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Final Report
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Project #1: Seed Potato Project

Project Summary

Alaska is one of 17 states that grow certified seed potatoes and has a state certified seed potato program. Necrotic strains of Potato Virus Y are a current threat to the potato industry since these new strains affect tuber quality and production, causing significant losses for tablestock and seed potato producers. Producers of certified seed potatoes in Alaska, continue to expand the production of different varieties, to meet the demand of the home gardening markets and maintain adequate seed stocks for tablestock producers. Currently, Alaska's disease tolerances, in certification, are measured during the summer field readings with tolerances for virus at 0.1% for Potato Virus Y (PVY) and 0.1% for Potato Leaf Roll Virus (PLRV) and 0.2% PVX (visible). These tolerances are the strictest in the nation. Prior to 2014, Alaska was at a competitive advantage with rare to little known occurrences of PVY, PLRV and Potato Virus X (PVX). Table 1 describes the lots rejected, acreage amount, % entered and viruses found in 2014-2015:

Table 1

Crop Year	Lots Rejected	Acres Reject	% entered	Virus
2014	17	4.7	14%	PLRV, PVX (visible), PVY
2015	7	5.5	11%	5 lots PLRV, 2 lots PLRV/PVY

In 2014, Alaska certification rejected 14% of the seed potato acreage, primarily due to PLRV. Also discovered was PVY in two of the certified, seed potato fields, which was a first occurrence in Alaska. In 2013, PVY was discovered in a tablestock field, which imported and planted seed from Montana. Montana currently has necrotic strains of PVY and allows seed to be certified in their state with up to 0.5% virus (90 diseased plants per acre) and up to 2% for export to other states. These necrotic strains were first found in Europe and now are currently spreading through North America, mostly due to the difficulty to detect visually (latent) in the field. Oregon State University (OSU) with the cooperation of state seed potato certification agencies generated a list of latent varieties: https://seedcert.oregonstate.edu/sites/seedcert.oregonstate.edu/files/paalatentvarieties.pdf . In 2014, the total of AK certified seed potato acreage grown, consisted of 38% of these latent varieties. Today, most states require mandatory testing, in addition to, visual inspections within certification. Alaska certification does not require mandatory testing since, historically, Alaska has little to no prevalence of disease and the testing would be cost prohibitive. At the time of this project proposal, it was critical to test due to the recent disease issues, to determine if the visual diagnostics in the field are enough within the AK Seed Potato Certification or if a mandatory testing component should be developed. This project did not build on a previous funded project with the SCBGP.

Project Approach

During FY 2016- FY 2018, the Leaf Sampling Program (LSP) activities and tasks performed consisted of hiring an intern, ordering field and laboratory supplies, reviewing seed potato applications, identifying grower participation, latent varieties, Alaska (AK) named and experimental lines to be tested, creating a database for sample determination, collecting samples in the field, diagnostic processing and testing those samples, and creating a database for data entry and results. During the project period, latent varieties tested were Calwhite, French Fingerling, Pink Fir Apple, Russet Norkotah and Shepody and 10 Alaska named lines were Delta Reds (22-1), AK Frostless, AK Red, Bush's Peanut, Denali, Fiesta (29-6), Haida, Iditared, Magic Molly, Magic Myrna (8-3) and 8 AKTSP experimental lines. Leaf samples were collected at a 1% level or minimum of 10 leaves per lot. Table 2 summarizes the total data, consisting of the number of Certified Seed Potato Producer who participated, leaf samples collected, # Lots, # Varieties tested and the Results. The 2016 and 2017 data was presented at the Alaska Seed Grower Inc. (ASGI) Meeting, the final report will be presented at the ASGI (ASGI) meeting in 2019.

Table 2

Crop Year (CY)	# Seed Producers	#Leaf Samples	# Lots	#Varieties
2018	12	2,060	65	17
2017	13	1,950	72	17
2016	13	1,996	65	23

Goals & Outcomes Achieved

During the FY 2016- FY 2018 project year, the leaf samples were collected during the first field inspection and results were provided in time for second field inspections. The varieties that were identified were tested for PVY, PLRV and PVX in 5 leaf composites on a sap extractor tested by ELISA (Enzyme Linked Immunosorbent Assay). Table 3 summarizes the total number of lots that were positive for each virus type:

Table 3

Crop Year (CY)	Total # of lots positive	PVY	PLRV	PVX
2018	4	0	1	3
2017	8	1	3	2 (latent), 2 (visual)**
2016	5	0	2	3 (latent)
Total	17	1	6	10

It should be noted that although these lots were found to be positive for disease, they were not rejected. The amount of diseased plants was minimal and the PVY and PLRV were able to be detected visually and removed (rogued) from the field, in time for the final field inspection. The PVX is only measured visually within certification, so lots considered to be determined latent for

PVX were not rejected. The lots that were detected visually were removed (rogued) from the field in time for the final field inspection.

Due to the timing of the leaf collection coinciding with the field inspections we were able to draw a comparison of the LSP and the visual inspections in certification. Table 4 and 5 demonstrates this comparison:

Table 4

Crop Year (CY)	LSP Detections	PVY variety	Not detected visually in the field	Varieties determined to be PVX latent
2018	PVX, PLRV	NA	NA	NA
2017	PVY*, PLRV, PVX	French Fingerling	PVX	Magic Molly and Delta Reds
2016	PLRV, PVX	NA	PVX	Iditared, Magic Molly and Delta Reds

*During the second inspection, PVY was observed in two plants and confirmed via PVY immunostrip (see picture in additional information). These plants were rogued and the producer did not replant the lot the following year.
Also, to be noted is that the French Fingerling did visually express symptoms during second inspections, which according to the OSU list it is considered a latent variety.

The PVX that was not visually detected during the field inspection was in the Iditared, Magic Molly and Delta Reds. Please note Magic Molly and Iditared** were seen visually and rogued in 2 different lots (see table 3).

Table 5

Crop Year (CY)	Visual Detection of PVY in the field	Detected in the LSP?	Variety
2018	1	No	Shepody
2017	0	NA	NA
2016	0	NA	NA

In 2018 there was a PVY visual detection (3 plants) in Shepody, confirmed by immunostrip during the second field inspection. This lot was sampled and tested in the LSP, but it was not detected. It is to be noted that sampling protocols were to collect at a rate of 1% of the lot or a minimum of 10 leaves, where the visual inspection was the entire lot.

This project had success in confirming whether PVY was existent in the Alaska's certified seed potato fields. It was determined that this virus was found in one lot out of the 202 that were tested. In addition to the PVY, we were able to confirm the presence of PVX and PLRV. PLRV was found to be in 6 lots out of the 202 tested and PVX was found to be in 10 lots of 202 tested.

The goal and outcomes of this project initially were to identify Alaska PVY latent varieties and whether to develop testing protocols in certification based on what was detected by the LSP. This goal was not achieved since this could not be measured, due to the low incidence of PVY discovered in the fields from 2016- 2018.

An outcome was to present a report highlighting our data at multiple conferences, as well as, have it available on the website and in the newsletter, where a majority of potato growers would attend. The goal was achieved since this data was presented at the ASGI meeting in 2017 and 2018, where a majority of the potato growers do participate. A final report will be presented in 2019 at the ASGI meeting. This information was not presented at the other meetings identified in the report, Produce Growers Conference and Potato Industry Meeting, since these meetings did not occur in 2017 and 2018. This information was not put on the AK Division Agriculture website due to staffing reductions which have not allowed for information to be updated on the website. The Division of Agriculture newsletter changed its structure as well, where it is no longer a monthly newsletter, therefore, less opportunities to share this information. It was determined that not having this available on the website and in the newsletter, did not impact the project, since the presentation at the ASGI meetings, met the goal.

Beneficiaries

The potato industry continues to be significant in Alaska, accounting for $2.7 million on 450 acres in tablestock and seed potato production with sales at $2 million. Over the project period certified seed potatoes average 41 acres (16 growers, 295 lots, 84 different varieties) in production to be sold to tablestock growers for seed and the home garden market. If a seed lot is rejected due to exceeding the tolerances, they are not allowed to be sold as seed, which affects all potato growers who buy certified seed as well as the garden market. The State of Alaska currently has a regulation in place that states that" all potatoes for sale represented as seed potatoes must be certified." This project confirmed little incidence of potato disease in certified seed potato fields which is a benefit for the health of the industry.

Lessons Learned

The lessons learned from the project:

- ✓ Currently, PVY incidence is not at a level where lots are being rejected in Alaska.

- ✓ PVY was symptomatic in the French Fingerling variety, that was considered latent, according to the list. The positive test results were provided prior to the second inspection, did this information influence the inspection since PVY was detected by the LSP? Further research is recommended, when there is a higher prevalence of PVY identified in Alaska.

- ✓ Was the LSP sampling protocols adequate at 1%, since PVY was found visually (confirmed via immunostrip in the field) during second inspections, in the Shepody variety that was LSP tested? Shepody also was also symptomatic, considered latent, according to the list. Are other factors influencing this: Alaska's growing conditions, adequate watering, fertilization, strain-type? Further research is needed on whether a 1% LSP protocol is adequate and also on whether Alaska's growing conditions, watering, fertilization and strain type is affecting latency and is recommended when there is a higher prevalence of PVY identified in Alaska.

- ✓ PVX, although does not cause necrosis in tubers, was latent in AK varieties, Magic Molly, Delta Reds, Iditared.

In conclusion, mandatory testing in certification is not recommended due to the low incidence of disease in Alaska's potato fields. If disease incident increases, testing should be considered, and testing protocols developed, following a disease outbreak.

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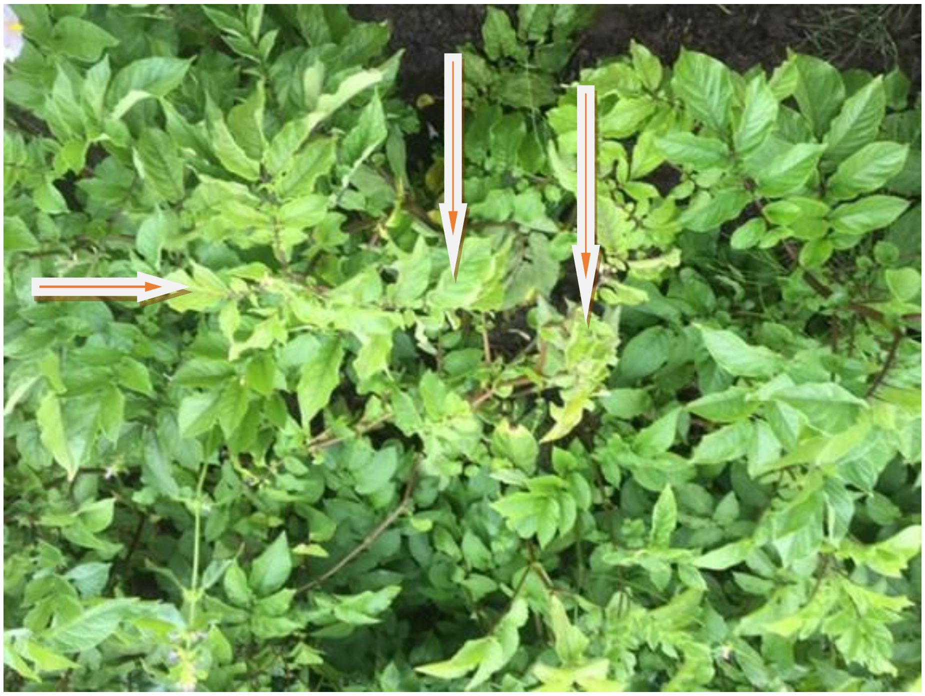


Photograph of PVY plant with visual symptoms in French Fingerling

<u>Project # 2: APGA Botrytis</u>

Project Summary

The purpose of this project was to provide information on disease identification, mitigation, and management to peony growers in Alaska. *Botrytis* gray mold was identified by Alaska peony growers as one of the most important in-field and postharvest pathogens of peonies. Initial studies indicated there were multiple novel species of *Botrytis* infecting peonies in Alaska. The goals of this project included providing growers with the range of *Botrytis* species present in peony fields in Alaska, the prevalence of fungicide-resistant isolates, information on environmental conditions likely to influence disease development, the prevalence of *Botrytis* on different peony cultivars, and potential post-harvest cut flower treatments and their effect on *Botrytis*.

Additionally, this project served to identify the range of other peony pathogens in Alaska. Field surveys during this project helped to identify many other pathogens causing economic damage to Alaskan peony fields. Prior to this project, growers were unable to identify these diseases accurately, therefore limiting their ability to manage disease adequately. This project has led to the development of educational tools to enable peony growers in Alaska to diagnose and manage diseases affecting their crop.

- Successful management of *Botrytis* gray mold and other diseases is essential for the economic viability of the peony industry in Alaska. Alaska currently occupies a competitive niche in the world peony industry due to the ability to produce flowers at a time of year when world markets have few, if any, supplies of fresh cut peonies. Managing diseases is essential to the state's success in marketing high-quality flowers. Diseases build up over time. Therefore, rapid identification and effective management as new peony farms are established is key to maintaining the long-term health of the peony industry.

- This project built on a very limited 2013 survey and a 2014 SCBG project that was conducted to identify *Botrytis* species that were damaging peonies in Alaska. *Botrytis* gray mold is the single most important disease of Alaska field-grown peonies and cut stems in storage. *Botrytis* species tend to be aggressive, host specific pathogens that can reduce yields by 60% and have the potential to cause the complete pre- and post-harvest destruction of cut flowers. DNA sequencing of isolates from Alaska fields revealed five *Botrytis* species, not just the two, *B. cinerea* and *B. paeoniae*, that had been identified previously on peonies. During our current project, a more extensive sampling of Alaska fields was conducted to verify species identification and to study the biology and pathogenicity of these *Botrytis* species.

- During previous surveys, growers also expressed an interest in regional differences in environmental conditions that favor *Botrytis* development, so an attempt was made to identify regional environmental triggers that result in disease manifestation. Previous interactions with growers also indicated that they were interested in using biopesticides to control gray mold on peonies. As a result, a number biopesticides were evaluated for their effectiveness in controlling *Botrytis* during our current project. Finally, our previous interactions with growers indicated there was a critical need for educational efforts to enable them to improve their disease management programs.

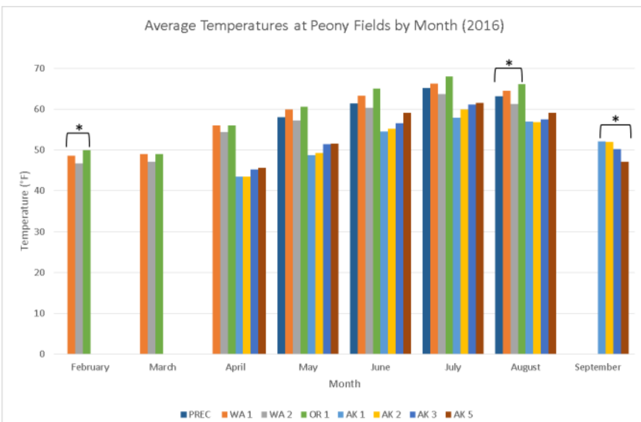
- Cultivars differ in the manifestation of *Botrytis* disease. Early in the season, the damage occurs on some plants at ground level where stems blacken and become limp very shortly after they emerge. Later in the season, often after flowering, circular lesions begin to appear on the foliage and enlarge until foliage is cut. Flower petals landing on the foliage can act as sugar sources for leaf infection. During the flowering season, spores can land directly onto the flower buds. In some instances, the infection is quite rapid, and the gray mold spores become visible on buds that are prevented from opening. Most often, however, spores germinate at the base of the bud near the sepals, often where nectar has dried. The infection does not become evident until stems are cut and placed into a high humidity cold storage room. Buds can show complete degradation in the cooler or become brown very shortly after returning to room temperature either in a shipping box or vase.

