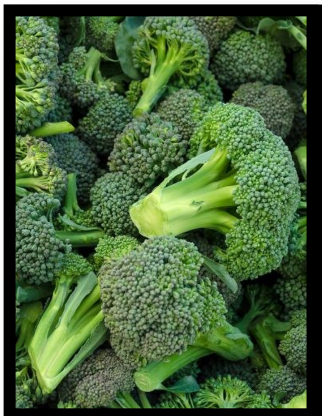
2020—2021
Proposals



Oregon
Processed Vegetable
Commission



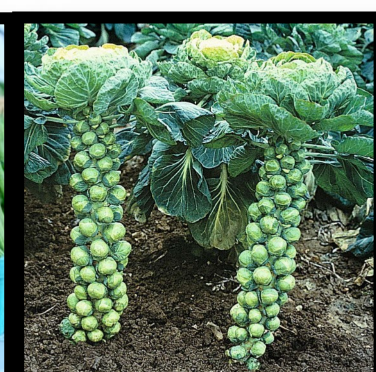


Table of Contents

Proposals

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

YEAR INITIATED: 2019-20 **CURRENT YEAR:** 2020-21 **TERMINATING YEAR** 2021-22

PERSONNEL & COOPERATORS:

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FUNDING REQUEST FOR 2020-21: $35,000

JUSTIFICATION: 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.

Soilborne diseases caused by fungi like *Fusarium* species are increasingly important. Although breeding for plant resistance to *Fusarium* species is valuable, it is not the end-all in disease management because *Fusarium* is capable of genetic adaptation for quickly overcoming plant resistance genes. Soilborne *Fusarium* propagules that survive between crops are unreachable by most chemical applications. Fungicide seed treatments provide only short periods of efficacy and cannot protect throughout the growing season for vegetable crops like sweet corn and snap bean. Soil fumigants and other soil treatments are costly, destroy beneficial soil microorganisms, and do not control *Fusarium* existing in plant debris.

Plant pathologists have informally and formally discussed the increased presence of pathogenic *Fusarium* species. The factors behind the greater yield impacts from *Fusarium* are complex and potentially have synergistic interactions. In western Oregon soils, soil temperature and moisture levels during the growing season as well as during the non-cropping months greatly affect disease pressure. It is likely that conditions occurring during winter and early spring months promote the survival and/or propagule increases of *Fusarium* species. It could be a direct effect such as periods of warmer winter temperatures that promote both weed growth and *Fusarium* reproduction on weedy hosts, or indirectly by the modulation of the breakdown of crop plant residues after harvest as well as the variation of other soilborne microflora (bacteria, actinomycetes, other fungi) that are antagonistic to pathogenic *Fusarium* species.

Little has been done in investigations on soil water and temperature effects on these Fusarium diseases in processing vegetables in western Oregon. Peachey (2005) showed that an irrigation regime that imparted drier soil conditions was associated with lower levels of root rot in sweet corn. However, Fusarium crown and stalk node rot disease severity may increase or have earlier onset in sweet corn fields under drier, hotter soil conditions. For long term success in managing fields to suppress Fusarium, we need to have enhanced information on how soil temperature and moisture affect disease levels.

During the first year (2019-2020) of research on this project, we found that the number of *Fusarium* colony forming units per gram of oven-dried soil were very high overall in the two sweet corn and one snap bean field monitored, especially in the sweet corn field on one farm where Fusarium levels in the soil ranged well above 100,000 CFU/g soil. This would explain the overall severe crown root that was found early in sweet corn plants. Root rot was severe in snap beans while root rot was minimal on the adventitious roots of sweet corn.

HYPOTHESIS & OBJECTIVES: We hypothesize that the incidence of *Fusarium* diseases can be predicted by soil temperature and moisture levels. It may be possible to reduce *Fusarium* diseases and their associated losses in sweet corn and snap bean fields by connecting the interaction of *Fusarium* and soil environment with the physical properties of soils and cropping practices such as irrigation and residue management or choice of rotational crops. The proposed investigations would aid in improving the sustainability of processing vegetable production in Oregon.

The objectives of this project are:

1. Evaluate soil conditions (temperature and moisture) as predictors of *Fusarium* levels in the soil.
2. Evaluate *Fusarium* disease incidence and severity of crops in monitored sweet corn and snap bean fields.

PROCEDURES:
Objective 1: Evaluate soil conditions as predictors of *Fusarium* levels in the soil.

We will continually monitor soil temperature and soil moisture through the growing season and overwinter. Each field will have two TDR-315 sensors installed in the top 6-inches of soil and two sensors at 12-inches. TDR probes will be connected to data loggers (equipment owned by Buckland's program) that will be located at recording stations within the field. Data will be downloaded at regular intervals and used to describe overall field conditions throughout the season. We anticipate being able to identify temperatures as well as duration of conditions, such as excessively dry and hot summer conditions or winter low temperatures, which may discourage the growth of *Fusarium* or promote propagule die-out. In 2020-21, we anticipate beginning to overlay crop lifecycles with disease incidence to begin to develop predictive modeling. We will also complete a basic soil health assessment including soil physical, chemical and biological properties as a reference for soil moisture and temperature data.

