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Project #1: Specialty Crops in Hospital and University Meals

Project Summary

To increase specialty crop availability and consumption in health care and university settings, the Department of Natural Resources: Division of Agriculture began an investigative pilot mini-grant project. Due to rising interest from food service staff at hospitals and universities in Alaska, this project seeks to connect food service operations to Alaska Grown Specialty Crop producers. These institution settings typically have a numerically consistent consumer base, which will be helpful for specialty crop farmers, as they can plan according to the institution's purchasing needs. In addition to the economic benefits, the project will promote educational opportunities. Many food service operators are unaware of the bounty of Alaska specialty crops available to source. The educational component will further be expressed at the consumer level, who will benefit from locally sourced specialty crops in their food at these settings. Having specialty crops at the institution level will help build understanding of the bounty and potential of these crops.

Since July of 2014, seven different hospitals and university institutions reached out to the Division of Agriculture seeking information on how to source more local foods in their operation. Hearing this interest, follow-up phone calls were conducted to gauge needs and barriers to sourcing specialty crops. Two of the most frequent responses were the need for a coordinator and for sampling customer response to determine the priority of specialty crops to source. If there is evidence of positive interest and economic results from this project, the Division of Agriculture would hope to expand project reach into more institutional settings in the future. This project also serves as a test for the active interest in hospital and university settings to determine practicability of expansion of this program. A growing institution market will allow specialty crop farmers an avenue to increase production, the program will assess the possibilities and barriers of these market settings. If we see positive interest and economic results from this pilot, we hope to expand the project to reach more institutional settings in the future.

Project Approach

To accomplish increased Alaska Grown specialty crops in health care and university settings, project staff administered sub-grants to approved sites. From previous experience with certain institutional setting grant programs, the Division of Agriculture found it important to streamline the grant and reporting process to broaden reach of the program. The first year of the project in 2016 had unfortunately low return on mini-grant applications, with only one initiative being funded. Thus, in 2017, the project extended the scope of institutions, including education and health care related institutions. As a result, the second year had four new applicants and one returning applicant, making a total of five institutions being funded by the program. Funds could be utilized for the following categories: project supplies, marketing supplies, site coordinator fees, recipe development, and taste tests. For future Farm to Institution programs, there will need to be an increased amount of outreach to applicable universities and hospitals, as well as creating best practices to share along with program information. While interest may be apparent, it is recommended that there be better initial research in navigating the hurdles of supplying Alaskan specialty crops in such locations to propagate better response to the program.

To ensure the overall project scope benefitted only specialty crops and no other commodities, the sub-grantees' initiatives had to be strictly related to specialty crops. Based on applications, final reports from recipients and the agency's follow ups with sub-grant recipients, the funding for this program solely enhanced the competitiveness of specialty crops.

Project partners included Alaska Department of Natural Resources, Division of Agriculture, and Farm to Institution Program. The program was coordinated from the Division of Agriculture, which is a part of the Department of Natural Resources. Contributions included outreach to eligible sites for the program, managing the application process and finances, and program coordination. To determine eligible sites and create the outreach plan, the Division of Agriculture used the Farm to Institution Program as a resource.

Goals & Outcomes Achieved

While the original goal of building relationships between specialty crop farmers and hospitals and university foodservice operations was not feasible for this current program cycle to the level initially desired, the program goals to promote specialty crops at institutions remained but was expanded to include having them grow specialty crops for their operations. To achieve the promotion and use of specialty crops, sub-grant applicants had to develop a project that would work towards the goals. A Farm to Health Care or University Program coordinator discussed the project activities with applicants to ensure it would meet the specialty crop requirements and fit criteria. To educate food service operators about the availability of specialty crops, it was stated in the application and contract process that a food service staff had to be involved at some level in the project activities. The goal of increasing specialty crop availability and consumption in university and hospital settings was measured by how each site used their funds to initiate this and their results. Recipients were required to complete a final report and were contacted by a program coordinator to gather information and data on the projects supported through the Farm to Health Care and University Program. To ensure consistency between reports, a template via online survey was distributed to sites.

Progress toward long term outcome measures was accomplished primarily through customers and other people from the community that will benefit both from the economic stimulus of the activities and from the multiplier effect of information sharing in the general population. Approximately eight-hundred and fifty-three people were impacted, directly and indirectly by the projects during the funding period, and impact will grow out from this base.

Progress towards increasing food service knowledge of specialty crops and their availability was accomplished through sites utilizing local agriculture resources to support their specialty crop focused initiatives. As several of the locations used these resources to grow produce at their site or increase procurement for their site, food service staff became more aware of the seasonal growth of specialty crops in Alaska, as they witnessed the growing season first-hand. Several beneficiaries expressed that many of the specialty crops that were part of their initiatives were ingredients not typically utilized in food service and carried a slight learning curve for preparation. Overall, the food service operations and people involved gained access to specialty crops that they typically would not have access to, allowing for increased knowledge on availability, growing effort, and culinary uses.

Progress in increasing the number of menu items and quantity of Alaska Grown Specialty Crops purchased was accomplished through the locations' increased sources of specialty crops, including both grown and procured. For the beneficiaries who utilized certain produce for the first time, it allowed for creation of new items in their food service. With the creations and successes using these products, the beneficiaries will increase their demand for specialty crop seedlings and Alaska specialty crops in the future growing seasons.

In regards to the goal of at least three University or Hospital Food Service Program sites will gain access to fresh local specialty crops, there were five education and health services institutions with sustainable specialty crop projects with the purpose of providing these crops to their consumers. To accomplish the goal of getting garden coordinators into the institutions, stipends were an allowable use of funds for recipients. Of the five recipients, three of the institutions had a paid coordinator or assistant role as part of their project. From interviews with recipients at the completion of the funding term, one-hundred percent of places plan to continue their initiatives in the future. The impact of the program was eight-hundred and fifty-three people and nine communities, including three initiatives in the Anchorage community. Approximately 1,150 pounds of produce was produced specifically for project initiatives and was available for consumers.

Beneficiaries

The major beneficiaries were the institutions awarded the sub-grants and the communities they have influence over. While four of the five funded projects did not focus on the foodservice operations at a hospital or university institution, all five projects funded an institution related to health care or education. In total, there were fourteen beneficiaries impacted, as described below:

- Alaska Pacific University was awarded a sub-grant in 2016 and 2017. Spring Creek Farm is an educational farm in Palmer and satellite site of the university. The funds went to Spring Creek Farm to support their operation and the university campus in Anchorage by increasing availability of specialty crops on the campus. As the university food service operation already purchases produce from Spring Creek, a goal of their initiative was to get specialty crops available to students. A refrigerated display case at the university was purchased for university students to purchase produce on campus. They conducted surveys among students through sticker voting at the cooler. Providing an avenue for increased economic revenue for Spring Creek Farm supports the specialty crop production operation, as well as increased awareness at the student level of the bounty and variety that producers can grow in Alaska. Examples of their promotional activities, which include partial views of their surveys and cooler, are pictured below.

- Maniilaq Association provides health and social services to about 8,000 residents living within the Northwest Arctic Borough and the village of Point Hope. Because of their relation to healthcare, they were eligible to apply and were awarded a sub-grant for their specialty crop initiative. For their project, there was a garden coordinator that traveled to seven different villages, taught local gardening and began specialty crop garden projects in each community as health improvement outreach. As each of the communities began gardening operations as result of the project, the seven communities are counted as beneficiaries.
- Anchorage School District is the largest school district in Alaska with a student population over 47,000. Because there was a low turnout of university applicants and they are an educational institution, they were determined to be eligible for a sub-grant and were awarded for their initiative to establish apple orchards across the school district by teaming up with a local orchard specialist. Once producing, the harvested apples will go into the classrooms and, once up to scale, in the foodservice operation for the school district.
- Providence Center for Child Development is a childcare site for health care workers at Providence Alaska Medical Center, community affiliates, and their families in Anchorage. Their relation to the hospital setting made them eligible to apply, and they were awarded a sub-grant for a garden project to grow specialty crops that would be utilized in the foodservice on site. The children benefit from the educational component of growing specialty crops and the nutritional benefit of the harvested produce.
- Rainforest Recovery Center at Bartlett Regional Hospital serves Southeast Alaska through residential and outpatient services for substance use and co-occurring metal disorders. Their specialty crop initiative was to build a garden for specialty crops and to use the garden in conjuncture with the recovery program, as well as utilize the crops in their foodservice. They purchased specialty crop seedlings from Glacier Gardens, a local nursery in Juneau, adding another beneficiary to the program and a relationship built to a specialty crop grower. Their garden is featured in a video about the

program and can be watched with the following link: https://www.youtube.com/watch?v=YEEO6UKauA0.

Lessons Learned

The Farm to Health Care or University Program was an investigative pilot project, thus making the information gained from the completion of the project highly valuable. Overall, responses from those who received sub-grants were positive, and useful information was gathered on the successes and barriers of this type of program. Recipients expressed that funds were needed support to start initiatives that they can keep building upon and expressed achievement in results within the funding period.

After having several universities and hospitals reach out about sourcing specialty crops, it was surprising to have a low turnout from these institutions. It was determined that outreach focused to food service operators needs to be the priority. As well, it will be helpful to develop best practices for sourcing specialty crops from Alaskan producers for these large-scale food operations. As the original goals were altered to make the program more successful and increase reach, certain measurable outcomes were not able to be achieved. Measurements of food service knowledge of specialty crops through pre- and post- tests was not accomplished. As well, data on the number of menu items and quantity of Alaska Grown Specialty Crops purchased for food service was not collected through pre- and post- surveys, since it did not fit the reformed project purpose. For the future, the Division of Agriculture recommends having the foodservice operators more involved in the process compared to the project managers or grant managers at these institutions. Providing trainings or resources for pre- and post- tests to institutions would be useful for future efforts to gain evaluation data. Lastly, the beneficiaries of the project did not include a minimum of 5-10 farmers who will build new relationships with a hospital or university foodservice operation. Since four of the five projects focused on specialty crop growing at the institution and the fifth project built upon an already established farmer connection, this outcome was unable to be met. For future projects, outreach to both institutions and farmers could foster better response in the relationship building outcomes.

Although it did not fit the initial plans, there was a positive response from allowing institutions to use funds to grow specialty crops. The added educational aspect of growing food was valuable to the consumers at these institutions. While the program focused more on economic benefits of specialty crop sourcing, recipients were passionate about the health aspect of local specialty crops through their projects. This will reap economic benefits long-term, as it still is promoting the consumption of local specialty crops to consumers. Knowing the positive response of marketing Alaska specialty crops as a health strategy, outreaching to university and hospital settings as such could harness increased interest.

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Project #2: Chef at the Market

Project Summary

The Alaska specialty crop industry is growing; in 2007 the USDA National Agricultural Statistics Service recorded 686 farms in the State and in 2012 the number was up to 762 – an 11% increase. Alaska has experienced a dramatic increase in the number of farmer's markets; in 2005 there were 13 markets; in 2015 there were 44 markets. These trends represent that not only are the number of farms growing in our State, but there is also a growing interest in local food production. This increase has resulted in many more Alaskans being exposed to Alaska Grown specialty crops. In an effort to enhance the competitiveness of Alaska Grown specialty crops, Chefs gave demonstrations at Alaska farmers markets showing how to utilize Alaska Grown specialty crops available at the market that day.

This project was launched with State funding in June of 2011 and enhanced with 2011 SCBG-FB funding. It has not been submitted to nor funded by any other State or Federal grant program. It was the goal of the project administrator to identify other funding sources and ways for the project to become self- sustaining beginning in 2016. However, due to current budget constraints with the State of Alaska and lack of additional funding opportunities, Chef at the Market will not continue in 2016.

Project Approach

In March of 2015 Division staff announced the availability of funds. Six applications were received, requesting $16,750 dollars for 42 different events. $20,000 was available for Chef at the Market (CATM) 2015. A review committee evaluated, scored and ranked the proposals. Six projects were selected for funding and contracts were signed. Staff communicated with Chefs on a regular basis to ensure that specialty crops were the focus of demonstrations. Market demonstrations took place June-December 2015.

Goals & Outcomes Achieved

The 2015 CATM project was highly successful. Forty-Four CATM events took place in 2015 with 4,468 consumers engaging with the demonstrations. The specialty crops highlighted included: Broccoli, cabbage, carrot, cauliflower, celery, cucumber, garlic, herbs, kale, lettuce, onions, peas, pepper, potato, rutabaga, tomato, turnips, and zucchini.

Each market manager was provided an example sheet of how to gather sales data for market sales on CATM demo day's vs regular market days. They were allowed to use their own form, reporting tool, etc. due to the wide variation in management styles – i.e. some markets require daily sales reporting while the majority of markets do not gather any sales information at all. The results of the market sales data were mixed.

Six of the seven participating farmer's markets noticed an increase in attendance on CATM demo day's vs other market days. All markets reported either the same amount of sales or increased sales on CATM demo days. This was based on anonymous vendor surveys. We were not able to capture actual sales data because the vendors would not share that information with the Farmers Market Managers. Managers gave various reasons for why sales remained the same. Some of the reasons include: bad weather deterred customers from visiting the market, CATM demos held on a weekday had less customers than CATM demos on a weekend because more people visit the market on the weekend, lack of crop available to purchase because of poor/small harvest.

Percent increase in sales on CATM days for specialty crop vendors:
Our goal was to see a 15% increase in sales for specialty crop vendors on CATM days. Unfortunately, we were not able to collect actual sales data from the markets primarily because the majority of the Farmers Market Managers do no collect sales data from their vendors. In 2014, getting the sales information was unsuccessful, even trying to get the vendors to tell us anything about their sales was difficult. In 2015, on the Market Manager Evaluation form, we asked them if they saw no change in sales, some increase in sales or a large increase in sales. Market Managers also passed around forms to vendors, where vendors told us if they saw a change in sales on CATM days vs non-CATM days.

As a result, the only data we were able to collect was through the survey results, summarized below, instead of actual sales and percent increase in sales.

- Market sales information for all markets that submitted data showed mix results. On average, sales remained the same or increased on CATM demo days vs non-CATM demo days. Survey responses pointed out that there were other factors to consider when looking at increase in sales. For example, there is more customer traffic on Saturdays versus Wednesdays; therefore, there will always be more sales on Saturdays compared to Wednesday regardless if there is a CATM demo or not. Weather is another factor, some market managers commented that the days on which the CATM demo took place and the weather could have affected sales numbers. If it rained on a CATM demo day, then there were fewer customers at the market then on sunny market days.

Beneficiaries

The beneficiaries of this project include specialty crop producers, Chefs and the general public. Specialty crop producers saw increased sales at the market on the days of the demonstrations. Chefs developed their customer base, gained valuable support and furthered their relationships with Alaska Grown specialty crop producers. Members of the public benefited from increased awareness and knowledge about specialty crops.

Direct beneficiaries of the project include the approximately 370 specialty crop producers at the five different farmer’s markets on CATM demo days. The 4,468 people who learned new techniques for preparation of specialty crops are also beneficiaries.

Lessons Learned

This year, chefs were provided additional funds to create marketing materials, such as signs and banners, for their demonstrations. All chefs that took advantage of these funds reported customers coming to their demonstrations because they saw the signs and banners.

Many chefs reported that their main challenge was unpredictable weather. The weather made demonstrations difficult some days due to high wind and rain.

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Additional Information

Recipes were gathered from participating Chefs and will be featured on a website at http://eatlocalalaskagrown.org/chef-at-the-market-recipes/ this website is promoted through the Division of Agriculture's Alaska Grown Facebook page which has over 40,000 likes and a weekly reach of over 100,000 people

Project #3: Determining Feasibility for Cultivating Species of Edible Fungi (Mushrooms) for Food and Packaging in Interior and South Central Alaska

Project Summary

Edible mushrooms have excellent potential both as a nutritious food source and as a source of biomaterials for Alaska. No such research existed at the start of this project. Our project addressed this gap in knowledge by exploring the feasibility of developing small and medium-scale mushroom farming operations in Alaska to address food security and to provide knowledge base for future mushroom farming and production of biomaterials.

The need for diversified local food production in Alaska is clear. Many Alaskan communities face difficulties in accessing healthy and nutritious produce, including mushrooms, and have high rates of vitamin D deficiency. Mushrooms are high in vitamin D, contain and variety of other vitamins and nutrients, and their regular consumption could yield health benefits. We proposed to study the feasibility of the year-round commercial cultivation of several species of mushrooms in Alaska for future mushroom farming and production of biomaterials. Our objectives were three-fold: Perform variety trials for edible species suitable for Alaska and of the highest commercial interest; Perform trials to select promising and fast growing species of white-rot fungi for packaging material; and, develop a suitable locally-sourced substrate to grow mushrooms for food and biomaterial for insulation and packaging.

Through the species trials, data collection, and several mushroom farm site visits we determined which species and strains, substrates, and environmental conditions could result in productive, sustainable mushroom cultivation in Alaska. For each trial, we measured and documented substrate composition and yield. These experiences and detailed results are available to be shared with the local growers for the benefit of the local communities and to support the Alaska Grown agriculture.

Project Approach

Our project partners

During the 2 years of the project we forged several collaborations with the Alaskan farmers (Northern Lights Mushrooms, Kenai) with two professional mycologists (Dr. Gary Laursen, UAF and Dr. Dan Royce, Penn State). Our partners provided critical contributions to the overall success of this project. In order to acquire practical knowledge and experience we visited and observed the full scale of operations at 2 successful and nationally-known mushroom farms, Hamakua Mushroom Farm, HI and Kenneth Square Mushroom Specialties, PA. We express our profound gratitude for the generosity of our partners for their generosity, time and willingness to freely share their many years of mycology and farming knowledge and for welcoming us at their farms to observe their sophisticated operations.

Process

We were specifically interested in the cold-resilient strains suitable for Alaskan conditions. We experimented with two edible mushroom species and one white-rot polypore. In order to conduct trials, we first needed to create a small-scale version of the mushroom farm, complete with a lab, spawn production, substrate preparation, and growing room/shed. At the same time. we identified and cultured two promising cold-weather strains of Pleurotus ostreatus and one strain of Hypsizygus tessulatus, isolated from the wild specimens harvested in the Interior (near Ester, AK).

We grew out both species from the master cultures. The process included field identification of several candidates and verification by Dr. Gary Laursen, followed by culture work to isolate biologically viable tissue from the fruiting bodies of the wild fungus laminar flow hood. This step was followed by propagation of the mycelia on nutritive agar medium and “cleaning” of each stain to achieve a pure culture for at least 10 plates for each strain. This step took approximately 2 weeks. Successful “master cultures” were then created and “expanded” into the sterilized millet grain to produce “spawn”. The spawn was also incubated to permit the full colonization of the grain by vegetative mycelia. Figures 1—2: P. ostreatus harvest. Finally, we created production bags and columns from several blends of feedstock (blends’ composition is fully documented our lab log). We used only blend ingredients available at low cost in Alaska and collected data on yields, appearance, and shelf life for each blend and species. We determined that two of the strains of P. ostreatus produced the most prolific yields in the range of 55—70 degrees F. In our trials, we achieved sustained yields of 5 lbs. Yields ranged from 2—3 lbs. for the 1st. flush, and 1—2 lbs. in the 2nd. flush.

Because we specifically were interested in the cold-resilient strains suitable for Alaskan conditions we identified one promising edible species, Hypsizygus tessellatus. We isolated its mycelium from the wild specimens harvested in the Interior (near Ester, AK). After we successfully cultured it in our lab we experimented with its production.

H. tessellatus is a cosmopolitan edible mushroom traditionally cultivated in East Asia, where it is commonly marketed under the name of Buna Shimeji. To the best of our knowledge, H. tessellatus has never been grown commercially in Alaska but it very popular and tasty specialty mushroom worldwide, widely cultivated in more temperate climates in Europe, North America and Australia and sold fresh in food markets. In nature, H. tessellatus are gilled mushrooms that grow on deciduous woods. In more temperate climates it is found on beech trees, hence the common name, Beech Mushroom (Brown Beech Mushroom - Hypsizygus Tessellatus, n.d. Wikipedia, Web. Accessed on 06 Dec. 2014).

In Alaska H. tessellatus has been initially identified by Dr. Gary Laursen, UAF in the Interior, where it grows breach and alders. We created a clean culture, expand it into spawn and grew it out on 2 blends of substrates. Blend 1 has rye straw and no sawdust added. Blend 2, has rye straw and sawdust added (please refer to full list of ingredients and amounts for each blend). We discovered that while the mycelium of the wild Alaska strain of H. tessellatus grows well on birch in the Alaskan forests, it does not fruit on Blend 1 with rye straw. We were successful in producing very attractive and commercially viable fruiting bodies tessellatus on columns and bags using Blend 2 substrate, which has the sawdust upward of 20% by the dry weight. We discovered that the minimum period for completing the mycelium run to achieve full colonization after the spawning of Blend 2 substrate with H. tessellatus spawn is about 6 weeks, which is too long for most growers.

Additional challenge we identified with producing H. tessellatus and other slower-growing species of fungi including shiitake, is the current lack of sterilization equipment for mushroom substrates in Alaska. We used “hot water bath” pasteurization method to prepare our substrate. The challenge of using pasteurization versus the more common sterilization method to produce substrate is that the pasteurization method requires a very quick colonization of the substrate the desired fungus, least the contaminants set in. In our experience, the substrate needs to be fully colonized in 2–3 weeks at most and then the fruiting can be initiated by changing environmental controls. However, the However, Alaskan strain as well H. tessellatus required approximately 6 weeks of “mycelium run” to achieve the full colonization. We noted that after 3 weeks many of the bags and columns with H. tessellatus became contaminated with Trichoderma and needed to be discarded.

Figure 3: Hypsizygus tessellatus growing on birch tree in Ester, AK.

Figure 4: Purified H. tessellatus culture growing on nutritive agar medium.

One possible solution to this challenge is to inoculate logs and to leave them outdoors for fruiting the next summer. We have experimented with this technique with summer and inoculated 10 birch logs with spawn of Hypsizygus tessellatus in August 2016. We will have the results of this experiment next fall.

Figure 5: Students learn how to insulate birch logs with the cold-resistant strain of *H. tessellatus* cultured from the wild specimen

Harvesting

We experimented with 2 different methods of harvesting the mushrooms from the columns or bags — a) cutting, and b) twisting off the fruit bodies. We determined that the best practice to keep the mushrooms appealing and to prevent drying and welting is to harvest them by manually twisting the clusters off the bags instead of cutting. This method preserves part of the mycelial mat with a very small amount of substrate (3-5 grams per cluster) entrapped by the hyphae. This harvest method keeps the picked mushrooms supple and preserves their appearance for up to 2 weeks if stored at 35-40 degrees F. This harvest method is practiced at the Hamakua Farm in Hawai'i.

