Delaware Department of Agriculture

2010 Specialty Crop Block Grant Program

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Below is the final report for the 9 projects that are funded under this Specialty Crop Block Grant.

Project Title: The Establishment of Highbush Blueberries on Delaware Soils

Project Summary: The goal of this project was to develop a highly productive, yet still cost effective, model method for establishing blueberries on soils typically found in southern and central Delaware. Various research trials were also conducted, to look at some of the challenges that blueberries face in their establishment in Delaware growing conditions. In order to thrive, blueberry plants require a unique set of soil conditions that are seldom found naturally in the state, and are different from almost all other crops grown here. Of the few blueberry operations that have been established here in the past, even fewer of these growers have taken the time to properly recreate these necessary conditions, therefore limiting the productivity of their plants. In addition, blueberry consumption and demand are currently at all-time highs in the US. For these reasons, blueberries are a mostly untapped specialty crop market for Delaware farmers, despite their success when grown properly. The project goal was reached through a series of both grower and extension service trials and high quality growing practices, addressing the main issues that blueberries face in their establishment in Delaware growing conditions.

Project Approach: To reach the goals of this project, field trials were created to look at the variables being tested. The trials included pre-plant soil amendments, peat moss amounts, varieties, mulch materials, and irrigation designs. Once these plantings were set up, established data on plant growth and development was taken twice a year throughout the life of the project to evaluate the success of these variables in plant establishment. The following information is a complete summary of the findings of all of these trials.

Irrigation Study at Bennett Orchards

- There was some indication that two lines of drip irrigation per row were beneficial to blueberry plant growth in the first two years of establishment. The average height of plants was significantly greater in plants with two drip-lines, but the other parameters measured were not significantly different.
- It may be that the benefits of two drip-lines will be more apparent as plants continue to grow.

Peat Moss Rate Study at Bennett Orchards

- One gallon of peat moss added to the planting hole was beneficial to blueberry plant growth in the first two years of establishment. The two gallon treatment and the no peat moss treatment had significantly lower change in average height compared to the 1 gallon treatment. The no peat moss treatment also had significantly lower stem diameter and change in stem diameter.

Pine Bark Fines Study at Bennett Orchards

- Pine Bark Fines as an amendment to the planting row were beneficial to blueberry plant growth in the first two years of establishment. The plants receiving the pine bark fines treatment had significantly higher average stem diameter, maximum stem diameter and change in stem diameter than the control plants that did not receive pine bark fines.

Alternative Soil Amendment Study at Georgetown

• Some high organic matter, low pH materials may be useful as alternatives to peat moss for planting hole amendments but there were no clear differences between the treatments in terms of growth.

• Effects of any high organic matter soil amendment will be more noticeable in low organic matter soil; the site at Georgetown is a higher organic matter soil.

Mulch Material Trials at Georgetown REC and Bennett Orchards

Based on the mulch material evaluations at Georgetown and Bennett Orchards several mulch materials are recommended: pine bark, hardwood sawdust, waste hay, waste straw and yard waste wood chips. Some of the materials trialed caused the soil pH in the plots to rise so we recommend that growers test the pH of their mulch material and/or monitor their soil pH carefully to avoid mulches that raise the pH.

Material	Positives	Negatives	Recommended
Pine Bark	• Lasts a long time • Maintains low pH • Can be spread mechanically	• Expense and availability	Yes
Hardwood Sawdust	• Lasts a long time • Can be spread mechanically	• Can blow or wash around easily if too fine	Yes
Waste Hay	• Good insulation of root zone from high temps may provide growth benefit	• Cannot be spread mechanically • Weed seed could be a problem • Degrades quickly	Yes
Waste Straw	• Good insulation of root zone from high temps may provide growth benefit	• Cannot be spread mechanically • Degrades quickly, but not as quickly as hay	Yes
Yard Waste Wood Chips	• Lasts a long time • Can be spread mechanically		Yes

Chipped Construction Waster	• Can be spread mechanically	• Degrades quickly • Caused pH to rise	No
Sawdust Horse Bedding	• Added nutrients	• Degrades quickly • Caused pH to rise • Added nutrients can cause burn and dieback	No
Cornstalks	• Good insulation of root zone from high temps may provide growth benefit	• Floating and movement out of place a major problem • Weed seed could be a problem	No

Variety Trials at Georgetown and Bennett Orchards

Growth of the plants at Georgetown and Bennett Orchards differed significantly between the varieties, but plants were of different sizes at planting and had been obtained from different sources so this variability is not extremely useful in evaluating the varieties. Several of the southern highbush varieties exhibited excellent growth in the establishment years, but some of these varieties exhibited freeze damage to flower buds in 2012 and more so in 2013. Star and Misty grew well but sustained an unacceptable level of freeze damage in 2013. Jubilee also grew well and may be less prone to freezing injury. Legacy, a northern/southern highbush intermediate had excellent growth in the establishment years and minimal freeze injury was observed. Evaluation of the varieties will continue through yield data collection funded by the Specialty Crop Block Grant awarded in 2012: "Evaluation of Established Highbush Blueberry Variety Trials and Crop Management Studies"

The results from these trials will allow growers to make a more educated decision in their own growing practices.

Project Approach (Cont.) In addition, a larger planting was included in the project, with the goal of creating a high quality system of growing practices for growers to follow when creating their own commercial blueberry planting in Delaware. The idea here was to go above and beyond standard blueberry growing practices in Delaware. This would prove that the extra expense and effort required would pay dividends in the future, in the form of better established and earlier producing blueberry plants. By the end of the grant, this idea was well proven, as the plants growth and development exceeded even the expectations of project partners, and demonstrated to growers just how successfully blueberries can be grown in Delaware, when

certain practices are followed. It is expected that these larger and healthier plants will reach their peak in productivity much sooner than normal, which is a highly desirable result for a crop as slow growing as blueberries.

All project partners worked together in unison to ensure that the goals of the project were completed, summarized and documented effectively, to maximize the potential benefit to future blueberry growers in Delaware.

Goals and Outcomes Achieved: Once the initial work was completed to set up the project, and results began to become apparent, the second phase of the project was implemented. Findings and recommendations, in the form of plant growth data and overall grower experiences, were gathered and presented to growers and potential blueberry growers throughout the state. This was achieved through on farm open houses at both project locations and annual presentations at the Delaware Fruit and Vegetable Growers' Association meetings in January. In addition, these project results were posted on the UD Extension Service website as an additional resource for growers to consult. This abundance of information will allow growers considering a blueberry planting in Delaware to look at the conclusions and recommendations made, and then make more educated decisions based on the findings presented.

Another measure used to evaluate the success of the project was the grower survey conducted at Bennett Orchards during the field day in the final year of the project. Approximately 25 people attended the event, and participated in the survey. Survey results indicated a wide range of previous experience levels when it came to growing blueberries in Delaware. While some individuals already had commercial blueberry plantings in production, others had not yet planted a single plant. Despite these differences, everyone surveyed felt that the field day and project results presented were helpful in their decision making process on growing blueberries. Additionally, many felt better informed, and thus more likely to plant blueberries commercially at some point in the future. Survey questions were also added to evaluate what areas these potential growers would like to see more information on in the future, pertaining to blueberry production in Delaware. Not only does this survey information demonstrate the project's success in enhancing the competitiveness of blueberries as a specialty crop in Delaware, but it will provide useful insight to the project members as to what areas in blueberry production need more attention in the future.

It should also be mentioned that another Specialty Crop Block Grant has been approved and initiated to evaluate yield data for many of the project research trials in the years to come. This will provide further insight into just how these variables affect plant growth and establishment in the early years, but also fruit yields once the plants have become productive.

It can be concluded then, that when compared to the initial goals laid out by the project proposal, all final conclusions clearly demonstrate that the practices undertaken in the project were successful in not only producing larger, better established blueberry plants, but also conveying this information to the growers in a multitude of ways. No other project has been previously conducted in Delaware in such a comprehensive manner, as to significantly increase the competitiveness of blueberries as a specialty crop in the state.

Beneficiaries: Anyone in Delaware who is currently considering, or already growing blueberries, stands to benefit significantly from the findings of this project. Such a group could range from a backyard grower with only a few plants, to a large commercial grower. In addition, it can be assumed that others who were previously not considering a blueberry planting, are doing so now thanks to the findings of this project. Between Ag Week presentations, on farm fields days and a multitude of online resources, it can be estimated that up to 100 individuals throughout the state have been, at the very least, better informed as to the challenges and opportunities of growing blueberries in the state. Blueberry supply in Delaware is currently far exceeded by demand, and it is hoped that this project will have a significantly positive impact on what is now a very small market.

Lessons Learned: In any agricultural endeavor, unforeseen obstacles often emerge and must be dealt with by the grower. This project was no exception and while the issues were minimal overall, they did serve as a valuable learning experience for everyone involved.

One such issue in the first year of the project was a leaf burn that occurred on some plants, caused by very hot summer temperatures in combination with the limited root systems of these very young plants. While not a major setback, this partial defoliation of the plants did cause reduced growth and vigor in the plants during the first growing season. Delaware is on the southern edge of the suitable climate for Northern Highbush Blueberries and therefore such issues will need to be addressed in future studies to ensure successful plant establishment in the early years.

Other issues also occurred with the pH management of the planting soil and the acquisition of suitable mulch materials at a price and quantity necessary for the grower. These lessons were closely documented and presented to ensure that other future plantings could hopefully avoid the same issues at their own locations. Despite these issues, it was still clearly demonstrated that blueberries have a large potential as a successful specialty crop in Delaware when proper growing practices are followed.

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Additional Information: Below is a link to the online resources and field day descriptions that occurred during the project. Also, photos and articles documenting the project in its entirety can also be provided upon request.

http://extension.udel.edu/vegetableprogram/

Project Title: Envelop Your School in Agriculture

Project Summary: Many students have no knowledge of healthy eating habits and no concept of what is involved in producing specialty crops. This project sought to provide students with an opportunity to grow and eat specialty crops and to develop life skills regarding nutrition, which would result in a healthy lifestyle including consumption of specialty crops.

The Envelop Your School in Agriculture project was developed by Dr. Judith Leith of the Delaware Department of Agriculture, focusing on grades K-5, to introduce, foster appreciation of, cook and eat, and grow specific produce and horticultural products, and to develop food choices using those specialty crops.

Project Approach: Students from several Delaware elementary schools in grades K-5 were introduced to various Delaware specialty crop fruits, vegetables and herbs through tastings and identification and informational activities, reaching about 2,900 students over the approximately year and a half that the program operated in full.

The program operated as planned during the 2010-2011 school year and during the fall semester and part of the spring semester of the 2011-2012 school year. It did not operate in most of spring 2012 after the project facilitator was placed on restricted duty following an automobile accident, and it was put on hold for the 2012-2013 school year due to the facilitator's medical condition. The remaining project funding balance was then transferred to another project – the Laurel Farmers' Auction Market – and the Envelop Your School in Agriculture work was halted permanently.

Schools involved included:
>> Lake Forest South Elementary, Harrington
>> Central Elementary, Felton
>> St. Matthew School, Newport
>> Greenwood Mennonite School, Greenwood
>> Cedar Lane Early Childhood Center
>> Brick Mill Elementary School
>> All Saints Elementary School / St. Matthew School

Project partners included:

>> Lake Forest High School FFA. Prepared planting areas and constructed 12 garden beds.
>> Hodgson Vocational-Technical High School landscape and technology students. Mentored fouth-grade students at St. Matthew School.
>> Parents, staff and faculty at St. Matthew School and Greenwood Mennonite School. Built garden beds, landscaped area, maintained garden during summer.
>> Delaware Department of Agriculture. Provided salary and time for project facilitator and funding for foods and supplies for tastings.

Individual partners included Ms. Lisa Guth of Brick Mill Elementary School, who helped coordinate classroom activities and summer maintenance; Mr. Justin Benz, Hodgson Vocational Technical School, who oversaw his student mentors and grew plants in greenhouses for school

gardens; and Ms. Kathleen Brownlee of All Saints Elementary School, who oversaw establishment of old and new beds and coordinated summer maintenance.

Goals and Outcomes Achieved: Students in grades K-5 at participating schools were introduced to various Delaware specialty crop fruits, vegetables and herbs through tastings and identification and informational activities. Students were taught strategies to identify and practice good food choices using specialty crops, kept weekly food journals, and assisted in compiling family menus and shopping lists involving specialty crops.

Fourth-grade students participated in the additional activity of planning and maintaining gardens which featured Delaware specialty crops. Fifth-grade students participated in additional activities on consumer education, including nutritional terms, food labels and body mass index calculations. Fifth-graders also performed analysis of school cafeteria menu choices and offered suggestions using Delaware specialty crops.

Tastings included carrots, honey, strawberries, wheat, rye, barley, oats, spinach, peppers, basil, oregano, thyme, onions, potatoes, garlic, tomatoes, celery, leeks, cauliflower, cabbage and green peas. All foods and related tasting supplies were paid for by the Delaware Department of Agriculture.

At the beginning of the full school year, a list of Delaware specialty crops was given to students and posted in each classroom to be filled in as a bar graph. Students were asked initially how many items they could identify and had eaten. The initial survey resulted in school-wide numbers as follows:

>> Identification: 18-41 %
>> Tasting: 21-54 %

Another survey was taken in June, after students had learned to identify specialty crop items, and had been given the opportunity to taste these items through project tastings, school lunches or at home. The improved results are as follows:

>> Identification: 60-100%
>> Tasting: 63-91%

Surveys illustrated a marked increase in foods which the children tasted due to participation in the program. For example, the majority of students had never tasted rye bread, oregano or cabbage.

Favorable evaluations were also received from educators at several participating schools.

Beneficiaries: The project reached more than 3,500 students at seven schools throughout Delaware, including public, private and parochial schools. They included:

>> Lake Forest South Elementary, Harrington
>> Central Elementary, Felton
>> St. Matthew School, Newport

>> Greenwood Mennonite School, Greenwood
>> Cedar Lane Early Childhood Center
>> Brick Mill Elementary School
>> All Saints Elementary School / St. Matthew School (St. Matthew participated in the first year, and was merged with All Saints for the second)

Lessons Learned: The primary challenge faced involved logistical coordination at participating schools, including scheduling and keeping class numbers manageable. Continuing maintenance of school gardens during the summer was also a challenge at some schools. Organizations considering similar projects are advised to work with a single point of contact from each participating school who can coordinate information, space, scheduling, maintenance and evaluations.

Additionally, the state testing regimen forced one school to withdraw from participation during the spring semester. Using a single point of contact with the authority to fit the project in around testing schedules would be of benefit.

Several schools requested that multiple grades be included, which was granted. However, this created certain logistical issues, and it is recommended that schools just enroll a single grade in the program.

The overall goals and outcome measures for the full three-year program were not met due to the medical leave of the project facilitator. It is recommended that similar programs have a backup facilitator identified who can take over in case of temporary incapacitation.

The measureable outcomes and methodology were all well received.

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Project Title: Field and Greenhouse Screens of Lima Bean Germplasm for Resistance to *Phytophthora capsici*, the Causal Agent of Lima Bean Pod Rot

Project Summary: Lima bean (*Phaseolus lunatus* L.) is an important processing vegetable crop in Delaware and the Mid-Atlantic region with approximately 5,670 ha of lima beans planted in the state each year. Lima bean is Delaware's most widely planted vegetable crop. Lima bean pod rot, caused by *Phytophthora capsici*, has increased in incidence in recent years and is becoming more important to lima bean growers and processors in the region. For this project we will screen accessions and cultivars of lima bean for their reaction to *P. capsici* to identify sources of resistance which might be incorporated into elite lima bean lines for use in Delaware.