Fusarium population levels in fields will be determined in representative soil samples collected immediately prior to sowing the crop, every two to three weeks until harvest, and then, monthly during the fall/winter until sowing the following spring. Twelve-inch soil cores will be collected in a systematic manner across each of four blocks in each commercial field site. Soil cores will be combined within each block and three subsamples for each block will be evaluated for *Fusarium* colony forming units by soil plating onto a *Fusarium*-selective medium.

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

For the crops rotated into the three monitored fields, rot of belowground portions as well as any crown tissues will be evaluated every two to three weeks beginning in June. Plants will be evaluated by digging up 10 plants from each block (40 plants per field), washing soil from the root balls of each plant, and rating for the disease incidence and severity. A sub sample of plants will be plated onto a *Fusarium*-selective medium to confirm the presence of *Fusarium* spp.

ANTICIPATED BENEFITS/EXPECTED OUTCOMES/INFORMATION TRANSFER:
We anticipate that the data from continual soil monitoring will be the start of a database that will identify conditions under which Fusarium diseases will pose an increased likelihood of crop loss. We anticipate the need to continue soil and plant health monitoring over three seasons to gather data under a wide variety of environmental conditions. With these results, growers and field agronomists can adapt crop rotation, irrigation scheduling and crop disease scouting intervals as needed to minimize crop losses.

PROJECT TIMELINE:
Temperature and moisture data will be recorded continually throughout the year. Soil will be sampled in late spring and at planting for full chemical, biological and physical analysis. Soil pathogen sampling and crop sampling will begin in June, after which samples will be collected every 2-3 weeks throughout the growing season.

Activities	Year 2			
	2020-2021			
	Spring	Summer	Fall	Winter
Soil monitoring				
Soil samples				
Soil pathogen sampling				
Sampling of plants in the three fields being monitored				

LITERATURE REVIEW: *Fusarium* species are common soil inhabitants that can infect most crop species and cause a range of symptoms and types of diseases. Fusarium wilts, root rots, and seed/seedling diseases occur world-wide, causing economically important disease outbreaks (Summerell et al., 2010). Many of the disease symptoms in important annual crops caused by *Fusarium* species lead to lodging, stunting, or death of the plants, and can also result in the accumulation of harmful mycotoxins. In this proposal, we focus on sweet corn and snap bean because of the agronomic importance of these crop species in the processing vegetable systems and the plethora of associated *Fusarium* diseases (Table 1). Many *Fusarium* species are associated with rot of corn roots, stalks, and ears. Root rot of corn has been studied in the Midwestern US for decades. A new *Fusarium* disease that became yield limiting in sweet corn, was observed on *Zea mays* in western Oregon during the 1990s (Fig. 1; (Miller and Ocamb, 2009)). This disease is incited by *F. oxysporum* var. *redolens*, which can cause Fusarium crown and stalk node rot in sweet corn, dent and silage corn (Ocamb, *unpublished*). *Fusarium solani* f. sp. *phaseoli* causes root rot in snap bean (Fig. 1; (Silbernagel and Mills, 1990)). *Fusarium* diseases are common on sweet corn and snap bean in western Oregon processing fields. Ocamb previously investigated sweet corn root rot and Fusarium crown and stalk node in western Oregon (OPVC reports 2002 through 2013) as well as Fusarium root rot of snap bean (OPVC reports 2010 and 2011).

Managing irrigation rates to change the soil moisture content has been shown to impact yield loss due to Fusarium root rot in beans (Miller and Burke, 1998). Clearly, soil moisture content is also affected by air temperatures and precipitation events. Investigations into soil moisture and temperature effects have also been linked with incidence and intensity of *Fusarium* and other soilborne pathogens in other crops (Smiley, 2009). Modeling tools currently exist for crops such as wheat to predict *Fusarium* pressure based on climatic events (http://www.wheatscab.psu.edu). Our proposed work involves different disease and crops, yet promises to provide the basis for future decision making tools.

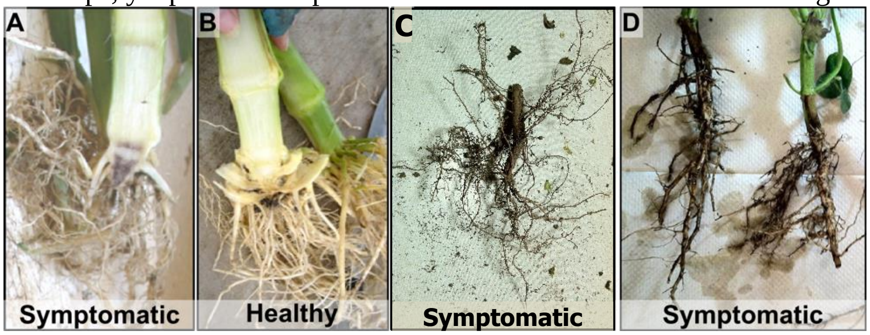

Figure 1. Crown and stalk node rot of sweet corn, 'Jubilee' and root rot of snap bean. (A) Sweet corn plant exhibiting crown and stalk node rot. (B) Crown of corn plant unaffected by Fusarium crown and stalk node rot. Initially, corn leaves turn brown starting at the base of the plant as *Fusarium* grows up the stem and to the roots; infection of the brace root occurs as the pathogen(s) spreads from infected crowns. Rot of stalk nodes and crown tissues interfere with transport through the vascular system and negatively affects yield. This disease is widespread across the Pacific Northwest and occurs on both sweet corn and Round-up Ready dent corn lines. Plants with similar symptoms have been found in sweet corn produced in Midwestern US, Europe, and South America. (C & D) Snap bean plants grown in western Oregon exhibiting root rot due to soilborne *Fusarium*.