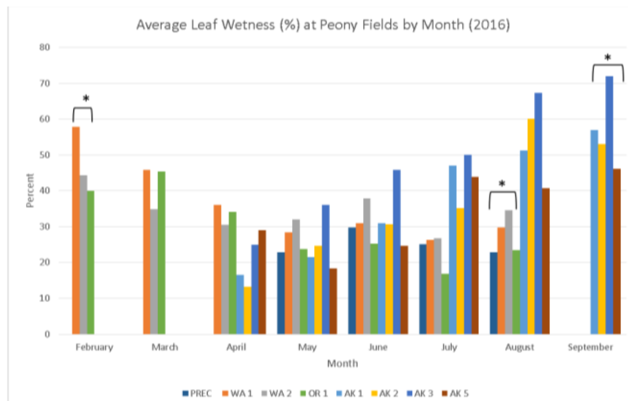
Project Approach

The following activities were performed, and results, accomplishments, conclusions, and recommendations reached:

Activity 1: Travel to grower sites and install weather stations in Alaska—Weather stations were set up at 4 commercial peony farms during the 2015 and 2016 growing season in the 4 main peony production regions of Alaska: North Pole, Trapper Creek, Soldotna, and Homer. Data on temperature, leaf wetness, and rainfall were tracked for each location at 30-minute intervals from late April, prior to peony emergence, to mid-September, upon plant senescence. Monthly averages of each parameter were calculated for each farm location and the 2016 data are reported alongside environmental data collected in Washington and Oregon Figures 1, 2, & 3. One of the most significant findings from a disease development perspective is that leaf wetness, an essential component for fungal pathogen spore germination and infection, is low towards the beginning of the season and increases throughout the season. This pattern is likely advantageous for Alaska peony growers as leaf wetness is low when plants are young and putatively more susceptible to fungal infections. The results also suggested that the ranges in leaf wetness among farms in Alaska likely indicates a range in the risk of disease development, depending on region, with the wetter regions more at risk.

Activity 2: Monitor progression of *Botrytis* infection on peonies — The progression of *Botrytis* infection on peonies was monitored at all four locations in Alaska where weather stations were installed and in September, samples were collected, and final disease ratings were taken. Linear regression analyses were performed to determine any relationship of disease development to the environmental parameters measured. Temperature, rainfall, leaf wetness, individually and in combinations of parameters were plotted against final disease ratings for each location. For all individual parameters and combinations, no apparent correlation between environmental conditions and disease development were identified for the 2016 data due to lack of significant p-values.





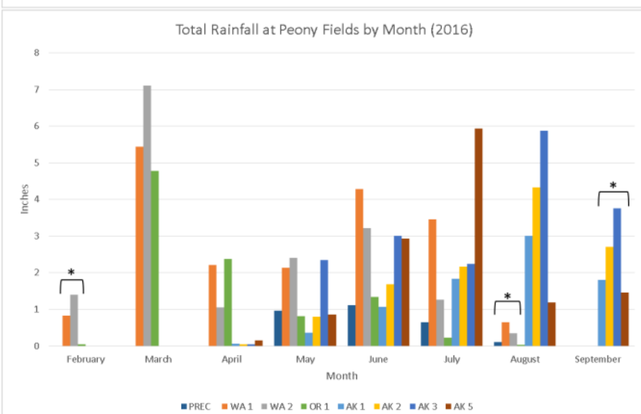


Figure 1. Monthly temperature, leaf wetness, and rainfall from late April, prior to peony emergence, to mid-September, upon plant senescence four farms in AK (AK1=Homer, AK2= Soldotna, AK3=Trapper Creek, and AK5=North Pole) alongside similar data from three sites in WA (PREC, WA 1, WA2) and one site in OR (OR1). An asterisk (*) indicates that data were collected for only part of the month. Where no bar is present, data were not collected.

In an attempt to give the test more power, 2016 data were combined with 2015 data from Alaska, Washington, and Oregon and the final disease ratings were compared to leaf wetness and temperature parameters conditions that are favorable for *Botrytis* spore germination and infection. The environmental parameters assessed were as follows: the number of leaf wetness periods greater than or equal to 4 hours; the average temperature during leaf wetness periods greater than or equal to 4 hours; and the number of instances of leaf wetness that occurred when temperatures were 53.6-86°F. The results of those linear regression analyses are shown in Figure 2 with R^2 and p-values, none of which are significant. Due to lack of statistically significant data in 2015 and 2016, the decision was made to abandon weather monitoring in 2017 as it would allow us to focus on research that is more likely to be valuable for growers. A list of potential reasons for lack of significant data are presented in the outcomes section below.

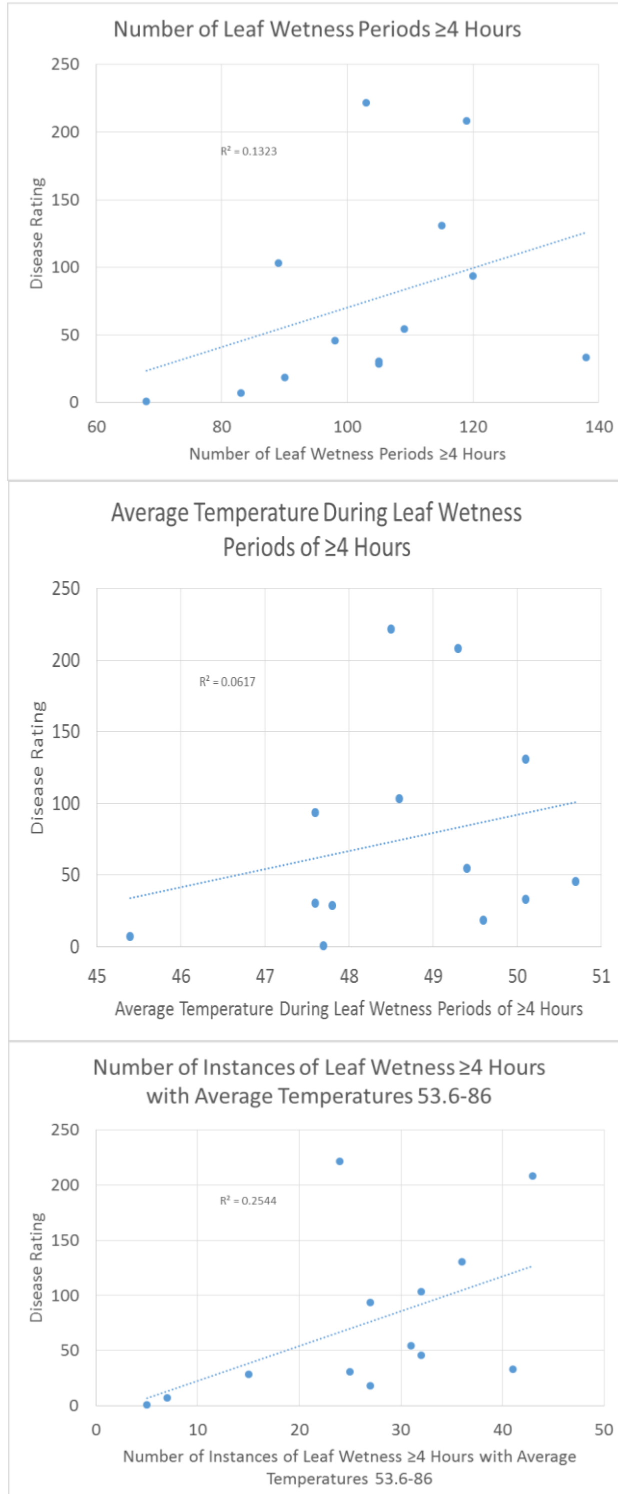


Figure 2. Relationship of leaf wetness and temperature to final disease ratings. P values were 0.22, 0.41 and 0.08 for the top, middle, and bottom regression, respectively.

Activity 3: Identify biopesticides and conventional fungicides that are effective in controlling Botrytis gray mold. - In 2016 and 2017 trials were conducted to evaluate the effectiveness of conventional fungicides and new biopesticides in controlling *Botrytis* species. on outdoor, container-grown 'Sarah Bernhardt' peonies. In 2016, a total of 18 products were evaluated. Disease pressure in this trial was low to moderate and both *Botrytis cinerea* and *Graphiopsis chlorocephala* were isolated from symptomatic plants. *Graphiopsis chlorocephala* was formerly known as *Cladosporium paeoniae,* and causes the disease called measles on peonies. In addition to the treatments applied to the 'Sarah Bernhardt' peonies, these same products were also simultaneously tested on a set of container-grown, mixed varieties of peonies which had been previously identified in 2015 to have high levels of *G. chlorocephala.*

For both sets of peonies, disease incidence was rated on a scale of 0 to 10 scale, where 0 = none, 1 = 1-10%, 2 = 11-20%, and 10 = 91-100% of the foliage were diseased. Visible fungicide residue was rated on a scale of 0-3, where 0 = none, 1 = slight, 2 = moderate, and 3 = severe fungicide reside on foliage. Basal rot stem decay due to *Botrytis* was assessed by counting the total number of stems and the number of decayed stems. An overall plant quality assessment was taken on July 6, 2016. Plant quality was rated on a scale of 1-9 where 9 = perfect plant, 6 = commercially acceptable (I would be that), 1 = dead. Residue was rated only on the 'Sarah Bernhardt' peonies on a scale of 1-3 where 1 = slight, 2 = moderate, and 3 = severe residue present. (Note: in Figures 4-11, columns with the same letter are not significantly different, P=0.05, Tukey's Studentized Range Test.)

Disease and plant quality on the 'Sarah Bernhardt' peonies were highly variable in the *Botrytis* trial (Data not shown). *Botrytis* disease incidence ratings on the foliage ranged from 1.2 to 4.8 and stem dieback severity ranged from 0.0 to 1.4 diseased stems per plant. The incidence of *G. chlorocephala* ranged from 0.0 to 3.8 and overall plant quality ranged from 3.4 to 8.0. None of the treatments had a statistically significant effect on disease ratings.

Disease and plant quality on the mixed varieties of peonies were also highly variable (data not shown). The severity of *G. chlorocephala* ranged from 0.0 to 6.3 and *Botrytis* severity ranged from 0.0 to 2.5. Overall plant quality ranged from 3.4 to 8.0. None of the treatments has a statistically significant effect on *Botrytis* disease ratings. However, applications of Pageant, BAS 703 06 (Orkestra) and both rates of SS00 had significantly less *G. chlorocephala* than the non-treated check.

In 2017, a total of 20 products were evaluated for their effectiveness in controlling *Botrytis* species. on container grown 'Sarah Bernhardt' peonies (Table 1). Foliar applications were applied with a CO2 sprayer equipped with an 8002LP Tee-Jet nozzle at 15 psi in the equivalent of 100 gallons of water and sprayed to wet. The initial applications occurred on April 4th and treatments were applied at 7 or 14-day intervals until the flower stems were harvested in mid-

May. Each treatment was applied to a single plant in each of five blocks. Disease development and visible residue levels were monitored as described for the 2016 trials.

Table 1. Products included in the 2017 peony fungicide test.

Trade name and formulation	% active ingredient and common name	FRAC Code[1]
Badge	24.6% copper oxychloride, 22.9% copper hydroxide	M01
BAS 703 01F (Orkestra)	21.3% pyraclostrobin +21.3 % fluxapyroxad	11 + 7
Botector	1.06 x 10^9 cfu/g *Aureobasidium pullulans*	NC
BW165N	8 x 10^7 cfu/g *Ulocladium oudemansii* U3 strain	NC
Chipco 26019 N/G	50% iprodione	2
Daconil Weather Stik SC	54% chlorothalonil	M5
Decree 50WDG	50% fenhexamid	17
F9110 WG	20% extract of *Lupinus*	NC
Fore 80 WP	80% mancozeb	M3
Kenja 400 SC	36.0 isofetamid	C2
MBI110 AF5	1 x 10^8 cfu/mL *Bacillus amyloliquifaciens* strain F727	NC
Medallion 50WP	50% fludioxonil	12
NUP 09092 50L	40.3 % fludioxonil	12
Pageant 38 WG	12.8% pyraclostrobin + 25.2% boscalid	11 + 7
Palladium 62.5WG	37.5% cyprodinil + 25% fludioxonil	9 + 12
Prophytex EC	*Bacillus subtilis* strain B1111	44
Prophytex WP	*Bacillus subtilis* strain B1111	44
Proud 3	5.6% thyme oil	NC
S2200 4SC	42-45% mandestrobin	11
Zerotol	27.1% Hydrogen dioxide + 2.0 perozyacetic acid	NC

[1]FRAC Code List 2017. http://www.frac.inf accessed 15 May 2017

(Note: Some of these pesticides were tested under an experimental use permit granted by WSDA. Application of a pesticide to a crop or site that is not on the label is a violation of pesticide law and may subject the applicator to civil penalties. In addition, such an application may also result in illegal residues that could subject crops to seizure or embargo action by WSDA and/or the U.S. Food and Drug Administration. It is your responsibility to check the label before using products to ensure lawful use and obtain all necessary permits in advance.)

Treatments of Daconil and Fore resulted in significantly higher residue levels on the foliage than the non-treated check and all of the other fungicides except Badge X2, which had intermediate residue ratings (Data not shown). Disease ratings on the peonies were low. *Botrytis* disease incidence ratings on foliage during the period between emergence and flower harvest ranged from 0.0 to 2.4 and the percent of stems with basal decay ranged from 7.5% to 41.8%. The incidence of measles, caused by *G. chlorocephala,* ranged from 0.0 to 3.6. None of the treatments significantly reduced the incidence of basal stem decay or the incidence of foliar symptoms often associated with *Botrytis* infection. However, applications of Orkestra (8 fl oz), the high rate of S2200 (15 fl oz), and Palladium (6 oz) had significantly less measles than the non-treated check (Data not shown).

Given the limited disease development on the plants, leaves were harvested after the last treatment application and inoculated with mycelial plugs of *B. cinerea* and *B. paeoniae* to assess the residual activity of the fungicide treatments. Checks consisted of non-sprayed leaves that were inoculated with mycelial plugs of *B. cinerea, B. paeoniae,* or plugs of uncolonized media. Lesion development on the treated leaves was compared to the size of lesions that developed on inoculated checks. No lesions developed on the non-inoculated checks (Figure 3).

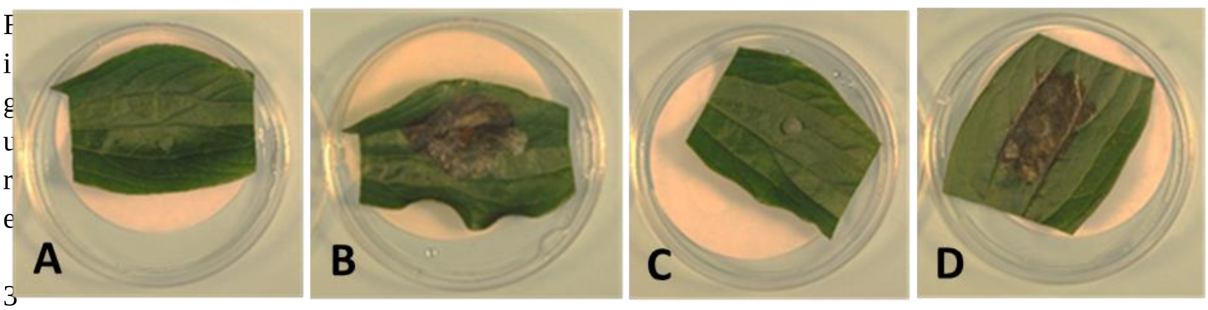


Figure 3. Lesion development on peony leaves inoculated with *Botrytis paeoniae* (B) and *B. cinerea* (D) on May 22, 2017. No lesions developed on the non-inoculated checks (A & C).

