SPECIALTY CROP BLOCK GRANT PROGRAM

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Promoting the Availability of Connecticut Specialty Crops through Connecticut's Radio Waves

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Project Summary

To bring awareness to Connecticut consumers about the availability and diversity of Connecticut specialty crops available year-round. The late fall, holidays, and winter are a time in Connecticut when consumers stop thinking about buying local farm products. The short day and cold winters give consumers the idea that local specialty crops are unavailable. This project reinforced the year-round availability of specialty crops and highlighted lesser known specialty crops to increase consumer awareness.

Through the Specialty Crop Block Grant, radio advertisements were conducted on a monthly basis from January 2015 through mid-September 2017. This timespan enabled the specialty crop industry to establish a presence and brand with radio listeners.

Promotion from commodity specific specialty crops is often limited. Financial resources tend to be focused on educating growers in lieu of marketing the industry. Those commodity associations that do incorporate marketing have limited resources and cannot afford a media outlet such as radio on a regular basis. This project reiterates a need from the producers' perspective in order to market their crops. From the consumer perspective, the awareness and availability of specialty crops, the length of the growing season, and diversity of specialty crops grown in Connecticut will be reinforced in a medium that is accessible and trusted by the consumer.

This project did not build on a previously funded project with the SCBGP.

Project Approach

The Connecticut Department of Agriculture (DoAG) contracted with Pandora Radio, iHeartRadio, and Bomba 97.1 FM to air audio and/or visual content via traditional and digital radio. Additional funds were allocated to Facebook advertising to increase post engagement and website clicks to the specific specialty crop commodity. The project manager engaged with producers of the monthly featured specialty crop to confirm availability and coordinate start dates of promotions to coincide with peak crop production.

Year One

Beginning in January 2015 through September 29, 2015, the Connecticut Department of Agriculture performed the following activities on a monthly basis:

- Created audio and visual content geared towards promoting a specific commodity
- Updated commodity specific webpage on ctgrown.gov with fresh content designed to be user-friendly and eye-catching
- Created Pinterest page with pins specific to growers and uses of the specialty crop commodity

- Submitted approved audio and visual ad copy to three radio outlets: Pandora Radio, iHeartRadio, and Bomba 97.1 FM
- Scheduled ads on Facebook to increase website clicks and post engagement

Featured specialty crops included the following:

January 2015: Connecticut Grown Honey
February 2015: Connecticut Grown Roses
March 2015: Connecticut Grown Maple Syrup
April 2015: Connecticut Grown Plants & Flowers
May 2015: Connecticut Farm Wineries
June 2015: Connecticut Grown Strawberries
July 2015: Connecticut Grown Blueberries
August 2015: Connecticut Grown Raspberries
September 2015: Connecticut Grown Apples

Year Two

During year two of the project from September 30, 2015-September 29, 2016, the Connecticut Department of Agriculture has continued to perform the following activities on a monthly basis:

- Created audio and visual content geared towards promoting a specific commodity
- Updated commodity specific webpage on ctgrown.gov with fresh content designed to be user-friendly and eye-catching
- Created Pinterest page with pins specific to growers and uses of the specialty crop commodity
- Submitted approved audio and visual ad copy to three radio outlets: Pandora Radio, iHeartRadio, and Bomba 97.1 FM
- Scheduled ads on Facebook to increase website clicks and post engagement

Featured specialty crops included the following:

October 2015: Connecticut Grown Pumpkins
November 2015: Connecticut Grown Winter Squash
December 2015: Connecticut Grown Christmas Trees
January 2016: Connecticut Grown Hydroponics
February 2016: Connecticut Grown Jams, Jellies, Relishes
March 2016: Connecticut Grown Maple Syrup
April 2016: Connecticut Grown Plants & Flowers
May 2016: Connecticut Farm Wineries
June 2016: Connecticut Grown Strawberries
July 2016: Connecticut Grown Blueberries
August 2016: Connecticut Grown Raspberries
September 2016: Connecticut Grown Apples

Year Three

During year three of the project from September 30, 2016 through September 29, 2017, the Connecticut Department of Agriculture performed the following activities on a monthly basis:

- Created audio and visual content geared towards promoting a specific commodity
- Updated commodity specific webpage on ctgrown.gov with fresh content designed to be user-friendly and eye-catching
- Created Pinterest page with pins specific to growers and uses of the specialty crop commodity

- Submitted approved audio and visual ad copy to three radio outlets: Pandora Radio, iHeartRadio, and Bomba 97.1 FM
- Scheduled ads on Facebook to increase website clicks and post engagement

Featured specialty crops included the following:

October 2016: Connecticut Grown Pumpkins
November 2016: Connecticut Grown Winter Squash
December 2016: Connecticut Grown Christmas Trees
January 2017: Connecticut Grown Honey
February 2017: Connecticut Grown Root Vegetables
March 2017: Connecticut Grown Maple Syrup
April 2017: Connecticut Grown Plants & Flowers
May 2017: Connecticut Farm Wineries
June 2017: Connecticut Grown Strawberries
July 2017: Connecticut Grown Blueberries
August 2017: Connecticut Grown Peaches
September 2017: Connecticut Grown Apples

Shortly after the start of year three, it was determined funds would not be fully expended due to a late program start and expenses being lower than estimated. Funds were then allocated to the promote the use of the Women Infant and Children (WIC) Farmers' Market Nutrition Program (FMNP) checks at Connecticut farmers' markets. This budget change was less than 20% and therefore an amendment request was not required. The FMNP checks are only allowed to be used to purchase fresh fruits and vegetables. More information can be found at https://www.fns.usda.gov/fmnp/wic-farmers-market-nutrition-program-fmnp.

Promotion specific to this effort included the following:

- 26 spots per week over 6 weeks for 156 spots total on Bomba Radio
  - One message was utilitized in August and September and translated into Spanish: *Do you participate in the WIC program? Your benefits include fresh fruits and vegetables from Connecticut farmers' markets. Contact your local office to find out more or visit CTGrown.gov/FarmersMarkets to find a market near you. Sponsored by Connecticut Department of Agriculture and USDA.*
- 21 spots per week over six weeks for 121 spots total on iHeart Radio
  - Two messages were utilized August and September:
    - *Do you participate in the WIC program? Your benefits include fresh fruits and vegetables from Connecticut farmers' markets. Contact your local office to find out more or visit CTGrown.gov/FarmersMarkets to find a market near you. Sponsored by Connecticut Department of Agriculture and USDA.*
    - *Do you participate in the WIC program? Your benefits include fresh fruits and vegetables from Connecticut farmers' markets. Contact your local office to find out more or visit "C-T GROWN DOT GOV SLASH FARMERS MARKETS". Sponsored by Connecticut Department of Agriculture and USDA.*

Goals & Outcomes Achieved
The original goal was to increase site visits to the agency website where consumers can find information on where to buy Connecticut specialty crops as a result of conducting the specialty crop radio marketing campaign.

The agency can confidently say that was accomplished. The baseline of all pages and website views for consumers to source specialty crops increased by 31.1% from 2015-2017.

Below is a summary of the outcomes from each year.

Year One

During the reporting period, the agency aired a total of 388 radio spots promoting specialty crops on iHeartRadio and Bomba 97.1 FM. In addition the Pandora audio and display ads received more than 1,602,000 impressions. These activities resulted in substantial increases of traffic to the agency website and time users spent on the page.

Traffic to the agency Facebook page has seen a significant increase during the specialty crop reporting period, with an increase of fans from 152 to 924. During the reporting period, monthly data collected from Facebook users was utilized to better target future campaigns for maximized results. As a result, during the reporting period, Facebook ads reached 152,525 people.

Year Two

During the reporting period, the agency aired a total of 508 radio spots promoting specialty crops on iHeartRadio and Bomba 97.1 FM. In addition, the Pandora audio and display ads received 2,198,592 impressions and 2,834 clicks to the website.

Traffic to the agency Facebook page has seen a significant increase during the specialty crop reporting period, with an increase of fans 924 to 2,168. During the reporting period, Facebook unveiled more targeted advertising opportunities allowing us to capitalize on directing consumers to our website. As a result, during the reporting period, Facebook ads reached 118,689 people with 1,746 clicks to website.

Year Three

During the reporting period, the agency aired a total of 474 radio spots promoting specialty crops on iHeartRadio and Bomba 97.1 FM. In addition the Pandora audio and display ads received more than 2,130,832 impressions and 762 clicks to the website.

Traffic to the agency Facebook page has seen a significant increase during the specialty crop reporting period, with an increase of fans from 2,168 to 2,832. During the reporting period, monthly data collected from Facebook users was utilized to better target future campaigns for maximized results. As a result, during the reporting period, Facebook ads received 202,596 impressions and 3,478 clicks to the website.

In addition, the funds dedicated to the WIC FMNP check promotion for the purchase of fresh fruits and vegetables at Connecticut farmers' markets showed an increase in redemption of 13.74% over the 2016 redemption rates. This increase was exceptionally important this year given the trend in redemption has been declining. Only 5.5% of the total project budget went towards promotion of FMNP check redemption at authorized farmers' market. Since FMNP checks can only be used for the purchase of fresh fruits, vegetables, herbs and honey, this portion of the project solely enhanced the competitiveness of Connecticut specialty crops.

Below is a summary, in quantifiable terms, about the successful outcome of the project:

Page Title	Baseline (2014)	2015 Page Views	2016 Page Views	2017 Page Views	% Change 2014-2017
Apple Picking: Fun for the Whole Family	241	759	524	1067	3.427385892
Greenhouse and Nursery Products	211	172	148	210	-0.00473934
Connecticut Grown Pick-Your-Own (pumpkin feature)	264	648	354		0.340909091
Honey Producers in Connecticut	532	1850	617	1284	1.413533835
Connecticut Farm Wineries	1018	4172	3915	7164	6.037328094
Cut-Your-Own Christmas Trees	2974	1657	1733	0	-0.41728312
Connecticut Grown Maple Syrup	910	738	1246	941	0.034065934
Connecticut Grown Pick-Your-Own	1628	2210	1235	2266	0.391891892
Connecticut Grown Roses	0	317	28	15	
Connecticut Grown Pick-Your-Own (strawberry feature)	418	491	4390	6868	15.43062201
Farm Stands and Stores Throughout Connecticut (winter squash feature)	93	503	426		3.580645161
Connecticut Grown Pick-Your-Own (blueberry feature)	684	1310	867	1479	1.162280702
Connecticut Department of Agriculture Homepage	57971	65114	67747	41096	-0.29109382
Overall Results					31.10554633

Beneficiaries

Connecticut has 72 orchards, the largest greenhouse cut flower rose grower in New England, 332 pumpkin growers, at least 500 nursery/greenhouses growers, 32 farm wineries, and 73 Christmas tree growers; 500 fruit and 637 vegetable growers, 135 maple producers, 165 apiaries, 287 herb growers, and 179 pick-your-own farms.

While orchards, pumpkins, some fruits and vegetables, and pick-your-own farms are more commonly recognized and thought of in Connecticut, wine, Christmas trees, hydroponics, cut roses, honey, and maple syrup, are often forgotten as an available specialty crop in Connecticut. This radio marketing campaign will work to change that mentality and increase sales of the featured specialty crops.

The agency worked in cooperation with the commodity associations of the highlighted specialty crops to develop effective, meaningful radio advertisements. The commodity associations benefitting from this project are:

- Connecticut Apple Marketing Board;
- Connecticut Farm Wine Development Council and the Connecticut Vineyard and Winery Association;
- Connecticut Christmas Tree Growers Association;
- Connecticut Maple Syrup Association;
- Connecticut Beekeepers Association;
- Connecticut Fruit and Vegetable Growers Association;
- Connecticut Pomological Society;
- Connecticut Greenhouse Growers Association;
- Connecticut Nursery and Landscape Association;

Beneficiaries of the WIC program include pregnant, breastfeed, postpartum and children under the age of five. It is estimated that 2,595 additional WIC participants utilized their FMNP checks to buy fresh fruits and vegetables as a result of this additional project. Since FMNP checks can only be used for the purchase of fresh fruits, vegetables, herbs and honey, this portion of the project solely enhanced the competitiveness of Connecticut specialty crops. In Connecticut there are approximately 350 farmers who grow fresh fruits, vegetables, herbs and honey who are eligible to accept the FMNP checks from WIC participants.

Lessons Learned

The agency sought proposals from multiple radio outlets, including WNPR, Pandora Radio, iHeartRadio and Bomba 97.1 FM. After analyzing costs and taking into consideration budgetary constraints, the decision was made to explore new avenues available through Pandora, iHeartRadio and Bomba 97.1 FM. The agency opted to not partner with WNPR and instead channeled the allocated funds into the aforementioned radio stations. This did result in the promotion beginning one month later than originally planned, with a start date of January 2015. As a result, this slightly increases the budget available to promote each monthly specialty crop, which has been channeled into social media advertising through Facebook.

Severe weather made it challenging to appropriately time when audio spots should begin airing. For example, with some radio stations, we had a one week on, one week off schedule running the first and third weeks of each month. While our partners tried to accommodate scheduling changes, it wasn't always possible due to availability of air time. On the opposite end of the spectrum, we featured peaches as our August 2017 specialty crop after the 2016 crop was devastated due to a hard freeze after a mild winter to reassure consumers that Connecticut Grown peaches were back, with a robust crop.

As radio continues to evolve and digital radio gains more listenership, the digital options with our radio buys proved to be an essential component. However, as enhancements to backend website tracking were changed and updated, reporting numbers also saw fluctuations as they were no longer comparing apples to apples. The same could be said for our Facebook advertising dollars as they continue to refine the reporting insights. Over the course of our campaign, this did allow us to better target our audience, resulting in higher rates of engagement and clicks to the website.

Additional Information

www.pinterest.com/GrowCTAg
Apples: http://www.ct.gov/doag/cwp/view.asp?a=3260&q=399560
Greenhouse/Nursery: http://www.ct.gov/doag/cwp/view.asp?a=3243&Q=530680&PM=1
Pumpkins: http://www.ct.gov/doag/cwp/view.asp?a=3260&q=399070
Honey: http://www.ct.gov/doag/cwp/view.asp?a=3260&q=399066
Wine: http://www.ct.gov/doag/cwp/view.asp?a=3260&q=399108
Christmas Trees: http://www.ct.gov/doag/cwp/view.asp?a=3260&q=399042
Maple Syrup: http://www.ct.gov/doag/cwp/view.asp?a=3260&q=399068
Pick-Your-Own: http://www.ct.gov/doag/cwp/view.asp?a=3260&q=399070
Farm Stands/Stores: http://www.ct.gov/doag/cwp/view.asp?a=3260&q=418062

Demonstrating the Use and Value of Scientific Based Management Tools for Fertilizer Decisions

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Project Summary

A needs assessment survey of CT fruit growers, conducted in the fall of 2013 by M. Concklin, identified the number 1 issue as a better understanding of plant nutrition, making fertilizer decisions, and of plant & soil health. This indicates a desire to learn on the part of fruit growers.

Fertilizer decisions for fruit crops should be made based on scientific evidence of need. This is accomplished using tissue analysis every 1-2 years and soil analysis every 2-4 years. A tissue analysis indicates the levels of macro and micro nutrients present in the plant. Optimal levels of each nutrient have been established for specific fruit crops, and in some cases cultivars, based on research. A soil analysis indicates the levels of macro (not nitrogen) and some micro nutrients available in the soil, as well as pH. However, in each of the years 2011-2013, just under 1% of CT fruit growers utilized tissue analysis and approximately 5.5% utilized soil analysis as management tools to determine their fertilization decisions (Information from Analytical Labs of UConn, UMass, Cornell combined with number of fruit farms listed in USDA census). This would suggest that fertilizer decisions have been based on previous experience, advice from sales representatives, recommendations listed on the fertilizer container, plant age, or plant appearance. When decisions are made based on previous experience, a grower could be missing interactions of elements where visible symptoms are not yet showing that are hindering production and/or quality. This can also lead to the over-application of nutrients the plant does not need. For example, excess phosphorus doesn't impede plant growth but creates environmental problems that are well documented. Although recommendations on fertilizer containers have a scientific basis, they are considered a maintenance amount and are not reflective of the nutrient needs of a specific farm site. Plant age does not take into account specific plant needs and soil requirements/needs. When fertilizer decisions are based on visual appearance, reductions in crop yield or quality have likely already occurred. Diagnosing based on appearance alone does not take into account nutrient interactions.

