FY 2011 SPECIALTY CROP BLOCK GRANT PROGRAM – FARM BILL
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#1

Research-Based Response to the Invasion of Mid-Atlantic Tree Fruit Orchards by the Brown Marmorated Stink Bug - Final Report

I. Project Summary

Since its initial outbreak in 2010, brown marmorated stink bug (BMSB) has remained the most significant direct pest of tree fruit crops in the Mid-Atlantic region. Although aggressive, insecticide-based intervention by tree fruit growers has at least partially mitigated the economic impacts of BMSB, this approach has been entirely at the expense of Integrated Pest Management (IPM) tactics. In the near term, a return to sustainable pest management in tree fruit systems and the refinement of management recommendations will require information on, 1) the relative effectiveness, optimal timing and application method of registered insecticides against BMSB under field conditions and 2) the development of monitoring tools upon which management decisions can be based. This project was a collaborative effort between Virginia Tech and USDA and leveraged support from other funding sources to investigate management and monitoring tactics for BMSB.

II. Project Approach

Research on aspects of the efficacy of various insecticides and insecticide-based management programs was conducted in experimental orchards in Virginia (Virginia) and West Virginia (USDA), and in commercial apple and peach orchards in Virginia. Standard protocols were used to assess injury from or effects on BMSB and effects on other pests. Specific projects included, 1) alternate-row-middle (7-day intervals) versus complete (14-day intervals) spray applications of single insecticides full season, 2) the effect of an adjuvant on program efficacy, 3) the residual effectiveness of insecticides, and 4) large-scale demonstration trial in commercial apple and peach orchards.

Alternate-row-middle (i.e. spraying one half of each row per application) sprays at 7-day intervals provided numerically, but not statistically lower levels of BMSB at harvest than complete sprays (i.e. spraying both sides of each row) at 14-day intervals. Of the products evaluated, Leverage 360, Baythroid, Danitol, and Venom provided superior control that was significantly better than the untreated checks. These results conform to the outcome of insecticide residual efficacy trials, which showed that the effectiveness of all products tested against BMSB adults diminished within 3 to 7 days following application. The addition of the adjuvant, LI-700, to each spray in a full season program did not affect levels of BMSB injury at harvest. The second year of a three-year demonstration trial in commercial apple and peach orchards in Virginia was completed in 2012. Prescribed programs were compared with "grower standard" programs. In 2012, the prescribed programs involved the use of alternate-row-middle spray applications through most of the season and inclusion of two products that received Section 18 Emergency Exemptions targeting BMSB, dinotefuran and bifenthrin. Across the apple blocks, mean injury at harvest was 5.5 ± 0.5% and 9.1 ± 3.5 SE % (not statistically different) in the prescribed and standard programs, respectively. Among the peach blocks, mean injury at harvest was identical between the prescribed and standard blocks, at 0.1 ± 0.1 SE %. In 2012, BMSB injury levels were likely affected by relatively low populations at the start of the season, although populations rebounded substantially during the growing season and very high numbers of overwintering adults were detected in fall 2012.

Collaborative research on the development of a pheromone-based trap for monitoring BMSB was conducted in commercial orchards in Virginia, West Virginia, and several other states. In Virginia and West Virginia, black pyramid traps were deployed at the edge of woodlands bordering commercial tree fruit orchards. This trial evaluated and compared early-season and season-long attractiveness of a newly-identified BMSB pheromone (#10 lure), a commercially available BMSB lure that does not contain the specific BMSB pheromone, and un-baited traps. Captures were recorded weekly, revealing that BMSB were trapped season-long in traps baited with the newly-identified BMSB pheromone, although captures

were very low during early- and mid- season, and did not reflect local population densities. The commercial lure, which contained the compound methyl (2E, 4E, 6Z)-decatrieonate, was very attractive to adult BMSB in the latter part of the growing season. A trial comparing the effect of pheromone concentration on captures revealed that traps baited with #10 lures containing 10 mg of pheromone captured ~11x more BMSB adults than un-baited traps and that when the pheromone loading was increased to 100 mg per lure, a ~25-fold increase in captures was recorded, compared with un-baited traps. Based on the results of trapping studies and homeowner reports, overwintering BMSB populations in 2012 are at least 60% higher than in 2011, indicating that growers will need to be extremely vigilant in 2013.

In West Virginia, the effectiveness of black pyramid traps containing promising light-based stimuli for BMSB was evaluated in the field. Three treatments included white, black (ultraviolet), and blue fluorescent light sources. Season-long captures revealed that significantly greater numbers of BMSB were captured in traps provisioned with a white bulb, although significantly greater numbers of non-target insects (e.g. moths, wasps, flies, and beetles) were also captured compared with the others. Traps provisioned with a blue bulb captured fewer BMSB than those with while light, and fewer non-target insects. Traps provisioned with an ultraviolet (black) bulb captured the fewest numbers of BMSB. Despite differences in total numbers of BMSB captured, seasonal capture patterns were identical among traps baited with each light source.

III. Goals and Outcomes Achieved

Overall, the results of our insecticide studies have significantly advanced our ability to refine management recommendations for BMSB in commercial tree fruit orchards. Demonstration of the relative effectiveness of alternate-row-middle spray applications, using a systematic approach and standardized methods, lends confidence to a tactic that many growers had voluntarily adopted and that conforms well to their routine practices. As well, our comparative demonstration of the relative performance of specific products provides support for recommendations on insecticide selection and timing within the season. However, data from other studies highlight the on-going challenges with respect to BMSB management. In particular, the short residual activity of all products tested reveals the difficulties associated with controlling BMSB. As well, it has become apparent that most of the most effective products against BMSB are in chemical classes known to have a broad spectrum of insecticidal activity and are therefore likely to be highly toxic to the biological control agents of some secondary pests in tree fruit orchards. Although reports from growers in Virginia and West Virginia near the end of the 2012 growing season indicated that spider mites and San Jose scale were not widely problematic, the insecticide programs used to control BMSB incited outbreaks populations of woolly apple aphid in some apple orchards.

While data from large-scale demonstration trials has revealed that injury from BMSB can be reduced, the insecticide programs required are not considered sustainable in the long-term and will need further refinement in conjunction with the information from new monitoring tools.
Studies assessing and comparing the attractiveness of commercial and experimental BMSB pheromone lures demonstrated that while the #10 lure showed promise for season-long BMSB monitoring, further refinements will be needed to improve the relationship between captures in traps and BMSB presence and abundance. The increased response of BMSB to higher concentrations of the compounds in the #10 lure provide guidance for further research on optimizing this monitoring tactic. Demonstration of the utility of light-based traps provides additional incentive to pursue this approach further. Construction costs per trap (~$50.00) were vastly lower than for standard, commercial blacklight traps ($2,500 each). Dr. Leskey is working with an engineering firm to build a prototype solar trap that will be evaluated in 2013. Ultimately, the use of optimally attractive olfactory (i.e. pheromone) and visual (i.e. light) stimuli alone or in combination in traps is expected to greatly improve our ability to relate BMSB captures to their presence and abundance, which in turn will tremendously enhance the ability of growers to respond with timely and appropriate intervention.

IV. Beneficiaries

During the performance period, formal presentations and informal discussions that included information derived from the research projects supported in part by this award were delivered to stakeholders at the following meetings:

Virginia/West Virginia Horticultural Society Annual Meeting, January 24-26, 2012, Richmond, VA

Winter Fruit Schools for Commercial Tree Fruit Growers, February 13-17, 2012 and February 11-15, 2013 (5 consecutive meetings that spanned the major tree fruit production counties in Virginia and that included growers from West Virginia and Maryland at the Frederick Co., VA meeting)

In-season, on-farm extension meetings for tree fruit producers held at locations in northern and central Virginia between April and August

USDA NIFA BMSB SCRI Stakeholder Advisory Panel Meeting, November 27, 2012, Kearneysville, WV

V. Lessons Learned

Significant improvements in pheromone-based monitoring of BMSB have provided a foundation for addressing several critical questions that will further advance our ability to interpret trapping data. USDA ARS scientists have shown that another compound, currently coded as “A”, synergizes BMSB response to the #10 pheromone. The #10 + A combination is the most sensitive BMSB monitoring tool identified to date and can be used to examine; 1) how quickly adult BMSB emerging from overwintering sites respond to baited traps, 2) the effect of trap location and adjacent habitat on captures, and 3) the relationship between captures and fruit injury. In combination, this information is expected to guide the further development of trap-based monitoring protocols and to influence management recommendations importantly. However, until further information on the aforementioned questions is available, we cannot recommend that growers expend time and resources on BMSB monitoring. Light-based trapping of BMSB, either alone or in combination with the pheromone, shows much promise as another BMSB monitoring tool, but requires additional research. Based on our first two field seasons of research, results from management trials in small-plot and on-farm studies suggest that maintaining acceptable control of injury from BMSB at harvest may be more readily achieved in some crops and cultivars than others, given the currently registered insecticides and access to some products (i.e. dinotefuran and bifenthrin) via Section 18 Emergency Exemptions. In general, managing BMSB injury in stone fruits (e.g. peaches and cherries) may prove to be easier than in mid- and late-season apple and pear varieties, since the period of risk is considerably shorter and given that post-bloom use of broad-spectrum chemistries in stone fruit is generally considered less problematic with respect to secondary pest outbreaks than in pome fruit. The high populations of BMSB that can build during the growing season pose a significant threat to pome fruit cultivars that are harvested in mid- to late-season. Our research has shown that some of the strongest products against BMSB are those that have not traditionally been recommended for use in the post-bloom period in apples and pears (e.g. pyrethroids). However, where heavy

BMSB pressure occurs in August and September, growers will likely need to consider some use of these products, with associated risk of secondary pest outbreaks during or following the season in which they are applied. These control measures are not considered sustainable in the long term, but are a stop-gap until additional management tools and tactics are developed and validated.

VI. Additional Information

Bergh, J.C. and T.C. Leskey. 2012. Latest update on BMSB. Virginia/West Virginia Horticultural Society Annual Meeting, January 24-26, Richmond, VA

Bergh, J.C. 2012. BMSB update. Winter Fruit Schools for Commercial Tree Fruit Growers, February 13-17, 5 locations in Virginia

Bergh, J.C. and S.V. Joseph. 2012. Prescribed versus grower standard programs targeting BMSB in commercial apple and peach orchards in Virginia. Entomological Society of America, Eastern Branch Annual Meeting, March 16-19, Hartford, CT

Bergh, J.C., S.V. Joseph, T.C. Leskey, D. Polk, G. Krawczyk, B. Butler, and S. Wright. 2012. Distribution of BMSB injury within Mid-Atlantic apple orchards. Entomological Society of America Annual Meeting, November 11-14, Knoxville, TN

Bergh, J.C. 2012. The impact of BMSB on orchard crops. Stakeholder Advisory Panel Meeting, November 27, Kearneysville, WV

Bergh, J.C. 2012. The impact of BMSB on IPM in orchards. Stakeholder Advisory Panel Meeting, November 27, Kearneysville, WV

Bergh, J.C. 2012. Brown marmorated stink bug management trials in Virginia, 2012. Cumberland-Shenandoah Fruit Workers Conference, November 29-30, Winchester, VA

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#2 Final Report
Sustainable Nitrogen Management for Fresh Market Tomato Production.

I. Project Summary

Tomato production systems drastically changed in recent years by the additions of plastic mulch, drip irrigation, cover crops, and hybrid varieties that have resulted in substantial yield increases. Therefore, current fertilizer needs are different than traditional bare-ground and processing tomato systems that are currently recommended. We estimated that recommended fertilizer rates at the start of this project were nearly half of what farmers needed to apply for optimal yields in Virginia for fresh market tomatoes grown using polyethylene mulch systems. This project was initially funded during the 2008 Specialty Crop Block Grant Program funding cycle. The tomato application methods and rates were successfully implemented during the 2009 and 2010 growing season; however, record high temperatures in 2010 impeded crop growth and data was marginal. Although we did garnish valuable data in both years (soil, plant tissue, and yield), we continued this project for a third year to ensure Virginia producers that new Extension nitrogen fertilizer recommendations are based on sound scientific data. The final year was used to finish laboratory analysis of soil and plant samples, run statistical analysis, and to write publications based on data from both grants based on three year field seasons.

II. Project Approach

Research was conducted at the Virginia Tech Eastern Shore Agricultural Research and Extension Center in Painter, VA on sandy loam soils; which is the predominant soil series for Vegetable production in Virginia. Faculty (Dr. Mark Reiter), staff (Mr. Tommy Custis), and graduate students (Dr. Catherine Fleming) were the main project partners that maintained plots, collected data, conducted laboratory work, analyzed data, wrote project reports, and presented data to stakeholders.

The project was established as a factorial arrangement of two nitrogen application practices and five nitrogen rates replicated four times. One application practice included 50% of the fertilizer incorporated into soil under the plastic mulch and the remaining 50% applied via fertigation. The second practice had 30% of the nitrogen soil incorporated, 20% placed in a band on top of the bed, and remaining 50% applied via fertigation. Both practices were applied at 0, 100, 200, 300, and 400 pounds of total nitrogen per acre. Plant tissue, petiole nitrate, NDVI, and yield were used to determine nitrogen uptake and fertilizer use efficiency. Suction cup lysimeters and incremental soil sampling were used to test groundwater nitrate concentrations below the tomato root zone. Lysimeter soil water readings were collected twice per week (Tuesday and Friday). Soil samples were collected from 0-6, 6-12, and 12-18 inch depths after last harvest and air dried. All data was analyzed using SAS software and either regressed against nitrogen rates or means were separated using least significant difference tests at alpha = 0.10.

A comprehensive introduction, materials and methods section, discussion of results, and data tables were included as chapter 3 in Dr. Catherine Fleming's dissertation at Virginia Tech (graduated May 2013) and is attached. General conclusions from yield indicated that Virginia N fertilizer recommendations for polyethylene mulched fresh market tomatoes should be updated to allow 178 to 216 lbs. N/acre. Of this total amount, 89-108 lbs. N/acre should be applied using the banded application method at application of polyethylene mulch and 89-108 lbs. N/acre should be applied using fertigation; which provides highest yields and reduces potential for plant injury.

These N rates using the banded method provide acceptable fertilizer recovery, ample petiole sap nitrate-N, and reduce residual inorganic soil N, compared to higher N rates and the incorporated method.

This project was discussed considerably with stakeholders throughout Virginia at 9 different training workshops/schools with 323 total in attendance. All of these trainings and schools were targeted to Virginia Cooperative Extension Agents, Soil and Water Conservation District Personnel, and USDA-Natural Resources Conservation Personnel. Therefore, information was given to the stakeholders charged with assisting homeowners and farmers with production decisions for improving yield, quality, and environmental integrity. Through the agency outlets, project information is available to any farmer desiring to view project outcomes. Additionally, project data was presented to 905 farmers, agency personnel, and other stakeholders via 11 farm production meetings and conferences that target producers directly.

III. Goals and Outcomes Achieved

To achieve the performance goals of this project, specific activities performed are summarized in the project approach section. Overall, our main goal was successfully met for this project during the granting period.

GOAL: The goal of this research is to define a sustainable comprehensive nitrogen management program for commercial fresh market tomato production; which will increase fertilizer efficiency and reduce overall nutrient loads into sensitive waterways. Specifically:

1. *Evaluate various fresh market tomato nitrogen fertilizer placement methods.*
2. *Evaluate different fresh market tomato nitrogen fertilizer nitrogen rates.*

We now have defined nitrogen recommendations for high-yielding fresh market tomatoes grown on polyethylene mulch in Virginia. The new nitrogen recommendations have been incorporated into official Virginia Cooperative Extension/Virginia Tech nutrient management guidelines for use by producers, regulators, and other interested stakeholders. We have increased the total nitrogen fertilizer recommendation by two-fold to ensure maximum yields by tomato farmers (60,000+ lbs. marketable fruit per acre). We now also recommend banded applications for initial nitrogen applications when polyethylene mulch is established to ensure optimal yields and to reduce risk of salt injury to transplants. Using these two approaches, we did not show increased nitrate risk to groundwater as compared to traditional fertilizer methodologies.

IV. Beneficiaries

Beneficiaries of this project include fresh market tomato producers in Virginia that utilize polyethylene mulch production systems, as well as tomato consumers on the east coast U.S.A. Tomato producers benefit by having updated Virginia Cooperative Extension/Virginia Tech fertility recommendations that are used for their own production systems, by consultants that assist with their production, and by potential regulators in Richmond/Washington D.C. As environmental concerns increase in the sensitive Chesapeake Bay watershed, farmers are under increasing scrutiny and regulators are consistently taking aim at farmers in Virginia. Having updated fertility recommendations that provide optimal yields, reduced environmental losses, and maximum economic benefit will benefit all producers in the area. Having optimal yields is also beneficial as this equates to a greater supply of product; which means more possible domestic

consumption for the target Northeast U.S.A. market. Domestic food sources are important, especially with fresh produce, as the tomatoes are grown using domestic production practices, food safety considerations, and so forth.

All tomato producers (representing 5,000+ acres per year) that utilize Virginia Cooperative Extension fertilizer recommendations will benefit from this project since we are using this data to update our *Commercial Vegetable Production Recommendations* publication. These Extension recommendations are also utilized by regulatory agencies for construction of nutrient management plans.

V. Lessons Learned

Overall, the project proceeded as expected during these two budget years. The prior grant did experience bad weather (a very hot and dry summer 2010) that negatively impacted yields. However, the growing season for this grant had acceptable yields. The graduate student supported by this proposal was able to finish analysis of all data as expected, wrote data findings into her dissertation, and graduated timely. All data was communicated to interested and pertinent stakeholders timely and has been incorporated into the proper Extension recommendations and publications.

VI. Additional Information

Data from this project has been incorporated into the *Virginia Commercial Vegetable Production Recommendations – 2013* that can be found at: http://pubs.ext.vt.edu/456/456-420/456-420.html. This guide is used by all Virginia Cooperative Extension agents, Specialists, consultants, and farmers growing commercial vegetables in Virginia. Also, we used our research data to validate information in the *Southeastern U.S. Vegetable Crop Handbook* that is co-authored by Virginia Extension Specialists and also used by farmers and consultants around the commonwealth. The Southeastern Guide can be found at: http://www.thegrower.com/south-east-vegetable-guide/. The full data chapter that contains a literature review, introduction, materials and methods section, results, discussion, data tables, and final recommendations can be found in Chapter 3 of Dr. Catherine Flemings dissertation at Virginia Tech at: http://vtechworks.lib.vt.edu/handle/10919/19292. A few photos follow:

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#3 Final Report
Year-round sustainable approach to weed control, nutrient uptake, and water management for nursery production

I. Project Summary

As a result of increasing financial and environmental impact, reduction in herbicide use has been a research focus. Container nurseries make from 2 to 6 applications of herbicide per growing season. It is estimated there are 12,000 acres of nursery production in VA, and 59% are in container production (Va. Ag. Statistics Service, 2003). This translates to approximately 150,000 pounds of synthetic herbicide applied annually in container production alone. Many nurserymen live on the property they farm, thus herbicide runoff and drinking water pollution is a concern.

The typical nursery grower applies 0.25 to 5 inches of water per day throughout the growing season, which translates to over 100,000 gallons per acre per day for Virginia nurseries. Conservation of potable water is a priority for EPA, as well as many land owners. The majority of nurseries are in urban areas; ever increasing urban sprawl is taxing water resources. Legislative action limiting the amount of water that can be pumped from wells or from potable sources is a concern to container nurseries. This has already occurred in Florida, where water permits have been reduced by 40% from 12 years ago (Beeson et al. 2004). The nursery industry anticipates increased water rates, as well as volume reductions. Creating a mulch layer as the cover crop decays, will reduce pot evaporations, and decrease irrigation needs.

Typical fertilizer application in nursery is 150 pounds of nitrogen and 100 pounds of phosphorous per acre per year. Based on total container acreage in Virginia; approximately 1 million pounds of N and over 700,000 pounds of P is applied annually. Assuming nitrogen and phosphorus uptake efficiency is 50% and 40% respectfully (Niemiera et al., 1994; Owens et al., 2008), annual container nutrient losses are estimated at 500,000 pounds of nitrogen and 280,000 pounds of phosphorous. Cover crops act as a “catch crop” by reducing nutrient leaching from the soil profile.

Through this research we documented decreases in herbicide and nutrient leaching in growing media through the use of cover crops. Cover crops suppressed weed establishment, which would results in a decreased need for herbicide application. Weed density decreased as cover crop seeding rate increased. Nursery crop growth was equivalent or greater in select cover crops compared to the standard herbicide program. Use of cover crops will lead to reduced need for fertilizer and herbicide application, as well as reducing offsite movement of these chemicals into waterways.

II. Project Approach

Activities completed for the ‘grow-your-own mulch’ system include cover crop evaluation for weed control, water evaporation, plant injury, nutrient and herbicide leaching potential for both mulched and non-mulched container grown ornamentals. Original cover crop seeding rates of 200 and 400 lb/A were found to be insufficient for weed control (Table 1). Seeding rates were changed to 800, 1,600, and 3,200 lb/A for winter wheat, triticale, cereal rye and annual ryegrass. Austrian winter pea seeding rate was changed to 3,200, 6,400, and 12,800 lb/A. The sudex hybrid was quite injurious to coreopsis and hydrangea, so this cover crop was left out in Spring/Summer of 2012 and 2013.

Cover crops were allowed to grow to a height of 3-4 inch, or 10-15 days, then selectively killed with sethoxydim (Poast Plus at 1.5 pt/A) or clopyralid (Lontrel at 2/3 pt/A). Winter wheat and Austrian winter pea did not germinate at the same time; these seeds continued to germinate over a period of approximately 1 month, thus another application of herbicide was needed.

Reduced number of herbicide application was noted in both hydrangea and coreopsis species for up to 5 months after for seeding rates of 800, 1600, and 3200 lbs/A under greenhouse conditions; likewise, cover crops afforded good weed control for up to 3 months for nursery plants grown outside on a container pad during the summer months.

Water evaporation was measured for mulched and non-mulched containers for all cover crops. Containers were thoroughly irrigated, until container capacity was reached. Container weight was then

recorded over time; 2, 4, 6, 8, 12, and 24 hours after irrigation. Water evaporation from the pot was drastically reduced for all cover crop 5 weeks after killing the cover crop.