Table 1. ***Fusarium* species reported for corn and snap bean in the USA**

Crop	***Fusarium* species reported***	**Diseases incited**
Corn (*Zea mays*)	*F. acuminatum, F. avenaceum, F. culmorum, F. episphaeria, F. equiseti, F. graminearum, F. merismoides, F. oxysporum, F. poae, F. proliferatum, F. rimosum, F. sambucinum, F. scirpi, F. semitectum, F. solani, F. sporotrichioides, F. subglutinans, F. temperatum, F. tricinctum, and F. verticillioides*	Crown rot; crown and stalk node rot; damping-off; ear rot; root rot; seed rot; seedling blight; and stalk rot.
Snap bean (*Phaseolus vulgaris*)	*Fusarium oxysporum* f. sp. *phaseoli,* and *Fusarium solani* f. sp. *phaseoli*	Root rot; and wilt.

Literature Cited:

Miller, D, Burke, D (1986) Reduction of Fusarium root rot and Sclerotinia wilt in beans with irrigation, tillage, and bean genotype. *Plant Disease* 70:163-166.

Miller N, Ocamb CM (2009) Relationships between yield and crown disease of sweet corn grown in the Willamette Valley of Oregon. *Plant Health Progress* doi:10.1094/PHP-2009-0831-01-RS.

Silbernagel MJ, Mills LJ (1990) Genetic and cultural control of Fusarium root rot in bush snap beans. *Plant disease* 74:61-66.

Smiley, RW (2009) Water and temperature parameters associated with winter wheat diseases caused by soilborne pathogens. *Plant Disease* 93:73-80.

Summerell BA, Laurence MH, Liew E, Leslie JF (2010) Biogeography and phylogeography of *Fusarium*: a review. *Fungal Diversity* 44:3-13.

2019-20 BUDGET:

	OPVC
Salaries: Faculty Research Assistant (0.20 FTE)	$11,200
Other students	$6,500
Employee Benefits (OPE): Faculty	$7,480
Equipment	$2,600
Travel: Domestic (in state)	$1,977
Soil testing	$243
Operating Expenses[1]	$5,000
Total	$35,000

[1] Laboratory and field soil and plant sampling supplies.

ANTICIPATED REQUESTS IN COMING YEARS (if applicable):

We anticipate repeating the study as described in 2021-2022. Depending on the quality of the data produced, we would plan to expand the soil moisture sensing capability to be able to monitor fields with different rates of irrigation as a comparison. We anticipate the funding request in 2020-2021 would be approximately $35,000 to allow for the purchase of additional sensors with a similar amount of time and salary required to complete the trial. The proposed request in 2021-2022 would not require additional moisture sensors and could be slightly reduced, depending on current salary rates, and is estimated as a $30,000 request.

OTHER SUPPORT OF PROJECT:
Faculty time, laboratory and field lab space as well as existing equipment from both Buckland and Ocamb is available and will ensure the project is adequately supported; the value of the faculty time (not including Facility Research Assistant time) during 2019-2020 was estimated at $24,926 for Ocamb's effort and $11,612 For Buckland's effort.

PROPOSAL TO THE OREGON PROCESSED VEGETABLE COMMISSION (2020)

1. OPVC PROPOSAL COVER PAGE (1 page)

PROJECT TITLE: Green Bean Breeding and Evaluation

PROPOSED PROJECT DURATION: 1 year (renewed yearly)

BUDGET TOTALS
TOTAL BUDGET REQUEST (all years):

Year 1:	$29,352 breeding
	$7,800 processing
	$37,153 total

Contributions from the OSU breeding program

Year 1: **$20,865**

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2. PROPOSAL NARRATIVE (maximum 5 pages)

JUSTIFICATION and LITERATURE REVIEW

Green beans grown for processing in the Willamette Valley contribute significantly to the Oregon state economy each year ($23.6 million in 2018). 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. Based on 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. In particular, we have a number of crosses to the wax bean 'Unidor' which has shown good white mold resistance. These need to be evaluated for resistance, increased, and placed into replicated yield trials. Additional crosses are in earlier generations, and need to be moved along the pipeline. We also have about 300 advanced lines ready for screening for disease resistance.

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.