Excessive rates of certain nutrients can cause interactions leading to deficiencies of other nutrients. For example, high rates of nitrogen can lead to an induced potassium deficiency which has a negative impact on winter hardiness and fruit size. An over application of potassium can lead to an induced deficiency of calcium which would show up as bitter pit in many apple cultivars. The lack of scientific evidence when making fertilizer decisions can result in over as well as under applications of many nutrients. The resulting imbalance can affect yield, quality, and may contribute to ground or surface water contamination. Nutrient imbalances can also affect the longevity of a planting which can have an economic impact on a farming operation.

Nutrient deficiencies can result in stunted growth, reduced fruit yield and quality, and overall reduced plant health. Excessive rates of nutrients can cause a delay in fruit maturity, an over-abundance of vegetative growth, reduced bud set, and an increase in insect and disease problems. Improper soil pH for a crop can lead to nutrient deficiencies and toxicities affecting fruit quality and plant health.

This proposal, which is a key part of a three-part project (the first 2 parts were already funded: part 1-survey growers, part 2-comprehensive workshop), will take the knowledge fruit growers gained in the March 2015 Fruit Crop Plant Nutrition comprehensive workshop, to the field, in a multi-year demonstration with grape, berry and tree fruit growers. The demonstration outlined in this proposal will work to address the number one issue identified by CT fruit growers in the 2013 fruit grower survey: plant health –nutrition, fertilization, soil health, soil & tissue analysis.

Project Approach

The project initially was planned to work with 15 fruit growers. The over-whelming response by growers to this project necessitated re-budgeting and working with 29 grape, berry, and tree fruit growers. One grower dropped out summer 2015 because he was not able to plant the field, two were dropped after 2 years (one was selling the farm, the second was following the advice of another source in the treatment block). Fertilization histories were collected in spring and summer 2015, as well as the summers of 2016 and 2017. Treatment and check areas were designated at each farm – treatment areas were to be fertilized based on M. Concklin' s recommendations; the check areas were to be treated the way the grower routinely did.

Soil samples were collected from the check and treatment areas at each farm and submitted to the UConn Nutrient Analysis lab for analysis in 2015 and 2017. The 2015 soil tests were also analyzed for organic matter (OM) content which was used when determining additional nitrogen rates. Tissue samples were collected in the summer of 2015, 2016 and 2017, and submitted to the UConn Nutrient Analysis lab for analysis.

Fertilizer recommendations were developed each year for each participant's treatment and check areas by M. Concklin using the soil, OM and tissue analysis results plus crop load, plant growth, grower cultural practices (pruning, ground management, irrigation) and environmental conditions. Participants were to apply the recommendations to the treatment areas. Analysis results regarding the check areas were not shared with the growers until the end of the study. During the project period, growers were to fertilize the check areas using their usual practices. That didn't always happen. Some growers used the information from the treatment area and applied it to the check area as well.

The drought conditions of 2016 – lack of snow and rainfall – and the negative impact it had on nutrient uptake were discussed with all the growers. Recommendations provided the previous fall were modified or omitted by growers with peaches and

apples that were lost due to the Valentine's Day freeze and multiple frost events in April 2016. Several of those growers had made applications of some nutrients in the fall of 2015. This was a learning experience for many growers of the important role water plays in movement of nutrients into and throughout trees and plants as well as the need for soil moisture which impacts the ability of soil microbes to convert nutrients into forms utilized by plants. These events played a role in the recommendations provided in the fall of 2016.

Potassium levels in excess of 2.0% in grape petioles can result in an increase in wine pH. When this was pointed out to grape growers, two commented that their winemakers had indicated the wine pH was too high with these varieties (the ones in the study) and they now understood why. Others indicated they did not realize this impact.

The growers were actively involved in the decision of areas and crops on their farms to use for the treatment portion and the check portion of this demonstration. Some farms involved multiple crops and multiple blocks in the study. They contributed to this project by following protocol (most of them), purchasing and applying fertilizers based on my recommendations, and following up with observations of any changes. Discussions of the impact and importance of particular nutrients, observations of impact, and answering their questions occurred each year in one-on-one meetings. Several growers expressed concern that they would be bumped from the project because nutrients that were recommended were not applied due to the drought and 2016 crop loss. I reassured them that would not happen and that this real-life situation is a good lesson in what happens to nutrients and plant responses to drought and crop loss.

A written survey was given to each participant when M. Concklin met with each in August and September 2107. The survey examined changes to yield and plant growth which would translate to economic feasibility, grower perception of using a combination of factors to develop scientific based fertilizer programs, grower perception of the usefulness of the scientific basis for fertilizer applications and their expectations for continuing this practice.

A factsheet with the results of this 3-year study has been written and is available at http://ipm.uconn.edu/documents/view.php?id=1242 In addition, a factsheet titled "Developing Fertilizer Programs for Fruit Crops Utilizing Soil and Tissue Analysis" has been written, published and is available on the UConn IPM website at http://ipm.uconn.edu/documents/view.php?id=1232. Both factsheets will be available at upcoming grower meetings including the 2017 CT Pomological Society Annual Meeting, the 2017 New England Vegetable & Fruit Conference, the 2017 UNH Fruit Grower Meeting, and the 2018 UConn Extension Vegetable & Small Fruit Conference.

Goals and Outcomes Achieved

The goal of this project was to increase the use of tissue and soil analysis as a management tool for fertilizer decisions by fruit growers. To help determine if the

goal was achieved, a written survey was given to each of the 26 participants with 23 (88.5%) responding.

Of the 23 respondents, 16 (69.6%) indicated this was the first time they had received fertilizer recommendations based on a combination of soil and tissue analysis combined with crop load, plant growth, cultural practices, and environmental conditions. When this was discussed in 2015, 6 of the 26 participants had indicated they used soil and tissue analysis. However, no one mentioned using these analyses with the additional factors. Of the 23 participants, 22 (95.6%) planned to continue using this protocol for future fertilizer decisions with one indicating s/he was unsure, commenting 'We hope to, time permitting'. With the 7 participants utilizing these tools prior to the study, to 23 participants planning to utilize this scientific method going forward, the result would be a 328.5% increase over the 3-year study. Our initial target was a 20% increase each year. All participants indicated they would recommend this method to other growers and two indicated they have already told other growers about this.

Beneficiaries

According to the 2012 USDA census, Connecticut has 469 berry farms encompassing 1049 acres, and 365 orchards encompassing 3335 acres. The fruit growers that collaborated in this project, and other CT fruit growers will be made aware of the results of using scientific data for developing fine-tuned fertilizer programs. Ultimately, this program has the potential to impact most of the 469 berry farms and 365 orchards, providing the growers with a valuable tool that will fine-tune fertilizer programs, reducing negative environmental impact, improving plant and soil health with a positive impact on crop quality and yield, which will improve the farm's long term economic viability.

Twenty-six farms directly benefited from this project. M. Concklin has reached an additional 203 farms through presentations made at Extension programs throughout New England, with 2 additional presentations scheduled for November and December 2017. The presentations are listed under 'Additional Information'.

The participating growers were:
Applebrook Farm, Tom & Sharon Muska, Broad Brook
Beckett Farm, Chip Beckett, Glastonbury
Bishops Orchards, Jonathan Bishop, Guilford
Blue Hills Orchard, Eric Henry, Wallingford
Buell's Orchard, Jeff Sandness, Eastford
Burdick Rd Orchard, Marty Post & Donna Howard, New Hartford
Chestnut Hill Vineyard, Garry McDonald, Columbia
Drazen Orchard, Eli Drazen, Cheshire
Dzen Farms, Don Dzen, East Windsor
Fox Run Vineyard, John Cordes, Brooklyn
Hayward Farm, Peter Hayward, New Hartford
Heartstone Farm, Walt & Nancy Tabor, Columbia

Holmberg Orchards, Rick & Russ Holmberg
Hopkins Vineyard, Jim Baker, New Preston
J. Preli Vineyard, John Yushkevich, South Glastonbury
Jones Family Farms, Jamie Jones, Shelton
Land of Nod, Chris Granger, East Canaan
Lapsley Orchards, John Wolchesky, Pomfret
Orchard Farm, Diane Cooper, Bethany
Preston Ridge Vineyards, Steve Sawyer, Preston
Rogers Orchards, John Rogers, Southington
Savino Vineyards, Jerry Savino, Woodbridge
Starberry Farm, Bob & Sally Futh, Washington
Sunset Meadow Vineyards, George Motel Sr & Jr, Goshen
The Hickories, Dina Brewster, Ridgefield
Woodland Farm, Peter & Erica Teveris, South Glastonbury
Allyn's Red Barn, Fred Allyn, Jr, Ledyard – participated for 2 years
Evergreen Berry Farm, Bob Alex, Watertown – participated for 2 years

The two factsheets that are available online as well as in print, will potentially reach hundreds of additional growers.

Lessons Learned

Lesson 1 – More growers were interested in participating in this project to learn about plant nutrition and fertilizer programs than was anticipated. Although the project proposal was to work with 15 growers, almost twice as many applied. After a re-budget to reduce the amount of travel funds needed (a fleet car was used which made this possible) and increase the funds for testing, 29 growers initially were part of the project. That dropped to 28 the first summer when a field was not planted as expected.

Lesson 2 – The protocol was explained to all participants – a treatment block that would follow the fertilizer recommendations of the PI, and a check block that the grower would fertilizer any way s/he wanted. Both blocks would be tested, but fertilizer recommendations would be provided for only the treatment block the first 2 years. At the end of the third year, the participants would be provided the information for the check block for the 3 years. Lesson learned – some growers liked the information provided for the treatment block and fertilized the check block the same which resulted in not having a check block to compare to. The positive from this – those growers decided early in the program that using this method for fertilizer decisions is the best way to go in the future. It would have been better if they had waited until the project ended but their intentions were in the right direction.

Lesson 3 – this is a long-term project that requires more time to see major impacts to the crops and plants, particularly when year 1 was data collection with fertilizer recommendations for 2016 and 2017 (recommendations given this fall are for 2018), and year 2 saw a catastrophic crop loss in tree fruit as well as a major drought. When asked if any changes to the plants were noticed in the 3 years through participation in this project, the majority indicated yes but 31.8% (7, n=22) said no or were unsure.

When asked the same for crop/yield, 40.8% (9, n=22) indicated no, unsure, or mixed (mixed comment was 'plant health & yield better, fruit quality consistent). This was not unexpected particularly due to the environmental events of 2016. It is to be considered a positive that growers identified positive changes in this short time.

Lesson 4 – Catastrophic weather events impact nutrient uptake and plants usage. Growers saw this in the test results. For example, potassium deficiency showed up in the tissue analysis, as well as visual symptoms in the plants in some blocks, where there was ample potassium in the soil. This was a result of the drought. Adjustments were made in recommendations for 2017. Based on discussions with growers during 2016, adjustments were made such as adding foliar nutrient sprays that would be more beneficial to the plant and crop instead of soil applications that would not be utilized by the crop in a drought.

Comments from growers of lessons learned:

- Tremendous learning experience for us! We had no information prior to this study. Ex. We had no idea that we could use lime to improve the availability of nutrients to the trees. We will immediately begin remediating the soil to make it less acid.
- It is always helpful to have a knowledgeable person/consultant looking at the total picture and helping to determine what is going on.
- This combination will show the truest picture of your fertilizer program.
- This is the only way to determine fertilizer recommendations. Using soil tests and fine tuning with leaf samples keeps the plants looking great and ensures a good fruit set the next year.
- It seems like the most "robust" way to determine fertilizer needs – like good IPM, a combination of data is better than just relying on foliar.
- Very helpful, would be worth paying for! But thanks for making "your tax dollars do the work" ☺
- It's been very important to me to have detailed scientific data on when to base my decisions and to further my goal of greater plant vitality based on increased soil health.
- I have found that having both the soil and petiole analysis has made fertilizer decisions much easier and more precise, without having an added price tag on nutrients that are not needed. Fine tuning the nutritional program is cost effective and beneficial to the plants. I have learned more about the nutritional needs and the movement of nutrients from this program. I hope it can continue to help farmers and growers across the state.
- This is a God's sent help, because on my own I couldn't possibly integrate all of these.
- We have mostly used soil analysis in the past and assumed that the nutrients in the soil translated to plant nutrition – not true. It was somewhat of a shock to find out that some nutrients which were plentiful in the soil were not fully being picked up by the plants.
- Analysis provided a much more dialed in recommendation of yearly fertilizer requirements than I have had in the past.
- Saved money and took the guessing out.

- I think the combination is a more true picture of the plants than either technique alone.
- It was very helpful and beneficial.
- It seems "you are what you eat" applies to plants as well as people! Our farm does not have ideal growing conditions. The soil is unusual and weather can be extreme. The recommendations from Mary were very stream lined and cost effective. We saved money by not applying certain nutrients. We learned too much of one nutrient can be just as bad as not enough. Now plants are stronger for cold weather and crop load doubled.
- Any soil amendments, pesticide or PGR applications applied in agriculture should be made based on science and observation. The methodologies formerly stated are great tools to guide application decisions. As farmers we greatly benefit when we receive cost effective and seamless guidance from our university based scientists who collect samples, perform analysis and provide reports and guidance.
- A more integrated approach is definitely more work but worth it.
- The program works and I have been working with my fertilizer supplier/maker to come up with the right fertilizer based on the recommendations that I have been given in the study.
- More information gives us a better ability to make more informed decisions.
- This program was very valuable to us. Soil and leaf testing is something we have not done. The results will help us to improve tree health and apple quality. We sell all of our crop directly to the public so quality is our primary concern.
- The more detailed data I have, the better my decisions will be.
- I feel it is an excellent way to measure the health of the plants.
- It works and the results are evident
- It shows how successful the plant is in taking up nutrients. Info is complete.
- The protocol helps make our decisions more cost effective and give us and our customers a better product.
- More information gives us a better ability to make more informed decisions.
- We trust Mary Concklin's findings as she is very knowledgeable and communicates very well while teaching us.
- I am very grateful to have been part of this program. I learned a lot and it has been very rewarding to see my work pay off.

Additional Information

Factsheet links:

"Developing Fertilizer Programs for Fruit Crops Utilizing Soil and Tissue Analysis"
http://ipm.uconn.edu/documents/view.php?id=1232 and
http://ipm.uconn.edu/documents/raw2/1232/Developing%20Fertilizer%20Programs%20for%20Fruit%20Crops%20Utilizing%20Soil%20and%20Tissue%20Analysis%202017.pdf

"Developing Fertilizer Programs for Fruit Crops – Results of a 3 Year Study"
http://ipm.uconn.edu/documents/view.php?id=1246 and
http://ipm.uconn.edu/documents/raw2/1246/Developing%20Fertilizer%20Programs%20for%20Fruit%20Crops%20-%20Results%20of%20a%203%20Year%20Study.pdf

Presentations made by M. Concklin on this topic which included discussion of this study:
Concklin, M. 2015. **Nutrition Management for Grapes**. Intensive Fruit Crop Nutrition Management Short Course: Tree Fruit, Berries and Grapes, South Windsor, CT. March 18, 2015.

Concklin, M. 2015. **Nutrition Management for Tree Fruit. UNH Tree Fruit Production Choices-Risk Management Seminar. Goffstown, NH.** November 7, 2015.

Concklin, M. 2016. Nutrient Management for Tree Fruit. MA Nutrient Management Meeting. Westhampton, MA. January 26, 2016.

Concklin, M. 2016. Nutrient Management for Tree Fruit. MA Nutrient Management Meeting. Northboro, MA. January 28, 2016.