After 96 hours of incubation at 18C, lesion width on the *B. paeoniae*-inoculated leaves ranged from 0.0 to 4.37 cm and from 0.0 to 5.15 cm on the *B. cinerea*-inoculated leaves (Figures 4 & 5). Several fungicides either reduced or eliminated the growth of lesions compared to the inoculated checks in the *B. paeoniae*-inoculated leaves. The most effective treatments were Daconil WS, S2200, Kenja 400 SC, Orkestra, Pageant 38 WG, NUP 09092, and Medallion WDG. Fewer fungicides were effective against *B. cinerea* than *B. paeoniae*. Treatments of Medallion and NUP09092 were the only ones that had lesions that were significantly smaller than the inoculated checks in the *B. cinerea* test.

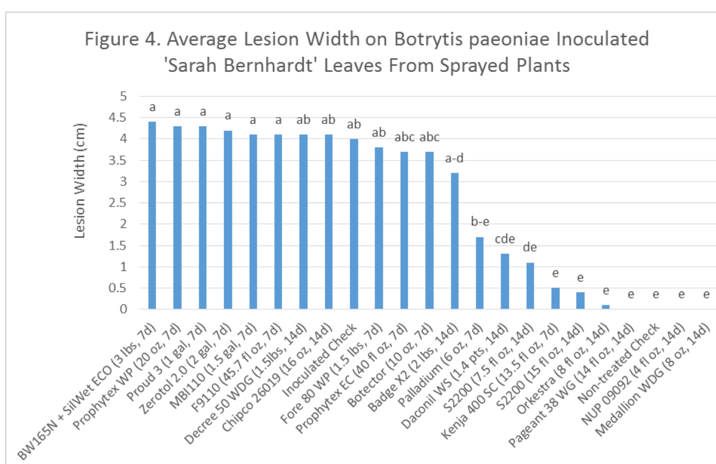


Figure 4. Average Lesion Width on Botrytis paeoniae Inoculated 'Sarah Bernhardt' Leaves From Sprayed Plants

To assess the effect of the preharvest applications of fungicides during the growing season on the postharvest development of gray mold on the foliage and flower buds on cut stems during cold storage, three stems were harvested from each plant and held in cold storage for 4 weeks at 1 to 5C. Just prior to storing, the bundles of flowers were sprayed with *Botrytis cinerea* spores and then wrapped in paper to encourage disease development. The foliage was rated for disease severity on a scale of 0 to 10 scale, where 0 = no foliar decay and 10 = 91 to 100% of the foliage is dead. Disease development on the flowers was rated on a scale of 0-3 where 0 = none, 1 = slight infection (< 25% of flower infected), 2 = moderate infection (25-50%), 3 = severe (>50% of flower infected). Flowers that were held in cold storage for 4 weeks had high levels of disease on both the foliage and flowers (Figures 6 & 7). Disease ratings on the foliage ranged from 0.1 to 7.4 and treatments with MBI110, Badge X2, Daconil WS, S2200, NUP 09092, Pageant 38 WG, Kenja 400 SC, Orkestra, Palladium, and Medallion WDG had significantly lower disease ratings on the foliage than the inoculated check. However, compared to the inoculated check, none of the fungicides significantly lowered disease ratings on the flower buds.

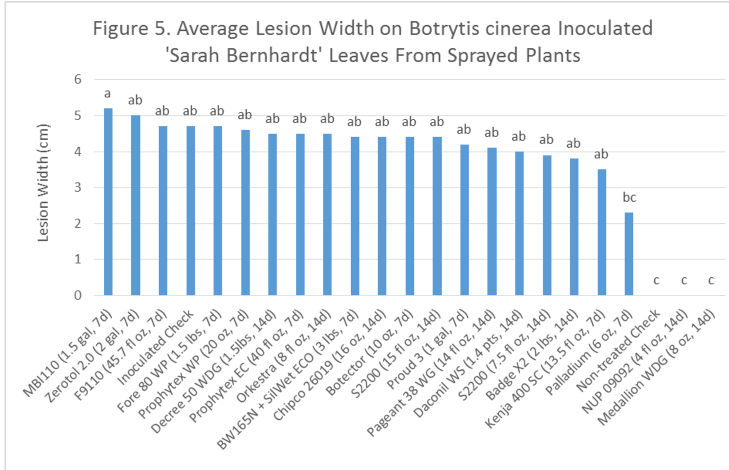


Figure 5. Average Lesion Width on Botrytis cinerea Inoculated 'Sarah Bernhardt' Leaves From Sprayed Plants

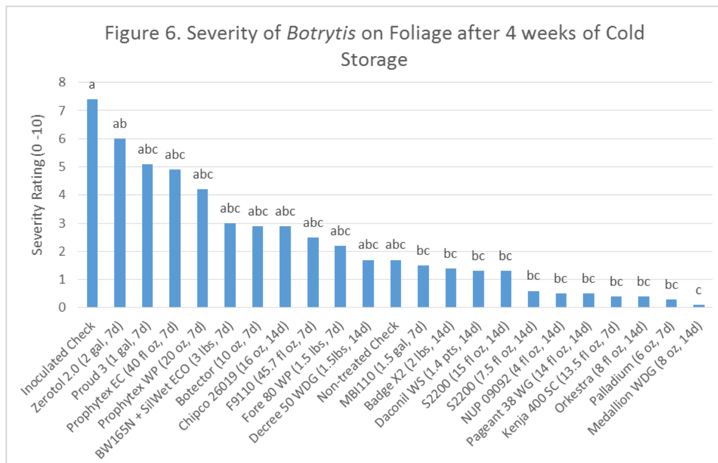


Figure 6. Severity of *Botrytis* on Foliage after 4 weeks of Cold Storage

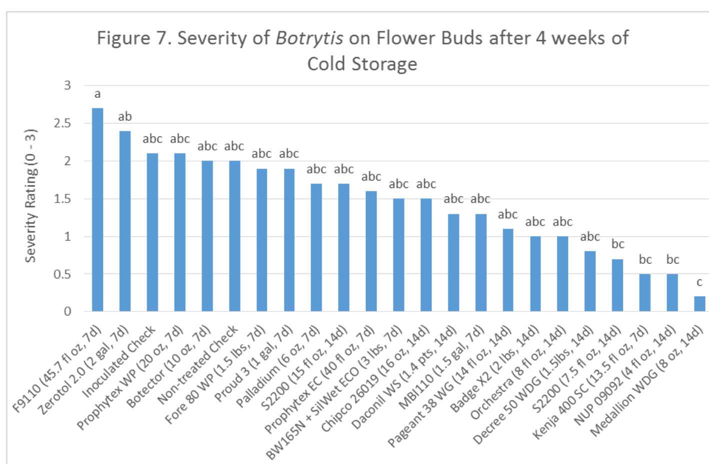


Figure 7. Severity of *Botrytis* on Flower Buds after 4 weeks of Cold Storage

To determine if the limited effectiveness of some of the fungicides in the spray trials was due to inadequate fungicide coverage on the leaves, leaves were collected from field-grown 'Sarah

Bernhardt' peonies that had not been treated previously fungicides. The leaves were then dipped in fungicide solutions at the same concentrations used in the spray trial. The surface of the leaves were allowed to dry before placing mycelial plugs of *B. cinerea*, *B. paeoniae*, *Sclerotinia sclerotiorum*, and *Graphiopsis chlorocelphala* on the upper surfaces of the leaf sections. The inoculated leaves were incubated at 20C for 4 days with the exception of the *Graphiopsis* leaves which were incubated for 15 days. Inoculated and non-inoculated checks consisting of leaves that had not been treated with a fungicide were included in this test.

Compared to the inoculated checks, 12 products significantly reduced lesion sizes of *B. paeoniae*, and 9 significantly reduced lesion sizes of *B. cinerea* and *G. chlorocephala* (Figures 8, 9, & 10). Eight fungicides (Orkestra, NUP 09092, Pageant, Chipco 26019, Medallion, Palladium, Decree, and Kenja) significantly reduced lesion development of all three pathogens. With respect to *B. paeoniae*, three additional fungicides had significantly lower lesion size development. These were as follows: Daconil WeatherStik, Badge X2, and Fore. Far fewer fungicides controlled lesion development on the leaves inoculated with *Graphiopsis*. Only treatments of NUP 09092 and Medallion had lesions that were significantly smaller than the inoculated checks (Figure 11). The increased number of fungicides that were effective in controlling the *Botrytis* lesions in this dip test illustrates the importance of having good coverage on plants when applying fungicide sprays.

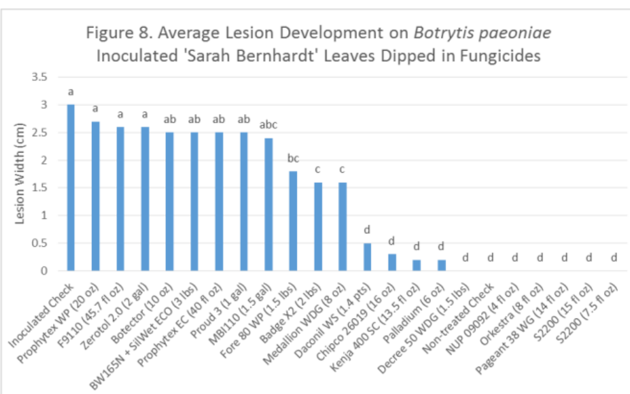


Figure 8. Average Lesion Development on *Botrytis paeoniae* Inoculated 'Sarah Bernhardt' Leaves Dipped in Fungicides

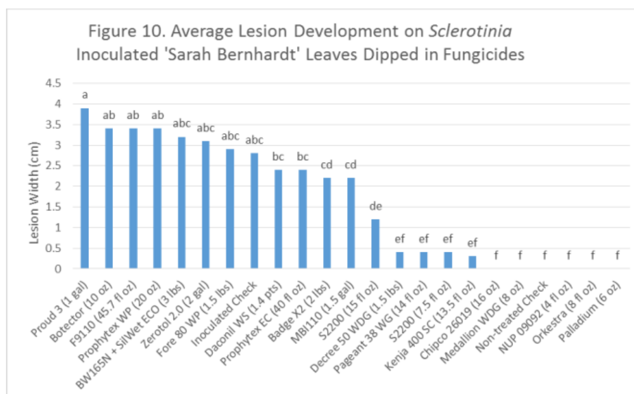


Figure 10. Average Lesion Development on *Sclerotinia* Inoculated 'Sarah Bernhardt' Leaves Dipped in Fungicides

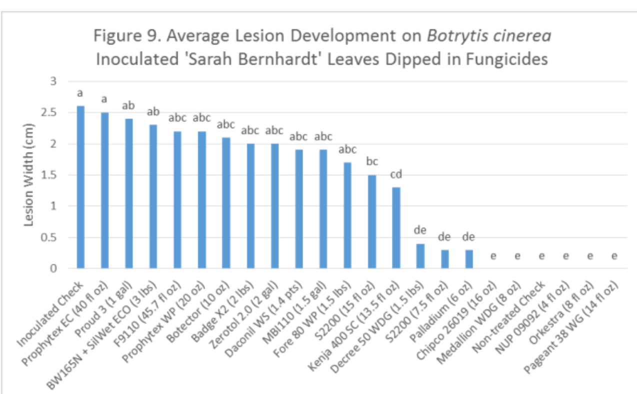


Figure 9. Average Lesion Development on *Botrytis cinerea* Inoculated 'Sarah Bernhardt' Leaves Dipped in Fungicides

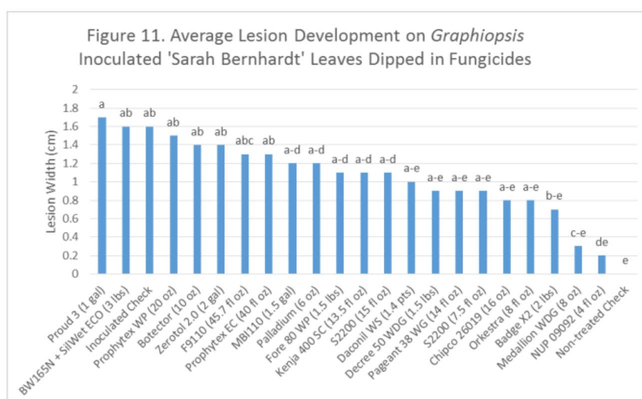


Figure 11. Average Lesion Development on *Graphiopsis* Inoculated 'Sarah Bernhardt' Leaves Dipped in Fungicides

Activity 4: Travel to the APGA Conference and disseminate information to growers about research trials— Updates on this project were provided to growers at the 2016 Alaska Peony Grower's Association (APGA) Conference in Homer and the 2017 APGA Conference in Fairbanks, AK. At the 2016 conference the PhD student presented the environmental and disease development data from the 2015 field season. Growers were especially interested to see the data on the differences in climate patterns between regions of Alaska and Washington and Oregon.

At the 2017 conference, Dr. Chastagner and PhD student, Andrea Garfinkel held a pre-conference workshop on disease management of peonies that included information on: basic plant pathology and disease management, proper use of fungicides including how to properly use fungicides to reduce the risk of fungicide resistance, information on how to read a pesticide label, and how to identify common peony diseases and their management strategies. During the regular program, the PhD student, Andrea Garfinkel, presented information on the diseases observed in surveys of peonies across the United States, indicating those which were most common in Alaska, and Dr. Chastagner presented information on the efficacy of reduced-risk and biocontrol fungicides in controlling diseases on bulb crops and the potential to reduce the number of fungicide applications in *Botrytis* disease management programs by using a crop phenology-based, integrated disease management program. In 2017, Dr. Holloway presented the results of her research on post-harvest handling of peony cut flowers

Activity 5: Travel to Alaska to collect material from peony farms to identify range of peony pathogens—Three trips were made to the peony fields during 2016 to survey for pathogens: in April, July, and September. In July 2016, a 10-day survey of fields ranging from the Interior to the Kenai Peninsula was conducted. During this time, the PhD student, Andrea Garfinkel, and Dr. Chastagner visited 35 fields and collected samples with a variety of disease symptoms.