Production in Bags and Columns

We tested two production methods, in 5-micron filtered 5-lb. bags produced by the Unicorn Corporation, and polypropylene columns approximately 10-inch diameter and 4—5 feet tall. We did not have access to an autoclave and therefore could not sterilize the substrate and pasteurized it instead using hot water bath. The column method produced approximately lb. of the fresh mushrooms per lb. of wet substrate (60-65% moisture content). The bag method appeared to be more prone to contamination and resulted more bags with contaminated substrate than the column method. Approximately 10% of the bags became contaminated in the growing room and needed to be removed to be composted. This resulted in lower overall yields using bags.

Spawn Blends

To prepare 4 large Unicorn bags of grain spawn we used:

- 4.6 kg of dry white millet (moisture content below 10%)
- 200 g Calcium Sulfate (gypsum) for buffering
- 200 g corn starch -- for easier breakup of kernels later.
- 5000 ml of distilled water

Unicorn bags worked well if filled up to approximately 3.5 kg of this blend. Using the amount of grain above we produced 4 bags of millet spawn. All ingredients were mixed well, poured into bags with water added. pH was checked wit with a pH strip. It should be between 5 and 6. If the pH was more acidic, we used additional Calcium Sulfate to buffer it. he bags were left overnight to permit the possible contaminants to sprout from the spores, which would permit more complete sterilization. The bags were taped and folded over.

We autoclaved for 1 hr. on "Liquid" setting at 121°C and then transferred the taped bags to laminar flow hood bench for cooling (4-6 hours). Under LFH, the worker either poured 60ml liquid culture or inserted 10 wedges of "master" mycelium (if using wedges from the Petri or tube culture on agar media) in each bag, sealed the bags with impulse sealer under the hood, wiped with alcohol, checked for air leaks, and shook the bags. Bags them where placed in an incubator on rack at 21 degrees C for 2 weeks.

We checked the spawn bags daily for contamination and examined them for the spread of mycelium and contaminants. Once the growth patches were visible, we shook the bags again (approximately in 7 days). Once the incubation was complete, the spawn was expanded to production bags or columns in the growing room. One bag of spawn can be used inoculate 50 large (5-lbs) bags of substrate blend or approximately 175kg.

Also, see http://plantpath.psu.edu/facilities/mushroom/cultures-spawn/spawn-preparation for additional details.

Spawn and Substrate blends

We have shown that there are several blends for economical and nutritive substrates that can be sourced from the by-products of Alaskan agriculture and forestry for production of edible fungi. Our key criteria for substrate selection were the nutrient content, texture, cost, and availability. We have been successful in establishing through several trials that there is ample supply of the inexpensive feedstock, including the local sawdust, woodchips and rye straw (from Delta Junction and Palmer).

Blend 1 (used for *Pleurotus ostreatus):*

- 10 lbs. wheat bran
- 35 lbs. or 1 bale of dry rye straw (moisture content approximately 13%)
- 4 lbs. of gypsum
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Blend 2 (used for *Hypsizygus tessulatus):*

- 35 lbs. or 1 bale of dry rye straw (moisture content approximately 13%)
- 17.5 lbs. of birch chips (approximately 1/2 inch)
- 17.5 lbs. of birch sawdust
- 4 lbs. of gypsum
- 10 lbs. wheat bran

In the contiguous United States the primary feedstock used for Pleurotus spp. production are chopped wheat straw (Triticum aestivum L) or cottonseed hulls (Gossypium hirsutum L) or mixtures of both (Penn State Mushroom Research Center, 2010). However, these feedstocks are not available in Alaska and their import would be cost-prohibitive for an Alaskan farm. At Penn State's Mushroom Research Center (MRC) and at the Kenneth Square Farm in Pennsylvania a large-capacity, a scale-mounted feed mixer is also used to simultaneously grind and mix the material as water is added to increase the moisture content to 65 — 69%. We did not have such equipment. There are some other characteristics of that should be considered when choosing a substrate. It should pack tightly, but provide small pockets (interstices) of air. Sawdust is too fine and does not provide good interstices and is best mixed with wood chips or/and straw or other field materials. It is very difficult to pack straw and some other field wastes unless it is chopped to 4—6 inch. In order to improve packing a hammer mill or other chopping device is usually used before pasteurization.

We did not have a scale-mounted feed mixer available and mixed our blends by hand. It proved to be time- consuming process. We first wetted the straw using a garden hose with a sprayer head in a large pig feeder to make the straw more flexible and then added all the other ingredients on a large tarp and loaded the blend into the pasteurizer.

Adjustment of the Initial Goals in Year 2: Nutrient content analysis and mycological material as alternative to plastics for packaging and insulation. After consultations with the program administrator at the AK DNR, we decided that two of the initial goals that we established at the onset of the project could not fully achieved with the resources at hand. We planned to perform the full nutritional analysis of each selected edible species grown on 2 different substrates for dietary fiber, protein, vitamins B6, C, and D, Folate, Thiamin, Riboflavin, Niacin, Pantothenic Acid, and minerals. However, we determined that the cost of such analyses, many of which could not be carried out in Alaska, would be far beyond the amount of the entire grant award.

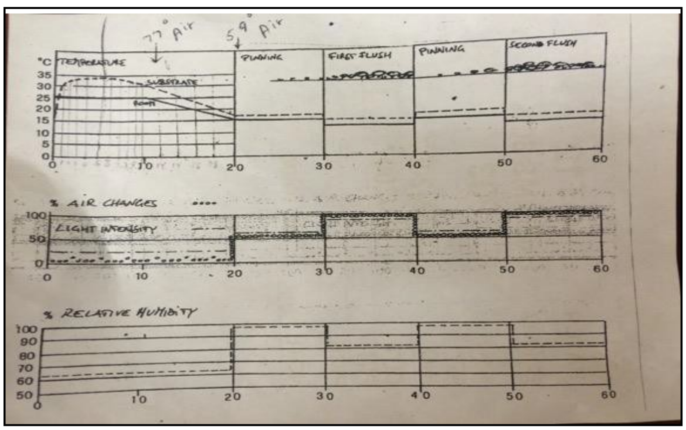
One of our initial goals was to produce evidence of feasibility of using Alaskan white-rot fungi grown through various substrates for packaging material. However, after we began the project it became clear that goal is only partially achievable due to the proposed timeline and the resources available for this project. Our preliminary tests with the biomaterial showed that it could be used as an alternative to plastics for packaging and insulation. A technical paper describing the properties is forthcoming.

Figures 6-7 shows samples of biomaterial samples produced and tested.

We produced samples of biodegradable packaging material made out of white-rot polypores and determined that mycelium (the vegetative part of the fungus), can provide a fast-growing, safe and inert binder and creates a composite biomaterial, which we called biofoam. We speculate that when fully developed, biofoams could serve as viable replacements for the petroleum-based polymers for packaging and for geoengineering applications. Mycology composites offer several advantages over polymeric foams, including freedom from petroleum products, low energy inputs and low cost of production, fast renewability, carbon capture and storage, and bio-degradability at end of use.

Our tests characterized the prototype production process as well as key occupational health, thermal and mechanical properties of such fungal mycelium-based biofoam. Samples were tested for cytotoxicity, density, thermal conductivity, elastic moduli, and compressive strength. Findings indicate that this material is not-cytotoxic, and its compressive strength and thermal conductivity meet or exceed like characteristics of the conventional polymeric thermal foams except dry density. The results suggest that fungi mycelium-based biofoam offers a strong potential for application as an alternative to polymeric foams particularly in cold regions. Potential future uses include packaging, road underlayment and backfill for geoengineering applications, and as insulation in buildings and infrastructure.

Figures 8-10: Modified greenhouse shed for mushroom production, installed in a heated and plumbed space. We did not have the ideal space for production. We chose to use a greenhouse shed about 8 X 6 Ft. and 6 ft. tall. We modified it to suit the mushroom farming needs and installed in a heated and plumbed space. In order to control humidity and air quality within the shed we installed a large-capacity specialized humidifier and HEPA filtered air duct with an intake blower and special rails that permit us to hang bags or/and columns. The humidifier was controlled by humidistat. This air handling system provides 5—6 full air exchanges/hour. We monitored CO2 and kept it under 900 PPM. Temperature was kept in the range of 60-70 degrees F.



Figures 11: Temperature, humidity, and lighting requirements graph

Goals and Outcomes Achieved

Below we describe the activities that were completed in order to achieve the performance goals for YR 1 and 2 by listing the identified in the approved project proposal and in the report for YR1. We also provide a comparison of actual accomplishments with the goals established for the reporting period.

Table of Activities Performed in Year 1 and 2:

Item #	Goals	Original Targets	Revised Targets
1. Edible mushroom species/strains trials for Alaskan conditions	Produce evidence of best edible mushroom species/strains for Alaskan growers by increasing the current reported yield by the end of year one.	Yields will be increased to 100 lbs./week in a 30' wide x 40' long x 10' tall shed.	Goal 1: We increased the yields to produce up to 1 lb. of high-quality mushrooms per 1 lb. of substrate. This achievement is remarkable, especially on the background of the fact that our pre-project survey showed that in Alaska there has not been a successful mushroom operation that produced such high yields. However, due to the high cost of the rental space a labor, we were not able to meet our goal for YR2 to increase the growing space to the total 600 sq. ft. to accommodate spawn room and fruiting room necessary for the proposed production.

2. White-rot fungi selection trial	Produce evidence of feasibility of using native white-rot fungi grown through spent grain and sawdust substrate for packaging material.	Produce data on feasibility of using native white-rot fungi based material for packaging by end of year two.	Goal 2: We produced evidence of feasibility of using Alaskan white-rot fungi as the binder for green, compostable packaging and thermal insulation material. More research is required to commercialize this innovation.
3. Substrate selection	Evidence for economical and biologically efficient substrates sourced from the by-products of Alaskan industries for both edible and white-rot fungi by the end of year one.	Achieve biological efficiency of substrate at or above 150% BE.	Goal 3: We met this goal by achieving biological efficiency of substrate at or above 150% BE.

4. Nutritional value trial and fungi appearance	Evidence of nutrient-rich and marketable mushrooms crop to indicate farming potential that will supplement diets in Alaska.	Perform nutritional analysis of each selected species grown on 2 different substrates for dietary Fiber, Protein, Vitamin B6, Vitamin C, Vitamin D, Folate, Thiamin, Riboflavin, Niacin, Pantothenic Acid, and minerals	Goal 4: The goal of performing nutritional analysis of each species grown has not been met due to the high costs of such an analysis, which greatly exceeded our budget. However, this long-term goal had some progress towards achievement because we identified the certified lab which could perform this analysis once funding is available.

5. Temperature and relative humidity level	Produce evidence of appropriate and economical temperature and humidity range for growing mushrooms in Alaska.	Document effects of lower temperatures at the same relative humidity level.	Goal 5: This goal was achieved by us through the documentation of the effects of lower temperatures at the same relative humidity level on yields. Decrease in temperatures below 50 degrees produced a rapid decline in fruit bodies formation, prolonged time to harvest from 2 weeks to 3 weeks and drop in the yields down to only 44% of the yields from the same substrate at same RH level grown in the temperature range of 60—70F. For ranges of temperature/lighting/humidity levels that produces the largest yields please refer to the graph.

Beneficiaries

The data generated by this project will assist Alaskan farmers in making decisions on the feasibility of developing future local mushroom farming operations. P. Amstislavski used the experience gained in the course of this project to provide hands-on workshops and lectures on mushroom farming in the cold climates. He gave a talk and taught a full-day mushroom cultivation workshop geared toward farmer audiences interested in professional mushroom farming at the Fungus Fair in Girdwood in summer 2016 The talk and the workshop attracted approximately 45 attendees. The workshop was sold out within days of its announcement. According to Ms. Kate Mohatt, US Forest Service Ecologist and long-time organizer of the Fungus Fair, the mushroom cultivation workshop was highly successful and P.

Amstislavski accepted an invitation to teach the mushroom cultivation workshop at the next Fungus Fair in summer of 2017. Such workshops provide an invaluable exchange of information and experience in the nascent mushroom farmers in our state. P. Amstislavski also gave a talk this project at the Alaska Native Plant Society on November, 7 2016 and at the Anchorage Science Pub on November 13, 2016.

The Alaskan farming community at large benefits from the results of this project, primarily because they provide several viable strategies to create small and medium scale mushroom farming operations in Alaska that are environmentally and economically sustainable and meet the urgent need to provide fresh, nutritious and high-value mushrooms to Alaskans year around and to improve our food and economic independence. Furthermore, this project made it possible for us to consider developing the 1st. state-of- the-art mushroom farm in Alaska. We are currently weighting a possible future collaboration with a local farm.

Lessons Learned

The knowledge and experience created in this first experiment of its kind in Alaska provides insight and guidance for future development of mushroom farming in cold climates. Currently, Alaska food businesses pay high costs for importing out-of-state mushrooms, many of them are of poor quality. By the time they arrive to the consumer, these mushrooms are often at the end of their shelf life, with reduced nutritional content and often are slimy and unappetizing in appearance. There is growing market for the Alaska-grown, fresh mushrooms and produce. Our survey showed that there is a strong demand for the fresh locally produced mushrooms by the local chefs and restauranteurs, and food stores.

The only obstacle to meeting this clear demand is that before this project the Alaskan growers had very little experience with mushroom cultivation. This project produced proof-of-concept data and transferred valuable mushroom knowledge and cultivation expertise from framers in Pennsylvania, Hawaii, Israel, and Germany. We showed that a successful mushroom farming enterprise is possible in Alaska. Our project created new knowledge and materials to help close this existing gap between demand for local mushrooms and their supply by testing the feasibility of developing small and medium-scale commercial, environmentally responsible operations that could cultivate high-quality, affordable, fresh, appetizing, nutrient- and vitamin-rich mushrooms year-round.

Some of the unexpected factors that affected this project are difficulty with renting a growing space, difficulty in staying on budget with the high cost of labor and materials in Alaska. Higher level of technical project assistance and an increased level of funding from the State (DNR) and the USDA that takes into account the high costs and unique challenge that Alaska faces in developing specialty corps would be very beneficial in meeting all this project’s goals. Matching funds from the industry and from other sources would also be an excellent way to achieve future success.

Challenges

We encountered the following challenges that need to be addressed for the local specialty mushroom industry to succeed:

Currently, there is no local provider of mushroom cultures, spawn, substrates, and mycological supplies. Farmers are required to ship all mushroom cultures, spawn, and mycological supplies from out of state. Alaska needs to invest in a local mushroom supplies/laboratory businesses.

The cost of the purchase, licensing and installation of autoclave must be included as a startup cost for successful local specialty mushroom farms. Excessive cost of purchasing and licensing an autoclave or retort for sterilization of the substrates currently prevents local growers from producing large amounts of mushrooms needed to meet the Alaskan market's demands. In fact, the unmet need for a retort to sterilize the substrates was a major stumbling block in this project. Due to lack of sterilization, contaminants in our bags and columns required us to discard up to 12% of our containers.

Cost of temperature and humidity-controlled space is high in Alaska and this issue must be addressed at the beginning of the farm planning process.

We did not have a scale-mounted feed mixer available and mixed our blends by hand. It proved to be time-consuming and very labor intensive process.

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Additional Information

1. USDA. Specialty mushrooms: Production, price & value, 1986/87-2009/10. http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1212. Published 2011.

2. Stamets P. Growing Gourmet and Medicinal Mushrooms. Ten Speed Press; 2011.

5. National Agricultural Statistics Service. Mushroom Value of Sales. 2015. http://usda.mannlib.cornell.edu/usda/current/Mush/Mush- 08-20-2015.pdf. Accessed March 16, 2016.

6. Chowdhary A, Kathuria S, Agarwal K, Meis JF. Recognizing filamentous basidiomycetes as agents of human disease: A review. Med Mycol. 2014. doi:10.1093/mmy/myu047.

Web resources:

Penn State Mushroom Lab: http://plantpath.psu.edu/facilities/mushroom/cultures-spawn/spawn-preparation/

Hamakua Mushroom Farm: http://hamakuamushrooms.com/

Kenneth Square Farm: http://www.ksssales.com/ Cultures, equipment vendors:

Fungi Pefecti http://www.fungi.com/ Unicorn Bags: unicorn.com

Project #4: UAF Botrytis: Identification and Management of *Botrytis* Gray Mold Species for Alaska Growers

Project Summary

Botrytis gray mold is the single most important disease of Alaskan 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 postharvest destruction of cut flowers Botrytis gray mold has been tentatively identified in nearly every commercial peony operation in Alaska from the Interior to the Kenai Peninsula. Preliminary DNA sampling of Alaska grower fields in 2013 revealed Botrytis species grouping into 5 distinct genetic clades, not two as had been identified previously on peonies. We found a greater diversity of Botrytis species impacting peonies in Alaska than in Washington, Oregon, and The Netherlands. One of our selections is a new species not found in other regions.

Our sampling of roots for Botrytis was not successful, but our tests indicated that Botrytis was able to infect root tissue and cause chocolate brown lesions on cut root surfaces. Disease development was low during the 2015 growing season as indicated by the low disease values. Disease development within Alaska was variable and ranged from 0.69 (very little to disease) to 78.57 (0-500 rating scale). Disease ratings were higher in Trapper Creek and Delta Junction than in Soldotna and Homer. Although data were not statistically significant after one year, there was a slight trend toward increasing periods of leaf wetness and increasing temperatures during periods of leaf wetness as contributing to higher disease. Because Botrytis levels were very low in 2015, fungicide treatments were inconclusive. They did show that at recommended commercial rates, no fungicide showed phytotoxic effects on peonies (Pageant®, Dithane®, Champ® and Zerotol®). From 0 to 64% of petals that dropped and stuck to leaf surfaces showed evidence of Botrytis infection on the leaves. Petals are a significant food source for Botrytis infection and should be removed from the field before petal fall.

Approach

Twenty-six Alaska peony farms in three major production regions (Interior, Mat-Su Valley, Soldotna area, and the Kenai Peninsula) were surveyed during the 2014 growing season. Samples were collected for molecular analysis of the G3PDH gene to identify the species and races of Botrytis of concern to peony growers. A phylogenetic tree was created to show the relationship among species and to identify new species unique to Alaska. We sampled roots to attempt to recover Botrytis from rootstocks and root material to determine if roots sold to growers are carriers for Botrytis. Clean roots were also inoculated to determine if Botrytis had the ability to colonize root tissues.

Weather stations were set up at four peony farms in Alaska in four different peony production regions: Delta Junction, Trapper Creek, Soldotna, and Homer. Four additional weather stations were deployed in Washington and Oregon. The weather stations gathered season-long data on temperature, rainfall, and leaf wetness to ascertain possible environmental triggers for Botrytis growth. The incidence of disease related to these environmental parameters were analyzed using linear regression. Disease progression was monitored either in-person or remotely using photographs supplied by growers. Final disease data were taken in person at the end of the growing season. We developed a disease rating system to evaluate disease development which resulted in a possible range of 0 to 500, with 0 being no disease and 500 being total dieback due to disease.

The effectiveness of four fungicides (commercially sold as Pageant®, Dithane®, Champ® and Zerotol®) was evaluated for Botrytis control and phytotoxicity. Each was applied six times during the early season through cutting stage.

Flower petals that drop naturally after bloom. We speculated that petals that land on a leaf or stem might be a conduit for Botrytis infection. The UAF staff selected up to 50 leaves at random from 20 peony selections and cultivars or selections, removed the brownish petal from their surface, and recorded the incidence of Botrytis on the leaf surface beneath the petal.

Goals and Outcomes Achieved:

Goal 1: Expanded DNA analysis of peonies on grower cooperator farms to explore the species of Botrytis occurring in Alaska.

26 Alaskan peony farms in 4 major production regions of Alaska (the Interior, the Mat-Su Valley, Soldotna area, and the Kenai Peninsula) were surveyed during the 2014 growing season. A total of 234 isolates of Botrytis were collected from these farms and are archived at the Washington State University (WSU) Puyallup Research and Extension Center (PREC). Due to difficulties in molecular techniques and availability of funding to analyze all 234 samples, 115 isolates were selected for further analysis. Molecular analysis of the G3PDH gene of these Botrytis isolates indicated that Alaskan Botrytis isolates grouped into at least 6 genetic clades (see supplemental PDF attachment "Alaskan peony Botrytis isolates G3PDH" for a phylogenetic tree illustrating the genetic clades), and potentially more than 6 species. The species found include B. cinerea (n=43) and B. paeoniae (n=22), which are commonly described on peony, and B. pseudocinerea (n=1), a cryptic Botrytis species that has only been described on peonies in Chile. The remaining isolates do not appear to be genetically identical to any other named species of Botrytis, however, further genetic analysis is currently underway to confirm exact placement of these isolates.

These results indicate that there is a great diversity of Botrytis species impacting peonies in Alaska, much greater than in Washington, Oregon, or The Netherlands, as indicated by other surveys that we are currently performing. Fig. 1 shows pie graphs of the relative diversity of Botrytis species on peony in each of these major peony production regions. In WA and OR, 81% of isolates were either B. paeoniae or B. cinerea and in The Netherlands 100% of the isolates were these two species. However, in Alaska, only 58% of the total isolates were either B. paeoniae or B. cinerea with 41% of the Alaskan isolates collected categorized as species other than B. cinerea, B. paeoniae, or B. pseudocinerea.

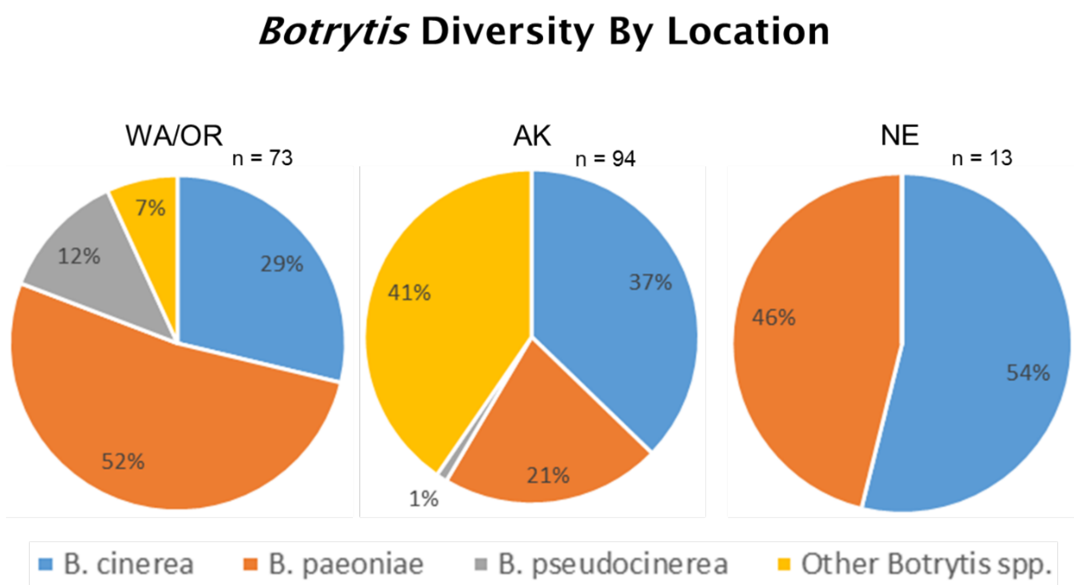

Figure 1. Diversity of *Botrytis* species found on peony in three major commercial peony production regions. WA/OR = Washington and Oregon, AK = Alaska, NE = The Netherlands.