Nutrient and herbicide losses were evaluated for annual ryegrass. Soil columns were used to determine herbicide movement under mulched (seeded at 3200 lb/A) and non-mulched systems. Eight soil columns were packed with pine bark; four were seeded with ryegrass (mulched) and four not seeded (non-mulched). After mulched reached 3 inches, all columns (mulched and non-mulched) were treated with sethoxydim (1.5 pt/A). After 5 days, 3.0 lb/A pendimethalin (3.3EC) was applied to all columns. Next, irrigation was simulated at one inch of water per day for seven days. Pine bark was extracted from each column in the following depths from the surface: 0-3 cm, 3-6 cm, 6-9 cm, 9-12 cm, 12-18 cm and 18-24. A crabgrass bioassay determined herbicide leaching. Pendimethalin movement was greater in the non-mulched system.

The pour through extraction method was used to gauge nutrient leaching potential in 1 gallon containers seeded with annual ryegrass at 800, 1600, and 3200 lb/A. Coreopsis 'Early Sunrise' plugs were planted in all pots, with three pots per treatment and four replications. Immediately following planting, all containers received 1 tsp Osmocote Professional fertilizer per 1 gal container. Four weeks later annual ryegrass was seeded. After mulch height reached 3 inches sethoxydim was applied to all containers. One week after sethoxydim application, container pour through extraction was conducted. The pour through method is an estimation of plant available nutrients in the container. All containers were irrigated to container capacity, and allowed to drain for 2 hrs. Next, 300 ml of irrigation was applied displacing approximately 40 ml of container water, which was analyzed using the Exact Eco-Check spectrophotometer (Industrial Test Systems, Inc.). A 4 ml aliquot was used to determine nutrient concentrations in ppm, for each treatment and untreated control (non-mulched). Each treatment consisted of three containers and four replications. Electrical conductivity and pH was measured using Hannah Combo meter (Hannah Instruments, Inc.). Ammonia, samples were diluted by 50%, due to the range limit of the spectrophotometer (0.01-2.4 ppm).

All data was subject to Statistical Analysis Software (SAS) to generate means, and Fisher's LSD, based on $P<0.05$. Student's T-test was performed with Excel (MS Office 2010).

III. Goals and Outcomes Achieved

Goal #1: Reduce the number of herbicide application by at least 25%. Results indicate the grow-your-own mulch system provided good weed control in greenhouse conditions for up to 5 months, and good control for outdoor production for up to 3 months; this program will reduce yearly herbicide applications by 25-30% annually. Based on an average of 4 herbicide applications/year at $679.50/application/ha, this grow-your-own mulch system will save the grower between $680-$816/ha in herbicide costs annually. Growth index was not significantly different up to 16 WAT, during the peak growing season for coreopsis 'Zagreb' (Table 2) or hydrangea 'Pink Shira' (Table 4) for seeding rates of 800, 1600, and 3200 lb/A (Table 3&5). Winter wheat and annual ryegrass displayed fair control of crabgrass and groundsel 12 weeks after killing the cover crop (Table 6 and 7).

Table 1a. Mean number of weeds per pot 4 WAT.

	mean #weeds/pot	
Treatment	Spotted spurge	Eclipta
Winter wheat		
200 lb/A	5.88	1.79
400 lb/A	4.04	1.75
800 lb/A	4.29	1.29
1600 lb/A	1.25	0.21

Winter pea		
200 lb/A	8.25	0.00
400 lb/A	8.58	0.00
800 lb/A	10.83	0.00
1600 lb/A	3.50	0.00
Tritical		
200 lb/A	5.17	1.50
400 lb/A	5.92	1.33
800 lb/A	6.25	1.25
1600 lb/A	5.33	0.50
No Co/No Herb	10.58	4.17
No Cover + herb.	2.25	1.17
LSD	0.85	1.11

Table 1b. Mean number of weeds as affected by cover crop seeding rate, averaged across all cover crops.

treatment	Spotted spurge	Eclipta
200 lb/A	6.29	1.27
400 lb/A	5.06	1.18
800 lb/A	6.42	0.96
1600 lb/A	2.83	0.23
No Co/No Herb	10.58	4.17
No Cover + herb.	2.25	1.17

Table 2. Coreopsis 'Zagreb' growth index as influenced by cover crop.

	mean growth index (in.)			
cover crop	4WAT	8WAT	12 WAT	16WAT
winter pea	7.15	8.82	9.96	10.45
annual ryegrass	6.91	8.86	10.16	10.80
cereal ryegrass	7.26	9.16	10.34	11.01
triticale	7.47	9.42	10.68	11.35
winter wheat	7.07	8.53	9.47	9.96
no cover/no herb	7.10	8.32	9.02	9.52
no cover + herb	6.83	8.23	9.02	9.60

LSD	0.67	0.66	0.80	0.85

Table 3. Coreopsis ‘Zagreb’ growth index as influenced by cover crop seeding rate.

Seeding rate lb/A	mean growth index (in.)			
	4WAT	8WAT	12WAT	16WAT
0	6.97	8.28	9.02	9.56
800	7.33	9.00	10.03	10.65
1600	7.20	9.06	10.28	10.88
3200	7.23	9.10	10.35	10.95
6400	6.81	8.58	9.81	10.31
12800	6.27	8.11	9.29	9.92
LSD	0.67	0.66	0.80	0.85

Table 4. Hydrangea ’Pink Shira’ growth index as influenced by cover crop.

		mean growth index (in.)			
cover crop	2WAT	4WAT	8WAT	12WAT	16WAT
winter pea	3.13	4.49	7.22	10.01	11.85
annual ryegrass	3.56	4.60	7.33	10.08	11.74
cereal ryegrass	3.62	4.76	7.55	10.31	12.01
triticale	3.31	4.51	7.32	10.14	12.31
winter wheat	3.79	5.14	8.04	10.76	12.26
no cover/no herb	3.71	5.17	8.17	11.18	12.88
no cover + herb	4.27	5.15	7.97	10.80	11.79
LSD	0.43	0.66	0.84	0.89	0.99

Table 5. Hydrangea ‘Pink Shira’ Growth index as influenced by seeding rate

Seeding rate lb/A	mean growth index (in.)				
	2WAT	4WAT	8WAT	12WAT	16WAT

0	3.99	5.16	8.07	10.99	12.33
800	3.69	4.92	7.83	10.86	12.54
1600	3.45	4.73	7.53	10.35	12.27
3200	3.42	4.57	7.24	9.88	11.42
6400	3.31	4.73	7.57	10.45	12.33
12800	3.21	4.44	7.15	10.03	11.85
LSD	0.43	0.67	0.85	0.89	1.0

Table 6. Mean percent cover 4, 6, and 12 WAT for crabgrass and groundsel after killing cover crop.

	mean % cover					
	4WAT		6WAT		12WAT	
cover crop	crabgrass	groundsel	crabgrass	groundsel	crabgrass	groundsel
winter pea	15.4	0.0	100	0.1	100	0.3
annual ryegrass	12.1	0.0	70.4	0.0	78.6	0.0
cereal ryegrass	30.6	0.8	95.4	3.0	93.7	3.3
triticale	41.3	0.1	92.2	0.7	94.2	1.1
winter wheat	14.9	0.0	43.9	0.3	51.0	0.3
no cover/no herb	13.3	3.6	89.6	7.9	90.8	9.2
no cover + herb	8.5	0.8	33.8	2.5	40.4	5.4
LSD	10.4	0.8*	7.2	4.4	7.5	2.3

*denotes not significant, p >0.05

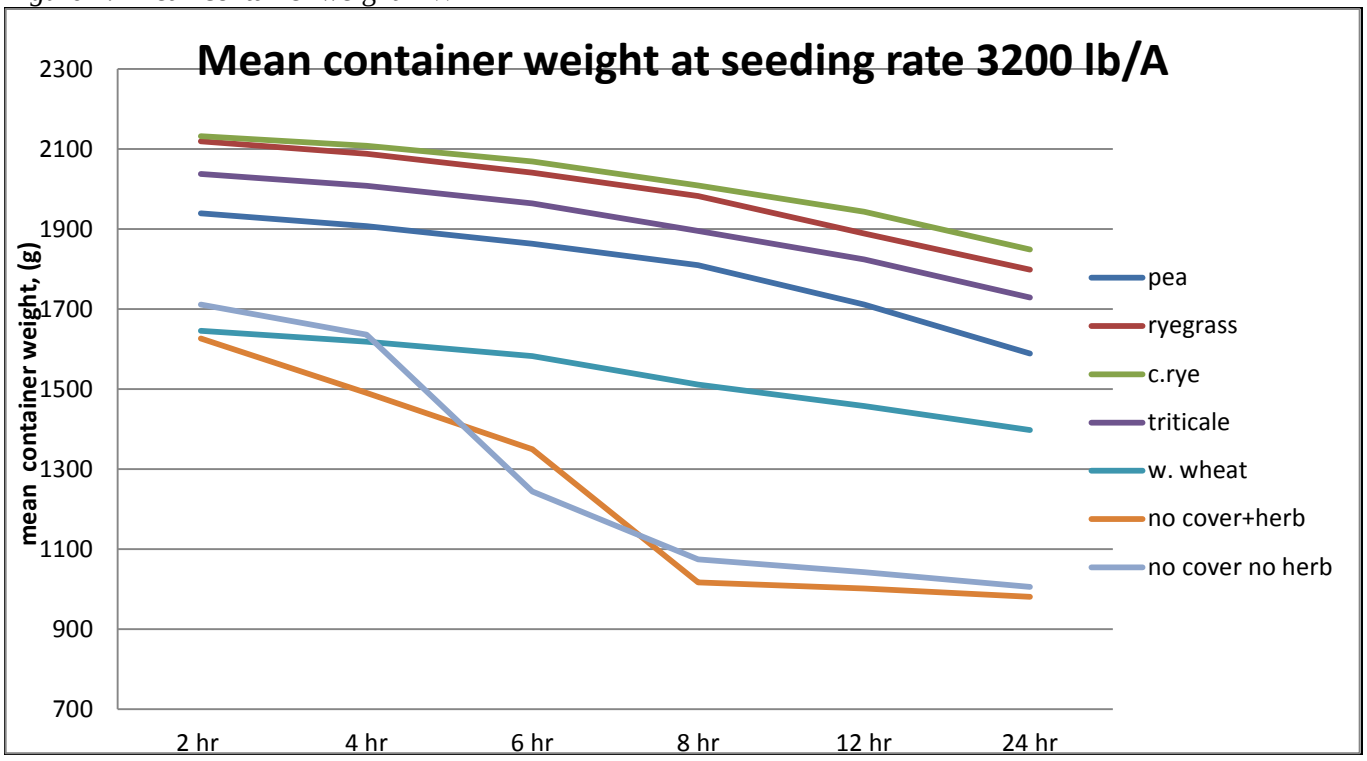
Table 7. Mean percent cover of crabgrass and groundsel as influenced by seeding rate.

Seeding rate lb/A	mean % cover					
	4WAT		6WAT		12WAT	
	crabgrass	groundsel	crabgrass	groundsel	crabgrass	groundsel
800	35.5	0.5	85.3	1.8	88.8	2.7

1600	18.1	0.1	75.5	0.2	80.2	0.2
3200	19.8	0.1	71.9	2.1	74.8	0.6
herbicide	8.5	0.8	33.8	2.5	40.4	5.4
control	13.3	3.4	89.6	7.9	90.8	9.2
LSD	11.8	1.0	8.2	5.0	8.5	2.6

Goal# 2: Reduce irrigation usage by 20%. Grow your-own-mulch system greatly reduced irrigation needs over a 24 hours period (Figure 1) for all cover crops over all seeding rates, at 3200 lb/A seeding rate. Winter wheat and cereal rye covers at 3200 lb/A reduced water loss by 40%, and 85%, 4 WAT during the month of June, 2012. The non-mulched treatments were at wilting point after 24 hours.

Figure 1. Mean container weight 4 WAT



Goal #3: To reduce nutrient and herbicide leaching from container media.

Nutrient leachate was evaluated for coreopsis seeded with annual ryegrass at 800, 1600, and 3200 lb/A as well an untreated/non-mulched control. Nitrite (NO2-N), ammonia (NH4-N), nitrate (N2O-N), calcium carbonate (CaCO3), phosphate (PO4), and copper (Cu+2) was determined by the pour-thru extraction procedure mentioned earlier. No significant differences were found between mulched and non-mulched containers for nitrite, calcium carbonate, phosphate, or copper. Nitrate concentrations in effluent were significantly less in mulched

compared to non-mulched. Similar results were noted for ammonia; concentrations for all seeding rates were significantly less than non-mulched control. As the seeding rate increased, NH4-N leaching decreased. At the highest seeding rate, 3200 lb/A, nitrate and ammonia concentrations were reduced in leachate by approximately 50% compared to the non-mulched control.

Soil leaching columns were used to measure pendimethalin movement for annual ryegrass seeded at 3200 lb/A. Pendimethalin leaching was greater in on-mulched compared to mulched plots. Pendimethalin leached through the 6-9 cm and 3-6 cm depth in the non-mulched and mulched treatments, respectively, based on crabgrass root length and root weight. Herbicide movement was decreased by 33% for the grow-your-own mulch system.

Table 8. Movement of pendimethalin (3.3 EC) in mulched and non-mulched pine bark as indicated by a large crabgrass bioassay. Mulched columns were seeded at 3200 lb/A annual ryegrass.

	Root weight[a]		Root length[b]	
Depth from surface	Non-mulched[c]	Mulched	Non-mulched	Mulched
cm	% of untreated large crabgrass			
0-3	5[c]	8[c]	10[c]	8[c]
3-6	22[c]	55[c]	40[c]	71[c]
6-9	59[c]	99	67[c]	115
9-12	113	109	102	94
12-18	100	116	100	105
18-24	98	111	89	103
LSD	23		27	

[a]Mean untreated root weight 0.37g.

[b]Mean untreated root length 11.6 cm.

[c]Significantly less than untreated based on student's t-test (p = 0.05).

Table 9. Mean nutrient concentrations determined by pour through extraction method for 1 gallon container seeded with ryegrass at 800, 1600, and 3200 lb/A, 4 weeks after seeding mulch.

	mean concentration in leachate[a]		
seeding rate	EC	NO3-N	NH4-N
lb/A	mS/cm	ppm	ppm
800	2.2	16.7	3.2
1600	1.6	13.0	2.5
3200	1.1	10.5	1.9
control	2.5	20.2	4.1
LSD	0.5	3.4	0.8

[a]pH values ranged from 4.7-5.9

IV. Beneficiaries

The nursery industry will benefit from the results of this research. The use of crops covers will reduce the need for herbicide application as well as improve irrigation efficiency in

container nursery production, the fastest growing segment of the nursery industry. The results showed decreased herbicide leaching and decreased leaching of nitrate and ammonia forms of nitrogen through seeding of cover crops. This will benefit the Chesapeake Bay and other bodies of water in Virginia, were reductions in nutrient and pesticide loading is especially beneficial.

V. Lessons Learned

The sudex hybrid was quite injurious to coreopsis during the initial period of 11/2011-4/2012. We decided to omit this cover crop in future trials. No weed control was attained using seeding rates of 200, and 400 lb/A (see Table 1). Seeding rates were increased to 800, 1600, and 3200 for winter wheat, triticale, Italian ryegrass, cereal rye. Austrian winter pea seeding rates were increased to 3200, 6400 and 12800 lb/A for future evaluations.

Nutrient evaluation was somewhat inconsistent for the pour through extraction method. Containers did not seem to be at uniform container capacity. After using 150 ml to displace water in the media within the container, varying amounts of water was leached, ranging from 0-80ml; this inconsistent container capacity may have contributed to a wide range in nutrient concentrations. In order to overcome this problem, the containers were irrigated overnight to ensure uniform watering, then allowed to drain for two hours. Next 300 ml was used to displace container water, which worked quite well.

VI. Additional Information (Include contact information)

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Literature Cited

Beeson, R.C., Arnold, M.A., Bilderback, T.E., Bolusky, B., Chandler, S., Gramling, H.M., Lea-Cox, J.D., Harris, J.R., Klinger, P.J., Mathers, H.M., Ruter, J.M., and T.H. Yeager. 2004. Strategic vision of container nursery irrigation in the next ten years. J. Environ. Hort. 22(2):113-115.

Niemiera, A.X., Bilderback, T.E. and C.E. Leda. 1994. Pine bark physical characteristics influence pour-through nitrogen concentrations. HortScience 29(7):789-791.

Owen, J.S., Warren, S.L., Bilderback, T.E., and J.P. Albano. 2008. Phosphorus rate, leaching fraction, and substrate influence on influent quantity, effluent nutrient content, and response of a containerized woody ornamental crop. HortScience 43(3):906-912

VDACS Facts and Figures 2003. http://www.vdacs.virginia.gov/agfacts/index.shtml Accessed: March 21, 2011.

#4 Final Report
Genetically Improved Seed Orchard
Mount Rogers Area Christmas Tree Growers

I. Project Summary

The Grayson Highlands Park Seed Orchard, managed by the Mount Rogers Christmas Tree Growers Association, has sustained the flow of Mount Rogers Fraser fir seed since its establishment. The first two hundred trees were planted in the seed orchard in 1980 as a result of concerns over the dwindling natural stands of Fraser fir. The native trees were dying due to the balsam wooly adelgid, an introduced insect from Europe. Planting trees in an area where they could be managed, and the harmful insects controlled, was viewed by many as the only way to preserve the gene pool and to have a sustainable supply of seed for the Christmas tree industry.

In 1981 four-hundred trees were added to the seed orchard from the Cabin Ridge section of Mount Rodgers National Recreational Area. Additional selections of Mount Rogers strain Fraser fir have been added throughout the orchards life. At present there are approximately 1200 selected trees in the orchard. The natural stands of Fraser fir continue to decline and the Grayson Highlands Seed Orchard remains a major source of seed for the Fraser fir Christmas tree industry.

The health of these original seed trees is beginning to deteriorate. Consequently, the Mount Rogers Christmas Tree Growers Association in cooperation with the Virginia Division of Forestry decided to establish a new Fraser fir seed orchard at the Old Flat site on Mount Rogers. The Virginia Commonwealth State Forester, Carl Garrison, III, shared the vision of the collaboration and partnership for a seed orchard as a way to preserve the superior characteristics of the Mount Rogers Fraser fir for many generations of Christmas tree farmers and their customers in the future.

II. Project Approach

The Virginia Department of Forestry initiated a land exchange with the Virginia Department of Conservation & Recreation, which lead to the establishment of the "Old Flat State Forest" and the new Mount Rogers Fraser Fir Seed Orchard. The land exchange was a four year process which was approved by the unanimous consent of the Virginia State Legislature and signed by the Governor. Preserving the native Mount Rogers Fraser fir for its unique gene pool will have long lasting environmental significance, which is important to the Department of Forestry's vision.

In April of 2010, the initial site preparation, fertilization, and planting of Mount Rogers strain Fraser fir root stock was completed at the Old Flat Seed Orchard. Fourteen hundred and fifty two grafting rootstock were transplanted on 15 by 15 foot centers with orchard roads established every 30 feet. Dr. John Frampton, Associate Professor of Forestry at North Carolina State University, created an orchard design with the goal of grafting 50 genetically superior; Mount

Rogers strain Fraser fir, in a managed replication to minimize inbreeding and maximize the orchards ability to produce the highest quality Fraser fir seed.

Members of the Mount Rogers Area Christmas Tree Growers Association have been searching their fields for the "best of the best" Fraser fir to graft into the Old Flats Seed Orchard. All of the trees selected for the Old Flat Seed Orchard must be the Mount Rogers strain of Fraser fir. Other attributes of these "super trees" include but are not limited to bud set, growth potential, form, bud break, needle length, and overall vigor as compared to the surrounding Fraser fir in the plantation. The selected trees are also being tested by Dr. John Frampton to establish their ability to hold needles.

1. **Identify Outstanding trees that can supply scion material for grafting into the orchard:**
   Members of the Mount Rogers Area Christmas Tree Growers Association have been searching their fields for the "best of the best" Fraser fir since 2010 to graft into the Old Flat Seed Orchard. All of the trees selected for the Old Flat Seed Orchard are the Mount Rogers strain of Fraser fir. Other attributes of these "super trees" include but are not limited to bud set, growth potential, form, bud break, needle length, and overall vigor as compared to the surrounding Fraser fir in growers' plantations. The selection of outstanding trees was expanded in 2013 with Christmas tree growers in Tennessee and North Carolina (that have known Mount Rogers Strain Fraser fir) also searching for possible selections in their fields.
2. **Evaluate each potential tree based on needle holding ability, color bud set, overall form, growth, insect and disease resistance:**
   After growers have identified potential seed orchard Fraser fir, Della Deal, Laurel Branch Contractors, evaluated, tagged, and collected samples from each tree to be certain the selections meet the criteria (bud set, growth potential, form, bud break, needle length, and overall vigor as compared to neighboring Fraser fir) recommended by Dr. John Frampton, North Carolina State University (NCSU) Professor of Tree Genetics and Extension Specialist. The selected trees were also tested at NCSU by the Tree Improvement Coop to establish their ability to hold needles.
3. **Collect scion material and graft on to root stock presently established at the Old Flat site:**
   The first trees to be evaluated were selected from the Mount Rogers Grayson Highlands Progeny Test planted on Mount Rogers Tree Farm owned by Rodney Richardson in Whitetop, Virginia. Sixteen exceptional Fraser firs were selected based on the attributes listed above. These trees were tested for needle retention in 2010 and 2011 and 2012. Twelve of these superior trees expressed excellent needle retention and were chosen to be the first trees grafted into the Old Flat Seed Orchard. On Friday, April 20, 2012, scion material collected from these twelve trees was grafted onto 326 trees on pre-tagged rootstock throughout the orchard.
   Fifty-five additional "Super trees" from Christmas tree farms in the Mount Rogers area were tagged in 2011 and 2012 as possible selections for the Old Flat Orchard. All of these trees showed superior growth, color, bud-set, density, and overall appearance as compared to the tens of thousands of other trees surrounding them. Of the 55 additional trees selected only 22 exhibited "excellent" needle retention. This demonstrates the importance of performing the needle retention study before allowing trees to be grafted into the orchard.

In mid-April 2013, scion material collected from 25 superior Fraser fir were grafted onto approximately 700 Fraser fir rootstock in the Old Flat Fraser Fir Seed Orchard. The scion collected included re-grafts from the 12 initial parent trees originally grafted in 2012 and an additional 13 parent trees. Parent tree selection was based on the results of a genetically superior tree selection and needle retention study completed by Della Deal and Dr. John Frampton, NCSU in the winter of 2012/2013. As described in previous reports the genetically superior Fraser fir display superior growth, color, needle length, bud set, and needle retention as compared to other Fraser fir in the same fields. The superior trees were selected out of hundreds of thousands of Fraser fir all of the Mount Rogers strain. Of the 67 total Fraser fir carefully chosen based upon growth characteristics; 25 have been grafted into the orchard, 9 will be reevaluated for grafting in 2014, and 33 have been excluded for poor needle retention.

