings or damage to seedlings that either Entrust of Tracer seed treatments reduced damage caused by seed corn maggot. In Exp 2, no larvae were found, and because of high variability among treatments, evidence was weak that treatments reduced damage from seed corn maggot. However, single degree of freedom contrasts between the Entrust and other treatments suggested that Entrust may have reduced seed corn maggot damage to roots (P=0.06). Tracer did not reduce damage to seedlings. Capture LFR (bifenthrin) was included as a treatment in this Exp but did not affect any of the variables measured for seed corn maggot damage.

Exp 3 (Keizer) had the greatest amount of damage of all 5 snap bean experiments, and maggots were frequently observed on roots despite the application of Mocap (ethoprop) by the grower to the entire field. In treatment 12, maggots were noted on 31% of the seedlings. The varieties Pierroton and SB4734 had very poor emergence with less than 25% of the seeds producing seedlings in some treatments. Entrust and Tracer did not appear to reduce seed corn maggot damage to the variety Pierroton when compared to nontreated seeds, but poor emergence may have masked treatment effects. Seeds of Huntingdon and Outlaw treated with spinosad + 972 (see footnote in Table 3 for active ingredients) appeared to be the most effective at reducing SCM damage, but nontreated seed was unavailable for this trial, and a direct comparison of effectiveness was not possible.

Percent emergence for the variety Pierroton was much greater in Exp 4 than Exps. 1, 2 and 3, but seed corn maggot damage to seedlings was again low and highly variable. However, there was some evidence that maggot damage was less with Entrust and Tracer treatments on Pierroton seeds. There were fewer snakeheads observed (damaged cotyledons) with these treatments for the variety Pierroton and a stunting rating later in the season indicated better growth with these treatments. The Regard treatments on the varieties Rogue and Pierroton provided by Syngenta were less effective than in Exp 3 and Capture LFR did not reduce damage.

Poor emergence of both Pierroton and Rogue varieties in Exp 5 was related to low moisture and high heat after planting. Maggots were not found, and maggot-damaged seedlings were fewer in the Regard treatment on the variety Rogue.

**Sweet corn (Tables 6 and 7).** Very few maggots or maggot damaged plants were found at the two sites. Even though trends suggest potential affects, there were no differences between treated and untreated seeds, statistically. A later evaluation (9-Jul) indicated that spinosad seed treatments may have improved crop growth slightly at the Corvallis site (Table 6).

**Table 1** (Exp. 1)**.** Efficacy of spinosad for control of seed corn maggot in snap beans var. Pierroton at unifoliate growth stage. OSU Vegetable Farm, planted May 8 and evaluated May 24, 2021 (n=4).

| | Insecticide | Rate | | Stand count | Vigor of entire plot | Stand count | Snake heads | All maggot damaged seeds or seedlings | Maggots present |
|---|---|---|---|---|---|---|---|---|---|
| | | | | *No./plot (200 seeded in 20 ft)* | *10-dead, 0=best* | *-------------no. in 3 ft of affected row------* | | | |
| 1 | No insecticide on seed | | | 149 | 2.3 | 27.8 | 2.0 | 3.0 | 0.1 |
| 2 | Entrust | 0.125 | mg ai/seed | 146 | 2.5 | 26.9 | 1.4 | 3.4 | 0 |
| 3 | Tracer | 0.25 | mg ai/seed | 150 | 2.2 | 22.0 | 1.1 | 2.4 | 0 |
| ANOVA (P>F) | | | | ns | ns | 0.15 | ns | ns | ns |
| FLSD (0.05) | | | | - | - | 6.4 | - | - | - |

**Table 2** (Exp 2)**.** Efficacy of spinosad for control of seed corn maggot in snap beans var. Pierroton at unifoliate growth stage. OSU Vegetable Farm, Corvallis, OR (n=4), planted May 18 and evaluated June 10, 2021.