Concklin, M. 2016. **Nutrition Management for Tree Fruit. VT Apple Growers Association Annual Meeting, Middlebury, VT. February 18, 2016.**

Concklin, M. 2016. Nutrition and Nutrient Management Recordkeeping for Small Fruit. New England Vegetable and Berry Growers Association, Portsmouth, NH. December 3, 2016

Concklin, M. 2017. **Nutrient Management in Fruit Crop Production**. CT Pomological Society Annual Meeting, Middletown, CT. November 28, 2017

Concklin, M. 2016. Nutrition for Fruit Farms. 2017 New England Vegetable and Fruit Conference, Manchester, NH. December 14, 2017

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This final report was previously approved in April 2017

Exploring the Economic and Production Viability of Ethnic Vegetables and Novel Small Fruits in Connecticut

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Project Summary

This research focused on understanding production and marketing of ethnic vegetables/novel small fruits (e.g. okra, tomatillo, yardlong bean, kale, etc.). The importance of these specialty crops cannot be understated. Many ethnic (and non-ethnic) communities rely on ethnic vegetables/novel small fruits as a central part of their diet. For instance sales in Toronto, Ontario of ethnic vegetables to three ethnic groups (Chinese, Afro-Caribbean, and South Asian) is estimated at >$61 million/month (Adekunle et al. 2010). Given Connecticut has a diverse population (2012 Census estimates: 14% Hispanic/Latino, 4% Asian, 30% non-white) the potential for ethnic vegetables/novel small fruit production and consumption on the Connecticut economy is considerable. However, little if any information exists on the market size, consumer needs, and production barriers/issues for producing these specialty crops. This research directly addressed several of the USDA and CT Dept. of Agriculture's priorities: increasing production and consumption of specialty crops, agricultural education and outreach, promotion/marketing of specialty crops, and nutrition education and consumption. Furthermore, this project directly engaged beginning and socially disadvantaged farmers in order to facilitate production of ethnic vegetables/novel small fruits. Thereby, this project encapsulated the Governor's Council for Agricultural Development's plan of increasing consumption and production of CT foods, while integrating key research and extension personnel throughout CT.

This research was based on an integrated approach that encompasses a dynamic team with an array of expertise on ethnic vegetable/novel small fruit production and marketing. First, this project estimated the market size (current and future) and production barriers of ethnic vegetable production in Connecticut. This research was critical in providing complete information to potential producers of these specialty crops. This objective was achieved with a combination of a large consumer survey and a smaller survey targeted directly at Hispanic consumers (14% of CT population). The large survey focused on broad issues of consumption and reasons for not consuming ethnic vegetables. The small-scale survey examined ethnic consumer, such as Hispanic and Asian, purchasing of ethnic vegetables as increasing access and consumption of these vegetables is essential. The results of the surveys fed into the second objective which was to understand production issues within CT. We will also focus on expanding ethnic vegetable/small fruit production in CT, while also examining the barriers to increasing production especially in urban areas. The above objectives provide critical information for production research established via a demonstration garden and research trials. As a part of knowledge

transfer process, beginning and socially disadvantaged producers will be directly targeted, especially those producing or considering producing in urban areas. The demonstration garden site (6.5 ac.) has already been secured with UConn Extension collaborating with a farm in New Milford.

Project Approach

In order to assess consumer purchasing levels of various ethnic vegetables an online survey was utilized. The consumer survey consisted of having around 600 CT consumers of various ethnicities answer questions on purchasing habits of various ethnic vegetables. Consumers were recruited via an online panel provider.

Results from the project found that consumers have distinct purchasing behaviors associated with vegetables. Notably, the average CT consumer purchases traditional vegetables such as bell peppers, orange carrots, etc. fairly frequently (Table 1). However, new varieties or and what are considered ethnic vegetables are less frequently purchased. For instance, orange carrots are purchased by 84% of our sample, but red carrots are only purchased by 21% of the sample. Other interesting findings, though not unexpected, are that vegetables such as amaranth, bok choy, okra, daikon radish, etc. are not being purchased, but of keen interest is that a majority of consumers indicate that they have no interest in purchasing these vegetables. The reason for no interest is unknown, but it is most likely due to consumers being unaware how to consume them.

Only looking at the sample as a whole has the potential to miss important ethnic differences in the population. In looking at Tables 2-5, it is apparent that ethnic groups have varying purchasing behaviors for ethnic vegetables. For instance, Asian consumers consume amaranth quite extensively in their diets while Caucasian, African American, and Hispanic consumers used amaranth are a less frequency with many of these consumers indicating no interest in adding it to their diet. This differences offer key opportunities for CT producers to develop niche markets that focus on providing specifically needed vegetables to ethnic groups that consume them. Table 6 gives a specific breakdown of interested, non-interested, and heavy consumers of various vegetables across ethnic groups.

Understanding the market is only the first part of growing the ethnic vegetable industry in CT. Producers must be aware of demand as well as the amount of acreage that demand is capable of supporting before producers must look to export. Table 7 notes per capita demand and acres that can be supported if all demand is fulfilled by CT producers. In some cases, acreage is relatively small. For instance, only 160 acres of okra production is needed to satisfy CT okra demand. Okra acreage in access of this number would need to be exported unless CT demand is increased. Of course, all demand will not be fulfilled by CT producers only, but this acreage does showcase that only a small amount of acreage is needed to satisfy demand. On the other hand, over 51,000 acres are needed to satisfy hot pepper demand. With hot peppers being consumed by various ethnic groups, notably Hispanic consumers, there seems to be ample room for expansion of this crop in CT

especially given 14% of the CT population identifies as Hispanic.

Identifying the barriers to purchasing CT produced ethic vegetables is also critical. As noted in Table 8, roughly one in five consumers indicate that okra, bok choy, and Asian long purple eggplant produced in CT are not available. For these consumers, they are not able to find CT produced vegetables if they are looking for them. On the other hand, quality, expense, and lack of organic vegetables does not seem to be barriers to purchase. In deciding what/how to produce, no external damage is the most important external characteristic with freshness and price being the most important overall characteristics (Table 9). Given these findings producers need to concentrate on delivering a fresh, unblemished product to market, while being aware that consumers may be hesitant to pay extra if production costs are higher than product from alternative sources.

Goals and Outcomes Achieved

Goal	Identify the market size and economic viability of the ethnic vegetable/novel small fruit market in CT, thereby increasing production of these vegetables within CT.
Perf. Measure	Estimate the impact of increased production of ethnic vegetables/fruit in CT, especially in urban areas. Use information to increase production of ethnic vegetables in CT.
Benchmark	The USDA 2012 Census indicates little ethnic vegetable production in CT. On-the ground efforts indicate 6 producers experimenting with okra, limited pak choi, bok choy, and yardlong bean production and no tomatillo production. Most likely awareness is low and barriers are high.
Target	Confirm the market size and economic impact in CT. Using this information along with production information we will attempt to (1) Increase awareness by 20% for in-demand vegetables/fruit by producers. (2) Five established producers will begin small scale trials of ethnic vegs/small fruits; 2 new or socially disadvantaged producers will begin small scale production. (e.g. 1 acre of okra has been shown to yield b/t 3-5 tons of okra, implying potential for a large influx of CT production).
Monitor Plan	Use data from surveys, USDA, and CT Dept. of Agriculture.
Information Dissem.	On-site tours of trials along with presentations at workshops, published materials (e.g. factsheets, articles, etc.) and websites including social media will be used. In order to keep track, we will count the number of producers visiting the trials and workshops. Finally, we will conduct workshop and trial evaluations to assess uptake and impact of our results.

Main target measures to complete this objective:
The open house sponsored by the CT Experiment Station at their Hamden research farm were held August 5, 2015 and August 3, 2016. It is estimated that between 1,000 and 1,100 people attended each event. At both open houses, the ethnic crop trials were highlighted by being selected to be on the "walking tour". On the tour, 50-75 people were provided with a 10 minute summary of the experiments. Throughout the day, Dr. Maynard was present at the plots to discuss the experiments with anyone that came along leading to an estimated 50 people at each event having one-on-one direct contact to discuss ethnic vegetable production at the commercial growers and backyard level.

In addition, Dr. Maynard answered 77 emails or phone calls about ethnic vegetables during the life of the project while also visiting 22 farms and 16 farmers markets to discuss ethnic vegetables. The My New Crops Program brochure was updated and reprinted and is also available on our website, http://www.ct.gov/caes/lib/caes/documents/publications/brochures/the_new_crops_program.pdf

Because of a phone call, email, farm visit, or open house, 13 growers that Dr. Maynard was in contact are now growing okra and 5 started growing calabaza. These are known increased in production numbers as there was direct contact; however, these numbers are likely conservative as there is no way to measure increased production due to indirect contacts.

Production Barriers
Producers for the most part not growing more ethnic vegetables because (1) they are in a part of the state where there is not a market and (2) consumers do not know how to prepare (cook) many ethnic vegetables. Most producers who are involved in inner city farmers' markets grow some ethnic vegetables.

Beneficiaries
The main beneficiaries of this project include producers, current and potential ethnic vegetable producers, as well retailers and industry stakeholders. As noted earlier, awareness amongst commercial and backyard producers was increased with a number of producers beginning limited production of certain ethnic vegetables.

Lessons Learned
- There is demand for ethnic vegetables in CT. However, producers/retailers that can identify niche markets associated with groups of consumers that demand certain types of vegetables will be most successful.
- Consumer barriers to more CT grown ethnic vegetables
    - Availability
    - Some other reason than listed – most likely lack of knowledge how to use new vegetables
        - An educational campaign by producers in their market areas

would most likely lower this barrier.

- Producer barriers
    - Lack of market – producers/retailers should study demographic trends throughout the state, and other areas, for expansion/demand opportunities
    - Lack of knowledgeable consumers – provide educational materials with their product to increase awareness and knowledge

Additional Information

Review/Working Papers

Demander, L.* and B.L. Campbell. "Preference and Willingness-to-Pay for Ethnic Vegetable Attributes."

M.S. Thesis

Lars Demander, Dec. 2015, Connecticut Market for Ethno-Cultural Vegetables.

Extension Publications

Completed:
Abigail Maynard, The My New Crops Program brochure
http://www.ct.gov/caes/lib/caes/documents/publications/brochures/the_new_crops_program.pdf

Factsheet in-progress:
Ben Campbell/John Bovay, The Connecticut Ethnic Vegetable Market

Table 1: Interest and Frequency of Vegetable Consumption: Total Sample.

Vegetable	Never and not interested	Never but interested	Daily	A few times a week	Once a week	A few times a month	Once a month	Once every 3 months	Greater than every 3 months
Amaranth	69%	20%	0%	1%	1%	1%	1%	1%	4%
Asian long purple eggplant	50%	20%	1%	2%	3%	3%	5%	5%	10%
Bitter melon	68%	16%	1%	1%	1%	2%	2%	2%	6%
Bok choy	52%	13%	1%	2%	2%	5%	5%	7%	12%
Bottle gourd	69%	18%	0%	1%	1%	2%	2%	2%	5%
Chili pepper	47%	10%	2%	3%	5%	7%	5%	9%	13%
Chinese (Napa) cabbage	50%	19%	1%	3%	2%	4%	5%	6%	11%
Colored bell peppers	14%	3%	3%	14%	15%	23%	14%	7%	8%
Daikon radish	57%	17%	1%	2%	3%	2%	4%	4%	10%
Edamame	48%	14%	1%	3%	4%	5%	7%	8%	11%
Eggplant	26%	5%	1%	4%	7%	14%	11%	15%	16%
English cucumber	26%	8%	3%	9%	10%	14%	11%	10%	10%
Escarole	47%	15%	1%	3%	3%	7%	6%	6%	11%
Fuzzy melon	58%	22%	1%	2%	1%	2%	3%	4%	7%
Green beans	8%	2%	4%	12%	19%	22%	13%	12%	8%

Green bell pepper	15%	2%	4%	14%	17%	19%	12%	8%	8%
Habanero pepper	55%	11%	2%	2%	1%	4%	5%	7%	13%
Hungarian wax pepper	64%	21%	1%	1%	1%	2%	1%	2%	7%
Okra	57%	12%	1%	3%	2%	4%	4%	5%	12%
Orange carrot	11%	5%	5%	15%	18%	20%	13%	8%	6%
Portabella mushroom	28%	7%	2%	4%	9%	15%	11%	11%	13%
Potato	2%	1%	4%	22%	19%	22%	16%	7%	6%
Red carrot	52%	27%	1%	3%	3%	3%	3%	2%	5%
Romanesco	63%	19%	0%	2%	2%	2%	3%	1%	6%
Shiitake mushroom	39%	13%	1%	4%	4%	8%	7%	11%	13%
Sweet peas	19%	5%	3%	9%	12%	19%	11%	12%	10%
Tatsoi	72%	17%	1%	0%	1%	1%	1%	1%	4%
Tomatillo	56%	22%	1%	2%	2%	2%	3%	4%	6%
Tomato	5%	1%	9%	25%	23%	19%	8%	5%	5%
Yardlong bean	60%	23%	1%	2%	2%	2%	2%	2%	6%
Zucchini	18%	3%	2%	8%	12%	20%	14%	13%	10%

Table 2: Interest and Frequency of Vegetable Consumption: Caucasian Consumers.

Vegetable	Never and not interested	Never but interested	Daily	A few times a week	Once a week	A few times a month	Once a month	Once every 3 months	Greater than every 3 months
Amaranth	53%	20%	1%	2%	2%	3%	4%	4%	10%
Asian long purple eggplant	71%	15%	0%	1%	1%	2%	2%	1%	6%
Bitter melon	54%	13%	1%	1%	2%	4%	5%	7%	12%
Bok choy	51%	9%	2%	2%	4%	6%	5%	9%	13%
Bottle gourd	53%	19%	1%	2%	1%	3%	4%	6%	11%
Chili pepper	15%	3%	3%	13%	15%	23%	14%	7%	8%
Chinese (Napa) cabbage	60%	18%	1%	2%	2%	2%	3%	3%	9%
Colored bell peppers	26%	8%	3%	8%	10%	13%	11%	11%	10%
Daikon radish	48%	15%	1%	2%	3%	7%	5%	6%	12%
Edamame	60%	23%	1%	1%	1%	2%	3%	3%	6%
Eggplant	16%	2%	4%	13%	17%	19%	13%	8%	8%
English cucumber	58%	10%	1%	2%	1%	3%	4%	7%	14%
Escarole	65%	21%	1%	1%	1%	2%	1%	2%	7%
Fuzzy melon	61%	13%	1%	1%	2%	3%	4%	4%	12%

Green beans	11%	4%	5%	14%	18%	21%	14%	8%	6%
Green bell pepper	27%	7%	2%	4%	8%	16%	11%	11%	14%
Habanero pepper	2%	1%	4%	22%	19%	22%	17%	7%	6%
Hungarian wax pepper	55%	29%	1%	2%	2%	2%	2%	2%	5%
Okra	65%	18%	0%	2%	2%	2%	3%	1%	6%
Orange carrot	39%	13%	2%	3%	4%	8%	7%	12%	13%
Portabella mushroom	27%	5%	1%	4%	7%	14%	11%	14%	17%
Potato	75%	16%	1%	1%	0%	1%	1%	1%	5%
Red carrot	58%	21%	1%	2%	2%	2%	3%	3%	7%
Romanesco	5%	1%	8%	26%	24%	19%	7%	5%	5%
Shiitake mushroom	71%	20%	0%	1%	1%	1%	1%	1%	4%
Sweet peas	72%	17%	0%	1%	1%	1%	2%	2%	5%
Tatsoi	48%	14%	1%	2%	3%	5%	7%	8%	11%
Tomatillo	63%	23%	1%	1%	1%	2%	1%	1%	6%
Tomato	17%	2%	2%	8%	12%	21%	14%	14%	11%
Yardlong bean	19%	5%	2%	8%	12%	19%	12%	11%	11%
Zucchini	7%	2%	3%	11%	19%	23%	14%	12%	8%

Table 3: Interest and Frequency of Vegetable Consumption: African American Consumers.