To date 400 Grafted trees representing 25 "super trees" are thriving at the Old Flat Fraser Fir Seed Orchard. Additional parent tree selections have been made and are awaiting the results from needle retention samples sent to Dr. John Frampton in October 2013.

In the spring of 2013, 275 wildlings from the Grayson Highlands Seed Orchard were lifted and potted in one gallon containers. In the spring of 2014 plans are to bench graft these trees with the improved selections in a greenhouse to improve grafting success. These newly grafted trees will be used to replace damaged trees in the Old Flat Seed Orchard. Financial support for this will be provided by the Mount Rogers Area Christmas Tree Growers Association.

4. **Deep incorporate phosphate and add other needed fertilizer to ensure optimal fertility:** Due to the large number of rocky outcroppings throughout the Old Flat site, attempts to deep incorporate phosphate have been unsuccessful. The initial site prep included the application of dolomitic lime, gypsum, and the broadcast of balanced fertilizer. Yearly applications of 20-20-10 have been applied at the drip line of the orchard trees. This balanced fertilizer is a blend of Diammonium phosphate (DAP) and sulfate of potash based on soil test recommendations.
5. **Weed control**
   Initial weed control has focused in the removal of woody vegetation (hawthorns), brambles and heavy grasses (nonnative fescues). Yearly mowing and use of low rates of glyphosate herbicides have established a groundcover comprised of wildflowers, milkweed, and clover.

III. Goals and Outcomes Achieved

To date 400 Grafted trees representing 25 "super trees" are thriving at the Old Flat Fraser Fir Seed Orchard. Additional parent tree selections have been made and are awaiting needle retention studies that will resume in mid-October.

In the spring on 2013, 275 wildlings from the Grayson Highlands Seed Orchard were pulled and potted into one gallon containers. In the spring of 2014 the potted Fraser fir will be bench grafted in a greenhouse in order to increase our grafting success. These trees will be used to replace damaged trees in the Old Flat Seed Orchard.

Throughout the summer months of 2013 additional superior trees have been selected to include in the needle retention study. The needle retention study will begin in late October with many thanks to Dr. John Frampton and Anne Margaret Braham of NCSU. We hope to have an

additional 25 genetically superior Fraser fir to graft into the Old Flat Seed Orchard in the spring of 2014.

1. National Christmas Tree Association:
   - August 2010 : Mount Rogers set up a booth at the National Christmas Tree Association meeting in Winston Salem, NC and handed out information regarding the establishment of the Old Flat Seed Orchard.

2. North Carolina Christmas Tree Association:
   - 2011 through 2014: Biannual updates regarding the Old Flat Orchards establishment have been given to the NC Christmas Tree Association Board of Directors and to the Fraser Fir Promotional Committee Members by Della Deal, Laurel Branch Contractors

3. Virginia Christmas Tree Growers Association:
   - 2013 Winter Meeting: Della Deal gave a presentation regarding the progress of the Old Flats Orchard in Hillsville VA

4. Mount Rogers Area Christmas Tree Growers Association:
   - 2010-2014: Quarterly Updates to Membership and Board of Directors

5. Cooperative Extension Personnel from Virginia and North Carolina:
   - The Old Flats Orchard has been visited regularly by personnel from the Extension Service of both Virginia and North Carolina. These Agents and Specialist are the best promoters of the Old Flat Orchard due to their industry ties and credibility.

6. Outreach, Media Coverage and handouts:
   - American Farm Publications: http://americanfarm.com/publications/mid-atlantic-grower/archives/1000-christmas-tree-growers-get-grant
   - Mount Rogers Area Christmas Tree Growers Website: www.**mtrogers**fraserfir.org/pdf/**MtRogersSeed**TreeSelection.pdf
   - Mount Rogers Area Christmas Tree Growers Facebook: https://www.facebook.com/pages/Mount-Rogers-Area-Christmas-Tree-Growers-Association/308684202501732
   - Virginia Christmas Tree Growers News Journal: http://issuu.com/hortman48/docs/vctga_fall_nl_web/15
   - Independence Declaration: http://www.independencedeclaration.com/content/mount-rogers-fraser-fir-preservation-efforts-underway
   - Galax Gazette: http://www.galaxgazette.com/content/old-flat-state-forest-dedicated

IV. Beneficiaries

The Virginia Commonwealth State Forester, Carl Garrison, III, shared the vision of the collaboration and partnership for a seed orchard as a way to preserve the superior characteristics

of the Mount Rogers Fraser fir for many generations of Christmas tree farmers and their customers in the future. The Mount Rogers Fraser fir Christmas trees are an economic engine for Grayson County, Virginia, surrounding counties, and the entire Commonwealth.

1. The Virginia Division of Forestry and General Forest Management of a Unique Forest Resource:
   - "Due to the introduced balsam woolly adelgid and, secondarily, the harmful atmospheric depositions, old growth Fraser fir has been almost entirely decimated and the prospects for naturally regenerated younger trees are uncertain. For this reason Fraser fir is considered to be a globally threatened species (G2)." Dr. John Frampton, NCSU
   - The establishment and maintenance of the Old Flat Fraser Fir Seed Orchard ensures the preservation of the Mount Rogers Strain of Fraser fir and the Virginia Highland Spruce/Fir Forest Ecosystem; "which is the northern most geographic population of Fraser fir and is believed to possess unique genes that may prove to be important for the long-term success of the species." Dr. John Frampton, NCSU.
   - Allows Virginia Division of Forestry to have an educational Spruce/Fir Orchard for future programs and training on species preservation, best management practices, and wildlife.
   - Due to the low impact fencing placed around individual orchard trees wildlife corridors are protected and wildlife (deer/bear/wild horses/birds) will be able to utilize the heavy shelter provided by the Fraser fir / Spruce as they mature.

2. Fraser fir Christmas Tree Farmers:
   - Christmas tree producers will have a secure, competitive, improved Fraser fir seed supply for the future.
   - Having access to an improved seed source will allow Fraser fir Christmas tree growers to increase the percentage of USDA Premium and Number one trees harvested per acre and decrease the number of years in a rotation.
   - Increased yield at decreased intervals will increase the revenue potential per acre per year for Christmas tree farmers which will boost the local economies in production areas.
   - Increased yield at decreased intervals will also decrease the overall amount of pesticides used per acre over a rotation.

3. Mount Rogers Area Christmas Tree Growers Association:
   - The Old Flat Fraser fir Seed Orchard should begin to produce seed in 10-15 years providing the Mount Rogers Area Christmas Tree Growers Association with a second generation Fraser fir seed source to offer its membership and other Christmas tree farmers. The seed will help to replace lost seed poundage as the Fraser fir in the Grayson Highlands Seed Orchard age out of cone production.
   - Mount Rogers Area Christmas Tree Growers will be able to harvest a higher percentage of improved grade Fraser fir on a shorter rotation schedule, increasing profits and decreasing costs.
   - Plans are to conduct progeny tests from seed collected from the Old Flat "Super Trees" in order to isolate the best cone trees and improve the Fraser fir genetics.

4. Southwest Virginia, Northwest North Carolina and Northeast Tennessee Highland Region:
    - VA Counties: Grayson, Washington, Smyth, Wythe, Carroll, Patrick and
    - NC Counties: Ashe, Alleghany, Watauga,
    - TN Counties: Carter, Johnson
    - Harvest 6.75 million Christmas trees annually, valued at 130 million annual sales, (Extension Agent Survey Highland Counties) Agricultural multiplier (impact as income moves throughout the community according to Kevin Spurlin, Grayson County Extension) is 3x; placing the economic impact in the Highland District at 390 million dollars annually.

5. Grayson County Virginia:
    - According to the Grayson County Comprehensive Plan, adopted December 12, 2013, Christmas Trees are the #1 Agronomic crop in Grayson County with 11,000 acres planted and $15 million dollars in annual sales.
    - A typical agricultural goods multiplier placing the true economic impact of the Grayson County Christmas Tree Industry to be $45 million annually.
    - The establishment of the Old Flat Fraser fir Orchard ensures a reliable and improved seedling source for future Fraser fir growers.

V. Lessons Learned

• Offer insights into the lessons learned by the project staff as a result of completing this project. This section is meant to illustrate the positive and negative results and conclusions for the project.
• Provide unexpected outcomes or results that were a effect of implementing this project.
• If goals or outcome measures were not achieved, identify and share the lessons learned to help others expedite problem-solving.

1. Wildlife damage has increased each year at the Old Flat Fraser Fir Orchard. In an attempt to stop the damage from deer, bear, and wild horses the grafted Fraser fir trees have been individually fenced. This will allow game to move through the area without damaging the orchard trees.
2. Establishing a meaningful improved genetic Fraser fir seed orchard takes years of dedication. However, it is possible when working with a group of growers that are excited about being involved in a program that will help generations of farmers and foresters to come.
3. The initial plan was to pull Red spruce wildlings from Mount Rogers to use as a living border. The rocky ground prevented this from being a viable option on a large scale. Red spruce grown from Mount Roger's seed is not commercially available. Consequently, it was necessary to hand collect seed (with help from the Grayson Highlands Park Staff). The Mount Rogers Area Christmas Tree Growers Association is now in the process of growing out our own Red spruce seedlings in cooperation with a private nursery.

VI. Additional Information

http://www.mtrogersfraserfir.org/pdf/MtRogersSeedTreeSelection.pdf

http://www.mtrogersfraserfir.org/members.html

Public Education and Outreach:

On February 23, 2013, the Virginia Christmas Tree Growers Association held a winter meeting for all of Western Virginia and surrounding areas. Della Deal, Laurel Branch Contractors, presented a PowerPoint regarding the goals, timeline, and progress of the Old Flat Fraser fir Seed Orchard on Mount Rogers State Forest in Virginia. Christmas tree growers, Department of Agriculture personnel, and representatives from Virginia Department of Forestry were in attendance for the presentation. A copy of the presentation is included.

On September 26, 2013 an update regarding the Old Flat Seed Orchard was given during the Fraser fir Promotional Committee meeting of the North Carolina Christmas Tree Association.

Accomplishments of our Old Flat Fraser Fir Seed Orchard have also been published in the Virginia Christmas Tree Growers Newsletter and the Independence VA Declaration.

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#5 FINAL

UNDERSTANDING THE BIOLOGY OF THE INVASIVE BROWN MARMORATED STINK BUG AND MANAGEMENT STRATEGIES FOR VEGETABLES

i. Project summary

The brown marmorated stink bug (BMSB), *Halyomorpha halys* (Stål), was accidently introduced from Asia into Pennsylvania in the late 1990s. Since then, BMSB populations have spread rapidly and grown exponentially. By fall 2010, the pest was found throughout most of the Commonwealth of Virginia and had become a serious nuisance in many households. In some areas of the state, this pest has also caused unprecedented damage to tree fruit and vegetables such as peppers, tomatoes, beans, and sweet corn. There is much that we do not know about this invasive stink bug species, and entomologists are scrambling to understand its ecology and find effective management strategies. However, there is no doubt that this bug has a major significance to the long term sustainability and profitability of specialty crops in Mid-Atlantic U.S.

The overarching goals of this project were to determine the role of winter climate and surrounding habitat on the population ecology of BMSB, and to develop management strategies to minimize crop losses in vegetables. Specific objectives are to:
Examine the overwintering physiology of BMSB and determine the critical freezing point temperatures so that we may better understand the impact of winter climate on bug populations.
Quantify BMSB abundance, phenology, and natural enemy complex in different managed and unmanaged habitats throughout the season.
Determine effects of different insecticides on BMSB, and develop use guidelines for vegetable crops.

ii. Project approach

Obj. 1. Examine the overwintering physiology of BMSB and determine the critical freezing point temperatures so that we may better understand the impact of winter climate on bug populations.

☐ Adult brown marmorated stink bugs (BMSB) were collected monthly from plants (May to Oct) from various locations throughout Virginia and West Virginia.
☐ BMSB collected during the fall were held in artificial overwintering habitats consisting of 5-gallon buckets with ½ inch foam pipe insulation strips inside the bucket to mimic a typical overwintering habitat in man-made structures. The buckets were kept outside.
Supercooling points are determined by gradually exposing whole insects, or the hemolymph of insects to subfreezing temperatures and recording the temperature of the insect. The point of crystallization of the blood occurs when there is a spike in temperature during a period of gradual lowering of the temperature.
☐ Each month, a sample of at least 5 males and 5 females were analyzed. Whole body BMSB were removed monthly from each overwintering habitat and placed onto a stage assembly equipped with 0.13mm diameter, Teflon® insulated copper constantan thermocouple. Good

thermal transfer was ensured using a small amount of thermal grease contacting the BMSB with the thermocouples.

☐ Cold temperatures were generated using a refrigerated water bath with a 50/50 water and ethanol mixture maintained at -8°C, in circulation with a cold plate. The cooling system was capable of providing temperatures down to - 28°C.

☐ The cooling system was programmed to provide a cooling temperature rate of -0.3°C per minute, for optimizing the freezing point determinations.

☐ Temperature data were obtained from the copper thermocouples using DaqView software and the supercooling point was determined by observing the lowest temperature before a phase change, where the temperature increased.

Obj. 2. Quantify BMSB abundance, phenology, and natural enemy complex in different managed and unmanaged habitats throughout the season.

Objective 2. From late April through October in 2011, 2012, and 2013, we performed weekly three-minute/plant visual surveys of stink bugs on various wild tree hosts and agricultural plants in southwest Virginia. All life stages of BMSB and other stink bugs were counted and recorded weekly in order to develop a profile of the stink bug life stages over time. Over 2,000 visual sample surveys were conducted on plants and over 1,100 BMSB were observed. Through these surveys, we estimated that 1 to 2 generations of BMSB occurred naturally over the season in southwest Virginia.

Fig. 1. Brown marmorated stink bug adults mating on mimosa in June (left) and nymphs on corn in August in southwest Virginia.

Obj. 3. Determine effects of different insecticides on BMSB, and develop use guidelines for vegetable crops.

The efficacy of over 25 different foliar insecticides against BMSB was determined using bean-dip bioassays in the laboratory and small-plot field efficacy tests conducted on bell pepper, green beans, sweet corn, and tomato; several currently-registered as well as experimental insecticides were found to be efficacious.

Bean-dip Bioassays: Insecticide solutions were mixed based on the highest labeled rate and a 100 gal /acre output. Green bean (Phaseolus vulgaris) pods were dipped in solution for 5 sec, allowed to dry for ≈½ hr under a fume hood, then placed in a 9-cm Petri dish with filter paper and either 5 BMSB adults or nymphs (2-3 instars) per dish. There were 4 Petri dishes per treatment for a total of 20 insects tested each bout. Each insecticide treatment was replicated at least 3 times.

Field Insecticide Efficacy Experiments: From 2011-2012, a total of seven efficacy experiments were conducted in peppers, three in tomatoes, two in snap beans and one in sweet corn. All experiments were conducted at the Virginia Tech Kentland Research Farm, Blacksburg, VA. Experiments were small plot tests arranged in a randomized complete block with four replications per treatment. Individual plots were 1 row x 20 ft. All foliar treatments were applied with a 3-nozzle boom equipped with D3 spray tips and 45 cores and powered by a CO_2 backpack sprayer at 40 psi delivering 34 GPA. All treatments that were evaluated as well as the dates of application and the dates of post-spray evaluations are presented in the results tables. In addition to the field trials mentioned above, the chitin biosynthesis inhibitors novaluron and diflubenzuron were assessed to determine a less disruptive strategy to control BMSB than conventional insecticides. Bioassays were completed to evaluate the effectiveness of these insecticides on adult mortality, nymphal growth, adult fecundity, and egg hatch.

iii. Goals and Outcomes achieved

Obj. 1. Examine the overwintering physiology of BMSB and determine the critical freezing point temperatures so that we may better understand the impact of winter climate on bug populations.

The supercooling point of brown marmorated stink bug adults ranged from -6.67 °C to -13.54 °C and varied over the course of the season and with gender. As would be expected, overwintering adult bugs could sustain lower temperatures (-13.19 °C to -13.54 °C) than bugs collected during the summer months (-7.64 °C to -10.86 °C) indicating a likely physiological change in the bug during winter diapause. Based on past research with other insects, an increase in cryoprotectant polyols in the haemolymph is one likely physiological change that might explain the changes in supercooling points. The results of this study indicate that BMSB utilize physiological strategies to endure severe winter temperatures in addition to behavioral strategies such as seeking shelter within manmade and natural structures as well as aggregating together in clusters. These results also suggest that BMSB will likely be able to survive in climates colder than the mid-Atlantic U.S.

Obj. 2. Quantify BMSB abundance, phenology, and natural enemy complex in different managed and unmanaged habitats throughout the season.

- Over 2,000 timed visual samples were conducted on wild trees and agricultural plants in the western (ridge and valley) region of Virginia, and over 1,100 BMSB of various life stages were observed. Using these data as well as observational data from others in the mid-Atlantic U.S., we published a list of host plants of BMSB (Brown Marmorated Stink Bug Working Group 2013 http://www.stopbmsb.org/where-is-bmsb/host-plants/), including several that are preferred plants such as: Tree of heaven (Ailanthus altissima), Catalpa (Catalpa spp.), Princess Tree (Paulownia tomentosa), cherry (Prunus spp.), Sensitive Plant (Mimosa spp.), corn (Zea mays), pepper Capsicum annuum, tomato (Solanu lycopersicon), and sunflower (Helianthus spp.). These plants were primarily the ones surveyed in 2011-2013 to track stink bug seasonal biology.

BMSB comprised 96.6, 86.2, and 86.6% of all species of stink bug adults observed in 2011, 2012, and 2013, respectively (Table 1).

*Tables, Figures and Objects are included in Appendix A.

iv. beneficiaries

The concepts and data presented in this report were presented at numerous meetings and venues including vegetable grower meetings and extension field days as well as a nationwide webcast on the Plant Management Netwrok (see below). The number of face-to-face contacts at these events exceeded 1,000 over the two years of this project. The primary beneficiaries included vegetable growers, tree fruit growers, corn producers, and numerous homeowners in the state of Virginia. In addition, several publications were written and published in peer-reviewed scientific journals, or other periodicals.

Scientific Meeting Talks

Aigner, J.D. and T.P. Kuhar. 2013. The potential of systemic neonicotinoids in controlling BMSB in vegetables. Oral Presentation: Georgia Entomological Society Annual Meeting 2013, April 10 – 12; Dawsonville, GA.

Kuhar, T.P, J.D. Aigner, and C.R. Philips. 2013. Management of brown marmorated stink bug in vegetable crops. Oral presentation: Georgia Entomological Society Annual Meeting, April 10-12; Dawsonville, GA.

Aigner J.D., T.P Kuhar, and K.L. Kamminga. 2013. Do soil applied neonicotinoids provide control of brown marmorated stink bug (Halyomorpha halys) in vegetables? 2013. Entomological Society of America, Eastern Branch Annual Meeting 2013, March 16 – 19; Lancaster, PA.

Lohr, A.K., T.P. Kuhar, B.L. Aigner, J.D. Aigner and C.R. Philips. 2013. Maximum lethal temperature and its potential use in predicting the distribution of the brown marmorated stink bug (Halyomorpha halys) in the US. Entomological Society of America, Eastern Branch Annual Meeting 2013, March 16 – 19; Lancaster, PA.

Basnet, S., D. Pfeiffer, T. Kuhar, and C. Laub. 2013. Stink bug community in primocane-bearing raspberry planting in southwest Virginia. Entomological Society of America, Eastern Branch Annual Meeting 2013, March 16 – 19; Lancaster, PA.

Aigner J.D., D.E. Mullins, T.P. Kuhar, K.L. Kamminga, S.B. Gabbert, A.K. Lohr and B.L. Aigner. 2012. Temperature extremes of the brown marmorated stink bug (Halyomorpha halys). Poster presented at: Entomological Society of America, National Annual Meeting 2012, November 12 – 14; Knoxville, TN.

Kuhar, T.P., K. Kamminga, and J. Aigner. 2012. Efficacy of insecticides for control of brown marmorated stink bug (Halyomorpha halys) in vegetable crops. Annual Meeting of the Entomological Society of America, November 11-14, Knoxville, TN.

Basnet, S., D. Pfeiffer, T. Kuhar, and C. Laub. 2012. Seasonal abundance and biology of brown marmorated stink bug, Halyomorpha halys (Stål) (Hemiptera: Pentatomidae), in Virginia vineyards. Annual Meeting of the Entomological Society of America, November 11-14, Knoxville, TN.

Kamminga, K., and T. Kuhar. 2012. Understanding the seasonality of the brown marmorated stink bug in Virginia. Annual Meeting of the Entomological Society of America, November 11-14, Knoxville, TN.

Kuhar, T. P., K. Kamminga, and C. Philips. 2012. Host plants and agro-ecology of the invasive brown marmorated stink bug in Virginia. Disturbed Environments: Ecological Impact & Management. Abstracts of the 2012 Annual Conference of the mid-Atlantic Chapter Ecological Society of America, April 14-15. Online publication. http://urbanforestry.frec.vt.edu/maesa/documents/bookofabstracts2012.pdf

Kuhar T., G. P. Dively, J. Whalen, G. C. Hamilton, G. Brust, and K. Kamminga. 2012. P015 Pest threat of the invasive brown marmorated stink bug to vegetable crops in the U.S. p. 85 in 2012 Proceedings of the 7th International Integrated Pest Management Symposium: IPM on the World Stage, March 27–29, 2012, Memphis, TN.

Aigner, J. D.*, T. P. Kuhar, D. Mullins, and S. Gabbert. 2012. Supercooling points of the brown marmorated stink bug (Halyomorpha halys). Annual Meeting of the Eastern Branch of the Entomological Society of America, March 16-19, Hartford, CT

Kamminga, K.*, T. P. Kuhar, and D. A. Herbert. 2012. Seasonal biology of the brown marmorated stink bug in Virginia, 2011. Annual Meeting of the Eastern Branch of the Entomological Society of America, March 16-19, Hartford, CT

Kamminga, K.L., T. Kuhar, H. Doughty, A. Wallingford, A. Wimer, J. Jenrette and C. Philips. 2011. Results of Bioassays on Halyomorpha halys. National Meeting of the Entomological Society of America. Reno, NV, Nov. 13-16.

Extension Talks

Kuhar, T.P. and J.D. 2013. Ongoing vegetable research at Kentland Farm in Blacksburg, VA and an update on brown marmorated stink bug. Oral Presentation. On-Farm Twilight Grower Meeting. July 9. Brightwood, VA.