One of the most frequently isolated species of Botrytis from peony in Alaska is currently under further analysis for formal description of a new species. WSU is collaborating with a team in Italy who found one isolate that is genetically identical to some of the isolates found in Alaska. We are currently performing additional genetic analysis, pathogenicity testing, and morphological analyses which we anticipate to be presented later this year.

A number of additional isolates comprising other clades have been subject to further genetic analysis by the RPB2 and HSP60 genes and the results are currently being analyzed. Two additional isolates comprising unique clades have also been confirmed as pathogenic on peony.

Goal 2: Sampling common root stock sources to determine if Botrytis is being imported on or within root tissues.

Surveys were conducted to attempt to recover Botrytis from rootstocks and root material, however, these attempts were unsuccessful. The chance of finding Botrytis in rootstock was likely low (maybe like finding a "needle in a haystack," so-to-speak).

Rootstocks were inoculated in the fall of 2015 to determine if Botrytis had the ability to colonize root tissues. Our tests indicated that Botrytis was able to infect root tissue and cause chocolate brown lesions on cut root surfaces (Fig. 2). The ability of the fungus to colonize root tissues increases our understanding of the biology of this pathogen and the possible epidemiological importance as it relates to movement of rootstock. Plants with inoculated roots are currently growing at the PREC and will be observed over the summer of 2016. In these experiments, only plugs of fungal mycelia were used (rather than conidia as indicated in the proposal) as we determined this the best way to maximize chance of infection and only one method to simulate infection during root processing and harvesting (rather than also infest soil with sclerotia) was used because we believed that this scenario was the most likely in the movement of this pathogen.

Figure 2. Chocolate brown lesion caused by Botrytis paeoniae on the surface of a cut peony root (indicated by red arrow).

An initial set of 8 molecular markers have been developed to test population structure of B. paeoniae in the major rootstock production areas and Alaska. These 8 markers, focusing on repetitive regions of the genome called "microsatellites," were developed from a draft genome of a B. paeoniae isolate collected during this study. 64 isolates of B. paeoniae have been identified out of the total collected in all survey locations (WA, OR, AK, and The Netherlands) and subject to analysis using the 8 molecular markers. Initial results indicated that these 8 microsatellite markers are insufficient to fully characterize the population structure, therefore, we are in the process of developing 8 additional microsatellite markers to use to answer the question of pathogen movement. Furthermore, as more B. paeoniae isolates are identified, additional isolates will be subject to analysis.

Goal 3: Identifying environmental triggers (air temperature, leaf moisture, etc.) that might control regional and seasonal differences in disease manifestation.

Weather stations were set up at 4 peony farms in Alaska during the 2015 growing season. The weather stations were deployed at farms in four different peony production regions in Delta Junction, Trapper Creek, Soldotna, and Homer. Four additional weather stations were deployed in Washington and Oregon. The weather stations gathered season-long data on temperature, rainfall, and leaf wetness. A comparison of these data with the data collected in Washington and Oregon can be seen in Figs. 3-5. Temperatures during the growing season varied 5-7°F among the Alaskan farms during the 2015 growing season, with Fairbanks (gray bar, Fig. 3) having the highest temperatures in June and July. Total precipitation ranged from under 1 inch to almost 4.5 inches per month (Fig. 4). Leaf wetness values were consistently highest in Trapper Creek (green bar, Fig. 5).

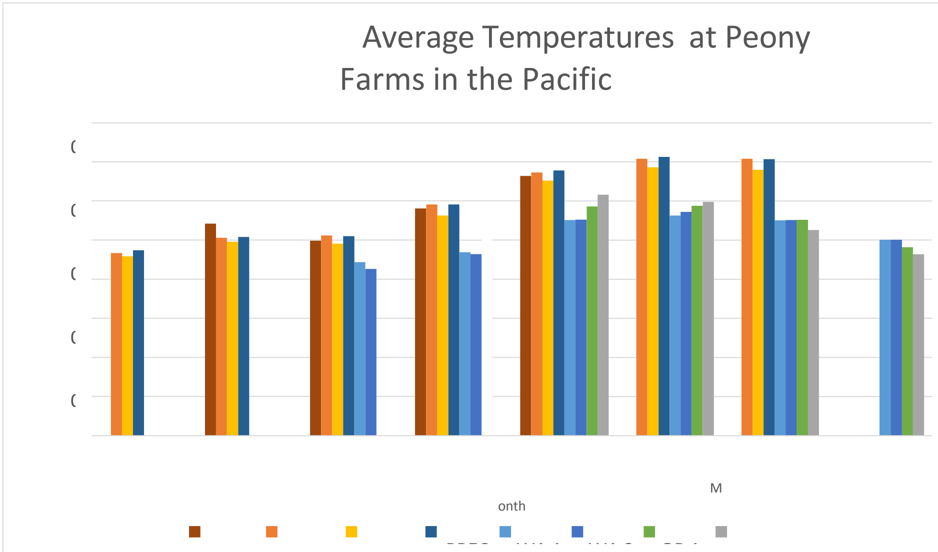

Figure 3. Average temperatures at peony farms in the Pacific Northwest during the 2015 growing season by month. PREC= Puyallup Research and Extension Center in Puyallup, WA, WA 1= Washington Farm 1, WA 2 = Washington Farm 2, OR 1 = Oregon Farm 1, AK 1 = Homer Farm, AK 2 = Soldotna Farm, AK 3 = Trapper Creek Farm, AK 4 = Delta Junction Farm.

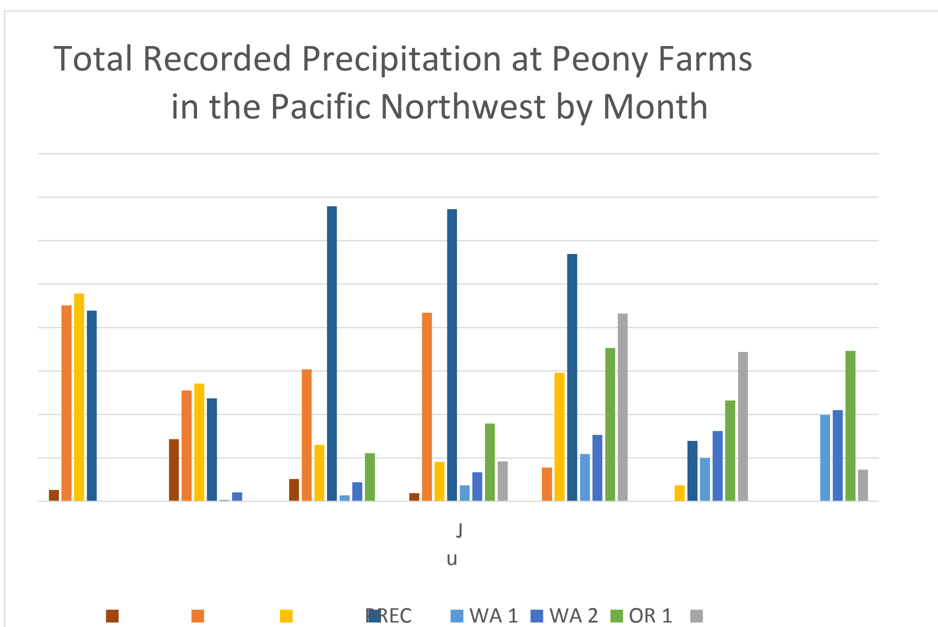

Figure 4. Total rainfall at peony farms in the Pacific Northwest during the 2015 growing season by month. PREC= Puyallup Research and Extension Center in Puyallup, WA, WA 1= Washington Farm 1, WA 2 = Washington Farm 2, OR 1 = Oregon Farm 1, AK 1 = Homer Farm, AK 2 = Soldotna Farm, AK 3 = Trapper Creek Farm, AK 4 = Delta Junction Farm.

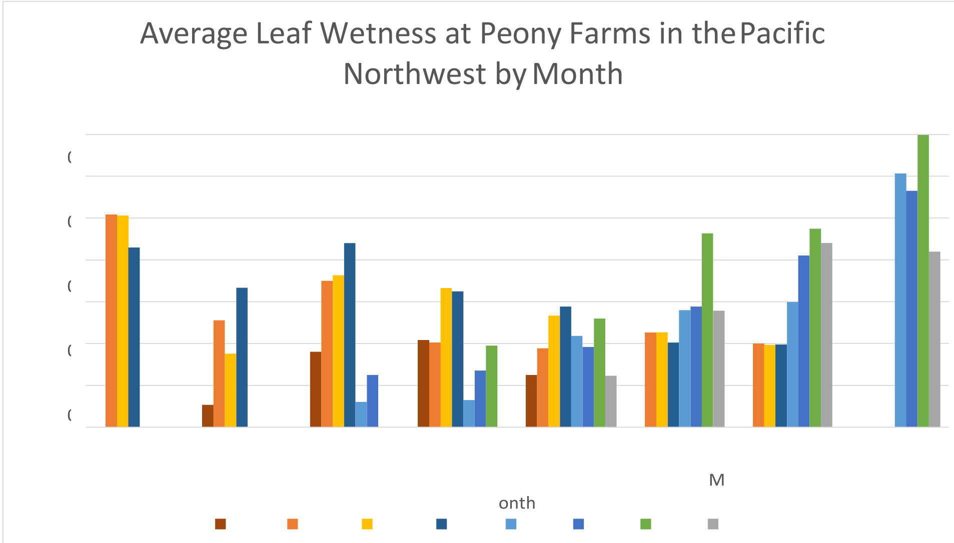

Figure 5. Average leaf wetness at peony farms in the Pacific Northwest during the 2015 growing season by month. PREC= Puyallup Research and Extension Center in Puyallup, WA, WA 1= Washington Farm 1, WA 2 = Washington Farm 2, OR 1 = Oregon Farm 1, AK 1 = Homer Farm, AK 2 = Soldotna Farm, AK 3 = Trapper Creek Farm, AK 4 = Delta Junction Farm.

Disease progression at all of the sites was monitored either in-person or remotely using photographs supplied by growers. Final disease data were taken in person at the end of the growing season. A disease rating scheme was devised to rate disease development which resulted in a possible range of 0 to 500, with 0 being no disease and 500 being total dieback due to disease. Final disease ratings are shown below:

PREC – 12.89
WA 1 – 30.62
WA 2 – 93.40
OR 1 – 33.30
AK 1 – 0.69
AK 2 – 7.00
AK 3 – 28.78
AK 4 – 78.57

PREC= Puyallup Research and Extension Center in Puyallup, WA, WA 1= Washington Farm 1, WA 2 = Washington Farm 2, OR 1 = Oregon Farm 1, AK 1 = Homer Farm, AK 2 = Soldotna Farm, AK 3 = Trapper Creek Farm, AK 4 = Delta Junction Farm.

Disease development was low during the 2015 growing season as indicated by the low disease values. Disease development within Alaska was variable and ranged from 0.69 (very little to disease) to 78.57 (a low to moderate amount of disease). Disease ratings were higher in Trapper Creek and Delta Junction than in Soldotna and Homer.

In order to determine if there was any relationship between disease development and the environment, linear regression analyses were performed (Figs. 6-8). Due to various factors, AK 4 and the PREC were excluded from the analysis. Linear regressions were inconclusive as p-values were not significant, however, this is likely due to the low number of data points in the linear regression and the corresponding lack of statistical power. We are currently deploying weather stations for the 2016 growing season and will add the data collected in 2016 to the data collected in 2015 to see if any trend emerges. Regardless of lack of statistical significance, it appears that a trend towards increasing periods of leaf wetness and increasing temperatures during periods of leaf wetness are contributing to higher disease (Figs. 6-8).

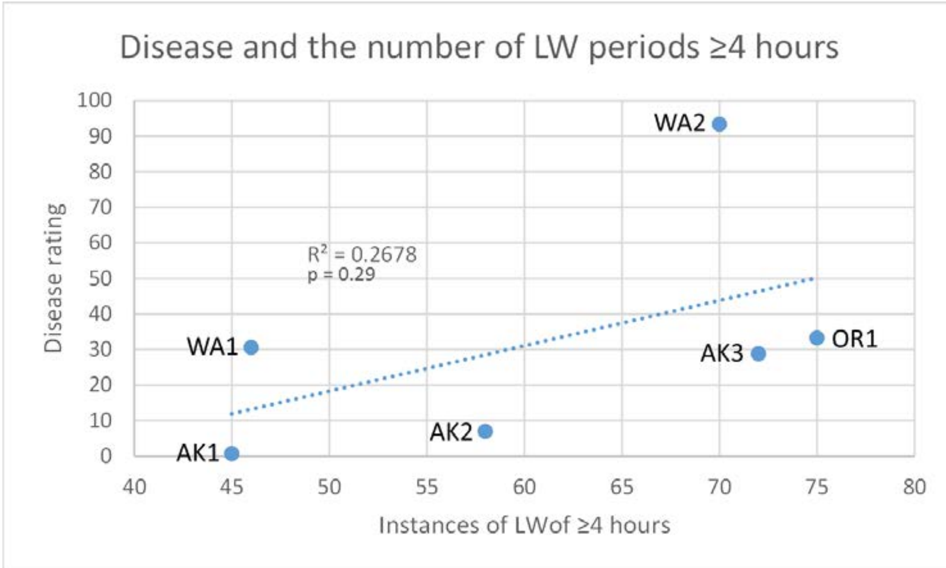

Figure 6. Linear regression describing the relationship between the number of leaf wetness periods that were greater than or equal to 4 hours at peony farms during the 2015 growing season.

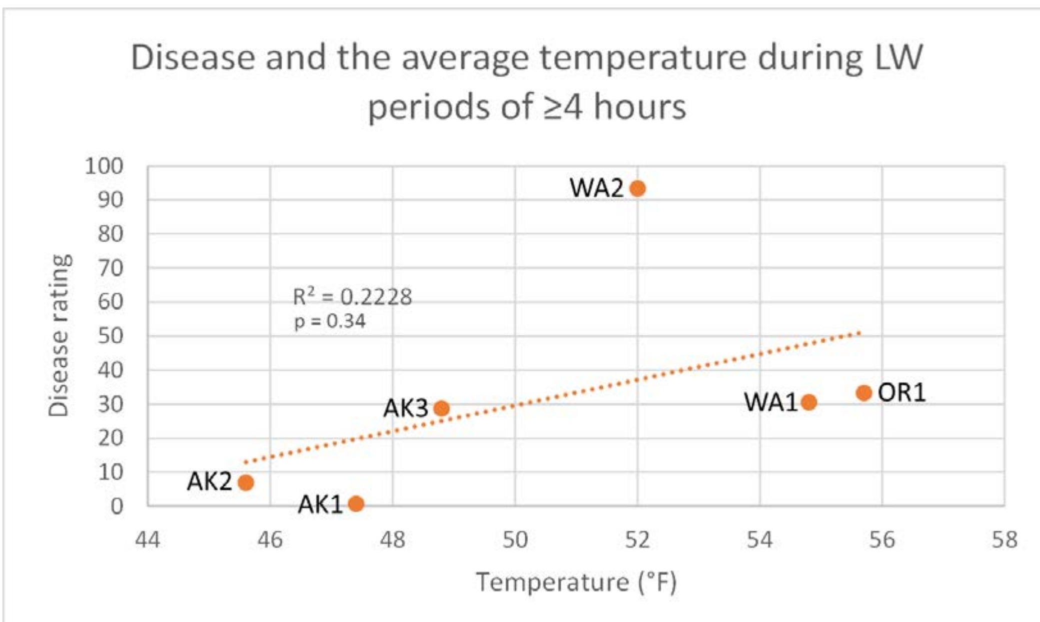

Figure 7. Linear regression describing the relationship between the temperature during periods of leaf wetness that were greater than or equal to 4 hours at peony farms during the 2015 growing season.

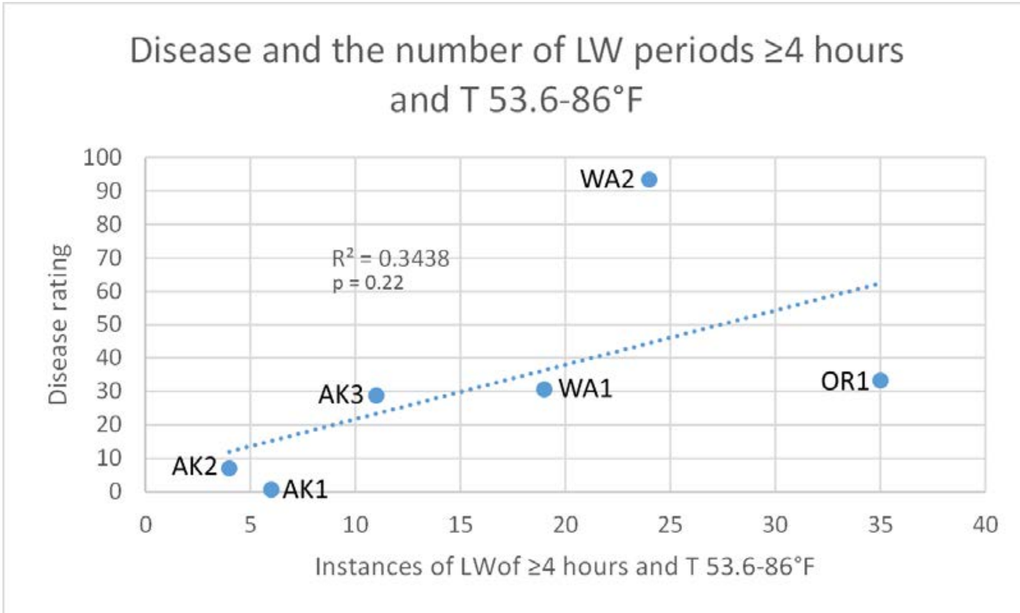

Figure 8. Linear regression describing the relationship between the number of leaf wetness periods that were greater than or equal to 4 hours that occurred when average temperatures were between 53.6 and 86°F (ideal temperature for *B. cinerea* conidia germination) at peony farms during the 2015 growing season. We are currently in the process of determining any influence of seasonal variation on Botrytis infection.

Goal 4: Examining the efficacy of different fungicides including potential bio pesticide controls that might be used by Alaska growers to manage this disease complex in commercial fields.

Based on information from growers, a disease management trial was set up in a peony planting at the UAF peony research plots. The trial compared the effectiveness of four fungicides applied 6 times during the early season through cutting stage in managing Botrytis infections. The fungicides are sold commercially as Pageant®, Dithane®, Champ® and Zerotol®. Pageant® is a well-known fungicide used throughout Alaska with fairly good Botrytis control. By the end of this trial, Botrytis was scattered throughout the entire plot as tiny spots on leaves or at the base of spent flowers. The incidence was so low, however, that no differences were recorded among treatments and the control. At commercial rates, however, no fungicide shows any phytotoxicity. Additional trials that are being supported by the IR-4 program will be conducted during the 2016 growing season at WSU Puyallup.

In a separate trial, we demonstrated that flower petals that fall onto leaves resulted in increased Botrytis infections. These observations can be used in future experiments to enhance disease development in future disease control trials

Cultivar (n= number of petals examined)	*Botrytis* detected beneath petals on leaves (%)
Eskimo Pie (n=2)	0
Double Red (n=47)	8
Corinne Wersan (n=48)	3
Avalanche (n=50)	2
President Taft (n=50)	2
Lowell Thomas (n=50)	4
Love's Touch (n=50)	0
Double White (n=50)	0
Sadie Fisher (n=50)	0
Helen Hayes (n=28)	
Festiva Powder Puff (n=50)	8
Lora Dexheimer (n=50)	0
Petite Renee (n=50)	8
Joker (n=22)	6
Mary Jo Legare (n=12)	7
Leslie Peck (n=31)	
Gay Paree (n=5)	0
Festiva Maxima (n=33)	5
Heidi (n=22)	
Sarah Bernhardt (n=50)	8

Beneficiaries

The project has benefited all peony growers in Alaska by providing baseline knowledge of a disease that will more definitely show up in their fields and storage facilities. It also has provided a foundation for future research with Botrytis. The visits to grower fields is critical to disease management. Even by experienced plant pathologists, diagnosis of diseases is difficult given the interaction with environmental, especially seasonal, factors and the fact that there is no historical research on Botrytis in Alaska aside from notes indicating its presence. The identification if five species of Botrytis, at least one of which may be unique to Alaska, has led to a much more complicated management structure that previously understood. We had also attempted to complete fungicide trials in Alaska but found that Botrytis is quite fickle in its appearance from year to year. Although field trials are necessity, preliminary surveys of fungicide efficacy are better accomplished under controlled, greenhouse conditions.

According to the Alaska Peony Growers Association, there are 69 growers with roots in the ground and an additional 8 growers who will plant in the next 5 years. As members of the APGA, these growers received copies of all interim and annual reports for this project.

Results from this project have been shared with 300 growers via presentations at the APGA annual conferences in 2015 (200 participants) and 2016 (100 participants), 189 growers that participated in the Arctic Alaska Peonies Co-Op (interior) and Mat-Su Farm visits in 2016.

Lessons Learned

The large diversity of Botrytis species on peonies in Alaska was unexpected. As a result of our surveys, we also learned that that there are a number other pathogens causing diseases on peonies.

Additional work on Botrytis and some of these other pathogens will be completed on during a newly funded project. We showed that four fungicides commonly used on peonies showed no phytotoxic effects on peonies, but their efficacy on Botrytis control was not clear because of warm, dry weather and low incidence of Botrytis. Our study hints that leaf wetness measurements and air temperature might lead to a useful predictive model for Botrytis severity in grower fields. Sanitation in fields is critical to managing Botrytis. Petals from old flowers can be a significant food source for the entry of Botrytis into leaves.

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Additional Information:

A phylogenetic tree showing the genetic diversity of 112 Botrytis species and 2 Sclerotinia spp. that were obtained from diseased samples can be found in the attached file.

Project #5: UAF Thrips: Impact and Management of Thrips in Alaska Peony Production Final Report

Project Summary

The objectives of this project were to document the biology and the impact of thrips on peonies in Alaska and to determine if management systems such as cut flower fumigation would be necessary for quality fresh cut flowers especially for foreign markets. We monitored thrips populations at the UAF Georgeson Botanical Garden, Fairbanks and on two grower farms, one in Willow, and a second in Kenai, Alaska.