The objective of this project is to develop both field and laboratory/greenhouse screening methods to evaluate germplasm of *Phaseolus lunatus* for resistance to *P. capsici*. Developing effective screening methods is the first step in breeding for resistance to this disease. Field and laboratory screening methods will allow us to first, identify lima bean lines with resistance to *P. capsici* and later incorporate that resistance into commercial cultivars. The development of laboratory/greenhouse screening methods is important in order to facilitate screening of exotic lima bean germplasm. Exotic germplasm is more likely to carry novel genes, which may confer resistance to *P. capsici*, however this material is largely photoperiod sensitive and will not flower under Delaware field conditions. Any resistant lima bean germplasm we identify will be incorporated into the lima bean improvement program at the University of Delaware

Delaware's signature vegetable crop is lima bean (*Phaseolus lunatus* L.), and the state is it's the second largest producer in the country. Annually, lima bean farming is a $6 million industry in Delaware and maintaining disease-free fields is essential to the state's agricultural health. If it cannot be grown profitably, many other processing vegetable crops worth nearly $20 million cannot be grown (Evans et al. 2007). In 2002 we described the first occurrence of a new disease, lima bean pod rot, caused by *Phytophthora capsici* (Davidson, Mulrooney, Carroll and Evans, 2002). Until this time it was believed that *P. capsici* was not a pathogen of leguminous crops. Rather, it was an important pathogen of pepper and cucurbits that causes epidemic losses. Unlike downy mildew of lima bean caused by *Phytophthora phaseoli* there is no known resistance to *P. capsici* in lima bean and managing the disease through crop rotation is impractical as the pathogen has numerous other known hosts and survives for up to 10 years in the soil. In recent years, Delaware lima bean growers have reported an increasing incidence of this disease and have indicated that it is potentially an even bigger threat to the profitable production of lima bean than downy mildew caused by *P. phaseoli* (L. Wolfe, personal communication). Fungicides may be effective to manage this disease in the field but none are currently labeled. With our assistance, Dr. Mary Hausbeck at Michigan State University is conducting field trials for the efficacy of fungicides to control this disease on lima bean and other leguminous crops. This proposal has not been submitted to other granting agencies and does not duplicate any other activity that we are aware of in the SCBGP-FB.

Project Approach: During the period from 2010 to 2013 approximately 40 distinct lines of lima bean will be evaluated in the field for resistance to *P. capsici*. Each year, field plots were established at the University of Delaware's Carvel Research and Education Center, Georgetown DE. Twenty seeds of each line were sown on in the first week of July and flowering began in the second week of September. Inoculum of *P. capsici* was produced in two ways. First, the surface

of disinfested cucumbers were inoculated with agar plugs from a lima bean isolate of *P. capsici* and maintained under sterile conditions at approximately 72°F under natural, diffuse daylight on a laboratory bench. After 10-14 days, cucumbers were fully colonized with mycelium and produced an abundance of sporangia.

The inoculum was prepared from these cucumbers by submerging them in 1 gallon of tap water for each 10 medium cucumbers, then crushing them manually. The suspension was then sieved to remove most plant material. Alternatively, inoculum was produced from an isolate of *P. capsici* from lima bean growing on V-8 juice agar or potato dextrose agar for up to 3 weeks. Plates were flooded with a small volume of sterile distilled water and gently scraped to remove sporangia and transferred to small misting bottles. Regardless of source of inoculum, pins and flat pods were sprayed to runoff using a backpack sprayer and plants were misted nightly using a low volume/low pressure misting system.

Overall, very little of the diverse lima bean germplasm which may carry resistance genes to *P. capsici* will flower and produce pods under Delaware's summer field conditions. Consequently much of the screening of diverse material for *P. capsici* resistance must be done in the greenhouse.

Goals and Outcomes Achieved: Two lines have produced pods and showed no symptoms in both the 2010 and 2011 field screens. They are PI 347826 a landrace collected in California, and PI 477041 a landrace collected in Arizona. . The results of this work have been presented at to lima bean growers and processors during the Lima Bean Forum on December 11, 2012 (round table meeting), the American Phytopathological Society meeting in Providence, RI in August 2012 with 2,000 researchers in attendance and during the Processing Vegetable Session of the Fruit and Vegetable Growers Association of Delaware Annual meeting held during Delaware Ag Week 2012 with 110 attendees at the Processing Vegetable Session. The results have also been published in the 2012 edition of the Bean Improvement Cooperative Annual Report on pages 27-28 of volume 55 http://bic.css.msu.edu/_pdf/Reports/BIC_2012_Annual_Report.pdf

In summer 2013, eleven lines were screened in the field at UD's Georgetown research farm for resistance to *P. capsici*. Two of the lines were susceptible checks, five lines were diverse lines that had not been tested before and were expected to produce pods under field conditions, the remaining four lines were diverse lines that had appeared resistant in past greenhouse or field screens. Results of the screening are presented in the table below.

During the winter of 2010/11, a greenhouse evaluation system for identifying lima bean lines with resistance to *P. capsici* was developed. Many lima bean lines are unable to produce flowers and pods in the field in Delaware under long days (more than 12 hours of daylight). This system included the use of a greenhouse room that has computer controlled blackout shades to establish growing environment of 12 hours light and 12 hours dark. As the majority of the plants to be screened in the greenhouse were indeterminate and would be very tall, they were screened in a newly constructed mist chamber within this greenhouse room. The chamber included high intensity lighting and a timer controlled mist system to provide ideal conditions both for plant growth as well as capillary mats to provide sub-irrigation and high humidity in the chamber. In the winter of 2011 greenhouse grown plants of the lima bean cultivar Concentrated Fordhook were successfully infected in our greenhouse chamber using both sporangial spray and agar plugs of *P. capsici*.

Nineteen lines of lima bean known to be photoperiodic and not capable of flowering and producing pods under long day conditions were screened in the greenhouse in winter 2011/12. On 15 Sept 2011 these lines were seeded into 12 inch pots in Promix and grown under 12 hour light and 12 hour dark conditions in a greenhouse at University of Delaware. After plants produced pods, they were transferred to the inoculation chambers for evaluation. Inoculum was produced from an isolate of *P. capsici* from lima bean growing on V-8 juice agar for up to 3 weeks. Plates were flooded with a small volume of sterile distilled water and gently scraped to remove sporangia and transferred to small misting bottles. Pins and flat pods were sprayed to runoff with inoculum and after inoculation plants were misted each hour for 4 minutes in an enclosed chamber. Plants were evaluated daily starting 5 days after inoculation for signs of infection which includes the formation of mycelium and sporangia and symptoms which include reddening of the pods. Infections are confirmed by microscopic examination of scrapings from potentially infected pods for sporangia diagnostic of *P. capsici.*

Two lines did not show symptoms after being inoculated twice in our greenhouse screens: PI 256405, a landrace from El Salvador, and PI 362772, a landrace from Brazil. Seeds from these putatively resistant plants were collected and will be further evaluated in fall of 2012 through summer of 2013. Two other lines, PI 347826 from California and PI 477041 from Arizona, were which were determined to be putatively resistant in both field and greenhouse screens have been crossed with susceptible cultivars to generate F_2 populations for field screening in 2012.

Table 1. Combined Field and Greenhouse Reactions to *Phytophthora caspsici* through 2012

Plant Material	Type	Country/State	Reaction in Field, 2010	Reaction in Field, 2011	Greenhouse Reaction
PI 189403	Plant Introduction	Guatemala	No pods produced	No pods produced	NS
PI 195339	Plant Introduction	Guatemala	NS*	NS	Susceptible
PI 200906	Plant Introduction	Guatemala	NS	NS	No pods produced
PI 201478	Plant Introduction	Mexico	NS	NS	Susceptible
PI 241790	Plant Introduction	Peru	NS	NS	Susceptible
PI 256384	Plant Introduction	El Salvador	NS	NS	Susceptible
PI 256405	Plant Introduction	El Salvador	NS	NS	No Symptoms**
PI 256804	Plant Introduction	Colombia	NS	NS	Susceptible
PI 256814	Plant Introduction	Ecuador	No Symptoms	Susceptible	NS
PI 256820	Plant Introduction	Ecuador	Susceptible	NS	NS
PI 256843	Plant Introduction	Peru	No pods produced	NS	NS
PI 256846	Plant Introduction	Peru	No pods produced	NS	NS
PI 256861	Plant Introduction	Peru	NS	NS	Susceptible
PI 256890	Plant Introduction	Peru	NS	NS	Susceptible
PI 256906	Plant Introduction	Peru	NS	NS	Susceptible
PI 260407	Plant Introduction	Peru	NS	NS	Susceptible
PI 260417	Plant Introduction	Bolivia	NS	NS	Susceptible
PI 257419	Plant Introduction	Argentina	Susceptible	NS	NS
PI 310620	Plant Introduction	Guatemala	NS	NS	Susceptible

PI 347777	Plant Introduction	California	Susceptible	NS	NS
PI 347779	Plant Introduction	Arizona	Susceptible	NS	NS
PI 347781	Plant Introduction	Arizona	Susceptible	NS	NS
PI 347786	Plant Introduction	Arizona	No Symptoms	Susceptible	NS
PI 347787	Plant Introduction	Arizona	Susceptible	NS	NS
PI 347792	Plant Introduction	California	No Symptoms**	No Symptoms**	NS
PI 347826	Plant Introduction	California	Resistant	NS	NS
PI 347842	Plant Introduction	California	Resistant	NS	NS
PI 355843	Plant Introduction	Ecuador	NS	NS	No pods produced
PI 362772	Plant Introduction	Brazil	NS	NS	No Symptoms**
PI 362801	Plant Introduction	Brazil	NS	NS	Susceptible
PI 362832	Plant Introduction	Brazil	NS	NS	Susceptible
PI 363023	Plant Introduction	Brazil	NS	NS	Susceptible
PI 363029	Plant Introduction	Brazil	NS	NS	Susceptible
PI 195342	Plant Introduction	Guatemala	NS	NS	Susceptible
PI 347781	Plant Introduction	USA	NS	NS	Susceptible
PI 347777	Plant Introduction	USA	NS	NS	Susceptible
PI 534918	Plant Introduction	New Mexico	Susceptible	NS	NS
PI 549478	Plant Introduction	Michigan	Susceptible	NS	NS
PI 549481	Plant Introduction	Michigan	Past Susceptible Stage	NS	NS
PI 549484	Plant Introduction	Louisiana	Susceptible	NS	NS
VA butterbean	Cultivar	Delaware	Susceptible	NS	NS
W6 17497	Cultivar	Argentina	Susceptible	NS	NS
184-85	Cultivar	USA	Susceptible	NS	NS
Cypress	Cultivar	USA	Susceptible	NS	NS
FH 1072	Cultivar	USA	Susceptible	NS	NS
FH 90-1	Cultivar	USA	Susceptible	NS	NS
DE0501801A	Breeding Line	Delaware	NS	Susceptible	NS
DE0501805A	Breeding Line	Delaware	NS	Susceptible	NS
DE0402701	Breeding Line	Delaware	NS	Susceptible	NS
DE0407903	Breeding Line	Delaware	NS	Susceptible	NS
DE0407905	Breeding Line	Delaware	NS	Susceptible	NS
DE0407906	Breeding Line	Delaware	NS	Susceptible	NS
DE0407907	Breeding Line	Delaware	NS	Susceptible	NS
DE0505002A	Breeding Line	Delaware	NS	Susceptible	NS
Fordhook 242	Cultivar	USA	NS	Susceptible	NS
Conc Fordhook	Cultivar	USA	NS	No Symptoms**	NS
C-elite Select	Cultivar	USA	NS	Susceptible	NS

NS* = Not Screened

No Symptoms** = material being rescreened

The two lines which had appeared to be resistant in past field screenings (PI 347826 and PI 477041), developed symptoms in the 2013 screen. Not unexpectedly the two lines identified as resistant in past greenhouse screens did not flower in the field under long day conditions, and we were unable to evaluate their reaction to the disease.

Lima bean lines PI 362772 and PI 256405 will be screened in the greenhouse again in Fall/Winter 2013-14 to confirm their resistance reaction. These two lines will also be crossed to adapted susceptible lima lines in Fall 2013 to develop breeding populations that will be screened for resistance in the future. Attempts to make crosses with these lines in the greenhouse in Fall 2012 was unsuccessful so segregating populations will not be available for screening until Summer 2014. An additional ten lines that were obtained from the USDA germplasm collection and are from the same regions as PIs 362772 and 256405 will be screened in the greenhouse in Fall/Winter 2013-14 in an attempt to identify additional sources of resistance.

Table 2. Disease Reaction Results for Individual Lines Screened for *Phytophthora capsici* Resistance in the Field in 2013

Line	Description	Reaction
PI 362772	greenhouse resistant	did not flower
PI 256405	greenhouse resistant	did not flower
1102-6	new line to test	minimal disease
1102-25	new line to test	did not flower
PI 162688	new line to test	susceptible
PI 476859	new line to test	susceptible
PI 347826	possible resistant	susceptible
PI 477041	possible resistant	susceptible
Cypress	susceptible check	susceptible
C-elite Select	susceptible check	susceptible

Beneficiaries: More than fifty farmers contract with one of four regional vegetable processors each year to grow lima beans each year in Delaware and Maryland. The Oomycete *Phytophthora capsici,* which causes lima bean pod rot, is an emerging pathogen of this regionally important vegetable crop (Davidson et al. 2002). Through this project, we have developed field and greenhouse screening methods to test lima bean lines for resistance to *P. capsici* and we have identified two landrace varieties of lima bean that appear to be resistant to the disease. Identification of sources of resistance to this pathogen is the first step in the process of breeding lima bean varieties with resistance to *P. capsici*. The resistant lines that have been identified are not adapted to Delaware growing conditions and do not have the quality characteristics necessary for commercial production. The benefit to growers and processors from this project is not immediate, since several years of breeding and selection will be necessary to transfer the useful resistance genes into varieties with acceptable agronomic and quality characteristics. However, they are the future users of, *P. capsici* resistant lima bean varieties, the intended end product of the work begun through this project.

Lessons Learned: While we have had some indication of resistance to *P. capsici* in lima bean accessions tested, we have yet to confirm it in any accession or cultivar and will continue to verify the occurrence of such resistance by both field and greenhouse screens through the third year of the grant. We have redoubled our efforts to confirm the first indication of resistance in several lines. In the event that these lines prove to be susceptible, we will continue to evaluate additional germplasm in search of potential genes for resistance to *P. capsici* that may be incorporated into horticultural acceptable varieties.

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Project Title: Enhancing Fresh Market Vegetable and Fruit Production and Marketing Opportunities for Producers in Delaware

Project Summary: There is increased interest and emphasis on buying locally and regionally and in supporting locally produced products. Delaware is strategically located to supply these markets. One major limitation is the ability to supply fresh produce for extended seasons. Cold temperatures and reduced day length limit late fall through early spring production and to a lesser extent hot temperatures limit summer production of some vegetables and fruits. Another limitation is lack of information on the economic feasibility of producing certain specialty vegetable and fruit crops in Delaware. This project was conducted to address vegetable and fruit production research needs to enhance fresh vegetable marketing opportunities in the region for Delaware producers. Market areas that were addressed included fresh cut/fresh pack production; production for schools and institutions; production for restaurants and farmers markets; production for specialty wholesale markets, and small fruit and grape production. .

Project Approaches: To address these opportunities, applied research was conducted in several areas. Season extension research included work on low tunnels, overwintering techniques, cold adapted and heat adapted varieties and types and summer shade production and cooling systems. Crops targeted for extended fall and/or spring research included the cole crop group, mustard group, lettuce group, onion group, pea group, and small fruits. Crops targeted for overwintering research included, kale, collards, mustards, onions (green and bulb), and peas. Crops targeted for extended summer production included lettuce and day neutral strawberries. Research on varietal adaptation focused on cold adaptation for fall/winter/spring or overwintering production of crops listed above and heat adaptation for some crops. Also included was a trial of vinifera grape clones in comparison to hybrid and American types, a seedless table grape trial, and a blackberry trial. Research on the potential for fresh pack legume production focused on testing a production schedule for extended supply with legumes adapted to Delaware.

The following is a list of research activities completed in this project:

<u>Overwintering Vegetable Trials</u>

Trials of overwintering vegetables were conducted in 2010-11, 2011-12, and 2012-13 and included:

1) Trials with multiple varieties of mustard, turnip, kale, and collards planted at different dates from July through September were conducted in in 2010, 2011, and 2012. Greens were fall harvested and then overwintered. Fall harvest results were reported as part of a previous greens production grant with one of the tables shown below:

Table 5. Yields of fresh market cut greens, fall 2011.

Variety	Type	Harvest Date					Total
		21-Sep-11	7-Oct-11	10-Oct-11	2-Nov-11	20-Dec-11	
		lbs/a	lbs/a	lbs/a	lbs/a	lbs/a	lbs/a
Reflex	Kale	.	6962	544	.	717	8223
Red Bor	Kale	.	.	304	.	396	700
Blue Ridge	Kale	.	.	1131	.	1355	2486
Blue Knight	Kale	.	.	1184	1191	1381	3756
Blue Armor	Kale	.	.	874	.	1134	2008
Starbor F1	Kale	.	.	954	.	1398	2352
Winterbor F1	Kale	.	.	869	.	2834	3703
Ripbor F1	Kale	.	.	.	.	442	442
Vates	Kale	.	.	746	.	1800	2546
Hi Crop	Collard	.	.	1310	5764	1881	8955
Flash	Collard	.	.	970	394	1460	2824
Top Bunch	Collard	.	.	471	.	1244	1715
Bulldog	Collard	.	.	2010	1470	1640	5120
Southern Green	Turnip	2434	8526	5188	7375	6384	29907
Topper	Turnip	2459	8747	5041	5116	2616	23979
All Top	Turnip	1864	5483	4294	4736	3265	19642
Just Right	Turnip	1700	7724	4650	6014	3411	23499
Alamo	Turnip	1633	8008	5063	6008	6279	26991
Top Star	Turnip	850	7340	3550	5247	4222	21209
Green Wave	Mustard	.	8001	3242	4064	3953	19260
Hybrid Savannah	Mustard	2286	7900	6398	6691	5117	28392
Southern Giant Curled	Mustard	.	4871	5001	5620	4438	19930
Champion	Collard	.	.	1045	889	689	2623
Seven Top	Turnip	2213	7894	3103	6307	2536	22053
Tendergreen	Mustard	1774	6102	3545	7394	7249	26064
Dwarf Siberian	Kale	.	6293	5313	5529	3898	21033

In this grant, all of the greens crops were overwintered and evaluated for spring production potential. In 2012 this also included row covers placed in early December.