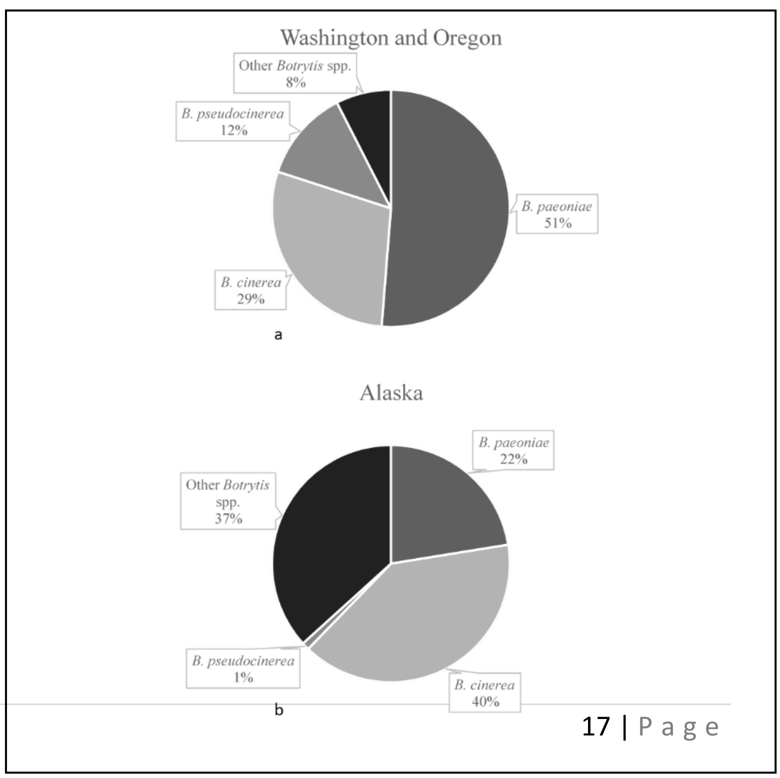


Figure 12. Percentage of isolates collected from peony in a) Washington and Oregon (n=80) and b) Alaska (n=98) that were identified as belonging to the genus *Botrytis*.

Activity 6: Isolate and identify pathogens obtained from peony samples—The PhD student, Andrea Garfinkel, isolated from 126 peony tissue samples. Multiple fungal plant pathogens were identified including several *Botrytis* spp, *Mycocentrospora acerina*, and *Phoma* spp. The *M. acerina* and *Phoma* spp. represent the first reports of these pathogens on peony in the state. Pathogenicity trials were conducted to confirm their ability to cause disease on peony.

A total of 179 isolates of *Botrytis* from peony were identified from Alaska, Washington, and Oregon. The breakdown of the identity of these isolates are described in Figure 12. In short, the majority of isolates from Washington and Oregon were identified as being either *B. cinerea* or *B. paeoniae*, whereas 35% of the isolates from Alaska were species other than *B. cinerea*, *B. paeoniae*, or *B. pseudocinerea*. Many of the isolates from Alaska represented new species, including the one that has been described as *B. euroamericana* as a result of this project. We also identified a number of fields that had peonies with symptoms of *Tobacco rattle virus* (TRV). Some fields appeared to have the disease in high frequencies. While at these farms, growers were advised on how to manage the disease appropriately and/or contact suppliers regarding the quality of planting material. These findings were reported to growers in the state at the 2017 APGA conference, at a workshop, during several grower field tours (see Activity 4) and via various publications (see Activity 11). This included providing growers with images of the disease symptoms caused by the pathogens found on peonies in Alaska (Figure 13).

Figure 13. Disease symptoms observed on peonies in Alaska. Botrytis gray mold on leaves (A), flower buds (B), and stems (C); *Mycocentrospora acerina* stem lesions (D); *Phoma* stem lesion (E); and ringspot symptoms on leaves caused by *Tobacco rattle virus* (F).

Activity 7: Conduct pathogenicity and rootstock infection studies on peonies— Pathogenicity trials were conducted for the *M. acerina* and *Phoma* spp. isolated from peony (see Activity 6).

Roots were inoculated with *Botrytis paeoniae* in the fall of 2015 to determine the potential for commercial rootstocks to become infected by *Botrytis*. Rootstocks were inoculated in three locations using agar plugs that had been colonized by *B. paeoniae*. The inoculated locations included: a cut root surface, an area below the next year's developing bud, and on a basal stem piece that remained intact on the rootstock. Inoculated material was incubated in a greenhouse. Only the cut root surface became infected with *B. paeoniae*, as confirmed by isolations. Rootstocks were then potted and left outside to vernalize over the winter. In the spring of 2016, plants were routinely observed for above-ground *Botrytis* disease development. None was observed in any of the treatments. At the end of the season, rootstocks were washed clean of soil and observed for lesion development. Lesions were not observed on any of the tissue and *B. paeoniae* could not be reisolated from any root tissue. Furthermore, there was no increase in disease development in above-ground tissues on inoculated plants versus control plants. Our results suggest that our method of inoculation to test the potential for movement of *B. paeoniae* within rootstock is either ineffective or the pathogen is not very aggressive on peony root tissue. Due to our lack of success with this method, we chose not to repeat this test in 2016, as indicated in our previous annual report.

A total of 16 microsatellite markers were developed for *B. paeoniae*, 15 of which are polymorphic in the isolates that have been tested from our collections. Development of these markers was aided by two draft genome sequences of *B. paeoniae*, one developed during this project and one that was provided by a Dutch university. The results of this project's marker development has been submitted for publication with the primer sequences and allele sizes. The microsatellite markers have been applied to 73 *B. paeoniae* isolates that this project's leaders collected throughout the United States and The Netherlands. Although there are 15 polymorphic loci, there are relatively few alleles per locus and few genotypes. Statistical tests to determine the number of populations represented in these 73 samples are inconclusive, suggesting either they represent one population or more information is needed to elucidate differences. The 73 isolates tested represents a small increase in the number of samples we tested and reported in our previous annual report, however, the results were still inconclusive. Further information about this objective and potential reasons for non-significant results is discussed below in the outcomes section.

Activity 8: Conduct fungicide resistance studies—A total of 50 isolates identified as *B. paeoniae* and 50 isolates identified as *B. cinerea* were tested in-vitro for their resistance to 7 fungicides (Table 2). Each isolate was grown on potato dextrose agar (PDA) amended with three rates of each fungicide (0.1, 1.0 and 10 ppm ai) to determine the concentration required to inhibit the growth of each isolate on PDA alone by 50% (EC50). The 50 isolates of each species represented those collected from Alaska, Washington and Oregon (Table 3).

Table 2. Fungicides included in the fungicide resistance tests.

Trade Name and formulation	% active ingredient and common name	FRAC Code[1]
Chipco 26019 N/G	50% iprodione	2
Cleary's 3336F	41.25% thiophanate-methyl	1
Decree 50WDG	50% fenhexamid	17
Emerald	70% boscalid	7
Empress	23.3% pyraclostrobin	11
Medallion 50WP	50% fludioxonil	12
Vangard WG	75% cyprodinil	9

[1]FRAC Code List 2017. http://www.frac.inf accessed 15 May 2017

Table 3. Geographical sources of isolates included in fungicide resistance tests.

	State			
Organism	AK	OR	WA	Total
B. cinerea	29	7	14	50
B. paeoniae	20	6	24	50

There was very little difference in the sensitivity of the isolates from the different states. Overall, all of the *B. cinerea* and *B. paeoniae* isolates were very sensitive to fenhexamid with EC50 values of <0.1 ppm. About 2% of the *B. cinerea* and *B. paeoniae* isolates had EC50s >10 ppm of iprodione. The addition of thiophanate-methyl, even at 10 ppm had very little effect on the growth of any of the isolates included in our tests. It is unclear if the lack of sensitivity is due to resistance or a problem with the testing method. The percentage of *B. cinerea* isolates with EC50s >10 ppm for boscalid, pyraclostrobin, and cyprodinil was 67.3, 49.0, and 98.0%, respectively. For *B. paeoniae* isolates the percentages with EC50's >10 ppm for the same fungicides were 31.9, 2.1, and 78.7%, respectively. These data suggest that strains of *B. cinerea* and *B. paeoniae* from peony fields in Alaska, Oregon, and Washington are resistant to a number of commonly used *Botrytis* fungicides. This indicates that grower disease management programs need to include practices such as fungicide rotations to manage fungicide resistance problems.

Activity 9: Post-harvest analysis of *Botrytis* by cultivar and incidence of *Botrytis* following treatment with chemicals that promote cut flower longevity. Cultivars showed varying levels of *Botrytis* infection in the field and as cut flowers. The incidence of the disease was low in 2017, Table 4 shows the vase life of individual cultivars growing at the Georgeson Botanical Garden with a notation if they showed *Botrytis* anywhere on the plant. Some cultivars exhibited *Botrytis* as stem blackening shortly after emergence. A second category showed leaf lesions usually late in the season. Finally, some *Botrytis* showed up in the buds during post-harvest storage (34 ± 3^{o}F; 90% RH) for one week followed by vase life studies (68^{o}F UAF horticulture lab, 24-hr fluorescent light, tap water)

Table 4. Vase life and presence of *Botrytis* on peony cultivars growing at the UAF Georgeson Botanical Garden, 2017*.

Cultivar	Flower class	Days to full bloom	Days from full bloom to petal fall/wilt	Total vase life	Botrytis presence
Alexander Fleming (Dr. Alexander Fleming)	Double	2.0	5.0	7.0	
Bowl of Cream	Double	1.8	8.0	9.8	Leaf lesions, flower buds
Bridal Icing	Bomb	1.5	4.5	6.0	Flower buds
Corinne Wersan	Double	1.8	5.4	7.2	
Festiva Maxima	Double	1.3	4.0	5.3	Flower buds, leaf lesions
Festiva Powder Puff	Double	1.0	5.4	6.4	
Gay Paree	Anemone	1.2	4.6	5.8	
George W. Peyton	Double	2.0	5.4	7.4	
Heidi	Japanese	1.2	6.4	7.6	
Joker	Double	3.0	6.3	9.3	Flower buds
Kansas	Double	2.0	5.4	7.4	
Ken Shan		3.0	6.0	9.0	
Lady Alexandra Duff	Double	2.7	5.7	8.5	Flower buds
Lady Kate	Double	2.2	6.0	8.2	Flower buds
La Lorraine	Double	3.0	5.3	8.3	
Largo	Japanese	2.0	4.0	5.5	
Lauren	Japanese	1.2	6.2	7.4	
Leslie Peck	Japanese	1.4	4.2	5.6	
Lora	Double	3.0	3.8	6.8	

Dexheimer					
Love's Touch	Semi-double to double	1.8	5.4	7.2	Flower buds
Lowell Thomas	Semi-double	2.6	3.2	5.8	
Mme Claude Tain	Double	2.0	7.0	9.0	
Mme Emile Debatene	Double	2.8	4.0	6.8	
Mary Jo LeGare	Double	3.0	5.8	8.8	
Mons. Martin Cahuzac	Double	2.0	6.6	8.6	
Nippon Beauty	Japanese	2.0	4.4	6.4	
Paul M. Wild	Double	2.3	4.7	6.2	
Petite Renee	Japanese	1.6	3.4	5.0	
President Roosevelt	Double	2.0	6.0	8.0	
President Taft	Double	2.2	5.6	7.8	
Sadie Fisher	Double	2.0	2.4	5.4	
Sarah Bernhardt 1	Double	2.5	5.8	8.2	Emerging shoots, leaf lesions, flower buds
Sarah Bernhardt 2	Double	2.0	6.1	8.1	Flower buds
Shirley Temple	Double	3.2	5.6	8.8	Flower buds
Sitka	Japanese	2.2	5.6	7.8	Flower buds
Victorian Blush	Double	1.8	6.4	8.2	Flower buds

*All cultivars grown at the Georgeson Botanical Garden except Mme Claude Tain, Sarah Bernhardt 2, and Bowl of Cream grown at Far North Peonies

A second experiment examined 10 post-harvest treatments with chemicals routinely used in the floral industry to prolong vase life. Three replicates of 10 stems each of ‘Sarah Bernhardt peonies were harvested and stored in a cooler (($34 \pm 3^{o}F$; 90% RH), for one week. One treatment consisted of spraying the foliage and flower buds with Floralife Clear Crowning Glory Hydration and Protection Solution® Spray according to manufacturer’s directions prior to storage. All other treatments occurred after storage as a pre-box-and-ship treatment. The treatments prior to placing in the vase were:

1. Floralife Clear Crowning Glory Hydration and Protection Solution® – post storage, foliage and flower buds sprayed to drip, then dried
2. Floralife Crystal Clear 200® plant food- food packets dissolved in water, 1 hr stem soak prior
3. Hyaluronic acid- Jarrow formula, hydration liquid, 1 hr stem soak
4. Floralife Quick Dip 100® Instant hydration pretreatment, 1 second dip
5. Trehalose powder Swanson Brand – 1 hour stem soak
6. Chrysal Professional Glory Flower and Foliage Shield®- spray
7. Tap Water- 1 hour hydration
8. No treatment- dry stems from cold storage into box
9. Direct to vase- no treatment, no storage

Following treatments, flowers were inserted into a standard peony shipping box (Polar Peonies) to simulate air transport for 24 hours. Boxes were packed with cotton batting and two frozen gel packs wrapped in newsprint. Boxes were held at 68ºF. After 24 hours, stems were cut 2 inches and placed in jars of tap water under the same laboratory conditions.

The purpose was to determine if the incidence of *Botrytis* was changed with the individual treatments. Although vase life was affected by the treatments (not published here), the incidence of *Botrytis* was impossible to study because of confounding physiological disorders caused by the treatments. *Botrytis* causes browning of the petals and receptacle and may or may not be visible when the stems are placed into the cooler. The result after one week can be a single small patch of brown, or the entire bud can be engulfed in brown. Some of the post-harvest treatments also caused significant browning mostly of the guard petals, in some cases amounting to 100% of the treated stems (treatments showing damage: hyaluronic acid, no water, Floralife Plant Food, Chrysal). Although we tried to ascertain if the browning was caused by disease or the treatments, it was impossible, at times, to separate the two. Therefore, no conclusions were drawn from this experiment on *Botrytis* incidence.

Activity 10. Analyze data, prepare quarterly and annual reports—Data have been analyzed and quarterly and annual reports have been submitted throughout the duration of the project.

Activity 11: Develop, organize, and execute educational programs for Alaskan peony growers—Educational programming was provided to peony growers in multiple forms and at various times during the project. Presentations and workshops were given at the APGA grower's conference during January 2017 (see Activity 4). The PIs, Dr. Patricia Holloway and Gary Chastagner, and PhD student, Andrea Garfinkel, attended the Mat-Su Peony Farm Tour and the Arctic Alaska Peonies Farm Tours (Interior) in July of 2016 and 2017 and gave field presentations on how to identify and manage diseases, the range of *Botrytis* species discovered during surveys in Alaska, identification and management of TRV, and post harvest issues with peonies.

During the 2017 tours, a new Fact Sheet on TRV management in peonies was provided to growers. Growers' guides, including the TRV Fact Sheet and manuscripts are described below in Activity 11. We also conducted a photo quiz of diseases, physiological disorders, weather-related traumas, and insect pest damage to growers. Participants were asked to guess what they were viewing in a series of photographs. The quiz was well received, and more than 30 participants at each farm tour tried their luck. The PIs were pleasantly surprised to see the level of retention and identification exhibited by participants. Average response was 70% correct answers. Of course, in most instances, the individuals who felt they would not be embarrassed by low scores were the ones who chose to participate.

Activity 12: Prepare final report, grower disease management guides, and manuscripts for publication—This report is satisfying our objective of submitting a final report for this project. A general disease management guide is in preparation for future publication through WSU extension. An extension Fact Sheet has been published on TRV in peonies and can be found as open-access at this URL: http://extension.wsu.edu/publications/pubs/fs284e/. A journal publication describing the range of pathogens found on peonies in the United States, including Alaska, has been prepared for submission to the journal Plant Disease. A manuscript describing one of the new species of *Botrytis*, *B. euroamericana*, was published in Mycologia (http://www.tandfonline.com/eprint/MSxd2r4FbC9i2x3ptq67/full).