Additionally, we collected flowers at all stages of flower opening to identify when thrips enter the flowers, their location in the buds, which cultivars are most attractive to the thrips, and to make recommendations on management.

Thrips infest peony buds (lay eggs on the surface of flowers) as early as stage 1 when there is no petal color showing and the buds are green and totally enclosed in the calyx and bracts. The initial settling preference of thrips is independent of flower color or the presence of pollen. Thrips primarily overwinter at the edges of fields with smaller numbers overwintering within the fields. Aerial sticky traps indicate two and a partial generation per season in the Kenai and one and a partial generation in Fairbanks. Four to five different species of thrips were identified, including western flower thrips. Monitoring with yellow sticky cards by growers should begin in late April and continue through bloom time. Use overturned traps to identify "hot spots" for emergence. Possible management systems including insecticides and biocontrol's are discussed. Thrips definitely are present at the cutting stage on all colors of flowers. Fumigation may be required depending on the buyers. Finally, we conducted an extensive literature review of thrips biology and management for use by growers and to support future research.

Project Approach

Thrips Biology

Thrips* belong to the family Thysanoptera. Thrips hatch from an egg and develop through two actively feeding larval stages and two non-feeding stages (prepupa and pupa). In any one growing season, a thrips can complete a full or partial life cycle.

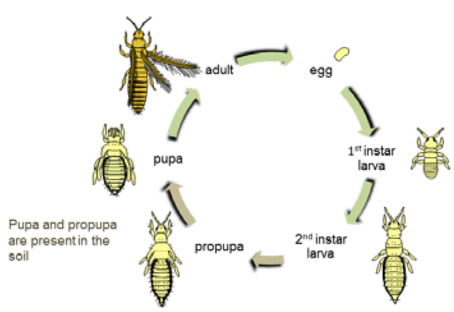


Fig 1. Thrips life cycle. (agric.wa.gov.au)

* The term, "thrips" is correct for both singular and plural. Thrip is an incorrect term.

Eggs are whitish and kidney shaped, and pest thrips insert them into plant tissue (Fig. 2), so they are very difficult to locate. In peonies, they can be found at the base of the inner side of the petal where the tissue is thicker. They may also be found in green peony tissue since immatures were observed between bracts and sepals, before buds begin to open. Eggs hatch to an active feeding stage, a larva (Fig. 2), which molts into a second larval feeding stage. They may drop to the soil to pass through 2 non-feeding pupal stages: the propupa (Fig. 4) and pupa (Fig. 5), or pass through their entire life cycle in peony blooms before molting into adults.

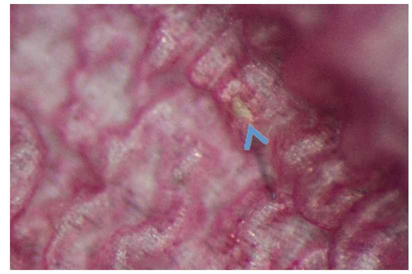


Fig 2. Thrips egg inserted into peony petal.

Adults have fringed wings but are weak fliers (Fig. 7). They can also be carried by wind or storm fronts. Adults cause damage by piercing plant tissue and sucking juices using a needle-like mandible. Thrips also transmit viruses to peonies.

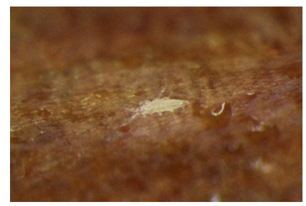


Fig. 3. There are two larval thrips stages. They both are minute and actively feed.

Fig. 4. The propupa has antennae that protrude forward and undeveloped wings.

Fig. 5. Thrips pupa stage has antenna swept backwards with undeveloped wings.

Fig. 6. Adult thrips with fringed wings

Peony morphology and thrips

In stage 1, the peony bud is very firm and the petals are tightly overlapping (Fig. 7). Although minute and flat, even thrips cannot penetrate a stage 1 bud. However, they can lay eggs on the outside of the bud in protected locations and the immature thrips will enter the bloom as the bud opens. Petals of *cabbage-head* peonies do not overlap in the center of the top of the bloom, which might allow earlier entry into these buds, but further observations are needed for verification.

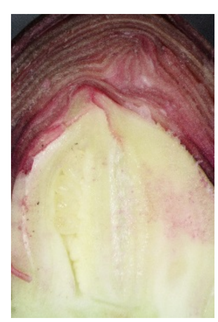


Fig 7. Stage one tightly closed bud.

Goals and Outcomes Achieved

Goal 1. Monitoring thrips populations at 3 locations

Performance measures: Emergence traps and aerial sticky cards

Aerial sticky cards were placed in peony fields; interior Alaska– UAF Georgeson Botanical Garden (64.85890 N, 147.83560 W); South central – Giggly Roots Farm, Willow and Kenai Peninsula – Echo Lake Farm, Soldotna (60.48670 N, 6151.07530 W) on 17 and 18 May, 2015. Growers were provided instructions on maintenance of traps and return of cards. With sticky cards, we monitored thrips movement for 2 months, between 29 May and 24 July at the Georgeson Botanical Garden and 18 May to 31 July at Echo Lake Farm. Sticky cards at Giggly Roots Farm were reported lost in a windstorm.

Georgeson Botanical Garden

Emergence traps

Thrips movement and cultivar preference was studied at the Georgeson Botanical Garden in Fairbanks, AK, between 29 May and 24 July using aerial sticky cards, and two types of emergence traps. The purpose of traps was to pinpoint exact time of thrips emergence in the Fairbanks peony-growing region and to determine if thrips primarily overwinter inside or outside of peony fields.

Two types of emergence traps were used: 1) closed boxes, 22 May - soil samples were collected from various weedy borders and from inside the peony field and placed into individual plastic shoeboxes (Fig 8). Yellow sticky cards were affixed to the inside of the plastic lids and boxes placed in a protected area out of the sun. 2) Overturned traps, 26 May - overturned plastic shoeboxes were positioned in weedy borders and inside the peony field with sticky cards attached to the inside of the box tops.

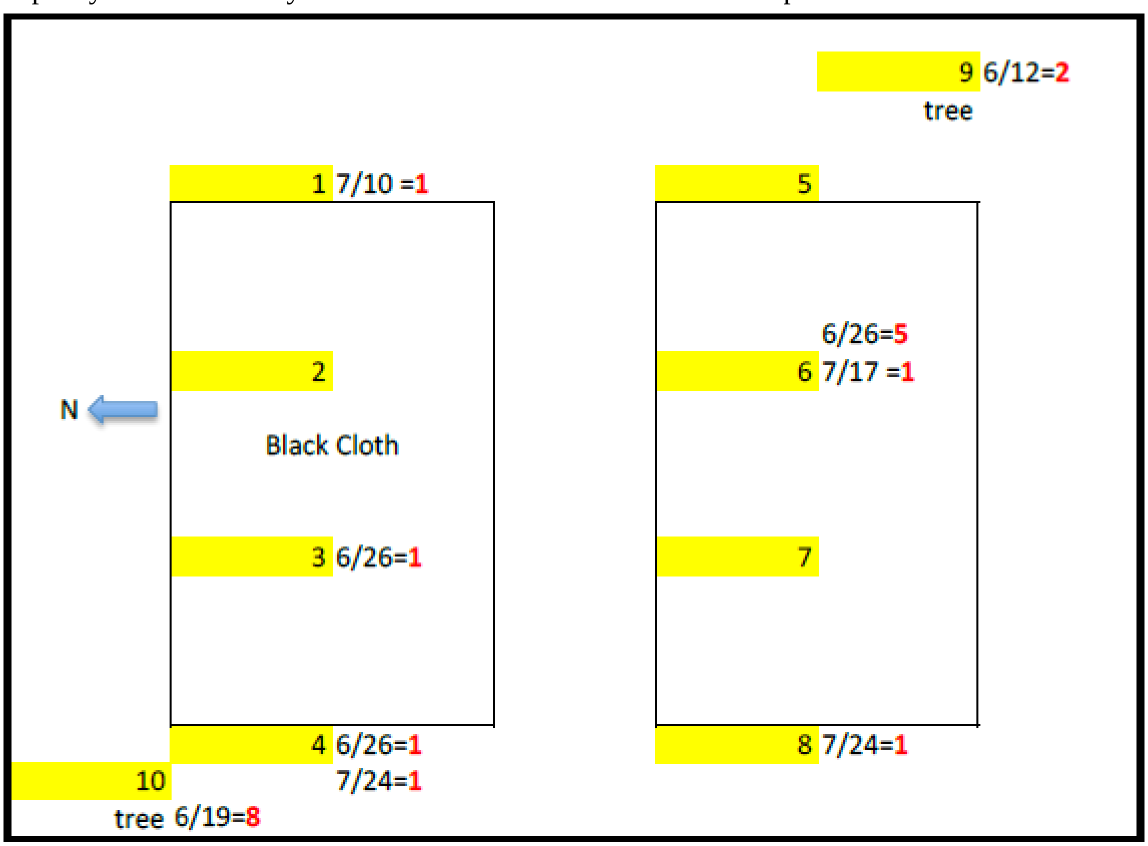


Fig. 8. Georgeson emergence trap locations closed boxed and overturned traps 5/24-7/24.

Closed box soil samples captured a single thrips the week of June 19. Overturned boxes captured seven thrips from boxes positioned inside the field and of those, only 1 came from the field with weed-barrier cloth. Four thrips emerged on the western border of the field and 10 thrips emerged from 2 overturned boxes positioned near two separate trees on the eastern and western sides of the plot (2, 8 respectively). Thrips peaked simultaneously in both the aerial sticky cards and field boxes the week of 19 June (Figs. 9 & 10).

Closed box soil samples were collected from depths of up to 3 inches, which unfortunately was too shallow to reach thrips, which overwinter at depths of 4" to 24" (Franssen & Huisman 1958). Overturned traps consisting of overturned plastic boxes however, successfully measured thrips emergence and are recommended for future studies.

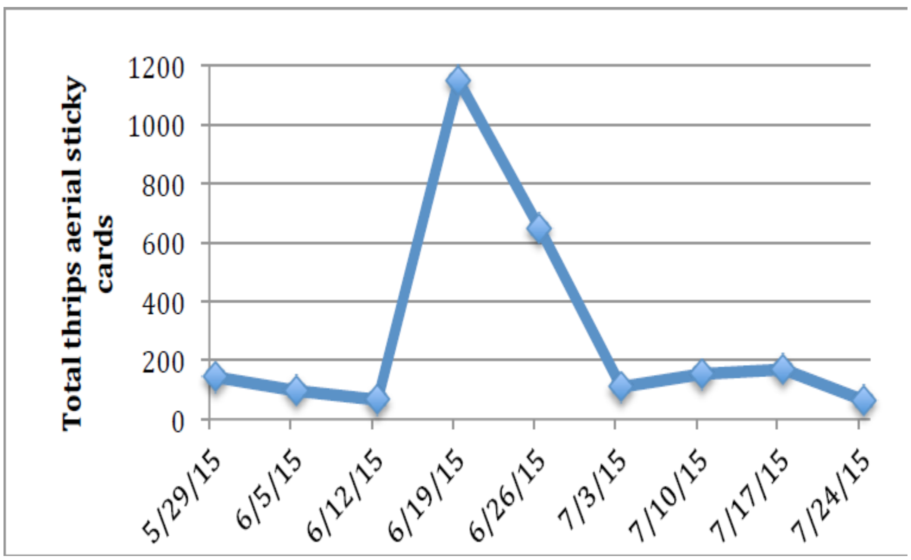


Fig. 9. Thrips flight period indicated by aerial sticky cards at the Georgeson Botanical Garden, UAF, Fairbanks, AK.

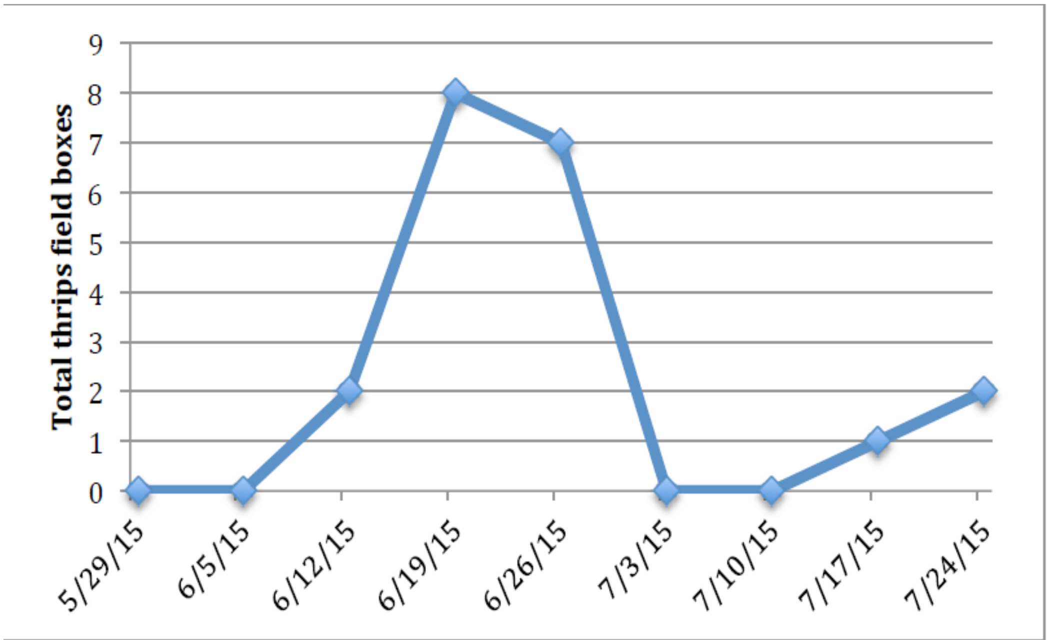


Fig. 10. Field box emergence dates for thrips at the Georgeson Botanical Garden, UAF, Fairbanks, AK

Aerial sticky cards

Aerial sticky cards captured 2,591 thrips, while boxes collected only 21 thrips (Fig. 9). Thrips had already begun to emerge prior to placement of the first aerial sticky cards on 29 May, which suggests trap placement should occur no later than late April to 1 May to ensure success. Setting them out too early increases likelihood of debris sticking to the cards.

Aerial sticky card catches indicate a single and a partial second thrips generation/year occurs in the Fairbanks area, beginning early to mid-May and peaking 1 month later in mid-June (Fig. 10). Compared with earlier studies performed by ARS scientist, Dr. Alberto Pantoja in 2010 and 2009, thrips peak flight period in 2015 occurred approximately 2 weeks earlier than the 30 June flight period in 2010 but coincided with approximately the same peak flight of 15 June in 2009. The 2-week variation in emergence dates in the 2 consecutive years underscores the effects extended winter conditions may have on thrips emergence.

Trapping summary

Although the numbers of emergence traps were few (10 closed box, 10 overturned), the information suggests the following trends:

- Thrips overwinter both inside and outside the field, especially in soil near trees.
- Thrips numbers were higher in plots without weed barrier cloth, which suggests use of weed barrier can reduce chances of thrips overwintering in the field but cannot prevent infestation from thrips flying in from weedy borders.
- A single thrips generation plus a partial second generation occurs in Fairbanks.
- Overturned style boxes are more effective in measuring thrips emergence than closed boxes.

Aerial Sticky Cards - Cultivar preference studies

Aerial sticky cards were placed within rows of forty-five different cultivars at the Georgeson Botanical Garden between 6/30 and 7/10 (Fig 11). Although earlier observations seemed to indicate that thrips prefer light colored flowers, peonies of various colors including several dark colors were also infested (Table 1). This is because color is not a factor when thrips initially move into fields from overwintering sites. See results section, Goal 4.

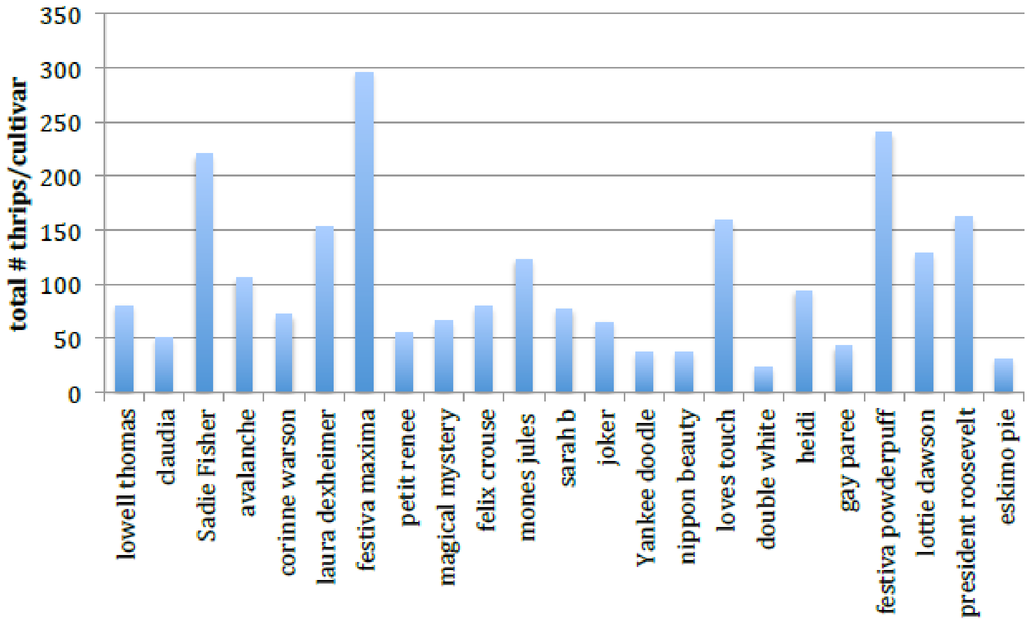


Fig. 11. Total thrips from aerial sticky cards within cultivars, Georgeson Botanical Garden. Collected 6/30/15 to 7/10/15

Table 1. Cultivar color and % infested at Georgeson Botanical Garden, Fairbanks, AK.

	Buds			
Cultivar	**Infested**	**not infested**	**% infested**	**color**
Avalanche	32	20	61.5	white
Ann Cousins	2	28	6.7	white
Avis Varner	6	25	19.4	Dk. pink
Bartzella	0	13	0	Yellow
Best Man	5	41	10.9	Dk. pink
Bridal Icing	5	15	25	White
Cheddar Supreme	9	17	34.6	Dk. pink
Claudia	14	22	38.9	Dk. pink
Corinne Werson	34	26	56.7	Dk. pink
Double White	42	22	65.6	White
Eskimo Pie	7	5	58.3	White
Felix Crousse	8	22	26.7	Dk. pink
Festiva Maxima	30	36	45.5	White
Festiva Powder Puff	21	42	33.3	White/Lt. pink
Fragrant Pink Improved	2	50	3.8	pink
Gay Paree	2	14	12.5	Dk. Pink/white center
Glory Hallelujah	7	57	10.9	md. pink
Heidi	19	11	63.3	md. pink
Helen Hayes	10	32	23.8	Dk. pink
Hermione	4	42	8.7	Lt. pink
Irwin Altman	6	62	8.8	Dk. pink
Joker	19	7	73.1	Md. pink
Julia Rose	7	9	43.8	Md. pink
La Lorraine	5	43	10.4	Lt. pink
Largo	7	53	11.7	Med. pink
Leslie Peck	17	39	30.4	Med. Pink yel. center
Lady Kate	2	36	5.3	Lt. pink
Lora Dexheimer	13	48	21.3	Dk. pink
Love's Touch	20	47	29.9	Lt. pink
Lowell Thomas	49	37	57	Dk. pink
Mary Jo Legare	2	28	6.7	Dk. pink
Magical Mystery Tour	6	30	16.7	Yellow
Mons. Jules Elie	16	28	36.4	Med. pink

	Buds			
Cultivar	**Infested**	**Cultivar**	**Infested**	**Cultivar**
Nippon Beauty	39	21	65	Dk. red
Orlando Roberts	4	48	7.6	Red
Petite Renee	22	46	32.4	Med. pink
Pres. Roosevelt	14	18	43.8	Dk. pink
Pres. Taft	18	44	29	Lt. pink
Sadie Fisher's Peony	56	16	77.8	White
Shirley Temple	0	58	0	Lt. pink
Sarah Bernhardt	22	48	31.4	Lt. pink
Singing in the Rain	0	7	0	Yellow
Sitka	10	42	19	Med. Pink
Smith Family Yellow	1	11	8.3	Yellow
Yankoo Doodle Dandy	1	9	10	Dk. pink

Yellow highlight indicated top two-percent infested cultivars.

Influence of daylight hours and temperature on generations

Total daylight was calculated for collecting dates in Fairbanks. Numbers of thrips collected from aerial sticky traps were plotted alongside total minutes of daylight/day (Fig. 12). Predictably, thrips numbers increase with increasing light and warmth (Fig. 13). Peony growers in the Fairbanks region should use yellow sticky cards to monitor thrips flight period beginning late April to early May depending on snow cover and ability to get into the fields. Overturned traps can provide information on overwintering sites and should be placed at the same time as aerial sticky cards.