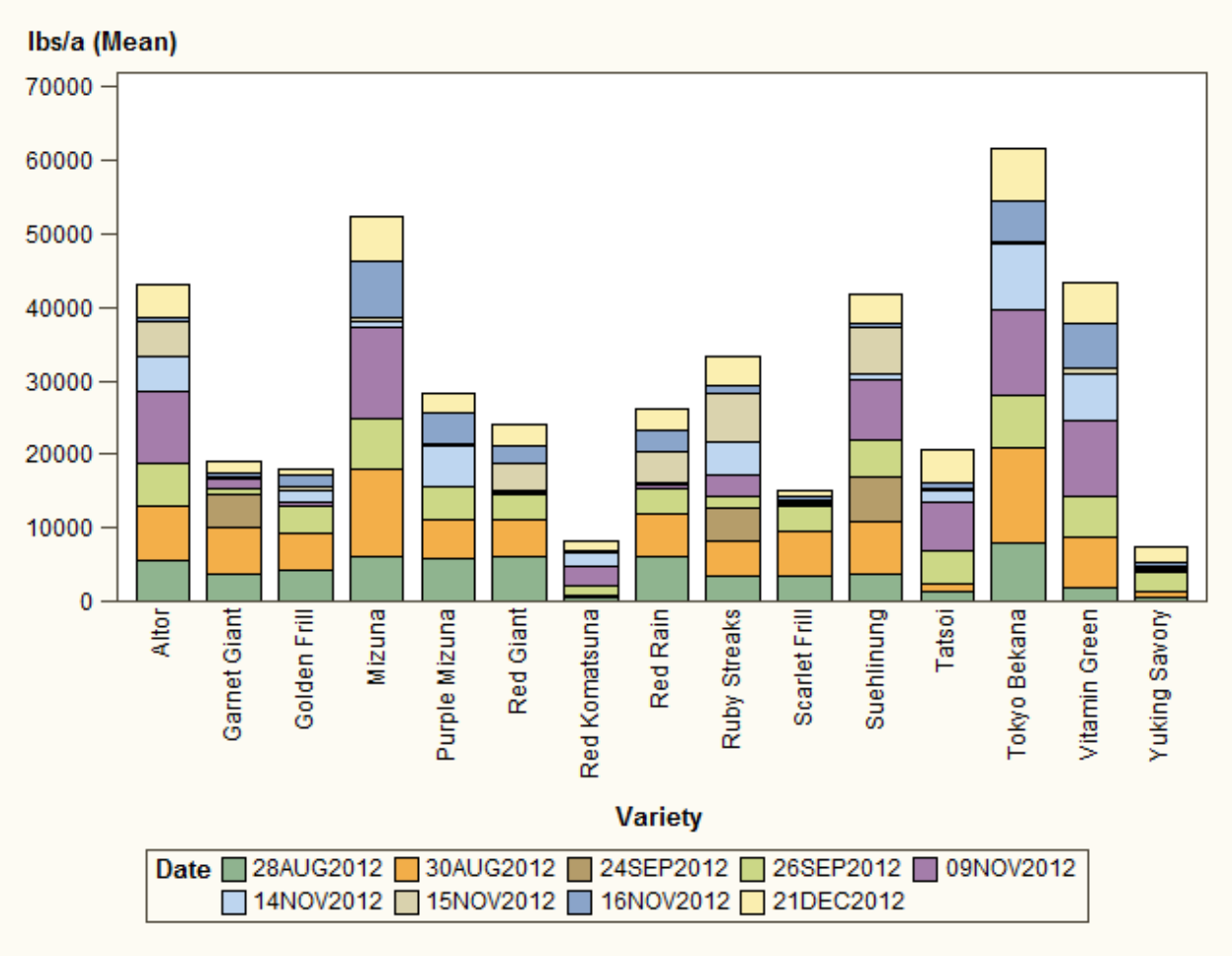
Results from these trials showed the difficulty of producing overwintered greens in the field. All varieties tested of these greens species tested bolted in the spring after overwintering. Early September planted Siberian Kale and Tendergreen mustard were the slowest to bolt.

2) Trials with over 30 varieties of green onions were planted in September and October 2011, and 2012 and then overwintered. Result showed that September plantings had higher amounts of bolting and only three varieties planted in September did not bolt. In contrast, October plantings

had little bolting in all. These varieties performed well in late planted overwintering trials: Parade, Green Banner, Pride, Nabechan, and SSR B0-06. These results indicate that overwintering green onions are best planted in early October to avoid bolting. September plantings for earlier spring harvest the next year are limited in variety choice to slow bolting types.

3) Small plot overwintering bulb onion trials were conducted in 2010-2011 and 2011-2012 with late August and early September planting dates that were overwintered and then harvested in early June. From these trials, four varieties were identified for further testing: Bridger, T-420, and Toughball (all yellow types) and Desert Sunrise (a red onion type). These varieties were put in large plot trials in 2012-2013 under another grant. Results showed that there is potential for growing overwintering bulb onions in Delaware with potential for May harvest.

4) Asian greens were planted in late August, fall harvested and then overwintered in a 2012-2013 trial. Fall harvest results are shown below:



These results showed high potential for several Asian greens to extend fall harvest in a direct seeded unprotected planting through December. Notable were Mizuna, Tokyo Bekana, Alto, Vitamin Green, and Suehlihung This trial was then row covered and overwintered. Spring ratings showed that all of the Asian greens bolted. Slowest bolting were the Mizuna types.

5) Small overwintering legume observational trials were done with Fava beans, peas, and winter peas. In these trials, there was high winter mortality in the English Peas and Fava beans due to wet late winter conditions. Winter peas survived and can be used for pea shoots (normally used as a cover crop) but not for eating the immature seeds. In the early 1990s crosses were made between high quality, highly adapted traditional spring pea types and available Austrian winter peas with the ultimate goal of developing fall-sown varieties which are suitable for traditional human food markets. Tests of some of these lines were planned but seed could not be obtained. A future goal of the UD vegetable program to test these varieties. In one trial, spring oats and green pea were interplanted in October. The peas survived the winter and the oats winter killed. However, the oats had too much biomass and smothered the peas. This system needs be further explored using a late October planting.

Row Cover and Low Tunnel Observational Trials

Low tunnel and row cover observational trials were conducted with mustards, turnips, kales, collards; mizuna, tatsoi, and other Asian greens; spinach, chard, and beet greens; and lettuce and endive in 2012. With covers and low tunnels, harvest of these crops was extended into January. and then resumed in the spring. Most successful were spinach, beet greens, chard, lettuce, and mizuna. Spring harvests started in March-April.

Lettuce, Salad Mix, and Fresh Pack Vegetable Trials.

Lettuce trials were conducted in 2012 as a focus of this research. This included two spring and two summer plantings for late spring, summer, and fall harvest. Salad mix trials were conducted using 4 spring plantings, two summer plantings, and one fall planting. Several butterhead, crisphead, romaine, and head lettuce varieties were identified that were well adapted for early and late spring production and for summer and fall production. Spring and fall broccoli trials were also conducted. A summary of lettuce trial information is presented below.

Variety		Company	Color	Taste Rating*		Bolting**			
				Late Spring	Fall	Early Spring	Late Spring	Early Fall	Late Fall
BUTTERHEAD	Forlina RZ	Rijk Zwaan	Green	1	1	n	n	n	n
	Harmony	Siegers	Green	2	2	n	n	y	y/n
	Hungarina RZ	Rijk Zwaan	Green	2	2	n	n	y	y/n
	Roxy	Seedway	Red	2	na	y/n	y/n	y	y
	Alkindus	Siegers	Red	3	na	y/n	y/n	y	y
	Rhapsody	Shamrock/Seedway	Green	3	na	n	n	y	y
	Santoro RZ	Rijk Zwaan	Green	3	na	n	n	y	y/n
	Skyphos	Siegers/Rijk Zwaan	Red	3	1	n	n	n	y/n
	SSC 2835	Shamrock	Green	3	na	n	n	y	y
	Nerea	Siegers	Green	4	4	n	y	y	n

	Variety	Company	Color	Taste Rating*		Bolting**			
				Late Spring	Fall	Early Spring	Late Spring	Early Fall	Late Fall
ROMAINE	Dov	Seedway	Green	1	2	n	n	y/n	y/n
	Rubicon	Siegers/Nunhems	Green	1	na	n	n	y	y
	Camino Verde	Siegers	Green	2	na	n	y	y	y
	Rio Bravo	Siegers	Green	2	na	n	y	y	y
	8893	Siegers	Green	3	na	n	n	y	y
	Monte Carlo	Seedway	Green	3	4	n	n	y	y/n
	Pomegranate Crunch	Seedway	Red	3	4	n	y	y	y
	Stryker	Shamrock	Green	3	na	n	n	y	y
	Cuore	Nunhems	Lt Green	3	2	n	n	y	n
	Caitlin	Nunhems	Green	3	na	n	n	y	y/n
	1581 Calshot	Siegers	Red	4	na	n	y	y	y
	Beretta	Seedway	Green	4	na	n	y	y	y
	Fresh/Heart	Siegers	Green	4	na	n	y	y	y
	Ideal Cos	Siegers	Green	4	na	n	y	y	y
	Jemez	Siegers	Green	4	na	n	n	--	--
	Julius RZ	Rijk Zwaan	Green	4	na	n	y	y	y
	Musena	Siegers	Green	4	2	n	n	y/n	y/n
	Salvius RZ	Rijk Zwaan	Green	4	na	n	y	y	y
	SSC 3083	Shamrock	Green	4	na	n	y	y	y
	Exp. T12	Nunhems	Green	4	na	n	y	y	y
ICEBERG	Acropolis	Shamrock	Green	1	1	n	n	n	n
	Excalibur	Shamrock	Green	1	na	n	n	y	y
	Keeper	Seedway/Siegers	Green	1	2	n	n	n	y/n
	Spartacus	Shamrock	Green	1	1	n	n	n	y/n
LEAF	Starfighter	Siegers/Rijk Zwaan	Green	1	1	n	n	n	n
	New Red Fire	Siegers	Red	2	3	n	n	y	y/n
	Ruby Sky	Siegers/Rijk Zwaan	Red	2	na	n	y	y	y
	Red Tide	Nunhems	Red	2	na	n	y	y	y
	Kodiak	Seedway	Green	3	na	n	y	y	y
	Kremlin	Nunhems	Red	3	na	n	y	y	y/n
	Bergams Green	Siegers	Green	4	na	n	y	y	y
	Cherokee	Siegers	Red	4	na	n	y	y	y
	North Star	Nunhems	Green	4	na	n	y	y	y/n
	Tehama	Nunhems	Green	4	na	n	y	y	y

Forlina was the only variety adapted to all seasons as a butterhead variety, Dov was the best adapted romaine variety, Starfighter was the most widely adapted leaf lettuce, and Acropolis was a well-adapted iceburg type.

Broccoli trials in the fall showed great promise for Green Magic for high yields. Spring planted trials again showed that broccoli does not perform well under Delaware conditions for spring or summer production.

Table 1. Broccoli yields and percent of heads marketable, UD-REC, Georgetown, fall 2010.

Variety	Yield		Marketable
	lbs/acre	boxes/acre	%
Arcadia[1]	6387 b[2]	304	95
Batavia	7728 ab	368	99
Beaumont	5000 b	238	80
Belstar	5770 b	275	88
Captain	5938 b	283	79
Castle Dome	4670 b	222	58
Diplomat	7489 ab	357	100
Fiesta	5873 b	280	95
Green Magic	10988 a	523	100
Imperial	8629 ab	411	83
Iron Man	4376 b	208	63

[1]Varieties underlined are those currently recommended for Delaware.
[2]Means followed by the same letter are not significantly different at the 0.05 level by least squares means.

Onion Trials

Two trials with transplanted bulb onions were conducted in 2012 from spring planting. Two overwintering direct seeded onion trials were conducted in 2011-12 (results given above in the overwintering section) Six trials with direct seeded green onions and mini bulb types were planted in the spring, summer, and fall of 2011 and 2012 (overwintering trials described previously). Two direct seeded onion trials were planted in 2011.

Bulb onion trials have identified varieties with potential for Delaware in direct seeded overwintered conditions and for spring transplanting. Spring direct seeded onions performed very poorly. Recommendations are given in the chart below. Over 30 different green onion varieties have been tested and those with best adaptation for spring, summer, and fall have been determined. Newer varieties recommended include Parade, Green Banner, Pride, Nabechan, and SSR B0-06 which perform well across seasons.

The following are current bulbing onion variety recommendations:

Recommended Bulbing Onion Varieties								
Variety	Hybrid	Type[1]	Days	Description[1]	Color	Storage	Method[3]	Size
Ebenezer	No	Long Day	120	Storage LD	Yellow	Long	Sets	Med-Large
Sedona	Yes	Long Day	120	Storage LDSP	Yellow	Long	DS, TP	Large
Southport Red Globe	No	Long Day	120	Storage LD	Red	Long	DS, TP	Large
Bradley	Yes	Long Day	118	Storage LDSP	Yellow	Long	DS, TP	Large
Delgado	Yes	Long Day	118	Storage LDSP	Yellow	Long	DS, TP	Med-Large
Red Wing	Yes	Long Day	118	Storage LD	Red	Long	DS, TP	Large
Talon	Yes	Long Day	110	Storage LDSP	Yellow	Long	DS, TP	Large
Fortress	Yes	Long Day	110	Storage LDN	Yellow	Long	DS, TP	Medium
Red Sky	Yes	Long Day	110	Storage LDSP	Red	Long	DS, TP	Med-Large
Braddock	Yes	Long Day	107	Storage LDN	Yellow	Long	DS, TP	Large
Safrane	Yes	Long Day	106	Storage LDN	Yellow	Long	DS, TP	Medium
Prince	Yes	Long Day	105	Storage LDN	Yellow	Long	DS, TP	Large
Tequila	Yes	Long Day	120	Spanish	Yellow	Medium	DS, TP	Very Large
Mesquite	Yes	Long Day	120	Spanish	Yellow	Medium	DS, TP	Very Large
Spanish Medallion	Yes	Interm. Day	110	Sweet Spanish	Yellow	Medium	DS, TP	Very Large
Expression	Yes	Interm. Day	98	Sweet Spanish	Yellow	Short	TP	Large
Super Star	Yes	Interm. Day	100	Sweet Spanish	White	Short	TP	Large
Candy	Yes	Interm. Day	95	Sweet Spanish	Yellow	Very Short	TP	Very Large
Exacta	Yes	Interm. Day	94	Sweet Spanish	Yellow	Very Short	TP	Large
Bridger	Yes	Overwinter	n/a	Storage	Yellow	Long	DS	Large
Hi-keeper	Yes	Overwinter	n/a	Storage	Yellow	Long	DS	Med-Large
T-420	Yes	Overwinter	n/a	Storage	Yellow	Long	DS	Med-Large
Toughball	Yes	Overwinter	n/a	Storage	Yellow	Long	DS	Medium

[1]Long day onions direct seeded or transplanted in early spring; Intermediate day onions normally early spring transplanted; and Overwintering onions direct seeded in later summer.
[2]Onion descriptions: Storage = long keeping types; LD = Long Day; SP or Spanish = Spanish type; N = Northern type; Sweet Spanish = short keeping softer scale sweet types.
[3]Method of establishment: DS = Direct Seeded, TP = Transplanted

Fresh Shelled Legumes

Trials of green baby lima beans, Fordhook lima beans, edamame, fava beans, peas, and cowpeas were conducted in 2012. This included variety trials at different planting dates. Over 100 varieties and types were tested on 6 different planting dates.Results indicated that green baby lima beans could be produced from the end of July through the middle of November. However, the last month of lima bean production required freeze protection with row covers. Early production is limited by losses to heat. Fordhook lima beans were only successful for September through November harvest, again with the last month under row cover. A wide range of specialty lima beans have also shown promise and heat tolerant colored and white types can give some July production. Edamame could be produced from July through November with protection in the last month. Fava beans could only be produced in May and June and were low yielding. Peas could only be produced from Mid-May through early July in the spring. Attempts at extending peas into July failed. Fall pea crops proved to be low yielding. Cowpeas could be produced from July through October and shelled beans could be produced from June through October although July yields were low. Pea and lima bean trial results can be found at http://extension.udel.edu/ag/vegetable-fruit-resources/vegetable-small-fruits-program/variety-trial-results/. Research on fresh pack processing was not conducted due to the lack of a

collaborator; however, research has been conducted at a number of other institutions and has been summarized for growers interested in best practices for packaging and handling of fresh shelled legumes

Summer, Fall and Spring Production of Day Neutral Strawberries.