| | Insecticide | Rate | | Stand count | Vigor of entire plot | Stand count | Snake heads | All maggot damaged seeds or seedlings | Maggots present |
|---|---|---|---|---|---|---|---|---|---|
| | | | | *No./plot (200 seeded inn20 ft)* | *10-dead, 0=no damage* | *------------no. in 3 ft of affected row---------* | | | |
| 1 | No insecticide on seed | | | 111 | 1.1 | 17 | 0.3 | 2.5 | 0 |
| 2 | Entrust | 0.125 | mg ai/seed | 120 | 0.1 | 18 | 0.7 | 0.7 | 0 |
| 3 | Tracer | 0.25 | mg ai/seed | 101 | 0.3 | 14 | 0.3 | 2.7 | 0 |
| 4 | Capture LFR | 8.5 | fl oz/a | 109 | 2.0 | 18 | 1.0 | 2.3 | 0 |
| ANOVA (P>F) | | | | 0.12 | ns | ns | ns | ns | ns |
| FPLSD (0.05) | | | | 26 | - | - | - | - | - |

**Table 3** (Exp 3). Efficacy of spinosad and other seed treatments on seed corn maggot in snap beans at unifoliate growth stage, Keizer, OR. Planted 13-May-2021; evaluated 1-June-2021 unless noted (n=3).

| | Cultivar/Source of seed treatment | Seed treatment/ insecticide | Rate | Stand | No. seedlings | Snake heads | All damaged seeds or seedlings | Maggots visible on roots | Stunting (29-Jun) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | *no./plot (200 seeded)* | *---------- No. in 3 ft of row in area with poor stand -------* | | | | *%* |
| 1 | Pierroton/IR-4 | Nontreated[a] | - | 57 | 9.0 | 0.7 | 3.0 | 0.7 | 30 |
| 2 | Pierroton/IR-4 | Entrust[a] | 0.125 mg ai/seed | 38 | 4.7 | 1.3 | 2.3 | 0.0 | 43 |
| 3 | Pierroton/IR-4 | Tracer[a] | 0.25 mg ai/seed | 77 | 8.3 | 1.3 | 2.7 | 0.7 | 17 |
| 4 | Pierroton/Syn | Regard | 0.15 mg ai/seed | 74 | 7.0 | 1.3 | 4.7 | 0.0 | 17 |
| 5 | Pierroton/Syn | Nontreated | - | 35 | 7.0 | 2.3 | 4.7 | 2.3 | 77 |
| 6 | Pierroton/Syn | Regard | 0.15 mg ai/seed | 76 | 10.3 | 1.0 | 3.7 | 0.0 | 0 |
| 7 | Pierroton/Syn | Nontreated[a] | - | 86 | 10.3 | 4.0 | 7.0 | 3.7 | 50 |
| 8 | Pierroton/Syn | Capture LFR[a] | 16 oz/A, 4 inch band over row | 110 | 10.0 | 0.7 | 2.7 | 0.3 | 23 |
| 9 | SB4734/Syn | Nontreated | - | 44 | 6.7 | 1.7 | 5.0 | 1.0 | 60 |
| 10 | SB4734/Syn | Nontreated | - | 52 | 6.7 | 1.3 | 4.7 | 2.0 | 40 |
| 11 | SB4734/Syn | Regard | 0.15 mg ai/seed | 72 | 9.0 | 0.7 | 2.0 | 0.3 | 8 |
| 12 | Rogue/Syn | Nontreated | - | 104 | 13.7 | 2.7 | 7.0 | 4.3 | 20 |
| 13 | Rogue/Syn | Regard | 0.15 mg ai/seed | 97 | 9.3 | 0.7 | 4.0 | 0.7 | 8 |
| 14 | Huntingdon/Syn | 972[b] | - | 169 | 22.3 | 2.3 | 3.0 | 0.0 | 10 |
| 15 | Huntingdon/Syn | 333[c] | - | 166 | 20.7 | 1.3 | 4.3 | 1.7 | 28 |
| 16 | Huntingdon/Syn | 972 + spinosad (Regard) @ 0.15 mg/seed | | 167 | 17.0 | 0.0 | 1.3 | 0.0 | 8 |
| 17 | Outlaw/Syn | 972[b] | - | 170 | 15.3 | 1.3 | 2.7 | 0.0 | 5 |
| 18 | Outlaw/Syn | 333[c] | - | 169 | 19.3 | 0.3 | 0.3 | 0.0 | 13 |
| 19 | Outlaw/Syn | 972 + spinosad (Regard) @ 0.15 mg/seed | | 170 | 20.3 | 0.7 | 0.7 | 0.3 | 23 |
| | ANOVA (Pr>F) | | | 0.001 | 0.001 | 0.5 | 0.04 | 0.13 | 0.002 |
| | FPLSD (0.05) | | | 28 | 7.3 | ns | 3.7 | 2.9 | 2.9 |