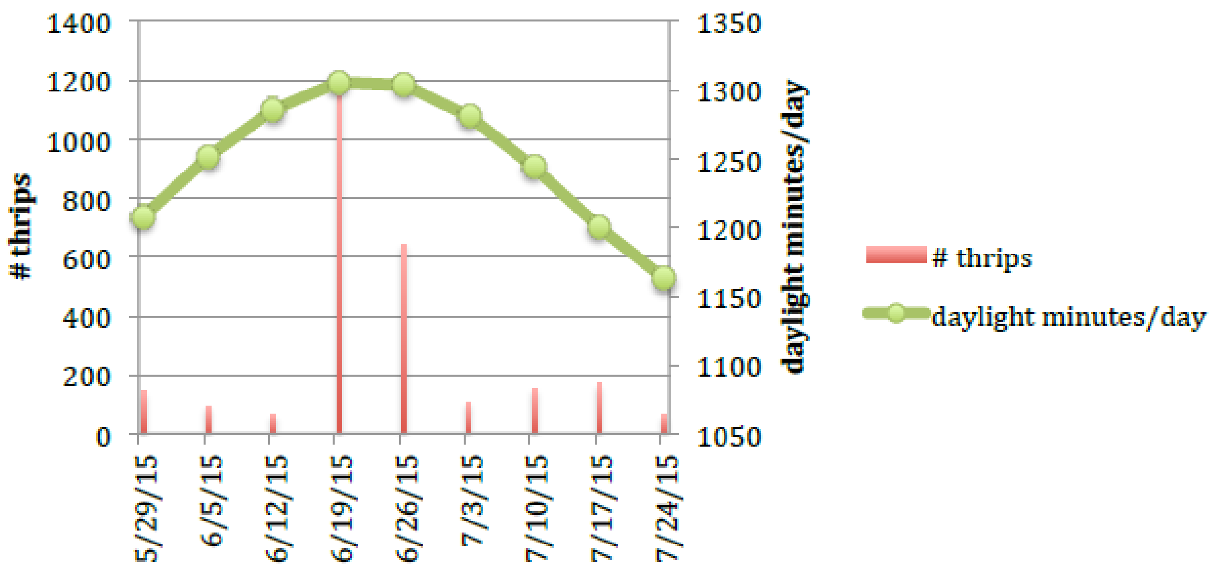


Fig. 12. Aerial thrips catches with total daylight hours/day at Georgeson Botanical Garden, UAF, Fairbanks, AK

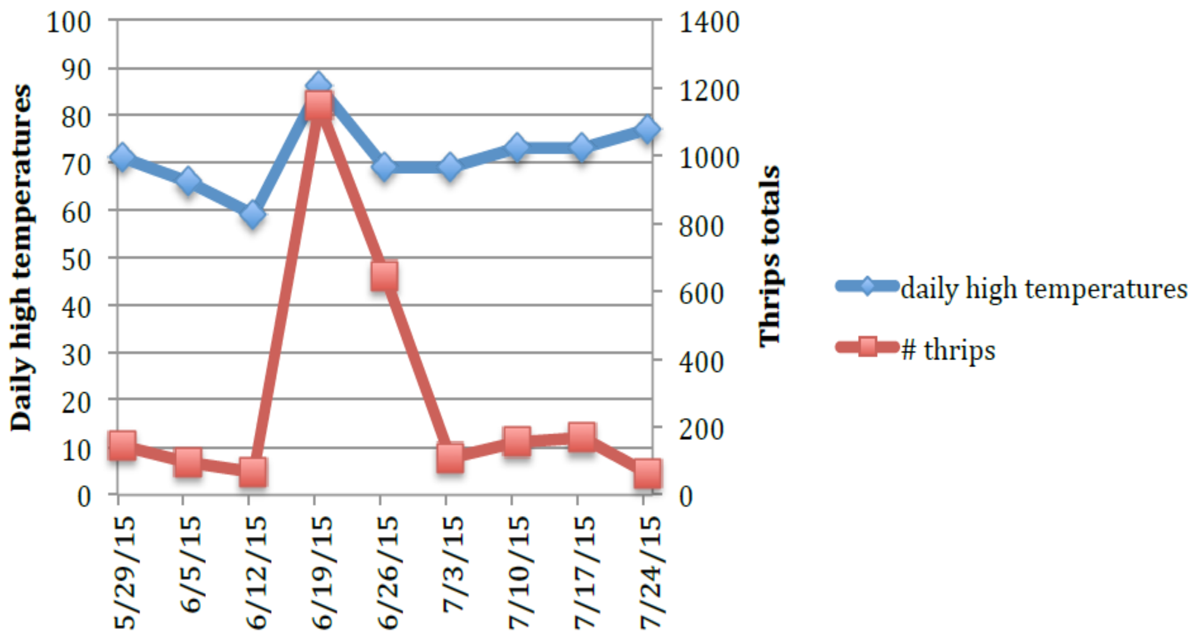


Fig. 13. Total aerial thrips catches plotted with daily high temperatures. Georgeson Botanical Garden, UAF, Fairbanks, AK

Echo Lake May 18 – August 27

On the Kenai Peninsula, a multiple variety peony field was divided into 4 quadrants (Fig. 14) to track movement of thrips using aerial sticky cards and emergence traps. Soil samples for the closed box emergence traps were taken on 18 May in Soldotna, AK from field borders and from inside the field, with and without weed-barrier cloth. Overturned traps were not used since they weren't added to the protocol until the Georgeson Botanical Garden site. The closed box soil samples were not successful in trapping any thrips. In the future overturned traps will exclusively be used as emergence traps for thrips studies.

Quadrant 1 Total 268 F25 B243	**Quadrant 2** Total 224 F14 B210
Quadrant 4 Total 99 F20 B79	**Quadrant 3** Total 133 F28 B105

Fig. 14. Echo Lake quadrants with total thrips collected in the field (F) and borders (B) in Soldotna, AK.

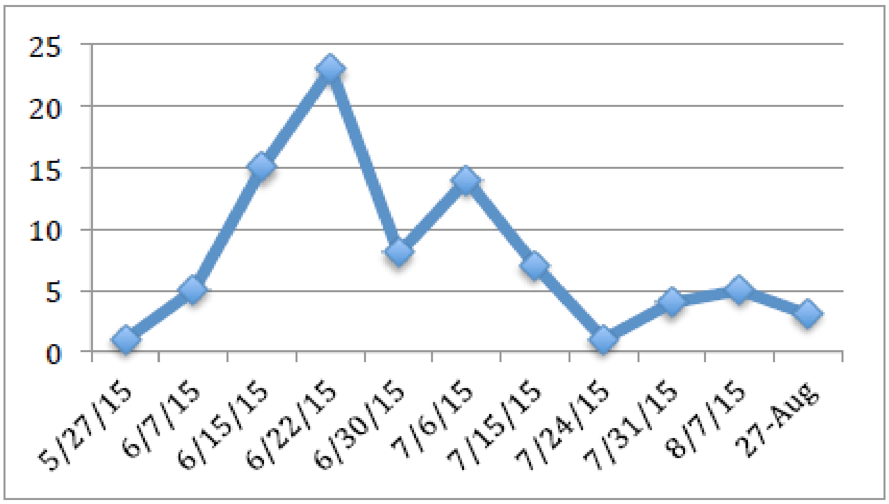
Overwintering and Generations

A sticky card was placed on each quadrant border and centered within each field quadrant. There were 2x the number of border sticky cards than within-field sticky cards. Cards were changed weekly. A total of

88 aerial sticky cards were analyzed. Total thrips collected from border sticky cards was 637 while 87 thrips were collected within the field. To compare activity, the total number of thrips trapped in border sticky cards was divided in half, 318.5. A 3.7-fold difference in thrips activity was observed between the field and borders, suggesting that while most thrips overwinter outside the field, some also overwinter in the fields. Weed barrier was used in that field but not exclusively. As previously mentioned use of weed barrier may reduce thrips overwintering in the field but not prevent infestation from surrounding areas.

Differences between thrips totals in each of the quadrant borders suggests some possess more favorable overwintering sites. Borders of quadrants 1 and 2 had uncultivated areas on two sides while quadrants 3 and 4 had a single uncultivated border as well as bordering the cultivated peony field to the south. Presence of weedy borders results in greater numbers of thrips so controlling border weeds could reduce thrips, but may not be humanly possible. Using emergence traps can help growers pinpoint areas with high numbers of overwintering thrips. Thrips adults are weak fliers and wind direction may also play a role in dispersal.

Sticky cards identified 2-3 peaks in thrips activity in Soldotna representing two and a partial summer generations in the Kenai Peninsula (Figs. 15 &16), mid-June and mid- July.



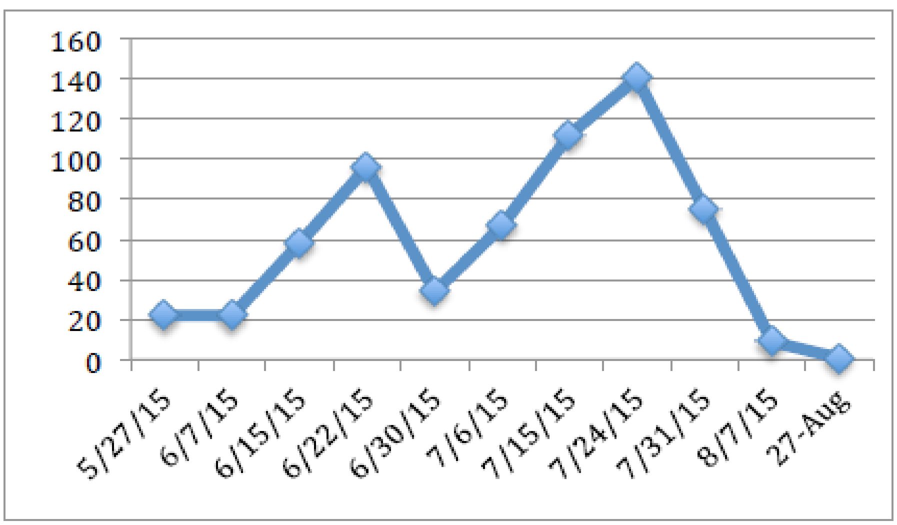


Fig. 15. Echo Lake aerial sticky cards. And Fig.16. Echo Lake aerial sticky cards field borders.

Thrips Peony Phenology

Bud stage was recorded along with sticky cards at Echo Lake Farm. Records indicate overwintering adults begin to move into the field in mid-May when peony plants are just 3-4 inches tall with no buds present. However, by mid-June stage 1 peony buds were recorded, coinciding with the first peak flight or 1st generation of thrips. The first summer generation occurs before the buds show color and therefore initial distribution is independent of color. These data concur with that of the Georgeson Botanical Garden, where thrips were discovered first infesting exteriors of stage 1 buds. Once thrips infest a peony bud, they lay eggs and move in as their numbers increase and the buds open.

The 2nd peak flight occurs mid-July when buds are at stages 3 and 4. Depending on cultivar, harvest occurs between bud stages 1.5 - 4.5. Harvest period at Echo Lake began prior to and continued during the highest thrips numbers (Figs. 17 & 18), which occurred during the 2nd flight period in mid-July.

The highest temperatures, 840 F occurred mid-June during the 2015 Soldotna peony harvest, with the highest average daily temperature reaching 68.50 F (20.280 C) on 17 June. Between 21-23 June, peak daylight hours reach 19. Combined, long daylight and high temperatures promote rapid development and precede a rise in thrips numbers. Between 770 F and 870 F, generation time for western flower thrips takes approximately 11 days in California but effects of long daylight in Alaska may decrease generation time. Thrips populations reached their peak in July when high temperatures stabilized between 550 F and 730 F. By 21 July, light drops below 18 hours shortly before nighttime temperatures also begin to drop. Thrips, like all insects, are affected by photoperiod and temperature. As long days increase during the Alaskan summer, so do thrips populations but light dropping near 18 hours combined with dropping nighttime lows, result in big changes to the thrips populations after 15 July (18h: 13m). At that time, thrips numbers (trap catches on yellow sticky cards) plunged 2.2-fold from 176 to 79, followed by a second drop 8.3-fold to fourteen by 31 July (17h 4m) and finally to only four thrips by 7 August.

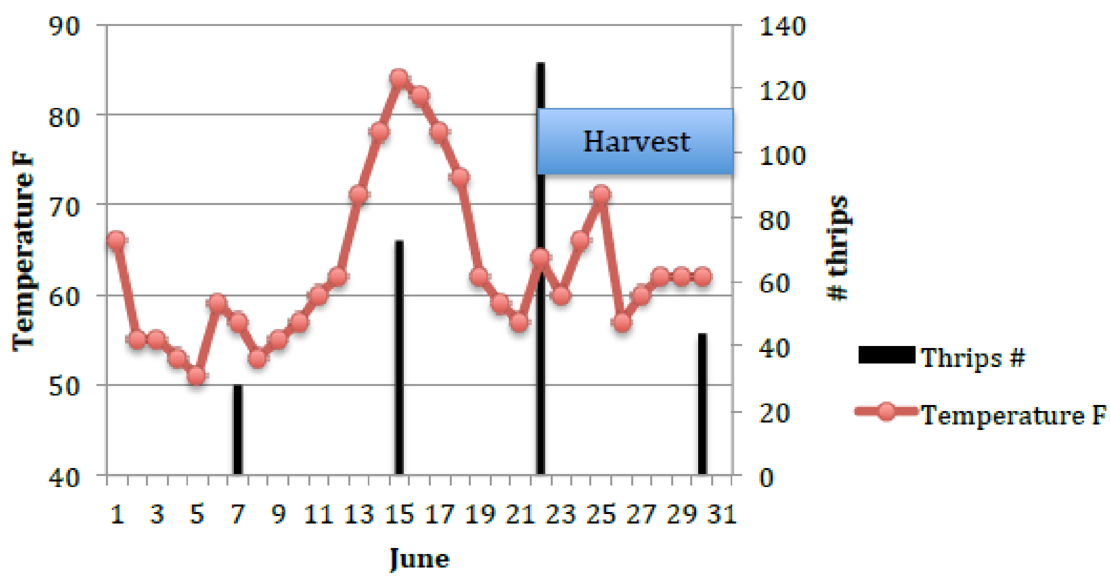


Fig. 17. Total number of thrips plotted with daily high temperatures in June at Echo Lake Peony Farm, Soldotna, AK.

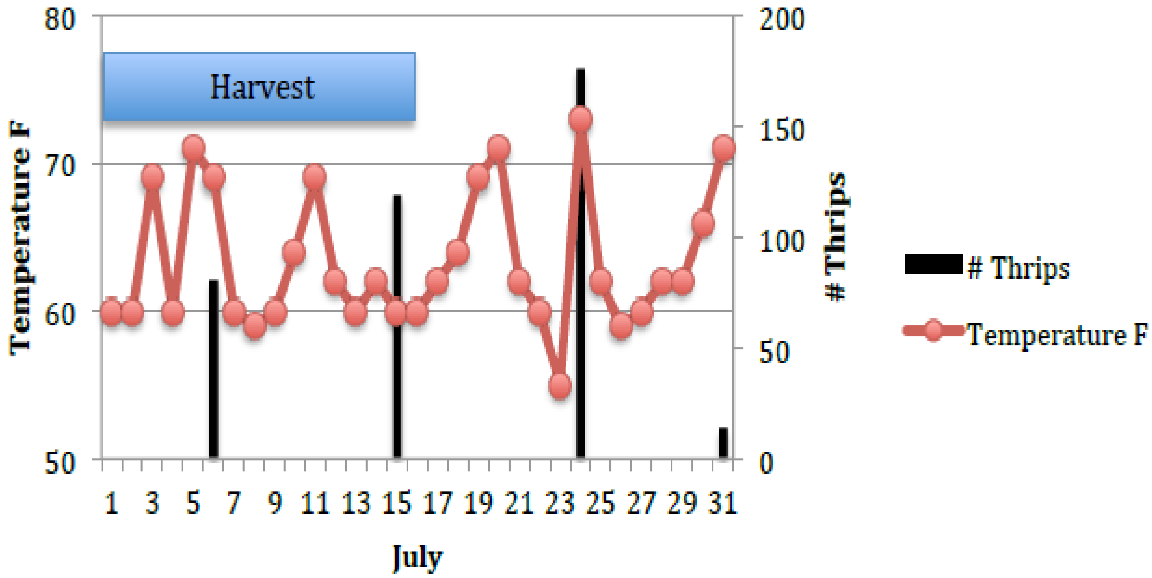


Fig. 18. Total number of thrips plotted with daily high temperatures in July at Echo Lake Peonies in Soldotna, AK.

Multiple cultivars

Besides daylength and temperatures, additional factors assist thrips populations to flourish in peony fields. Growers tend to grow multiple cultivars with varying bud maturity, stimulating thrips populations by providing a continuous source of susceptible buds. Poor sanitation practices, failing to deadhead, allow thrips populations to build to maximum levels unchecked.

Correct timing of insecticide applications is imperative. Timely early season applications can impact thrips moving into the field, ultimately preventing or suppressing the larger second summer generation in July. Adequate insecticide coverage is easy when buds are in stage 1 since there are no petals present. See discussion under management. The second peak generation in Soldotna occurred in mid-July when buds reach stage 3 and 4.

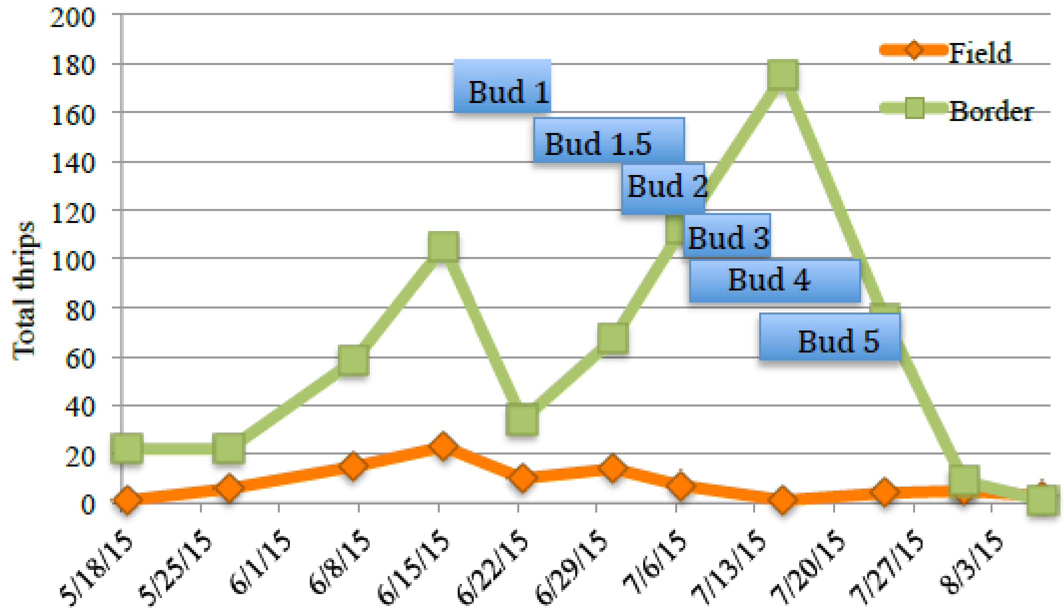


Fig. 19 Bud stage plotted with movement of thrips totals within the field and along borders at Echo Lake Farm, Soldotna, AK.

Thrips Flight Periods Comparison

Comparison in thrips flight periods between Georgeson Botanical Garden, Fairbanks, AK and Echo Lake Farm, Soldotna, AK indicates Echo Lake undergoes 2 generations and a partial 3rd generation during the peony season, while Fairbanks experiences one and a partial 2nd generation (Figs 9, 20). Georgeson Botanical Garden is situated at 64.850 N, while Echo Lake Farm is located 60.480 N, representing nearly 5-degree difference in latitude. Nevertheless, Georgeson's flight peak in 2014, nearly coincided with Echo Lake's first flight peak, 19 June. Depending on occurrence of unseasonal weather conditions, these partial generations could drop back or result in an additional full generation.

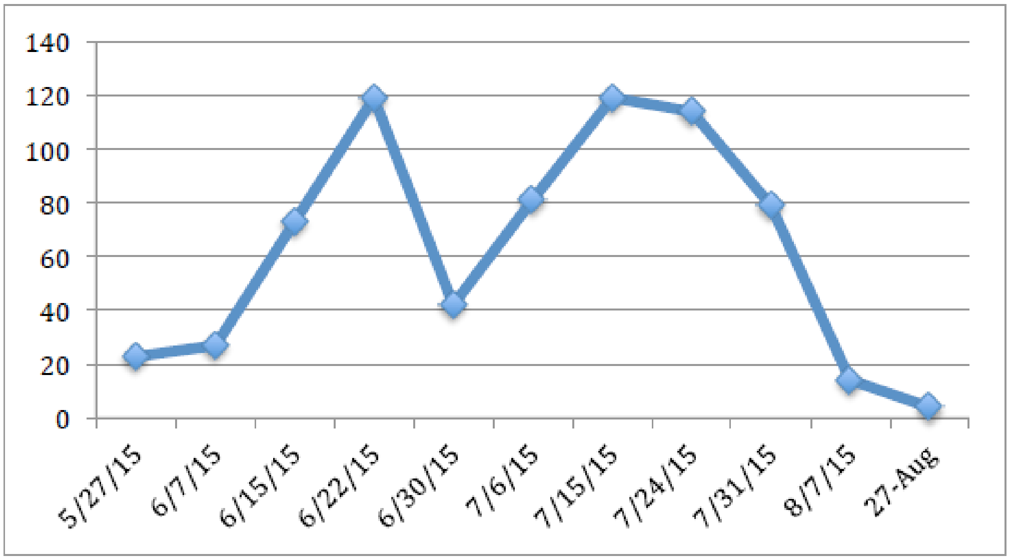


Fig. 20. Thrips flight periods combined field/border sticky cards – Soldotna.

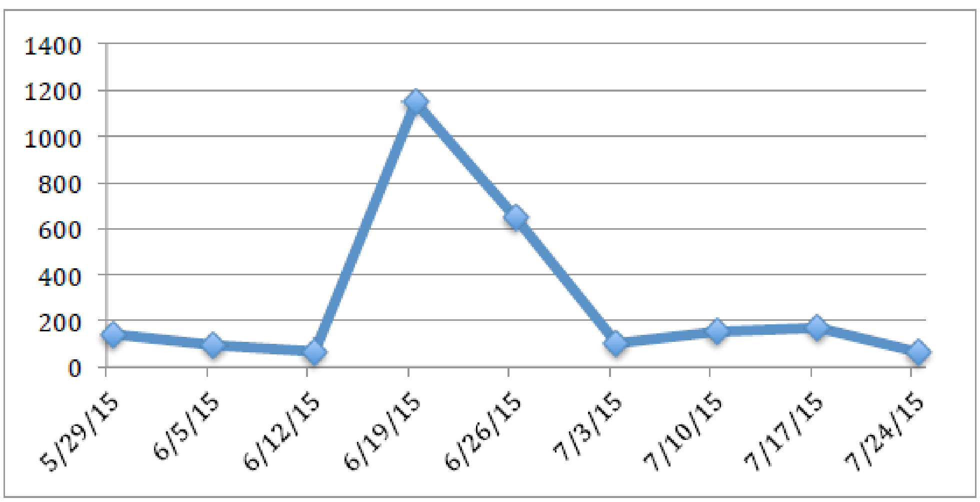


Fig. 9. Repeated flight period. Georgeson Botanical Garden, Fairbanks, AK.

Goals 2 & 3. Identify when thrips require management. Compare thrips on all cultivars at the UAF Georgeson Botanical Garden to identify preferences.

A total of 1,720 Peony buds representing various stages (1, 1.5, 2, 2.5, 3, 4, and 5 or full) of 45 cultivars from the Georgeson Botanical Garden were collected and individually placed in ziplock bags for analyses. Buds were placed in shipping containers with cold packs and shipped overnight to Washington State where they were dissected and thrips presence recorded. All were dissected. Color, life stage and numbers of thrips were counted for each bud. A few buds in stage 5 buds, full bloom, were rotten when studied and in that case only presence or absence of thrips was recorded.

Buds were scored infested or uninfested and % infested calculated for both bud stage and cultivar (Table 1). For all buds, 45% were infested. The cultivars dissected with the highest % infestation was ‘Sadie Fisher’ with 77.8% and Joker at 73.1%.