Trials were conducted in the spring, summer, and fall of 2011 and 2012 with four day-neutral strawberry varieties. Trials in 2013 focused on summer and fall production with two varieties. Yield, size, and harvest period data were taken. Trials included three colors of plastic, a water based cooling system, and two shade cloth treatments.

Results of the 201l and 2012 trials showed that of all the Day Neutral types tested, Albion showed the most promise for extended spring and early summer production. Mid-summer and fall production were found to be uneconomical with the varieties tested. Trials in 2013 showed that San Andreas was better suited for late summer and fall and Albion for Spring and early summer. Albion started producing earlier than Sweet Charlie or the standard Chandler but was lower yielding through May and then continued to produce an extra four weeks into early July. Overall yields were still lower than Chandler. In the 2012-2013 trial, Albion was produced at a higher plant population (1/3 more plants) and out-yielded Chandler showing that higher densities are needed for maximum yields. Shade cloth did help to increase summer production marginally and reflective mulch had the highest summer yields.

Primocane Blackberries

Two commercially available primocane (fall bearing) blackberry varieties planted in 2011 were harvested from August-November in 2012. In addition, five experimental fall-bearing thornless varieties from the University of Arkansas that were planted in 2011 were harvested from July through August in 2012. A portion of these were left to fruit on floricanes in 2013 as well as on new primocanes. Yields for primocane production in 2012 were low at around 5000 lbs per acre. In 2013, floricane yields in Ark 45 were over 16,000 lbs/a with an additional 6,000 lbs per acre on the primocanes. This is twice the expected yield. Several experimental varieties also had high yields. This dual production system is promising for high production and extended production an extra 10 weeks. However, there was heavy pressure from Spotted Wing Drosophila in 2013 with this extended production.

Grapes

Three vineyard plantings established in 2011 including Vinifera, hybrids, and table grapes. Lists of varieties, rootstocks, and clones are given below. Trellises were established and plants were trained (cordons were established) in 2012. Additional table grapes were planted in 2013 from the new Arkansas breeding program releases. Initial fruiting information was collected from table grapes in 2013 with the most promising being Marquis and Mars (shown in picture below – Marquis green and Mars purple). The best yields from fruited hybrids was with Cayuga White. Only a small number of Vinifera were fruited in 2013 for observation.

Varieties established are listed below:

Vinifera:

Cabernet Sauvignon 7/3309 Grade 1
Cabernet Sauvignon 191/3309 Grade1
Cabernet Sauvignon 337/3309 Grade1
Cabernet Franc #1/3309 Grade1
Cabernet Franc #332/3309 Grade1
Merlot 3/3309 Grade1
Merlot 181(15Davis)/3309 Grade1
Merlot 348/3309 Grade1
Sangiovese #2/3309 Grade1
Riesling 90/3309 Grade1
Riesling 10/3309 Grade1
Riesling 198/3309 Grade1
Sauvignon Blanc 1/3309 Grade1
Chardonnay 76/09 Grade1
Chardonnay 95(37Davis)/09 Grade1
Chardonnay 96(70Davis)/09 Grade1
Chardonnel(GW9)/3309 Grade1 Certified
Petit Verdot 400/3309 Grade1
Syrah #383/3309 Grade1
Gruner Veltliner/3309 Davis Grade1
Petit Manseng/3309 Grade1

Pinot Gris#1/3309 Grade1
Pinot Gris 146/3309 Grade1
Pinot Gris 152/3309 Grade1
Viognier(Horton)/3309 Grade1

Pinotage

Hybrids:
NY95.0301.01

Chambourcin / 3309
Seyval Blanc / 3309
Traminette / 3309
Vidal Blanc / 3309
Chambourcin / 101-14
Traminette / 101-14
Vidal Blanc / 101-14
Seyval Blanc / 101-14
Cayuga White/ 3309
Cayuga White/ 101-14
Regent/3309

Seedless Table Grapes
Thomcord
Somerset Seedless
Canadice
Einset
Mars
Reliance
Vanessa
Marquis
Faith
Hope
Gratitude
Joy

Goals and Outcomes Achieved: The overall goal of this project was to provide a research base to enhance the production and marketing of fresh market vegetables in Delaware. Research was conducted on extending production seasons, varietal adaptation, fresh legumes, small fruits, and grapes. This research was designed to investigate the potential for producing for fresh cut and fresh pack vegetable and fruit enterprises (including fresh pack shelled legumes); for producing and selling to institutions, schools, restaurants, and expanded sales at farmers markets; for producing and selling to specialty wholesale markets; and for growing and selling wine grapes and table grapes. Results presented in the Approach section above showed that goals of the project were met.

Onion research identified spring and overwintered varieties and growing methods for both bulb and green types. Research with greens, both southern and Asian types, showed the potential to produce into the early winter, but not as overwintering crops in field plantings. Research with salad greens identified varieties that can be grown in four seasons and which are most appropriate for each season. Research with broccoli showed that it is still mostly a fall crop with only limited use as a spring crop in Delaware. Shelled legume research confirmed the potential production seasons and limitations. Overwintered legumes did not perform well enough to commercialize. Small fruit research showed the potential for extending spring, summer, and fall production in strawberries and the potential for five month production of blackberries. Grape research has been initiated and initial results have identified table grapes and hybrids that perform well under Southern Delaware conditions. This work will continue into the future.

Results from this project have been delivered to growers at the Fruit and Fresh Market Vegetable sessions at the Fruit and Vegetable Growers Association of Delaware annual meeting at Delaware Agriculture Week with 532 growers and industry representatives attending one or more sessions. Several reports from this research have been posted at the University of Delaware Vegetable and Small Fruit web site at http://extension.udel.edu/ag/vegetable-fruit-resources/vegetable-small-fruits-program/ and through distribution of extension publications through the University of Delaware at meetings and field days. To date 632 downloads or printouts have been distributed. Four special interest field/days were held which featured this research with 162 in attendance over the 3 years of this project. In addition, there have been 4 meetings with presentations on selling to institutions, schools, and restaurants; a workshop on grape production; and a workshop on specialty vegetable and fruit production and marketing attended by 157 growers. Findings from this work have been presented to wholesale buyers with the goal of connecting buyers with growers and developing markets within the state of Delaware. In addition to grower outreach, information from this study was presented at professional and industry meetings including the Mid-Atlantic Vegetable Workers Conference and the American Society for Horticultural Science (regional and national), the Mid Atlantic Vegetable Convention, and several other regional meetings reaching an estimated 450 professionals and growers.

Beneficiaries: Beneficiaries from this project have been Delaware growers that attended meetings, field days, workshops, and special programs where this research was presented. This included 532 growers attending the Fruit and Vegetable Growers Association of Delaware annual meeting at Delaware Agriculture Week; 162 in attending field days featuring this research; 157 attending one or more presentations on selling to institutions, schools, and restaurants; grape production; specialty vegetable and fruit production and marketing; season extension; and early season production. Regional and national presentations have reached an additional 450 growers and professionals. Over 600 growers and professionals have also downloaded or obtained paper copies of research reports and many have visited our website the University of Delaware Vegetable and Small Fruit web site at http://extension.udel.edu/ag/vegetable-fruit-resources/vegetable-small-fruits-program/. In electronic and meeting surveys, 35 farmers are using the small fruits and grape research to start or expand operations, 68 growers are doing additional season extension; and 131 growers are using information from one or more of the research projects to expand or modify their production and marketing.

Lessons Learned: Onion research identified spring and overwintered varieties and growing methods for both bulb and green types. Research with greens, both southern and Asian types, showed the potential to produce into the early winter, but not as overwintering crops in field planting. Research with salad greens identified varieties that can be grown in four seasons and which are most appropriate for each season. Research with broccoli showed that it is still mostly a fall crop with only limited use as a spring crop in Delaware. Shelled legume research confirmed the potential production seasons and limitations. Overwintered legumes did not perform well enough to commercialize. Small fruit research showed the potential for extending spring, summer, and fall production in strawberries and the potential for five month production of blackberries. Grape research has been initiated and initial results have identified table grapes and hybrids that perform well under Southern Delaware conditions. This work will continue into the future Research on fresh pack processing was not conducted due to the lack of a collaborator;

however, research has been conducted at a number of other institutions and has been summarized for growers interested in best practices for packaging and handling of fresh shelled legumes. In the early 1990s crosses were made between high quality, highly adapted traditional spring pea types and available Austrian winter peas with the ultimate goal of developing fall-sown varieties which are suitable for traditional human food markets. Tests of some of these lines were planned but seed could not be obtained. A future goal of the UD vegetable program to test these varieties.

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Project Title: Strengthening Outreach Programs for Vegetable and Fruit Industries in Delaware

Project Summary: Projects and activities were developed by the Fruit and Vegetable Growers Association of Delaware to provide additional support to growers on Good Agricultural Practices and Good Handling Practices (GAP/GHP) farm plan development; to enhance farm to school and farm to institution sales; and to promote increased consumption of local vegetables and fruits. The FVGAD worked with produce growers to develop finished farm food safety plans and prepare for audits and sponsored GAP/GHP trainings. The FVGAD also worked with food service managers to better understand produce food safety and GAP's, encouraged all growers selling to schools and institutions to attend GAP/GHP training programs, and sponsored educational programs on producing for and selling directly to schools, colleges, institutions, and restaurants. The FVGAD increased outreach to promote vegetable and fruit consumption in Delaware and promote locally produced vegetables and fruits. One area of emphasis as on the Internet: revamping and updating the FVGAD website, FVGAD Facebook pages, and Twitter pages. Other areas of emphasis were to promote vegetable and fruit consumption around the state at public events targeting parents, bringing programs to elementary schools to educate about the importance of eating fruit and vegetables and on what produce is grown in Delaware, providing education based on farm to school programs emphasizing the health benefits of the local produce being supplied to schools, supporting direct marketers in Delaware and supporting school garden initiatives.

Project Approach: The goals of these projects were to provide additional support to growers on GAP/GHP farm plan development; enhance farm to school and farm to institution sales; and promote increased consumption of local vegetables and fruits. The following is an outline of the approaches to achieve these goals.

GAP/GHP Plan Development

To increase implementation of GAP/GHP practices in Delaware the FVGAD co-sponsored 6 GAP/GHP trainings on writing produce food safety plans and going through a GAP/GHP audit with 128 going through the trainings. In addition, FVGAD board members and staff worked directly to help growers complete food safety plans. From these trainings and one-on-one work, 24 farms have started farm food safety plans, 18 farms have developed completed plans or updated their plans, and 12 farms have gone through one or more audits or have scheduled an audit. There has been a general reluctance in going through an audit until specifically required to do so by wholesale buyers. Plan development activities have identified several areas where educational emphasis or research is needed including chlorine use in produce washing and hydrocooling, sanitation of trucks and produce transport implements, sanitation of packing lines, providing adequate hand washing facilities, and water testing.

Water Testing For GAP/GHP Plans

In addition to plan development, the FVGAD developed a cooperative water testing program with the Delaware Public Health Laboratory to complete water tests necessary to complete farm food safety plans. In the three years of the project, 245 water tests have been analyzed through this program. Water tests have revealed a number of water sources including both surface water

and wells above recommended standards for irrigation water and several wells used in potable water with microbial loads. Water testing has provided valuable information for growers on their water systems and potential hazards.

Food Service Manager Training and Interactions

In January, 2011 a workshop was delivered for food service managers to better understand produce food safety and GAP's and what produce growers do to ensure safe produce with 42 in attendance. In addition, board members delivered information on GAP/GHP practices directly to food service managers in meetings and through one-on-one contact. Overall, FVGAD has reached over 95% of the school districts in the state with information on GAP/GHP and buying produce locally. Through these interactions, food service managers understand what questions to ask of growers when purchasing locally. Another important result was the acceptance of Delaware school food service managers of grower GAP/GHP training rather than full audits for sourcing local products. Another positive impact from FVGAD involvement is that all school districts have expressed an interest in buying from local farms and many have started to buy local produce.

Farm to School, Farm to Institution, and Farm to Restaurant Educational Programs

The FVGAD has delivered, sponsored, or co-sponsored training programs; had board members serve on planning committees; or has provided speakers to multiple programs on selling to schools, institutions, or restaurants. One area of emphasis has been on providing GAP/GHP education and has included 5 trainings for growers on GAP/GHP practices for direct to school, institution, restaurant sales or direct marketing with 95 in attendance. FVGAD has also sponsored three programs and 5 field days on practices to produce out of season or year round for these markets and three programs on how to sell to these markets with 248 in attendance. These programs were put on in partnership with the University of Delaware, Delaware State University, and Delaware Department of Agriculture. These programs have shown that there are many small growers and new growers on small acres interested in selling into these markets that would be considered non-traditional producers. There is also an interest from traditional growers in expanding markets. The largest challenge was to have product for the school year which requires out of season production techniques or storage capacity. All GAP/GHP programs were well received and growers indicated in post program surveys that they would change practices or include practices to better insure produce food safety.

Promoting Fruit and Vegetable Consumption on the Internet.

The FVGAD increased its reach through internet resources. This includes a FVGAD website on Wordpress, a FVGAD Facebook site and a FVGAD Twitter site. The Facebook and Twitter sites have 130 followers (see links below). Analytics have shown that these site have had been viewed over 11,500 times. Some interested information gathered from these sites is that teachers are looking for information on fruits and vegetables to use in their classrooms, many consumers were unaware of what was available locally and when produce was available from local sources,

and many consumers were unaware of the nutritional content of the fruits and vegetables that they eat.

Promoting Fruit and Vegetable Consumption to Parents

The FVGAD had presentations or displays at 14 events for the general public including the Delaware State Fair, 3 health fairs, 4 school events, and other events sponsored by hospitals or local communities (4). The main target of these presentations was parents. An estimated 7100 adults have been reached through these efforts. In addition, the FVGAD has interacted with dieticians and Master Food Educators through the University of Delaware, providing information and training on local fruits and vegetable availability and food safety. Additional outreach by these groups and individuals multiplied the efforts of the FVGAD.

Promoting Fruit and Vegetable Consumption with Education of Elementary School Children and Education on Farm to School Programs.

FVGAD staff and board members interacted with school children with direct educational programs, with programs aimed at teachers, with programs aimed at school cafeterias, and with programs aimed at science education in schools. Direct educational programs reached 1,120 school children in 6 school districts, cafeteria based programs in five school districts with board members present reached an estimated 3,000 children, and FVGAD information for teachers reached 496 teachers with an estimated multiplier of 14,000. A total of 22 FVGAD members have interacted with schools, selling produce and going to schools as special guests to speak with students. These activities reached an estimated 8,000 elementary school students. Educational programs with schools have been very positively received and there is an increased awareness of Delaware grown fruits and vegetables.

Support of Direct Marketers

Direct marketer support by FVGAD was provided in a number of ways. First was promotion through the various FVGAD web based sites (see web histories of sites listed below). The second was by sponsoring educational workshops or providing speakers for workshops on direct marketing. A total of 4 workshops were supported reaching 111 direct marketers. The third was by providing GAP/GHP education specifically aimed at direct marketers. Workshops were held each year on GAP/GHP at multiple locations and 2 special sessions were provided for direct market groups. Targeted were those selling at farmers markets, roadside stand owners, growers selling to restaurants, CSA's and college student groups selling produce. These programs reached 82 growers and marketers.

Support for School Garden Programs

The FVGAD has worked to provide input into school garden programs throughout the state through direct contact of board members with school districts, FFA programs, and special grant programs (particularly in New Castle County). The FVGAD has been a sponsor or cooperator on several grants received to promote school gardens.

Goals and Outcomes Achieved: Projects and activities were developed by the Fruit and Vegetable Growers Association of Delaware to provide additional support to growers on Good Agricultural Practices and Good Handling Practices (GAP/GHP) farm plan development; to enhance farm to school and farm to institution sales; and to promote increased consumption of local vegetables and fruits.