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

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 2020 is to evaluate over 300 advanced lines that are potentially resistant to white mold for field performance and processing quality. In 2019, we evaluated 140 lines for white mold resistance, 112 of these for field performance and raw product quality and 55 of these for processing quality. From these, we arrived at 32 lines that performed well in all aspects and merited trialing again in 2020. We will place these lines in trial along with as many of the remainder of advanced lines as we handle to again evaluate yield quality and disease resistance. Preliminary trials of approximately 75 entries each with two reps and appropriate BBL checks will be grown as described below. In addition to yield and quality trials, these will be screened in our white mold disease trial.

Varietal Development: The program will continue with crosses among elite lines and the best white mold resistant lines. Pedigree and single seed descent breeding methods will be used to advance and select early generation materials. While the emphasis will be on breeding for white mold resistance, we also need to continue to incorporate improved plant architecture and conduct yield and processing trials of the best lines. Preliminary yield trials will be planted between May 10 and July 5. Plots will consist of a single 20-foot row from which 5-foot sections will be harvested for graded yield and raw product evaluation. Lines will be evaluated for growth habit, yield and graded samples will be evaluated for pod smoothness, straightness, seed to pod ratio, and color. Those that meet expectations in the raw product evaluation will be canned and frozen for evaluation of the processed product. User panels will evaluate quality of canned and frozen samples. Where the opportunity presents in the preliminary yield trials, we will evaluate white mold resistance. Most of the entries in this the preliminary trial are larger sieve size materials.

Advanced Lines: Seed increase, roguing, and sub-line maintenance of the historical releases will continue. 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.

PITFALLS

White mold disease can vary from year to year. However, we have managed to achieve consistent results by using fields with a high sclerotia load and managing them for enhanced infection at bloom.

3. BUDGET DETAILS (maximum 2 pages)

1) Breeding (Myers)	
Salaries and benefits	
Faculty Research Assistant	$16,843
OPE @ 71.3%	$12,009.20
Wages and benefits	
Student Wages	$0
OPE @10%	$0
Supplies	$500
Travel	$0
Land and greenhouse rental	$0
Total	$29,352
2) Processing Evaluation (Wiegand)	
Salaries and benefits	
Faculty Research Assistant	$2,800
OPE @ 61.59%	$1,725
Wages and benefits	
Student wages	$1,780
OPE @ 10%	$196
Supplies	$1,300
Total	$7,800
Grand Total	**$37,153**

Contributions of the OSU breeding program	
Student Wages	$9,120
OPE @ 10%	$912
Supplies	$500
Travel	$93
Land and greenhouse rental	$10,241
Total	$20,865

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 ft2 at $1.55 per square foot.

PROPOSAL TO THE OREGON PROCESSED VEGETABLE COMMISSION (2020)

1. OPVC PROPOSAL COVER PAGE (1 page)

PROJECT TITLE: Broccoli Breeding and Evaluation

PROPOSED PROJECT DURATION: 1 year (renewed yearly)

BUDGET TOTALS
TOTAL BUDGET REQUEST (all years):
Year 1: **$7,992 (breeding)**
$4,976 (processing)
$12,968 (total)

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2. PROPOSAL NARRATIVE (maximum 5 pages)

JUSTIFICATION and LITERATURE REVIEW

Oregon has an ideal climate for summer production of broccoli with 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 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 20 years to develop cultivars that have architectural traits that make the cultivar more amenable to machine harvest. Beginning in 2016, we have worked with the Crescent Valley Robotics team to better understand what is needed in a mechanically harvestable broccoli. We also received funding in 2018 from a Western SARE grant to examine production questions related to developing the machine harvest package. In the past two years, we visited the Norpac plant to examine the in-plant process to investigate what traits amenable to genetic manipulation might be modified in a broccoli cultivar.

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.

Another issue facing broccoli growers in Oregon is that of climate change. Historically, the Willamette Valley of Oregon has been a good environment for broccoli production, with cool days and nights. In recent years, summer temperatures have been warmer but there have been more extreme daytime high temperatures as well. In 2019, we conducted a heat tolerance trial supported by Western SARE funds of commercial hybrids and a few experimental inbreds to identify materials that showed stable performance across the season. This evaluation needs to be extended to the experimental material in the OSU breeding program to identify those with better buffering to abiotic stresses.

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.

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.

METHODS

We will continue to derive new inbreds and use these on a small scale to produce F_1 hybrid seed for replicated yield trials. Inbreds lines saved from the 2019 fall trials will be grown from cuttings in the greenhouse. During the winter of 2020, these will be bud-pollinated to perpetuate the line, and crossed to other inbred lines to evaluate combining ability for F_1 hybrid production. Crossing efforts will focus 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 will trial hybrids in the spring as well. New inbreds will be obtained from selections of a random-mated mass selected population originally developed under organic production systems, where cuttings will be 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 will be grown in the 2020 main fall planting in the field in a single replicate observation trial, and hybrids alone in a replicated yield and quality evaluation trial. Plots will be evaluated for head size, shape, and exsertion, segmentation, floret texture and color, maturity and disease resistance.