Over fourteen percent of Stage 1 of the 1,720 buds dissected, were infested with thrips. Observations indicate thrips first settle between the bracts and sepals or between sepals and petals of early stage buds. From these protected locations, thrips lay eggs and progressively move further into the bud as the bud slowly opens. The progression of movement into the bud along with observation of the new generation provides some clues as to arrival and of passage of time, so notes on level of penetration were recorded, such as row of petals where thrips were observed or whether the thrips were found in the center of the bud.

Once the thrips have settled into the buds in these protected locations, contact insecticides will no longer be effective against them but they could protect the buds from additional incoming thrips for a few days depending on the residual activity of the insecticide. Peony buds should be protected from thrips, beginning with the button stage to minimize infestation at harvest. For growers who want a less toxic approach, there

are a few options but efficacy and speed of results are slower, see Biological/sustainable management options.

Borders versus within field

Immature thrips were first observed inside the bud as far as the petals by stage 1.5 (‘Nippon Beauty’ 25 June; ‘Petite Renee’ 29 June; ‘Bridal Icing’ 6 July), indicating thrips had infested these cultivars earlier than others. The plot map (Fig. 21) shows the location of all three cultivars. Likewise, the highest numbers of thrips/cultivar based on aerial sticky cards (Fig. 9) were observed in: ‘Festiva Maxima’ (plots 6,15), ‘Festiva Power Puff’ (plot 6) and ‘Sadie Fisher’ (plot 6). Both of these incidences, (earliest observed immatures and highest aerial trap captures) were border plots. Thrips primarily enter the fields from borders.

The appearance of immatures in late June represents first observations of the F1 generation for the 2015 season at the Georgeson Botanical Garden. A comparison of infestations (adults + immatures) among cultivars is shown in Table 1. The bud stage with the highest incidence of immature thrips is stage 4. Bud stage with highest incidence of mature thrips is stage 5. Last reported immature thrips was 7 July.

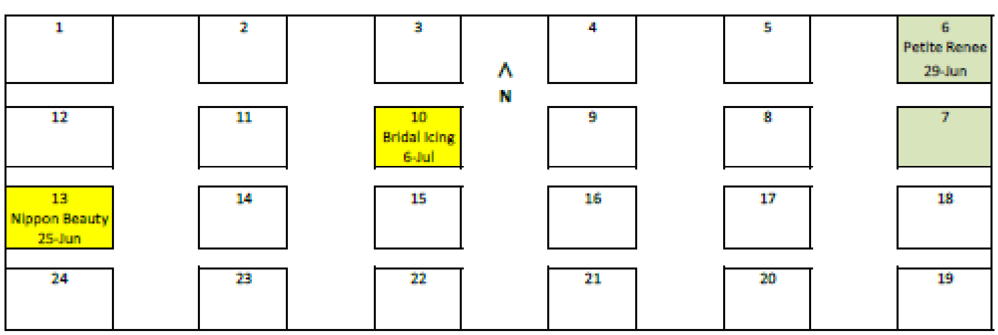


Fig. 21. Georgeson Botanical Garden Plot Map 2015.

Thrips Identification

In 2010, Alberto Pantoja identified four thrips species associated with peonies: Thrips tabaci, Taeniothrips orionis, Thrips vulgatissimus and Frankliniella occidentalis based on collections from 3 localities. This study focused on thrips species from peonies at Georgeson Botanical Garden in Fairbanks. One hundred and fourteen thrips were mounted on 49 slides with Strandtmann's mounting medium. Strandtmann's requires ringing in glyptol for longterm preservation. Thrips were sorted to 4-5 morphospecies. Species identified included members of 2 families of thrips, Thripidae and Aeolothripidae. Members of Thripidae included Western flower thrips, Frankliniella occidentalis. Several morphospecies did not match any of the 4 species Pantoja identified and likely after 6 years there are new species especially with the rapid growth in the peony industry and increase in plant movement within Alaska. The thrips slides may provide useful information for further studies but should be maintained at the UAF museum to increase access and longevity. This study was not intended to be anexhaustive survey of thrips infesting peonies in Alaska. The Pantoja survey 6 years ago provides a baseline for that data.

Goal 4. Define peony flower color and correlate thrips infestations with color and form.

Peony Flower Attractivity

Thrips were observed on all except two cultivars, 'Shirley Temple' and 'Singing in the Rain. The lack of thrips on these cultivars is possibly due to small sample size.

Peony exudates

Peonies are noted for their sticky exudates, which contain sugar and are highly attractive to numerous insects including ants and wasps. The exudate is produced by nectaries located on the edge of the sepals. Presence of a sticky exudate on the peonies was observed from the very beginning with the first bud shipment. At UAF, Dr. Pat Holloway reported that the entire plants were sticky and questioned whether lack of rain could have been the cause. It is obvious that volume and viscosity of the exudates diminish as the season progresses as the buds open and also perhaps washed off with rain as Dr. Holloway suggests. It is logical that the sugary exudate could attract thrips and provide nutrients required for oviposition, however there was no evidence of specific attraction in stage 1 buds from exudates. Alternatively, the sticky nectar may actually entrap thrips as has been reported in some Australia flowers with copius nectar, http://thrips.info/wiki/Thrips_and_plants. Buds were harvested and placed into plastic bags for shipment to Washington State, which eliminated the chance to observe if thrips were found trapped in the sticky exudate. Curious and sharp-eyed growers can answer this question if they regularly monitor their fields.

Plant volatiles

Specific plant volatiles can play a role in thrips attractivity. Certain thrips such as western flower thrips prefer unopened buds to open flower buds which is attributed to higher amounts of the chemical (E)-β-farnesene found in the buds compared to leaves and open flowers (Manjunatha et al 1998). It is likely other species exhibit similar preferences. The notion that thrips could be attracted or repelled by plant volatiles and that these same chemicals could be utilized to assist in controlling or repelling thrips on peonies sounds appealing but this avenue of research is in its infancy and a lot of variables exist. More research is needed in this area.

Pollen

While some species of thrips are omnivores and can be predatory on their own immatures, they are best known for feeding on plant tissue and on pollen (Fig. 22). Thrips reportedly are more attracted to peony cultivars with pollen. However, thrips were observed on cultivars regardless of pollen. Pollen is not available in early stages of bud development because anthers do not mature and split open with pollen until later stages, thus presence of pollen is not a requirement for infestation.

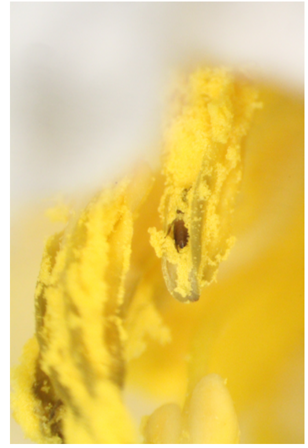


Fig. 22. Thrips feeding on pollen.

Pollen is a rich food, high in proteins that promote egg-laying (fecundity) and thrips population increase as the season progresses, coinciding with an increase in availability of pollen. The increase in availability of pollen as the season progresses could stimulate egg-laying, therefore while initial infestation is not influenced by presence of pollen, increasing availability of pollen in mid to late season may play a role in overall field populations.

Color

Thrips are reported to be attracted to light colored flowers and to investigate this we looked at both light and dark peony buds. Cultivars dissected included white, pink, dark fuchsia and apricot. Thrips were found infesting all colors. Furthermore, over 14% of buds stage 1, were infested, when no color is visible. Initial movement into the field from overwintering sites and settling is not influenced by color, but does flower color influence within-field movement? When cultivars (Table 1) are divided between light colors (white, light pink, yellow) and medium to dark colors (medium pink, dark pink, red), surprisingly the % infested for each group is nearly identical, with 46.3% of light flowers infested (266/574) and 46.2% of dark flowers infested (379/821).

Human eyesight is not the same as thrips and generalizing about bud color and attractivity can be misleading. Insects are attracted to the ultraviolet portions of the color spectrum (Menzel 1975) and surface properties can further influence color (Hunter & Harold 1987). Color is considered a short-distance attractant compared with plant volatiles that can attract thrips from long distances and are considered the major attractive factor for thrips such as western flower thrips.

This research did not find any differences in preference based on color but as we know from the research mentioned above a simple comparison between colors will not provide these answers. Observations of large numbers of thrips on stage 5 light colored flowers may be due to several factors:

- Thrips are easier to see on light flowers.
- Stage 5 blooms of any color will have higher numbers of thrips than earlier stages simply from exponential growth of thrips populations.
- Presence of pollen available on late season blooms can boost egg production.

Goal 5. Conduct a literature review on thrips management.

A literature review is attached separately and includes links to websites, articles and information on thrips' biology, sampling, management including fumigation. References at the end of this report are specific citations for this report.

Management

- The initial protective spray is critical, time the insecticide spray to protect button peonies. Effects of the exudates and their potential to dilute the protective insecticides should be evaluated. Effects of insecticides at this time on beneficial non-target insects attracted to exudates should be investigated. Season-long insecticide control programs may not be compatible with picking schedules.
- Use of synthetic pyrethroids can be challenging to pickers, because of the REI interval (restricted entry interval) required by the label.
- Ideally monitor thrips activity with sticky cards.
- Weekly sample buds for infestation by tapping them hard over a white plate or pan and watch for minute elongate thrips.
- Most likely protective cover sprays will need to be applied throughout the season based on flight activity.
- Perform proper sanitation, deadheading spent blossoms and remove all plant debris from the field and dispose properly to prevent buildup of thrips.
- Removing weeds to create a border around the field sounds logical but is it feasible?
- Use of weed barrier may reduce thrips overwintering in the field but it won't prevent infestation.
- Growers could determine direction and intensity of incoming thrips using sticky cards to delineate thrips movement identifying any hot spots.
- This knowledge also identifies most vulnerable areas of the field, which could be closely monitored.

Fumigation

Major flower export countries use fumigation to control thrips but effects specifically on peonies, are unknown. Fumigation might provide an additional management safety net but cost and potential phytotoxicity and effects on bud longevity have not been investigated. Is there an advantage to pretreat shipments? Will fumigation certification, or other forms of disinfestation pretreatments be recognized by target countries and simplify the process? Whose responsibility is it and who pays?

Thrips are minute insects that search out tight crevices and cracks to hide. Even so the adults are easily found with careful visual inspection. The cryptic nature of eggs and immature stages indicates shipments with these stages could pass inspection. Effects of postharvest treatments during transport (e. g. cooling) on thrips have not been studied, but it appears that infested flowers could arrive at their foreign ports of entry and be subject to disinfestation or rejection.

Biological/sustainable management options

Use of insecticides can be problematic in a crop that has short picking intervals like peonies and other cut flowers, because of the REI required by the labels, pickers can re-enter the field until a prescribed time following an application. There are several alternative control methods if suppression is adequate. Softer control methods usually don't work as fast as chemical approaches and biological control is always more effective when pest populations are low. Here is the latest research on sustainable approaches to thrips control:

Minute pirate bugs – (Hemiptera: Anthocoridae) (Fig. 23). These small true bugs are already present in peony fields. They insert their eggs into plant tissue like thrips but the nymphs hatch and feed on thrips eggs and larval stages. At the numbers I observed, they are not capable of adequate suppression.

Predatory mites – the predatory mites, Amblyseius cucumeris and/or A. degenerans may provide some protection but most likely not enough. The predatory red whirligig mite, Anystis already is present in fields and was observed on peony buds from UAF but at such low numbers natural populations cannot effectively control thrips. Use of either minute pirate bugs or predatory mites would require purchase and shipment from a commercial biological control company, which might be cost prohibitive and the shipment distances could impact quality of the beneficials.

Fig. 23. Minute pirate bugs were occasionally found on peony buds from the Georgeson Botanical Garden. They insert eggs into petals like their thrips prey.

Fungal pathogens – Fungal pathogens are insect specific pathogens whose spores attach to the insect and hyphae grow into the insect's cuticle resulting in death. Fungal pathogens include Beauveria bassiana, that can assist in controlling pests and are available as foliar sprays. Some reportedly have shown efficacy against western flower thrips. My experience with fungal pathogens is they are very slow to act but do have some value in other pest systems, where they usually suppress rather than eliminate the pest. Combinations of a fungal pathogen + an insecticide also have shown efficacy.

If there is a zero tolerance for thrips, insecticide applications remain the best option. Thrips have also been known to develop resistance. Development of an effective insecticide program must include the following points:

- The insecticides selected must be effective against thrips.
- They must rotate between different classes of insecticides to minimize resistance development.
- The REI intervals of selected insecticides must be compatible with grower/picker schedules.
- Insecticide choices must meet the particular criteria of your buyer. For example, some buyers advertise that neonicotinoids are not used on their flowers, as a selling point.

Developing a season long effective program will require research and diligent testing but it is possible.

Summary

Results of this study provide many details on thrips and their peony hosts unknown until now. In summary:

- Thrips infest peony buds (external sites) as early as stage 1.
- Initial settling preference is independent of color or presence of pollen.

- Thrips primarily overwinter outside the fields with smaller numbers
- overwintering within the fields.
- Aerial sticky traps indicated two and a partial generation in the Kenai and one and a partial generation in Fairbanks.
- Four to five different species of thrips were identified, including western flower thrips but at least 2 species did not match Pantoja's survey in 2010.
- Development of a season-long program to control thrips, which addresses efficacy, resistance management and grower/picker schedules, is highly recommended.

References: (see also literature review)

Blumthal, M., R. Cloyd, A. Spomer and D. Warnock. 2005. Flower color preferences of western flower thrips. HortTechnology 15: 846-853.

Franssen, C. and P. Huisman. 1958. The biology and control of Thrips angusticeps Uzel. Versl. Landbouwk. Onderez. RijksandhProegstn. 64:104pp.

Hunter, R. S. and R. W. Harold. 1987. The measurement of appearance. Wiley, New York.

Manjunatha, M., J.A. Pickett, L. J. Wadhams and F. Nazzi. 1998. International Journal of Tropical Insect Science. 18:139-144.

Menzel, R. 1975. Colour receptors in insects, p. 121-154. In: G. A. Horridge (ed.). The compound eye and vision in insects. Oxford Press, London, U. K.

Beneficiaries

Results of our study provided critical information to members of the Alaska Peony Growers Association. This burgeoning cooperative is comprised of commercial peony growers as well as those interested in the emerging peony industry in Alaska. According to the APGA annual survey for 2015, there were 69 growers with roots in the ground and 8 addition growers will plant within the next 5 years for a total of 77 growers. Total number of roots is 166,347. Its growers are located across the state from the Interior region of Fairbanks and North Pole through central Alaska's Matanuska Valley all the way to the southern shores of the Kenai Peninsula on Kachemak Bay. Alaska's long cool growing seasons and soil help produce large buds and vibrant colors so desired in the marketplace. According to Alaska Peony Distributors, Alaska has the world's only supply of peonies during the months of July, August and September, which happen to coincide with the prime wedding season. Alaska's climate and geographic location give the state a clear advantage in the peony production and exportation industry. Alaska boasts the second-largest cargo hub in the United States, the Ted Stevens International Airport, making it logistically ideal for exportation. The peonies are capable of being shipped to 90 percent of the developed world in less than 9 ½ hours. There is a strong potential for foreign export with Asian markets along with South African, Australian, Greek and Italian markets. Alaska Perfect Peony has already established some of these relationships while also shipping to all of the U.S. and several wholesalers in Singapore and Hong Kong. While Alaska's agricultural sector has long taken second place to oil and minerals, peonies have re-energized the potential for agriculture to help diversify and stabilize the states' economy. (Sources of information include: The Anchorage Economic

Development Corp. https://aedcweb.com/alaska-business-news-alaskas- budding-industries-peony-marijuana-growing/ and the Alaska Peony Growers Association http://www.alaskapeonies.org)

Lessons Learned

The results of this study provided the first in-depth information on the biology and seasonality of thrips on Alaskan peonies. It determined the following:

- The increased thrips activity observed in the border sticky cards compared to sticky cards placed in the fields, suggests most thrips migrate into the fields but a few overwinter inside the fields.
- Presence of weedy borders results in greater numbers of thrips so controlling border weeds could reduce thrips, but may not be humanly possible.
- Using emergence traps can help growers pinpoint areas with high numbers of overwintering thrips.
- In both locations (Georgeson Botanical Garden and Echo Lake Farm) overwintering adults begin to move into the field in mid-May when peony plants are just 3-4 inches tall with no buds present.
- By mid-June stage 1 peony buds were recorded, coinciding with the first peak flight or 1st generation of thrips.
- The first summer generation occurs before the buds show color and therefore initial distribution is independent of color. This data concurs with that of the Georgeson Botanical Garden, where thrips were discovered first infesting exteriors of stage 1 buds.
- Observations indicate thrips first settle between the bracts and sepals or between sepals and petals of early stage buds. From these protected locations, thrips lay eggs and progressively move further into the bud as the bud slowly opens.
- The second peak in activity occurs in mid-July, coinciding with bud stages 3 & 4.
- Although flower color does not affect initial infestation preference, it may affect within-field movement.
- Comparison in thrips flight periods between Georgeson Botanical Garden, Fairbanks, AK and Echo Lake Farm, Soldotna, AK indicates Echo Lake undergoes 2 generations
- Forty-five % of the total number of buds evaluated was infested. The cultivars dissected with the highest % infestation were 'Sadie Fisher' with 77.8% and 'Joker' at 73.1%.
- Four to five different species of thrips were identified, including western flower thrips but at least 2 species did not match Pantoja's survey in 2010.

Management Implications:

- Peony buds should be protected from thrips, beginning with the button stage to minimize infestation at harvest to prevent damage and risk export complications (e.g. disinfestation, rejection).
- Once thrips infest peony buds, control is difficult because of the hidden stages protected within the bud.
- Development of a season-long program to control thrips, which addresses efficacy, resistance management and grower/picker schedules, is highly recommended.

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Project #6 UAF Nutrient

Project Summary

Alaska peony cut flower industry has grown at a fast pace in recent years. As more growers join the industry, knowledge on soil and plant nutrient management is in a great demand. In the past, most soil fertility studies have focused on agronomic crops. Little is known about soil fertility conditions and nutrient requirement for peonies in Alaska. A field survey was initiated in 2012 and recommendation from that survey was to take soil and plant tissue samples from peony fields across the state both from well grown peonies and poorly grown peonies so that reference concentrations for nutrients in soil and plant tissue can be established. Upon such establishment, growers should be able to check their soil and tissue test results against those reference numbers so that their peony nutrient status can be ascertained. Also, there are needs for growers to understand the correct way of sampling soil and plant tissues so that they can gain more insight on their peony production.

The objectives of the project were: 1) collecting soil and tissue samples of well and poorly grown peonies; 2) analysis of the nutrient concentrations in the samples; 3) interpret the test results to individuals where samples are taken; 4) compile the results and establish the nutrient standards in Alaska; 5) present the results in the growers' conference and publish the results in APGA web site; and 6) create a YouTube video of the sampling procedure and standardize the sampling protocol for growers' use.

Project Approach

State wide soil and tissue samples were taken in the summer of 2015 in three regions: interior, south central, and Kenai Peninsula. In all, there are 90 soil samples, and 126 plant samples (Objective 1). Of those samples, 80 soil and tissue samples were sent to Brookside Lab for analysis for soil and plant nutrients. The remaining samples were the samples that are not in the project plan but requested by growers late in the season, and those samples were prepared and were sent for analysis in the Palmer Soil Laboratory of the School of Natural Resources and Extension, University of Alaska Fairbanks (Objective 2). The analytical items for soil included soil organic matter content, soil pH (both active pH and buffer pH), soil cation exchange capacity (CEC), mineral N, extractable P, exchangeable K, Melhich 3 Ca, Mg, Mn Cu, Zn and hot water extractable B. The analytical items for plant tissue included the nutrient concentration of N, P, K, Ca, Mg, B, Fe, Cu, Zn. The results were interpreted and sent to individuals through email from which his/her results were compared with the regional level for those analytical items. This whole process was finished by the end of May of 2016 (Objective 3). Regional average and ranges for well-and poorly- established peony were calculated and tabulated (Tables 1 to 5), and they can be used for the reference of growers' sample analysis (Objective 4). A YouTube video of how to take soil samples and meaning of the soil test items were made in cooperation with the publication office of School of Natural Resources and Extension (Objective 6).

Goals and Outcomes Achieved

The 2015 results that have been interpreted and sent to individuals through email for his/her results relative to the regional level for those analytical items were gone over and discussed with each individual grower over the winter of 2015 – 2016 prior to spring (Objective 3). All research results were presented in the annual peony conference in Homer in Jan 28 – 30 of 2016 (Objective 5).

All 2015 results were compiled and summarized in tables (Tables, 1, 2, 3, 4, and 5). There were apparent difference between “good” and “poor” for both Sarah Bernhardt and Duchess in soil organic matter content, active soil pH and total cation exchange capacity (Table 1), but those differences were very narrow, indicating that those parameters were not the ones that related to status of peony growth in the field at time of soil sampling. Comparing the mineral N, extractable P and Mehlich 3 P, a difference was found for mineral N in the interior for Sarah Bernhardt and in South Central for Duchess between “good” and “poor” (Table 2). For extractable P, the difference between “good” and “poor” was relatively large for both Sarah and Duchess for the interior, south central and Kenai Peninsula (Table2). For exchangeable K, a difference was also found between “good and “poor” for Duchess in the interior and Sarah Bernhardt in the Kenai Peninsula (Table 2). For micro nutrients, the only large difference was found in Zn for Duchess in the interior and south central between “good” and ‘poor” (Table 3). Other micronutrients were similar between “good” and “poor” for all regions.

For nutrient concentration in peony tissues, a large difference was found for N concentration between “good” and “poor” in all three locations for both cultivars (Table 4), but those differences were narrow for P and K concentration. In some occasions, the “poor peony” had a higher P and K concentrations (Table 4). There were narrow differences between “good” and “poor” for all micronutrient concentrations (Table 5).

We have taken soil and tissue samples both “good” and “poor” peonies at each peony field. In soil samples, there were P and K cases where the concentrations in soil were different between “good” and “poor”. But in plant tissue samples, only N showed a larger difference between “good” and “poor”.

Apparently, the tissue results do not correspond with the soil test results, which means the soil test results at time of soil sampling didn’t reflect plant tissue nutrient status. For perennial root crops, such as peonies, the root has a tendency to store nutrients. In previous studies at UAF, Zhang et al. (2014) reported that Sarah Bernhardt roots contain 0.94% N, 0.17% P, 0.62% K, 0.46% Ca, 0.11% Mg, and trace amount of micronutrients (3.3 mg Cu, 19 mg Zn, 4.4 mg B, 182 mg Fe, and 18 mg Mn per kg root stock) in the root samples taken in the fall. Those stored nutrients would be used to support shoot and root growth in the next spring. Since N is needed in large quantity, the stored N in roots may not satisfy the plant growth in the spring, therefore for soil without enough N supplement, plant would show stunted growth as compared with the “good” ones. Soil test mineral N is only an instant status of N in soil because soil N released from organic matter is totally controlled by microorganism activities in soil, which is in turn affected by environmental factors such as temperature, and water availability.