In the area of GAP/GHP's goals were achieved through FVGAD sponsored trainings on produce food safety plans and audit reached that 128 growers and through direct one-on-one work with growers. Through these trainings and one-on-one FVGAD staff work with growers, 24 farms have started farm food safety plans, 18 farms have developed completed plans or updated their plans, and 12 farms have gone through one or more audits or have scheduled an audit. A total of 18 growers were aided with 245 water tests necessary for audits (reduced cost testing and direct assistance with sampling).

With school food programs, food service managers have been informed about GAP/GHP's on farms with a total of 42 managers received a training and board members delivered information on GAP/GHP practices directly to food service managers in additional meetings and through one-on-one contact. Overall, FVGAD has reached over 95% of the school districts in the state with information on GAP/GHP and buying produce locally. Through these interactions, food service managers understand what questions to ask of growers when purchasing locally. Another important result was the acceptance of Delaware school food service managers of grower GAP/GHP training rather than full audits for sourcing local products. Another positive impact from FVGAD involvement is that all school districts have expressed an interest in buying from local farms and many have started to buy local produce. FVGAD sponsored 5 trainings for growers on GAP/GHP practices for direct to school, institution, restaurant sales or direct marketing with 95 in attendance and has sponsored three programs and five field days on practices to produce out of season or year round for these markets and three programs on how to sell to these markets with 248 in attendance, These programs have encouraged many growers to sell to these markets and on the food safety side growers have adopted practices to better insure produce food safety when selling to schools and restaurants.

The FVGAD increased its reach in promoting fruit and vegetable consumption and local fruit and vegetables through internet resources with a website, Facebook site and a Twitter site. These sites have 130 followers and have been viewed over 11,500 times. Noted success has been with educators looking for information on local fruit and vegetables. Goals on promoting fruit and vegetable consumption with parents were reached by presentations or displays at the Delaware State Fair, three statewide health fairs, four school events, and four other events sponsored by hospitals or local communities that reached an estimated 7100 adults and through information provided to dieticians and Master Food Educators at the University of Delaware on local fruit and vegetable availability and food safety.

Goals on educating about healthy eating and the importance of fruits and vegetables for children, farm to school programs, and local fruits and vegetables were reached by direct educational programs offered by FVGAD staff that reached 1,120 school children in 6 school districts, cafeteria based programs in five school districts with board members present that reached an estimated 3,000 children, FVGAD provided information that reached 496 teachers with an estimated multiplier of 14,000 and the efforts of 22 FVGAD members with selling into farm to school programs and going to schools as special guests to speak with students reaching an estimated 8,000 elementary school students.

Beneficiaries: By training 128 farmers and assisting produce growers to develop produce food safety plans, 18 farms have passed or will be able to pass third party GAP/GHP audits, insuring future wholesale markets for Delaware produce.

By providing GAP/GHP information to school and institutional food service managers and by offering additional training to growers on growing and selling to schools and institutions, 95% of school districts have accepted farmer training programs as their base for buying from local farmers benefitting all produce growers interested in farm to school programs. Twenty-two farmers are selling into farm to school programs and this total is expected to increase greatly over the next 5 years.

By educating parents, teachers, outreach staff, and elementary school children about the benefits of vegetables and fruits, obtaining fruits and vegetables from local growers, and ways to increase vegetable and fruit use at home FVGAD has had an impact on over 30,000 children and their parents in the state.

Lessons Learned: GAP/GHP training programs and plan development activities has identified several areas where educational emphasis or research is needed including chlorine use in produce washing and hydrocooling, sanitation of trucks and produce transport implements, sanitation of packing lines, providing adequate hand washing facilities, and water testing. Water tests have revealed a number of water sources including both surface water and wells above recommended standards for irrigation water and several wells used in potable water with microbial loads. Water testing has provided valuable information for growers on their water systems and potential hazards.

Food service managers did not fully understand GAP/GHP's and did not understand what questions to ask of growers when purchasing locally. Trainings and discussions with food service managers were needed for the acceptance of grower GAP/GHP training rather than full audits for sourcing local products. A positive impact from FVGAD involvement is that we learned that all school districts have expressed an interest in buying from local farms and many have started to buy local produce.

Programs aimed at assisting growers to sell to schools, institutions, and restaurants have shown that there are many small growers and new growers on small acres interested in selling into these markets that would be considered non-traditional producers. There is also an interest from traditional growers in expanding markets. The largest challenge was to have product for the

school year which requires out of season production techniques or storage capacity. All GAP/GHP programs were well received and growers indicated in post program surveys that they would change practices or include practices to better insure produce food safety.

In promoting fruit and vegetable consumption, it was learned that teachers are looking for information on fruits and vegetables to use in their classrooms, many children did not have much knowledge on fruits and vegetables and consumed very little fruits and vegetables, many parents and students were unaware of what was available locally and when produce was available from local sources, and many parents and children were unaware of the nutritional content of the fruits and vegetables and their importance in a healthy diet.

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Additional Information: Internet Resources:
https://twitter.com/FVGAD
https://www.facebook.com/FVGAD
http://delawarefruitvegetable.wordpress.com/

Project Title: The Development of Best Practices for the Management of Commercial Bumble Bees on crops in Delaware

Project Summary: The 'western' honeybee (*Apis Mellifera* L.) is the most widely used and economically important managed pollinator in Delaware. The economic value of honey bees in the state is estimated at **~$15 million dollars** with an annual value of $14.6 billion nation-wide. Unfortunately, honey bee populations have been declining over the past decade due to their susceptibility to numerous pests and pathogens which have had profound negative effects on their ability to over winter. This decrease in managed pollinator populations during the blooming period of many important crops has growers and pollination ecologists concerned and looking to alternative pollinators, and growers are facing increasing difficulties in achieving pollination of their crops.

To help combat this issue, the investigation of native pollinators and their efficacy as pollinators has begun. A common native pollinator in the state of Delaware is the Common Eastern Bumble Bee (*Bombus impatiens* Cr.). In numerous studies, the bumble bee has been found to be a stronger pollinator when compared to the honey bee, as it forages in adverse conditions and has the ability to use buzz pollination. This specialized pollination technique, also known as sonication, is the ability of the pollinator to shake loose pollen when it is not easily dislodged from the anther of a flower. For bumble bees this is accomplished by creating high frequencies by the movement of the thorax and the rapid beating of the wings. Sonication is not seen in honey bees and gives bumble bees an advantage in the pollination of certain crops. It has also been determined that bumble bee activity starts earlier and ends later in the day than managed honey bees and they forage in lower temperatures. Honey bees begin to forage around 16 ºC whereas bumble bees will start at 10ºC. Additionally their long tongues enable them to better pollinate flowers with deeper corollas than honey bees.

Due to the observable strengths in pollination behavior that characterize bumble bees, commercial rearing began in the 1980s. The popularity of using this alternative pollinator has reached an all time high in closed systems for use in pollinating tomatoes, peppers and other greenhouse crops, but up until now there has been little work showing the efficacy of commercially reared bumble bees in a field setting. This project was inspired by watermelon growers in the state of Delaware in direct response to poor yield and fruit quality in fields that only used honey bees. The aim of the project was to investigate bumble bees and determine when, where, and how to appropriately place and utilize these commercial pollination units in the field. Ultimately, the aim was to assist growers in producing the best yield possible from their crops.

Project Approach: The first field season began in March of 2011 and concluded in October 2011. This field investigation included six farms throughout the Kent and Sussex Counties of Delaware. There were two main areas of investigation, each with various subsets: the biology of the bumble bee and the crop product. In total, 42 commercial bumble bee colony quads (four colonies in one quad box) and 2 single colonies were obtained from the Biological Supply Company, Koppert Biological Systems© (170 colonies in total). Studies were conducted in three different crops, strawberry watermelon, and pickling cucumbers.

The second field season began in March of 2012 and concluded in October 2012. This field investigation included seven farms throughout the Kent and Sussex Counties of Delaware. There were two main areas of investigation, each with various subsets: the biology of the bumble bee and the crop product. In total, this year, 42 commercial bumble bee colony quads (four colonies in one quad box) were obtained from the Biological Supply Company, Koppert Biological Systems© (168 colonies in total). Studies were conducted in four different crops, strawberry, watermelon, pickling cucumbers, and pumpkins. GPS coordinates of all quads and crops were recorded. Experiments are broken down by crop.

Strawberry Methods – Studies in the strawberry crop began each year in March and the strawberry harvest was over by mid-June. During the first year, two quads and an additional colony were placed in the closed strawberry high tunnels to accommodate an early harvest of the crop. Quads were then placed outside of the high tunnels for pollination of the later crops. The second year, no high tunnels were used and only two quads were placed along the edge of the strawberry field. Pollen was collected from workers of colonies, from every colony, both years. Worker foraging was observed as a measure of productivity. Each hive was examined for 2 minutes (2011), and 5 minutes (2012), each week and the activity of bees entering and leaving the hive was recorded. Hobo data recorders were used to determine hive thermoregulation by measuring temperature and relative humidity. The early nature of the strawberry season allowed for the greatest observation of these pollinators throughout the season. In 2012, at the end of each colony's life, each was removed from the field and dissected. The number of cells, queens, males, and worker bees were counted. All other insects were noted and identified to family. Collected bumble bees and wax within each colony were also pooled with the other strawberry colonies and sent for pesticide testing

Results – Temperature and relative humidity were higher on average throughout the season in the high tunnels in 2011 than they were in colonies placed in the field, (Figures 1-2, Temperature: $F_{1,\ 10748}$=35.19, P<0.0001, RH: $F_{1,10748}$=53.36, P<0.0001). In 2011 strawberry pollen was the most common strawberry grain seen in the pollen samples within the strawberry crops. It was present in 45% of samples. The other types of pollen most commonly seen were peach (18%), Japan Quince (18%), and English Plantain (18%). In 2012 out of the 24 strawberry samples taken from the corbiculas of the commercial bees within the field, 2 samples contained strawberry pollen. The most common pollen grains that were found in the strawberry samples and the percentage of samples that they were found in each were peach (33%), eastern redbud (25%), sedum (20.8%), blueberry (16.67%), and mullein (16.67%).

Watermelon Methods – Bees were placed in the watermelon fields during Memorial Day weekend (2011 – twenty quads between 2 fields) and the first week in June (2012 – thirty quads between 3 fields) to accommodate the beginning of the fruit bloom. Tests done in the watermelon paralleled those performed in strawberry, with some additional studies. Following the Goulson et al. (2002) study, which weighed hives to determine productivity of the hive, hive weight was measured weekly, to the half gram, throughout the season. Foraging data was also taken by counting bees flying in and out of the hive for 5 minutes. All colonies were frozen at the end and were analyzed in a post mortem analysis as was done with the strawberry colonies. Watermelon surveys were also conducted throughout the season on various farms across the area regardless of what pollinator was placed on the field (2011). These surveys assessed the health and vigor of the plant by determining the placement and amount of flowers and fruit developed.

In 2012, a similar watermelon study was run that determined fruit set twice per field at varying distances from the quad. A second harvest study was conducted that determined weight of fruit just before harvest. Relative humidity and temperature were also measured by hobo data loggers placed in colonies throughout the field. The goal of the watermelon study was to determine how the location treatment of the quad affected longevity and production of the bumble bees, and how the presence of bumble bees on a field affected the vigor and health of the watermelon plants.

Results - In comparing treatments by total foraging of a colony through the season all colonies placed with shaded treatment yielded higher total foraging counts than those placed in the sun, (Figures 3-4, 2011: $F_{4, 71}$=9.93, P<0.0001, 2012: $F_{2, 99}$=8.31, P=0.0005). Average weight of each colony was taken and compared to its treatment. In 2011, all non-sun treatments had, on average, heavier colonies than those placed in the sun. In 2012 natural shade and shade structure treatments had higher average weights than those in the sun (2011: $F_{4, 25.62}$=11.67, P<0.0001, 2012: $F_{2, 99}$=8.29, P=0.0005). At the end of the season when each colony was determined to be 'dead', the colony was collected and analyzed. The number of total cells counted in each colony was compared against the treatment that it was given and the field in which it was placed. Both shaded treatments had more total cells than sun treatments, (Figure 5, $F_{2, 91}$=12.08, P<0.0001). In 2012, 18 out of 73 (25%) pollen samples taken from pollen baskets of bees placed within the watermelon fields contained watermelon pollen. The most common pollen grains and the percentage of which they were detected within the watermelon fields were English plantain (57%), crown vetch (37%), and bitter sweet (36%). In 2012, average weekly temperature and relative humidity of the colonies did not differ in colonies with different treatments, (Figures 6-7, Temperature: $F_{2, 61}$=0.34, P=0.715, RH: $F_{2, 20}$=3.30, P=0.0579).

Pickling Cucumber Methods – 10 quads were placed in two fields in mid-July (2011). In 2012, 10 quads were placed in 1 initial field and then removed and placed in another field a few weeks later after harvest. Experiments in the pickling cucumber crop mirrored those in watermelon, but added additional foraging tests. Foraging activity data was gathered by counting the number of flower visits per minute/bumble bee. Pollinators were then collected along five, 50 meter transects for 30 minute intervals to determine what species were actively on the plants. Further, at each 5 meter interval along those transects, bees were counted as they flew into the area over a one minute period. In 2012, bowl traps were placed in the field with soap detergent providing another sampling method. Also, a pollen transfer study was attempted that aimed to determine the number of bee visits that was required to develop a harvestable fruit. (This experiment was abandoned due to lack of bumble bee activity in the fields). Finally, bees were moved to a second field after the first harvest to determine the hardiness of bees after being transferred. Crop yield data was gathered by harvesting eight, 10 yard plots on various areas of the field, but was disregarded due to damaging effects of Hurricane Irene. GPS data points of each were taken to mark distance of harvest point to quad.

Results - The reflective A-frame shade treatment was the only treatment that was significantly different from the sun treatment in total season forage, ($F_{4, 75}$=3.37, P=0.0137). In 2011, all shaded structures had higher average weight of colony through season than sun. The natural shade had the highest average weight, of all treatments (2011: $F_{4, 31.09}$=43.49, P<0.0001, 2012: $F_{1, 38}$=1.23, P=0.2748). The total number of cells found in each colony was compared to the treatment that the colony was given. In 2011, the pentagon shade structure had more cells than the sun treatment. No difference was detected in 2012, (Figures 8-9, 2011: $F_{4, 22}$=5.52,

P=0.0031, 2012: $F_{1, 38}$=1.79, *P*=0.1891). In 2011, 168 pollinators were caught during the sweep net study, 132 of them were Apidae-*Apis.* Apidae-*Bombus* was the next most abundantly caught taxa with 17, followed by Syrphidae with 8. In 2012, out of 75 pollinators caught by sweep net, 65 were Apidae-*Apis.* The next largest amount of a pollinator taxa caught were Syrphidae. No Apidae-*Bombus* were caught. In the bowl traps, 84 pollinators were caught. Apidae-*Apis*, Halictidae, and Syrphidae were the most abundant taxa with 27, 20, and 20 individuals caught, respectively. Out of the 84 pollinators, 6 Apidae-*Bombus* were recorded, the other Hymenopterans were, Apidae-*Melissodes*, and Vespidae.

Pumpkin Methods - In 2012, soon after the pickling cucumber, bumble bees were placed in the second pickling cucumber field, honey bees began to overrun each colony. In order to prevent the complete demise of the purchased bumble bee colonies, the quads were removed and placed in a pumpkin field at the same mixed orchard that was used for the strawberry experiments. The same experiments were conducted within the new pumpkin location that was described above for pickling cucumbers. No pumpkin harvest was conducted.

Results – No pumpkin data was analyzed. Bumble bees were placed here to combat difficulties in the pickling cucumber fields in 2012. The analysis of this crop was out of the scope of this project.

Pesticide Results

Table 1.1. List of pesticides detected in bees and wax samples in ppb concentrations in 2011. All values in parentheses indicate honey bee LD50 from PPDB unless otherwise indicated. - = no detection, 2 = Thompson 2001, 3=Mullin et al. 2010, / = bumble bee LD50.