A replicated yield trial will be conducted in the fall. Up to 10 of the most promising OSU experimental hybrids and two to four check varieties will be planted. The other will consist of commercial hybrids selected chosen because of reported heat tolerance and/or have desirable mechanical harvest traits. Hybrids will be transplanted in one row plots 30 feet in length and replicated four times. In addition to observation data, yield data will be obtained. Entries in the yield trials will be taken to the OSU pilot processing plant for blanching and freezing. Frozen material will be evaluated at the OSU winter cutting and will be displayed at the PNVA meetings in Kennewick, WA in November.

Abiotic (heat) stress tolerance will be evaluated by planting sequential replicates at one week intervals across the growing season, with planting timed to span the period of greatest heat during the summer. OSU inbreds and hybrids with sufficient seed will be grown along with a selection of commercial cultivars that performed well in heat trials in 2019. Plots will consist of 10 plants per line per planting date and plants will be evaluated at harvest maturity for head quality.

Backcrossing of selected hybrids to place the nuclear genome in the Ogura cytoplasmic male sterile (CMS) background will continue. We will continue developing CMS forms of S454, S462, S463, S471, S473 and S475. Seed production of selected hybrid combinations using a fertile inbred as a male and a CMS inbred as a female will be evaluated in the field using isolation plots.

PITFALLS

Heat tolerance is difficult to evaluate if heat and the vulnerable period of heading do not coincide. By planting at weekly intervals, we maximize the chances of at least one planting being at the appropriate stage when heat occurs. If inbreds share the same self-incompatibility allele, it may not be possible to produce that combination commercially even if one parent is CMS. For that reason, we generally try to choose inbreds that are self-fertile for introgression of CMS.

3. BUDGET DETAILS (maximum 2 pages)

1) Breeding (Myers)	
Salaries and benefits	
Faculty Research Assistant, field, 0.30 FTE	$2,526
OPE @ 71.3%	$1,801
Wages and benefits	
Student Wages ($12/hr, 15 hr/wk, 8 wks	$1,440
OPE @ 10%	$144
Supplies	$300
Land use and greenhouse rental	$1,780
Total	$7,992
2) Processing (Wiegand)	
Salaries and benefits	
Faculty Research Assistant	$2,796
OPE @ 61.59%	$1,722
Wages and benefits	
Student Wages	$246
OPE @ 10%	$25
Supplies	$187
Total	$4,976
Grand Total	$12,968

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 71.3%. 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. $1,440 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).

RESEARCH PROPOSAL TO THE AGRICULTURAL RESEARCH FOUNDATION
FOR THE OREGON PROCESSED VEGETABLE COMMISSION

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

YEAR INITIATED: 1996 CURRENT YEAR: 2020-21 TERMINATING YEAR: ongoing

PERSONNEL & COOPERATORS:

RESEARCH LEADER/PI: Ed Peachey
ORGANIZATION: OSU
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ORGANIZATION: OSU
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FUNDING REQUEST FOR 2020-21: $18,364** (see footnote)

JUSTIFICATION

The VegNet program is a stable and widely-used IPM resource, and is necessary for sustainable crop production of processed vegetables in the Willamette Valley. For over 20 years, growers and crop consultants have come to rely on VegNet alerts as an 'advance warning' of insect pest problems. Not having a regional estimate of looper activity, for instance, may cause growers to apply insecticides prophylactically (too early), or as a rescue treatment (too late), and neither strategy is desired from an IPM standpoint. Instead, awareness of insect counts helps growers stay informed and develop their own decision-making process. This in turn reduces costs to producers as well as environmental impact of pesticides.

Real-time pest alerts is one facet of VegNet. The other aspect we rely on is interpretation of current activity levels compared to historical averages. For many years now, bertha armyworm (*Mythimna unipuncta*, BAW) has been the only armyworm species monitored by VegNet. Outbreaks of this pest are sporadic, and damage occurs mainly in field crops (mint, hops, and potatoes). One notable exception is in the early 2000s when the VegNet program manager was in close communication with growers near Mt. Angel who were growing bell peppers. A localized outbreak of BAW was detected, an alert was made, and the acreage was 'saved'. Other cutworm and armyworm species are generally a problem for field crops and the grass seed industry, but the effort involved in monitoring BAW may not be worth it, given this year's reduced funding and uncertain planting schedules. Alternatively, we could place a few seminal bucket traps for BAW and/or set haystack traps for beet armyworm (*Spodoptera exigua*), a vegetable specialist species that may exist in this region[3].

VegNet is the only monitoring and reporting program for processed vegetable growers in the region. It is widely used by OSU Extension personnel as well as regional private sector agri-chemical and seed company representatives. Specific metrics are available upon request, but people that utilize VegNet data regularly include:

- OSU Extension personnel (community horticulture, small farms, specialty seed, mint, field crops)
- Regional ag-chemical and seed representatives (Valley Agronomics, Universal, CPS/Nutrien, Corteva, and Syngenta)
- Processors (Stahlbush, National, etc.)
- Growers (vegetable, family farms, diversified organic, blueberry, nursery, and more)

Relation to other PNW projects:
Statewide, VegNet is being used to inform legislatures on the critical work being done in agricultural extension and natural resource stewardship[2]. Other pest alert services exist in the region, and are, for the most part, commodity specific (Potato pests (OR/WA/ID), forest monitoring (ID), fruit and vegetable (ID), mint (OR/WA)).
It may be worth noting that programs very similar to ours operate in other vegetable growing regions of the eastern (Univ. of Kentucky) and mid-Atlantic (Univ. of Delaware) US. In Kentucky, they monitor for 6 species of field crop pests at 2 sites, and have an annual operating budget of around $23K[2].