Dr. Chastagner and Andrea Garfinkel also coauthored a chapter on the management of diseases on peonies for the new Springer "Plant Disease Management. Handbook of Florists' Crops Diseases" book and provided more in-depth information to growers about TRV on peonies in the Fall 2016 issue of the Association of Specialty Cut Flower Growers (ASCFG) Cut Flower Quarterly.

This project did not benefit any other commodity groups outside of specialty crops.

This project would not have been possible without the knowledge, leadership and collaboration of Washington State University professor and graduate student, Dr. Gary Chastagner and Andrea Garfinkel and the Alaska Peony Growers Association. Alaska does not have a full-time expert at the University of Alaska or State in the dynamics of *Botrytis* and other fungal diseases. This partnership was critical to the success of this project and to the future of the peony industry in Alaska and worldwide. Andrea Garfinkel, WSU Ph.D., student, organized surveys to collect disease samples, identified the diversity of *Botrytis* species and other pathogens on peonies, developed molecular markers to detect *B. paeoniae*, conducted pathogenicity studies, helped organize educational activities, and helped prepare publications, updates and necessary reports

Dr. Gary Chastagner directed all plant pathology research and worked with a dynamic team at Washington State University, Puyallup to complete these studies.

Dr. Patricia S. Holloway was the APGA Industry Professional and Collaborator on this project. She provided input an assistance relating to the environmental monitoring and fungicide trials, was a liaison with growers collaborators, and helped prepare updates and necessary reports.

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Katie Coats, WSU Molecular Biology Research Assistant, assisted Andrea Garfinkel with the molecular studies to identify pathogens and the development of the molecular markers for *B. paeoniae*.

Annie DeBauw, WSU Agriculture Research Tech. III, conducted disease control trials and assisted with the preparation of reports.
WSU hourly part-time help provided assistance with the maintenance of plant material and isolate collection, isolations from disease samples, pathogenicity studies, and fungicide-resistance tests.

Todd Steinlage- Plant Pathologist, Alaska Division of Agriculture Plant Materials Center worked in partnership with the WSU researchers to clarify and identify Tobacco rattle virus in Alaska peonies.

Janice Chumley, Alaska Cooperative Extension Service, Kenai, assisted in field collection of Tobacco rattle virus and Botrytis samples.

Growers - This project would not have been possible without the cooperation of a number of growers in Alaska who provided access to their fields, helped collect environmental data, and provided plant material needed for this project. The PIs and PhD student would specifically like to thank the following farms for their assistance with the environmental monitoring studies: Alaska Perfect Peony, Arctic Sun Peonies, Boreal Peonies, DeGoede Bulb Farm, Echo Lake Peonies, Hoffman Acres Farms, Oregon Perennial Company, and Our American Roots.

Goals & Outcomes Achieved

The performance objectives and a description of their completion are described below:

Objective 1: Correlate *Botrytis* disease development with environmental conditions by tracking temperature, leaf wetness, and rainfall at peony fields in the four major peony production areas in Alaska—We were unable to complete this objective due to lack of statistical significance in the data we collected (see Activities 1 & 2). The failure to identify a correlation likely is not due to the irrelevance of the environmental data collected in disease development, but rather the prevalence of confounding and uncontrolled factors in the systems observed such as: differences in patterns of fungicide use, the prevalence of fungicide resistance, the presence of a diversity of *Botrytis* species present among fields, initial inoculum loads present in fields; differences in phenological development in periods conducive to disease development, planting density, and irrigation practices. In-vitro tests to assess variability among *Botrytis* species to infect peonies under various environmental conditions could lead to better understanding of conditions favorable to disease development.

Objective 2: Identify biopesticides and conventional fungicides that are effective in controlling *Botrytis* gray mold. – Extensive trials were conducted in 2016 and 2017 (see Activity 3) to identify conventional fungicides and biopesticides. Although none of the biopesticides provided effective control in any of the trials, a number of the conventional fungicides were effective in reducing disease development. The effectiveness of the specific fungicides varied by pathogen and the type of trial that was conducted. With respect to management of Botrytis gray mold, it is clear that there are fewer fungicides that are effective in controlling *B. cinerea* than *B. paeoniae*. It is unclear why this difference occurs, but additional studies are needed to obtain a better understanding of the fungicide sensitivity of Alaska's diverse *Botrytis* pathogens on peonies. The postharvest storage tests also suggest that while preharvest applications of fungicides have a significant effect on the development of gray mold on foliage in cold storage, they appear to have minimal effect on disease development on the flower buds. Additional studies are needed to confirm these results and potentially identify postharvest treatments that are effective in limiting disease development on flower buds. Although a number of new biopesticides were included in our trials, none of them proved to be effective under our test conditions. Additional work is needed to identify ways to potentially increase the efficacy of these types of products under field conditions.

Objective 3: Use molecular markers to determine if *B. paeoniae* is being introduced into Alaska via infested rootstock—Molecular markers were developed (see Activity 7) and tests were run to assess movement using the *B. paeoniae* isolates collected throughout the course of studies conducted in Alaska. Results of these tests were statistically inconclusive, potentially due to the small number of *B. paeoniae* isolates collected in Alaska. Nonetheless, inoculation trials showed that *B. paeoniae* could infect roots, although perhaps infection does not spread after planting. *B. paeoniae* was identified in 2017 on roots from a rootstock producer in Oregon. Therefore it is likely that the potential for movement of this pathogen exist. Although the movement of *B. paeoniae* could not be confirmed, the markers developed indicated other surprising results. These included the likelihood that there is no sexual recombination occurring in *B. paeoniae* based on the distribution of mating types among the isolates sampled. This is a major contribution to the knowledge of *B. paeoniae* because never before have the frequencies of mating types been described for this pathogen, nor have the sequences of the mating type idomorphs (alleles) been described as was done as a result of this project. Furthermore, this project's technique that was used to identify microsatellite markers in *B. paeoniae* is a novel method never used before with fungi. These contributions to science, including the primers for the microsatellite loci, will be published and can therefore be used in the future to answer additional questions about *B. paeoniae* biology.

Objective 4: Conduct surveys at a minimum of 3-4 peony farms in each of the four major production regions of Alaska to identify the range of all pathogens that infect peonies in Alaska—35 farms were surveyed to identify the range of pathogens found in peonies in Alaska, for a total of more than 8 average per region. These surveys confirmed a greater diversity of *Botrytis* in peonies than has been seen in any agroecosystem. This includes up to 10 unnamed new *Botrytis* species. As a result of this study, one of the new species found in Alaska was formally named *B. euroamericana*, as published in the journal Mycologia. Additional species will be described in a future publication. Two new fungal pathogens, *Mycocentrospora acerina* and a *Phoma* spp. were identified on peonies in Alaska, with pathogenicity trials confirming their ability to cause disease. These results will be published in the journal Plant Disease and a diagnostic guide will be developed to help Alaskan growers identify these diseases in the field. Furthermore, our surveys helped to identify a widespread problem with TRV in peonies in Alaska. Due to the prevalence of this pathogen, we developed a grower's guide (see Activity 11 and Objective 5 below) to help growers identify and manage this disease.

Objective 5: Develop and provide educational programs and materials for peony growers regarding *Botrytis* and other peony disease identification and management—One extension Fact Sheet on TRV in peonies has been published, with Alaska-specific information on the virus' vector, and more in-depth information about TRV on peonies was reported in the Fall 2016 issue of the ASCFG Cut Flower Quarterly. The PI and PhD student also coauthored a chapter on the management of diseases on peonies for the new Springer "Plant Disease Management. Handbook of Florists' Crops Diseases" book. Research updates and ways to improve disease management were provided to growers who attended the 2016 and 2017 APGA Annual Conferences, a 2017 workshop, and four regional farm tours in 2016 and 2017.

The measurable outcomes and a description of their status are described below:

Outcome 1: Determine if *B. paeoniae* is being introduced into Alaska via infested rootstock (GOAL) by applying molecular markers developed with funding from a 2014 Alaska SCBG and 2014 Washington SCBG (TARGET) to a minimum of 20 Alaskan *B. paeoniae* isolates (BENCHMARK) by the end of this project (PERFORMANCE MEASURE).—The goal of determining if *B. paeoniae* is being introduced on infected rootstock was not achieved. However, a number of additional benefits were gained as a result of pursuing this goal. See Objective 3 above.

Outcome 2: Disseminate information on the diagnosis and management of diseases on peonies (GOAL) by developing a Peony Diagnostic Guide (TARGET) that is provided to a minimum of 100 growers (BENCHMARK) that are attending the annual APGA conference in 2017 (PERFORMANCE MEASURE).—An extension Fact Sheet on TRV on peonies was produced and disseminate it to approximately 120 growers in attendance at two summer field tours during 2017 in Alaska. This publication is also available for free online to Alaska peony growers. A full diagnostic guide on all diseases of peonies will be ready for submission to WSU extension prior to the end of 2017. All results of this project were also posted on the blog, HortAlaska Peonies: https://alaskapeony.wordpress.com/.

Beneficiaries

Information on disease diagnosis and management was given to the approx. 80 people who attended the APGA conference in 2016 and 250 people in 2017 as well as the 18 people who attended our day-long workshop in 2017. This study also directly benefitted the approx. 240 people who attended the farm tours in Fairbanks, Willow and Kenai Peninsula in 2017. There are currently 113 peony farms in the state of Alaska, all of which will benefit from the information developed as a result of this study. A link was sent to all 113 farms with the fact sheet on Tobacco rattle virus, and all will receive a copy of this report.

Lessons Learned

There were a number of positive and negative lessons from this project. Examples of lessons learned that were outcomes of this project include:

- the realization that *B. paeoniae* exists at low frequencies in Alaska, complicating the issue of collecting enough isolates sufficient for microsatellite analysis;
- too many confounding factors likely exist to adequately correlate environmental data with disease development in the systems studied, and more controlled in-vitro studies of *Botrytis* on peonies would likely be an important first step in determining environmental conditions conducive to disease development;
- important regional differences in environmental conditions exist among Alaskan peony production regions in terms of temperature, rainfall, and leaf wetness.

Understanding the seasonal changes in these parameters could help understand the risk of disease development throughout the state;

- the realization that not all diseases can be easily diagnosable in the field and there are still questions about the cause of some symptoms seen on peonies in Alaska;
- that the great amount of diversity in pathogens infecting peonies in Alaska increases the need for accurate diagnosis. Additional research into the biology and epidemiology of these pathogens is warranted;
- research into post-harvest environment and potential treatments for *Botrytis can* be difficult and confounding. Without an on-site, trained plant pathologist in Alaska, many of these studies will not be possible in the future.
- that growers are eager for information on peony diseases and that there is an ongoing need for education, given the number of new growers and the likelihood that diseases will continue to increase as plantings mature;
- one-on-one interactions with growers are extremely valuable and on-site tours of peony farms are essential for identifying novel diseases, their prevalence in the field, and possible management solutions;
- none of the tested biopesticide products appeared to be effective at managing Botrytis gray mold, but a number of conventional fungicides were efficacious and could be used to improve disease management in peonies in Alaska.

Examples of unexpected findings include:

- Analysis of the markers revealed an important aspect of *B. paeoniae*, biology, namely that it is likely not undergoing sexual recombination.
- Even though at least five new species of *Botrytis* were expected, many more species were found than anticipated. As a result of collecting *Botrytis* isolates for this study, up to 10 new species of this fungus may have been identified.
- There are a number of pathogens present in Alaska on peonies that have never been reported before in the literature on peonies in the United States.

Outcome 1 was not achieved due to a small sample size of *B. paeoniae* isolates for which a population genetics analysis can be performed. Although we collected hundreds of isolates, our sampling revealed that *B. paeoniae* exits at a relatively low frequency in Alaska peony farms, therefore, successful completion of this objective would likely require collection of many more isolates than was accomplished during the course of this study.

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<u>Project #3: UAF Pesticide</u>

Project Summary

- Provide a background for the initial purpose of the project, which includes the specific issue, problem, or need that was addressed by this project.

Peony growers in Alaska have been clear about the difficulty in controlling weeds in their crop and their desire for more information on herbicide efficacy so they can make science-based decisions when selecting weed control methods. Additionally, in the summer of 2014, a lygus bug infestation in interior Alaska served as a wakeup call for a need to have insecticides available that will control the next outbreak while having minimal impact on beneficial insects. The goal of the study was to screen 6 herbicides and 4 insecticides on 4 peony farms in Alaska. We expected improved (up to 50%) and sustainable yields of peonies as a result of good weed control. And we expected the insecticides would be able to stop potentially devastating losses (>50%) of peony buds if lygus bug or thrips populations suddenly increase in the spring. In addition, herbicides could save upwards $500 per acre in reduced hand weeding costs. As a result of this project, peony growers throughout Alaska now have Alaska-based information on what pesticides will work best to control insects and weeds on their farms as part of an overall Integrated Pest Management plan.

- Describe the motivation for this project; its importance and timeliness of research.

Peonies are a rapidly expanding specialty crop in Alaska, grown both for cut flowers and eventually for tubers or container plants. The number of peony roots planted is a measure that is collected by the Alaska Peony Growers Association. Since 2004 root numbers have increased from just a few to almost 170,000 throughout Alaska. Peony is a minor, but high value, crop in Washington and Alaska, with cut-flowers ranging from $2 to $8 per stem depending on cultivar and the number of stems in a single order. Tubers sell for $2 to $50 each, and prices for individual plants range from $18 to $50, with some especially sought-after cultivars retailing for several hundred dollars each. The cost for establishing an acre of peonies is at least $39,000 for plant material alone, without considering land costs, planting bed preparation, irrigation system installation and water costs, and labor. Upon reaching maturity several years after transplanting, an average peony cultivar will produce about five marketable stems per plant per year, with a gross value from $195,000 to $780,000 per acre.

Peony plants generally grow slowly early in the season and have a shallow root system so they are highly susceptible to weed competition, particularly during the first years after planting. Perennial weeds generally become more problematic the longer a peony planting persists, many of which are creeping perennials that are particularly difficult to control without use of herbicides. Glyphosate is sometimes used in spring to kill emerged weed seedlings prior to emergence of peony foliage, but there is danger of crop injury from glyphosate uptake by less than-fully dormant buds located above the soil line. Glyphosate will also control most creeping perennials. There are several other herbicides registered for use on peonies, but most of these have not been well studied and additional herbicides will greatly aid peony growers by providing more effective control of a broader spectrum of weeds, which will drastically reduce the cost of hand weeding.

Insect pests of peony include aphids, cutworms, thrips, and lygus bugs which can increase the percentage of deformed or otherwise unmarketable flowers. Of particular concern are pests of phytosanitary interest such as western flower thrips. If a flower shipment bound for certain countries contains even a single western flower thrips, the entire shipment may be destroyed. In the summer of 2014, an outbreak of native lygus bugs near Fairbanks damaged thousands of peony buds. Effective management of these and other insect pests is critical to maintain the economic growth of these flower crops and expand their production. Currently, insecticide efficacy data on these insect pests in the Pacific Northwest and Alaska are lacking.

Peony ranks in the top ten of the most desirable wedding flowers. Production of quality peony flowers requires control of insect pests and weeds. The objectives of this project were to (1) evaluate herbicides to provide manufacturers with data that will give them confidence to add peony to their product labels, and (2) identify insecticides with good efficacy on insect pests known to be troublesome in peony. With reduced labor costs, increased flower production, and fewer insect-damaged blooms, Pacific Northwest and Alaska flower availability should increase, enhancing the competitiveness of this specialty crop.