Crop	Watermelon		Pickling Cucumber		Strawberry	
Field	**3**		**2**		**1**	
Substrate	**Bees**	**Wax**	**Bees**	**Wax**	**Bees**	**Wax**
Chemical (concs in ppb) (LD50)						
Acetamiprid *(8,090) 48 hour contact*	-	-	-	-	-	12.5
Azoxystrobin *(25,000) 48 hour oral*	22.7	168	56.6	313	-	-
Carbendazim *(50,000) 48 hour contact*	-	-	13.1	40.6	10.9	72.4
Chlorothalonil *(40,000) 48 hour oral*	312	4860	-	1240	-	-
Chlorpyrifos *(59) 48 hour contact/ (11,400)*[2]	-	-	-	3.7	-	-
Coumaphos *(46,300)*[3]	-	29.7	-	48.4	-	24.9
Cyfluthrin *(1) 48 hour contact*	-	-	4.9	-	-	-
Cyprodinil *(113,000) 48 hour oral*	45.8	39.8	-	-	57.1	39.4
Difenoconazole *(>100,000) 48 hour contact*	266	-	-	-	138	-
Fludioxonil *(>100,000) 48 hour contact*	-	-	-	-	47.2	75.2
Fluvalinate *(not available)*	-		-	8	-	-
Hydroxychlorothalonil *(not available)*	-	226	-	-	-	-
Methomyl *(800)*[2]*/(3,200)*[2] *24 hour oral*	-	-	13.5	12	-	-

Phosmet *(220) 48 hour contact*	-	-	-	-	-	38.1
Pyraclostrobin *(>73,100) 48 hour oral*	-	-	-	-	46.1	120
Tebuconazole *(>83,050) 48 hour contact*	40.3	49.2	-	-	-	-
Tebufenozide *(> 234,000) 48 hour contact*	-	-	-	-	73	153
Thymol *(>200,000) 48 hour contact*	62.8	71.8	-	-	-	-

Table 1.2. List of pesticides detected in bees and wax samples in ppb concentrations in 2012. All values in parentheses indicate honey bee LD50 from PPDB unless otherwise indicated. - = no detection, 2 = Thompson 2001, 3=Mullin et al. 2010, / = bumble bee LD50.

Crop	Watermelon		Pickling Cucumber		Strawberry	
Field	**3**	**3**	**2**	**2**	**1**	**1**
Substrate	**Bees**	**Wax**	**Bees**	**Wax**	**Bees**	**Wax**
Chemical (concs in ppb) (LD50)						
Azoxystrobin *(25,000) 48 hour oral*	-	-	73.4	-	103	2970
Bifenthrin *(150)*[3]	7.8	-	-	-	-	31.2
Boscalid *(1,550,000)*[3]	-	-	-	-	70	79.5
Captan *(100000) 48 hour oral*	-	-	-	-	-	2440
Carbendazim *(>500,000) 48 hour contact*	-	-	-	-	-	20.1
Chlorfenapyr *(120) 48 hour exposure type not reported*	2.8	-	-	-	-	-
Chlorothalonil *(40,000) 48 hour oral*	5710	48700	-	34400	-	178
Chlorpyrifos *(59) 48 hour contact/(11,400)*[2]	-	6.2	-	-	5.1	25.5
Coumaphos *(46,300)*[3]	-	-	-	-	-	13.1
Cyprodinil *(113,000) 48 hour oral*	72.4	11.3	-	-	32.5	43.7
Fenbuconazole *(1,490,000)*[3]	-	-	54.8	-	-	16.9
Fenpyroximate *(15,800) 48 hour contact*	6.3	-	-	-	-	-
Fluvalinate *(15,860)*[3]	-	2.5	-	-	-	-
Hydroxychlorothalonil *(not available)*	-	196	-	-	-	-
Methoxyfenozide*(>100,000) 48 hour oral*	-	-	60	-	-	-
Pendimethalin *(100,000) 48 hour contact*	16.6	40.4	-	-	45.9	43.3
Phosmet *(220) 48 hour contact*	-	-	-	-	17.1	129
Pyraclostrobin *(>73,100) 48 hour oral*	-	-	-	-	11.2	19.9
Tebuconazole *(>73,100) 48 hour oral*	21.1	12.7	47	81.1	-	-
Tebufenozide *(>234,000) 48 hour contact*	-	-	-	-	-	103
Trifloxystrobin *(>200) 48 hour oral*	-	-	-	-	-	49.3

Two other grants were awarded to this project in 2012. A grant from Pickle Packers International was awarded to provide summer housing for field researchers and assist in providing for various field supplies and pesticide testing for up to $3000. A second award was also won from Northeast SARE. This grant funded summer technicians to aid the main researcher in the field throughout the summer field season. The amount awarded was $5,696.

Goals and Outcomes Achieved: Goals for this last reporting period were to complete data analyses, continue to perform outreach and to publish the research. Much of the data analyzed from this last reporting period was given in the above 'Project Approach' section. A full 110 page report was completed in a thesis in fulfillment of the requirements for graduation from the University of Delaware. In pursuit of the second goal of this reporting period, this project was presented at two additional conferences and was printed in one grower publication; 2013 Vegetable Growers Association of NJ Convention (February 2013), 2013 Mardel Watermelon Growers annual conference, Cambridge, MD (March 2013), University of Delaware Cooperative Extension – Weekly Crop Update (April 2013). Two additional manuscripts are in the process of being submitted for publication and are expected to be in print in 2014.

Beneficiaries: The following is a list of avenues in which information from this project has been publically available or presented. The list of outreach activities have been categorized into two groups of either *highly effective outreach* or *moderately effective outreach*. Given our main goal was to reach out to growers we determined that those methods that focused exclusively on growers were most effective in publicizing our work. Further, the response from these outreach attempts were positive in that our efforts were informative and constructive and growers gained welcomed knowledge. In the *moderately effective outreach* category are the outreach efforts that were given to an audience that did not include growers (mostly beekeepers and academics). Despite missing the main target audience of the project, these efforts were important as they shared research ideas with other professionals in the field. Oftentimes feedback was received allowing for the expansion and fine tuning of our research methods and overall goals.

Highly effective outreach

- 2011 Mid-Atlantic Vegetable Workers Conference (November 2011) *(audience of 40)*
- 2012 Delaware Agricultural Week (January 2012) *(audience of 110)*
- 2013 Vegetable Growers Association of NJ Convention (February 2013) *(audience of 60)*
- 2013 Mardel Watermelon Growers annual conference, Cambridge, MD (March 2013) *(audience of 80)*
- University of Delaware Cooperative Extension – Weekly Crop Update (April 2013) *(audience of 200)*

Moderately effective outreach

- New Castle County Beekeepers Monthly Meeting (April 2012) *(audience of 70)*
- USDA-ARS Pollinating Insects Lab (June 2012) *(audience of 15)*
- Eastern Apicultural Society Native Pollinator Workshop (August 2012) *(audience of 100)*
- Entomological Society of America (ESA) Meeting (November 2012) *(audience of 100)*
- ESA Eastern Branch Meeting (March 2013) *(audience of 35)*

Lessons Learned: As discussed in the 2012 report, the pickling cucumber bumble bees were overrun by honey bees in the second field and were quickly relocated to a pumpkin field. We speculate a few reasons for this happening. To begin, honey bees and bumble bees were placed too close together within the field before full bloom. Additionally, in anticipation of the early arrival to the field, bumble bees were given additional resources for satiation before full bloom occurred. Analyses of these colonies showed that they were declining by the time we received them. Therefore, having bumble bees arrive after a certain date during the growing season may affect the quality of pollination services that can be expected.

We attempted to examine pollen transfer of bumble bees through a study that determined the number of bee visits required to produce a marketable crop. This experiment was only to be performed in the pickling cucumber field. Unfortunately, through our study we observed very little bumble bee activity on the pickling cucumber blooms, therefore this experiment was not feasible. With this in mind, we do not suggest bumble bees as an appropriate alternative pollinator in pickling cucumbers as they were not found in the fields in either year. However, as stated above problems with the quads in 2012, lead us to believe that further testing may be warranted.

In the initial watermelon study design, we decided to bury some of the quads to mimic conditions of a natural nest. This idea was abandoned in 2012 because often times the quads became very muddy and soggy and made it difficult to conduct our weekly examination experiments.

Developed Best Management Practices

General

- Bumble bees can be used for strawberry and watermelon but not for pickling cucumber horticultural crops.
- Place bumble bees in the field after crops have begun to bloom. Allow time for bees to settle before opening units.
- Close bumble bee units before each pesticide application.
- Dispose of bumble bee colonies in a timely and humane fashion.

Colony Placement

- Bumble bees can be placed in the middle or on the edge of the field.
- Place bumble bees under shade, to increase productivity and longevity of the bumble bees.
- Keep bumble bees away from honey bees.
- Strap down bumble bee units.
- Bumble bee units may successfully be transferred to another field.

Pesticide Sprays

- Close up colonies before each spray

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Additional Information: Currently we are working on publications that are in the final stages of the writing process and we are optimistic that these articles will reach publication in 2014.

These publications will be submitted to HortScience, The Journal of Economic Entomology, and Bee Culture Magazine.

Appendix 1 Figures and Tables

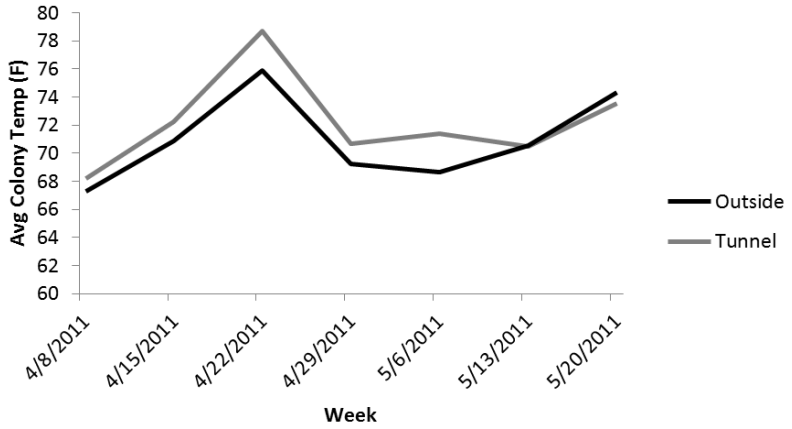


Figure 1. 2011 Strawberry, average weekly temperature by placement of colony

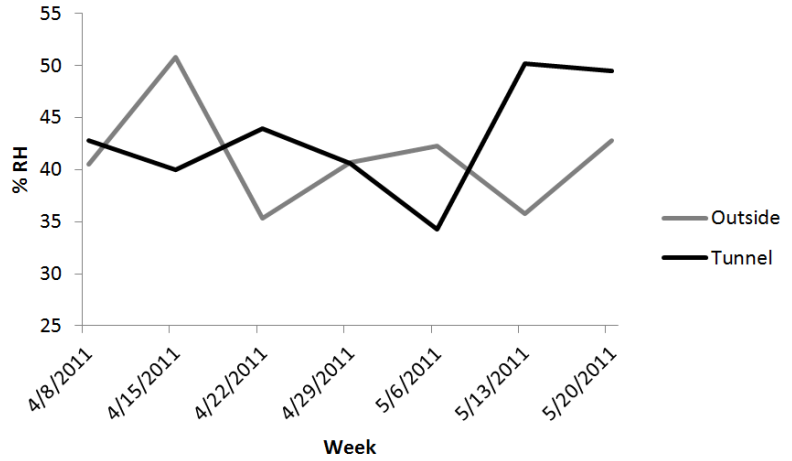


Figure 2. 2011 Strawberry, average weekly percent relative humidity by placement of colony.

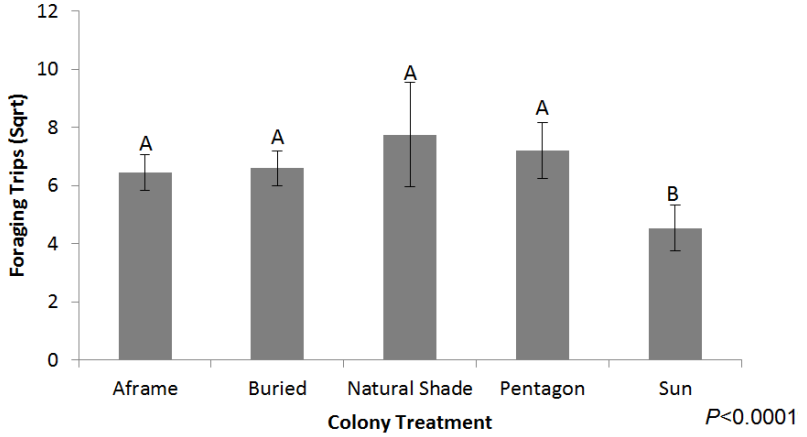


Figure 3. 2011 Watermelon, total season foraging by colony treatment (square root transformed). Error bars indicate 95% confidence intervals, and letters denote statistical significant differences as determined by Tukey Kramer post hoc test.

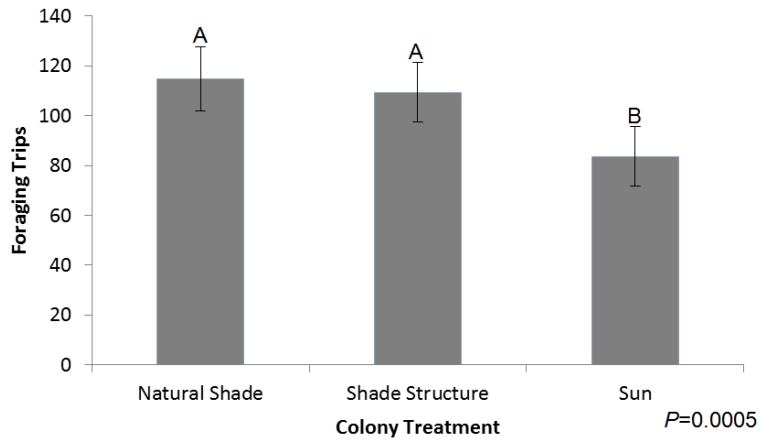


Figure 4. 2012 Watermelon, total season foraging by colony treatment. Error bars express 95% confidence intervals, letters denote statistical significant differences determined from Tukey Kramer post hoc test.

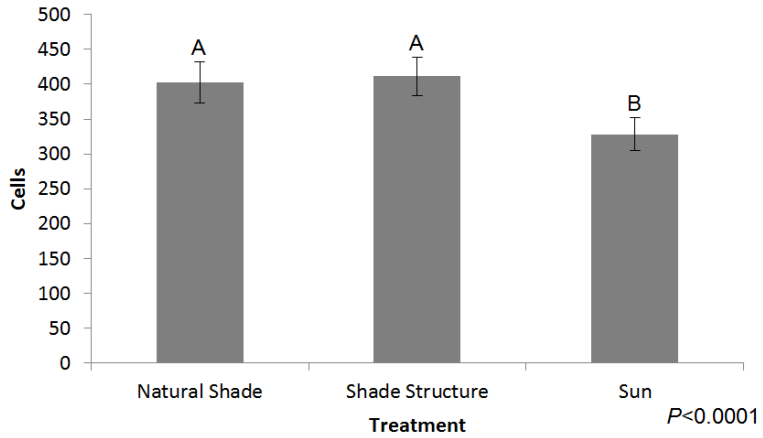


Figure 5. 2012 Watermelon, total cells by colony treatment. Error bars denote 95% confidence intervals, letters denote significance difference by a Tukey Kramer post hoc test.

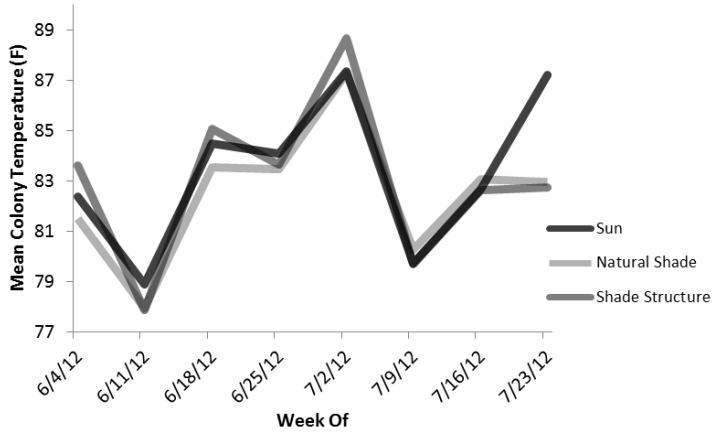


Figure 6. 2012 Watermelon, weekly average temperature by colony treatment.