HYPOTHESIS & OBJECTIVES

Advance warning of insect pest activity levels helps protect vegetable crop producers. To support this concept, we propose to:

1. Continue operation of a regional pest monitoring and reporting network by gathering data to strengthen knowledge of pest patterns. This year's targeted species will be: black cutworm, variegated cutworm, corn earworm, cabbage looper, and cucumber beetle.
2. Conduct a mid-late season preliminary trapping effort for beet armyworm.

PROCEDURES

OBJ. 1 - Field sites will be determined according to grower cooperation and planting schedules. At each location, 'Texas cone' traps will be placed and baited with species-specific pheromone lures. Yellow sticky traps will be used in similar fashion to monitor cucumber beetles and other non-target insects that may be of interest. We aim to collect data at each site for 20 weeks (May 1st to September 20th), but traps will remain in place at each site from shortly after planting through harvest. In addition to weekly data reports, a field day will be scheduled for vegetable growers and field reps to review seasonal trends and potential implications for the following year.
OBJ. 2 – Identify three locations that can be monitored with minimal extra effort (research farms, en route to existing sites, etc.) as seminal trap sites for either bertha or beet armyworm. Both species tend to have high activity from late July into September. Pheromones will be deployed and traps will be monitored as described in OBJ. 1.

ANTICIPATED BENEFITS, EXPECTED OUTCOMES, AND INFORMATION TRANSFER:

The most obvious short-term benefit of VegNet is the advance warning of pest problems so that vegetable producers can make informed IPM decisions. Long-term benefits include: strengthening the long-term dataset of activity trends for the species we track. These data will be published in an open-access format that can be used by other agencies to confirm crop pest models. Increased adoption of IPM is another long-term goal. In other vegetable growing regions, IPM adoption has been quantified and observed through reduced crop damage and insecticide usage[1].

Information transfer with this project is quite unique compared to other Extension programs. Rather than quarterly or monthly updates, VegNet results are published weekly – which is a necessity when working with multi-generational, temperature dependent row crop pests, but it does limit the amount of in depth analyses that can be done. Trap counts are reported through an email subscription platform and more detailed information is posted on a companion blog (beav.es/ZwK).

PROJECT TIMELINE:

- Early May – identify field sites and place traps
- May through August – monitor traps and issue activity alerts, communicate specific concerns with growers & reps

- September – field day at OSU Veg Farm
- November – attend and present at PNVA annual conference

LITERATURE REVIEW:

1 Development of the Regional Multi-State Insect Trapping Network for Use in Issuing Scouting Alerts and Predicting Potential Field Crop Insect Damage in the Heartland. Univ. of Kentucky Regional IPM Grant Report, project # 348.<http://news.ca.uky.edu/article/insect-trapping-network-early-warning-system>

2 "Our Impact": Statewide's critical work on natural resource policies and issues. Biennial funding cycle summary: <https://ourimpact.oregonstate.edu/initiative/2019-21-biennium/sustainable-agricultural-food-and-natural-resource-production>

3 Mitchell, E.R. 1979. Migration by *Spodoptera exigua* and *S. frugiperda*, North America style, Pp. 386-393. *In*: Rabb, L.R. & G.G. Kennedy (eds.). Movement of highly mobile insects: Concepts and methodology research. North Carolina State University

BUDGET

	OPVC
Salaries: Faculty	$7,380
Graduate student	----
Other students	----
Other labor	$3900
Employee Benefits (OPE): Faculty	$4797
Graduate student	----
Other students	----
Other labor	$312
Equipment	----
Travel: Domestic (in state)	$1125
Domestic (out of state)	$340
Foreign (conferences, etc.)	----
Operating Expenses [1]	$510
Other Expenses [2]	----
Total Requested	**$18,364**[**]

ANTICIPATED REQUESTS IN COMING YEARS - TBD

OTHER FINANCIAL SUPPORT

In lieu of recent events, we realize that funding for this project will inevitably be needed. We are currently having conversations, both within OSU, and well as with external agencies to develop a long-term funding plan. One possibility is to pursue industry support, and a donation account has been set up with the Agricultural Research Foundation to handle those arrangements. We have also considered partnering with the new Oregon IPM Center (formerly IPPC), but their funding cycle has not yet begun.

** If, for example, we are able to secure .10FTE salary of the program manager from OSU, and if we can secure $2000 from various industry supporters, the amount funded by OPVC could be $11,444.

*A sincere and heartfelt **Thank You** extends to OPVC*

for supporting VegNet as a top priority for over two decades.