Vegetable	Never and not interested	Never but interested	Daily	A few times a week	Once a week	A few times a month	Once a month	Once every 3 months	Greater than every 3 months
Amaranth	43%	24%	0%	5%	0%	0%	10%	5%	14%
Asian long purple eggplant	52%	24%	5%	0%	0%	0%	5%	10%	5%
Bitter melon	48%	24%	5%	0%	0%	5%	0%	10%	10%
Bok choy	24%	24%	0%	0%	14%	14%	0%	10%	14%
Bottle gourd	43%	24%	5%	0%	5%	10%	5%	5%	5%
Chili pepper	5%	5%	10%	14%	14%	19%	10%	19%	5%
Chinese (Napa) cabbage	48%	5%	5%	0%	5%	0%	10%	14%	14%
Colored bell peppers	24%	14%	10%	5%	5%	29%	5%	5%	5%
Daikon radish	48%	14%	0%	5%	5%	5%	5%	5%	14%
Edamame	52%	24%	5%	0%	0%	10%	0%	5%	5%
Eggplant	0%	10%	14%	5%	14%	29%	10%	10%	10%
English cucumber	33%	24%	5%	0%	0%	5%	5%	24%	5%
Escarole	67%	10%	5%	0%	0%	0%	0%	10%	10%
Fuzzy melon	29%	0%	5%	14%	14%	10%	0%	14%	14%

Green beans	5%	14%	10%	5%	24%	14%	14%	10%	5%
Green bell pepper	38%	5%	10%	5%	0%	5%	14%	10%	14%
Habanero pepper	0%	0%	10%	19%	19%	19%	10%	19%	5%
Hungarian wax pepper	43%	5%	10%	10%	14%	5%	0%	5%	10%
Okra	52%	19%	0%	5%	0%	5%	5%	0%	14%
Orange carrot	48%	14%	0%	0%	0%	0%	5%	19%	14%
Portabella mushroom	29%	0%	5%	0%	19%	14%	5%	24%	5%
Potato	70%	10%	5%	0%	0%	0%	0%	15%	0%
Red carrot	48%	24%	5%	0%	0%	5%	5%	14%	0%
Romanesco	10%	5%	24%	5%	24%	14%	14%	0%	5%
Shiitake mushroom	65%	15%	0%	5%	0%	0%	0%	10%	5%
Sweet peas	57%	19%	0%	0%	5%	0%	0%	10%	10%
Tatsoi	67%	10%	0%	0%	0%	0%	0%	10%	14%
Tomatillo	45%	30%	5%	5%	0%	5%	5%	5%	0%
Tomato	30%	10%	0%	10%	5%	20%	15%	5%	5%
Yardlong bean	15%	20%	10%	0%	15%	20%	0%	10%	10%
Zucchini	15%	0%	15%	5%	15%	15%	5%	15%	15%

Table 4: Interest and Frequency of Vegetable Consumption: Hispanic Consumers.

Vegetable	Never and not interested	Never but interested	Daily	A few times a week	Once a week	A few times a month	Once a month	Once every 3 months	Greater than every 3 months
Amaranth	42%	16%	5%	11%	5%	0%	11%	0%	11%
Asian long purple eggplant	42%	16%	5%	0%	11%	5%	5%	0%	16%
Bitter melon	47%	5%	5%	5%	0%	16%	5%	11%	5%
Bok choy	32%	16%	0%	5%	5%	5%	21%	5%	11%
Bottle gourd	37%	11%	5%	11%	0%	0%	21%	0%	16%
Chili pepper	11%	5%	0%	32%	21%	16%	11%	0%	5%
Chinese (Napa) cabbage	37%	5%	5%	11%	0%	11%	16%	0%	16%
Colored bell peppers	37%	0%	5%	11%	11%	11%	16%	5%	5%
Daikon radish	53%	5%	11%	5%	5%	5%	5%	0%	11%
Edamame	42%	5%	0%	0%	11%	11%	5%	16%	11%
Eggplant	21%	5%	0%	32%	11%	16%	5%	5%	5%
English cucumber	32%	5%	5%	5%	16%	11%	16%	0%	11%
Escarole	58%	11%	0%	5%	11%	0%	5%	0%	11%
Fuzzy melon	42%	5%	0%	5%	5%	11%	11%	5%	16%

Green beans	16%	5%	0%	16%	26%	21%	5%	0%	11%
Green bell pepper	44%	0%	6%	11%	11%	0%	6%	17%	6%
Habanero pepper	5%	0%	5%	11%	26%	21%	16%	11%	5%
Hungarian wax pepper	37%	16%	5%	5%	16%	0%	5%	5%	11%
Okra	47%	16%	5%	5%	5%	0%	11%	0%	11%
Orange carrot	42%	5%	0%	16%	11%	5%	11%	0%	11%
Portabella mushroom	26%	5%	0%	11%	11%	5%	26%	11%	5%
Potato	53%	11%	5%	0%	16%	0%	5%	0%	11%
Red carrot	42%	16%	0%	0%	11%	11%	5%	5%	11%
Romanesco	5%	0%	0%	42%	5%	21%	16%	5%	5%
Shiitake mushroom	50%	6%	0%	11%	11%	11%	6%	0%	6%
Sweet peas	53%	11%	11%	0%	5%	5%	5%	0%	11%
Tatsoi	37%	5%	0%	16%	11%	5%	11%	0%	16%
Tomatillo	53%	11%	0%	11%	11%	0%	5%	0%	11%
Tomato	32%	5%	0%	11%	16%	11%	16%	5%	5%
Yardlong bean	16%	5%	5%	16%	11%	11%	16%	16%	5%
Zucchini	22%	6%	0%	17%	6%	28%	11%	6%	6%

Table 5: Interest and Frequency of Vegetable Consumption: Asian Consumers.

Vegetable	Never and not interested	Never but interested	Daily	A few times a week	Once a week	A few times a month	Once a month	Once every 3 months	Greater than every 3 months
Asian long purple eggplant	7%	0%	7%	11%	15%	15%	19%	19%	7%
Bitter melon	44%	11%	4%	11%	4%	4%	7%	4%	11%
Bok choy	30%	7%	0%	11%	7%	19%	15%	4%	7%
Chili pepper	19%	11%	7%	19%	11%	7%	11%	7%	7%
Chinese (Napa) cabbage	22%	4%	4%	15%	15%	15%	7%	15%	4%
Colored bell peppers	11%	0%	0%	15%	11%	37%	15%	4%	7%
Daikon radish	33%	7%	0%	7%	15%	7%	11%	11%	7%
English cucumber	15%	4%	7%	15%	11%	19%	11%	7%	11%
Escarole	33%	19%	0%	7%	7%	11%	15%	4%	4%
Fuzzy melon	48%	15%	0%	15%	7%	0%	0%	4%	11%
Green bell pepper	15%	0%	0%	26%	22%	19%	15%	0%	4%
Habanero pepper	33%	15%	11%	11%	0%	15%	0%	7%	7%
Hungarian wax pepper	52%	30%	4%	0%	4%	4%	4%	0%	4%

Okra	26%	4%	4%	19%	4%	15%	7%	11%	11%
Orange carrot	4%	11%	7%	26%	15%	15%	7%	15%	0%
Portabella mushroom	26%	4%	0%	7%	19%	22%	7%	7%	7%
Potato	4%	4%	0%	26%	19%	30%	11%	4%	4%
Red carrot	30%	22%	4%	15%	15%	7%	7%	0%	0%
Romanesco	52%	26%	0%	4%	0%	11%	4%	4%	0%
Shiitake mushroom	26%	4%	0%	11%	7%	19%	7%	15%	11%
Eggplant	0%	8%	8%	12%	4%	15%	19%	31%	4%
Tatsoi	59%	26%	0%	0%	4%	7%	0%	4%	0%
Tomatillo	38%	27%	4%	8%	4%	4%	8%	8%	0%
Tomato	0%	0%	15%	30%	22%	26%	4%	4%	0%
Amaranth	52%	22%	4%	4%	4%	0%	11%	0%	4%
Bottle gourd	44%	19%	0%	11%	7%	7%	4%	4%	4%
Edamame	38%	12%	0%	8%	8%	8%	8%	12%	8%
Yardlong bean	33%	15%	0%	11%	4%	7%	4%	7%	19%
Zucchini	12%	4%	0%	12%	15%	15%	35%	8%	0%
Sweet peas	15%	0%	0%	23%	12%	27%	8%	15%	0%
Green beans	4%	0%	15%	19%	19%	19%	11%	15%	0%

Table 6. Interest and Frequency of Vegetable Consumption by Ethnicity and Use.

Vegetable	Never and not interested				Never but interested				Heavy (Couple times a week or more)			
	Caucasian	African American	Hispanic	Asian	Caucasian	African American	Hispanic	Asian	Caucasian	African American	Hispanic	Asian
Amaranth	53%	43%	42%	7%	20%	24%	16%	0%	5%	5%	21%	33%
Asian long purple eggplant	71%	52%	42%	44%	15%	24%	16%	11%	2%	5%	16%	19%
Bitter melon	54%	48%	47%	30%	13%	24%	5%	7%	5%	5%	11%	19%
Bok choy	51%	24%	32%	19%	9%	24%	16%	11%	8%	14%	11%	37%
Bottle gourd	53%	43%	37%	22%	19%	24%	11%	4%	4%	10%	16%	33%
Chili pepper	15%	5%	11%	11%	3%	5%	5%	0%	31%	38%	53%	26%
Chinese (Napa) cabbage	60%	48%	37%	33%	18%	5%	5%	7%	5%	10%	16%	22%
Colored bell peppers	26%	24%	37%	15%	8%	14%	0%	4%	21%	19%	26%	33%
Daikon radish	48%	48%	53%	33%	15%	14%	5%	19%	6%	10%	21%	15%
Edamame	60%	52%	42%	48%	23%	24%	5%	15%	3%	5%	11%	22%
Eggplant	16%	0%	21%	15%	2%	10%	5%	0%	34%	33%	42%	48%
English cucumber	58%	33%	32%	33%	10%	24%	5%	15%	4%	5%	26%	22%
Escarole	65%	67%	58%	52%	21%	10%	11%	30%	2%	5%	16%	7%
Fuzzy melon	61%	29%	42%	26%	13%	0%	5%	4%	3%	33%	11%	26%
Green beans	11%	5%	16%	4%	4%	14%	5%	11%	37%	38%	42%	48%

Green bell pepper	27%	38%	44%	26%	7%	5%	0%	4%	13%	14%	28%	26%
Habanero pepper	2%	0%	5%	4%	1%	0%	0%	4%	45%	48%	42%	44%
Hungarian wax pepper	55%	43%	37%	30%	29%	5%	16%	22%	5%	33%	26%	33%
Okra	65%	52%	47%	52%	18%	19%	16%	26%	4%	5%	16%	4%
Orange carrot	39%	48%	42%	26%	13%	14%	5%	4%	8%	0%	26%	19%
Portabella mushroom	27%	29%	26%	0%	5%	0%	5%	8%	11%	24%	21%	23%
Potato	75%	70%	53%	59%	16%	10%	11%	26%	2%	5%	21%	4%
Red carrot	58%	48%	42%	38%	21%	24%	16%	27%	6%	5%	11%	15%
Romanesco	5%	10%	5%	0%	1%	5%	0%	0%	57%	52%	47%	67%
Shiitake mushroom	71%	65%	50%	52%	20%	15%	6%	22%	2%	5%	22%	11%
Sweet peas	72%	57%	53%	44%	17%	19%	11%	19%	1%	5%	16%	19%
Tatsoi	48%	67%	37%	38%	14%	10%	5%	12%	6%	0%	26%	15%
Tomatillo	63%	45%	53%	33%	23%	30%	11%	15%	3%	10%	21%	15%
Tomato	17%	30%	32%	12%	2%	10%	5%	4%	22%	15%	26%	27%
Yardlong bean	19%	15%	16%	15%	5%	20%	5%	0%	23%	25%	32%	35%
Zucchini	7%	15%	22%	4%	2%	0%	6%	0%	34%	35%	22%	52%

Table 7. Per Capita Demand for Select Vegetables and Acres Supported by Demand.

	2014 Per Capita Demand (Lbs.)	Annual Total Lbs.	Acres Supported
Tomato	17.4	62,481,416	2,083
Bell Pepper	9.8	35,190,683	78,202
Carrots	8.2	29,445,265	1,133
Cucumbers	6.8	24,418,025	1,221
Mushrooms	2.8	10,054,481	40,218
Snap Beans	1.4	5,027,240	628
Eggplant	0.8	2,872,709	144
Kale	0.5	1,795,443	150
Okra	0.4	1,436,354	160
Escarole	0.2	718,177	24
Green/English Peas *	2.7	9,695,392	1,385
Hot Peppers *	6.5	23,340,759	51,868

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Table 8. Barriers to Purchasing more CT Ethnic Vegetables.

	Okra	Bok Choy	Asian Long Purple Eggplant
Prefer produced elsewhere	1%	1%	2%
Does not matter where produced	19%	22%	19%
Not available	20%	23%	26%
Poor CT quality	2%	2%	1%
Too expensive	10%	17%	14%
No organic options	6%	5%	1%
Other	46%	38%	32%

Table 9. Importance of Characteristics for Purchasing Various Ethnic Vegetables (0 = Not important, 100 = Extremely important).

External characteristics	Okra	Bok Choy	Asian Long Purple Eggplant
Size	50.9	53.4	58.8
Shape	48.4	48.8	50.9
Skin color	58.0	58.1	64.1
Firmness	61.9	60.8	70.4
Origin	58.7	55.3	58.7
Smell	54.4	57.7	56.3
Variety	50.9	52.5	56.3
No external damage	65.5	65.8	70.7
Other	44.4	46.2	38.4

Overall characteristics	Okra	Bok Choy	Asian Long Purple Eggplant
Price	67.1	69.5	70.8
Freshness	73.4	73.2	77.5
Pesticide free	63.3	63.4	67.6
Locally produced	56.7	54.5	60.3
Organic	53.2	51.9	51.8
Non-GMO	58.4	59.1	59.7
Other	42.0	44.7	37.9

Phytophthora Management in Christmas Tree Plantings of True Firs

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Project Summary

This project addressed focal areas described in the Specialty Crop Block Grant Program: (1) developing new and improved seed varieties of a specialty crop and (2) managing pests and diseases; and development of sustainable production practices. Christmas tree growers throughout Connecticut have observed increasing losses of trees due to root rots caused by *Phytophthora* spp., a water mold disease organism with long lived resting spores. *Phytophthora* diseases are expected to increase in importance in the Northeast if climate change results in an increase of high rainfall events, which provide conditions favorable to water molds and subsequent Christmas tree death. Plant disease infections can take place when there is a combination of (a) susceptible hosts, (b) pathogen inoculum, and (c) conditions that allow infection to take place. This project tested aspects related to host resistance and manipulation of soil conditions to reduce problems associated with phytophthora. Because our native firs (balsam and Fraser firs, in particular) are so susceptible to root rot, non-native fir species that are tolerant of phytophthora were tested under adverse growing conditions (heavy soils, which favor root rots). The best-performing trees were Turkish fir from Kokez and Keltepe sites, which had better survival and horticultural characteristics than either of the geographical sources for Trojan firs. Our native firs are tolerant of very acid soils, which may limit the growth or survival of phytophthora organisms. We found that reduction of soil pH from 6 to 4 resulted in improved establishment, survival, and growth of Fraser (susceptible) and Canaan (less susceptible) firs grown from bare-root transplants in a field with high levels of phytophthora inoculum. Growing Canaan fir under low pH conditions is an immediately available option to growers to avoid phytophthora root rots.