Kuhar, T.P. 2013. Efficacy of insecticides for controlling tomato pests including brown marmorated stink bug. Tomato Session - – 2013 New Jersey Agriculture Convention and Trade Show, Feb 4-6; Atlantic City, NJ.

Kuhar, T.P. 2013. Efficacy of new insecticides for controlling worms, aphids, and stink bugs in sweet corn, peppers and cole crops – Hot Topics Session – 2013 New Jersey Agriculture Convention and Trade Show, Feb 4-6; Atlantic City, NJ.

Kuhar, T. 2012. Peer-reviewed Webcast. “Pest Threat of the Invasive Brown Marmorated Stink Bug to Tomatoes in the U.S.”. Focus on Tomatoes Webcast, Plant Management Network, International, June 2012.
http://www.plantmanagementnetwork.org/edcenter/seminars/Tomato/bmsb/

Kuhar, T. 2012. Managing brown marmorated stink bugs and more from the frontiers of entomology. Tri-County Vegetable and Small Fruit Growers Meeting, Penn State Cooperative Extension, February 22, Shippensburg, PA

Kuhar, T. 2012. Insecticide Efficacy Research on Brown Marmorated Stink Bug on Vegetables in Virginia. 2012 Atlantic Coast Agriculture Convention and Trade Show and the New Jersey Agricultural Convention, January 18, Atlantic City, NJ

Kuhar, T. 2012. Host plant visual sampling and insecticide efficacy research. Brown Marmorated Stink Bug IPM Working Group Meeting., June 12-13, Westminster, MD.

Kuhar, T. 2012. Insect Management Update Including Brown Marmorated Stink Bug. February 24., Richmond Area Vegetable Growers Meeting.

Kuhar, T. 2011. Update on stink bug biology and control in Virginia. Webinar for Virginia Cooperative Extension Agents, November 3, Blacksburg, VA

Kuhar, T. 2011. Seminar. Biology of the invasive brown marmorated stink bug. Ecology and Evolutionary Biology Seminars, Department of Biology, Virginia Tech, September 1, Blacksburg, VA

Kuhar T. 2011. Insecticide Toxicity Data from Virginia and Research in 2011. Online publication of presentation at the 2011 Brown Marmorated Stink Bug Working Group Meeting, Biglerville, PA

In-Service Training

Clark R., T. Kuhar. November 2011. Update on Stinkbug Biology and control in Virginia. Special Virginia Coop. Ext. Educational Webinar.

Kuhar, T. 2012. Host plant visual sampling and insecticide efficacy research. Brown Marmorated Stink Bug IPM Working Group Meeting., June 12-13, Westminster, MD.

Kuhar, T. 2012. Insect Management Update Including Brown Marmorated Stink Bug. February 24., Richmond Area Vegetable Growers Meeting.

Kuhar, T. 2011. Update on stink bug biology and control in Virginia. Webinar for Virginia Cooperative Extension Agents, November 3, Blacksburg, VA

Kuhar, T. 2011. Seminar. Biology of the invasive brown marmorated stink bug. Ecology and Evolutionary Biology Seminars, Department of Biology, Virginia Tech, September 1, Blacksburg, VA

Radio interviews

Kuhar, T. P. and T. Leskey. Brown marmorated stink bug radio interview with Tom Graham Senior Producer, Virginia Insight. WMRA - NPR Affiliate in northern Virginia, May 1, 2013 – Previous broadcasts posted at http://www.wmra.org/programs/virginia-insight

Aigner, J. 2012. Interview with Brashear, G. 2012. For farmers, crop-hungry stink bugs are more than irritating houseguests. Charlottesville Weekly. November 23, 2012. – Phone Interview

Publications:

Kuhar, T. P., K. L. Kamminga, J. Whalen, G. P. Dively, G. Brust, C. R.R. Hooks, G. Hamilton, and D. A. Herbert. 2012. The pest potential of brown marmorated stink bug on vegetable crops. Online. Plant Health Progress doi:10.1094/PHP-2012-0523-01-BR.

Kuhar T., H. Doughty, K. Kamminga, and L. Lilliston. 2012. Evaluation of insecticides using a bean dip bioassay for control of brown marmorated stink bug, 2011. Arthropod Management Tests 2012, Vol. 37: L1. Online publication. doi: 10.4182/amt.2012.L1.

Kuhar, T.P, H. Doughty, K. Kamminga, A. Wallingford, C. Philips, and J. Aigner. 2012. Evaluation of foliar insecticides for the control of brown marmorated stink bug in tomatoes in Virginia, 2011. Arthropod Management Tests. Vol. AMT37. Sec. E72. doi: 10.4182/amt.2012.E72.

Bergmann, E., K. M. Bernhard, G. Bernon, M. Bickerton, S. Gill, C. Gonzales, G. C. Hamilton, C. Hedstrom, K. Kamminga, C. Koplinka-Loehr, G. Krawczyk, T.P. Kuhar, B. Kunkel, J. Lee, T.C. Leskey, H. Martinson, A.L. Nielsen, M. Raupp, P. Shearer, P. Shrewsbury, J. Walgenbach, J. Whalen, and N. Wiman. 2013. Host Plants of the Brown Marmorated Stink Bug in the U.S. Technical bulletin publication of the Brown Marmorated Stink Bug IPM Working Group in conjunction with the Northeastern IPM Center posted Online http://www.StopBMSB.ORG , October, 7, 2013.

Kuhar T., H. Doughty, K. Kamminga, C. Philips, J. Aigner, A. Wallingford, A. Wimer, L. Lilliston, B. Aigner, L. Nottingham, A. Lohr, E. Fread, J. Jenrette. 2012. Performance of Insecticides on Brown Marmorated Stink Bug on Vegetables. Virginia Coop. Ext. Pub. No. ENTO-28NP.

v. lessons learned

The supercooling point of brown marmorated stink bug adults ranged from -6 degrees Celsius to -15 degrees Celsius and varied over the course of the season and with gender. As would be expected, overwintering adult bugs could sustain lower temperatures than bugs collected during the summer months indicating a likely physiological change in the bug during winter diapause. Based on research with other insects, an increase in cryoprotectant polyols in the haemolymph is one likely physiological change that might explain the changes in supercooling points. The results of this study indicate that BMSB utilize physiological strategies to endure severe winter temperatures in addition to behavioral strategies such as seeking shelter within manmade and natural structures as well as aggregating together in clusters. These results also suggest that BMSB will likely be able to survive in climates colder than the mid-Atlantic U.S.

Based on more than 2000 visual samples of wild tree hosts and agricultural crops from 2011 to 2013, BMSB comprised more than 85% of all stink bugs observed suggesting that it has become the dominant stink bug species on farms in the western half of Virginia.

The timing of BMSB occurrence on vegetable crops in Virginia was determined to be primarily from mid-July to mid-September; however, we observed early-planted sweet corn to be attacked even earlier (possibly late-June) if ears are fully developed.

The efficacy of over 25 different foliar insecticides against BMSB was determined using bean-dip bioassays in the laboratory and small-plot field efficacy tests conducted on bell pepper, green beans, sweet corn, and tomato; several currently-registered as well as experimental insecticides were found to be efficacious.

The efficacy of various neonicotinoid insecticides applied to the root-zone were evaluated using BMSB caged on pepper and corn plants; thiamethoxam, dinotefuran, clothianidin, and imidacloprid each provided effective control of BMSB for more than 14 days.

vi. additional information

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#6 FINAL
Establishment of Virginia wine grape vineyards using organic production methods.
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Project Summary: The proportion of organically produced crops in U.S. agriculture has been steadily increasing. The total acreage of certified organic farmland, recorded at 914,800 acres in 1995, had risen to 843,866,715 acres in 2011 (USDA, 2013a), and organic grape production has increased from 12,575 acres in 2000 to 38,664 acres in 2011 (USDA, 2013b). Consumers concerned with contamination of their properties by neighboring farms, and the potential negative health effects of consuming conventionally produced crops are demanding agricultural practices with minimal effect on the environment (Desta, 2008). Wine grapes are an important specialty crop in the Commonwealth. The Virginia Department of Agriculture and Consumer Services (VDACS) ranked grapes as the 20th most profitable commodity in Virginia with cash receipts of 9 million USD in 2011 (VDACS, 2013). Virginia wineries and associated vineyards have increased appreciably over the last ten years to approximately 234 wineries (Virginia Wine, 2013) and over 3000 acres of vines (VDACS, 2010). However, as of 2013, the Hambsch Family Vineyard of North Garden, Virginia was the only vineyard in the state reported to have successfully applied organic management practices to wine grape production, (QCS, 2013). In the Eastern United States, fungal diseases are typically the most difficult vineyard diseases to control organically, with black rot being one of the biggest challenges (Gu et al., 2007). In a 2008 survey conducted by the Virginia Wine Board, industry members identified sustainable production practices (78.9%), organic farming systems (47.7%), and cultivar and clonal selection and evaluation (71.1%) as priority areas for state viticulture research (VVA, 2008). These research areas are important for Virginia vineyards because of the need to capitalize on the flourishing organic market-U.S. sales of organic wines reached $80 million in 2005, a 28% increase over the previous year (OTA, 2006)-and to avoid losing market share to wine regions that have adopted organic production methods.

Project Approach: The study was conducted at a vineyard established in 2012 in Chesterfield County, Virginia utilizing the grape varietals petit manseng, vidal blanc, corot noir, and arandell. The cultivar selection was based on fungal disease resistance and potential wine quality. Vine management consisted of a cane pruned vertical shoot positioning system.

Two organic fungicide spray programs using pesticides certified by the Organic Materials Review Institute (OMRI), and a conventional program (Table 1.) were designed to assess the disease management of downy mildew, powdery mildew, black rot, and phomopsis cane and leaf spot. The sprays were conducted on a weekly basis beginning two weeks post bud break on May 6, 2013 and May 3, 2014. Both organic spray programs were formulated using a foundation of fixed copper (copper hydroxide, Nucop HB, Albaugh Inc. Ankey, IA) hydrated lime (calcium hydroxide, APG Lime Corp., Kimballton, VA) and sulfur (Kumulus DF, BASF, Florham Park, NJ), with the addition of Serenade in one program. Serenade is not labeled for downy mildew, black rot, and phomopsis cane and leaf spot but has improved the management of these diseases in other climates (Ellis and Nita (n.d.), Schilder, 2008). During the 2014 growing season an organic sticking agent, Nu Film P (Miller Chemical and Fertilizer Company, Hanover, Pennsylvania) was included in both organic spray programs.

In order to minimize the potential effects of fungal spore inoculum from neighboring panels, the middle two vines of a four-vine panel were selected for disease assessment. Disease assessment

was done visually during the growing season on each vine by randomly selecting three shoots per vine and five leaves per shoot (120 leaves per cultivar) for analysis. In total, four leaf assessments were conducted in 2013 (July 22, August 6, August 20, and September 3) and four leaf and cluster assessments were conducted in 2014 (June 18, July 2, July 16, and July 28). The performance of organic and conventional pesticide spray programs were compared and the percentage of fungal disease incidence (percentage of leaves and clusters exhibiting diseases symptoms) and disease severity (percentage of leaf coverage) was documented and analyzed using a linear mixed model (SAS 9.2, Cary NC) where fungicide treatment and cultivar were considered fixed effects and block was considered a random effect. Significance of differences was determined utilizing Duncan's multiple range test at $P < 0.05$.

Table 1. Overview of 2013 and 2014 Growing Season Fungicide Spray Programs. During the 2014 growing season an organic sticking agent, Nu Film P (Miller Chemical and Fertilizer Company, Hanover, Pennsylvania) was included in both organic spray programs.

Treatment	Pesticide	Brand name	Volume per acre	Spray timing
Organic A	Copper	Nucop HB	1 lb	Weekly interval
	Hydrated lime	Southern States	2 lbs	Weekly interval
	Sulfur	Kumulus DF	2.4 lbs	Weekly interval
Organic B	Copper	Nucop HB	1 lb	Weekly interval
	Hydrated lime	Southern States	2 lbs	Weekly interval
	Sulfur	Kumulus DF	2.4 lbs	Weekly interval
	Bacilius subtilis	Serenade ASO	2.4 qts	Weekly interval
Conventional	Mancozeb	Manzate Prostick[z]	3 lbs	Weekly interval (Removed 66 days prior to typical harvest date)
	Potassium phosphite	Prophyt[y]	2 Pts	Weekly interval (Replaced Manzate for the 66 days prior to typical harvest date interval)
	Sulfur	Kumulus DF	2.4 lbs	Weekly interval

zManzate Prostick (United Phosphorus Inc., King of Prussia, PA)
yProphyt (Helena Chemical Company, Collierville, TN)

Total precipitation for the 2013 growing season was higher than in 2012 and exceeded the 30-year mean for the Chesterfield County site where the vineyard is located (Table 2). A review of climate data for Winterpock and Petersburg weather stations (NCDC 2014a, NCDC 2014b) shows that the rainfall total in June 2013 was considerably higher, 3.58", 5.71" respectively, than the historical mean, potentially promoting an abnormally high fungal spore population and an increased spore count for the remainder of the season. Due to the increased moisture in 2013 and the buildup of fungal disease spores from the 2012 growing season, the incidence and severity of phomopsis, black rot, and downy mildew were considerable. Total precipitation for the 2014 growing season was typical of the Chesterfield County site (Table 3).

An analysis of the effectiveness of the three spray programs in inhibiting downy mildew, black rot and phomopsis during the 2013 season showed statistically significant differences at $P < 0.05$ (Tables 2). Powdery mildew was not detected in any disease assessment in this study. The organic spray programs were not as effective as the conventional spray program at reducing the incidence of black rot. The inclusion of Serenade in the Organic B spray program did significantly reduce the incidence of black rot as compared with the Organic A spray program. There were no significant differences between the Organic B and Conventional spray program in reducing the severity of black rot.

The Organic B spray program was statistically equivalent to the conventional spray program at reducing the incidence of phomopsis. There were no significant differences between spray programs in reducing the severity of phomopsis.

There were significant differences between spray programs in reducing the incidence of downy mildew. The Organic B spray program did significantly reduce the incidence of downy mildew compared to the Organic A spray program. There were no significant differences between the organic spray programs at reducing the severity of downy mildew but they were both significantly different the conventional spray program which had a superior performance.

Petit manseng and corot noir were not significantly different in their resistance to black rot, phomopsis, and downy mildew but were not as effective as arandell (Table 2). Resistance in vidal blanc was significantly lower than in all other cultivars with heightened susceptibility to downy mildew being observed under organic management (Table 2).

The varietal trial outlined the significant disease resistance of arandell during the 2013 growing season and the potential for successful organic production in Virginia. The disease incidence and severity of phomopsis, black rot, and downy mildew detected on arandell was consistently and significantly lower than in the other three varietals (Tables 2). Even under abnormally wet conditions, the symptoms of listed diseases were almost undetectable and it is likely that arandell can ultimately achieve organic certification in Virginia.

The results suggest that the organically registered fungicide Serenade is effective in reducing the severity and incidence of black rot and phomopsis (Table 2). The significant differences detected between the organic spray programs in the incidence of phomopsis on corot noir, petit manseng, and vidal blanc suggest that Serenade can improve the efficacy of organic fungicides. There were no significant differences in the performance of Organic B and conventional spray programs in reducing black rot severity or incidence on petit manseng and vidal blanc vines. The only significant difference detected was a reduction in downy mildew disease incidence on corot noir and petit manseng after inclusion of Serenade.

An analysis of the effectiveness of the three spray programs in inhibiting downy mildew, black rot and phomopsis during the 2014 season showed statistically significant differences at $P < 0.05$ (Tables 3). Powdery mildew was not detected in any disease assessment in this study. There were no significant differences between the organic spray programs at reducing the incidence and severity of black rot. Both organic spray programs were significantly more effective than the conventional spray program at reducing the incidence and severity of black rot.

There were no significant differences between the organic spray programs at reducing the incidence and severity of phomopsis. The conventional spray program was significantly more effective than the organic spray program at reducing the incidence and severity of phomopsis.

The organic A spray program was the most effective treatment at controlling the disease incidence and severity of downy mildew. The conventional spray program was the least effective treatment at controlling the disease incidence and severity of downy mildew.

The varietal trial again in 2014 outlined the significant disease resistance of arandell and the potential for successful organic production in Virginia. The disease incidence and severity of phomopsis, black rot, and downy mildew detected on arandell was consistently and significantly lower than in the other three varietals (Tables 3).

Petit manseng and corot noir were not significantly different in the level of black rot disease incidence and disease severity (Table 3). Resistance in vidal blanc was significantly lower than in all other cultivars.

Petit manseng and corot noir were not significantly different in the level of phomopsis disease incidence but corot noir had a significantly lower level of disease severity than petit manseng (Table 3). Phomopsis resistance in vidal blanc was significantly lower than in all other cultivars. Petit manseng and Vidal Blanc had the highest level of downy mildew disease incidence and disease severity (Table 3).

The abnormally wet 2013 growing season potentially led to higher than normal fungal disease pressure. In both our conventional and organically managed vineyards, Downy mildew infestation reached levels that can be detrimental to overall vine health, and similar observations were made for conventionally managed Virginia vineyards during the 2013 growing season. It should be noted that regardless of the effectiveness of a fungicide spray program, significant shifts in weather can lead to excessive fungal disease pressure and infestation.

During the 2013 growing season the Organic B spray program, which included Serenade, significantly reduced the severity and incidence of black rot and phomopsis, and incidence of downy mildew compared to spray program A. There were no significant differences in the organic spray programs during the 2014 growing season. During the 2013 growing season an adjunct was not used in conjunction with Serenade potentially reducing its efficacy. Serenade has been shown to be increasingly effective when used in conjunction with the adjunct Nufilm 17 (Pinolene, Miller Chemical and Fertilizer Corp., Hanover, PA.) (Schilder, 2008). Unfortunately Nufilm 17 is no longer labeled organic so during the 2014 growing an alternative organic adjunct Nu Film P (Miller Chemical and Fertilizer Company, Hanover, Pennsylvania) was included in both organic spray programs in an effort to increase the potential for successful organic vineyard management in Virginia. Overall disease incidence and severity in 2014 was very low but the disparity between conventional and organic treatments regardless of the inclusion of Serenade was much less than 2013. The 2014 organic spray program was significantly effective at controlling black rot, phomopsis, downy mildew, and powdery mildew in Virginia and further study including Nu Film P is warranted. The disease incidence and severity during the 2014 growing season was so low it could be argued that an insufficient level of disease occurred to properly compare the benefit of including Serenade in organic spray B.

Table 2. 2013 season mean disease incidence (percentage of leaves exhibiting diseases symptoms) and disease severity (percentage of leaf coverage) of phomopsis, black rot, and downy mildew per treatment (= Cultivar and Treatment).

Black Rot	**Variety**	**Disease incidence**		**Disease severity**	
	Arandell (NY95.0301.01)	1.7	C	0.03	C
	Corot Noir	7.8	B	0.21	B
	Petit Manseng	7	B	0.18	B
	Vidal Blanc	11.2	A	0.31	A
	Treatment	**Disease incidence**		**Disease severity**	
Organic A	Cu (1lb) + $Ca(OH)_2$ (2lb) + Sulfur (2.4lb)	9.4	A	0.27	A
Organic B	Cu (1lb) + $Ca(OH)_2$ (2lb) + Sulfur (2.4lb) + Serenade ASO (2.4 qt)	6.7	B	0.17	B
Conventional	Conventional (Mancozeb 3lb + Prophyt 2pt + Sulfur 2.4lb)	4.6	C	0.12	B
Downy Mildew	**Variety**	**Disease incidence**		**Disease severity**	
	Arandell (NY95.0301.01)	0.01	C	0.03	C
	Corot Noir	26.5	B	1.95	B
	Petit Manseng	27.9	B	1.79	B
	Vidal Blanc	49.4	A	8.29	A
	Treatment	**Disease incidence**		**Disease severity**	
Organic A	Cu (1lb) + $Ca(OH)_2$ (2lb) + Sulfur (2.4lb)	31.1	A	3.5	A
Organic B	Cu (1lb) + $Ca(OH)_2$ (2lb) + Sulfur (2.4lb) + Serenade ASO (2.4 qt)	27.6	B	3.27	A
Conventional	Conventional (Mancozeb 3lb + Prophyt 2pt + Sulfur 2.4lb)	19.8	C	2.27	B
Phomopsis	**Variety**	**Disease incidence**		**Disease severity**	
	Arandell (NY95.0301.01)	2	C	0.03	C
	Corot Noir	14.1	B	0.29	B
	Petit Manseng	14.1	B	0.28	B
	Vidal Blanc	21.1	A	0.52	A
	Treatment	**Disease incidence**		**Disease severity**	
Organic A	Cu (1lb) + $Ca(OH)_2$ (2lb) + Sulfur (2.4lb)	16.4	A	0.32	NS (p=.06)
Organic B	Cu (1lb) + $Ca(OH)_2$ (2lb) + Sulfur (2.4lb) + Serenade ASO (2.4 qt)	11.7	B	0.29	
Conventional	Conventional (Mancozeb 3lb + Prophyt 2pt + Sulfur 2.4lb)	10.4	B	0.24	

zMean separation in columns by Duncan's multiple range test at $P \leq 0.05$ uppercase letters or NS = not significant at $P>0.05$.

Table 3. 2014 season mean disease incidence (percentage of leaves exhibiting diseases symptoms) and disease severity (percentage of leaf coverage) of phomopsis, black rot, and downy mildew per treatment (= Cultivar and Treatment).