[a] Seed also treated with fungicide
[b] 972 = Captan, 2.5 fluid oz; thiram 2.0 fl oz.; mefenoxam 0.45 fluid oz.; **thiamethoxam 1.28 fluid oz**.; streptomycin 0.3 oz/A; sedaxane (fungicide) 0.08 fl oz, all applied at rate specified/100 lbs of seed.
[c] 333 = Captan, 2.5 fluid oz; thiram 2.0 fl oz.; mefenoxam 0.45 fluid oz.; **thiamethoxam 1.28 fluid oz**.; streptomycin 0.3 oz, all applied at rate specified/100 lbs of seed.

**Table 4** (Exp 4)**.** Efficacy of spinosad and other seed treatments on seed corn maggot in snap beans at unifoliate growth stage, Monroe, OR. Planted 17-May; Evaluated 4-Jun unless noted. N=4.

| | Snap bean cultivar | Seed treatment/ source of seed | Rate | Stand in plot | Vigor rating | Seedling count | Snake heads | All maggot-damaged seeds or seedlings | Maggots visible | Stunting (29-Jun) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *200 seeded/ 25 ft* | *10=dead; 0=no damage* | *-------------no. in 3 ft of affected row---------* | | | | *%* |
| 1 | Pierroton | Nontreated/Syn | - - | 175 | 2.5 | 27 | 0.5 | 2.5 | 0 | 23 |
| 2 | Pierroton | Regard/Syn | 0.15 mg ai/seed | 183 | 1.3 | 29 | 1.0 | 1.0 | 0 | 10 |
| 3 | Rogue | Nontreated/Syn | - - | 172 | 0.0 | 33 | 2.0 | 3.3 | 0 | 14 |
| 4 | Rogue | Regard/Syn | 0.15 mg ai/seed | 178 | 0.0 | 26 | 1.5 | 2.0 | 0 | 6 |
| 5 | Pierroton | Nontreated/IR-4 | - - | 152 | 2.3 | 23 | 2.3 | 3.3 | 0 | 29 |
| 6 | Pierroton | Entrust/IR-4 | 0.125 mg ai/seed | 151 | 2.8 | 28 | 0.8 | 1.5 | 0 | 13 |
| 7 | Pierroton | Tracer/IR-4 | 0.25 mg ai/seed | 149 | 1.8 | 26 | 0.8 | 2.5 | 0 | 15 |
| 8 | Pierroton | Capture LFR; banded over seed row | 8.5 oz/a | 162 | 2.5 | 24 | 1.3 | 2.5 | 1.3 | 15 |
| | ANOVA (P>F) | | | 0.01 | 0.2 | 0.06 | 0.11 | 0.13 | 0.45 | 0.68 |
| | FPLSD (0.05) | | | 11 | ns | 6 | 1.3 | 1.7 | ns | ns |

**Table 5 (**Exp 5). Efficacy of spinosad and other seed treatments on seed corn maggot in snap beans at unifoliate growth stage, Macksburg, OR. Planted 3-Jun; evaluated 7-Jul (n=3).