Project Approach

The Connecticut Christmas Tree Growers' Association was funded $36,092 in 2010 for three years for a long-term project "Genetic Improvement of Christmas Trees for Connecticut Farms," in which work was successfully completed as a collaboration between CCTGA growers and The Connecticut Agricultural Experiment Station (CAES). Besides the original 2010 work plan, this award enabled cooperation of the CCTGA and the CAES with leading researchers from five other states in the U.S., and one researcher in Denmark, who had just formed CoFirGE (Collaborative Fir Germplasm Evaluation). In 2010, the CT SCBG supported field tests of European species of firs; the best trees from these tests were transplanted in 2014 to establish a permanent seed production orchard at the CT Agricultural Experiment Station Research Farm in Griswold. CoFirGE has a mission identical to that proposed in our 2010 SCB grant. In 2013, 6,000 European fir trees were planted in CT as part of CoFirGE. The focus of CoFirGE is on Turkish and Trojan firs, which are known to be tolerant of heavier soil textures and phytophthora root rots. One goal was to select the best performing of

these trees to add to the seed orchard. However, although these species are less susceptible to *Phytophthora*, they are not immune. Furthermore, these species were found from our 2010 plantings to break dormancy earlier than Fraser and Canaan firs, and so can be disfigured by late frosts.

Continued profitable production of real Christmas trees requires finding one or a combination of (1) methods to make soil conditions unsuitable for survival of phytophthora, (2) ways to enhance the trees' endogenous defenses to prevent infection, and (3) ways to grow marketable phytophthora-resistant trees. This project addressed each of these avenues for managing phytophthora root rots by funding further collaborative work between CCTGA growers and the Connecticut Agricultural Experiment Station, to determine which practices are cost effective for Connecticut Christmas tree growers.

Goals and Outcomes Achieved

(1) To determine whether soil acidification to a pH of 4.0 will prevent infection of Fraser firs (a susceptible species) at sites with phytophthora.

Outcome: The hypothesis that soil acidification will protect firs from infection by phytophthora is based upon the knowledge that fir trees are unusually tolerant of acid soils, while many species of Phytophthora are not. Firs naturally grow in acidic soils containing few nutrients in various mountain ranges. There are several species of *Phytophthora*; species affecting Christmas trees in CT have been identified as *P. kelmania*, *P. pini*, *P. plurivora*, and *P. cactorum*. These species have varying degrees of tolerance of acidity (Cowles and LaMondia, unpublished data), as determined in laboratory experiments. The general observation is that *Phytophthora* spp. production of sporangia increases exponentially as soil pH increases (Jung, et al. 2000. Plant Pathol. 49: 706 – 718).

The incorporation of one ton of sulfur per acre with a rototiller to a depth of six inches in 2014 resulted in soil pH within the sulfur treated plots of 4, whereas the soil pH in the untreated plots remained at about 6. The growth performance of Fraser and Canaan firs planted in the spring of 2015, was measured in September, 2015, August, 2016, and September, 2017. Each sampling date evaluated the overall color of each tree and the terminal growth of the leader. The incorporation of sulfur improved the root health during the year of planting, as indicated by subtle but highly statistically significantly improved color during that year. Although the color of all surviving trees was very good the next year, the effects of soil acidification with sulfur persisted in 2016, as evident by doubling of the terminal growth for the trees planted into acid soil compared to trees growing in higher pH conditions. Based upon the annual evaluation of tree survival, it is clear that soil acidification greatly reduces the mortality rate for trees. The order for increasing mortality rate is Canaan fir in sulfur treated plots, Canaan fir in higher pH plots, Fraser fir in sulfur treated plots, and Fraser fir in higher pH plots. I estimate that it should be feasible to grow Canaan fir in this field, in spite of high Phytophthora inoculum levels, with sufficiently low losses due to root rot to harvest a profitable crop, and may meet the stated target of experiencing less than 10% overall losses due to root

rot during a crop cycle. The increased growth rate for trees planted into sulfur-amended plots suggests that this crop could be harvested one year earlier than it would have been if sulfur had not been incorporated, which would greatly improve grower profitability. Although the mortality rates for both Fraser and Canaan firs were reduced with the addition of sulfur to the soil, the mortality of Fraser fir would still be great enough to warrant avoiding planting this species on sites subject to losses due to phytophthora root rots.

(2) To determine whether a root dip at the time of planting and use of an annual basal bark spray of materials (imidacloprid and phosphites) known to induce the plants' systemic acquired (SAR) pathways can permit Fraser or Canaan firs to be grown in sites with phytophthora.
Outcome: The root dip with chemicals known to induce the SAR pathways varied in their response. Unlike a previous experiment, neonicotinoid insecticides were not found to benefit the initial establishment of the trees. Potassium phosphite significantly improved the establishment of Fraser firs when used as a root dip, but a subsequent basal bark spray (in the following year) did not improve growth. The phosphite product did not improve the establishment or growth of Canaan fir, suggesting that one mechanism protecting this species from infection could be constitutive (vs. induced) activation of the SAR pathway.

(3) To measure the survival and growth rate of Fraser and Canaan fir scions top-grafted onto European fir rootstocks.
Outcome: The attempts at grafting were unsuccessful. Consultation and training provided by a grower in Rhode Island revealed that the lack of success was due to attempting grafting when the scion wood was active. Grafting requires that the rootstock be actively growing, but the scion wood be dormant.

(4) To measure the growth, survival, and bud break phenology of Turkish, Trojan, and Nordmann firs planted into heavy-textured soils.
Outcome: The goal of the CoFirGE project was to cooperate in obtaining seeds and evaluating seedlings of Turkish and Trojan fir species for use as Christmas trees across production regions of the United States and Denmark. Container-grown seedlings were produced at a nursery in Oregon from the seed collected in 2010. Each provenance (location) was represented by cones collected from 20 mother trees, resulting in a total of 100 open-pollinated families (5 provenances × 20 families per provenance). Not all lots of seeds grew well in the nursery, and so rather than 100 representatives of these two species, there were 88. The remaining dozen genetic types to fill in the experiment included five accessions of Nordmann fir (*A. nordmanniana*), and one accession each of noble, balsam (*A. balsamea*), concolor (*A. concolor*), Fraser, grand (*A. grandis*), Korean (*A. koreana*), and Turkish fir from a North American seed orchard. A total of 30,000 seedlings were produced and then distributed to five regional cooperators around the country. Each cooperator was responsible for establishing two test plantations. Within the test plantations, each of the 100 families was replicated 30 times resulting in a total of 3,000 trees per plantation.

In the Connecticut planting, trees were subjected to being planted in waterlogged soil, by harsh winter temperatures caused by polar vortex events, and droughts during the 2015 and 2016 growing seasons. Of the Turkish and Trojan firs, there was poorer survival of Trojan fir (Kazdagi accessions). Families of Trojan firs from both seed collection sites had fewer individuals surviving until 2017 (40 and 44% survival), compared with the Turkish fir sites (53 – 58% survival). Of the Turkish fir accessions, those from the Kokez and Keltepe sites had the greatest survival, which differed significantly from accessions of Trojan firs, while those from Dokorcun were intermediate. This survival rate does not look favorable, until you consider how harsh the soil conditions were and how poorly the other species survived. The Nordmann fir accessions were similar to Turkish fir (average, 59% survival), whereas the other species had survival ranging from 6 – 18% of the trees planted.

There are several horticultural difficulties inherent with growing Turkish firs. They appear to be highly palatable to vertebrate pests, including gophers, rabbits, and deer. They have early bud break, which may predispose them to injury from late spring frosts. Most importantly for harsh northern conditions, they are prone to bud abortion, especially of the leader bud and sometimes a significant proportion of buds in the top whorl. In our experience, trees that reestablish strong apical dominance after aborting the terminal bud can result in trees that continue to have a pyramidal form. A new replacement terminal will not form from the adventitious buds at the center of the plant (where the leader bud died) for about two years. Growers attempting to use these center buds to grow a new leader, and who cut off side whorl shoots when trying to maintain a straight trunk will find that it will form a rather unsatisfactory weak leader with a poor whorl bud count, and a short, squat, slow-growing tree. A better strategy is to immediately select a side whorl bud to form a new leader, even though this will result in a crooked stem. The replacement leader formed from a side bud will be missing a whorl bud pointed toward the center of the tree after the first year of growth, which could leave a gap in foliage. If the tree is allowed to grow, this gap will be filled in by the growth from the adventitious buds that break where the original leader bud had died.

The extent of bud-break was scored on a single date for each location. Bud-break was scored on a scale of 0 (no bud swell) to 6 (shoots elongated). Based on this rating, a higher number indicates earlier bud-break. Both provenances of Trojan fir exhibited earlier bud-break than the Turkish fir provenances. This suggests that the Trojan fir may be at a higher risk for damage from early spring frosts than Turkish fir. The Turkish fir exhibited a phenology of bud break in the order Dokorcun, Kokez, and Keltepe, a west to east ordering.

In spite of early bud break characteristics and higher mortality, the Trojan fir from the Kazdagi location had the greatest average height, the greatest number of whorl buds, and overall better pyramidal form than the other Trojan and Turkish firs when grown in Hamden, Connecticut. The lack of a clear relationship between bud break phenology and form suggests that at this geographical location, early bud break may not be the most important predictor of horticultural value of these fir species.

It is important to recognize that there was considerable variation from each seed sampling location among the traits we measured in the CoFirGE plots in Connecticut: mortality, bud break phenology, height, number of whorl buds, and proportion of whorl buds surviving. This suggests that with some effort, the best trees could be identified out of these groups, and kept for starting seed orchards to generate new generations of trees to further improve upon the traits that we value for growing Christmas trees. It will be a long process, but being able to consistently grow quality trees under highly variable temperature or precipitation conditions may increase the relevance of Turkish and Trojan firs to Christmas tree growers in North America.

Measurable outcomes

(1) A statistically significant and higher proportion of Fraser and Canaan firs will survive in acidified soil when also protected with products that induce the SAR pathway, when compared with those planted in non-acidified soil and left untreated.
Outcome: There was a highly statistically significant improvement in survival and growth of Fraser and Canaan firs planted into highly acid soil, compared with soil with pH of 6. In addition, Fraser fir survival and growth benefitted from a root dip with potassium phosphite. The proposal's expected measurable outcome was to have less than 10% mortality of trees planted within a phytophthora-infested field reach harvestable size. This goal probably can be reached with Canaan fir (the trees would not be harvested for another four years, so we aren't certain), but not for Fraser firs.

(2) At least ten Connecticut growers will purchase Turkish, Nordmann, or Trojan firs to establish new plantings of these species on their farms.
Outcome: A follow-up survey of growers has not been conducted, but at least two Christmas tree growers in CT have planted Turkish firs.

Beneficiaries

Connecticut Christmas tree growers are the immediate beneficiaries of this project, because they have been informed first of the results. However, these results are being shared through the Christmas Tree Board (established since the start of this project), and will be published in peer-reviewed journals, as well. The Country Grower magazine has featured results from this work, which garnered interest from growers and extension specialists from North Carolina to Washington State.

Lessons learned

The idea to plant fir trees in saturated soil conditions for the CoFirGE part of this work led to extremely high mortality of most species of firs, including Turkish and Trojan firs. This was necessary as an "acid test" of the ability of these species to tolerate unfavorable soil conditions. One lesson learned was that these species of firs should not be planted in saturated soils. However, we also observed that Korean fir survived

quite well under extremely wet soil conditions, and so this species could be considered for planting in very wet (but not saturated) sites.

We had preconceived ideas that early bud break traits would make accessions of firs unsuitable for growing as Christmas trees. The surprise is that some of the accessions with early bud break compensated for damage with extremely vigorous growth, high bud counts, and high ability to reestablish apical dominance.

Grafting requires rootstock and scion in different physiological states: the rootstock has to be actively growing, and the scion must be dormant at the time of grafting.

Producing Cut Flowers for Profit and to Enhance Biological Control of Vegetable Pests

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Project Summary

There is a heightened interest and need of developing integrated pest management (IPM) systems that include as much as possible help from the pests' natural enemies (predators, parasitoids, etc). One IPM approach that has been successfully employed in a variety of vegetable and fruit crops is conservation biological control. Conservation biological control involves manipulation of the environment to enhance the survival and fecundity of natural enemies as to increase their effectiveness. In conservation biological control, flowering plants that attract natural enemies are strategically added in proximity to the crop plants. Many insect parasitoids and predators visit these flowers to obtain nectar and/or pollen that provide essential nutrients. This in turn improves fecundity, longevity and increases rates of parasitism/predation. It is of key importance to select plants that actually attract the natural enemies relevant to the pest of concern and that the floral resources are accessible to the natural enemies.

The purpose of this project was to identify plants that can attract and provide nutritional resources to key natural enemies of the caterpillar pest complex (diamondback moth, imported cabbageworm, etc.) on cole crops. The plants identified by the project should also provide an economic benefit from their sale as cut or dry flowers and herbs. Not all cut flower species are suitable for attracting natural enemies due to their harvest time, flower features attractive/useful to natural enemies and likelihood of attracting pests. Thus, it is essential to have a detailed study of cut flowers species that can serve for conservation biological control purposes. This project will examine species that have a very good potential to attract natural enemies and that are grown in Connecticut. Growers interested in using plants to attract natural enemies will be able to obtain a benefit from harvesting the plants too. This project is important and timely because it will provide information on plants that can aid in pest management for specialty crops such as cole crops and that can provide additional income as a specialty crop themselves (cut flowers).

Project Approach

Twenty cut flower cultivars were evaluated for their attraction of insect natural enemies and to monitor for any pest activity on these plants. The screening of the cut flowers was a success in terms of documenting which plants were most attractive to natural enemies and the type of pests that they may harbor or attract.

For each plant type, observations were done on the type of natural enemies that visited the flowers for nectar/pollen and shelter. Insects and other arthropods observed directly on the flowers were quantified and collected for species identification. Sample analysis results documented a high diversity of natural enemies visiting the flowers and they are summarized in Figure 1 by the number of insect families collected. Information was also

collected for pollinator species. Some flowers like *Ammi majus* attracted a high number of parasitoid and insect predator families. Other flowers that attracted numerous natural enemies included Gomphrena 'Vegas White', Celosia Cristata 'Kurume' and Celosia Cristata 'Triangle Mix'.

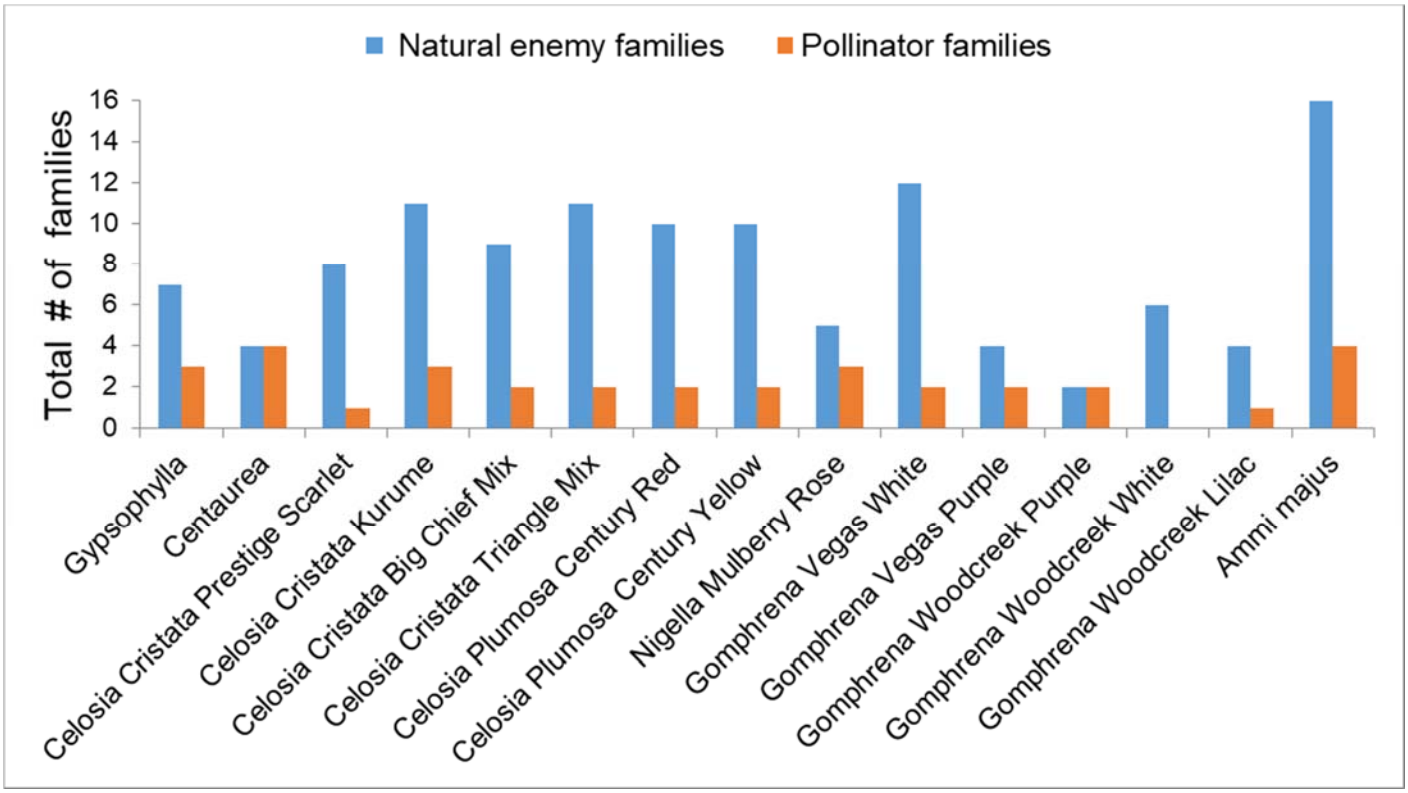


Figure 1. Total number of insect natural enemies and pollinators collected from and observed on flowers.