Black Rot	Variety	Disease incidence		Disease severity	
	Arandell (NY95.0301.01)	0.01	C	0.02	C
	Corot Noir	0.03	B	0.05	B
	Petit Manseng	0.03	B	0.07	B
	Vidal Blanc	0.06	A	0.14	A
	Treatment	**Disease incidence**		**Disease severity**	
Organic A	Cu (1lb) + $Ca(OH)_2$ (2lb) + Sulfur (2.4lb)	0.03	B	0.06	B
Organic B	Cu (1lb) + $Ca(OH)_2$ (2lb) + Sulfur (2.4lb) + Serenade ASO (2.4 qt)	0.03	B	0.05	B
Conventional	Conventional (Mancozeb 3lb + Prophyt 2pt + Sulfur 2.4lb)	0.04	A	0.1	A
Downy Mildew	**Variety**	**Disease incidence**		**Disease severity**	
	Arandell (NY95.0301.01)	0	B	0	B
	Corot Noir	0.004	AB	0.009	AB
	Petit Manseng	0.006	A	0.012	A
	Vidal Blanc	0.006	A	0.012	A
	Treatment	**Disease incidence**		**Disease severity**	
Organic A	Cu (1lb) + $Ca(OH)_2$ (2lb) + Sulfur (2.4lb)	0.001	B	0.001	B
Organic B	Cu (1lb) + $Ca(OH)_2$ (2lb) + Sulfur (2.4lb) + Serenade ASO (2.4 qt)	0.005	AB	0.009	AB
Conventional	Conventional (Mancozeb 3lb + Prophyt 2pt + Sulfur 2.4lb)	0.006	A	0.014	A
Phomopsis	**Variety**	**Disease incidence**		**Disease severity**	
	Arandell (NY95.0301.01)	0.007	C	0.007	D
	Corot Noir	0.057	B	0.08	B
	Petit Manseng	0.042	B	0.05	C
	Vidal Blanc	0.092	A	0.13	A
	Treatment	**Disease incidence**		**Disease severity**	
Organic A	Cu (1lb) + $Ca(OH)_2$ (2lb) + Sulfur (2.4lb)	0.055	A	0.08	A
Organic B	Cu (1lb) + $Ca(OH)_2$ (2lb) + Sulfur (2.4lb) + Serenade ASO (2.4 qt)	0.058	A	0.08	A
Conventional	Conventional (Mancozeb 3lb + Prophyt 2pt + Sulfur 2.4lb)	0.036	B	0.04	B

zMean separation in columns by Duncan's multiple range test at $P \leq 0.05$ uppercase letters.

Goals and Outcomes Achieved: The study demonstrated that organic vineyard management practices can be successful in the establishment and maintenance of wine grapes in Virginia. Certification was not requested but all USDA's National Organic Program's standards were followed and at the completion of the study all organically managed vines were healthy and produced sound fruit. In the original proposal a benchmark of less than 30% disease incidence and less than 10% disease severity was developed to measure successful management as well as vine health. In 2013, a season that was abnormally wet and certainly not conducive to organic management, the benchmarks were all met except in the case of the disease incidence of downy mildew (Table 2). At 31.1% disease incidence the benchmark was very close to being achieved. Growers throughout Virginia struggled to manage downy mildew disease incidence during the

difficult 2013 growing season. In the 2014 growing season the disease incidence and disease severity benchmarks were met (Table 3).
During the 2014 growing season the first harvest was also conducted and healthy ripe grapes were produced (Table 4.) During the 2014 season bird damage was substantial and arandell was harvested early on 8/22 to ensure the entire crop was not decimated. On 8/26 the remaining varieties where covered with bird netting (Picture 1) but substantial berry loss still occurred in all varieties. The average weight per vine achieved is not representative due to the yield loss caused by bird damage.

Table 4. 2014 growing season fruit chemistry and yield data.

2014 Harvest	Organic Spray A				Organic Spray B				Conventional Spray			
Variety	Arandell	Corot Noir	Petit Manseng	Vidal Blanc	Arandell	Corot Noir	Petit Manseng	Vidal Blanc	Arandell	Corot Noir	Petit Manseng	Vidal Blanc
Brix	18.7	20	24.3	21.7	20.1	20.2	23.9	21	18.8	20.1	24.4	21.5
pH	3.3	3.4	2.7	2.8	3.3	3.4	2.7	2.9	3.3	3.4	2.8	2.9
TA (g/l)	8	7.8	8.5	7.8	8	7.6	9.6	7.9	8	7.6	9.4	8
Average Weight per vine (lbs)	2.7	2.6	1.3	4.9	2.2	3.3	1.4	4.9	2.3	2.2	1.3	4.9

Picture 1. Bird netting installed during the 2014 harvest to reduce bird damage.

Beneficiaries: All Virginia viticulturists benefited from the research conducted in this study. At the time of this report only one Virginia vineyard is managed organically. The rest of the industry could choose to adopt the successful practices developed in this study and then take advantage of the growing organic market. The results of this study will be available to all interested growers and Virginia viticulture extension agents will be able to share the results and lessons learned in the course of the study. Hopefully growers will have confidence to at least include organic practices in their management plans or better yet adopt a strict organic management plan.

Lessons Learned: The most valuable lesson learned in this study is the importance of careful choice of disease resistant varieties at time of planting. Not only are disease resistant varieties vital to the success of organic viticulture management in Virginia but not including disease intolerant varieties in an organic vineyard is also critical. It is common practice to reduce fungal spore populations by removing woody material from the vineyard at the end of the season that may harbor fungal spores. A grower can also reduce the fungal spore population in their vineyard by not planting varieties that are disease prone.

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Additional Information: We are currently submitting a paper for publication with the Journal of Horticultural Technology.

#7 FINAL
Collection and Validation of Environmental Data for Grape and Apple Disease Risk Assessment System
M. Nita
VA Tech

I. PROJECT TITLE

Collection and validation of environmental data for grape and apple disease risk assessment system

II. PROJECT SUMMARY

Initial purpose of the project

This project is a subset of currently on-going project that is to establish an online, map-based disease risk assessment system for major fungal and bacterial diseases of grape and apple in Virginia. The objectives of this proposed study is to evaluate the quality of data from the NOAA, and to develop a model to substitute leaf wetness measurement, which is often used in plant disease models, but not available in regular weather data. In order to achieve these objectives, we propose to place weather stations with several leaf wetness sensors (to measure different part of the canopy) in four geographically separated vineyard and apple orchard locations in VA. Hourly observation of temperature, relative humidity, precipitation, wind direction, and leaf wetness will be made, and these data will be compared against observed weather data from NOAA, and also will be used to either validate a model to estimate leaf wetness period.

Adjustments made to the purpose

Although our goals have not been changed, due to a delay in the map-based system (which is not a part of this proposal), we have adjusted some of objectives for this project. Rather than comparing RTMA data for the map, we have decided to provide weather data collected through our weather station directly so that growers can benefit from it sooner. In addition, on this report, I will spend more space on the effect of canopy and elevation on the leaf wetness, which were new information obtained through our weather stations.

Take home messages from this project

1) We have established a weather station network that covers major grape and apple growing regions in VA
2) We have developed a new website for growers to obtain weather data
3) As we expected, there is a significant benefit of higher elevation, in terms on number and length of wetness event. Lower elevation tends to have more and longer wetness events throughout the season
4) To our surprise, leaf wetness within a canopy resulted in shorter wetness length in many cases. More researches on meso- to micro- scale weather information are warranted
5) Neural network models showed a very promising result as a platform to develop a leaf wetness estimation model

Timeline

Proposed timeline from the proposal

Adjustments and an actual timeline
2012-2013: The PI (Nita) was trained at Campbell Scientific at Logan, UT in April 2012. Order for weather stations were placed in late 2012. The order was delayed due to the time to design the proper weather stations and also an internal ordering issue.
2013: Parts for weather stations arrived in May 2013, stations were build in May-June 2013, and stations were installed at the destinations (Table 1) in June-Sept. 2013. Thus, actual weather data collection was delayed from the original timeline. Since the application of weather data in this project is not time sensitive, the delay was not critical.
2014: In order to provide an access to weather station data, we have developed a web-based database (please see the section 1.2).
2014: Comparisons of weather data from different source (i.e., ambient vs. canopy, differences in elevation) have been made. Modeling of leaf wetness is underway. Preliminary results are discussed in this report.
2014: One of weather station locations (Southern Piedmont AREC) lost its vineyard due to a financial constrain. The weather station was moved to Rees vineyard near Shipman, VA. The new location is in traditionally apple and grape growing area, and will provide a good reference point to nearby growers.
2014: Weather data from RTMA has been collected for a comparison; however, stored in a different database due to a limitation in our database. This issue will be addressed in the near future.

III PROJECT APPROACH

1) Establishment of weather station network

1.1) Weather station installment

We established weather stations at four geographically distant locations (Fig. 1). We selected these locations by following criterions: closeness to existing wine grape or apple production area; elevation (topography at the location); and distance from existing public weather stations (e.g., FAA stations). Each location has grape vineyard and/or apple orchard. At two locations, weather stations were placed at three different elevations (Table 1) to monitor the influence of elevation. Overall, we have sensors installed at 7 vineyards and 4 apple orchards.

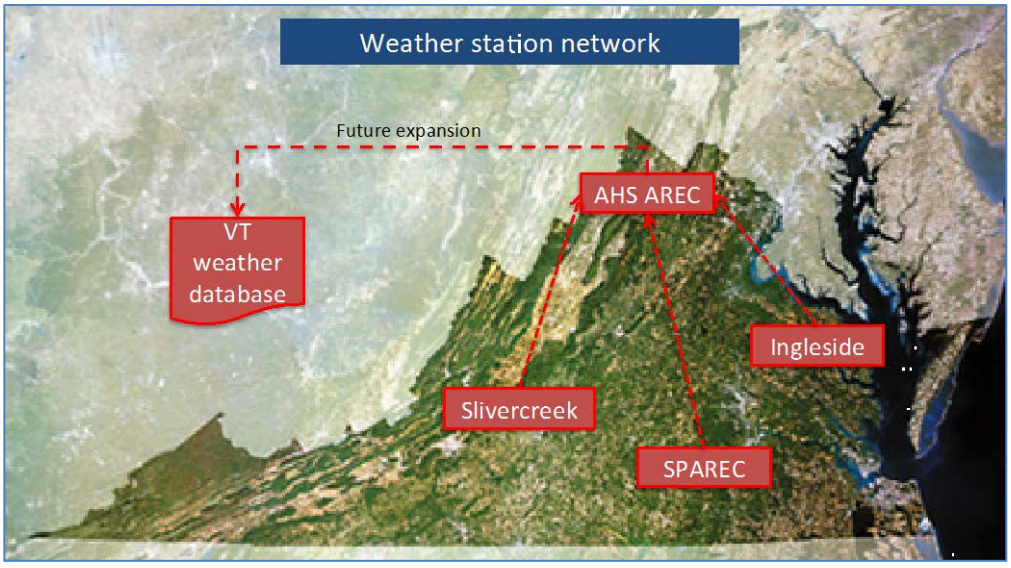
The weather stations were installed in June-Sept of 2013, and each station collected environmental data over the growing season. Measurements made are temperature, relative

humidity, leaf wetness duration, and precipitation using appropriate sensors (Fig. 2). At selected locations (Ingleside, Silver Creek, and SPAREC) wind direction sensor was also added since there were no public weather stations nearby. Temperature, relative humidity, and leaf wetness sensors were placed bot inside and outside of a canopy (Fig. 2) so that we can monitor the effect of canopy to these measurements.

1.2) Weather data collection, and development of a new website for weather and disease risk information

Originally, our plan was to keep data internally; however, number of growers contacted me to share the weather data. Moreover, we have indicated in our timeline that there will be benefit of the project beyond the life of this project. Thus, we have obtained additional funding from USDA EIPM and Southern Region Small Fruit Consortium to develop a web-based database where growers can access to our weather data, as well as some of grape disease models (apple models are under development). Weather data from stations are collected every 6 hours. Disease risks of black rot, downy mildew, Phomopsis cane and leaf spot, and Botrytis gray mold of grape are calculated based on a past 24-hours of weather information. Users can view a daily summary (Fig.3), or specify the dates to either see or download weather data. The URL of the site is <grapepathology.org>.

Figure 1. Overall regional weather station network for this project, communication between



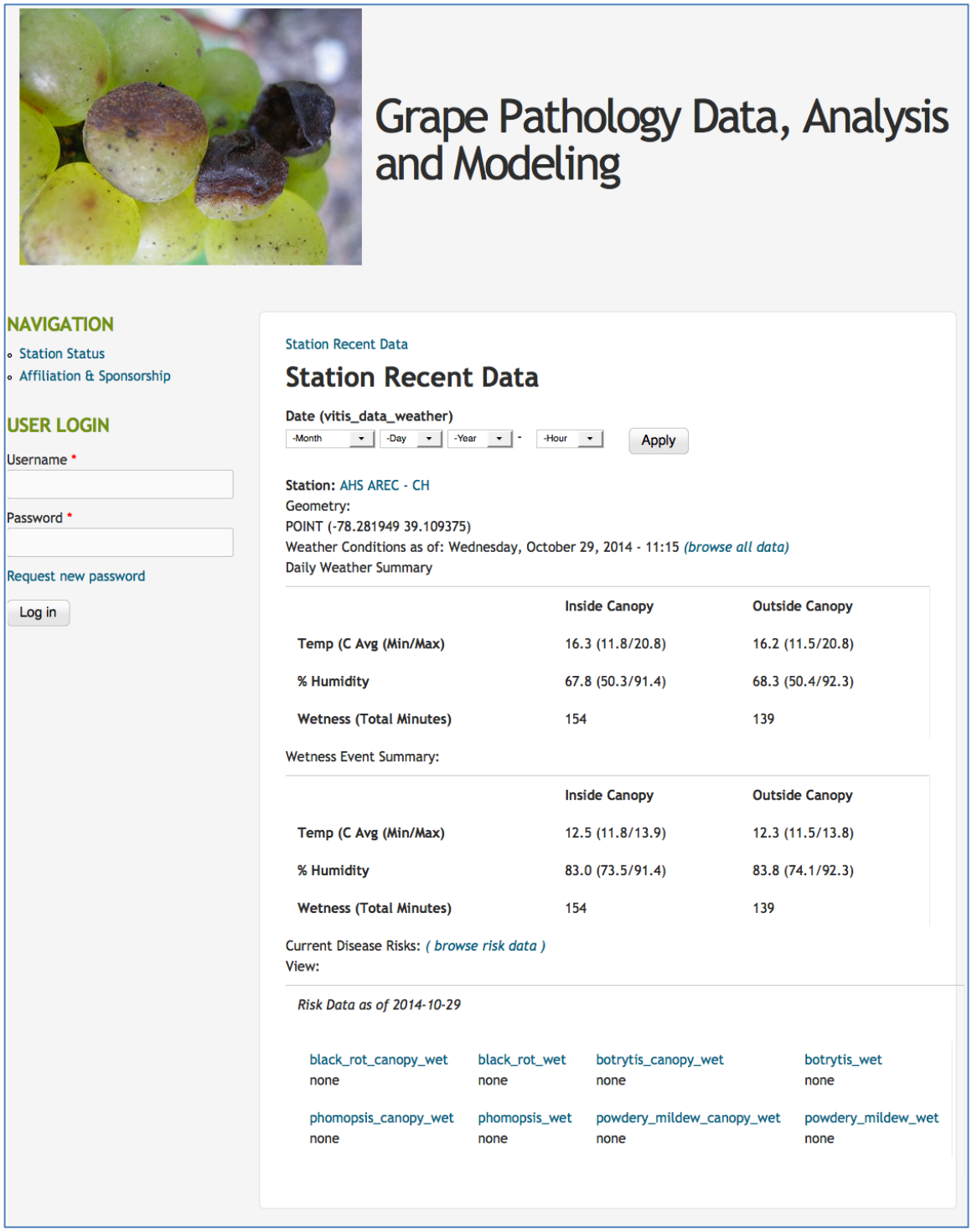
weather station and the base computer at AHS AREC are established either cellular or the internet

Figure 2. An example of installed weather station, and a leaf wetness sensor set up within a grape canopy

Table 1. Information on weather station locations and their attributes

Station name	Location	Attributes
AHS AREC (Weather station network)	Northern VA	• Three stations; 1) lower Chardonnay vineyard (946 ft), 2) lower Apple orchard (908 ft); and 3) higher Organic vineyard (982 ft) (both vineyards are trained in VSP) • The central station communicates with the AHS AREC base at the lab via radio (= up-to-minute information will be available) • Sub-stations communicate with the central station via radio
Ingleside (Single station)	Northern neck	• Commercial vineyard location, but there is an orchard within a few miles • The station will communicate with winery's Wi-Fi, and information will be sent to the AHS AREC base via the internet (= up-to minute information can be obtained)
Slivercreek (Weather station network)	Central VA	• A commercial orchard and vineyard • Three stations were placed at different elevations (700 ft, 900 ft, and 1200 ft) • At each stations, sensors were extended to both apple and grape canopies to take leaf wetness samples • The central station communicates to the base at AHS AREC via cellular network • Sub-stations communicate with the central station via radio
SPAREC (Single station)	Southern Piedmont (2013) Rees vineyard (South central VA, 2014)	• Experimental vineyard location, variety Norton (Geneva double curtain) • A new location has a Cabernet Franc trained in VSP • The station communicates with the AHS AREC base via cellular network

Figure 3. "Grapepathology.org" for hosting weather data, as well as providing daily grape disease risk information



2) Examination of weather data

2.1) Overall summary of wetness events in 2013-2014 seasons

With a total of 8 weather stations, we were able to collect a total of 2,690 wetness events (Table 2). Some are very short interval (only 1 min), but some are long wet event (up to 3,714 min or almost 62 hours).

Table 2. A summary table of wetness events observed in 2013-2014

	Ambient			In Canopy		
	Wetness (min)	Temperature (C)	RH (%)	Wetness (min)	Temperature (C)	RH (%)
Min	1.00	-7.06	33.33	0.00	-7.41	33.23
Mean	327.86	17.47	89.96	242.10	17.44	89.67
Max	3714.00	38.26	100.00	3568.00	32.86	100.00

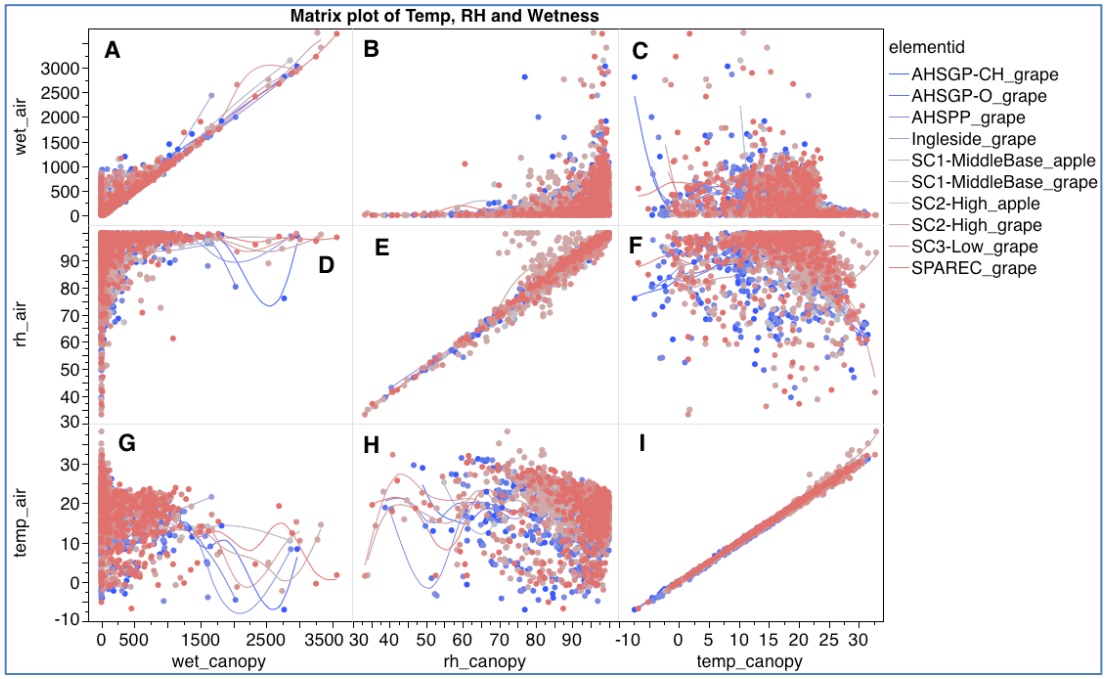
2.2) Comparisons of wetness, temperature, and relative humidity (RH) between in and outside of canopy

As you can see in Table 2, a comparison between wetness duration within canopy and outside canopy were clear. Wetness within a canopy tends to be longer that of outside (ambient) condition. It was bit of surprising finding since both grape and apple canopies are not very dense, thus, we anticipated that we might not see any difference, or we might see longer wetness within a canopy due to the coverage they provide (i.e., longer drying time due to the shadow of the canopy). Please note that they are only 10-30 feet apart from each other.

However, wetness measurements in a canopy were consistently shorter, especially with shorter wetness event. You can see the trend in Fig. 4 panel A, where data points are located above (or the right of) the 45-degree line. The trend is clear on wetness event where a total min is less than 1,000 min (= 16.7 hours). If both ambient and canopy wetness are similar, it should form a 45-degree line, as you see in Fig. 4 panel I, where temperatures within a canopy and ambient were compared. The good agreement in temperature within a canopy and ambient conditions were expected because sensors are cased in a protective housing to avoid direct sunlight.

Relative humidity measurements between within canopy and ambient conditions were relatively similar to each other; however, as with wetness, there are more points located above the 45-degree line with ambient (Fig. 4, panel E).

Figure 4. Visual representations of relationship between wetness measurement, humidity, and temperature in ambient and within canopy conditions



2.3) Elevation effect on temperature, relative humidity, and wetness event

At two of the locations, we placed three weather stations at different elevations. The purpose is to examine the differences of number of wetness events, as well as quality of wetness events in terms of temperature, RH, and amount of precipitation during these wet events. Table 3 is showing a summary of wet events at AHS AREC station where weather stations were placed at an apple orchard (AHS_PP, elevation 908 ft), an organic vineyard (AHS_O, elevation 982 ft), and Chardonnay vineyard (AHS_CH, elevation 946 ft). The locations between weather stations are 350 m between AHS_PP and AHS_O (and about the same distance between AHS_PP and AHS_CH), and 86 m between AHS_O and AHS_CH.

The effect of elevation on the leaf wetness was very obvious at AHS AREC location (Table 3). AHS_O station, which was located at the highest point, had less number of wetness event, and significantly shorter sum of wetness duration ($P < 0.05$), compared with AHS_PP and AHS_CH. In addition, the lowest location (AHS_PP) had significantly higher RH during recorded wetness events. Not surprisingly, there was no significant difference among total amount of precipitation. Thus, the differences in wetness length among these locations are most likely due to the differences in air circulation. Lower elevation tends to experience more stagnant conditions that promote more dew formation as well as less ideal condition for drying of leaves after a rain event. On the other hand, the higher elevation tends to see more air movement, which promotes faster drying of wet surface, as well as lower risk of dew formation.

Table 3. Temperature, RH, and amount of precipitation during recorded wetness hours at AHS AREC 2013-2014, the different letters next to the number indicate a significant difference ($P < 0.05$)

Location code	Elevation (ft)	# of wet event	Sum of Wetness (in min)		Average Temperature in C		Average RH (%)		Sum of Precipitation (mm)	
AHS_PP	908	310	368.22	A	16.86	A	91.36	A	2.19	A
AHS_CH	982	270	345.34	A	16.54	AB	88.47	B	2.04	A
AHS_O	946	262	267.99	B	15.23	B	88.40	B	1.94	A

2.4) Comparison of canopy types (apple vs. grape)

At Silver creek orchard, locations of stations were selected based on the proximity to both apple and grape blocks, so, that we can measure environmental conditions under two different canopies at the same time. When the length of wetness, mean temperature and relative humidity during the wetness events were compared between apple and grape canopies (Table 4), only mean relative humidity at one of station (SC2-High) was significantly different ($P<0.05$), where apple canopy resulted in significantly higher mean relative humidity than grape. Since grape canopy tends to be more open, we anticipated that leaf wetness length will be longer than apple; however, there were no significant difference observed.