To conduct this study screened 6 herbicides and 4 insecticides on 4 peony farms in Alaska. Pre-emergence herbicides were applied early in the spring before weeds had started growing and insecticides were applied when insect populations were rapidly increasing in early summer. These peony farms all had sticky traps that were changed weekly to measure insect populations.

Herbicides tested were:

Product	Active	Manufacturer
Tower	Dimethenamid-p	BASF
Freehand	Dimethenamid-p + pendamethalin	BASF
Dimension	Dithiopyr	Dow
Marengo	Indaziflam	OHP
Gallery	Isoxaben	Dow
Echelon	Sulfentrazone + prodiamine	FMC

These products provide pre-emergence control of many annual weeds in AK and WA and should assist growers in their weed management efforts. Percent weed control and weeding times will be measured for all treatments as will herbicide effects on peony foliar growth (canopy height and width) and flower number, stem length, and general quality.

Insecticides tested were:

Product	Active	% active	Manufacturer	IRAC class	Insects
Entrust*	spinosad	22.5	Dow	5	T
Acephate 97	acephate	97	AMVAC	1B	A,T,PB
Malathion 8	malathion	81.8	Loveland	1B	A,T,PB
Aria**	flonicamid	50	FMC	9C	A,T,PB

*Organic formulation
** Not registered in AK, but active ingredient is registered (Beleaf 50 SG, FMC) A = aphid, T = thrips, and PB = plant bugs

Three of the 4 insecticides are registered in Alaska and all 4 are registered in Washington State. Aria is the only insecticide selected that is not registered in Alaska, however the active ingredient is registered here under an agricultural use label, Beleaf® (flonicamid) and data from this study could assist registration of Aria in Alaska. None of the insecticides are labeled *restricted use* and none are listed on the *endangered species Bulletin*, plus Aria is reasonably safe for pollinators. Three of the 4 are effective against the 3 most problematic pests of peonies. Entrust provides an option for organic production against thrips. All together these 4 insecticides will provide Alaska growers with management choices for rotating mode of action chemistries among the 3 classes of insecticides for effective insect resistance management.

- If the project built on a previously funded project with the SCBGP or SCBGP-FB describe how this project complemented and enhanced previously completed work.

Project did not build off previous research.

Project Approach

- Briefly summarize activities and tasks performed during the entire grant period. Specifically, discuss the tasks provided in the Work Plan of the approved project proposal. Include the significant results, accomplishments, conclusions and recommendations. Include favorable or unusual developments.

Project Activity	Who did the work?	When the activity was accomplished?
Herbicides were applied	Steven Seefeldt and Janice Chumley	May 2016
Herbicides were be applied	Gino Graziano	June 2017
Herbicide effects on peony and weeds were determined	Darcy Etcheverry, Janice Chumley and peony farmers	June and July 2016 and 2017
Insecticides were applied	Steven Seefeldt and Gino Graziano	June and July 2016 and 2017
Plants were monitored for presence of thrips, aphids and lygus bugs	Dr. Beverly Gerdeman, Darcy Etcheverry, Janice Chumley, and peony farmers	June and July 2016 and 2017

Activities were performed as planned with all herbicide and insecticide applications. The only deviations were with the number of growers. One grower backed out of insecticide trials in 2017.

- If the overall scope of the project benefitted commodities other than specialty crops, indicate how project staff ensured that funds were used to solely enhance the competitiveness of specialty crops.
  No other commodities benefited from this project.
- Present the significant contributions and role of project partners in the project.
  Dr. Beverly Gerdeman was essential to the project as she provided insect identification and scouting. Growers provided excellent assistance with providing adequate areas although there were other issues that impacted data that were out of their and our control (see lessons learned). The peony growers association was integral to the project providing a venue to give presentations disseminating the results of the work.

Goals & Outcomes Achieved

- Describe the activities that were completed in order to achieve the performance goals and measurable outcomes identified in the approved project proposal or subsequent amendments.
- If outcome measures were long term, summarize the progress that has been made towards achievement.

- Provide a comparison of actual accomplishments with the goals established for the reporting period.
- Clearly convey completion of achieved outcomes by illustrating baseline data that has been gathered to date and showing the progress toward achieving set targets.
- Highlight the major successful outcomes of the project in quantifiable terms

Weed control was improved through registration of herbicides for peony. Data from the study was collect as described in the Project Purpose section. The results of the experiments were analyzed. All herbicides performed equally, with no impact seen to peonies. However, the lack of consistent weed coverage in fields made herbicide efficacy comparisons difficult to measure.

Insecticide treatments for thrips, aphids and plant bugs were evaluated for peony and we proposed the economic gain for each product be determined based on reduction in the percentage of flower culls. It was anticipated that culls will be reduced by 20% by products providing effective control of these insects. However, field conditions prevented being able to identify a reduction in culls as pest pressure dropped overall due to surrounding fields being treated. Some good insight was gained, however. See the attached report from Dr. Gerdeman.

The results of the herbicide and insecticide trials were disseminated to the general public through several pathways. First, there is an Extension Bulletin about Integrated Pest Management in Peonies and data from this study will support the recommendations made in the bulletin. Second, the information from this study was presented at the annual Alaska Sustainable Agriculture Conference and at the annual Alaska Peony growers Conference. Because there were two years of data collection in this project, there were two presentations the Peony grower conference, but only one SARE conference occurred during this time. Both of these conferences attracted over 200 attendees. Third, we developed an online course that details managing insects in peony field production.

Measurable outcomes:

1. Two IPM in Peonies Extension Bulletin
   https://www.uaf.edu/files/ces/invasives/2018-Lygus-6-26.pdf
   https://www.uaf.edu/files/ces/invasives/2018-Thrips-Peony.pdf

2. Eight presentations at Alaska Annual meetings reaching over 200 people at each meeting (200 x 8 = 1,600)

3. One online course on managing insects in peony fields.
http://peonypests.open.uaf.edu/

4. Tours of farms, 4 farms in two regions over a two year period with over 50 people at each tour. This deliverable was not completed as indicated for two main reasons, and with the following deviations. 1st, the local members of the Peony Growers Association already conduct tours through the summer and we did not want to put together a standalone tour that would draw from this. However, we had staff at the Peony Growers Association tour in the interior, and on the Kenai Peninsula. In the case of the interior tours at least two farms that participated in the project hosted tour participants. We

lacked sufficient participation from farmers on the Kenai Peninsula which resulted in no farms from the Kenai included in the workshop. While the tours were not specific to weeds and insect pests this is of course a part of the discussion. Our staff were present to pass out fact sheets we developed for lygus and thrip management, as well as answer any IPM related questions. Because we experienced cost savings from not hosting these tours we were able to create an online course on managing insects in peony fields.

Beneficiaries

- Provide a description of the groups and other operations that benefited from the completion of this project's accomplishments.

Beneficiaries of this project are peony growers in Alaska.

- Clearly state the number of beneficiaries affected by the project's accomplishments and/or the potential economic impact of the project.

The number of beneficiaries of this project are the 38 farms that are members of the Alaska Peony Growers Association as well as the many additional peony growers that they reach. To be more exact peony 85 current or potential growers that attended our presentations at the Alaska Peony Growers annual conference where we presented results and recommendations we could provide from the herbicide and insecticide trials. Thirty-two growers attended the weed management presentation, and 53 attended the insect management presentation in 2018.

Lessons Learned

- Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.

Working with growers on implementing these projects had positive and negative consequences towards the outcome. Positive consequences resulted from increased interaction with the growers, and them seeing what we were doing for applications and monitoring. These interactions no doubt increased their knowledge of often overlooked details like proper ppe, how and where to set monitoring traps for insects and various other factors with applications. The negative consequences of working with producers was less control over the experiments. Ideally herbicide and insecticide trial conditions would be standardized across all treatment areas, however working with multiple growers does not allow that. The growers own practices with insecticides outside of the areas we had plots in were likely a reason for dropping levels of insects prior to our treatments which made our data less useful. In the herbicide study, every farm had different weed issues, much of which were perennial weeds when we were testing pre-emergent herbicides which are primarily for annuals.

- Describe unexpected outcomes or results that were an effect of implementing this project.

Our unexpected outcome that came from implementing this project was discovery of some new damage causing agents that are not yet identified. While examining peony buds for insects Dr. Bev Gerdeman noted damage from a disease agent on buds from one producer. This producer was provided instructions on how and when to sample in order to get a proper identification.

- If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.
- Lessons learned should draw on positive experiences (i.e., good ideas that improve project efficiency or save money) and negative experiences (i.e., lessons learned about what did not go well and what needs to be changed).

We were unable to submit a peer reviewed journal article resulting from the project work because of the variability in farm weed management issues, and insects present. Studying insect pressure on peony and mediating that pressure using insecticides would be better accomplished in an area where a whole farm is dedicated to the project. This will allow for peonies to build populations of insects in untreated areas that can migrate into treated areas, thus testing the effectiveness of the insecticide. As this project was completed the adjacent fields were treated which lowered our insect pressure negating good measures of the effectiveness of individual insecticides. For the herbicides, ideally we would start with a weed free peony field, and introduce annual weeds, seeding them into the peony field. Doing this would allow for uniform comparison of efficacy of an herbicide on weeds.

Contact Information

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Additional Information

- Provide additional information available (i.e. publications, websites, photographs) that is not applicable to any of the prior sections.

Project # 4: Demand for Local Produce

Project Summary

Spork Consulting, under a USDA Specialty Crop Grant, conducted a ten-month market analysis to understand the size and scope of the current wholesale market for specialty produce crops in the Municipality of Anchorage and to identify potential areas for growth and distribution. The study focused solely on buyers in the Municipality of Anchorage and growers in the both the Palmer and Anchorage areas. The analysis aims to provide information with which Southcentral Alaska growers can determine what type of joint marketing effort, such as a food hub, co-op, or other type of distribution facility, would be best to facilitate increases in net farm production and income while increasing the amount of locally produced specialty crops purchased in Anchorage.

Wholesale buyers typically fall into one of three general categories: institutions, retail grocery stores, and restaurants. Specific areas of focus for this study include: preferences, pricing, buying cycles, and requirements of wholesale, retail, and institutional buyers. Producers are separated into large and small operations. Specific areas to be included in the producer's analysis include: produce quantity produced, type of produce produced, growing season, growing preference, ability to expand, and requirements of producers to sell their products. This market analysis focuses on the needs and requirements of the four groups most able to affect change (i.e., producers, institutions, retail grocery stores, and restaurants). It also addresses additional issues such as the need for processing and distribution infrastructure, local food policies, the communication network between producers and wholesale buyers, and marketing resources.

This study aims to bridge the knowledge gap between producers and buyers by informing Anchorage area and Palmer-based farmers of the opportunities that exist to expand sales and production, as well as to inform Anchorage buyers about the availability of Alaskan agricultural specialty crop products.

Project Objectives

In recent years, the discussion of and demand for local foods has increased substantially. This trend has been spurred by consumers' desire for supporting local communities, diversifying our state economy, more nutritious and flavorful dining options, and in response to recent concerns around the lack of independent food security in the State of Alaska.

According to a July 2014 report by the Alaska Food Policy Council (AFPC) and Ken Meter (Meter and Goldenberg, 2014), 95% of the $2 billion spent annually on food purchased in Alaska is imported. Anchorage, which is the largest city in the state and home to almost one-third of Alaska's residents, is an urban center with limited agricultural potential. Palmer, which is approximately 45 miles outside of Anchorage, is a rich agricultural area that may be able to provide a greater quantity of locally grown food to Anchorage consumers.

Producers and buyers face a number of barriers, both perceived and real, to expanding the production and sale of local agricultural products. Some of the barriers include inconsistency and lack of supply to meet demand, insignificant communication channels, lack of distribution capacity, and time demands when dealing with multiple customers. These barriers prevent Alaskan producers from both meeting existing demand and selling directly to larger retail and wholesale markets throughout the state. Because of these challenges, there has been a substantial increase in the discussions around and intention to form alternative distribution channels, such as cooperative businesses and food hubs, for Alaskan grown produce including a recent series of meetings with the Anchorage Economic Development Council (AEDC) and the Alaska Food Policy Council (AFPC) regarding food hubs as well as a number of specific conferences organized by individuals and non-profits in the region. These alternative models may provide a way for local products to reach consumers on a larger scale while avoiding the barriers to traditional distribution.

With permission, this study will be modeled on the Alaska Cooperative Development Program's *Demand for Local Produce in Interior Alaska* and will incorporate the questionnaires and research methodology that was created for the study. The study proposed herein aims to bridge the gap between producers and buyers by informing Anchorage/Palmer-based farmers of the opportunities that exist to expand sales and production, as well as to inform Anchorage buyers about the availability of Alaskan agricultural products.

Project Approach

The information in this study is derived from the best available information published by the United States Department of Agriculture, the United States Census, and the State of Alaska. Survey data was collected on a volunteer basis with producer and commercial buyers who expressed an interest and willingness to participate. The surveys were broadly distributed through community list-serves, targeted Facebook advertising tools, the Anchorage Economic Development Corporation. The majority of surveys were completed through in-person interviews with Melissa Heuer, MBA or Ming Stephens, M.S. as well online through Survey Monkey. A potential bias may exist in this study because of the voluntary basis of participation. Buyers and producers who are interested in expanding and incorporating locally grown produce may be more likely to participate in this survey.

Local

The term "local" in this report refers to farms and organizations located within the Municipality of Anchorage and Palmer including the communities of Eagle River and Girdwood. Although the Alaska Grown definition of local includes produce from throughout the state of Alaska, the focus of this study was solely focused on produce grown and purchased in this geographic region. In this study, "local" is specifically referring to produce produced in the Municipality of Anchorage and Palmer.

Agricultural Scope

The aims of this study were solely focused on produce, which includes vegetables, fruits, and herbs. There are a number of farmers in Southcentral exclusively growing flowers, feed grains, and livestock who were intentionally excluded from this study.

Producer Survey

This survey focused on produce farmers based within the Municipality of Anchorage and the Palmer area. Producer data was gathered over the phone and digitally collected using Survey Monkey from July through October, 2017. Using the Alaska Grown Online Source book, identifying farmers that participated in area Farmers Markets, speaking with restaurants and other farmers, 52 potential farms were identified. Of the 52 farms, 10 were discounted for either not meeting the requirements of the survey or for no longer being in business, and an additional ten were unable or unwilling to participate in the survey. Thirty-two farmers, slightly more than 75% of the qualified farmers in the region completed the survey fully. See Appendix A for the Producer Survey template.

Buyer Survey

A buyer list was developed of businesses listed with the Anchorage Economic Development Corporation, the Alaska Division of Agriculture, through distribution lists from area distributors, and by word-of-mouth. Buyer data was gathered over the phone and digitally collected using Survey Monkey from September through November 2017. Of the 109 restaurants, hospitals, distributors, and grocery retailers contacted, 39 completed the survey. See Appendix B for the Buyer Survey template.

Goals & Outcomes Achieved

A combination of business demand and increased production has resulted in a high level of local produce purchases in the Southcentral Alaska region. We expect continued growth and demand for local produce. Businesses of all types and sizes are able and interested in buying more local produce and most farmers have the ability and intention to increase their production. There is substantial room for growth in local foods consumption with a range of opportunities from expanding or taking over existing farms, starting alternative operations, or filling needs within processing and distribution. Throughout the system, a number of mutually beneficial opportunities exist in the local food sector in Southcentral.