Insects collected from each flower type were identified to family. From these results, the cut flower *Ammi majus* was selected for further work in cabbage because of the high diversity and number of natural enemies attracted. The natural enemy families are summarized below in Table 1.

Each family contains several species so it is easier to summarize the results using this taxonomic level. Altogether, 14 families representative of insect parasitoids were collected along with 9 families that include mostly insect predators. *Ammi majus* stood out among all plants because of the largest number of natural enemy families collected from it (Fig. 1). Other flowers that attracted a good diversity of insect families included *Gomphrena globosa* 'Vegas White', *Celosia argentea cristata* 'Kurume' and *C. argentea cristata* 'Triangle Mix'. It was expected that all *C. argentea cristata* would attract many syrphids however this was not the case. Only one syrphid was collected from *C. argentea cristata* 'Triangle Mix'. This was surprising considering this plant is described by others as one that attracts syrphids. A large number of parasitoid families were found

across several cut flower cultivars. For example, braconidae parasitoids were collected from many plants and the highest number of specimens came from *C*. *argentea cristata* ‘Kurume’.

The project also collected data on other arthropods found on the flowers that could be considered a pest. While several types of insects were recorded throughout the project, there was no group that reached pest status and impacted plant quality. In fact, it was notable that most of the plants did not suffer damage from leaf feeding beetles that were found in high numbers in the vicinity of the cut flowers. Thus, this is an observation that deserves follow-up study as these plants could be considered resistant to these pest beetles. In addition to potential pest resistant qualities of the cut flowers examined, several of the cut flowers selected can be also sold a dried flowers such as all of the *Gomphrena* cultivars and in particular *Nigella damascena* which produces a very interesting and aesthetically pleasing seed pod that can be used as a dried component in flower arrangements.

In conclusion, from these results, the cut flower *Ammi majus* was selected for further work in cabbage because of the high diversity, type and number of natural enemies it attracted. Moreover, one can recommend several of the cut flowers examined for natural enemy attraction and conservation. In particular, all of the flowers tested attracted a high number of anthocorids which are important general insect predators. Most flowers attracted coccinellids (ladybird beetles) and only a few flowers were acceptable for syrphid fly (hover fly) attraction. Plants recommended for attracting these insect predator families are listed in Table 2. In regards to insect parasitoids, only *Ammi majus* attracted both braconids and ichneumonid parasitoids (Table 1) and the only other plants that can be suggested for braconid attraction are cultivars of *Celosia argentea cristata* and *C. argentea plumosa.* Both braconid and ichneumonid families include many important parasitoids of vegetable pests.

FLOWER NAME	INSECT NATURAL ENEMY FAMILIES
Gypsophylla	Anthocoridae Syrphidae Coccinellidae Figitidae
Centaurea	Anthocoridae Braconidae Syrphidae
Celosia Cristata Prestige Scarlet	Anthocoridae Superfamily: Chalcidoidea Braconidae Coccinellidae Mymaridae
Celosia Cristata Kurume	Anthocoridae Superfamily: Chacidoidea, Torymidae Superfamily: Chacidoidea, Eulophidae Conopidae Coccinellidae Braconidae Figitidae Encrytidae Platygastridae
Celosia Cristata Big Chief Mix	Anthocoridae Coccinellidae Scelionidae Figitidae Superfamily: Chacidoidea/Eulophidae Superfamily: Chacidoidea/Eupelmidae Superfamily: Chacidoidea/Encrytidae
Celosia Cristata Triangle mix	Coccinellidae Anthocoridae Figitidae Ceraphronidae Superfamily: Chacidoidea, Eulophidae Anthocoridae Tiphiidae Syrphidae Platygastridae
Celosia Plumosa Century Red	Braconidae Diapariidae Anthocoridae Coccinellidae Platygastridae Nabidae Geocoridae Tachinidae
Celosia Plumosa Century Yellow	Coccinellidae Anthocoridae Braconidae Superfamily: Chacidoidea, family Chalcididae Bethylidae Nabidae Superfamily: Chacidoidea, Eulophidae Figitidae
Nigella Mulberry Rose	Anthocoridae

	Figitidae Superfamily: Chacidoidea, Torymidae Coccinellidae Syrphidae
Gomphrena Vegas White	Coccinellidae Anthocoridae Syrphidae Superfamily: Chacidoidea, Eulophidae Platygastridae Bethylidae Superfamily: Chacidoidea, Torymidae Figitidae Phoridae
Gomphrena Vegas Purple	Anthocoridae Syrphidae
Gomphrena Woodcreek Purple	Anthocoridae
Gomphrena Woodcreek White	Platygastridae Coccinellidae Anthocoridae Tachinidae Phoridae
Gomphrena Woodcreek Lilac	Braconidae Anthocoridae
Ammi majus Queen of Africa	Superfamily: Chacidoidea, Eulophidae Tiphiidae Figitidae Braconidae Ichneumonidae Sphecidae Phoridae Tachinidae Syrphidae Anthocoridae Coccinellidae Superfamily: Chacidoidea, family Torymidae/Eupholidae Scelionidae Cecidomydiidae

Table 1. Natural enemies families collected and identified from selected cut flowers

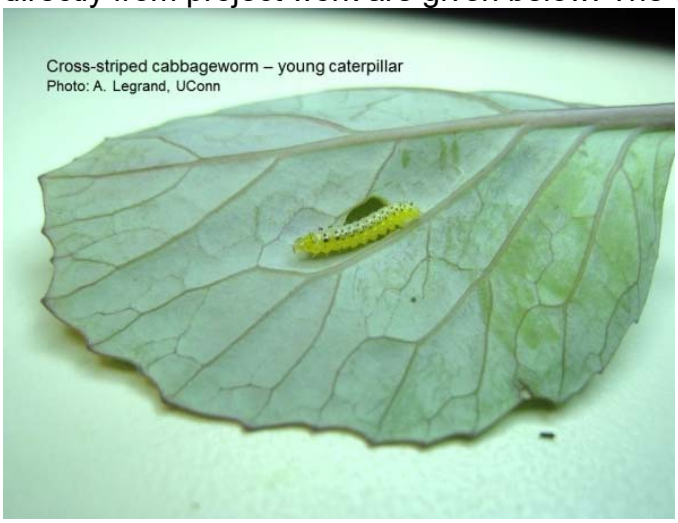
As a follow up on the project results, a field experiment is underway to test the hypothesis that cabbage plots which included *Ammi majus* in the planting will attract more natural enemies and therefore cabbage caterpillars will suffer more predation or parasitism. Plots were established successfully in 2016 and 2017 and cabbage caterpillars were sampled through each season from June to the end of September to determine the number of caterpillars found in plots with and without the cut flower plantings. Also, all caterpillars found were collected to rear out internal parasitoids in the lab. This yielded a significant number of parasitoid specimens for identification. Table 2 summarizes information on the caterpillar species collected and the parasitoid species reared from them in the lab. The following primary species were collected as part of the cabbage caterpillar complex: imported cabbage worm *Pieris rapae*, Diamondback moth *Plutella xylostella*, cabbage looper *Trichopusia ni* and the cross-striped cabbageworm

Evergestis rimosalis. Secondary species that were also collected but not in significant numbers included the celery leaftier *Udea rubigalis* and the saltmarsh caterpillar *Estigmene acrea.*

Parasitoid family	Parasitoid species	Caterpillar host
Ichneumonidae	*Diadegma insularis* *Diadromus subtilicornis* *Gelis* sp. - Hyperparasitoid of *D. insularis* and *Cotesia rubecula* pupae	3rd to 4th instars of *Plutella xylostella* Pupae of *Plutella xylostella*
Braconidae	*Cotesia rubecula* *Cotesia glomerata* *Cotesia orobenae* *Microplitis plutellae*	Early instars of *Pieris rapae* Early instars of *Pieris rapae* Early instars of *Evergestis rimosalis* Early instars of *Plutella xylostella*
Tachinidae	*Phryxe vulgaris*	Late instar of *Pieris rapae*
Eulophidae	*Oomyzus sokolowskii* *Tetrastichus galactopus* – hyperparasitoid of *Cotesia rubecula*	3rd and 4th instar of *Plutella xylostella*
Pteromalidae	*Pteromalus puparum*	Late instar of *Pieris rapae*
Encrytidae	*Copidosoma* sp.	Late instar of *Trichopusia ni*

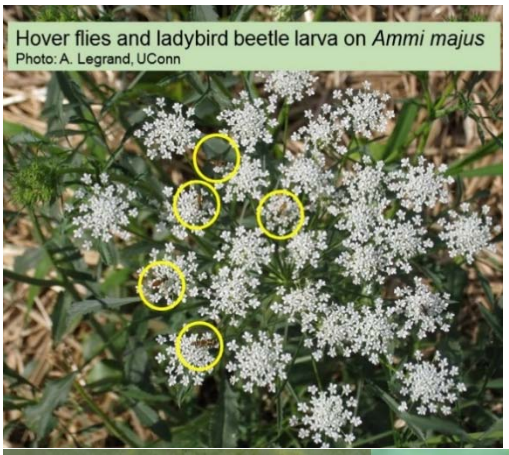
Table 2. Parasitoid species and cabbage caterpillar species collected from cabbage.

A favorable development from this project was the ability to contribute information to the weekly IPM Extension Vegetable Pest and Disease Update sent by e-mail to growers in the state. Information on pest occurrence, identification and management was shared through this pest alert. Examples of photos included in the weekly updates and derived directly from project work are given below. The update text is not included below.



Most tasks described in the project plan were accomplished except for the work with stink bugs which as described below was not possible. Also, it was decided not to periodically harvest the cut flowers as initially planned because for experimental reasons it was deemed necessary to keep them in place throughout the season until they were killed by frost.

Cross-striped cabbageworm – older caterpillar
Photo: A. Legrand, UConn



Hover flies and ladybird beetle larva on *Ammi majus*
Photo: A. Legrand, UConn

Hover fly larva crawling on cabbage. The larvae of these flies feed on aphids.
Photos: A. Legrand, UConn

Goals and Outcomes Achieved

The goal to identify cut flowers that attract beneficial insects was met and follow-up work has started to develop applications of this knowledge for vegetable pest management. The results from this project were used to update the IPM Program fact sheet titled 'Plants that attract beneficial insects' so that it includes the latest information from this project. Also, 9 presentations were developed and delivered based on the results from this project. These are listed at the end of this section.

Evaluations from presentation attendees were collected to measure the gains in knowledge. The following table summarizes the measurable outcome and evaluation results. The target goal for the project outcome was to develop new information and the proposed measure was increase/change in knowledge. It was proposed that at least 70% of attendees will increase their knowledge and this target was met by 92% of respondents indicating a good or significant increase in knowledge regarding conservation biocontrol/insectary plants and 92% indicating an increase in knowledge regarding cut flowers as insectary plants.

Expected Measurable Outcomes

		Evaluation Results
GOAL	The project will develop new information currently not available to growers regarding use of cut flowers plants to enhance biocontrol.	
PERFORMANCE MEASURE	Increase in knowledge	
TARGET	At least 70% of attendees will increase their knowledge on conservation biological control and on the project results.	92% of attendees indicated a good or significant increase in knowledge regarding insectary plants. 92% of attendees indicated a good or significant increase in knowledge regarding the use of cut flowers as insectary plants. 8% indicated a small increase and 0% indicated no changes in knowledge. 96% of attendees indicated that they were very likely to use the cut flowers as insectary plants.
INFORMATION DESSEMINATION	Workshops, presentations, publications	9 presentations/workshops were delivered.

Presentations:

Legrand, A. 2016. Conservation of beneficial insects for vegetable pest management**.** NOFA Winter Conference Workshop. March 12, 2016.

Legrand, A. 2016. Gardening for beneficial insects. Garden Barn Vendor Days Education Series. April 3, 2016.

Legrand, A. 2016. Plants to attract and conserve beneficial insects. Goodwin Conservation Center Seminar. September 17, 2016.

Legrand, A. 2016. “Preparing for next spring” Plants to attract and conserve beneficial insects. Southington Library Evening Talk Series. September 20, 2016.

Legrand, A. 2016. Identification of insectary plants for conservation biological control. Northeast IPM Center 2nd Online Conference in November 9, 2016.
Legrand, A. and P. Obeysekara. 2017. Survey of beneficial insects visiting specialty cut flowers. ESA EB Meeting. March 19, 2017.

Legrand, A. 2017. A bouquet for beneficials: which insects do cut flower plantings attract? NOFA Winter Conference Workshop March 11, 2017.

Legrand, A. 2017. A bouquet for beneficials: insectary plants for conservation biocontrol. Xerces Society Conservation Biocontrol Short Course. June 13, 2017.

Legrand, A. 2018. Use of insectary plants to attract beneficial insects. CNLA Winter Symposium Spanish Program. To be presented Jan. 25 2018.

Beneficiaries

The main goal of the project is to determine the suitability of flowering plants to aid in natural enemy conservation and to provide income from their sale. The knowledge generated by this project will serve to provide additional integrated pest management (IPM) tools and pest biology information to benefit any interested vegetable and flower grower.

Vegetable production, especially for the fresh market, is an important component of Connecticut agriculture. According to the 2012 Census of Agriculture, there were 952 farms, reflecting an increase of 29.9% from the number reported in 2007. Market value of sales reported during that census totaled $36,386,000 (including melons, sweet potatoes, and potatoes). According to the New England Fruit and Vegetables Report for 2012, 64% of Connecticut producers market their products directly to consumers and 19% market directly to retail. A diverse line of products such as flowers and vegetables is attractive to consumers in direct market situations such as farm stands or farmer's markets. This project will benefit Connecticut growers and the knowledge generated will also benefit vegetable growers in the Northeast region.

Lessons Learned

The planting of the cut flowers was somewhat delayed due to weather conditions during the first year and improvements were made in subsequent years to improve plant establishment and protection from vertebrate herbivores which turned out to be more of a concern for the flowers than arthropod pests. In fact, the flower plants selected did not suffer from insect pest problems. It was interesting to observe that many of the plants selected were not at all susceptible to attack from some common beetle pests that were found in high numbers in nearby areas. However, these observations will need to be corroborated with an experiment. As part of the project activities, the project director carried out a survey of the caterpillar pest complex found in cabbage and of stink bugs that could be found in peppers. For this purpose, cabbage and sweet pepper field plots were established. In cabbage, the survey was a success in terms of providing baseline

data on the type and number of each caterpillar found. Species collected were detailed above. The survey of insects in peppers planted at the Research Farm did not yield a significant number of stink bugs of any type and therefore work did not continue with peppers.

Additional Information

The following photos depict the project field activities.