| | Snap bean cultivar | Insecticide/ Source of seed treatment | Rate | Stand in plot | Vigor rating | Stand | Snake heads | All maggot-damaged seeds or seedlings | Maggots present |
|---|---|---|---|---|---|---|---|---|---|
| | | | | *130 seeded/ 15 ft* | *10=dead; 0=no damage* | *----------------no. in 3 ft of affected row---------------* | | | |
| 1 | Pierroton | Nontreated/Syn | - | 41 | 3.7 | 7.0 | 0 | 3.0 | 0 |
| 2 | Pierroton | Regard/Syn | 0.15 mg ai/seed | 44 | 1.5 | 11.7 | 0 | 0.3 | 0 |
| 3 | Rogue | Nontreated/Syn | - | 63 | 2.3 | 13.0 | 0 | 4.0 | 0 |
| 4 | Rogue | Regard/Syn | 0.15 mg ai/seed | 54 | 1.7 | 15.0 | 0 | 0.3 | 0 |
| 5 | Pierroton | Nontreated/IR-4 | - | 30 | 5.0 | 9.3 | 0 | 0.3 | 0 |
| 6 | Pierroton | Entrust/IR-4 | 0.125 mg ai/seed | 23 | 3.0 | 4.3 | 0 | 0.0 | 0 |
| 7 | Pierroton | Tracer/ IR-4 | 0.25 mg ai/seed | 22 | 6.3 | 7.0 | 0 | 0.3 | 0 |
| | ANOVA (P>F) | | | 0.01 | 0.07 | 0.03 | ns | 0.08 | ns |
| | FPLSD (0.05) | | | 23 | 3.3 | 6.3 | - | 3.2 | - |

**Table 6**. Efficacy of Entrust for seed corn maggot control in sweet corn, Corvallis, OR. Planted 18-May 2021.

| Seed treatment | Product rate | Stand (40 seeds sown/plot) | Vigor rating (22-Jun) | Seedling count (22-Jun) | Damaged seedlings (22-Jun) | Maggots present (22-Jun) | Vigor (9-Jul) | Runts (9-Jul) |
|---|---|---|---|---|---|---|---|---|
| *GSS1477* | *mg ai/seed* | *no/plot* | *10-dead, 0=best* | ----------- *No. in 3 ft of affected row* | | ---------- | *10-dead, 0=best* | *no./plot* |
| 1 No insecticide | N/A | 31.1 | 2.8 | 4.8 | 0.8 | 0 | 1.9 | 3.5 |
| 2 Entrust | 0.125 | 32.6 | 2.4 | 6.8 | 0.3 | 0 | 0.2 | 3.3 |
| 3 Entrust | 0.25 | 31.0 | 2.5 | 5.3 | 0.5 | 0 | 1.0 | 3.0 |
| ANOVA (PR>F) | | 0.51 | 0.91 | 0.38 | 0.44 | - | 0.06 | 0.91 |
| FPLSD (0.05) | | ns | ns | ns | ns | ns | 1.3 | ns |

**Table 7.** Efficacy of Entrust for seed corn maggot control in sweet corn, Macksburg, OR, 2021. Planted 2-Jun-2021 and evaluated 7-Jul at V6.

| | Seed treatment | Rate | Stand (40 seeds sown/plot) | Vigor rating | Runts | Damaged seedlings | Maggots present |
|---|---|---|---|---|---|---|---|
| *GSS1477* | | *mg ai/seed* | *no/plot* | *10-dead, 0=best* | no./plot | no./plot | no./plot |
| 1 | No insecticide/IR-4 | - | 27.3 | 1.8 | 2.7 | 0 | 0 |
| 2 | Entrust/IR-4 | 0.125 | 28.0 | 0.3 | 3.3 | 0 | 0 |
| 3 | Entrust/IR-4 | 0.25 | 25.7 | 1.3 | 2.7 | 0 | 0 |
| | FPLSD (0.05) | | ns | ns | ns | ns | ns |

Impacts:

Seed corn maggot (SCM) damage to snap beans was highly variable within sites and season. Only one of the sites (EXP3) had maggot damage that allowed us to reliably evaluate spinosad efficacy on SCM for Pierroton seeds. Three of the sites demonstrated spinosad efficacy on SCM for the larger seeded variety Rogue. Spinosad also reduced SCM damage to Huntingdon and Outlaw varieties at Keizer. The spinosad formulation applied to the larger-seeded varieties was Regard rather than Entrust and Tracer, and the Regard seed treatments were applied by Syngenta. Particularly effective were treatments 16 and 19 on Huntingdon and Outlaw varieties, respectively, that included both thiamethoxam (972) and spinosad applied to seeds (Table 3).