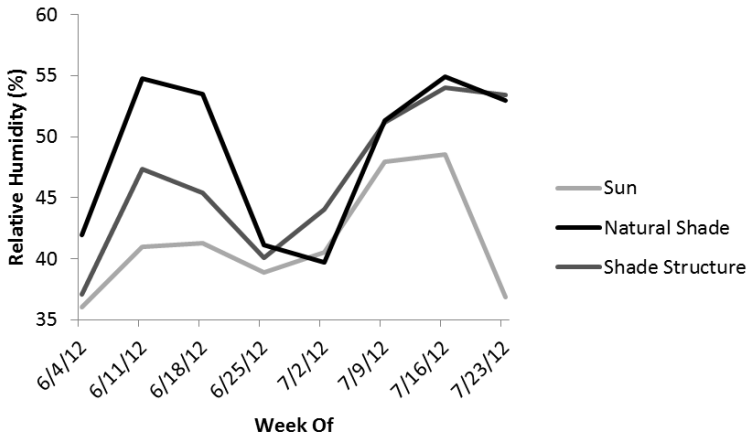


Figure 7. 2012 Watermelon, weekly average relative humidity by colony treatment.

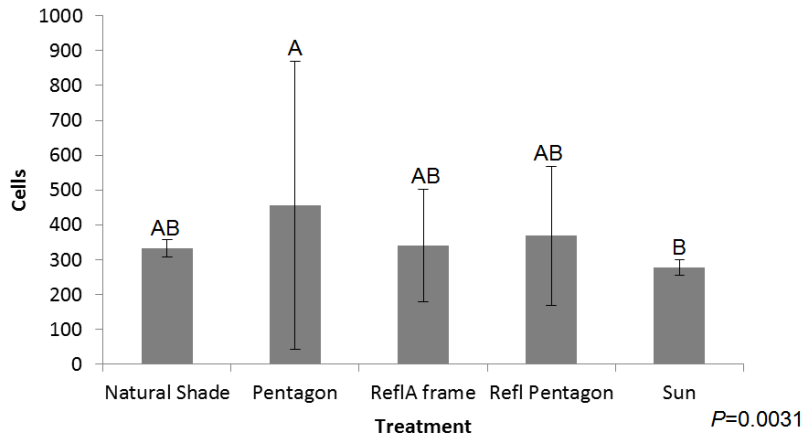


Figure 8. 2011 Pickling cucumber total cells by colony treatment +/- 95% confidence intervals. Letters denote significant differences as designated by a Tukey Kramer post hoc test.

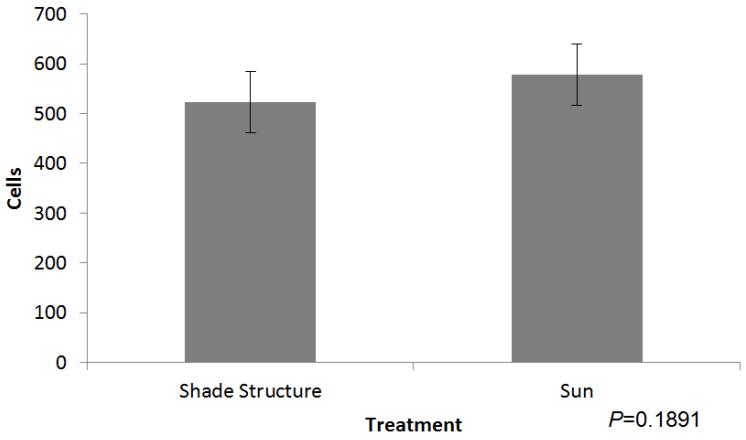
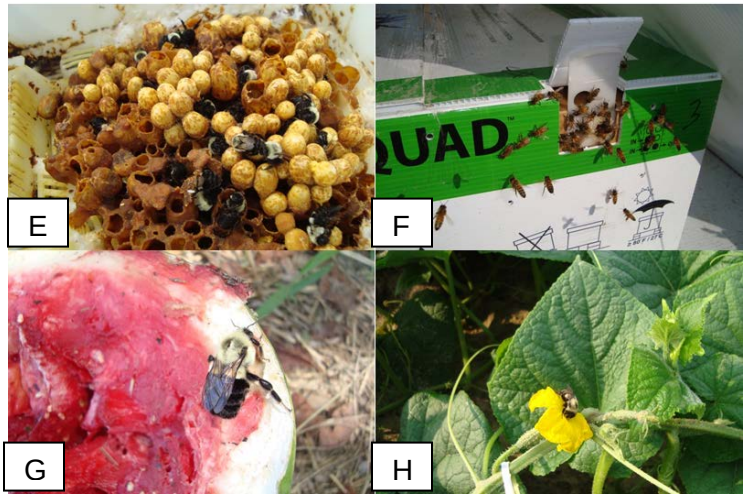


Figure 9. 2011 Pickling cucumber total cells by colony treatment +/- 95% confidence intervals.

Appendix 2 Pictures

A: Quad in A-Frame shade structure. B. Quad in direct sun. C. Quad in natural shade. D. *Bombus impatiens* leaving a colony within a quad.



E. *Bombus impatiens* nest during a post mortem analysis. F. *Apis mellifera* invading a *Bombus impatiens* quad. G. *Bombus impatiens* on a watermelon. H. *Bombus impatiens* on a pickling cucumber bloom.

Project Title: Study of Rhabdocline Disease Resistant Douglas Fir Trees

Project Summary: Rhabdocline needlecast fungus has infected several Delaware Christmas tree plantations. Occurrence of this infestation has been reported from moderate to severe. This fungal infection has been kept reasonably under control by the use of a fungicide that is chlorothalnil based but the financial impact of its use significantly increases the cost of growing the Douglas fir. The Douglas fir is one of the most popular fir trees for us to grow and its demand is quite strong for the Delaware consumer. Most Delaware Christmas Tree growers' prefer to use the seed from the Lincoln NF located in the Southern aspects of the Rocky Mountain Range. Since we primarily grow trees from this seed source this is where we have found our fungal infection problem.

Reports have come though written ,verbal, pictorial, and other sources that Douglas fir that has seed taken from the Mid-Rocky (deep mountain) to the extreme Northern Rocky mountain range (schuschwap lake) have less susceptibility to being infected with the Rhabdocline needlecast fungus. Thus, this project is designed to evaluate whether these two (2) seed source Douglas fir trees respectively will be more or less resistant to the fungal problem we now have with Douglas fir trees coming from the Lincoln NF seed source.

Project Approach: It has been the experience of our Delaware Christmas Tree Growers' that the onset of the Rhabdocline infection is most visible and prevalent in older trees. This observation was taken and discussed. As a result it was determined to purchase balled & burlaped (B&B) Douglas fir trees in the 5' to 6' range. These trees were older and hardier than seedlings or transplants. Since we have information on trees from three different seed sources a plan was developed to make purchases of Douglas fir trees from each seed source to be evaluated. Finally, since we have tree growers' in each of our three counties it was determined to establish a test farm in each of our counties (New Castle, Kent, and Sussex). Each farm chosen has had evidence of the Rhabdocline needlecast infection in years prior to this project. Soil sampling was also done at each test site and found to be acceptable to receive the trees to be purchased.

With the above basics settled, orders and delivery schedules of 252, Douglas fir trees was made in January of 2011.. Each test site was to receive 84 trees (28 of the Lincoln seed source, 28 of the Deep Mountain seed source, and 28 of the Schuschwap Lake seed source) The Lincoln trees came from Pennsylvania, and the Deep Mountain and Schuschwap Lake trees came from Michigan. The suppliers these trees were from reputable firms with several years in the business.

Working with the University of Delaware Extension Service we developed a planting grid for the position of each tree from each seed source. A scheme was developed where four rows of trees would be allowed with 21trees in each row, alternating each seed source specimen. Thus row one would start with a Lincoln and end with a Schuschwap; row two starts with a Scuschwsap and ends with a Deep Mountain; row three begins with a Deep Mountain and ends with a Lincoln; row four starts with a Lincoln and ends with a Schuschwap. This plan was designed to integrate the trees evenly to the potential exposure to the Rhabdocline infection should it be present.

The planting sites selected, size of trees determined, a planting scheme designed, orders placed, delivery and planting of the trees became the next target. It was determined that in order to save

costs we would have all of the trees delivered to our New Castle County test farm in Townsend, DE. At that location a tractor with a loader attachment was available to move the trees from the transport trucks to the ground. 84 trees were delivered on April 26, 2011, and 168 were delivered on April 27, 2011. Over those two days, three older gentlemen worked extremely hard to unload all 252 trees. Each balled & burlaped tree weighed in at an average of 275lbs. Unfortunately when we determined the tree height (size) we never considered the tree weight. The delivery process was not yet complete as we had to move 168 trees to the two other test tree sites (one in Kent County and one in Sussex County). Finally with the help of the original three volunteers plus a few more, we borrowed trailers (our original contract the move the trees for us fell through-it was said "trees too heavy") we were able to deliver the 84 trees to each test site in Kent and Sussex counties.

Trees delivered – now to plant. With the use of a rented Auger and a lift to pick up the trees and move them to the hole dug by the auger we were eventually able to plant all 252 trees over a period of about two weeks at all three test sites. As much as was tried we wanted to plant the trees where the top of the balled root system was even with the ground but sometimes we were not accurate in this goal. In some cases the hole was too deep or not deep enough, BUT sometimes we were just right. The problem here is that once the tree was placed in the hole there was no way to get it out and try to replant. After planting, each tree was assigned a number via a tagging system that identified the seed source of the tree, its actual tree number, and the farm on which the tree was located. This was done so as to track the history (disease problems, hardiness, virility, etc.) of the tree during this project.

One final note to conclude the Project Approach and that is two-fold. First, were the trees we received healthy and free of disease, and two, scheduled inspections needed to be set to determine and evidence of Rhabdocline Needlecast infection. On May 20, 2011, a visit from the University of Delaware Extension Service with a Plant Pathologist and an Etymologist visited all three farms and concluded that the trees we received we indeed healthy and free of disease. Furthermore it was determined that in May and October of each year of the project these same personnel would inspect and report their findings to us as keeping us on track with the goal of our project. It must be said that many thanks go to the University of Delaware Extension Service and specifically the team of Nancy Gregory and Dr. Brian Kunkle for their most valuable assistance with this project.

Goals and Outcomes Achieved: Initially it must be stated that it was our consideration that this project was to be one of a long-term basis. It was because of this that several inspections by the University of Delaware Extension Service were scheduled as follows: October 2011, 2012, 2013, and May of 2012 and 2013. Admittedly we thought we had a little longer time-frame in which to conduct our research but that is not the case so we can take a look at what has occurred since the test trees we planted in May of 2011.

This being said let's describe the activities that were taken to lead us toward our goal of observing what each different seed source tree was resistant to the Rhabdocline Needlecast fungus. Here we could begin to list a frightening amount of statistics that might just be extremely overwhelming. As not to do this a summary of each inspection might well initially suffice to describe our activities for this project. Two initial points to make here are that one, all

inspections were made as first scheduled and two, the inspection team remained constant throughout the entire project.

As previously stated the first inspection was made on May 20, 2011. This was done to assure the trees we received were healthy and disease free. The results confirmed that this was the case.

The second inspection was done on October 11, 2011. There was no evidence of any active diseases but overall it was discovered we had ten dead trees and ten trees put on a "watch" list due to some dying shoots or questions of hardiness. It was determined that the cause of the dead trees may have been due to the planting process which involved much tree movement or drought conditions that prevailed over the summer. So no real surprises at this point.

May 10, 2012, was the next inspection –the 3rd. Again no evidence of the fungus we have been looking for but still losing some trees. This inspection reports ten dead trees and sixteen trees put on the "watch" list. The "watch" list trees included hardiness symptoms such as color, dead shoots, and some indication of potential disease for which we have been looking. Samples taken from a few of the trees on the "watch" list proved to be negative for any disease. A point of note here is that other than dead trees the trees on the "watch" list are just about even with regard to the seed source orign.

Moving on to the next inspection of October23, 2012 things remained fairly uneventful. Noted were a few more dead trees from the Lincoln and Deep Mountain sources; three trees (one from each seed source) looked like there might be some fungal infection we wanted to find but tests were negative; and four trees across all of the tree types were put on the "watch" list for hardiness and color.

The May 16, 2013, inspection turned out to be an eye-opener! Here there may be some cause to get a little more graphic with numbers. This inspection revealed an invasion of not, Rhabdocline Needlecast fungus but that of SWISS NEEDLECAST fungal infection – equally threat to the health of Douglas fir trees. Numerically this is what the outcome of the May 2013 inspection revcealed:

Swiss Needlecast Infected trees:

Farm #1 - 57 out of 75 trees were infected or 76%
Farm #2 - 49 out of 73 trees were infected or 67%
Farm #3 - 25 out of 79 trees were infected or 32%

The most infection was found on the trees from the Schuschwap seed source and the least from the Lincoln. The Farm #3 in Sussex County had the least amount of infection and the Farm #1 in New Castle County had the most. All farms had 2 trees each that were put on the "watch" list for Rhabdocline Needlecast infection but nothing seems to develop out of the trees that have had past watches put on them and this case was no different.

October 22, 2013, inspections were done on test sites #3 and #2 (Sussex and Kent Counties respectively). The intensity of this evaluation was more detailed and site #1 (New Castle County) was done a few days later on October25, 2013. It was decided that for this evaluation we would take each remaining tree's seed source, assign an average Overall tree Rating at the

date of inspection, an average Rhabdocline tree Rating, an average Swiss Needlecast Rating and an average Final Tree Rating for each farm, again as of the evaluation date. It was determined that this would be the best way to disseminate our findings. Following is a summary listing of our findings based on the just mentioned rationale:

SEED SOURCE	AVG. OVERALL RATING	AVG.RHABDOCLINE RATING	AVG.SWISS NEEDLECAST RATING	FINAL TREE RATING
FARM #1 (Sussex County)				
Lincoln(24)*	1.17	0.00	1.00	2.13
Deep Mtn.(24)	2.43	0.00	1.04	3.5
Schuschwap(24)	2.48	0.00	1.13	3.36
FARM #2 (Kent County)				
Lincoln(20)	1.05	0.05	0.85	1.95
Deep Mtn.(26)	2.12	0.08	0.85	3.19
Schuschwap(26)	1.73	0.04	0.69	2.42
FARM #3 (Sussex County)				
Lincoln(24)	1.75	0.08	.917	2.83
Deep Mtn.(21)	2.52	0.00	1.19	3.71
Schuschwap(24)	2.63	0.167	1.08	3.13

*Denotes number of trees inspected for each seed source.

In summary, The Lincoln trees seemed to have done the best over the length of our evaluation. The Schuschwap followed by the Deep Mountain seemed to have finished in second and third respectively. It was disappointing that the Rhabdocline Fungal infestation did not take hold during this term. Only brief indications were observed but never came to fruition. Farm one had no indication the Rhabdocline and farms two and three only had a possibility. As a result the hypothesis of our experiment to expect Rhabdocline Needlecsat disease on the Lincoln trees and to a lesser extent, or even non-existent on the Deep Mountain and Schuschwap has not been proven. The highpoint of our investigation was that even though the Lincoln seed source tree may have its infection problems, that tree was the most hardy, the best looking, and in our minds, the most saleable Douglas fir we had in our test plots, regardless of the County.

Beneficiaries: The Delaware Christmas Tree Growers' Association and the University of Delaware Extension Service have been kept informed and participated in this project. During the length of the Grant, there were 12 presentations made to members and guests of the Delaware Christmas Tree Growers' Association. On an ongoing basis we reported to just about 176 persons. We are preparing a report for the University of Delaware who will be hosting several short courses to those in the Horticultural field in March, May, June and July. We shall specifically target the May meeting which is dedicated to Christmas tree growers and anticipate having approximately 35 attendees. To a lesser standpoint the Penn State Horticultural Department has had some input and feed –back on this project. We have not yet, but will do so, write and have published the scope of this project. CHRISTMAS TREES MAGAZINE, our "Trade Publication" is willing to take our findings to their national subscriber list. Discussion has been initiated with the editor of this magazine and it looks like we will not get our findings published until the fall of 2014. Their circulation runs between 1500 and 2000 copies per issue. In addition this publication is the only industry magazine used by Ebsco – a huge international data base that goes to libraries and institutions in over 200 countries. We are continuing to work with the University of Delaware in arranging publication of our project's onset and outset of

events. We have begun work on a written report to be sent out by the U of D Extension service to their chain of readers numbering several hundred. We are expecting this to come together in April 2014. Penn State Horticultural Department is on this list so we shall not leave them in limbo. Economic impacts of this project? Keep growing Douglas fir from the Lincoln seed source and dig in to your pockets to pay for available fungicides to control the onset of the fungus. The owners of the three test sites will agree, I'm sure.

Lessons Learned: The group of individuals spearheading this Grant did not have any experience in comprehending the scope of this plan. Initially, ordering the larger trees seemed to be the way to initiate the project. In retrospect, the problems moving the trees around the state proved to make us think that this was not a good idea. But, a core of good volunteers did pitch in and help making the hard work, not always a pleasure, but an unforgettable experience, and we did get a lot of laughs – at ourselves mostly. The planting of the trees was a real learning experience. Getting the planting depth for each tree was not the same which brought us back to the idea us using smaller trees. The planting team will not be recommending using balled and burlaped trees in the future on our own farms or elsewhere.