A YouTube video (https://www.youtube.com/watch?v=Y_MM9AbfHqs) of how to take soil samples and meaning of the soil test items was made in cooperation with the publication office of School of Natural Resources and Extension (Objective 6).

Beneficiaries

The beneficiaries of this research study are all of the present and future peony growers in the state of Alaska. In combination with previous soil and tissue sample results (e.g.2014), we are one step closer to develop an adequate nutrient management for peony growers. In addition, the YouTube video developed from this project will help growers to take soil and tissue sample correctly so that the results can be better used for diagnostics and for nutrient management in peony field.

The beneficiaries from this project were estimated about 154 people including current and potential growers, people from non-government organizations and private sectors. This estimated numbers were derived from two major events i.e. project presentations in the Alaska Annual Peony conference, and field days in the summer in the interior regions. In addition, the beneficiaries also included the growers from who samples were taken and results were interpreted through emails, and individuals who asked questions about nutrient management either through email or in person.

Lessons Learned

We have accomplished every objective in the proposal. The research results provide guidelines for peony nutrient diagnostic concentrations for “good peony” and “poor peony” for nitrogen nutrients. For other nutrients, problem existed with the interpretation of the 2015 final results, especially when compared with the results from previous years’ studies. Soil tests nevertheless provided ranges of sufficient and deficient nutrient concentrations. To develop a reliable peony nutrient management guideline, a minimum of three year results are needed to cover a wide range of weather variations since weather (i.e. temperature and precipitation) affects plant’s ability to take up nutrients. We have collected soil and tissue data in 2014, now 2015. We need to collect one additional year data in order to develop such guideline, and one additional year data to validate the to be developed guideline.

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Additional Information

Zhang, M., P. Holloway, R.V. Veldhuizen. 2014. Peony nutrient requirement. Annual Alaska peony conference. Jan. 30 – 31, 2014, Anchorage, Alaska, USA.

Zhang, M. R.V. Veldhuizen. 2015. Peony research report of 2014. Annual Alaska peony conference. Jan. 30 – 31, Fairbanks, Alaska, USA.

Zhang, M. and R.V. Veldhuizen. 2016. Peony research report 2015, presentation in annual conference of Alaska Peony Growers Association, January 28 to 30, 2016, Homer, Alaska.

Table 1. Average values of soil organic matter (SOM), pH, cation exchange capacity (CEC) from the interior, south central, and the Kenai Peninsula.

Analytical item	Sarah Bernhardt		Duchess	
	Good	Poor	Good	Poor
Interior				
SOM (%)	8.18 (2.69 – 13.3)	9.07 (3.03 – 16.5)	5.00 (2.27 – 8.40)	4.56 (2.60 – 6.5)

pH	5.8 (4.9 – 7.6)	5.8 (7.6 – 5.2)	6.0 (4.9 – 7.0)	6.2 (5.0 – 7.0)
CEC (meq/100g)	18.02 (10.81 – 22.70)	17.84 (7.53 – 23.90)	13.45 (8.34 – 21.30)	13.28 (7.09 – 17.80)
South Central				
SOM (%)	8.87 (3.41 – 14.50)	7.25 (2.14 – 10.77)	6.50 (1.32 -11.67)	5.94 (1.15 – 10.73)
pH	5.9 (5.5 – 6.8)	5.9 (5.3 – 6.9)	6.1 (5.5 – 6.7)	5.7 (5.7 – 5.7)
CEC (meq/100g)	9.97 (5.57 -15.00)	10.33 (6.65 – 14.73)	7.52 (6.40 – 8.64)	6.34 (4.30 – 8.38)
Kenai Peninsula				
SOM (%)	13.44 (11.68 – 15.38)	13.78 (12.32 – 14.69)	12.83 (8.89 – 16.63)	13.44 (7.95 – 17.45)
pH	5.7 (4.8 – 6.1)	5.4 (4.8 – 6.1)	5.6 (5.0 – 5.9)	5.6 (5.1 – 6.3)
CEC (meq/100g)	13.42 (9.37 – 16.84)	13.16 (10.45 – 14.91)	14.06 (10.11 – 25.19)	14.80 (10.45 – 21.08)

[1]Numbers in the parenthesis= range of the tested item in the samples.

Table 2. Average values (and Ranges) of soil mineral N (NH4-N + NO3-N), Mehlich 3 phosphorus, and exchangeable potassium concentration from the interior, south central, and the Kenai Peninsula.

Analytical item	Sarah Bernhardt		Duchess	
	Good	Poor	Good	Poor
Interior				
Ammonium (ppm)	27.6 (1.0 – 95.4)	37.4 (0.7 – 328.6)	6.2 (0.8 – 20.9)	2.5 (0.8 – 4.2)
Nitrate (ppm)	15.1 (0.5 – 59.4)	18.1 (0.5 – 77.1)	17.3 (0.5 – 63.9)	21.0 (0.5 – 95.7)

Mineral N (ppm)	42.7 (1.5 – 98.7)	30.5 (1.4 – 79.0)	23.5 (1.3 – 84.8)	23.5 (1.3 – 99.9)
Mehlich 3 P (ppm)	310 (81 – 518)	282 (61 – 775)	182 (54 – 360)	106 (76 – 131)
Exchange K (ppm)	430 (155 – 710)	467 (183 – 1883)	188 (45 – 265)	145 (68 – 215)
South Central				
Ammonium	2.3 (0.5 – 3.6)	2.6 (1.6 – 3.8)	2.2 (1.3 – 3.0)	2.4 (1.4 – 3.3)
Nitrate	3.4 (0.6 – 7.5)	3.5 (0.5 – 9.6)	14.3 (28.1 – 0.5)	8.1 (15.6 – 0.5)
Mineral N (ppm)	5.6 (3.1 – 8.0)	6.1 (2.6 – 11.2)	16.5 (1.8 – 31.1)	10.4 (1.9- 18.9)
Mehlich 3 P (ppm)	68 (42 – 101)	47 (24 – 101)	42 (36 -47)	37 (31 – 42)
Exchange K (ppm)	213 (130 – 315)	206 (140 – 360)	162 (126 – 197)	196 (187 – 205)
Kenai Peninsula				
Ammonium	3.8 (3.0 – 5.0)	5.0 (3.5 – 8.3)	5.6 (3.6 – 9.4)	6.3 (3.3 – 12.4)
Nitrate	5.9 (0.5 – 16.1)	10.4 (1.8 – 29.3)	14.3 (0.5 – 4.6)	13.8 (0.7 – 37.6)
Mineral N (ppm)	9.7 (3.8 (19.7)	15.4 (6.8 – 32.8)	19.9 (4.3 – 52.4)	20.2 (4.6 – 41.0)
Mehlich 3 P (ppm)	48 (19 – 93)	45 (10 – 74)	58 (13 – 99)	80 (10 – 255)
Exchange K (ppm)	163 (74 – 302)	137 (70 – 220)	131 (52 – 387)	147 (49 – 402)

[1]Numbers in the parenthesis = range of the tested item in the samples.

Table 3. Average values (and ranges) of key soil micronutrient concentrations from the interior, south central and the Kenai Peninsula.

Analytical item	Sarah Bernhardt		Duchess	
	Good	Poor	Good	Poor
Interior				
Ca (ppm)	1872 (909 – 2414)	1891 (597 – 2547)	1599 (510 – 2537)	1686 (437 – 2352)
Mg (ppm)	328 (86 – 581)	330 (73 – 469)	257 (54 – 601)	266 (45 – 522)
B (ppm)	0.69 (0.44 – 1.1)	0.67 (0.46 – 0.90)	0.63 (0.5 – 0.8)	0.61 (0.5 – 0.8)
Mn (ppm)	26.0 (11.0 – 49.0)	25.0 (8.0 – 50.0)	25.7 (10.0 – 54.0)	20.8 (8.0 – 39.0)
Cu (ppm)	2.8 (1.3 – 8.2)	3.0 (1.3 – 9.0)	3.3 (1.2 – 5.0)	3.0 (1.0 – 4.0)
Zn (ppm)	13.2 (2.5 – 60.0)	11.0 (2.2 – 27.0)	7.1 (2.1 – 15.0)	4.7 (2.0 – 9.8)
South Central				
Ca (ppm)	1261 (605 (2358)	1395 (637 – 2310)	1025 (987 – 1063)	751 (439 – 1063)
Mg (ppm)	101 (46 – 208)	94 (37 – 215)	50 (46 – 54)	52.0 (49.0 – 55.0)
B (ppm)	0.69 (0.5 – 0.8)	0.60 (0.5 – 0.8)	0.6 (0.5 – 0.7)	0.5 (0.5 – 0.6)
Mn (ppm)	18.0 (7.0 – 25.0)	16.5 (6.0 – 25.0)	37.0 (19.0 – 55.0)	20.0 (10.0 – 29.0)
Cu (ppm)	2.6 (1.3 – 5.8)	2.6 (1.0 – 5.8)	2.3 (1.2 – 3.4)	2.3 (1.3 – 3.3)
Zn (ppm)	5.0 (2.0 – 8.8)	3.9 (1.8 – 6.0)	8.0 (4.6 – 11.4)	4.1 (2.8 – 5.5)
Kenai Peninsula				

Ca (ppm)	1678 (543 – 2305)	1519 (974 – 2313)	1725 (1127 – 3277)	1818 (1129 – 3136)
Mg (ppm)	95.0 (34.0 – 152.0)	73.0 (25.0 – 98.0)	149 (75 – 411)	145 (60 – 324)
B (ppm)	0.6 (0.5 – 0.7)	0.6 (0.3 – 0.8)	0.5 (0.4 – 0.6)	0.6 (0.4 – 0.8)
Mn (ppm)	8.0 (6.0 – 13.0)	9.0 (4.0 – 12.0)	11.0 (6.0 – 19.0)	11.0 (5.0 – 19.0)
Cu (ppm)	1.3 (0.9 – 2.0)	1.1 (0.7 – 1.3)	1.4 (1.0 – 2.4)	1.8 (1.1 – 3.8)
Zn (ppm)	3.2 (1.8 – 4.7)	2.5 (1.9 – 3.5)	3.6 (1.9 – 5.3)	5.8 (1.7 – 20.2)

[1]Numbers in the parenthesis = range of the tested item in the samples.

Table 4. Average values (and ranges) of nitrogen, phosphorus, and potassium concentrations in peony tissue from the interior, south central and Kenai Peninsula.

Analytical item	Sarah Bernhardt		Duchess	
	Good	Poor	Good	Poor
Interior				
Nitrogen (%)	2.37 (1.96 – 2.95)	2.08 (1.55 – 2.99)	2.41 (2.13 – 3.06)	2.08 (1.65 – 2.89)
Phosphorus (%)	0.27 (0.19 – 0.36)	0.28 (0.16 – 0.35)	0.26 (0.19 – 0.34)	0.26 (0.20 – 0.33)
Potassium (%)	1.06 (0.79 – 1.33)	1.24 (0.86 – 1.85)	1.15 (0.97 – 1.32)	1.40 (1.09 – 1.77)
South Central				
Nitrogen (%)	2.01 (1.78 – 2.30)	1.67 (1.39 – 1.88)	2.07 (1.84 – 2.30)	1.70 (1.26 – 2.13)
Phosphorus (%)	0.24 (0.21 – 0.29)	0.24 (0.19 – 0.30)	0.22 (0.16- 0.28)	0.17 (0.16 – 0.18)

Potassium (%)	1.13 (0.97 – 1.29)	1.01 (0.87 – 1.19)	1.20 (1.13 – 1.27)	1.08 (1.01 – 1.15)
Kenai Peninsula				
Nitrogen (%)	2.00 (1.86 – 2.25)	1.59 (1.34 – 1.88)	2.03 (1.72 – 2.51)	1.93 (1.43 – 2.38)
Phosphorus (%)	0.22 (0.18 – 0.25)	0.19 (0.14 – 0.21)	0.20 (0.24 – 0.13)	0.19 (0.12 – 0.25)
Potassium (%)	1.05 (0.67 – 1.50)	0.99 (0.71 – 1.35)	0.92 (0.63 – 1.26)	0.99 (0.52 – 1.30)

[1]Numbers in the parenthesis = range of the tested item in the samples.

Table 5. Average values (and ranges) of key micronutrient concentrations in peony tissue from the interior, south central and Kenai Peninsula.

Analytical item	Sarah Bernhardt		Duchess	
	Good	Poor	Good	Poor
Interior				
Ca (%)	1.05 (0.64 – 1.42)	0.73 (0.42 -1.14)	1.23 (0.70 – 1.85)	0.90 (0.56 – 1.27)
Mg (%)	0.34 (0.19 – 0.47)	0.28 (0.14 – 0.35)	0.37 (0.29 – 0.48)	0.30 (0.25 – 0.35)
S (%)	0.21 (0.14 – 0.27)	0.19 (0.12 – 0.24)	0.20 (0.15 – 0.24)	0.18 (0.13 – 0.21)
B (ppm)	13.6 (2.3 – 51.6)	11.9 (2.7 – 25.0)	14.9 (2.1 – 21.7)	12.0 (1.3 – 24.2)
Fe (ppm)	77.6 (36.2 – 112.0)	64.4 (34.1 – 94.7)	56.5 (37.4 – 113.0)	58.4 (34.2 – 94.2)
Cu (ppm)	4.4 (1.5 – 5.7)	4.5 (2.0 – 6.3)	4.5 (3.9 – 5.3)	4.1 (2.7 – 5.3)
Zn (ppm)	28.2 (17.5 – 43.5)	28.0 (18.9 – 41.1)	35.6 (18.7 – 47.2)	30.5 (15.9 – 46.0)

South Central				
Ca (%)	0.91 (0.61 – 1.22)	0.90 (0.72 – 1.12)	1.12 (1.08 – 1.16)	0.96 (0.74 – 1.17)
Mg (%)	0.18 (0.11 – 0.22)	0.19 (0.13 – 0.23)	0.20 (0.13 – 0.26)	0.20 (0.14 – 0.25)
S (%)	0.18 (0.15 – 0.21)	0.17 (0.14 – 0.20)	0.21 (0.18 – 0.23)	0.15 (0.13 – 0.17)
B (ppm)	14.4 (5.6 – 25.6)	11.9 (7.3 – 17.0)	23.8 (17.2 – 30.3)	18.8 (10.5 – 27.1)
Fe (ppm)	57.7 (40.4 – 89.9)	45.3 (27.0 – 70.1)	38.5 (31.6 – 45.3)	38.5 (29.2 – 47.7)
Cu (ppm)	4.8 (3.2 – 7.0)	3.7 (3.2 – 4.1)	4.0 (3.6 – 4.3)	2.6 (2.2 – 2.9)
Zn (ppm)	37.4 (21.3 – 48.7)	37.6 (26.2 – 51.2)	56.1 (46.4 – 65.7)	45.7 (38.5 – 52.9)
Kenai Peninsula				
Ca (%)	1.05 (0.70 – 1.33)	0.92 (0.80 – 1.08)	1.27 (0.95 – 1.85)	1.20 (0.78 – 1.76)
Mg (%)	0.21 (0.10 – 0.33)	0.19 (0.11 – 0.25)	0.34 (0.21 – 0.45)	0.32 (0.20 – 0.43)
S (%)	0.18 (0.17 – 0.21)	0.15 (0.13 – 0.17)	0.19 (0.16 -0.23)	0.18 (0.15 – 0.24)
B (ppm)	17.0 (4.0 – 30.8)	15.3 (2.9 – 26.0)	16.7 (4.2 – 35.5)	16.7 (3.6 – 33.9)
Fe (ppm)	107.9 (33.2 – 360.0)	99.5 ((28.8 – 357.0)	78.6 (36.4 – 266.0)	79.0 (32.1 – 300)
Cu (ppm)	4.1 (2.7- 5.9)	3.2 (1.2 – 4.6)	4.2 (3.4 – 6.3)	3.6 (2.8 – 4.6)
Zn (ppm)	32.7 (20.8 – 45.9)	26.5 (18.5 – 31.6)	42.0 (17.2 – 56.2)	37.5 (14.7 – 52.4)

[1]Numbers in the parenthesis = range of the tested item in the samples.

Project #7: Cauliflower Trials

Partner Organization: Alaska Plant Materials Center, State of Alaska, Department of Natural Resources, Division of Agriculture

Project Summary

- Specialty crop producers are continuing to expand production to meet the requests and demands of the food service industry. One product that is continually requested from both farmer market shoppers and chefs is cauliflower. Research and field trials on cauliflower have not been done in Alaska. This project will help identify yield, head uniformity, maturation dates, field holding capability and head size, shape and color of 34 cauliflower varieties.
- Alaska has unique growing conditions that do not allow for direct fit of yield and performance criteria from other areas of the United States. Trialing cauliflower variety performance in Alaska will help demonstrate the qualities or lack of desired traits when observed in Alaska's climates. This planting will help identify those selections worthy of further evaluation.
- This project is timely and important in addressing the needs of the specialty crop industry in Alaska due to the lack of any other cauliflower variety trial research being conducted.

Project Approach

- Alaska is a large state with different climates located throughout. A survey was established on our website to find growers interested in participating throughout the state. A total of 20 growers with 21 locations were interested in participating. They were given the option of selecting the number of cultivars/varieties to grow with a minimum of 5 plants per variety. All the cultivars/varieties were grown at the Alaska Plant Materials Center (PMC) in Palmer, Alaska. The other locations were in Fairbanks, Glenallen, Copper Center, Homer, Nikiski, Nome, Gakona, Petersburg, Kenai, Ester, North Pole and Salcha.
- An adequate amount of seed was mailed to each grower with cultivation information and data collection sheets.
- Each grower was asked to share their cultivation techniques along with data collected; i.e. insect and disease issues, amount of leaf wrap and sun yellowing, harvest dates, and harvested diameter and weight.
- During the 2015 growing season, the plot at the PMC was tilled and amended with a 16-16-16 fertilizer at the rate of 128 lb./A of nitrogen. Goal 2XL was used as a pre-emergent herbicide. The seeds were germinated in the greenhouse and watered and fertilized as needed. After 4 weeks in the greenhouse, the seedling transplants were moved outside to harden off for one week. On May 28, the cauliflower was transplanted into the field, 18" O.C. and 42" between rows. Ten plants of each variety were planted. The rows were watered with drip irrigation as needed.
- The entire crop of cauliflower at the PMC was destroyed by moose during the 2015 growing season. It was also difficult to gather consistent data from the participating growers. Three of the growers had complete crop failure and only 10 of the remaining 18 returned their collected data. The data that was returned was extremely inconsistent. Due to these issues, the project was completed in a different manner for the 2016 and 2017 growing season. The cauliflower was only grown at the PMC by their staff for these two seasons to gather better results.

- One site visit was conducted in Homer. It was the only grower that requested many plants that had any success.
- During the 2016 and 2017 growing seasons at the PMC, the trial was conducted in the same manner as 2015 except that the location of the trial was moved into a fence enclosure.
- In 2016, all 34 cultivars/varieties were grown. The plants were transplanted on June 2 and the cauliflower was harvested from August 2 until September 6.
- In 2017, the same cultivars/varieties were grown except three due to seed failure; Baldo, BOS 92126 and Orbit. The plants were planted on June 1 and harvested from August 2 until September 12.
- The 2016 season was warmer and drier than the 2017 season. This can be observed in the graphs located in the additional information section.
- The plants were observed for insect damage, disease, amount of leaf wrap and signs of sun damage. At harvest the cauliflower heads were measured for size and weight.

Goals and Outcomes Achieved

- Determine if certain cultivars/varieties of cauliflower will perform well for producers or market growers throughout Alaska. Several white and some of the non-traditional, specialty, colored cauliflowers performed well during both seasons.
- An extremely early variety was Celeritas with some leaf wrap. Additional leaf wrapping would be needed to get a nice white head.
- None of the white open-pollinated varieties performed well. Some of the white hybrids also did not produce heads with tight curds. These varieties should not be grown; Snowball Self-Blanching, Snowball Y and Early White.
- Some of the top-performing white cauliflowers were Symphony, Synergy, Amazing, Titan, Denali, Casper, Cielo Blanco and Candid Charm, producing some leaf wrap and dense, white heads. Others to consider are Ravella, Minuteman, Bishop, Freedom and Skywalker. These are in no order. The top-performing yellow cauliflower was Cheddar. Orange Burst and Sunset were inconsistent in size and shape. The best purple cultivar was Graffiti although the two other varieties produced nice, white with purple heads. The best performing green cauliflowers were Vitaverde and Panther. All the Romanesca cultivars were unique and worth growing but Veronica performed the best.
- Since the project was continued for an additional growing season, a presentation will be given at the Alaska Sustainable Agriculture Research and Education Conference in 2018. The conference is attended by over 100 professionals and growers from around the state.
- During both successful growing seasons at the PMC, approximately 12 growers visited the plot throughout the season and during harvest.
- An article discussing the cauliflower trial and results will be published in The Alaska Division of Agriculture's Newsletter this winter. A final report will also be made available on the PMC website when finished.

Beneficiaries

- Over 500 farmers, market growers and home growers throughout the state will benefit from this evaluation trial.
- Over 70 restaurants and chefs, participating in the Alaska Grown® Restaurant Rewards program would be able to offer cauliflower on their menus. Tourism during the summer months creates a high demand on local restaurants offering locally grown food.
- Extension agents and master gardeners could benefit from this information for future recommendations and publications.

Lessons Learned

- Alaska is a large state with remote areas. It is difficult to get resources to individuals easily. Many growers may not have the space for germinating seed nor the area to grow many plants.
- Many growers in Alaska have full-time jobs along with their farming jobs. They cannot easily complete many of the requirements needed to complete this trial at multiple locations.
- Cauliflower is not only a delicacy to humans but moose find it to be the best tasting crop. As soon as the heads begin to form, the moose will eat every one before it can be harvested. It is expensive to fence large areas of land needed to produce a substantial amount of cauliflower.
- Soil tests should be done when growing brassicas in Alaska. There is an increased chance of boron deficiency in Alaskan soils when nitrogen is increased. This causes hollow stems in brassicas.
- During the 2015 and 2016 seasons, there was no signs of insect problems with cauliflower. In 2017, there was a significant amount of root maggot infestation. The cauliflower plants were not affected by the insects and still produced marketable heads.