Sudangrass cover crop used to protect soil and suppress weeds around cabbage experimental plots.
Photo: A. Legrand, Uconn

This final report was previously approved in April 2017

Technical Development of Year-Round Hydroponic Strawberry Cultivation in Controlled Environment Agriculture

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Project Summary

The sweet and tart strawberry is the fifth most consumed fruit in North America that is at $2.6 billion fresh fruit market. 2014 U.S. strawberry production was reported to be 36 billion pound (1) or translating to approximately 11 pounds consumed annually per capita. Strawberries have become a commonly seen fruit today in grocery stores and always in high demand throughout the year.

Despite the high popularity of strawberries, strawberry farm acreage in Connecticut stands only at 217 acres (2) out of 56,140 acres harvested in the U.S. (3). Because of the limited growing season (i.e., May-June, September) in Connecticut, the availability of local strawberries is limited and the market share is currently dominated by the out-of-state producers, especially from California. The short availability of the local berries can be attributed to our reliance on conventional open-field production; giving regions with moderate climate zones such as California and Florida advantages. However, in California, where 80% of the nation's strawberries are grown, many agricultural producers have been subjected under an unprecedented extreme drought now in its fifth year. The full implication of the drought if continued long-term is yet unknown at this time.

Commercial-scale field strawberry production, often employing practices like plasticulture, involves labor intensive land preparation and tireless pre- and post-crop management. Strawberries are prone to a myriad of pests such as strawberry bud weevil, two-spotted spiker mite, strawberry rootworm, and white grub, amoung others. They are also very susceptible to fungal foliar diseases, including leaf scorch, leaf spot, leaf blight, powdery mildew, as well as root diseases such as verticillium wilt and red stele. Many growers combat these issues with a soil sterillization practice called fumigation and foliar spraying of harsh chemicals. As result, 2014 USDA report (4) found 98% of strawberry samples they tested contained detectible traces of insecticides and fungicides, including some of the most toxic chemicals known, making strawberries the most "dirty" crop today. To give some perspective, fumigation practice requires nearly 300 pounds of fumigant per acre for strawberries whereas corn needs 5 pounds of pesticides per acre. These chemically-intensive procedures expose producers and consumers alike to dangerous levels of health detriment and lead to environmental degradations.

In this project, we investigated applicability and its viability of controlled environment agriculture (CEA) techniques, especially of an emerging sub-segment of CEA known as indoor vertical farming using hydroponic technique, on strawberry production. Vertical

farming allows for high density and year round production of fruits and vegetables in a climate controlled and pest free environment in multi-tiered platform. The cultivation method is agnostic to weather and uses significantly less water, making it well suited for production in urban or suburban areas; thus it has a potential to transform today's food production scheme to more decentralized production. The incentive arose from successful transition of strawberry production in many parts of the world using CEA techniques for decades. As an illustration, consider that CEA (in greenhouses) adoption for strawberries in the U.S. is mere 0.025%, or 14 acres (5), whereas approximately 87% of strawberries in Japan are grown in greenhouses (6).

Presently there are 149 active strawberry farms, predominantly "pick-your-own" operations, in Connecticut (5) that support an estimated $3 million industry (7). This proposal sought to enhance the competitiveness of Connecticut strawberries in the local markets through (Goal 1) research and development of strawberry cultivation techniques in hydroponics-based CEA, particularly in indoor vertical farming, to support scalable and in-state year-round production and (Goal 2) provide education outreach to provide practical information to the local producers on the developed CEA technique. Therefore, this research project attempted to develop hydroponic techniques for growing fresh and local strawberries that increase productivity and mitigate risks for the producers. Through seminars and workshops, the project goal was to inform the area producers of the technique that could enhance their competitiveness.

This project was not submitted to or funded by another prior federal, state or private entity grant programs.

Project Approach

The foundation of this effort was research and development in nature with an aim to furnish growers with useful information on various CEA techniques employed in strawberry cultivation domestically, including our own developed method, and abroad. To this end, we began our examination with literature search and online search on the subject. In order to obtain first hand information on CEA strawberry production, meetings with CEA professionals and leading researchers were arranged.

In order to apply collected knowledge towards practice, we converted a section of warehouse office into an indoor vertical farm. A growing room equipped with vertical farming racks and necessary lighting, irrigation, and growing containers and media was appropriated as well as an adjacent preparation room with a sink. The research was conducted at this premise for the duration of the project and cultivation data was collected.

The productivity of the techniques to be developed was measured by yield (in weight) per area per annum. Our initial production goal was set to increase the per area productivity by at least 50% of the baseline data which was the current starwberry productivity in Connecticut of 4,600 lb. per acre (or 0.516 kg m^{-2}) reported by USDA New England Fruits and Vegetables, 2012 Crop (7). The progress of strawberry

cultivation in CEA was recorded for each plant cycle. At the end of the cycle, the total harvested berry weight measured was compared against the baseline data.

Finally, we planned to disseminate our results and relevant findings to local growers in forms of newsletter publications and workshops. The educational outreach was aimed to increase growers' awareness on CEA techniques and encourage them to pursue indoor strawberry production as an alternative crop business.

Goals and Outcomes Achieved

The project consisted of mainly two primary objectives; research and development and educational outreach, to increase the viability of Connecticut strawberries.

Goal 1: Research and Development

Conduct survey of and receive training on the greenhouse hydroponic strawberry production

We began the project in January 2015 with a survey of the current state of hydroponic strawberry production in greenhouses, a form of CEA, from literature and online resources. Although the information on hydroponic strawberries was scarce and fragmented, there were enough to understand the state of current techniques used in the U.S. The majority of available hydroponic strawberry information found were for outdoor environment with little to no environmental control except for irrigation. We have also conducted a journal review and found limited publications on strawberry production in CEA. However, the information found remained mostly academic in nature.

A good review of strawberry production in the U.S. was compiled by a consortium of universities called the National Strawberry Sustainability Initiative led by the University of Arkansas. In its report (8), several greenhouse strawberry productions were introduced, however, many of them were limited to plasticulture within a protective environment. The most comprehensive information on CEA greenhouse strawberry production was available from Dr. Chieri Kubota of the Controlled Environment Agriculture Center at the University of Arizona (UA). Separately, University of Florida Horticultural Sciences offered limited information on greenhouse strawberry cultivation projects on their site.

Internationally, we found mentions of greenhouse productions from the Netherlands and Isreal. However, our review yielded no publicly accessible information from these countries. Additionally, information on raised bench greenhouse production was obtained from several Japanese horticultural science literature and research groups.

Therefore, based on the compiled information, a training session on the basics of strawberry physiology and CEA plant production practices was arranged with Dr. Kubota at the University of Arizona to learn their techniques first hand. The training topics covered were 1. Cultivar and planting materials, 2. Substrate basics and nutrient, and 3. Environmental control and crop management. Upon completion of the training, a report on the current state of the art greenhouse hydroponic strawberry was generated. A target benchmark performance goal set by the Kobota group was 7 kg m^{-2}, which was

approximately twice that of open-field yield productivity in California and considered to be the yield hydroponic strawberries become economically viable.

While we had limited successes in finding out the information on CEA greenhouse strawberry production, we were uable to find any information or training program on strawberries grown in closed-loop indoor farming using artificial lighting in the U.S. The technical development of off-season strawberry production in CEA, especially in indoor vertical farming, and their energy analyses were the main focus of this project because availability of cultivation data was lacking and climatically Connecticut has a very different profile than Arizona. Furthermore, the climate control methods and energy profiles are very different in indoor vertical farming from that of greenhouse. For example, in cold months, cooling may still be required in the closed-loop vertical farming whereas heating is generally required in greenhouses. The practical experience and knowledge gained from the project would become invaluable and open a path towards successful commercialization of a specialty crop for Connecticut producers. To our knowledge, this was the first project in the U.S. to explore the feasibility of commercial-scale strawberry production in the closed-loop vertical farming CEA.

Cultivar selection

Strawberry cultivar selection is an important criteria in the success of a commercial strawberry enterprise. Cultivar selection can affect quality, performance, climatic tolerance, disease resistance, as well as protectant resistance. June-bearing cultivars are more vigorous bearers but typically produce one crop a year after planting. Therefore, in our trial, we have decided on two day-neutral cultivars, designated as Cultivar A and Cultivar B. The day-neutral varieties were chosen based on their insensitivity to photoperiod, ability to continually bear fruits in the first year of planting, and their resistance to foliar diseases.

Figure 1. Day-neutral Cultivar A and Cultivar B.

Fitting-out of a CEA room and system installation

A section of warehouse office in South Windsor, CT was leased in February to be converted into a CEA production facility. The warehouse was emptied and cleaned in preparation of a fit-out. The site was surveyed and a renovation plan was drawn up by an architect to create cultivation rooms, a preparation and cleaning room, and a

vestibule. The interior was constructed in the subsequent months with appropriate electrical and water line works.

In this initial phase of the experiment, our primary objective was to establish a benchmark performance of hydroponically grown strawberries in an indoor environment. We decided to conduct the trial by following the methodology similar to the one developed and used by the UA with some original design modifications of our own incorporated.

The growing room was equipped with two 4-level racks dedicated for the strawberry cultivation experiment. Custom-designed fabric troughs were chosen to keep plant roots well drained and aerated, and maintain cooler temperature in the root zone from evaporative cooling effect. Six of our Triple-Band LED bars, proprietary horticultural LED lights that emit red-, green-, and blue-bandwidths to produce full-spectrum white light, were installed above each fabric trough to form two levels per rack or total of four 2 ft. x 4 ft. area trough beds. The LEDs were the sole light source in lieu of natural light in order to evaluate efficacy of LED lighting on strawberry plants. The photoperiod was 16 hours on and 8 hours off to secure per level minimum Daily Light Integral (DLI) of 15 mol at power consumption of 138W.

Two 6-inch deep troughs in one rack and two 12-inch deep troughs in another rack were set up to investigate the effect of root zone volume on yield performance. After disinfection protocol with a diluted hydrogen peroxide solution, a total of 20 bare root crowns per cultivar were planted in the fabric troughs filled with media that consisted of coco coir and perlite on December 30, 2015. Therefore, 10 crowns of each cultivar were planted in the 6-inch and 12-inch troughs, respectively. Cultivar A in the 6-inch trough was designated (A6) and in the 12-inch trough was designated as (A12). Similarly, Cultivar B in the 6-inch trough was designated (B6) and in the 12-inch trough was designated as (B12).

Figure 2. Indoor strawberry cultivation set up. In left top was B6 and left bottom was A6. In right top was A12 and right bottom was B12.


Figure 3. Cultivar B crowns after planting on Dec. 30, 2015.

Drip irrigation lines were set up in each trough from a shared 50-gal reservior with pressure-compensating emitters. Watering was controlled by a digital timer to turn on a pump at 6 or 8 hour intervals. Along with environmental conditions of air temperature and humidity, solution temperature, pH and EC were logged during the experiment.

Strawberry cultivation data collection and analysis

The strawberry plants started producing flower buds about a month after planting. However, all buds were pruned for the first two months to promote vegetative growth. We observed slower vegetative growth than anticipated possibly due to nutrient imbalance. We allowed the strawberry plants to flower beginning in March and fruits were producing by mid-April.

Figure 4. Strawberry plants under Triple-Band LED bars.

Figure 5. Strawberry flowers with healthy pistils.

The strawberry yield was recorded from April 2016 to September 2016 and is reported in Table 1. The strawberries kept yielding fruits after the 9th month after planting and we continued to monitor the yield. Strawberry fruits that weighed greater than 5 g per berry were deemed marketable in this analysis. The yielded harvests by growing beds from the experiment are summarized below:

Designation	Count	Total Weight	Avg. Weight	Max. Weight
A6	44 (marketable) 72 (harvested)	363 g (marketable) 475 g (harvested)	8.25 g 2.16 g (Std. dev.)	16 g
A12	80 (marketable) 104 (harvested)	794 g (marketable) 894 g (harvested)	9.93 g 2.89 g (Std. dev.)	21 g
B6	133 (marketable) 151 (harvested)	1,635 g (marketable) 1,706 g (harvested)	12.29 g 5.04 g (Std. dev.)	30 g
B12	111 (marketable) 126 (harvested)	1,665 g (marketable) 1,728 g (harvested)	15.00 g 6.22 g (Std. dev.)	32 g

Table 1. Strawberry yield by cultivar designation.

The two day-neutral cultivar types responded differently to the hydroponic cultivation technique despite being given the same environmental conditions. Cultivar A consistently and drastically yielded lower with smaller size berries compared to Cultivar B. Additionally, Cultivar A flowered close to the base of its crown whereas Cultivar B flowered away typically above their canopy. Therefore, the berries of Cultivar A were oftenly in contact with the media, causing more incidences of fruit rot and reducing marketable crop. Furthermore, increased trough depth positively affected the yield and berry size in both cultivar types; confirming that the root zone volume is an important parameter to consider.

The strawberries were harvestet every 2-3 weeks during the harvest period. B12 yielded the highest at 111 marketable strawberries (here defined as berry size of >5g) with a total weight of at least 1,665 g per 2 ft. x 4 ft. area in over just under 6 months or equivalently 2.24 kg m^{-2}. The average berry size of B12 was 15 g. This was the minimum reported yield as we had harvestable crops that were unreported because of operator errors. Our yield surpassed the productivity goal of 4,600 lb. per acre or 0.516 kg m^{-2} a year in the field reported in the USDA New England Fruits and Vegetables, 2012 Crop that we set forth by four times. However, the attained yield was significantly under the yield of 7 kg m^{-2} targeted by Kubota group.

Figure 6. Strawberries on May 7, 2016.

Figure 7. Strawberries on June 8, 2016.

Figure 8. Strawberries on August 17, 2016.


Figure 9. Strawberries on September 8, 2016.

The economic feasibility study was part of the data analysis after the experimental results were obtained. The initial capital expenditure, operational cost including utilities, labor cost, and marketing cost were analyzed for both greenhouse and vertical farming hydroponic strawberry productions. The feasibility study reviewed especially in the energy requirement of the production since the greenhouse and the vertical farming operations have two different energy profiles. The economic profiles of CEA cultivation were compared against to that of conventional field production budget data available from the Penn State University (9).

The study revealed that CEA greenhouse strawberry production at 10,000 SF and greater facilities can be very lucrative in the Northeast, especially during the off-season months where the market supports price range of $6.00-9.00 per pound (personal observation). In indoor vertical farming strawberry production, the utility expense will be comparatively higher than that of greenhouse, however, the operation can still be feasible if the yield performance approaches 7 kg m^{-2}. As with many forms of agriculture, labor came in as the highest expense; thus, reduction of labor cost is the determining factor in the success of CEA strawberry farming as well.

When compared against the budget for conventional field farming, CEA strawberry operation can be costly at the first glance because of high initial capital expenditures. However, CEA production offers the stability and security of year round market share that cannot be matched by conventional methods. Additionally, no expensive field equipment is required and the labor requirement is significantly lower in CEA production. These are important parameters to consider for a sound business decision.

Goal 2: Educational Outreach

Educational outreach of CEA strawberry production

We planned to disseminate our research findings to interested new and existing berry growers in the region in hopes of adoption of CEA strawberry production in our region. Based on the above mentioned results, we prepared an introductory material on basic strawberry production, discussion on various cultural systems, CEA plant production techniques and practices, integrated management of strawberry diseases in CEA, and finally its economics in forms of slide presentation and handouts. Workshops were planned to provide the materials, however, they were cancelled because of time constraint and extended cultivation research trial.

Beneficiaries

The majority of strawberries found in Connecticut today are produced out-of-state and about 6-7 days old before reaching consumers. Because of their fragile nature (i.e., bruising) and short shelf life, strawberries are an ideal candidate for local CEA production. As the current market demand for local berries far exceeds supply, Connecticut growers have a tremendous opportunity to reconnect to the consumers with fresh and superior tasting strawberries branded as “Connecticut Grown.”

We explain the potential of year round, protected strawberry production in the following illustrative example. The current local strawberry industry in Connecticut is just under $3 million in size, producing approximately 1 million pounds of berries a year in 217 acres. In order to double the production capacity by weight, Connecticut will only need to implement 45 of 10,000 SF greenhouses for strawberry production, or 10 acres. Because of off-season production capability, the industry could generate additional $6 million in revenue and capture 3% of the additoinal market share. Therefore, year round strawberry production would allow Connecticut producers to claim a larger market share from the out of state growers and enrich the state’s agricultural base with a steady production.