Pierroton is a very small seeded variety and emergence is often poor compared to other varieties (pers. comm. Dr. Myers). We have noted in the past that Pierroton emergence is often hampered by seed corn maggot, even when seed is commercially treated with thiamethoxam. Perhaps seed surface area of Pierroton is so much smaller than other varieties that the amount of insecticide applied is insufficient to suppress or control SCM. Interestingly, the higher rate of spinosad applied to seeds via the formulation Tracer often had damage comparable to the non-treated seeds, while the lower rate applied via Entrust was typically more effective. Tracer was used in this study because characteristics of the Entrust formulation prevented application of the required spinosad rate to snap bean seeds.

Capture banded over the seed row reduced seed corn damage at most sites and may be an important alternative until spinosad products are labeled as seed treatments. One caveat noted was the above average emergence of Pierroton at the site near Monroe, for reasons unknown.

Registrants always request demonstration of crop safety before pesticides can be labeled for specific uses. There was no indication that any of the treatments applied in these trials injured snap beans or sweet corn.

Relation to Other Research:

This project supports our program goals of providing integrated pest management tools for producers of processed vegetables. Specifically, this work will ultimately provide the efficacy and crop safety data needed to support a label for spinosad insecticide on both organic and conventionally grown snap beans. Bayer is the registrant of interest currently, as Syngenta no longer has access to the active ingredient to produce Regard. Bayer has indicated that more crop safety data is needed before this registration can move forward. A residue tolerance already exists for this product. Sponsors of this work include Interregional Project #4 (USDA) and Syngenta Corp.

# Research/Extension Progress Report for 2020-2021 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**: Thomas Barnett, Mike Christensen, Nick Ebner, Kendal Johnson, Jim Schlechter, Scott Zielinski

**Funding history:**
2018-19: $20,392
2019-20: $19,714
2020-21: $18,364
2021-22: $14,910

ABSTRACT

VegNet is a regional pest monitoring, detection, and alert service designed to benefit the Oregon processed vegetable industry. It has been operational for 25 years and is now an integral resource for many people. The program provides activity data, based on passive and active sampling, of 10+ species of common insect pests. Crops monitored include broccoli, cauliflower, sweet corn, and snap beans. Each week between May and September, subscribers receive a summary of data trends at each site, potential impacts, and other items of interest regarding vegetable crop production. These weekly reports are sent by email to over 400 subscribers. Cooperating growers and ag industry representatives then use the data to make informed IPM decisions. However, the program is free and utilized by home gardeners, OSU Extension personnel, state agencies, and the general public. Many of the species we track have wide host ranges (grasses, small fruits, nursery stock, etc.) and because monitoring occurs throughout the mid-Willamette Valley, subscribers often 'tune in' to become informed of possible outbreaks that might affect them. Comparative analyses between sites and years can reveal trends that directly inform pest management priorities. We make every effort to provide clear and concise information about insect issues. Two companion research blogs allow users to delve deeper into pest identification and biology.

KEYWORDS: insect, monitoring, sweet corn, broccoli, snap beans, IPM, pest, newsletter, black cutworm, Extension

OBJECTIVE

1. Continue operation of a regional pest monitoring and reporting network for damaging crop pests including armyworm, black cutworm, variegated cutworm, diamondback moth, cabbage looper, 12-spot beetle, and aphids.