Table 4. Comparisons of wetness (in min), average temperature during the wetness event in C, and average relative humidity during the wetness event under apple and grape canopy. Number in parenthesis is a standard deviation, and numbers in bold are significantly different from each other.

Station	Crop	Wetness		Temperature		RH(%)	
SC1-Middle	Apple	253.2	(389.5)	18.2	(6.0)	90.9	(11.3)
	Grape	239.9	(396.5)	18.1	(6.1)	90.1	(11.2)
SC2-High	Apple	215.7	(445.2)	17.8	(6.8)	**90.2**	(11.2)
	Grape	242.0	(467.5)	18.0	(6.7)	**85.4**	(10.2)
SC3-Low	Apple	254.9	(377.0)	17.8	(6.4)	91.4	(11.0)
	Grape	286.8	(370.9)	17.8	(6.4)	92.4	(11.0)

3) Development of leaf wetness prediction models

One of our major objectives was to develop a leaf wetness model(s) that utilize readily available variables (temperature, relative humidity, etc.) from ordinary weather station. The benefit of having such a model is to be able to estimate how long leaves were wet due to either rain or dew event, and it can be used to predict disease development risks. Many disease risk models use a leaf wetness as one of parameters; however the majority of weather station do not have a leaf wetness sensor.

3.1) Examine basic correlations

It would be ideal if there is a straight forward relationship between commonly available measurement and leaf wetness; however, a series of studies showed that it is not the case. Our results also show the similar trend (Table 5). Although the amount of rain had relatively higher correlation coefficient to leaf wetness in ambient condition (0.48) and leaf wetness under canopy (0.52), none of other measurements had a strong relationship.

Table 5. Correlation coefficient among measurements

	temp_air	rh_air	rain_mm	temp_canopy	rh_canopy
wet_air	-0.24	0.39	0.48	-0.24	0.38
wet_canopy	-0.21	0.31	0.52	-0.21	0.30

3.2) Use of nonlinear regression

It was obvious that the relationship between leaf wetness and other variables are linear (Fig. 1, panels B and C), thus, we employed a series of nonlinear regressions to estimate leaf wetness duration using relative humidity level and amount of precipitation (Table 6). AIC, BIC, and R-square are measurements of the fit of the model to the data. As you can see, none of the model had a distinctively higher or lower numbers. R-square values of 0.2-0.28 are very low, even considering we are dealing with environmental data.

Table 6. Non-linear regression models to predict leaf wetness duration using relative humidity.

	Relative humidity			Precipitation		
Model	AICc	BIC	R-Square	AICc	BIC	R-Square
Cubic	56416.24	56447.45	0.22	56085.61	56116.82	0.28
Exponential 2P	56408.50	56427.23	0.22	57032.13	57050.86	0.08
Exponential 3P	56408.25	56433.22	0.22	56585.86	56617.07	0.18
Gompertz 3P	56410.86	56435.83	0.22	56135.70	56160.67	0.27
Mechanistic Growth	56408.25	56433.22	0.22	56087.23	56112.20	0.28
Quadratic	56484.11	56509.08	0.20	56166.66	56191.64	0.26

3.3) Use of multivariate regression

Since a simple factor model did not yield a good result, we have also examined a multivariate regression, using a combination of different factors, and variation of factors to predict leaf wetness duration. One of the best resulting models is shown in Table 7. The R-square value of the model is 0.54, which is a big improvement from single variable models. However, the model is very complicated, and there is no biological bearing to it.

Table 7. Multivariate regression to predict ambient leaf wetness duration using a combination of ambient temperature, relative humidity, amount of precipitation, and time of the wet event.

Term	Estimate	Std Error
Intercept	-1747.182431	72.59630463
rain_mm	46.30847688	2.225231691
rh_air	23.9769684	0.745367725
temp_air	-14.57305168	0.756843478
(rain_mm-2.42661)*(rain_mm-2.42661)	-1.250866412	0.097146123
(rh_air-90.0921)*(rh_air-90.0921)	1.281565874	0.077621187
(rain_mm-2.42661)*(temp_air-16.9151)	-3.153614783	0.179441204
(rh_air-90.0921)*(temp_air-16.9151)	-0.286270844	0.063158766
(rain_mm-2.42661)*(start_time-3.48e+9)	4.00E-07	9.97E-08
(rain_mm-2.42661)*(rain_mm-2.42661)*(rain_mm-2.42661)	0.007526853	0.001086748
(rain_mm-2.42661)*(rain_mm-2.42661)*(rh_air-90.0921)	0.03199098	0.003801539
(rain_mm-2.42661)*(rh_air-90.0921)*(rh_air-90.0921)	0.059156974	0.009027747
(rh_air-90.0921)*(rh_air-90.0921)*(rh_air-90.0921)	0.015089648	0.001574023
(rain_mm-2.42661)*(temp_air-16.9151)*(temp_air-16.9151)	-0.146802597	0.017423181
(rain_mm-2.42661)*(rain_mm-2.42661)*(start_time-3.48e+9)	-2.00E-08	1.75E-09
(rain_mm-2.42661)*(rain_mm-2.42661)*(rain_mm-2.42661)*(rain_mm-2.42661)	-1.55E-05	2.68E-06

3.4) Use of a neural network model

Due to the complex nature of leaf wetness, a number of studies suggested the use of more computationally intensive analyses, and one of the methods is a neural network model (Francil and Panigrahi 1997; De Wolf and Francl 2000). An neural network model is a distributed information processing system that originated in research on a mechanical analogue of neuron behavior (McCulloch and Pitts 1943). Recent application of the model is a group of pattern recognition models for classification, optimization and prediction problems (Ripley 1996).

For the analysis of leaf wetness duration, we employed a very simple model (Fig. 5). It consists of three parameters in an input layer, and using the hyperbolic tangent function (a sigmoid function) as an activation function. Please note that there will be numerous combinations can be used, but the current purpose was to examine whether a neural network model is suitable or not. Thus, we kept our model as simple as possible. Using JMPPro 10 (SAS institute, Cary, NC), the model used randomly selected 67% of dataset to train (or build) the model, and rest (33%) to validate the model.

The results are shown on Table 8. The first model used unmodified fit option and the second model used robust fit, which minimize the impact of response outliers. Our dataset contains about 5 outliers (i.e., unusually long wetness duration), thus, use of a robust fit method probably is the best approach. Based on high R-square values from model 2 (0.68 for training and 0.72 for

validation), a neural network model seems to be a good candidate for leaf wetness estimation tool.

Figure 5. A diagram of neural network model used to predict leaf wetness duration using air temperature, relative humidity, and amount of precipitation. The hyperbolic tangent function was used as an activation function.

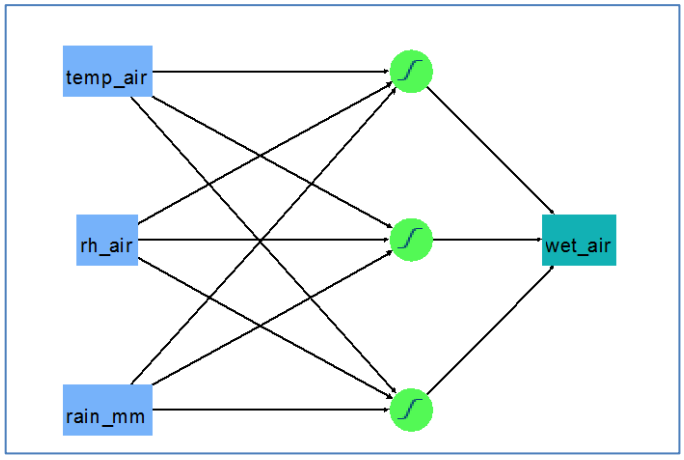


Table 8. Results of two neural network models. Models 1 and 2 have the same parameters, but model 2 uses a robust fit method to reduce the effect of outliers.

	Model 1		Model 2	
wet_air	Training	Validation	Training	Validation
RSquare	0.43	0.50	0.68	0.72
RMSE	335.74	321.10	335.72	337.07
Mean Abs Dev	210.73	202.72	191.51	183.84
-LogLikelihood	18377.59	9132.19	17648.09	8772.14
SSE	286310549.80	130946074.61	286273383.12	144291126.27
Sum Freq	2540.00	1270.00	2540.00	1270.00

3.5) Other models to be considered

We used two different approaches: 1) empirical model using regressions and 2) neural network model. The other potential models to be considered are 1) CART (Classification and Regression Trees), and 2) mechanistic model. The first approach will use a series of decisions to define a condition(s) for leaf wetness development. The second approach will use more physiological properties using a series of differential equation. We will examine these using the data obtained from this project.

Summary of the project

We have established a weather station network that is targeting major apple and grape growing regions in VA. Data are collected every 6 hours and stored on a web-based database where growers can have an access. Effects of elevation and canopy types are determined, and several candidate models for leaf wetness estimation have been developed. Obviously, there will be

more analyses are needed to refine our findings, but I believe majority of proposed goals are achieved.

VI Goals and Outcomes Achieved

1) Achievement of the proposed goals
    a. We have established a weather station network that covers major grape and apple growing regions in VA.
    b. Effects of elevation and canopy differences on leaf wetness duration have been characterized
    c. Leaf wetness models were developed. Using the obtained data, we will finalize model development in the near future for a publication of our results.
2) Achievement beyond proposed goals
    a. We have developed a new website that hosts our weather data as well as grape disease risk predictions.
        i. Apple disease risk models are under development
3) Adjustment made to the proposed goals
    a. One of proposed goals was to evaluate data quality of RTMA, but it is not reported in here. However, RTMA data are collected, and as soon as we figure out how to integrate two databases (one is hosting RTMA and other one is hosting our weather data), we will make a progress on this goal.

IV Beneficiaries

1) Apple and grape growers in the central, south central, northern, and northern neck regions.
    a. In terms of apple, we are probably covering more than 90% of production area. For grape, probably more than 75-80% of production area is covered.
2) Another potential impact is the use of the database to predict insect risks for apple and grape. The same database can be used for other crops, but relative impact will be low since these stations are placed in vineyards and orchards.

V Lessons Learned

1) Deployment of weather data has been received very favorably among growers
    a. Although the site information was disclosed to only a few key growers, the response has been very positive
    b. Weather data is important not only for pest management, but also visualizing abiotic factors such as spring frost events and ultra low temperature during winter months.
2) Setting up weather stations take a lots of time and effort
    a. None of the location is identical
        i. Each station has to be build for the site
    b. Wireless connection using a Wifi has been a bottle neck
        i. Very important information to know since having a cable connection can be expensive.
3) Development of web-database can be tricky
    a. Some of “unlimited” service are not truly unlimited
        i. For our service, we can develop unlimited number of databases, but each database has to be less than 1 GB in size.
    b. We are still working on the best presentation method (web interface) for our site.

VI Contact person

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VII Additional Information

Extension, education, and research presentations in 2011-2014 that contained information from this research project

Nita, M. (2014) "Grape Pathology Program at Virginia Tech's AHS AREC" Lecture provided for Plant Biology, University of Maryland Eastern shore 29 April 2014
Nita, M. (2014) Disease Management for wine grape production in Georgia with consideration of hybrid varieties, 4th annual wine grape symposium, GA 5 May 2014
Nita, M. (2014) Fungicide trial updates on powdery mildew, downy mildew, Botrytis and late season rots. Little Britain IPM workshop at Chester, PA 8 January 2014
Nita, M. (2014) "Fundamental of Grape IPM" Beginning grape growing at Virginia Vineyards Association Winter Technical meeting and Trade Show, Charlottesville, VA, 30 Jan 2014
Nita, M. (2013) "Fundamental of Grape IPM" Beginner's Grape Growing Seminar, AHS AREC, 11 April 2013
Nita, M. (2013) "Grape Pathology Program Updates" VT-PSU Field day, 10 Sept 2013
Nita, M. (2013) IPM Workshops (co-organizer, a full-day program, typically provide 60 min presentation and lead panel discussions): 27 March Stone Tower Winery, 9 April Barren Ridge Vineyards
Nita., M. (2013) "Introduction to Wine Grape Production and Cooperative Extension in Virginia" Shanghai Agricultural Commission Group visit 6 Nov. 2013
Nita, M. and Kelly, T. (2012) "Fundamentals of IPM" as a part of Vineyard Establishment and Operation Primer, Virginia Vineyards Association Winter Technical meeting and Trade Show, Charlottesville, VA, 2 Feb 2012
Nita, M. (2012) "Fungal disease updates and advance planning for the 2012 season" Virginia Vineyards Association Winter Technical meeting and Trade Show, Charlottesville, VA, 2 Feb 2012
Nita, M. (2012) "Grape Pathology Program Updates" VT-PSU Field day, 12 Sept 2012
Nita, M. (2011) "Grape Pathology Program Updates" VT-PSU Field day, 14 Sept 2011

Reference used in the report

De Wolf, E. D., & Francl, L. J. (2000). Neural Network Classification of Tan Spot and Stagonospora Blotch Infection Periods in a Wheat Field Environment. *Phytopathology, 90*(2), 108-113, doi:10.1094/PHYTO.2000.90.2.108.

Francil, L., & Panigrahi, S. (1997). Artificial neural network models of wheat leaf wetness. *Agricultural and Forest Meteorology, 88*, 57-65.

McCulloch, W., & Pitts, W. (1943). A logical calculus of the ideas immanent in nervous activity. *The bulletin of mathematical biophysics, 5*(4), 115-133, doi:10.1007/BF02478259.

Ripley, B. D. (1996). *Pattern recognition and neural networks*: Cambridge university press.

#8 FINAL
Profitable Cilantro Production in Virginia
VA Pumpkin Growers Association

I. Project Summary

• The purpose of this project was two-fold. First, in order to provide the best available information to our producers, we wanted to conduct research with a vacuum type planter. Secondly, the vacuum planter would be available for producers to use on their own farms. This would allow them to see the benefits of a vacuum planter fist hand.

• We have a solid market for cilantro. The company interested in this commodity is very reputable and has done business in Southwest Virginia for many years. This business is also willing to offer a predetermined contract price, which is almost unheard of in the fresh produce business.

• The overall goal of this project is to make Southwest Virginia the prominent cilantro growing area in this region of the country. With high fuel prices, along with demand for local produce, buyers are looking for East Coast product. The Blue Ridge Plateau of Southwest Virginia can fit this bill with cool summer temperatures and easy access to most of the Eastern Seaboard.

• We have an excellent Greens Program that has continued to grow over the last several years. The value of this program to the region's producers last year was over $850,000. This year's sales will exceed $1,250,000, if the weather permits. We have worked for several years to add cilantro to our successful list of greens products but have struggled to do so in large part, we believe due to the standard types of planters that we have used. We have a standing order for 4,000 boxes per week at an economically acceptable price. We have believed that if we could go to a five row monosem-type planter that we could actually get product planted thick enough to make it a good crop for the region. One of the largest costs to actually growing cilantro is harvesting. If the crop is thick enough, the growers can harvest it several times faster than they can if the is crop planted by a standard planter. Based on what we have seen by using the planter that we have leased with this grant our thoughts are correct.

II. Project Approach

• During the first year of the trial, a seed bed version of a Monosem vacuum planter was procured for use in the trial. The planter's ability to work in the rocky soils of Southwest Virginia was evaluated at two separate sites. This planter was designed for use on very fine, well prepared soils and did not work well in the soils found in Southwest Virginia.

• During the second year of the trial, a second Monosem planter was procured. This planter was designed to handle the rockier soils of Southwest Virginia. Due date it appears to be suitable for planting cilantro on and around the Blue Ridge Plateau area.

• In order to be able to recommend the "best" to the producers, a variety trial was conducted. 'Santo' was found to be the most consistent and one of the highest yielding varieties. The quality of 'Santo' was as good as or better than any other variety evaluated.

• Weed control is another issue facing growers. Cilantro is a low growing crop that must be hand harvested. Therefore, in order to maintain quality and minimize expenses excellent weed control is essential. Several herbicides have recently been labeled for use in cilantro. A cilantro herbicide trial was conducted. Results revealed several products to be very safe to the cilantro and efficacious in controlling the weeds found in Southwest Virginia. Products like Dual Magnum, Linuron, Caprol and Nortron all have potential. However, the best scenario appears to be to apply Linuron preemergence, followed by Dual Magnum at cilantro emergence and Linuron postemergence at 14 to 21 days after seeding. This treatment provided 99 to 100% control of all weeds.

• Another production issue of concern is adequate water. Therefore, an irrigation trial was to have been conducted in 2013. However, the extremely wet season made irrigation irrelevant. Growers will likely need irrigation during periods of drought, especially during germination.

• Another issue was that of harvest labor. When beginning this effort, some growers were paying almost $10 per box to harvest the cilantro. Many people had to pay at least $5 per box. Obviously, at $10.50 per box, this did not leave much profit for the grower's pocket. Therefore, the business wanting the cilantro produced sent a man that had harvested cilantro for many years to the Blue Ridge Plateau area to demonstrate harvest. After the demonstration and discussion of labor saving techniques, a grower that had been paying over $5 per box, lowered his harvest costs to between $3.00 and $4.00 per box.

• R. Allen Straw and Kevin Semones were both involved in the procurement of the planters. R. Allen Straw was also involved in the planting and evaluation of the trials. Kevin Semones has been involved in the administration of the project. The planter was leased by the Virginia Pumpkin Growers Association. It was not purchased by the Virginia Pumpkin Growers Association. We fully understand that we were not allowed to purchase such equipment with grant money. The word procure was used because of the struggle we had to find someone to lease such a machine from and secondly it took a lot of work to assist the lessor to find the machine that was properly equipped for the job. As we have stated no one in our region had a five-row monosem seeder and the total amount was under the 20% variance.

• As with any research project that we have completed, we encourage growers to come by, and in many cases, assist us with the research work. We always use hands-on education first if possible. There is no way to better educate a group of people than by them seeing it done and/or helping to do it. Secondly, all research information gained from each year's work is passed on at the next year's production meeting for the crop. We have an annual greens production meeting at which all information gathered from the research is passed onto the growers. The greens production meeting is held in March of each year. Thirdly, Dr. Straw speaks at various grower meetings around the state as well as hundreds of growers individually. The market also works with the growers on an individual basis.

III. Goals and Outcomes Achieved

• The primary activity critical to the success of this project was the procurement of a Monosem vacuum planter for research and demonstration purposes. Variety and herbicide trails were also conducted to provide production information to producers.

• The goal was to be producing 3,000 to 5,000 boxes of cilantro each week by the 2013 season. However, production issues during the extreme heat of 2011 and 2012 caused many growers to back away from cilantro production. Another issue has been that of labor. Cilantro harvest is very time consuming and can be quite expensive if workers are not familiar with the crop. However, at present it appears there will be at least 40 acres, and possibly 60 or 70 acres of cilantro planted on and around the Blue Ridge Plateau in 2014.

• Again, the goal was to be producing 3,000 to 5,000 boxes of cilantro per week by the end of this study. The 50 acres anticipated for 2104 should equate to 2,500 to 5,000 boxes of cilantro per week for a 10 to 12 week production window.

• The projected production in 2014 will come very close to reaching the goal of 3,000 to 5,000 boxes of cilantro produced each week. Since this is a new crop to our area, the baseline was essentially zero.

IV. Beneficiaries

• The beneficiaries of this project are the producers on the Blue Ridge Plateau, but also growers adjacent to the Plateau. Production will likely start at the lower elevations in the early spring move to the cooler regions of the higher elevations for the summer months and then possibly back to the lower elevations for fall.

• Depending on the yields per acre, 50 acres of cilantro should produce from 25,000 to 50,000 boxes of product, annually. At the contracted price of $10.50 per box, this would equate to a gross income of $262,500 to $525,000, annually. This would equate to approximately $5,000 to $10,000 per acre in gross revenue. With production costs of $3,000 to $5,000 per acre (most of which is harvest labor), this would result in net returns of $2,000 to $5,000 per acre to producers.

V. Lessons Learned

• Always take the weather into account. The first year of this trial was abnormally hot and dry, making cilantro production extremely difficult. Therefore, during the second year plans were made to address the heat issues on yield and quality. However, it was an extremely wet season and irrigation was never needed.

VI. Additional Information

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Southwest Virginia Farmer's Market

#9 FINAL
Facilitating the adoption of GAP, GHP and GMP plans in Virginia through the development of planning tools and the coordination of outreach education

I. Project Summary

- **Background:**
  In 2010 Appalachian Sustainable Development (ASD) was provided with a one year grant from VDACS that aided ASD in its work to support (among other things) the dissemination of Good Agricultural Practices (GAP) training to area farmers. The purpose of this request was to continue this project for another year in order to provide GAP training for new and transitioning farmers. The project leveraged the success we had in providing 12-hour GAP training sessions (including take home notebooks and DVDs and an on-farm session) to growers in our region.

- **Motivation:**
  The motivation for this project was primarily based on the fact that the wholesale produce industry is increasingly requiring GAP and Good Handling Practices (GHP) certification – at a minimum. (At this time smaller direct markets are not requiring such certifications.) Many farmers are ill-equipped to obtain these certifications and are at risk of losing markets because of it. ASD's proposal included creating model Good Manufacturing Practices (GMP) and GHP facilities and instructions to help farmers understand what is involved and to create scale-appropriate models. In order to make these processes more understandable, ASD also planned to work with area consultants and VA Cooperative Extension (Extension) to assist local and regional farmers with procedures for on-farm washing and packing of local produce.

II. Project Approach

- **Summary of Activities and Tasks Performed During Grant Period**
  Through its Appalachian Harvest (AH) network, ASD works with dozens of growers selling certified organic produce to major regional buyers such as Ingles, Whole Foods and Earth Fare. Currently, these wholesale buyers are driving the need for growers to address GAP certification. Food City, in Abingdon, VA, currently requires GAP certification for all produce. Produce Source Partners, Ingles, Horton Fruit, and others began requiring this certification this season.

  To address this situation ASD staff, with the help of Extension, developed a comprehensive manual and training course and refresher course to assist growers in meeting the standards of the GAP program. In the spring of 2011, over 50 Appalachian Harvest growers were expected to participate in this intensive training course that would result in each participant's farm being certification-ready should the need arise. These trainings were designed to assuage growers' fears about GAP certification and also to encourage farmers to make the necessary changes on their farms to better address the safety of food grown in Virginia.