Southcentral Buyers

The majority of participating businesses are located in Anchorage, with additional participants from Indian, Girdwood, and Eagle River. The businesses cover a wide range of restaurant types and organizational buyers. In 2016, excluding large grocery chains, participating businesses spent an average of $64,234 a year on produce purchases. The majority of produce purchased in the state is imported to Alaska; however, of the businesses interviewed, *on average an impressive 28% of produce is purchased from Anchorage area and Palmer businesses* and an additional 4% is purchased from other parts of Alaska.

Organization leadership, rather than perceived customer demand, is driving local food demand growth. Almost 75% of businesses in this survey are buying directly from local farmers in the Municipality of Anchorage and Palmer. The range of local produce usage varies across sectors, by size of business, and business type and appears to be driven internally by each business.

Restaurant buyers are most interested in flavor of produce, seasonality, sustainability, and customer preference. Many examine the quality of the fresh produce, the ease at which the product can be secured, and the final selling price for the dish compared to the cost of the produce. Restaurants specifically indicated that they can change their menus ranging from one week to two hours out, but they need knowledgeable staff that knows how and has the time to process the produce. Restaurants expressed concern about minimum order requirements, as some of the produce items are only available in larger quantities than they might use.

Every business indicated their ability to scale up their local produce purchases. If quantities were available, three quarters of businesses would use more than 50% local produce in their daily operations, while slightly less than half of businesses would use 90% - 100% of local produce if available. Additionally, the majority of businesses, 89%, would be willing to pay more for local produce, and more than half are willing to pay up to 15% more than produce that has been imported to Alaska. It is important to note that while businesses indicated their willingness to pay more for local produce, buyers have also indicated that produce pricing is a barrier to purchasing more local produce, and in reality, these estimates may be higher then what buyers are willing to pay on a regular basis.

Buyers are also concerned about consistency and the state of the produce such as how much dirt is on the produce and how much labor will be involved in processing. The temperament of the farmer, including willingness to work with a buyer and their ability to communicate also plays a huge role. Finding the right buyer or finding the right producer is key as each buyer is looking for something different.

Southcentral Farmers

Southcentral Alaska producers vary greatly in the size, type, and style of farming technique from small indoor and hydroponic operations to larger (one hundred acres and up) well established farms. Anchorage is home to smaller traditional farms and hydroponic growers, likely due to the higher cost of land in Anchorage, the low fixed price for reliable clean water, and the lowest power rates in the state. Farming outside of Anchorage is done almost exclusively outside through traditional farming practices. Farms vary in age, with new, inexperienced farmers starting new operations in Anchorage, and more experienced farmers farming on established farms on bigger plots of land outside of Anchorage.

This region represents a mix of experienced and new farmers selling their produce in a variety of ways from direct marketing, selling through a distributor, or by participating in farmers' markets and on-line food hubs. Many farmers are able to sell the majority of the crops, with some saved for personal use or given away; very little produce grown in the region is unused or composted for lack of market. More than 75% of farmers have the ability of scale up their overall production. In 2017, more than half of farmers grew their operation and an additional 58% are planning to expand their operation in 2018.

The Future of a Food Hub

Produce Buyers: The vast majority of buyers, 93%, feel that the development of a food hub, co-op, or alternative distribution model in Anchorage would benefit their business: it could add convenience, include a number of farmers, and streamline purchasing.

Buyers indicated that the potential services of a food hub could provide consistency and convenience for pick-up and planning as well as allow buyers to buy more quantities at one time from multiple local sources. Many buyers also felt that an alternative distribution model could help address specific regulatory issues, though did not specify what these were, and aid in economy of scale barriers.

Produce Farmers: In general, the majority of farmers, 80%, feel that the development of a food hub, co-op, or alternative distribution model in Anchorage would benefit their business. However, a number of farmers noted their concern about higher prices based on the Alaskan Grown label on produce that would be sold through the alternative model and felt that if that was the case, it would decrease the appeal for customers.

Overall farmers indicated that a food hub would provide them with a way to collectively join their voices to increase their marketing abilities, address food processing regulations, and potentially create a space for processing and value-added products.

General Business Community: The majority, 75%, of participants felt that the development of a food hub or alternative distribution model in Anchorage would benefit their business.

Community Space: The greatest need in the community in regard to community space is test kitchens. Both current and anticipated demands far outweigh what is currently available.

Funding: There is a high demand for funding now and an even greater expected demand in the future. There is a much greater need for general grant funding and an increased demand in the near future, with few existing opportunities. While there is some existing equipment funding, there is not enough to meet current needs and there is expected to be an even greater need in the future.

Land: Overall, the available land is greater than the curent demand for land. Exisitng available space meets or exceeds demand in all categories.

Processing: There an overall need now and an expected need for all types of processing equpment and space. While there is some commercial kitchen space available now, the current and future needs outweigh available supply. Demand for meat processing facitlities are currently outpacing supply and are expected to substantially do so in the near future.

Storage: The current demand for storage can be met with currently available resources. There is a surplus of dry storage and chest freezers and while the demand is expected to grow, the community may have enough resources to meet this need.

Transportation: There is a demand for both in-state and out-of-state distribution, with the need for both expected to rise in the future. While current supply can be meeting demand in both logistics and box truck space, the demand for both is expected to increase as well.

Overall, while the demand is high for many of the services a potential food hub or alternative distribution model could provide, there are number of resources currently available in our community that are going unused. The reasons for this vary; a limited ability to share available resources with the broader community is likely one of the main limitations, but quality of resource, price to use the resource, and location of the resource may also be deterrents. Demand is generally expected to increase for most community resources and could present a number of opportunities for individuals and organizations hoping to start a food hub or alternative distribution model, or for those trying to tackle a specific area of need.

Partner Participation:

Project partners presented one of the greatest challenges for this project. During the project duration, our main project partner, the Anchorage Economic Development Corporation, saw high turnover and three different, new employees were assigned to this project. In the end, the final employees were not interested in food project, as the initial employee had been, and they ended up contributing very little to this project outside of sharing survey questionnaires on Facebook and through their listserve. Because this roughly $5,000 of matching funds was re-appropriated to other projects within AEDC and were not spent in-kind on this project as expected.

Additionally, a University of Alaska graduate student was hired to work on this project. Because of changes within the University, student turnover was also quite high, and we were unable to find a reliable candidate until late summer. Eventually, this partnership worked out well and the student successfully contributed to the study.

Goals and Outcomes Achieved:

Of the hundreds of participants in this study, 84 competed the surveys and were qualified to be included in the analysis. The goals and objectives were met for this grant and can be seen in both written report for this project and in the summary above.

The outcome indicator for this project was to enhance the competitiveness of specialty crops through increased sales, by reaching 10-25 consumer or wholesale buyers, 15 of which will gain knowledge on how to access and produce specialty crops. This project reached well over 100 buyers and final report will be distributed to all participants and listserves. This report has insights on connecting, and communicating with farmers, where to find Alaskan specialty crops and how to increase business usage of Alaskan specialty crops.

Beneficiaries:
Southcentral Buyers

Thirty-two local buyers and seven chain retailers, institutions, and distributors participated in this survey. The majority of respondents are located in Anchorage, with additional participants from Indian, Girdwood, and Eagle River. Many businesses fill multiple roles, such as dining and catering, or brewery and café and provide insight into multiple sectors of produce buying.

Business Type	# Interviewed
Bakery	1
Brewery	3
Catering Company	5
Distributor	2
Food Hub	1
Grocery Retailer; Chain	1
Grocery Retailer; Independent	2
Hospital	1
Private Chef	1
Resort/Hotel	1
Restaurant; Café	6
Restaurant; Casual Dining	17
Restaurant; Fine Dining	7
Restaurant; Food Truck	1
Restaurant; Sandwich Shop	1
Restaurant; Seasonal	2
Specialty Retailer	3
Theatre Pub	1
Wholesale Manufacturing	2

Eighty percent of the participating businesses have been in business for five or more years while 12% percent have been in business for two or fewer years. Overall, 75% of businesses are run by experienced individuals who have been operating their organization for five or more years and only one organization with a buyer who had been with them for one year or less.

Farm Location	# Interviewed
Anchorage	8
Chickaloon	1
Eagle River	2
Palmer	21
Total Participants	32

Fifty-two farmers, including hydroponic growers, located in the Municipality of Anchorage and Palmer were contacted for this survey. Of the 52 farmers identified, thirty-two were qualified and willing to participate in the study.

The broader "Food Resources Assessment" survey was conducted from March through May 2017. Of the 212 participants, 49 surveys were completed within the geographic study area of Palmer and the Municipality of Anchorage. The survey was distributed through boosted targeted Facebook advertising tools, listserv emails and through outreach channels with the Anchorage Economic Development Corporation and the Alaska Food Policy Council.

Business Type	# Interviewed
Bed and Breakfast	1
Brewery	1
Brick and Mortar Restaurant	1
Catering Company	4
Co-Op	3
Distribution Company	3
Farmer	8
Farmers' Market	3
Federal Agency	2
Fish Monger	3
Fishermen	1
Food Entrepreneur	16
Food Hub	4
Food Truck	1
Government Agency	2
Institution; Hospital, Senior Center, Rehabilitation Center	5
Investor	2
Lending Agency	3
Non-Profit	13
Other	1
Retailer	6
School	6
Social Enterprise	1
Storage Facility	3
Test Kitchen	1

Lessons Learned

In 2016, excluding large grocery chains, 88% of participating businesses that responded to this question spent a total of $1,638,700 dollars on produce, with the average business spending $64,234 a year on produce purchases. This figure fluctuates with the business size, ranging from smallest businesses spending $1000 a year, while most spend between $15-$45k. A number of the larger businesses are spending between $200-$600k a year on all produce purchases.

The majority of produce purchased in the state is imported to Alaska. Of the businesses interviewed, an average of 28% of produce is purchased from Anchorage area and Palmer businesses and an additional 4% is purchased from other parts of Alaska. The amount of local produce being used varies substantially among businesses, with 17% of businesses buying local for more than 80% of their produce needs, while 43% of businesses use 10% or less of local produce. The range of local produce usage varies across sectors, size of business, and business type and appears to be driven individually by each business.

Organization leadership, rather than perceived customer demand is driving local food growth. When asked on a scale of 1-10, with one being not at all important to 10 being extremely important, how important supplying local food to local businesses is, 60% responded that it is extremely important to them, with 10% responding with less than a five, and no one responding that it is not at all important.

When asked on a scale of 1-10, with one being not at all important to 10 being extremely important, how important they thought supplying local food was to their customers, 30% responded that they thought it was extremely important to their customers, with slightly more than a quarter responding that they felt it was less important to their customers.

Buyer Challenges:

All buyers, including those who are currently buying local produce as well as those who are not, were asked what their barriers were to buy locally, and what would make the process easier to buy more local produce in the future. Buyers indicated a number of challenges with inconsistent supply, limited variety, and lack of convenience working with growers as their greatest barrier to purchasing local product.

Even with additions such as high tunnels, hoop houses, and greenhouses, the growing season for tradition produce in Alaska in limited.[1] Indoor hydroponic operations are extending the season for a number of leafy greens, herbs, and other vegetables and as this type of farming continues to expand in Alaska, we may see a greater variety and supply of Alaska grown produce in winter and spring months. Longer growing seasons may also address barriers around limited volume and lack of year-round availability.

Businesses are also facing issues when wanting to purchase smaller quantities of produce. Communicating and farmer relationships also present a challenge, and multiple buyers expressed frustration about working with specific farmers who are likely better at farming than at the business and logistical side of an operation.

Farmer Outcomes:

Slightly more than 50% of participants are selling their products directly to local restaurants and grocery stores, while zero participants are currently selling directly to institutions. Depending on the farmer, some are bringing their produce directly to their business, while others require the business to pick up from their farm. Asian and Chinese restaurants appear to be one of largest

[1] DNR 2014. Alaska Department of natural Resources, Seasonal Produce Availability. http://dnr.alaska.gov/ag/Marketing/PRODCHART.jpg

purchasers of local cucumbers, while the Bear Tooth, 49th State Brewing, Midnight Sun, and Spenard Roadhouse appear to be purchasing from multiple farmers as they were commonly listed in responses. Farmers are also dealing directly with Safeway, Fred Meyer, Walmart, New Sagaya, Red Apple, Natural Pantry, Arctic Harvest CSA and Evie's Brinery.

Half of the farmers interviewed did not sell at farmers' markets. Of the 50% that do, many sell at more than one market, and a number of farmers sell their produce to a farmers' market vendor who collects and sells their produce. The most common markets for farmers to sell at are all located in Anchorage. They are the Saturday South Anchorage market, the Saturday Spenard market, the Saturday Anchorage Market on Cordova Street, and the Center Market at Sears. While included as options, no farmers indicated their participation in the Depot market in Palmer, the Anchorage Downtown Market and Festival, the Eagle River market, the Northway Mall Wednesday market or the Saturday Eagle River market.

Farmer Challenges:

Unlike other parts of Alaska, the majority of farmers in Palmer and the Municipality of Anchorage are full-time working farmers who are not pursuing additional employment outside of farming. Farmers face a number of challenges when it comes to getting local produce to the public. While few indicated a problem selling their produce, many noted limited volume, inconsistent demand, and lack of convenience working with buyers as their greatest challenges. Other challenges included selling their products for enough to cover their costs and getting their products to buyers.

Farmers are also facing a number of a barriers to enter larger grocery retailers and are hindered by third party audit requirements, grocery store bureaucracy, and consumer education. Many new farmers experience a steep learning curve while both learning how farming works in general, understanding crop rotations for Alaska, and deciding where the best locations and marketing efforts are placed with limited time away from the farm.

Outside of actual farming, farmers indicated a number of hurdles to general operations with the greatest being labor. Finding affordable and reliable labor is an issue across the board for farmers. Food safety regulations, cottage food regulations, marketing, aging and expensive equipment, insurance costs, and general capital funding for growth are other operational hurdles facing farmers.

Food Hub Potential

Overall, while the demand is high for many of the services a potential food hub or alternative distribution model could provide, there are number of resources currently available in our community that are going unused. The reasons for this vary; a limited ability to share available resources with the broader community is likely one of the main limitations, but quality of resource, price to use the resource, and location of the resource may also be deterrents.

Demand is generally expected to increase for most community resources and could present a number of opportunities for individuals and organizations hoping to start a food hub or alternative distribution model, or for those trying to tackle a specific area of need. Additionally, people that have available resources and that are hoping to rent or share them need to communicate the availability with the public.

Study Analysis:

Overall, this study turned into a much larger analysis of potential ways to increase local specialty crops and exceeded both goals set forward in the grant proposal and the time allocation for the project. Additional challenges arose with partner expectations and working with changing staff and staff priorities with partner organizations.

Largely, this project exceeded the expectations in regard to wiliness of participants to share proprietary information. The level of involvement from all participants and their continued interest in procuring more specialty crops is a positive sign for continued community demand for local specialty crops. There are a range of opportunities for continued market growth and development and the future for increasing Alaska's food security if strong.

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Additional Information

The final results of this study are available in PDF from. The final report will be released to participants and the general public in early December, and will be available at www.sporkak.com

Project #5: Potato Post Harvest

Project Summary

Alaskan specialty crop producers continue to expand production to meet the requirements of the food service industries. Producers, restaurateurs and local processing facilities are seeking information on the feasibility of processing locally grown potatoes into chips and French fries. Potato processing evaluations on Alaska grown potatoes have not been done in this state. Alaska has unique environmental conditions that do not allow for a direct fit of postharvest performance criteria from other areas of the U.S. Trialing potato varieties will help demonstrate the qualities or lack of qualities which, when produced in Alaska's unique growing environment, stored and then processed affect the quality of the product. This project is timely and important in addressing the needs of the specialty crop industry in Alaska due to the lack of any other potato post-harvest evaluations being conducted.