RESEARCH PROPOSAL TO THE AGRICULTURAL RESEARCH FOUNDATION FOR THE OREGON PROCESSED VEGETABLE COMMISSION

TITLE: Effect of Planting Arrangement on Snap Bean Yield

YEAR INITIATED: 2019-20 **CURRENT YEAR:** 2020-21 **TERMINATING YEAR** 2020-21

PERSONNEL & COOPERATORS:

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

FUNDING REQUEST 2019-20: $5,394 2020-21: $7,969

JUSTIFICATION:

Nonchemical weed control strategies are in short supply in snap beans, particularly strategies that target weeds within the seed row. Recent work demonstrated the limitations of propane flaming and organic herbicides for weed control in stale seedbeds. There was very little improvement in weed control with propane flame or organic herbicides, and the stale seedbed system needed to make flame useful reduced snap bean yield by nearly 10 percent. Preliminary work in 2019 determined that adjusting seed placement in the row had little influence on yield, and may enhance opportunities for vision cultivation systems in snap beans that would improve non-chemical weed control options. The vegetable industry is evolving quickly, and new tools are now available to assist with in-row weed control. The Robovator uses electronic guidance to discriminate between weeds and crops and then activates a small sweep to remove weeds between plants. The Robovator effectively controls weeds in many widely spaced crops, but may not be suited for crops like snap beans unless modifications are made to the planting arrangements for snap beans.

HYPOTHESIS & OBJECTIVES:

1. Measure of the effect of in-row plant arrangement on snap bean yield. We hypothesize that snap bean seeds can be aggregated into 'hills' to increase the area of access by mechanical weeders such as the robovator, and that snap bean yield will not be impacted when using these compressed in-row seed arrangements.
2. Test the Robovator in field trials to determine if this is practical reality.

PROCEDURES:

Snap beans will be planted in 30 inch rows at the Vegetable Research Farm with 350 lbs 12-10-10 banded next to the row. Eleven treatments will be applied that represent reasonable plant populations in the field with between-seed spacings that provide a minimum of 6 inches between seed clumps or 'hills' (Table 1). Plots will be 15 ft long and 3 rows wide, but only the middle row will have varied plant spacings between rows. Weeds will be managed with Dual Magnum and Reflex herbicide PRE followed by Raptor and Basagran POST if needed. Snap beans will be harvested from 10 feet of each row and graded. Plant counts will also be taken.

In addition to the seed arrangement studies, a few rows of snap beans will be planted with the maximum in-row separation between bean seed hills of 9 inches. We will invite the services of GK Machine to weed the field with their robovator.

Table 1. Effect of in row seed density (seeds/foot) and spacing between seeds on seed-free area (gray cells) in the row.

		Spacing between seeds			Resulting plant population
	No. seeds /foot	0.5	0.75	1.0	30 inch rows
1	6	9.0	7.5	6.0	104544
2	7	8.5	6.75	-	121968
3	8	8.0	6.0	-	139392
4	9	7.5	-	-	156816
5	10	7.0	-	-	174240
6	11	6.5	-	-	191664
7	12	6.0	-	-	209088

ANTICIPATED BENEFITS/EXPECTED OUTCOMES/INFORMATION TRANSFER:

We were unable to find any references reporting this approach. If successful, new planting arrangements may pave the way for use of in-row electronically guided weeders in crops such as snap beans.

PROJECT TIMELINE: Snap beans planted in June and harvested in August.

2019-20 BUDGET:

		2019	Current 2020
Salaries (RA 3 weeks)		2596	3462
Benefits		1843	2458
Wages			
	Harvest labor	630	1050
Equipment rental		0	300
Supplies		0	0
Travel		0	0
Plot Fees		325	700
Other		0	0
Total		5394	7969

ANTICIPATED REQUESTS IN COMING YEARS $0
OTHER SUPPORT OF PROJECT: will propose this solution to WSARE if results are encouraging.

RESEARCH PROPOSAL TO THE AGRICULTURAL RESEARCH FOUNDATION FOR THE OREGON PROCESSED VEGETABLE COMMISSION

TITLE: Identifying heat tolerant broccoli cultivars for the processed vegetable industry.

YEAR INITIATED: 2020 CURRENT YEAR:2020 TERMINATING YEAR: 2020

PERSONNEL & COOPERATORS: Alex Stone
Horticulture Department, Oregon State University, alex.stone@oregonstate.edu

FUNDING REQUEST 2020 $8,953

JUSTIFICATION:

Broccoli is an important crop to Oregon's processed vegetable industry. Broccoli farmers have been working to fully or partially mechanize broccoli harvest to improve profitability. However, broccoli quality is compromised when summer air temperatures are high. For this reason, OSU is working with broccoli farmers and processors to identify new varieties that are high yielding and maintain quality when maturing under high and fluctuating air temperatures.

Temperature is often the main limiting factor in determining whether a broccoli variety can be successfully grown within a particular region (Farnham & Bjorkman 2011). Since most commercially available cultivars are bred for production in climatic regions outside of Oregon, the need to identify the best hybrids suitable for use by Willamette valley broccoli farmers is necessary to sustain the long term viability of broccoli in the processed vegetable industry. The broccoli heat trial was established in the summer of 2019 supported by a grant from Western SARE.