  The following steps were taken to facilitate the outcomes of this grant:

1. ASD and Extension assessed current GAP/GMP curriculum and implemented necessary modifications in accordance with changes in the Food Safety Standards and produced 75 manuals and 50 supplemental inserts for previously printed manuals.
2. ASD and Extension conducted 6 group classroom sessions for GAP/GMP processes, with 148 participants.
3. ASD and Extension conducted 54 one-on-one training sessions with Virginia farmers.
4. ASD and Extension collaborated to assess the Appalachian Harvest packinghouse facility to develop processes and create a model facility training site.

5. ASD and Extension identified solutions and created a training model for on-the-farm small scale producers.
6. Using these grant funds, ASD purchased the following to be checked out by packing facilities for the purpose of addressing facility sanitation needs:
    a) Wet wash/dry Vac floor sanitizer
    b) Backpack power blower/sprayer to ensure full coverage and application of sanitization solutions to all contact/surface areas.
    c) Contracted with local filming company to record GAP/GMP overall training session and produce 15 copies to be distributed to Extension agents, local Food Hubs and other farmer training advocates to ensure that training providers across the state deliver consistent training and training materials.
7. Three Virginia packinghouse facilities signed out and utilized the sanitation implements to ensure facility cleanliness prior to their inspections; we anticipate more utilization of these tools in future seasons. SOP's were written, reviewed and provided to each packing facility prior to checking these items out from the AH facility.
8. Using these grant funds, ASD purchased a HP Desk Jet3052A portable printer to be utilized by ASD staff and Virginia Cooperative Extension when traveling to Virginia family farms and assisting with the production and printing of the farmer's GAP and/or GHP manuals.

- **Role and Significant Contributions of Project Partners**
  With support from this one year VDACS Specialty Crop grant, ASD has built upon our successful and solid partnership with Virginia Cooperative Extension to widen the outreach of GAP training to train (or refresh) 150 participants in large group, small group and 1:1 sessions focusing on GAP and GHP. ASD in partnership with Extension developed a similar manual and 1:1 training for the development of GMP (Good Manufacturing Practices) plans for farmers and packinghouse operations in Virginia seeking this additional certification for their farming operations.

III. Goals and Outcomes Achieved

- **Activities completed in order to achieve the performance goals and measurable outcomes**
  Goal 1 GAP training for growers: By June of 2012, ASD and Virginia Cooperative Extension plan to have trained at least 200 farmers in GAP food safety plans. We expect at least 75 of those to be GAP certified.

  Results: ASD and Extension trained 145 farmers in GAP food safety plans. 50 of those have become GAP certified and/or have been re-inspected broadening their certification to GAP & GHP. At present, there are at least 5 additional Virginia producers who have submitted their request for inspections and are waiting to be scheduled for a 2012 inspection. Training logs, farm review records, and GAP certificates were maintained to track the success of this goal.

  Goal 2 GHP training for packinghouses and packing sheds: Work with Wythe Morris and Allen Straw of Virginia Cooperative Extension to develop a training manual and CD for Good Handling Practices (GHP), test the efficacy of the manual using the Appalachian Harvest Packinghouse Facility in Duffield, VA as a model facility, and conduct 4 regional training sessions for packinghouse operators and farmers with packing shed operations in the spring of 2012.

  Results: Our work with Wythe Morris and Allen Straw of Virginia Cooperative Extension to develop a training manual and CD for Good Agriculture Practices and Good Handling Practices (GHP) was successful. We were able to test the efficacy of the manual using the Appalachian Harvest packinghouse facility in Duffield, VA as a model facility, and conducted 4 regional training sessions for packinghouse operators and farmers with packing shed operations in the spring and summer of 2012. The packinghouse facility assessment required a variety of GAP/GHP implementations:

  (1) Lined and identified employee travel and product paths

(2) Numbered pest management stations
(3) Added food grade contact surfaces or required separation distances
(4) Created two additional hand washing stations for farmers and employees
(5) Developed sanitation unit cleaning logs and record keeping binders for all other areas of food safety record keeping. Training logs, record keeping binders and packing facility visitation records were maintained to ensure the success of this goal.

Goal 3 AH Post Harvest Training Site: To set up the Appalachian Harvest packinghouse facility as a model packinghouse for food safety compliance, including a smaller scale model that will represent a packing shed operation on a medium to large scale produce farm.

Results: In partnership with Virginia Cooperative Extension the Appalachian Harvest packinghouse facility was established as a model packinghouse for food safety compliance, including a smaller scale on-site model that represents a packing shed operation for small scale producers. This model can be easily replicated at low cost for small scale producers. Twenty-four (24) GHP manuals with supportive SOP's were created and provided to these producers. The facility also serves as a model facility for those medium to large scale produce farms that have on-site packinghouses. Four (4) GHP manuals have been created and distributed to these larger scale producers.

Goal 4 GMP Training for Food Processing Facilities: ASD will work with Virginia Cooperative Extension and the Virginia Tech Department of Food Science and Technology to develop a training manual and CD for Good Manufacturing Practices (GMP). ASD will work with People Incorporated of Abingdon, VA to develop a model kitchen for demonstrating GMP compliance as a part of their effort to develop a kitchen incubator in Washington County, VA.

Results: People Incorporated of Abingdon, Virginia was not able to provide the facility for this goal to be accomplished as originally planned. However, ASD worked with Virginia Cooperative Extension and the Virginia Tech Department of Food Science and Technology to discuss next steps for a comprehensive training manual and CD for Good Manufacturing Practices (GMP) that could be inclusive of packaged fruits and vegetables, value added products and processed goods. ASD will continue to work with Extension to develop a model kitchen for demonstrating GMP compliance as a part of their effort to develop a kitchen incubator in the southwest Virginia region. ASD and Extension have already hosted a farmer and community-based meeting to discuss such a facility including identifying potential partners and stakeholders. There is consensus of a genuine need for this component in our very rural region. A facility of this nature could increase Virginia farmer's profitability and expand their product lines. However, a more in-depth study of necessary equipment costs, facility criteria (e.g. city water & sewer), and costs of implementing GMP processes needs to be conducted. ASD will continue to explore this opportunity and seek additional partners and grants that can help fund the expertise and necessary capital investment to accomplish such a facility successfully.

Goal 5 On-Farm / Facility Technical Assistance: ASD and Virginia Cooperative Extension will follow up with each participant in our training courses – 2 times per year with GAP trained producers and at least 1 time per year for GHP and GMP trained operations. This is essential to both ensure that food safety practices are being implemented and also to identify and gaps or shortcomings with the training courses that can be fixed.

Results: ASD and Extension have followed up with each participant in our training courses a minimum of 2 times with GAP trained producers and at least 1 time per year for GHP trained operations. This is essential to both ensure that food safety practices are being implemented and also to identify any gaps or shortcomings with the training courses that can be fixed. Farmer/producer/facility visitation logs have been maintained to ensure the success of this goal.

- **Comparison of actual accomplishments with goals established for reporting period**

ASD and Virginia Cooperative Extension have trained farmers in 2 different settings, formal classroom settings and on-the-farm. We celebrate the many successful achievements of GAP & GHP certification by Virginia family farmers. Growers are still experiencing challenges in accomplishing their required paperwork and framing the implementation of their processes from farm operations to print. ASD and Virginia Cooperative Extension learned that while several producers had completed paperwork, mock audits, and had good intentions, their limited incomes prohibited them from scheduling their GAP inspections for 2012. Virginia family farmers at this level have already encountered additional costs for their farming operations associated with the implementation of GAP & GHP; therefore, an additional layer of costs from a 2012 inspection could not be absorbed by their farm business. Both, ASD and Virginia Cooperative Extension are currently searching for additional support to help offset the inspection costs with possible cost-share opportunities from other agriculture and local food system advocates. ASD was able to assist 10 farmers with a cost share opportunity of $300 per farm (the limited number of farms that qualified based on their audit-readiness during the timeline of the supplemental grant ASD received). Virginia family farmers whose small scale production financially prohibited them from accomplishing GAP certification during 2012 were also assisted by ASD in helping them find more direct markets and connecting them with additional farmer's market opportunities in hope to supplement their family farming operations until funds can be located to help offset the costs of GAP certification for small scale producers.

IV. Beneficiaries

- **Groups and other operations benefiting from the completion of this project's accomplishments:** This project has been supported by Virginia Tech Cooperative Extension, Virginia Produce, Produce Source Partners, and the Wallace Center. These partners bring their expertise in policy work, agriculture, education, production, and marketing and distribution to this project with energy and enthusiasm. The work that has been accomplished with funding from the previous VDACS grant has been greeted with enthusiasm from all parties. All are engaged and eager to proceed with providing this assistance to more farmers and expanding these efforts into facilities and post harvest efforts. Virginia consumers are considered to be key beneficiaries of this project as well. Without support and supportive grants from VDACS, and specialized support from the aforementioned partners, Virginia consumers would not have the benefit of still purchasing a vast variety of fresh, Virginia Grown fruits and vegetables.

- **Quantitative Data concerning beneficiaries or the potential economic impact of the project.** If Appalachian Harvest farmers had not been trained, the buyers available to them would have shrunk from 11 to 2 with the only buyers still an option for non-GAP certified farmers being two Whole Food Distribution Centers: Whole Foods South and Whole Foods Mid-Atlantic. This would have represented a reduction of 87% in sales. (To put this in perspective, sales through August for Appalachian Harvest were $815,567, with $571,167 going to farmers in the region.)

V. Lessons Learned

- **Insights from project staff into positive and negative lessons learned:**
  ASD has learned that one key ingredient in making our work with farmers easier and more flexible in customizing for each farm is the use of technology such as computers, printers, and laminators. However, for a vast majority of farmers using these tools is their weakest skill. One farmer in the Richmond area told the General Manager of Appalachian Harvest, "I'm 62 years old and have farmed all of my life. I have an adding machine and a cell phone, but have never owned a computer and wouldn't know how to turn one on." While his intentions and need to become GAP certified are strong and while it is not impossible to create a GAP manual and relevant SOP's manually, it is more practical for ASD to utilize available technology to streamline this

task. Therefore, there is a proven need for ASD (and Extension), to continue this work and provide the much needed 1:1 training and written food safety plans with farmers utilizing our technology to their benefit. Depending upon the individual farmer's time constraints this objective can often require several meetings/sessions to arrive at a final product for the farmer.

While it is vital for Virginia farmers to obtain the minimum of GAP certification in order to maintain their markets, many farmers continue to struggle with the cost of implementing these processes and certification costs. Whole Foods Market continues to work with local family farmers and at present does not require GAP certification. They do however require documented protocols for a variety of products and additional insurance coverage from farmers growing certain products. This is the only large scale wholesale to retail buyer that we are aware of who does not require the minimum of GAP. However, Whole Foods can only take a certain amount of product and this poses additional steps/costs to the aggregators and /or distributors handling non-GAP and GAP products. Once GAP certified boxes are received in a packinghouse facility, they must remain separate from non-GAP boxes in order to maintain food safety integrity. This makes the logistics and practicality of handling both GAP and non-GAP more costly with additional processes and associated required documentation.

- **Unexpected outcomes or results:**
  During this summer's organic inspections being conducted by a sub-contractor of Quality Certification Services, ASD received an unexpected and complimentary letter. This letter was from Mac Stone, a representative of Kentucky's Cooperative Extension Program. The letter commended ASD for our training and work in the areas of organic agriculture and food safety, noting that small, medium and large scale producers need more organizations such as ours doing this "hands on" support for farmers. ASD was very appreciative of the time taken to formally document the importance of our work. We remain very grateful and very humbled that VDACS continues to support our efforts and our passion to keep Virginia Family Farming productive and utilizing their agriculture landscapes to produce safe, healthy, locally grown food.

VI. Additional Information

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#10 FINAL
Determining the Feasibility of Designing and Operating a Multi-use Food Processing Facility in Central Virginia

I. Project Summary

The primary key goal of this project was to determine whether a small, locally situated processing facility could make it feasible for vegetable farmers and growers to add net income to their farming operations through co-packing their produce for use or re-sale; outright sale of their produce at a fair price; or using a local processing center and their staff to process their produce for a price. These types of services are not currently available for farmers in the region. An additional service to be studied was the feasibility of purchasing seconds, which may not be saleable in other markets. Primary processing services offered, at least initially, would be canning and jarring of fruits and vegetables for resale.

The study focused around developing these opportunities with an existing cannery in Prince Edward County (PEC), Virginia. The PEC cannery is one of only a handful of such facilities remaining in Virginia which offers individuals and organizations the opportunity to "home can" and otherwise further processes certain food items.

There were several reason for focusing on PEC. As already pointed out, the physical infrastructure is in place. It is very centrally located in the state with close proximity to major consumer markets. And the Virginia Tobacco Commission, which distributes tobacco settlement dollars for the purposes of economic development in tobacco dependent counties, had provided the county a substantial financial investment for infrastructure needs months prior to the grant application being filed.

There is an established produce industry in the region and at the same time some new and existing farmers are interested in growing produce in the region. In this specific instance much of this can be attributed to 3 things;

1. PEC is a "tobacco dependent county" meaning that tobacco was once a major crop not only in the county but the entire region. As the tobacco industry and production practices change dramatically, many farmers are looking for ways to transition out of tobacco into new crops, using land they already have.
2. Current farmers, and a growing interest from potentially "new" farmers across the U.S., clearly understand the added value they can achieve through further processing of their farm production.
3. If done correctly, significant income can be derived from fairly small acreage when looking at fruits and vegetables, especially if value added opportunities are readily available.

In addition, regional governments in Southside Virginia, which is still rural and agricultural, are beginning to embrace the idea of value added agriculture as a potential economic development tool. With the changes in the tobacco industry, coupled with the demise of small and large manufacturers which were once the backbone of these communities, this region has become economically distressed. County and regional support for these types of projects is growing; these early entrepreneurial activities will hopefully result in models which can be replicated in other parts of the state and region.

II. Project Approach

Upon being awarded the grant in 2012, the steering committee developed and distributed requests for proposals (RFP's) from individuals or companies qualified to conduct such research. The project leaders received proposals from 3rd parties capable of performing the tasks outlined in the application. The primary goal of the applicant was to assess the feasibility of creating and operating a facility where Virginia-grown food and other specialty agriculture products can be processed safely and affordably in Central Virginia. This project and those involved were focused on specialty crops throughout the project.

After reviewing applications in response to the RFP, the steering committee selected Smithson Mills, Inc. (SMI), an agricultural consultant from North Carolina with an extensive background in this particular area. A contract between the Virginia Foundation for Agriculture, Innovation and Rural Sustainability (VAFAIRS), which is the project administrator, and SMI was signed on December 15, 2011. Work began soon thereafter and the steering committee was provided with a preliminary report in April of 2012 with summarized work and findings to date. As a result, some minor adjustments were made to the initial program of work, which is standard upon receipt of interim reports, but none that changed the overall objective as described in the grant application.

Regular meetings were held over the course of the project by the steering committee, some in person and others via teleconference. The multiple partners outlined in the grant application remained engaged throughout providing in-kind hours by attending meetings, assisting with research, technical assistance, and other supporting activities. Even though this specific project has concluded, meetings continue among this group of stakeholders as the next steps for moving forward are identified.

Primary project partners included Prince Edward County, Virginia Department of Agriculture & Consumer Services (VDACS), Virginia State University, Virginia Tech, Virginia Cooperative Extension and Virginia Farm Bureau. All of these entities, which have years of experience state wide, have an outstanding record of partnering together on these types of projects. Robins Buck, Senior Project Manager in Agriculture and Forestry Development Services with VDACS has been a primary participant of the working group since the very first brainstorming meeting held 4 years ago, and he is still involved with the project. VDACS' Sales & Market Development regional staff member Bill Scruggs has become directly involved with this project over the past few months as well as other VDACS employees who helped answer questions and provide guidance on food safety.

Janet Bearden visited Mission Mountain in Montana in 2011, and then project leader Allie Hill visited ACENet in Athens in 2012. Also, Smithson Mills used Asheville's Food Ventures program as a model and drew on his knowledge of the Floyd County project in preparing the Feasibility Study. From the very beginning when the original working group conceptualized this idea, other similar ventures and projects from around the country were researched to help determine how best to proceed.

In 2011 a USDA Specialty Crop Block Grant, administered by VDACS was awarded to a group in Virginia wishing to add value to local farm–raised specialty crops through further processing. The application was submitted by VAFAIRS.

Although the application addressed opportunities in its introduction for any number of farm raised products, including those beyond specialty crops as defined by USDA, the text of the application stated that the studies or research done would have to focus specifically on specialty crops for this particular funding opportunity.

While the original application discussed researching potential for the building of physical infrastructure to accommodate such needs, the working group also realized there could be existing facilities that might make such a project more attractive, especially from a capital investment standpoint, in moving forward. In fact, the group was able to very early identify such a facility in Farmville, Virginia that operated as a home cannery but also was an inspected facility to allow processing of certain products beyond home use. The facility is owned by Prince Edward County, whose leaders enthusiastically agreed to work with the Bountiful Blue Ridge Planning Group with the hope that they could develop the site into a business incubator. The facility is located in a tobacco dependent region where farmers are looking at ways to continue farming but at the same time diversify and transition out of tobacco.

Several sections of the final report clarify that this document's focus throughout was on specialty crops. Copies of this report have been shared with the funding agencies and additional copies are available upon request.

From the executive summary: "opportunities exist for value added production of fruit jams and jellies, fruit-based sauces, and canned high-acid foods..."

From Section III Regional Agricultural Demographics: "For purposes of this study, our focus is on specialty crops growers including vegetables, orchard fruit, and small farm fruit including strawberries and blackberries."

While Section III uses *National Agricultural Statistics Service* (NASS) data for all agricultural production in an eight county area, it specifically has a subset that quantified acres in vegetable, potato, melon, and orchards for further use by the project team and their consultant.

Section IV, which gauged interest from prospective farmers in such a project, focused on 12 farms, every one of which grows specialty crops as a significant portion of their farm production, several of whom were focused almost exclusively on the production of specialty crops. And the questions asked of these farmers centered on specialty crop production.

Section IV which focused on market research and potential demand from both public and private sector interests: "In conformance with contracted services, researchers primarily investigated market conditions for canned high-acid fruit and vegetable products including canned peaches, canned apples, diced and whole tomatoes, hot-filled jams and jellies, and frozen small fruit".

The entire budget for this grant has been expended.

III. Goals and Outcomes Achieved

As stated throughout, the overarching goal was to assess the feasibility of creating and operating a facility where Virginia-grown food and other specialty agriculture products can be processed safely and affordably in Central Virginia. Furthermore, the project revolved around an existing facility owned by the county. It is not a new facility, significant physical upgrades are needed and there are other overriding issues that may not make this locale the ideal place to locate this business.

In the preliminary report dated April 12, 2012, SMI identified the following findings specific to this project:

- A measured demand exists from farm-based producers for services that will help them enter value-added food products businesses.
- Adequate raw product supplies can be sourced at either the farm level or the wholesale level for manufacturing of high-acid canned products for wholesale distribution by a business using the cannery's production space.
- The cannery as it currently exists is not suitable for significant commercial production of most food products.
- Certain types of food processing are not likely to be viable in the facility regardless of physical improvements.
- In order to strengthen the capacity of Virginia farm-based producers to enter and succeed in value-added food manufacturing and sales, certain organizational issues must be addressed.

- Previous experience has shown that projects of this nature can best succeed by forging collaborative programming with other organizations involved in agriculture and business development

These initial findings provided more detailed focus and direction that would be used to finalize the report. During the study period, one of the leaders of the steering committee formed two legal entities, one non-profit and the other for profit in order to begin developing the organizational infrastructure to keep moving forward. In addition some recipes were developed and some test batches run, under inspection, in order to begin determining the price structures and volume that will be necessary to be successful.

The final report from SMI contained very valuable recommendations and observations for moving forward. Organization structure and management needs to be further addressed. The current setup at the PEC cannery may not be suitable for a commercial business of this type, but that is not to say there are not other possibilities in the region. A detailed business plan needs to be developed as soon as possible and more work needs to be done regarding cost analysis coupled with issues of seasonality of production that are part of farming.

The results have not been shared with a minimum of 150 people. I expect the number to be closer to 50. All interested parties and stakeholders have been included in the distribution. As the project direction was modified before the feasibility study from generally assessing food processing in Central Virginia to assessing the PEC County Cannery as a food processing facility, there are fewer interested parties/stakeholders than the original grant text would have stated.

IV. Beneficiaries

While the primary beneficiaries of the project and the targeted audience were area and regional farmers, other interested parties were part of the discussion, including representatives from local and state government and farm membership organizations. All of these parties have a vested interest in working to foster an economically strong and viable farming sector statewide.

What this final report clearly stated is that there is demand from both farmers and consumers for this type of activity, and supply is available in the geographic region to be served. While farmers stand to be the primary beneficiaries should the project be successful, consumers will benefit from having access to a larger variety of local food products plus the opportunity for increased local/ regional economic development and activity would be enhanced.

V. Lessons Learned

The project team viewed this activity as well as the result, information, and recommendations as invaluable in determining whether to move forward, and if so, what direction to take. The opportunity to contract with a third party consultant well versed in this business arena who can be objective makes the recommendations much more credible.

It is safe to say the overarching goals of the group were attained for this activity. It certainly made the principals understand how much is involved in creating such a business and service, one that is unavailable at this scale in the state.

VI. Additional Information

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#11 Final Report
Cider Apple and Cider Production Feasibility Study
Nelson County

Project Summary
The purpose of the project is to support the production and expansion of the hard cider business in Virginia. The feasibility study and enterprise budget validate the market for and economic viability of hard cider as a beverage and quantify the interest in growing hard cider apple varieties. Making this technical information publicly available to growers and producers is also of vital importance to supporting this burgeoning industry.

The outcomes from this grant were intended to help overcome the limited availability of hard cider apples in Virginia by producing a better understanding of the market for and economics of hard cider and hard cider apples. Ultimately, the goal is to help new and expanding cideries develop successful business plans and increase the production of hard cider within the commonwealth.

Until this project was undertaken, there was no real data from cider producers and apple growers about the economic viability of growing hard cider apple varieties and opening cidery production facilities. The enterprise budget that was produced as a result of this grant has given both growers and cider producers the information they need to make important business decisions, as well as seek funding for business expansions. Virginia cideries are licensed as farm wineries; they must grow or lease 51% of their apples. The Virginia cider industry is seeing the same exponential growth as the Virginia wine industry did in its early years; therefore, growth of the local cider apple industry is critical to its success.