The project was endorsed by the Connecticut Pomological Society. Other beneficiaries include the Connecticut Greenhouse Growers' Association, local farmers' markets, and finally the consumers.

Lessoned Learned

Through this project, we obtained encouraging results that we believe will further the development of CEA strawberry production in Connecticut. We reflect our thoughts on the following areas below that we identified where optimizations are possible to improve the yield performance:

- Several foliar samples were collected periodically to be lab tested on proper nutrient delivery during the trial. They revealed that further nutrient refinements were possible both in vegetative and floral phases.
- Cultivar B actively kept growing runners (stolons) despite being a day-neutral variety while Cultivar A did not. Proactively pruning the runners could positively impact the yield by focusing the plants on fruit production.
- We encountered frequent losses from misshapen or small berry sizes from poor pollination of pistils. In our small trial, we pollinated artificially by a hand brush. Gentle breeze or vibration did not produce well, either, despite strawberries being considered to be self-fertile fruit. Insect pollination such as using honey bees are recommended for commercial greenhouse operations. Efficacy of such insect pollination in an indoor environment (e.g., warehouse) is still uncertain. Bringing bees into the growing environment increases likely introduction of other undesirable pests such as spider mites into the environment as well.
- During our trial period (from January-September 2015), we encountered no pest issues except for fungas gnats which did not present any harm to the plants. We suspect that eggs were present in the coir we used. The physical exclusion protocols we had implemented was adequate to prevent any major infestations. No biological or chemical treatments were applied to the strawberries. The gnat issue could be resolved by use of sticky traps and placing the irrigation line in the media to prevent surface wetting.
- While we did not have any major pest issues, we encountered several crop losses from fungal diseases. The most notable issue was losses from botrytis fruit rot. Any affected areas and dead leaves were proactively removed to mitigate the problem. We recommend proper air circulation and use of active air filtration to limit the occurrences.
- We further observed a mild case of angular leaf spot after about 6 months from the planting. The exact path of bacterium introduction is uncertain but it is likely that the plants were pre-infected as the bare root crowns we purchased were grown in the field. It may be necessary to culture young plantlets specifically bred for indoor agriculture to eliminate the issues we experienced. Sub-irrigation may also help limit the spread of bacterium. Again, we used no biological and chemical treatments in our trial. In a commercial production, it may be necessary to treat fungal diseases in order to maintain produtivity.

- Vegetative growth phase can be further shortened by enriching carbon dioxide concentration level. By enhancing plant growth vegetatively, the fruit yield is expected to increase as well.
- In this trial, no experiments on lighting effect were conducted. Lighting parameters including spectrum selection, photoperiod, and DLI can all influence the plant growth and physiology. As an example, it is reported that crown area exposure to red light can delay strawberry flowering. These lighting effects should be further investigated.
- Unlike in field cultivation, an advantage of CEA includes separation of vegetative and flowering phases. In early vegetative phase, plants can be cultured in higher density trays to reduce energy usage. Once the plants reach a certain growth level, they can be transplanted in preparation for flowering phase. In medialess hydroponics, the transplanting of strawberries may be easily accomplished. Additionally, the environment may be custom tailored to the particular phases of the plant for facile production.
- Other topics to investigate in future may include the effect of cultivar specific nitrogen treatment on stolon growth and ramet density, the effect of rooting tip container size and propagation time on early fruit production, other cultivar suitability and impact on commercial hydroponic productivity, floral bud induction with light regimen, proper thermal and humidity management for flowering, hydroponic culture design and irrigation methods, etc.
- A new hydroponic tray system was designed and machined for additional experiments that incorporated the lessons learnt from the present experiment. The new set up allows for easier transplanting to increase productivity and prevention of fruit spoilage. The new design is part of our continual research and development effort to increase productivity of strawberry cultivation and reduce capital expenses.

Additional Information
See photos included above.

Enhancing the Competitiveness of New England Specialty Crops through Regional Collaboration Final Report

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Project Summary

Schools, hospitals, restaurants, and other institutions are more conscious about where the food they're serving is sourced from. Consumers are demanding local food and transparency about where their food is grown. State and federal contracts are including language which stress the importance of buying local or regional food before buying nationally or even internationally.

To meet those demands and requirements schools, institutions, and restaurants are looking to purchase more regional specialty crops but are struggling to do so. This is an area of purchasing which is becoming more and more important yet harder to accomplish.

From an industry perspective, producers are hungry for and always say there is a need for education and educational opportunities. Evaluations from previous HNE-sponsored conferences reinforce this desire. Direct buying and one-on-one meetings with buyers are very uncommon but are expected to be positively received by the industry.

This project broke down barriers to regional specialty crop purchases at the wholesale level by:

Component 1, Producer Education: specialty crop producers had the opportunity to better understand the wholesale buying and marketing opportunities at the 2015 and 2017 Harvest New England Agricultural Marketing Conference and Trade Show.

Component 2, Consumer Education: educating consumers during HNE Day at the 2015, 2016, 2017 Big E, New England's' largest agricultural exposition, on the importance of regional food, where they can source it, and the importance of demanding it. This was accomplished through the *Passport to New England* where consumers, both adults and children, had the opportunity to learn about New England specialty crops by engaging in agricultural trivia in each state.

Component 3, Producer Buying Opportunities: Harvest New England in partnership with multiple state-specific groups provided one-on-one matchmaking meetings between wholesaler buyers and wholesale specialty crop producers.

This project built on previously funded projects and complimented and enhanced previous worth through the following:

Component 1, Producer Education, Harvest New England Ag Marketing Conference and Trade Show was a component previously funded by the USDA SCBG-FP program. The 2011 and 2013 conference was extremely well

received. The survey conducted at the 2013 conference concluded that 78% of respondents said they had an increase in sales as a result of marketing techniques learned at the 2011 and 2013 conference. The difference between the previously funded conference and the 2017 conference is the specific topic of focus. The focused area in 2011 and 2013 was direct to consumer sales. 2014 SCBG funds has allowed us to build upon the previously established conference and shift the focus for the 2015 and 2017 conference to wholesale marketing and marketing opportunities. New speakers, new tracks, and new seminars and workshop were developed for the 2015 and 2017 conference respectively. The 2011 and 2013 HNE Conference has had great significance to the industry, resulting in a positive impact and change, and is important to the target audience. A record attendance number reinforced the importance of the regional conference. Through continued funding, HNE had the opportunity to expand educational opportunities beyond direct-to-consumer topics and further develop and expand the conference for specialty crop producers.

Project Approach

Component 1, Producer Education, Harvest New England Ag Marketing Conference and Trade Show

In August 2014, the HNE board began planning the 2015 Harvest New England Agricultural Marketing Conference and Trade Show to be held in February 2015. The committee reached out to the Food to Institution New England (FINE) and the MA Association of Agricultural Commissions to create a conference which would work towards solely enhancing the competitiveness of New England specialty crops through wholesale channels. .

A total of 29 breakout sessions and two general sessions were provided to nearly 500 producers, which reported being a specialty crop producer, selling specialty crops or working with specialty crop producers and over 300 trade shower exhibitors and conference presenters.

The keynote speaker, Jonathan Raduns from FreshExpress presented on marketing strategies to improve sales for fresh fruits and vegetables. The general session speaker on day two discussed how to work with and think like a millennial to improve your business.

Other breakout sessions included:

- Branding your product and building a strong brand
- Breaking into the institutional market
- Merchandising and display techniques
- Establishing contracts with institutions
- Finding grant and loans
- Benefits of a marketing co-op
- Working with food hubs and processing centers
- Business succession

- Pros and cons of wholesaling to grocery stores and national chains
- What farmers need to know about selling to a distributor
- Budgeting
- Successful value-added products
- Capitalizing on the farm to table experience

Planning for the 2017 conference began in 2016. The planning committee thought that adding a hands-on options would be well received and two tour agendas featuring specialty crop farms were assembled and promoted. In the end, only enough participants attended to run one tour.

In December, information was released throughout the region by all of the six New England state departments of agriculture. The extent of the promotion in each state varied. Most included email distribution, information in an agency publication, on agency websites and communication to specialty crop commodity associations in each state. Information was also posted on the Harvest New England website and distributed to all previous conference attendees.

New this year, a Facebook event was developed and managed by the New Hampshire Department of Agriculture in conjunction with the registration manager that was hired. This was the first time, HNE had a presence on social media.

Again this year, scholarships were offered through ME Dept of Ag's SCBG allocation to the conference.

The keynote speaker selected was Craig Ostbo from Koopman Ostbo Marketing Communications in Portland, OR. Mr. Ostbo was the keynote speaker at the National Specialty Crop Block Grant Coordinators Conference in August 2015 and he was willing to travel to the Northeast to be the keynote and general session speaker at the 2017 HNE Conference. His presentations were all very well received and had a great response by attendees.

Component 2, Consumer Education, Harvest New England Day at the Big E HNE Day at the Big E was held again this year on September 29, 2017. All the materials produced for the 2016 event were purchased in a larger, more cost effective in 2016 quantity which allowed for the purchase of materials needed for the event in 2016 and 2017.

The postcards (passports) were distributed on the front lawns of the New Hampshire and Massachusetts/Rhode Island buildings. Here, HNE staff encouraged and explained to Big E attendees how the program worked. The program ran from 10:00 a.m. to 4:00 p.m. Passport go-ers had until 5:00 p.m. to turn in their completed passport in exchange for a reusable bag which promoted New England grown specialty crops.

It was decided the logistics of the program would remain the same as 2015 and 2016; users would pick up their passport and find the stamping location within each building.

They would be asked one or two questions about specialty crops within their state to obtain a stamp. Once all six stamps were collected they would complete three additional questions on the postcard about specialty crops and redeem the passport for a reusable specialty crop-themed bag.

Component 3, Producer Buying Opportunities, Matchmaking One-on-Ones:
In October 2015, the Harvest New England board began discussions for the buyer/supplier one-on-one meetings. Originally, it was expected the CT one-on-one meetings would happen between January and March 2016. It was determined that it would be an efficient use of funds and staff time to partner with an organization who was hosting a much larger event and incorporate the specialty crop one on one buyer/supplier meetings within it. Unfortunately due to timing, that arrangement wasn't logistically possible. It was then proposed the meetings take place in the winter of 2017. Again, logistical barriers came into play and it was determined the CT one-on-one meetings would not take place and it was be a more effective use of SCBG funds to invest in *Component 1: Producer Education, Harvest New England Ag Marketing Conference and Trade Show.* This budget adjustment to a previously existing portion of the project was exactly 20% of the total budget and an amendment request was not necessary.

At a regional level, HNE executed two one-on-one meetings in Maine and one-on-one meetings in NH and MA. All with very positive outcomes as a result of effective partnerships.

Goals and Outcomes Achieved

	AWARDED	**ACTUAL**
GOAL	To educate specialty crop producers and provide buying opportunities between specialty crop producers and wholesale buyers to increase sales and consumption of New England grown specialty crops.	We certainly reached our goal of educating specialty crop producers and providing buying opportunities between specialty crop producers and wholesale buyers with the intention of increasing sales and consumption of New England grown specialty crops.
PERFORMANCE MEASURE	Each component will have a specific performance measure to ensure the overall goal is met. *Component 1:* Specific questions on the evaluation form asking if specialty crop producers are better aware of how to work with wholesalers	*Component 1:* Questions were added to the conference evaluation specific to wholesale buying and purchasing and to measure if there was an increase in specialty crop sales as a result of knowledge gained at the HNE Conference. *Component 2:* The number of

	and institutions and market their specialty crop products as a result of attending the conference. *Component 2:* The number of consumers who complete the passport during the 2015, 2016, and 2017 Big E and the responses to the follow up survey which ask participant to assess their change in knowledge about regionally grown specialty crops and where to source them. *Component 3:* The number of wholesalers and New England producers who participate in the one-on-one buying meetings and follow up survey results afterward.	passports were counted and a follow up survey was answered by participants at the time of participation to assess their change in knowledge. *Component 3:* Pre and post surveys were completed which yielded the regional results below.
TARGET	Overall, there will be a 15% increase in the amount of New England grown product consumed and purchased.	Data provided by the National Ag Statistic Services is a challenge to compare. The 2012 census vs. the annual surveys do not provide data on the same categories or information on a state and regional level. Therefore it is hard to determine the actual increase in the amount of New England grown product consumed and purchased. However, based on the outcomes mentioned below, one can conclude there has been an increase in purchases and consumption of specialty crops throughout the region though that exact number cannot be determined.

Major successful outcomes in quantifiable terms:
Component 1, Producer Education, Harvest New England Ag Marketing Conference and Trade Show According to survey respondents, the benefits of attending the 2015 and/or 2017 Harvest New England Conference are extensive including:

- 58.33% (‘15) and 63.16% (‘17) of people said it was a great or really great conference
- 36.08% (‘15) and 42.6% (‘17) of people said their knowledge improved quite a bit or even a ton as a result of attending
- 64% of people said they are better aware of how to work with wholesalers and institutions as result of attending
- 16.87% (‘15) and 5.83% (‘17) were socially disadvantaged farmers and 19.12% (‘15) and 36.46% (‘17) have been faming for less than 10 years

Component 2, Consumer Education, Harvest New England Day at the Big E On average, 95% had a change in knowledge about what a specialty crop as a result of participating in the program, 80% said they will eat and buy more New England grown specialty crops and that they now know where to buy New England grown specialty crops. Participants were from the six New England states in addition to New York, Florida, George, Minnesota, Michigan, Tennessee, Pennsylvania, California, Ohio, Texas, Hawaii, and New Jersey.

Component 3, Producer Buying Opportunities

- While only 5 of the 13 responded, they felt they had developed good leads and a number of them reported buyer follow up after the event.
- An average of eight new buyer contacts were reported by specialty crop producers.
- The producers and buyers did not report sales figures as a result of the event.

Beneficiaries

For each component of this project, the following beneficiary groups can be identified:

Component 1, Producer Education, Harvest New England Ag Marketing Conference and Trade Show

- New England specialty crop producers, aprox 750 total in 2015 and 2017.

Component 2, Consumer Education, Harvest New England Day at the Big E:

- New England specialty crop producers
- Fairgoers at the 2015, 2016, and 2016 Harvest New England Day at the Big E.

Component 3, Producer Buying Opportunities

In Maine:

- 22 specialty crop producers
- 5 wholesale specialty crop buyers
- 9 service providers services wholesale specialty crop producers

In NH:

- Eight NH specialty crop producers
- Thirteen NH wholesale specialty crop buyers

In MA:

- Eight MA specialty crop producers
- Ten MA wholesale institutional buyers

Lessons Learned

Component 1, Producer Education, Harvest New England Ag Marketing Conference and Trade Show Outreach and marketing is key to the success of the conference. In 2017, a registration manager was hired to assist with conference administration (not paid for with Specialty Crop Block Grant Funds) and it made a huge difference. HNE board members were able to promote the conference better and spend more time identifying speakers, etc. We offered a scholarship program (paid for by ME Dept of Ag's SCBG allocation to the conference) and we could have awarded more scholarships but did have enough qualifying applicants. The tours were a nice offering but didn't have the response we were hoping for.

Component 2, Consumer Education, Harvest New England Day at the Big E: The one area that HNE always falls short on is staffing and/or volunteers. HNE members worked the event with only one break throughout the day. Given it's a very outgoing and interactive job, it turns out to be a rather exhausting day. More volunteers would make it a more effective and enjoyable event for all.

Component 3, Producer Buying Opportunities

Overall in Connecticut this activity was a huge disappointment. The state agency had anticipated working with an association that had established relationship with wholesale buyers of specialty crops. When that wasn't feasible in 2016 and logistics of the conference and timing affected an event in 2017 *and* the state agency found themselves short staffed by 50% the availability to organize an event became unmanageable. As a result, increasing efforts at the 2017 HNE Conference was the most logical and realistic use of funds.

Additional Information