Contact

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Division of Agriculture
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Additional Information

Varieties/Cultivars Trialed and Sources for Seed

- White
    - Amazing (F1) – Johnny's Selected Seed
    - Attribute (F1) – Burpee
    - Baldo (F1) – Osborne Seed Co.
    - Bishop (F1) – Johnny's Selected Seed
    - BOS 92126 (F1) – Osborne Seed Co.

- Candid Charm (F1) – Osborne Seed Co.
- Casper (F1) – Osborne Seed Co.
- Celeritas (F1) – Osborne Seed Co.
- Cielo Blanco (F1) – Osborne Seed Co.
- Denali (F1) – Johnny's Selected Seed
- Early White (F1) – Burpee
- Freedom (F1) – Veseys Seeds
- Minuteman (F1) – Veseys Seeds
- Ravella (F1) – Osborne Seed Co.
- Skywalker (F1) – Johnny's Selected Seed
- Snow Crown (F1) – Johnny's Selected Seed
- Snowball Self-Blanching (OP) – Burpee
- Snowball Y (OP) – Burpee
- Symphony (F1) – Veseys Seeds
- Synergy (F1) – Osborne Seed Co.
- Titan (F1) – Osborne Seed Co.
- Venus (F1) – Osborne Seed Co.

- Yellow
    - Cheddar (F1) – Johnny's Selected Seed
    - Orange Burst (F1) – Territorial Seed Co.
    - Sunset (F1) – West Coast Seeds

- Purple
    - Graffiti (F1) – Johnny's Selected Seed
    - Purple of Sicily (OP) – Baker Creek Heirloom Seeds
    - Violetta Italia (OP) – Baker Creek Heirloom Seeds

- Green
    - Green Macerata (OP) – Baker Creek Heirloom Seeds
    - Panther (F1) – Territorial Seed Co.
    - Vitaverde (F1) – Johnny's Selected Seed

- Romanesca
    - 26-701 (F1) – Osborne Seed Co.
    - Orbit (F1) – Osborne Seed Co.
    - Veronica (F1) – Johnny's Selected Seed

Bishop

Freedom

Denali

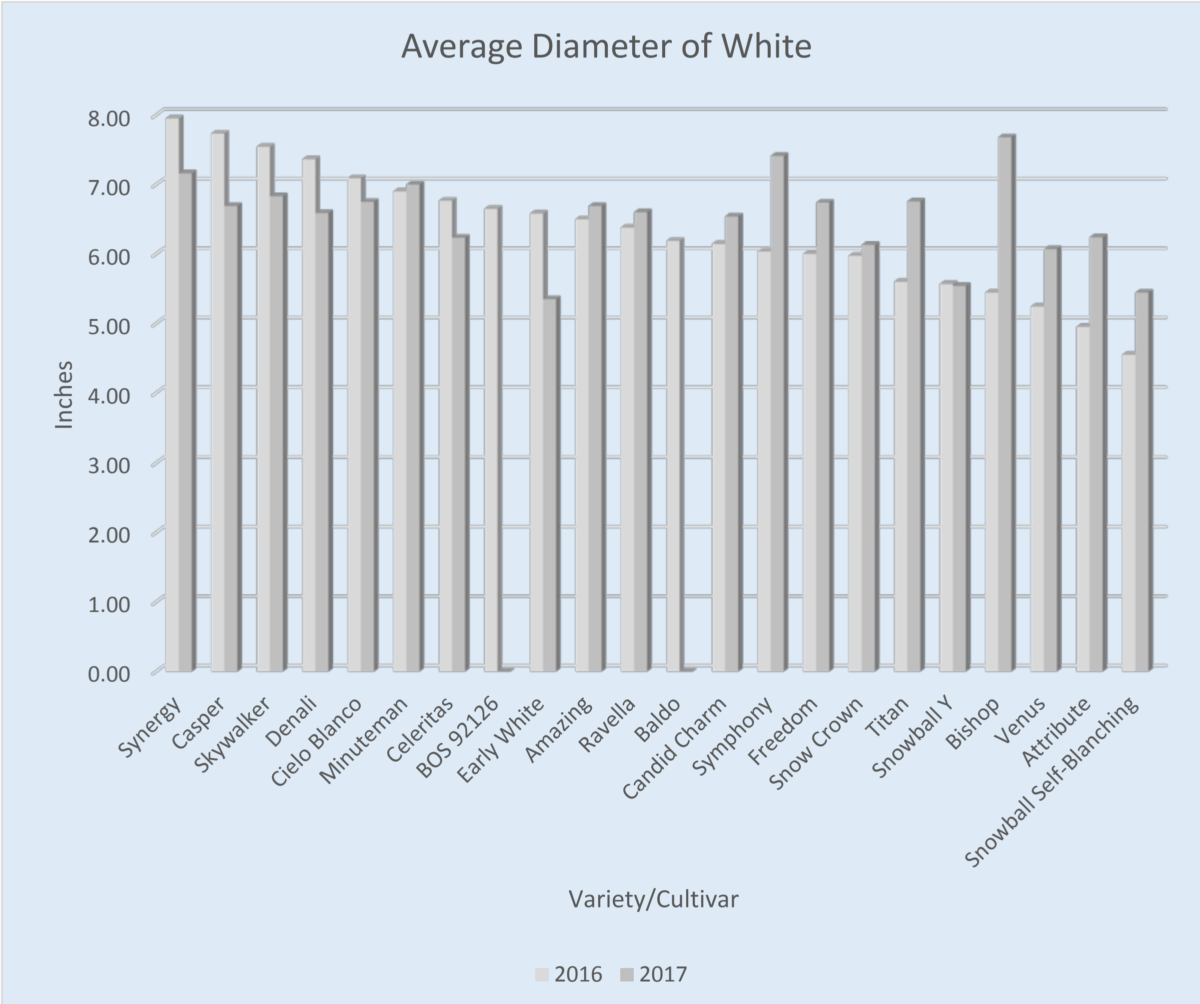
Minuteman

Candid Charm

Casper

Cielo Blanco

Skywalker

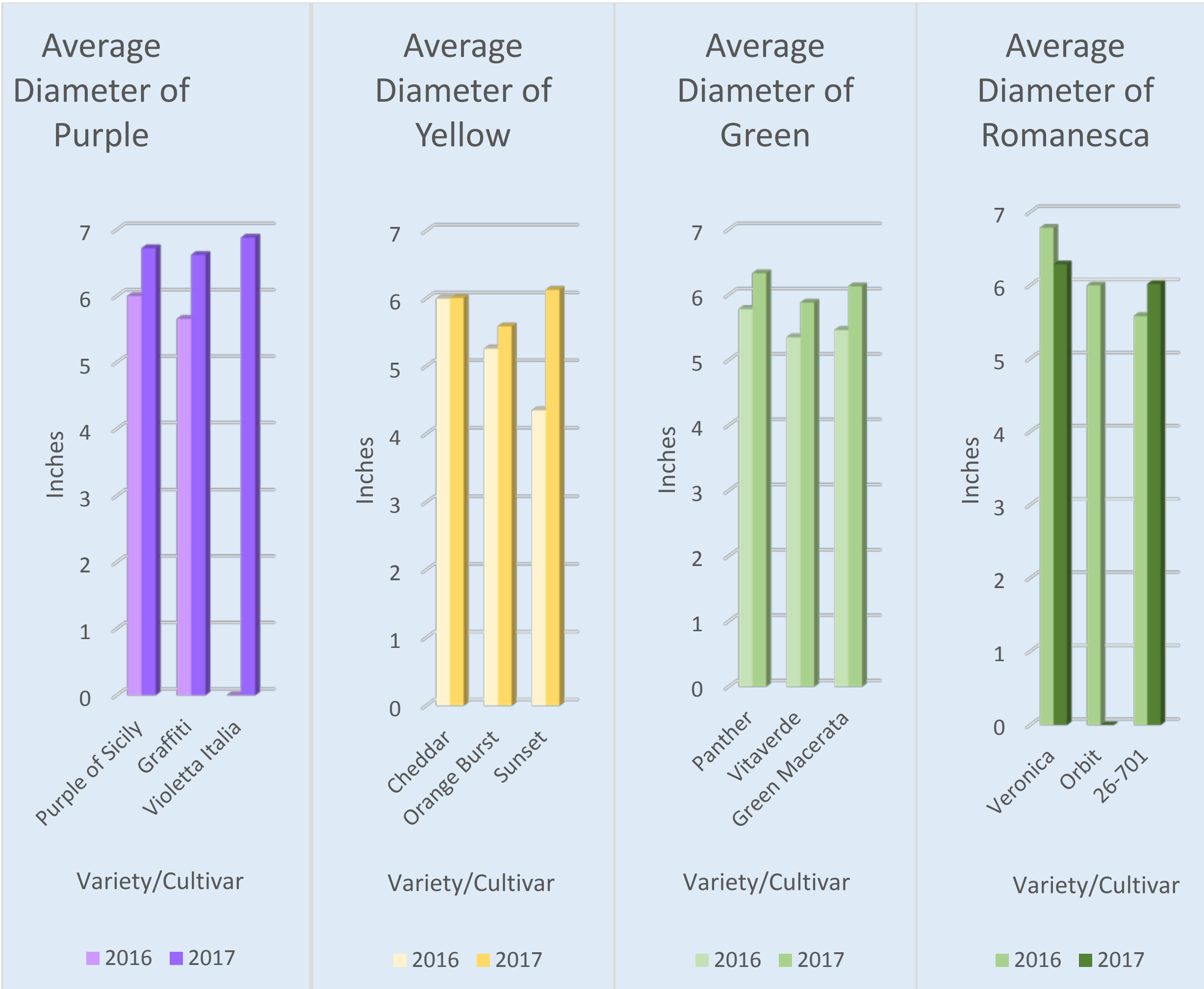


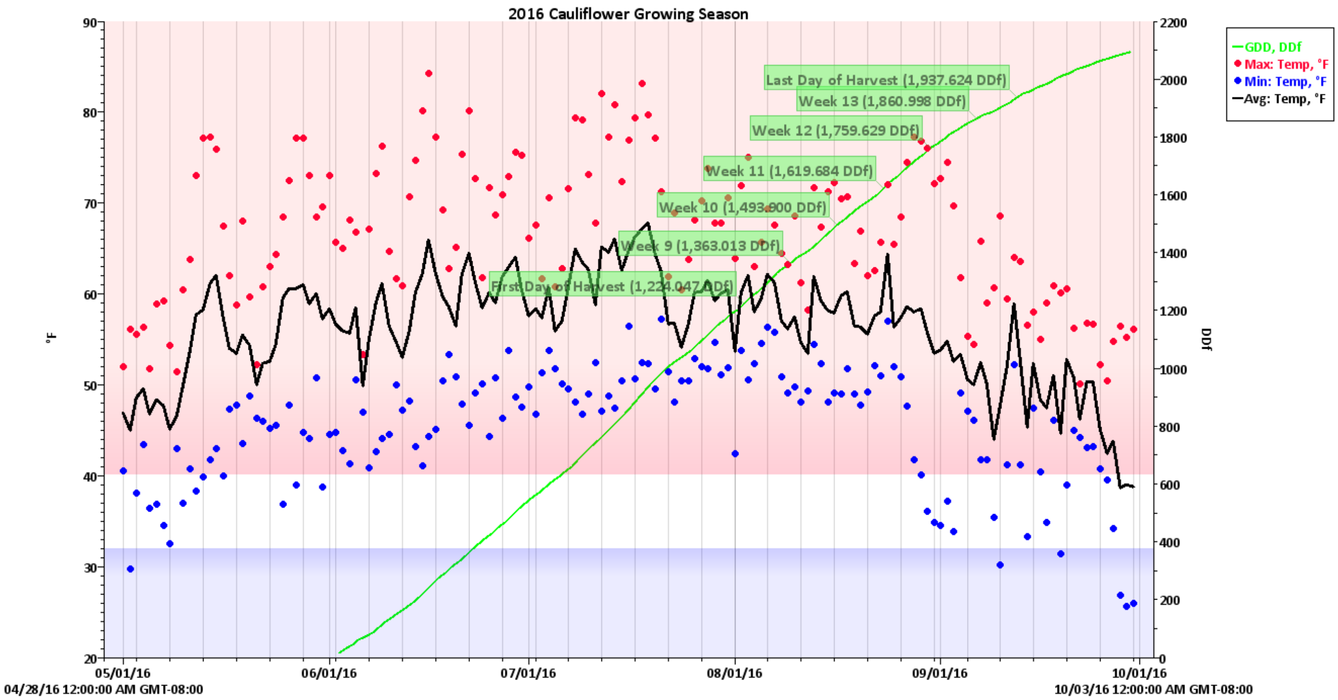
Cheddar

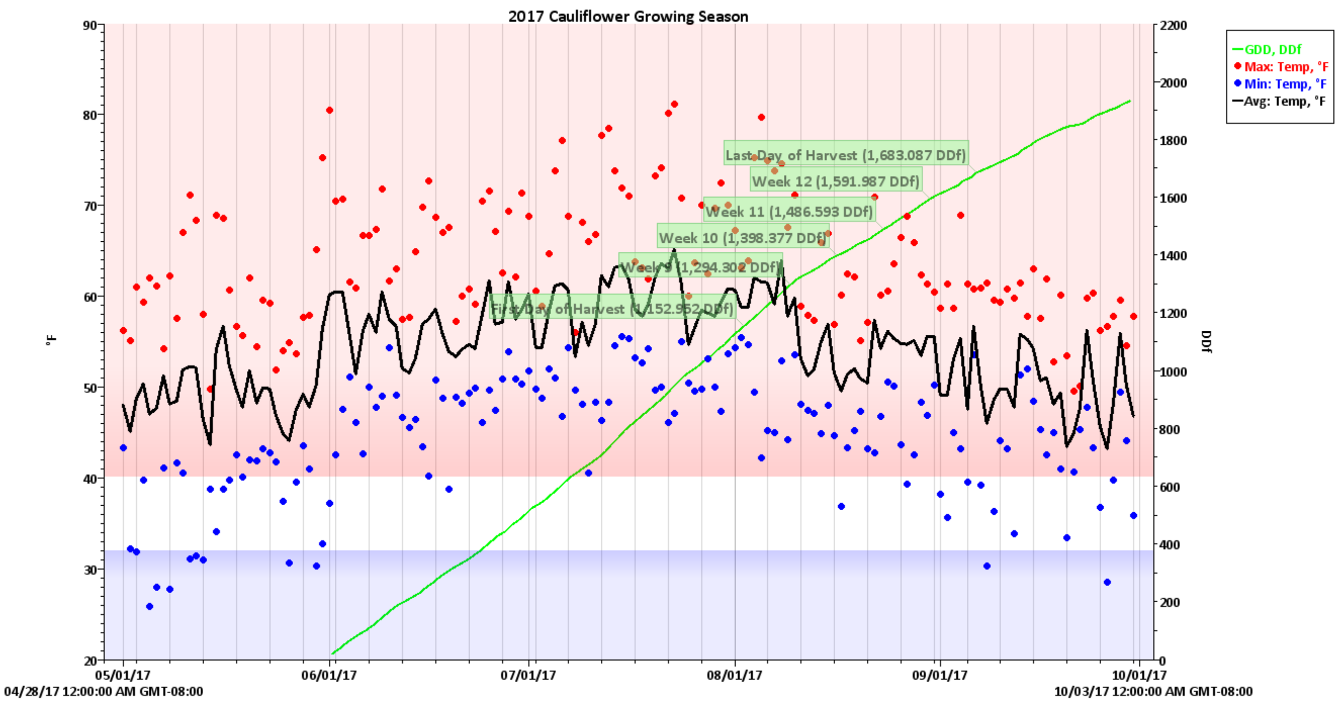
Graffiti

Vitaverde

Veronica


Average Diameter of Purple
Inches
7
6
5
4
3
2
1
0
Purple of Sicily
Graffiti
Violetta Italia
Variety/Cultivar
2016
2017
Average Diameter of Yellow
Inches
7
6
5
4
3
2
1
0
Cheddar
Orange Burst
Sunset
Variety/Cultivar
2016
2017
Average Diameter of Green
Inches
7
6
5
4
3
2
1
0
Panther
Vitaverde
Green Macerata
Variety/Cultivar
2016
2017
Average Diameter of Romanesca
Inches
7
6
5
4
3
2
1
0
Veronica
Orbit
26-701
Variety/Cultivar
2016
2017


2016 Cauliflower Growing Season
°F
DDf
GDD, DDf
Max: Temp, °F
Min: Temp, °F
Avg: Temp, °F
Last Day of Harvest (1,937.624 DDf)
Week 13 (1,860.998 DDf)
Week 12 (1,759.629 DDf)
Week 11 (1,619.684 DDf)
Week 10 (1,493.900 DDf)
Week 9 (1,363.013 DDf)
First Day of Harvest (1,224.047 DDf)
05/01/16
06/01/16
07/01/16
08/01/16
09/01/16
10/01/16
04/28/16 12:00:00 AM GMT-08:00
10/03/16 12:00:00 AM GMT-08:00


2017 Cauliflower Growing Season
°F
DDf
GDD, DDf
Max: Temp, °F
Min: Temp, °F
Avg: Temp, °F
Last Day of Harvest (1,683.087 DDf)
Week 12 (1,591.987 DDf)
Week 11 (1,486.593 DDf)
Week 10 (1,398.377 DDf)
Week 9 (1,294.302 DDf)
First Day of Harvest (1,152.952 DDf)
05/01/17
06/01/17
07/01/17
08/01/17
09/01/17
10/01/17
04/28/17 12:00:00 AM GMT-08:00
10/03/17 12:00:00 AM GMT-08:00

Project #8: On Farm Food Safety Workshops

Project Summary

Most Alaska's specialty crop farms are considered "micro" in size (0-5 acres) and few of them have pursued food safety inspection certifications such as USDA's Good Agricultural Practices (GAP). With the Food Safety Modernization Act and development of a state program there has been a resurgence on interest in farm produce safety requirements. Alaska farmers have been eager to get more produce safety training and development of farm plans. To build on our past workshops we intend to return to communities, host a refresher for basic farm food safety principles and host farm plan development to begin assisting producers with the creating their farm food safety plans.

Project Approach

Our intention with this program was to build off a previously funded project "On Farm Food Safety Workshops" funded in 2011 and 2013 by SCBG-FB. With this newly funded project we wanted to increase the food safety knowledge and skills of Alaska's farmers, prepare them for future GHP/GAP audits, and help provide much needed information about the differences between USDA's GHP/GAP program and FDA's FSMA (Food Safety Modernization Act) PSR (Produce Safety Rule). To accomplish these goals, we took these steps:

- We compiled all the resources used from the previously funded project and updated all the information. We then created a second set of information that was a condensed version of the original that encompassed the core areas of the GHP/GAP program and what the GAP requirements are for audit purposes.
- As we expected a large number of questions around FDA's FSMA PSR. We tried to add in content to explain the difference between FDA's program and USDA's GAP program. This was added to help bring understanding about USDA's GAP standards and requirements for the production of specialty crops.
- Once our information and materials for the workshops was compiled, we began looking for outreach opportunities and workshop venues. We contacted other agencies (University Cooperative Extension, Soil and Water Conservation Districts) to help plan and bring awareness to our upcoming workshops.
- Our first workshop was scheduled to be held in Fairbanks, AK where we had a total of 7 attendees. The workshop went well, the small number of attendees allowed for more questions to be asked and answered as well as ideas and best practices to be shared amongst the group. Growers that attended the workshop left with materials that would help facilitate a farm food safety plan and the knowledge and resources to create food safety plans for their operations.

After our initial workshop, we realized that the information and practices we were trying to provide were too complex for a traditional workshop setting, also it was hard to maximize grower attendance due the time of year. We initially planned for 4 other workshops to be hosted through the state but we did not have any attendees sign up. Ultimately these workshops were canceled due to the lack of participation. With this new information, we decided to take the efforts of the course and took the following steps:

- We took a more specialized approach to help individual growers create farm food safety plans for their growing operations.

- We began reaching out to growers who we knew were interested in creating farm food safety plans and would have the potential to sell or had previously sold to markets that required a farm food safety plan in place.
- We scheduled 4 individual meetings with growers in the state to plan and prepare farm food safety plans. Half of the scheduled meetings had to be moved due to harvest conflictions.

Goals & Outcomes Achieved

We were able to host 1 workshop with 7 attendees. The small number of participants allowed the attendees to ask more questions and give examples. This helped the group learn from each other as well as from our materials. Each individual left with information on how to create a farm food safety plan for their growing operation and the knowledge to practice the plans they put in place.

With our individual meetings, we were able to produce farm food safety plans specific to each of the grower's operations. Visiting the farms first hand was very helpful in creating food safety plans that actually worked with their farms. Many realized that they were following best food safety practices already but just need to change small parts or begin documenting what they were doing. This helped take the fear that they had associated with GHP/GAP programs and documentation and made it easy to practice.

Our Goal was: To increase specialty crop producers' knowledge of GAP and other on-farm food safety requirements through participation in a regional on-farm food safety workshop.

The benchmark was originally going to be measured through a pre-workshop survey. Unfortunately, our workshop was attended by our sister agency the Department of Environment Conservation (DEC), Office of State Vet who had been hosting produce safety workshops related to FSMA. With no collaborate effort to coordinate the few attendees we did have in attendance were quite confused by the multiple government staff and different information. As a result, we did not want to complicate the matter further and made the decision to not administer a pre/post survey.

Performance Measure: Increase in on-farm food safety knowledge measured by pre- and post-workshop surveys. While we did not administer this survey, we did collect anecdotal information from attendees and growers. Out of all three regions and nine attendees we had one food safety plan developed in Southwest Alaska, one is planning on writing a farm food safety plan next season, and the other attendees indicated they learned a significant amount compared to what they knew beforehand.

- Target: 50% increase in knowledge regarding GAP and other on-farm food safety requirements due to attending an on-farm food safety workshop. We believe, even though there isn't a pre/post survey, that 100% of the food safety workshop and consults resulted in an increase in knowledge regarding GAP and other food safety requirements.

Beneficiaries

Directly this program effected 11 specialty crop growers through the state. One of these growers will be working with a larger buyer who requires food safety plans to access and sell in their market.

Long term the program that was created can be easily used to help any additional growers who are ready to scale up their operations and create their own farm food safety plans.

Lessons Learned

- The timing of the workshops hindered our attendance numbers. August and September are big harvest months which keeps growers very busy. Even when we contacted growers to schedule a 1 on 1 meeting to review GHP/GAP practices and create food safety plans we were hard pressed to find a time that would work within those months.
- The audience that did attend our workshop was varied in their level of knowledge of GHP/GAP best practices. This presented a challenge to ensure that all attendees left with a better understanding of food safety standards. We decided that not removing any of the basic or fundamental information would have been best. This would provide essential information to first time attendees and a good refresher for those attendees who have a good foundation in farm food safety.

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