The most unexpected impact of this project was the infestation of the Swiss Needlecast Fungus that attacked our trees. No matter what the tree seed source was there was infestation to be found. This was just never expected. On the other hand, the etymologist from the University of Delaware Extension Service found little, If any insect problems with any of the test trees. So we did not achieve our goal of predicting Rhabdocline Needlecast basic ally only our Lincoln trees and not the others. Maybe we used the wrong size trees, planted them in the wrong locations, didn't plant them all the same way, and certainly weather was a factor. Initially we had drought conditions and this past summer we had record rains (at least in Sussex County). Overall, some hard work, but fun!

Contact Person: H James Landis, Delaware Christmas Tree Growers Association, Phone: 302-947-2404, E-mail: landistreefarm@aol.com

Project Title: Lima Bean Cultivar Improvement and Genetics Research for Heat Tolerance and Pest Resistance

Project Summary: Lima bean (*Phaseolus lunatus*) is Delaware's most widely planted vegetable crop and important for the state's processing vegetable industry. The majority of Delaware lima bean acreage is of the green baby type grown for processing, with approximately 12,000 acres planted in the state annually. One regional processor has also begun growing the Fordhook type, which produces a large plump seed; however the available Fordhook varieties produce inconsistent yields in our climate. Heat stress is a limiting factor for baby and Fordhook lima bean production in Delaware.

The purpose of this project was three-fold

1. To test advanced breeding lines from the University of Delaware lima breeding program on a larger scale and under diverse conditions in order to gauge tolerance to environmental stress, including heat and drought, and in order to identify lines that may be suitable for commercial release.

2. To test potential methods of screening for heat tolerance in lima bean, so that these tools can be used in the breeding program to enhance the ability to select and advance heat tolerant germplasm.

3. To increase our understanding of the cyanogenic glycoside production trait in lima bean, how it is expressed, how it may be important for insect resistance, and how high levels of cyanogenic glycoside in seeds may be screened for and avoided. Use of diverse lima bean germplasm (which may produce high levels of cyanogenic glycosides) in the breeding program depends upon the ability to effectively screen for these compounds in the seed.

Project Approach: Advanced baby lima bean lines from the UD breeding program were evaluated for yield and quality in a variety of locations with differing environmental conditions over the grant period. Trials were conducted both at UD's Georgetown, Delaware research farm and in grower fields, in cooperation with five different farmers and three of the four regional lima bean processors. Breeding lines that have performed well over multiple years and in multiple locations are being considered for release if they have commercially acceptable quality characteristics (i.e. DE0407905). Lines which have performed well but lack certain quality characteristics (i.e. DE0505002A) are being used extensively in the breeding program to develop lines with good adaptation, stable yield and quality. A number of breeding lines tested for the first time in 2012 and 2013 show superior stress tolerance and adaptability compared to the commercial standards. These superior lines are the result of using diverse germplasm from hot and drought prone climates in the breeding program and selection of breeding material under stress conditions in the field.

Advanced Fordhook lima bean lines from the UD breeding program were evaluated in replicated yield trials at the Georgetown research farm each year of the project. Plans to conduct trials of Fordhook lines in grower fields were thwarted by two failed attempts to have seed produced in off-site locations as we do for baby limas. Consequently, all Fordhook seed was produced in the greenhouse at Georgetown and was limited in supply. Several Fordhook lines have produced

high yields over multiple years of testing and seed increase of these lines for more extensive testing is underway.

Potential heat tolerance screening methods were tested in 2012 with assistance from project collaborator Dr. Gordon Johnson and more extensively in 2013 by Emmalea Ernest. Chlorophyll fluorometer based measurements of photosystem II efficiency Y(II) taken in the field under heat stress conditions were found to be higher in varieties with observed or reported heat tolerance. This trend was consistent across readings taken on eight different days over a two month period. We plan to use the chlorophyll fluorometer as a heat stress screening tool in future heat tolerance breeding and genetics work. Stomatal conductance was trialed as a screening tool in 2012 but was found to be too time consuming for the large scale screening that is necessary in the breeding program. In 2013, the amount of pollen shed onto stigma and style of flowers produced under heat stress conditions was found to be higher in varieties with observed or reported heat tolerance. This possible physiological mechanism for heat stress tolerance/susceptibility will be investigated as a part of future research. Use of pollen counts as a heat tolerance screening method is planned as we work to expedite and automate the data collection process using a microscope camera and computer software for counting pollen grains.

Insect feeding studies conducted with green and brown stink bugs and Mexican been beetle corroborated findings of other researchers in suggesting that high levels of cyanogenic glycosides in lima bean leaves and pods deter insect feeding on pods and leaves. We found that the level of cyanogenic glycosides in lima bean plant tissues vary with age, as well as with genotype. There is also differential expression between the different plant tissues, i.e. a plant with high cyanide leaves may have low cyanide seed and vice versa. However, consistent glycoside levels were observed across a genotype if sampling was done at the same stage of physiological maturity. Varieties, such as Dr. Martin, that have been observed to be more susceptible to feeding by insects (spider mite, stink bug and Mexican bean beetle) had consistently lower levels of cyanogenic glycosides produced in the leaves. Insect feeding studies were done in collaboration with Joanne Whalen.

Goals and Outcomes Achieved: One goal of the project was to develop methods by which we can screen lima bean germplasm for heat tolerance, as heat stress is yield limiting in both baby and Fordhook limas. Two nondestructive indirect methods of screening for heat tolerance were used successfully in 2013 field trials to evaluate diverse germplasm under heat stress conditions: quantifying pollen shed on to stigma and style of plants growing in high temperature conditions and use of a chlorophyll fluorometer to measure efficiency of photosystem II, Y(II). Using these techniques we identified seven lines that have demonstrated heat stress tolerance (ability to set pods under high night temperature conditions). In the future, populations derived from crosses with these seven lines will be used for heat tolerance breeding and for investigation of the genetic basis for heat tolerance in lima bean.

Another goal of this project is to investigate the apparent relationship between the quantity of cyanogenic glycosides (cyanide-producing compounds) in lima bean leaves and pods and insect resistance/susceptibility. In insect feeding studies we observed slower growth and/or death of stink bugs nymphs fed lima pods with high levels of cyanogenic glycosides. Mexican bean beetles raised on high cyanide lima leaves were smaller as adults. The connection between cyanogenic glycosides and insect resistance in lima bean has recently been studied in depth by Dr. Daniel Ballhorn at Portland State University, and his research presents good evidence for a insect deterrent effect of cyanogenic glycosides in lima bean.

Related to the above goal, we planned to conduct genetic studies on the inheritance of cyanogenic glycoside production. We are currently developing populations of recombinant inbred lines (RILs) that will help to answer questions about the genetic basis for cyanogenesis in lima beans, but we have not completed this objective. Work during the project focused on identifying lima bean lines that produced high and low levels of cyanogenic glycosides in various plant tissues (so that these could be used as parents of populations for study) and refining sampling and testing techniques to reduce variability and experimental error.

The final goal of the project was to identify baby and Fordhook lima bean lines developed by the breeding program that are consistently high yielding and can be released for commercial production. Over the course of the project baby lima bean breeding lines were trialed under irrigated and un-irrigated conditions, at various times during the season resulting in exposure to high and low levels of heat stress, and in various locations, soil types and management regimes. Several line have been tested for multiple years and show consistent high yields: DE0505002A, DE0407905, and DE0407907. Two of these varieties are being considered for release. There are a number of newer baby lima breeding lines that have not been tested as extensively as the aforementioned three, but have had even higher yields in recent trials. Fordhook breeding lines were tested each year of the project at the Georgetown research farm. One line was among the highest yielding in all years of the project, DE0600605C. Another newer line, DE0700904 has also been high yielding in multiple trials. Neither of these lines have green seed, as desired by processors, but they have been used extensively in crosses to develop new breeding lines. Some green seeded lines have also performed well in multiple years (DE0804404C and DE0701301A) but are newer and have not been tested as extensively. After testing in 2014 some of the high-yielding green-seeded lines will be considered for release.

Results from the heat tolerance and cultivar improvement aspects of this project were presented to horticultural scientists on July 25, 2013 by Gordon Johnson in a talk titled “Improving Lima Bean Productivity in the Mid-Atlantic Region” during the American Society for Horticultural Science Annual Meeting.

The heat tolerance work done as a part of this project was the subject of an oral presentation given by Emmalea Ernest titled “Identifying Heat Tolerant Lima Bean (*Phaseolus lunatus*) Germplasm and Development of Heat Tolerance Field Screening Techniques” which was presented at the 2013 Bean Improvement Cooperative (BIC) meeting in Portland, Oregon, October 27-30, 2013 to an audience of approximately 150 bean breeders and geneticists. A report on the project will be published as a part of the meeting’s proceedings in the 2014 BIC Annual Report.

Results from the heat tolerance part of the project were presented by Emmalea Ernest to approximately 40 regional extension agents and specialists during the Mid-Atlantic Vegetable Workers Conference on November 6, 2013.

Results from the heat tolerance and cultivar improvement aspects of the project were presented by Emmalea Ernest to approximately 60 certified crop consultants at the 2013 Mid-Atlantic Crop Management School on November 20, 2013 in a talk titled “Vegetable Legume Production in the Mid-Atlantic”.

Results from the heat tolerance and cultivar improvement aspects of this project were presented by Emmalea Ernest during the Processing Vegetable Session of the Fruit and Vegetable Growers Association of Delaware Annual meeting on January 16, 2013 and on January 15, 2014. This was an audience of about 120 individuals and included farmers, vegetable processor fieldmen, crop consultants and seed company representatives on each occasion.

Results from the heat tolerance and cultivar improvement aspects of this project were presented to lima bean growers, processors and Extension personnel in New York by Gordon Johnson in a talk titled "Getting the most out of your lima bean crop" during the Empire State Producers Expo on January 21, 2014.

I am not sure that we have reached the goal of 1000 scientists and Extension workers receiving information about the results of this study, but I am also not sure that that number was not a typographical error. There are probably about 100 scientists and Extension workers who would find the information generated through this grant useful and I think have done a good job of getting the information to them.

Beneficiaries: The ultimate beneficiaries of this project are the approximately 60 lima bean growers and four lima processing companies in the Mid-Atlantic region. The regional growers and processors are anxious for improved varieties to be released by the UD lima breeding program and, according to a needs assessment survey of lima growers and processors done in December 2012, heat tolerance is their number one priority trait for improvement in lima varieties. This project has enhanced our understanding of heat tolerance in lima bean and given us tools to use as we address the need expressed by farmers. Lima growers and processors from outside of the Mid-Atlantic region are also interested in trialing varieties developed by the UD breeding program.

Work done on heat tolerance screening methods is useful to researchers and breeders working on similar crops. We are collaborating with a common bean (*Phaseolus vulgaris*) breeder (Tim Porch, USDA-ARS) also working on heat tolerance. Similarly, work done on cyanide production and insect resistance is relevant to colleagues breeding dry limas for California production (Paul Gepts' program, UC Davis).

Lessons Learned: Three instruments, a chlorophyll fluorometer, a leaf porometer and an infrared thermometer, were tested as potential tools for assessing heat tolerance of lima bean germplasm in a field setting. Of the three, the chlorophyll fluorometer was the most useful, in terms of ease and speed of screening and consistency of results.

We had difficulty in characterizing cyanogenic glycoside content of different lima bean genotypes because of variability in the different tissues, variability due to age and possible variation because of environmental factors. In 2012 we conducted experiments to help us determine which plant tissues to test and at what age. We saw very little variation between samples taken from different plants at the same tissue and maturity stage. The inheritance of the cyanide production trait may be complicated and was not characterized within the timeframe of this project, although we have been able to make progress toward that goal.

Seed increases for Fordhooks and baby limas in off-site locations are essential since it is not possible to produce large quantities of good quality seed in the field in Delaware due to wet fall conditions. During the course of this project we used several different companies/organizations for seed increase service in various locations. We are satisfied with our current procedure for small scale winter increase of baby lima lines using a company based in Puerto Rico. Larger scale increase of baby lima lines was done by one of the commercial lima seed suppliers during the course of this project, but that option is no longer available and new arrangements will need to be made for future years. We have tried three different locations/collaborators for Fordhook lima bean seed increases and have not yet found a suitable procedure. This is an issue that we continue to work to address.

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Additional Information: Annual lima bean trial reports for baby and Fordhook lima bean lines that were evaluated as a part of this project are archived at http://extension.udel.edu/ag/vegetable-fruit-resources/vegetable-small-fruits-program/variety-trial-results/.

The heat tolerance work done as a part of this project was the subject of an oral presentation titled "Identifying Heat Tolerant Lima Bean (*Phaseolus lunatus*) Germplasm and Development of Heat Tolerance Field Screening Techniques" which was presented at the 2013 Bean Improvement Cooperative meeting in Portland, Oregon, October 27-30, 2013.

Project Title: Laurel Farmer's Auction Market Promotions and Marketing

Project Summary: The Laurel Farmers' Auction Market was created by a group of Delmarva Peninsula farmers in the 1940's. It is known as "The Block" and from July to September operates six days a week selling specialty crops. This project helped to promote specialty crops by allowing us to advertise and to promote the specialty crops by new means such as social media and a new website in order to gain new buyers and sellers for our locally grown specialty produce. Before this it was only locally and verbally advertised and was not changing and growing with the times and we needed to reach more buyers and sellers. We are located in a central area to reach the large cities, such as Philadelphia, Baltimore, Washington, Norfolk and even New York City.

Project Approach: We set up new displays at various functions to promote our specialty crops that are grown in this area and also to advertise the services we provide at the Auction Market.
We had new brochures made up promoting all of our specialty crops and their availability. Also, with the help of a web designer we constructed a new website which includes information about the auction market, policies and procedures. It is a guide for both new buyers and sellers and also keeps current customers abreast of what is happening, what crops are being sold etc..

Goals and Outcomes Achieved: The LFAM had a new website constructed which includes information about the auction market, policies and procedures, a guide for new buyers and sellers, an inventory report can be reported so buyers will know what will be available. A photo gallery to show daily operations and also show prospective buyers the auction system and atmosphere. The computer, monitor and printer was used solely for specialty crop marketing and promotion, including social media and production of marketing collateral such as posters, flyers and brochures.

The new signage and billboard at the market helped promote the market and its specialty crop offerings to passersby and to guide new buyers into and round the facility. New signs were displayed at community events and festivals – such as the Delaware State Fair and the Wicomico County Ag Fair in Maryland, to advertise the specialty crops. Brochures were used to market the specialty crops available to consumers and buyers. All materials and website content did primarily promote specialty Crops.

A new logo was formed also, to incorporate the local specialty crops. This is also used on our website and stationary and display.

Do to this marketing approach this year there was a 20% increase in vendors and an increase of approximately 25% in the buyers. We would like to keep this increase of just over 50 vendors and buyers going by continuing the advertising campaign we have in process now.

The highlight here is that we saw a major increase in both the sellers and the buyers coming the Laurel Farmers Auction Market during the 2013 selling season over the sales of the previous

years. We also continued into September this year, as long as the crops were available and that proved beneficial also.

One goal was to target new buyers and consumers of specialty crops, and we have done that. Our job is not finished it has only begun, we need to increase the number of buyers and sellers year after year.

Beneficiaries: The Capitol Food Bank in the District of Columbia, came to us and was able to provide fresh specialty crops to their clients. The local specialty crop markets benefited with a wide variety of high quality crops. This service which we provide directly, impacted thousands of people in a 100 mile radius, and also the economical impact of this project was approximately two million dollars.

This project was helpful to the specialty markets in this area. It also increased the awareness of the specialty crops we have in this area and help to put more of these foods on family tables.

We did not achieve our goals to the fullest, but believe by exposing more people and families to these specialty products that are grown locally we will continue to see the market grow. The objective for the 2013 was 300 buyers and 300 sellers and $300,000 in sales. However, we did increase sales by 30.25% over 2012 and we had a fall season of specialty crop sales which had never been done before. As the season went on awareness of the market grew, new customers all season.

Lessons Learned: Some of the lessons learned were that to make new changes you need good, loyal employees that are working for the good of the project. You need to cross train the staff so that you can keep the project on track. Changes are hard for people who have done the same thing year after year and don't like change.

It will be a ongoing task to continue to increase the awareness of the specialty crops at the Laurel Farmers Auction Market. We need to be visible on the internet, by billboards, social media, handouts, and most importantly word of mouth of satisfied sellers and buyers.

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