In January of 2019 project staff contacted broccoli breeders and seed companies to identify breeding and commercial broccoli lines with potential heat tolerance. Seed companies, university breeding programs, and a USDA funded broccoli breeding program sent seeds for evaluation in the trial.

In 2019, 38 broccoli lines were evaluated in a trial at the OSU vegetable research farm in Corvallis OR. All lines were planted on six different planting dates spaced one week apart to maximum the potential range of temperature variability within a single growing season. Bjorkman and Pearson (1998) have found there is a physiological period of in a broccoli plant's growth wherein excessive heat is the most detrimental to broccoli head formation. This 5-7 day period occurs when the broccoli plant is transitioning from vegetative growth to a reproductive phase, and the initial enlargement of bud primordia begins. Planting on 6 dates maximizes the potential of being able to correlate declines in plant performance with high or fluctuating ambient temperatures.

Of the 38 broccoli varieties trialed, many had irregularities in bead and color uniformity - the most common symptoms of a broccoli head affected by heat. Approximately ten of the broccoli varieties trialed this summer performed very well in all six plantings. Some of these are commercial broccoli hybrids widely recognized as being tolerant to heat, while others are not yet commercial.

Results from 2019 suggest that there are varieties with heat tolerance that produce high quality product that could be grown in the valley for processing. However, the trial needs to be conducted over several more seasons. This proposal requests funds to repeat the heat tolerance trial for a second season.

HYPOTHESIS & OBJECTIVES:

Goal: to Identify broccoli varieties that produce high quality product when grown in the high and fluctuating spring and summer temperatures in the Willamette Valley.

PROCEDURES:

Varieties:
Approximately 40 varieties will be evaluated. These will include varieties that performed well in 2019, along with new germplasm purported to be heat tolerant. Emerald Pride will be grown as the industry standard control.

The table below lists the 20 varieties with the best overall performance in 2019. These, with additional newly identified heat tolerant potential germplasm, will be grown in 2020.

Rank	Variety Name	Company
1	Eastern magic	Sakata
2	Eastern crown	Sakata
3	Kings Crown	Tainong Seed
4	Asteroid	HM Clause
5	Eiffel	Seminis
6	BC1764	Seminis
7	BC1691	Seminis
8	Imperial	Sakata
9	OCMS 93 x P9	Cornell Uni
10	Lieutenant	Seminis
11	Ironman	Seminis
12	Castle Dome	Seminis
13	Emerald pride	Sakata
14	Kariba RZ	Rijk Zwaan
15	Willandra RZ	Rijk Zwaan
16	Virgo F1	HM Clause
17	Darien RZ	Rijk Zwaan
18	Corato F1	Enza Zaden
19	Batory	Syngenta
20	Cascadia	OSU

Production:
Transplants will be produced at the OSU campus greenhouses and will be planted at the OSU research farm approximately 4 weeks later. For each of 5-6 plantings, 15 seeds of each broccoli variety will be started in seedling trays and the best 10 seedlings will be transplanted into the randomly assigned field plots using a transplanter at one foot in-row placings with 2.5 ft between rows. Seeds will be started every week for 6 weeks starting the second week in May. Two temperature data loggers will be placed in the trial to record the ambient air temperatures at canopy height for the duration of the trial. The growth of broccoli and trial site was closely monitored for any IPM related issues and treated as necessary.

Measurements:
Each head will be harvested individually when it reaches a prime stage of maturity. Heads will be evaluated for yield as measured by the weight of each head (cut to 6 in length), weight of total florets, and weight of usable florets (< 2.5in). Quality will be evaluated by color uniformity, bead uniformity, head uniformity, head firmness, and head diameter. Photos will be taken.

ANTICIPATED BENEFITS/EXPECTED OUTCOMES/INFORMATION TRANSFER
Identification of heat tolerant varieties that will improve profitability and sustainability of the broccoli processing industry in western Oregon.

PROJECT TIMELINE
March-April: Identify and obtain seed of germplasm for field trial
May-June: Grow transplants in greenhouse
June-July: Plant transplants in field trial
August-September: Evaluate germplasm in field trial
October-December: Analyze data, write and submit report
January: Present findings to OPVC

REFERENCES

Bjorkman, T and K. Pearson, 1998. High temperature arrest of inflorescence development in broccoli. Journal of Experimental Botany 49(318):101–106.
Farnham, M. and T. Bjorkmann, 2011. Evaluation of experimental broccoli hybrids developed for summer production in the eastern united states. HortScience 46:858-863.

2020 BUDGET

Personnel: Research Associate. Andy Nagy
$44004 annual salary. FTE 0.10. $4400
OPE 0.7846. $3453
Total Salary and OPE: $7853

Other direct costs:
Greenhouse supplies: $200
Greenhouse rental: $200
Land rental. $700
Total costs: $8953

ANTICIPATED REQUESTS IN 2021 and 2022 (years 3 and 4): 0

OTHER SUPPORT OF PROJECT:
A proposal was submitted to the OR Specialty Crop Block Grant Program for 2021 and 2022 funds.

Oregon
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