PROCEDURES

Field sites were selected based on target crop, relative geographical location, and grower cooperation. At each location, ‘Texas cone’ wire mesh traps were placed at field edges and baited with pheromone lures (AlphaScents, Inc.). Lures were changed every 4 weeks. Other passive sampling techniques included yellow sticky cards and delta wing traps (Great Lakes IPM). Insects from traps were collected weekly, counted, and retained for identification as necessary. Direct sampling was conducted periodically and included sweep nets to quantify larvae, and leaf pulls for presence/absence of aphids. Monitoring stations were set at 5 different field site locations throughout the Willamette Valley, OR. Sampling began the week of May 3rd and ended August 30th, 2021. Weekly reports were issued via an external email marketing system. Web traffic metrics (email opens, links clicked, etc.) of each report were monitored as a means of measuring impact of weekly content. A grower field day did not occur this year.

ACCOMPLISHMENTS

OBJ. 1 - *Regional pest monitoring and reporting.*
Continuous, long-term datasets such as VegNet provide a clearer picture of pest activity than programs that only monitor for one year or one season. One of the most notable items from 2021 was the early boom of black cutworm (BCW). First detected at the vegetable research farm in Corvallis on May 10th, an elevated count was also noted at the Lakebrook sweet corn site (near Keizer) by May 24th, and levels remained above average for most of the season. In contrast, variegated cutworm (VCW) was also about 70% higher in Corvallis in early May, but quickly leveled off and the regional average remained below normal for the rest of the season.

Brassica pests such as diamondback moth (DBM) and cabbage looper (CL) were relatively low at monitored sites. We did receive feedback from field scouts that DBM was above average at their fields (not monitored by VegNet), so in response, an informational training blog post was developed on July 29th and the link was sent out as part of the Week 13 report. The post covered biology of DBM, how to accurately scout for them, and why normal insecticide sprays may not be as effective as they once were.

A certain number of challenges plagued this year’s sampling season. Sites were limited due the budget reduction, and this affects a true ‘regional average’ because some weeks, that average was based on only 2 or 3 site locations. The heat events that occurred took a toll on people and vegetables alike! And finally, this year’s season was cut short by about 3 weeks due to program manager’s unexpected travel/family emergency. A full archive of weekly reports from 2021 is available here.

IMPACTS

Short term impacts to program subscribers are evident each week. Through email reports, users gain immediate benefit from site-specific pest activity alerts. These estimates of insect pest activity allow producers to make immediate, informed spray decisions. We have heard feedback from both industry and cooperators that VegNet is useful for their crop production goals. We hope that this information will eventually translate into medium and long-term impacts as growers embrace pest monitoring as a critical IPM tool.

Other impacts of the program are notable even when the content we produce is not directly related to processed vegetables. According to built-in analytics of the companion blog site, 74% of annual (Dec-Dec) views of the website occurred between March and July 2021. Of those views, 75% (3,482) were to access material about cicadas. Similar to last year's 'hot topic' of Asian giant hornet, public users were very interested in the 2021 brood of this interesting insect. While we don't have the large boom of periodic species here in Oregon, there was much interest throughout the community. A local elementary school sent me a photo of a newly hatched cicada, and it made for a good teaching experience for the kids.

The report issued in Week 10 included photos of heat stress in vegetables and also a link to an agricultural economics manuscript about irrigation choices in times of extreme heat and water scarcity. The Week 10 email received more opens and clicks than any other week of the year.

## RELATION TO OTHER RESEARCH / EXTENSION

VegNet has now become integrated into the Oregon IPM Center, with funding secured from a NIFA-Extension Implementation Program grant. The purpose of the grant is to "increase IPM implementation among the clientele served by an eligible institution". This partnership is mutually beneficial; VegNet is a well-established IPM program that can now be recognized under the umbrella of the OIPMC, and the Center has existing staff with expertise in pest modeling. Program staff are now more closely aligned and have started analyzing migration patterns, environmental parameters, and insect patterns as a way to make predictions that can help growers prepare for potential outbreaks.

Corn earworm (CEW) migration is highly dependent on weather and wind patterns. I recently compiled and submitted over 2,200 distinct data points of CEW activity, ranging from 1999 to 2015. The data will be incorporated into a national-scope journal article about CEW population dynamics. The article is being authored by a post-doc at North Carolina State University.