The vegetable industry is significant to Alaska, accounting for $6.9 million dollars in value in 2011, roughly 22% of the total value of all farm marketing cash receipts. Potatoes grown for processing may be a viable and valuable product for many of Alaska's specialty crop producers.

Project Approach

Data on the specific gravity and tuber shape, size and color of 208 varieties maintained by the PMC was collected and recorded. Degree Brix measurements were taken in 2016 & 2017. From this data, 103 cultivars were selected for processing evaluation. Criteria used for selection was primarily a specific gravity higher than 1.080 or a recommendation from the potato breeder for the cultivars use for processing.

The 2017 potato field was planted and maintained as usual. Through an operational oversight, the first 90 varieties planted did not receive any fertilizer. The tubers were smaller than usual, and yield was decreased for the affected potatoes as expected. Of the 15 varieties included in the final evaluation, Peter Wilcox, Atlantic, Allagash and Krantz did not receive any fertilizer. The tubers were planted May 30-31, 2017 and were evaluated weekly starting 5 weeks after planting. Chemical vine desiccation occurred 15 weeks after planting at 105 days, and harvest occurred 17 weeks after planting on September 26-27, 2017. In that time, we experienced 711 Growing Degree Days (GDD) according to the Alaska Climate Research Center as measured at the Palmer Airport. We also had several wind storms which damaged the vines of many varieties and likely affected yields and tuber quality as well. The top growth of the 90 field varieties that were not fertilized was markedly small and pale compared to the rest of the field although the specific gravity from the tubers was not notably inconsistent with that measured in other years when all the varieties were fertilized.

At harvest a 25-pound bag of each variety was collected and stored at 50°F with 99-100% humidity for 10-14 days. The temperature was slowly reduced over the following 2-week period to a holding temperature of 38°F and a holding humidity of 98%. After the tubers had equilibrated, a subsample of each of the 103 selected varieties weighing between 3.3-6.6 pounds was pulled and washed. This subsample was used to measure specific gravity which is determined by the formula;

Specific gravity= weight of tubers in air ÷ (weight of tubers in air) − (weight of tubers in water)

A Martin Lishman Digital Potato Hydrometer was used to obtain the specific gravity. Results were compared with specific gravity measurements from previous years as that data was available i.e. cultivars new to the PMC collection had fewer years of data available. Additionally, a degree Brix measurement was taken using an Atago Pocket Refractometer Pal-1.

In December 2017, the selected varieties were removed from 38°F storage, cut with a Redco InstaCut Series 15000 with a 3/8" (1 cm) screen and fried at 375°F for 3 minutes with a Pitco Economy Gas Fryer in canola oil. The material was not rinsed or pre-prepared in any way. The fries were compared to the USDA "Color Standards for Frozen French Fried Potatoes" (Fifth Edition, 2007), assigned a color rating and photographed. A panel of volunteers tasted the fries and shared their assessment which was noted. Taste was used as the most influential selection criteria and the top 15 preferred varieties were selected for the next stage of evaluation.

On April 3, 2018, the 15 selected cultivars were removed from 38°F cold storage and placed at room temperature, approximately 60°F, and allowed to undergo reconditioning for 14 days. The philosophy behind reconditioning is that at warmer temperatures the respiration rate of a tuber will increase, and it begins to convert the reducing sugars glucose and fructose back into starch thereby decreasing the sugar concentration in the tuber. Reducing sugars react with available free amino acids during frying via the Maillard reaction and high levels of reducing sugars at processing result in unacceptably dark products (fries or chips) with an unappealing burnt taste.

On April 17, 2018, after 14 days of reconditioning, a five-person project partner panel evaluated each of the varieties after they were sliced 3/8" thick and fried at 375°F for 3 minutes in canola oil. A value between 1-10, with 1 being unacceptable and 10 representing a highly favorable critique, was assigned for the following qualities: Color, Flavor, Texture, Appearance and Overall (See Figure 1). The color score in this instance was the opinion of the panel as to whether the fry was an appealing color, it is separate from the color rating based on the USDA color score chart. The overall category was an independent assessment from the panel, it was not an average of the other 4 criteria. In addition to being evaluated by the panel, the fries were also assigned a color rating based on the USDA Color Standards chart (Fifth Edition, 2007) and photographed. The data was compiled and analyzed and was compared to the USDA fry color rating obtained in the previous evaluation. The comments from both evaluations were considered as well. From the data, each of the varieties are ranked by potential processing quality (See Figure 2).

Figure 1: Average evaluation scores from the five-person assessment panel for each variety in each category (1=low appeal, 10=high)

Variety	Color	Flavor	Texture	Appearance	Overall
Cowhorn	4.8	3.0	5.4	5.4	4.0
4	6.6	5.6	5.6	6.2	5.6
Peanut	6.4	7.4	6.8	6.2	6.6
Tundra	9.0	7.4	7.4	8.6	8.2
Peter Wilcox	6.2	6.0	6.6	6.6	6.4
Allagash	7.4	7.2	7.4	8.0	8.0
Sage Russet	4.8	5.0	5.4	5.0	5.0
Atlantic	8.4	7.4	8.4	8.2	8.2
Lamoka	5.8	3.6	5.8	6.2	4.2
Bushes Peanut	4.0	5.4	5.6	4.2	5.0
Clearwater Russet	5.0	6.4	6.0	5.0	5.8
Gui Valley	6.2	7.4	7.6	6.4	7.2
Krantz	4.0	5.0	5.8	5.2	5.2
Alturas	4.6	6.2	6.6	5.4	6.0
Lelah	7.6	7.2	5.8	7.6	7.2

These 15 varieties were all selected for the final evaluation because they produced an appealing tasting French fry direct from cold storage, even though many of them fried a color darker than is acceptable to commercial processors, which typically allow a maximum color rating of 2. It is interesting to note the flavor assessment after reconditioning. Cowhorn, for example, had a very nice potato flavor straight out of 38°F storage, but had a strong unpleasantly bitter aftertaste for the quantitative assessment. Krantz, though it measured a 4 on the color rating out of cold storage, did not fry as dark as it did after reconditioning and it was a selected variety partially because it had a nice crispy skin. Lamoka as well developed what was described as an acidic aftertaste after reconditioning and received a low flavor score.

Figure 2: Varieties in order of rank based on the overall score and a description of the tuber. This data is only based on the final quantitative evaluation of the panel.

Variety	Overall Average (x/10)	Tuber Description (Alaska field**)
Tundra*	8.2	3-4" Round tuber, white skin & flesh
Atlantic	8.2	3-4" Round tuber, white skin & flesh
Allagash Russet	8.0	3-4" Blocky oblong russet, white flesh
Gui Valley	7.2	3-4" Round tuber, white skin & flesh, pink eyes
Lelah*	7.2	3-4" Round tuber, white skin & flesh
Peanut	6.6	3-4" fingerling, tan skin, light yellow flesh
Peter Wilcox	6.4	3-4" blocky oblong tuber, variable purple skin, pale yellow flesh
Alturas*	6.0	5" Oblong russet, white flesh
Clearwater Russet*	5.8	4-7" Oblong russet, white flesh
4	5.6	4-6" Oblong russet, pale yellow flesh
Krantz	5.2	4-5" Blocky oblong russet, white flesh
Sage Russet*	5.0	5-6" Oblong russet, pale yellow flesh
Bushes Peanut	5.0	5-7" Fingerling, tan skin, light yellow flesh
Lamoka*	4.2	4" Blocky round tuber, pale yellow flesh
Cowhorn	4.0	4-5" length fingerling, dark purple skin, white & purple flesh

* Registered varieties that fall under Plant Variety Protection (PVP) regulations.
**Results from Alaska PMC only; tuber sizes are likely very different under different growing conditions

Potatoes grow very well in Alaska. They thrive in our short, cool summers and the tubers store extremely well through our long winter season. Potatoes have been used as a source of winter vegetables in South-East Alaska for over 200 years according to an article by Charles Bingham (2018) on the Sitka Local Foods Network. Even so, the Alaska potato growers face intense competition from high volume growers in other states that supply table stock and seed to local stores and nurseries. One of the comments we often hear from the growers is that they could easily produce more potatoes, but the market only supports a limited volume. It is encouraging to hear about a new venue for Alaska grown potatoes as a processing product. These conditions that make the potato a trusted dietary staple, however, offer some challenges to producing a high-quality processing potato.

One of the most common assessments for processing suitability is specific gravity, or a measure of the density of a tuber. Starch is the most abundant compound composing tuber solids and is therefore the most influential factor affecting tuber specific gravity (Potato Production Systems, 2003). A high starch content is preferred by processors because it gives a dry, flaky texture and decreases processing costs by reducing the amount of raw material needed, reducing the cooking time and reducing the amount of oil absorbed compared to tubers with higher water content i.e. low specific gravity (Potato Production Systems, 2003). The amount of starch in a tuber is primarily variety specific, but it is influenced by environmental and management factors and therefore has a seasonal and regional variability. Some of the environmental factors in Alaska that affect specific gravity are the chemical maturity of the tubers and the amount of moisture in the soil at harvest. Alaska has a short growing season and many processing potatoes tend to be late maturing varieties. Very late maturing varieties, like Russet Burbank, reach chemical maturity between 146-149 days in Parma, Idaho (Waxman, et al., 2018). The onset of frost and decreasing air temperatures require that we harvest before the tubers can meet that time standard. At chemical maturity, the sucrose level in the tubers reaches its minimum concentration and the starch content reaches its maximum concentration (Sowokinos, et al., 1988). Therefore, harvesting before potato tubers reach their chemical maturity results in low specific gravity and increased levels of sucrose which leads to higher levels of reducing sugars during storage. Chemical maturity also affects the metabolic activity of potatoes. If the potatoes are still growing, they are in a high metabolic state and will continue to absorb excess water from the soil if high moisture levels are present. A high-water content in the tubers will decrease the specific gravity measurement. Alaska is typically very cool and rainy in the fall and high moisture levels are consistently present in the soil.

In addition to specific gravity, another metric used to evaluate the processing potential of a potato variety is the amount of sugar present in the tubers at the time of use. Some varieties are best suited to processing fresh from the field and some can tolerate extended periods of storage. These considerations are a function of how the tuber processes sugar, specifically sucrose ($C_{12}H_{22}O_{11}$). Sucrose is produced by photosynthesis and is translocated to the tuber where it is formulated into starch and excess sucrose is stored. After harvest, the enzyme invertase becomes active in the tuber hydrolyzing stored sucrose into the 6-carbon sugars fructose and glucose (Sowokinos et al., 1988). The effect of this reaction, referred to as cold induced sweetening or CIS, is variety specific and CIS resistance has been a focus in the development of new processing varieties (Gupta, 2017). Fructose and glucose are the reducing sugars that participate in the Maillard reaction causing dark color in fried products. Sucrose does not cause the same problematic darkening when present in the tubers. Therefore, a variety with a high sucrose content can be successfully processed fresh from the field but may turn unacceptably dark when fried just a few days after storage. If a cultivar is susceptible to CIS, cold storage temperatures will exacerbate the production of reducing sugars (Rosen et al., 2018). Often product designated for commercial processing will be stored at 45-50°F to minimize the sweetening effect. It would have been very interesting to do a fry and evaluation straight out of the field and then store the varieties that were processed for this trial at various temperatures, however, the PMC only has a single field storage unit and it is purposed for storing and keeping healthy seed from harvest to spring planting, so this trial was a "worst case scenario" for processing storage conditions.

Some take away points to consider when selecting varieties to grow and process in Alaska:

- The chemical maturity of the tubers is an important factor. Late maturing varieties will not have time to reach their highest specific gravity and lowest sugar levels which may present a problem for processing, especially after being stored.
- Reconditioning does not always improve the quality of the processed product. Know the variety with which you are working.
- The PMC would recommend Tundra, Atlantic or Allagash to Alaska growers for consideration as potential French fry varieties.

Goals & Outcomes Achieved

This project received a one-year extension from the original proposed end date. Therefore, no presentations were made in 2017 on this topic. Many of the conferences in 2018 occurred before the project report was complete. Staff at the PMC compiled a Power-Point presentation with the intention of presenting the results of this project as upcoming conferences are held around the state.

Long term goals include receiving feedback from growers and processors as recommended varieties are used and assessed. Recommendations and data will be updated as new information is available.

Listed Goal	Date Achieved	Achievement	People Reached
Field Day at the PMC	9/20/18 9/19/18	School Field Trip TV Channel 11 Interview	50 5000
Produce Growers Conference	Not Met	Due to budget restraints, this conference is no longer held	0
SARE Conference	Pending, Date TBD	Project Presentation	30
Annual AK Seed Growers Meeting	Pending Jan/Feb 2019	Project Presentation	30
AK Division of AG Newsletter	Pending	Project Article	600
PMC Website	12/19/18	Technical Paper Published	30

The major successful outcomes of the PMC Post Harvest Trial have been the accumulation of a great deal of baseline data for 208 of our potato varieties and the ability to recommend the top performing varieties for processing as a result of this study. An understanding of the specific gravity measurements for each variety is particularly useful because that is a great way to determine the best use of a variety. Industry standards, for example, recommend that chips are made from varieties with a specific gravity greater than 1.085, fries and baking potatoes from varieties with a specific gravity greater than 1.080, 1.060-1.075 is best for boiling and a specific gravity measurement of 1.060 or less lends itself to potato salad or a use where it is important for the potato to hold its shape after boiling. This data has already been used to make recommendations to home gardeners interested in a variety of uses, one commercial grower who was interested in processing varieties and two restaurant owners interested in a variety of uses, including the processing of chips and fries.

Beneficiaries

The completion of this study will benefit potato seed growers, ware producers, restauranteurs and processors in the state of Alaska. The use of Alaska Grown specialty crops in local restaurants is an underutilized niche in farm production strategies. It is anticipated that the introduction of this concept, with data to support variety selection could stimulate potato production demands and increase revenue for potato seed producers and potato growers. Additionally, locally owned businesses could benefit from the successful marketing of using Alaska Grown produce in their products. This project has the potential to impact roughly 100 different producers and processors with new knowledge about the postharvest quality of Alaskan grown potatoes.

Lessons Learned

A primary lesson learned was that it takes much longer to collect baseline data than we had expected. For example, we knew that we wanted to bring some new processing varieties into the state for evaluation and comparison. However, by the time that the varieties were ordered, received, were planted and harvested sometimes 1.5 years had elapsed. We needed to extend the timeline of the project to account for this delay. However, now that this baseline data has been collected, it has uses beyond the scope of this project. The PMC staff will make this information available to other Alaska potato researchers facilitating their research and improving future project efficiency.

An unexpected outcome of this project was the success of some of the heirloom potato varieties. There has been so much research and development of new varieties specifically bred for processing that it was a surprise to see Allagash Russet, Atlantic, Peanut and Cowhorn really perform well as processing potatoes. The PMC is pleased to recommend these varieties for processing consideration for those growers who prefer not to work with protected varieties. Another unexpected benefit of this project was coming to understand the chemical maturity of field tubers. Alaska grown potatoes are physiologically different from those grown in other climates, we were aware of this. Discovering the literature on chemical maturity monitoring and applying the information to the differences we see in tuber development has helped explain the reason for the differences and can be applied to all recommendations on variety selection that we make in the future.

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