Project Approach
Through surveys, round table discussions and on site visits to orchards and cideries, the baseline and project data was compiled. The feasibility study and enterprise budget offer never-before-collected information that a start up cidery can use for financing or other projects. The network of communication that the project spurred, from the Virginia Cider Association to the website, will ensure that the partnerships created will flourish and build the Virginia cider industry. The project partners worked as a team to complete all grant tasks, but will continue to work together to promote this industry.

Goals and Outcomes Achieved

- The three survey instruments (cider producers, apple growers and consumer) were created during October 2011 – January 2012
- The surveys were distributed by US mail and via email February 7, 2012. Response rate was over 90%, including 16 cider producers, 37 apple growers and 89 consumers.
- VA FAIRS was hired to conduct the feasibility study on the economic viability of artisanal hard cider production in March 2012
- Virginia Tech was hired to conduct the feasibility study on the economic viability of producing specialized, hard-cider apple varieties to supply regional hard cider producers May 3, 2012
- A roundtable discussion for the apple growers and cider producers was convened on March

2, 2012. 15 apple growers and cider producers attended.

- 3 Nelson County apple producers were interviewed on site at their orchards June 8 by Virginia Tech staff for the cider apple enterprise budget.
- The cider production feasibility study was finalized in August 2012
- The enterprise budget was finalized in August 2012
- Reports to the apple growers and cider producers are ongoing.
- In December 2012, the feasibility study and the enterprise budget were distributed to the apple growers and cider producers.
- In December 2012, surveys were completed to determine the increase in the number of acres of cider apples from 2011 to 2012 as well as the increase in the number of bushels of Virginia apples used in hard cider production from 2011-2012
- January 22, 2013, Virginia Tech staff and Virginia cidermakers presented the project findings at the annual Virginia State Horticultural Society conference
- February 2013, Virginia tech staff will provide an online and/or print document, such as a fact sheet, that contains selected and reviewed information on hard cider apple varieties and culture.
- February 7-8, 2013 at CiderCON in Chicago, Illinois, Dr. Greg Peck presented the project findings

http://www.arec.vaes.vt.edu/alson-h-smith/treefruit/horticulture/hard-cider/

One of the most exciting parts of the grant program was working with the apple growers and cider producers in the field. Conducting interviews, visiting the farms and cideries, encouraging the growers and cider producers to make commitments that mean more Virginia apples and more Virginia cider in the marketplace – that was one of the highlights. The compendium of information on the Virginia tech website has served as a launch point for many new growers and producers.

Dr. Gregory Peck, from Virginia Tech, presented the information about the grant and feasibility study during one of the panel discussions at CiderCon 2013. There were approximately 400 attendees to the conference and more than 100 attended the session where this was presented. Their response was excitement about the information and about Virginia's burgeoning cider industry.

2011-2012 Cidery Statistics – Virginia apples used in production

Albemarle Ciderworks
2011 – 1890 bushels produced 5956 gallons
2012 – 2326 bushels produced 6980 gallons

Foggy Ridge Cider
2011 – purchased 106 bins, average price per bin $175
2012 – purchased 154 bins, average price per bin $260

Old Hill Cider
2011 – 90 bushels purchased
2102 – 704 bushels purchased

Potters Craft Cider
2011 – 1314 bushels purchased, produced 4271 gallons
2012 – 3072 bushels purchased, produced 9000 gallons

Blue Bee Cider
2011 – 60 bins purchased
2012 – 105 bins purchased

From the subsequent cost share grant (Specialty Hard Cider Apple Varieties Planting #FFY2012-489), the following apple grower information was collected:
The goal was to help establish at least 10 new acres (or equivalent to approximately 450 trees per acre) of specialty cider apples.

We were able to plant a total of 68.2 acres and 10672 trees.

Beneficiaries
The beneficiaries from the project were the apple growers and the hard cider producers. In December 2012, surveys were completed to determine the increase in the number of acres of cider apples from 2011 to 2012 as well as the increase in the number of bushels of Virginia apples used in hard cider production from 2011-2012

The study created a forum for dialogue and positive relationship building that never formally existed before. It linked Virginia apple growers with cider producers and encourage both to consider a new value added product. It introduced Virginia tech and other technical resources to growers and producers. The enterprise budget gave those entering the market a baseline for performance that a financial institution would require.

· A quantification of the beneficiaries affected by the implementation of this project and/or a potential economic impact of the project.

2011-2012 Cidery Statistics – Virginia apples used in production

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Lessons Learned
Many of the most valuable experiences that this project provided were the partnerships that were created. Whether it was the introduction of an orchardist to Dr. Greg Peck, matching the cider producers to the apple growers, the project truly elevated the cider industry by improving the return not only on investment but on relationships (ROR). We are currently working on quantifying that ROR formula. Hearing the response of other cideries in other states during Greg Peck's remarks at Cider Conn was a true validation that this project has been successful.

Additional Information

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#12 Sustaining Organic Blueberry Production: Analysis of Practices and Assessing Outcomes

R. Miller Blueberry
Eastern Mennonite University

Final Report

I. Project Summary

Organic blueberry production has been minimal in the Shenandoah Valley of Virginia; in the few situations where organic blueberries have been produced, no specific information about best horticultural practices has become available. That lack led to the ***overall purpose*** of this project to develop a model system of sustainable organic blueberry production as a specialty crop in the Shenandoah Valley of Virginia. This goal emerges from a prior project that focused on creating conditions for initiating an organic blueberry operation at Knoll Acres.

The ***need*** for this project is illustrated by the increasing interest and involvement of area farmers in diversifying their agricultural operations to include blueberry horticulture. A measure of this interest is obtained by numerous visits to the blueberry internet website, phone calls, field visits, and interviews by prospective growers with Dr. Roman Miller, and finally the interest of growers who registered and attended the October 2013 berry conference, which was largely sponsored by this grant. Additionally the consumer desire for fresh local blueberries is not being met and most blueberries consumed in our area are transported in from outside of our region.

This current grant is ***based on a prior grant*** "Creating Conditions for a Small Sustainable Commercial Organic Blueberry Operation" (#2008-427) with goals focused on beginning an organic blueberry operation: *develop a small commercial organic blueberry production as a model system with best organic practices including soil preparation and nutrients, predation and insect control, selection, maintenance, and productivity of cultivars, and provide academic educational experiences for undergraduate students in sustainable agriculture.* The current grant enabled us to extend the initial grant by further establishing the basis for a good model system with evolving soil profiles, blueberry bush growth and foliar analyses, blueberry production data from a comparison of differing soil profiles and cultivars, and finally a preliminary look not only at berry quantity, but also berry quality including taste testing, brix levels, berry size, and antioxidant levels.

II. Project Approach

During the past two years, we have been able to obtain data from two harvest production and retail sale years (summers of 2012 & 2013), thus creating the beginning of a database that with realistic projections has the potential to show sustainable profitability for a small organic blueberry operation. Even at this stage of blueberry production at Knoll Acres, we have connected with area and regional farmers through our blueberry website (www.knollacresblueberries.com), publications and talks, and our berry conference for growers, held in October 2013. To determine best organic practices, we have monitored soil quality measures and nutrient profiles, foliar nutrient analyses, plant growth parameters, and berry production levels. We have gone beyond simple berry quantity production by also assessing the quality of produced blueberries as determined by measures of berry size, taste characteristics, brix values, and antioxidant levels. The environmental factors that promote a nutrient-rich blueberry in good quantities are identified. Finally we have maximized the value of this grant by involving the work of eight undergraduate science students who have carried out specific blueberry horticulture research projects under the supervision of one or more of the three EMU faculty persons working on this project. Specific quantification results are shown in the next section under the grant objectives.

Using collaborative research experiences of faculty (Drs. Kishbaugh and Cessna) with undergraduate students from Eastern Mennonite University (EMU), we were able to document some best organic practices that enhance sustainable blueberry production. Some of the research projects involved quantifying changing soil profiles, plant vigor characteristics (growth measurements, foliar nutrient content), and ultimately assessing the quality and quantity of produced blueberries. While total cost

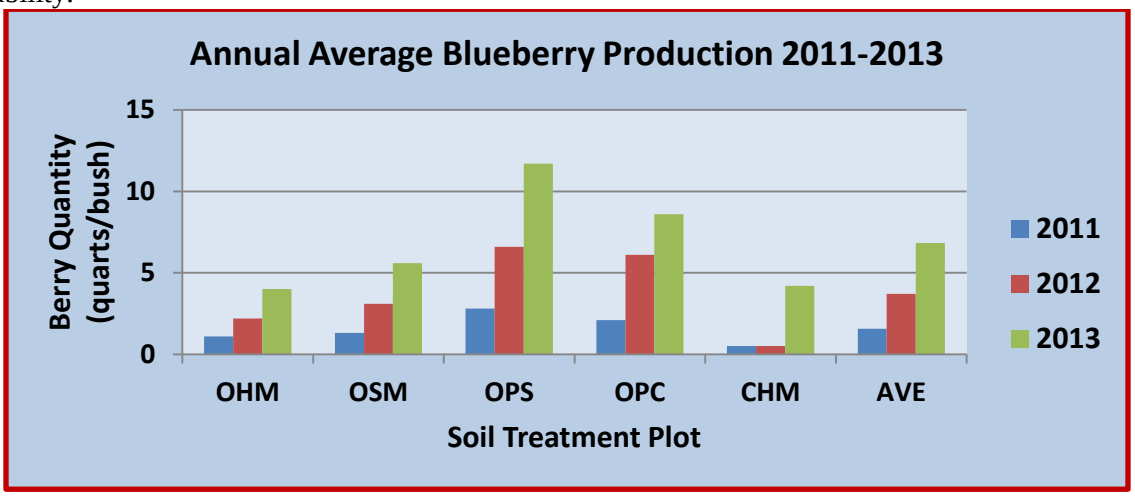
benefit analysis of organic versus conventional blueberry production has not been completed, preliminary production and berry quality data of organic versus conventional blueberries have been obtained. Specific project outcome data have been communicated to the broader publics via three avenues: (1) selected publications and presentations; (2) shared information on an internet blueberry website; and (3) organic and sustainable berry growers conference held at EMU in October 2013. Publication of project outcome is on-going with several manuscripts in preparation submission to journals in 2014.

III. Goals and Outcomes Achieved

Following activities and outcomes are linked to the six project objectives:

Objective 1: ***Develop a model system for economically sustainable organic blueberry production in the Shenandoah Valley***.

Continued progress on this objective was made this summer during the 2013 blueberry harvest season. My goal during the next months is to summarize the income data from the past two seasons, make realistic projections for the next few years to illustrate economic sustainability with this small commercial blueberry operation. The following chart "Annual Average Blueberry Production 2011-2013" depicts the trend in our blueberry operation. I anticipate that the average production (quarts/bush) will continue to increase substantially during the next two or three seasons and then level off. After average production doubles the current production (i.e. up to about 3- 4 gallons per bush), I believe that the increase rate will plateau. If good horticulture practices are maintain, this future production level should remain consistent for over ten years, thereby demonstrating potential for good economic sustainability.

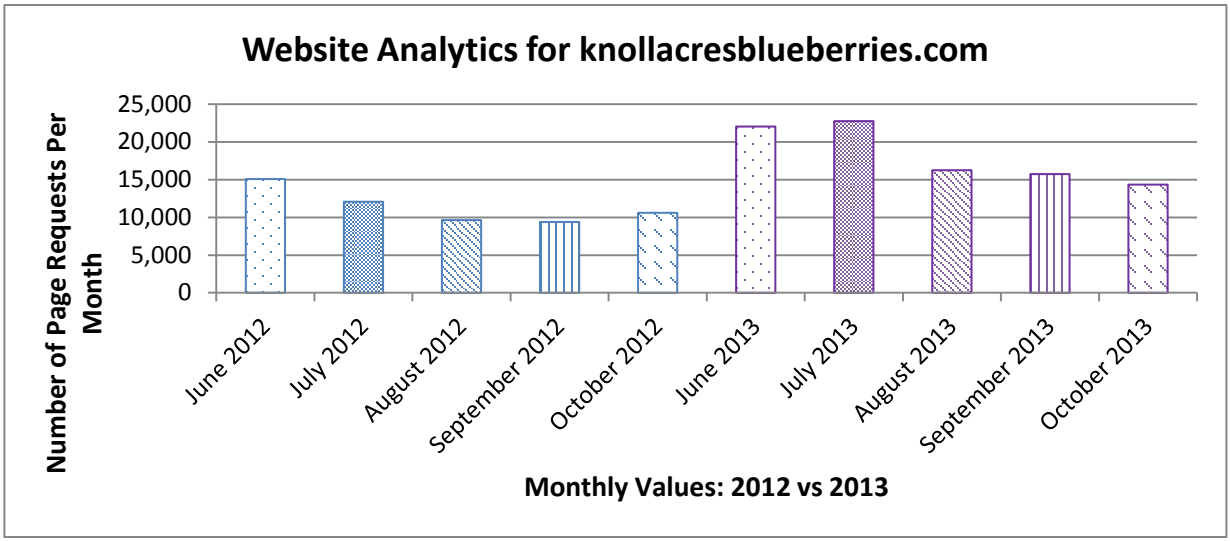


As shown on the above graph, productivity for all plots increased dramatically over the past three years. Total gallons of blueberries harvested each year on all plots were 31 (2011), 58 (2012), and 132 (2013).

Objective 2: ***Connect with area farmers interested in organic blueberry production.***

Three approaches demonstrate fulfillment of this objective: (a) organic blueberry website visitors, (b) consultation visits (either on the farm or via phone), and (c) the organic and sustainable blueberry and bramble berry conference held at Eastern Mennonite University (October 2013).

a) Organic blueberry website visitors. This information is based on a Site Analytics Report from



visitors to our website: www.knollacresblueberries.com Date Range: Comparison of June 2012 – October 2012 versus June 2013 – October 2013. In comparing these two time frame sets, we saw an increase of 60% of page requests (representing visitors to the site) in 2013 from the number seen in 2012.

Number Page Requests: June-October	**2012**	**2013**	**2012 & 2013 Combined**
Total	56,788	91,110	147,898
Monthly	11,358	18,222	14,790

b) Consultation visits. During the second day of the October 2013 Sustainable Blueberry Conference, approximately 20 visitors (growers and consultants) visited the Knoll Acres blueberry plots. Roman Miller gave a field talk and answered questions for about an hour with these visitors. During the prior 8 months (Feb-Sept, 2013), I hosted eight visits by growers (or potential growers) at Knoll Acres to discuss our blueberry operation and blueberry horticulture. During the same time period, I averaged several blueberry horticulture conversations per month either via telephone, email contact, or conversations at the farmers' market.

c) The Organic & Sustainable Blueberry and Brambleberry Growers conference was held on October 21 & 22, 2013 at Eastern Mennonite University. Information about the conference and the final program can be seen on our website: http://www.emu.edu/berryconference/

A copy of the conference program is included in the appendix. A brief summary of the conference and attendance is included here. Eighty people attended the conference; 57 regular paid registrations from growers; 2 student paid registrations, 3 exhibitor registrations, and 18 free registrations for EMU faculty, staff, planning committee, and conference presenters. Attendees were asked to fill out an evaluation form at the end of the first day of the conference; these are summarized in the appendix. Overall we had good speakers, good content, and enthusiastic attendees. Many attendees were very appreciative of the conference and indicated that they would attend another one if it were offered in the future. My biggest disappointment was the "exhibitor" turnout. We didn't do an adequate job to encourage commercial and educational exhibitors to be at the conference.

Objective 3: ***Determine best organic practices for sustainable blueberry production.***

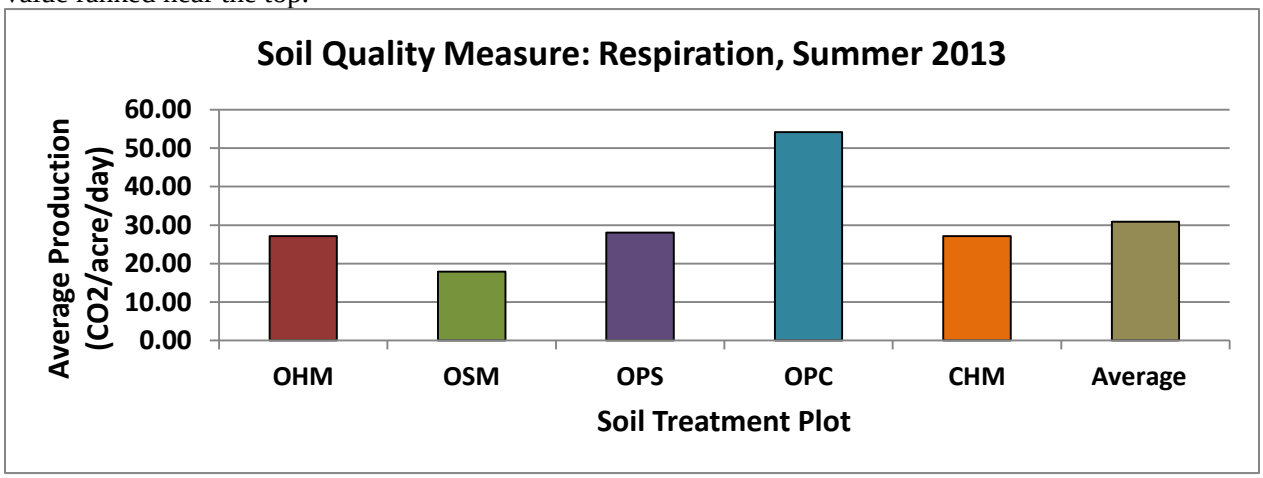
During 2013, we focused on three outcome measures: (a) soil health; (b) plant vigor; and (c) plant berry production. Soil health is the foundation for plant health and growth. Using both standard soil testing for macro- and micronutrients as well as soil quality measures (e.g. soil respiration values), different soil characteristics are profiled. Plant vigor, as measured by various physiology assessments (including direct plant growth measures, foliar nutrient analysis) when compared either across the various cultivars or across the soil treatment profiles, becomes an important indicator of best practices. However, ultimately berry production per bush is a most important measurement and provides insights when compared across cultivars or across soil treatments. Selected data follow to represent these measurements.

a) Soil Health. Soil nutrient testing was done at the Soil Testing Lab at Virginia Tech. Composite samples from the various plots were taken in May 2013; results are shown below in the following table. Basic macro- and micronutrient levels are all at adequate levels, no deficiencies. The pH levels for the most part are within optimal ranges except the organic sheep manure plot is still a little high which warrants additional treatments with sulfur to lower the pH to a more optimal level around 4.8-5.0.

5/15/2013 Results for Blueberry Soil Plots	**P (lb/A)**	**K (lb/A)**	**Ca (lb/A)**	**Mg (lb/A)**	**Zn (ppm)**	**Mn (ppm)**	**Cu (ppm)**	**Fe (ppm)**	**B (ppm)**	**Soil pH**	**Organic Matter (%)**
Organic Horse Manure	**174**	**131**	**1749**	**134**	**13.1**	**53.6**	**0.8**	**19.6**	**0.2**	**4.35**	**13.9**

Rating	**VH**	**M**	**H**	**M+**	**SUF F**	**SUF F**	**SUF F**	**SUF F**	**SUF F**		
Organic Sheep Manure	**697**	**135**	**4835**	**359**	**26**	**27.9**	**0.35**	**10.3**	**0.55**	**5.45**	**12.3**
Rating	**VH**	**M**	**VH**	**VH**	**SUF F**	**SUF F**	**SUF F**	**SUF F**	**SUF F**		
Organic Pine Straw	**164**	**173**	**786**	**97**	**4.05**	**69.9**	**0.75**	**29.2**	**0.2**	**4**	**9.85**
Rating	**VH**	**M**	**M**	**M**	**SUF F**	**SUF F**	**SUF F**	**SUF F**	**SUF F**		
Organic Planters Choice	**224**	**124**	**1951**	**147**	**11**	**59.9**	**0.85**	**18.3**	**0.4**	**4.55**	**11.7**
Rating	**VH**	**M**	**H**	**H**	**SUF F**	**SUF F**	**SUF F**	**SUF F**	**SUF F**		
Conventional Horse Manure	**219**	**162**	**2223**	**146**	**10.4**	**38**	**0.7**	**21.9**	**0.35**	**4.7**	**15.3**
Rating	**VH**	**M+**	**VH**	**H**	**SUF F**	**SUF F**	**SUF F**	**SUF F**	**SUF F**		
ORGANIC AVE	**314.75**	**140.75**	**2330.3**	**184.25**	**13.54**	**52.83**	**0.69**	**19.35**	**0.34**	**4.59**	**11.94**
ALL PLOT AVE	**295.6**	**145**	**2308.8**	**176.6**	**12.91**	**49.86**	**0.69**	**19.86**	**0.34**	**4.61**	**12.61**

Soil respiration, based on CO_2 production, was measured in all the plots (see following figure). Labels in the graph indicate soil treatment plots: OHM (Organic horse manure), OSM (Organic sheep manure), OPS (Organic pine straw), OPC (Organic planters choice) and CHM (conventional horse manure); the organic planters choice plot had the highest values, greatly exceeding the average. Respiration values exceeding 25, depict a vibrant and thriving soil ecosystem; values between 15-25 depict good soil environment. Interestingly the OSM value this year is the lowest while the prior year this value ranked near the top.



b) Plant Vigor. Direct plant growth measures including bush height, diameter, bushiness (relative measurement value based on number of primary and secondary stalks), and primary stalk diameters were taken on all of the blueberry plants in August 2013. This data is not totally analyzed yet, but will provide statistical measurements of plant growth when comparing five cultivars (Duke, Bluecrop, Bluegold, Jersey, and Chandler) across five soil treatment plots (organic horse manure, organic sheep

manure, organic pine straw, organic planters choice, and conventional horse manure). The cumulative data, describing plant growth characteristics for three seasons (2011, 2012, & 2013), are being summarized for a manuscript, planned for submission to *HortScience* or *Journal of Applied Horticulture* in 2014.

Composite foliar samples were taken in August 2013 to check for levels of macro- and micro-nutrients at a commercial testing laboratory (A&L Eastern Labs) and as a quality control for student analyses. No deficiencies were noted in these samples which differed depending on soil treatment (Bluecrop and Duke) or by varying cultivars within a given soil treatment (Planters Choice). Data are shown for macro-level nutrients.

Foliar Analysis of Bluecrop Bushes in Five Different Soil Treatments (August 2013)

Plot	N %	S %	P %	K %	Mg %	Ca %	Zn ppm	Mn ppm	Fe ppm	Cu ppm
OHM	1.89	0.14	0.11	0.7	0.18	0.83	18	830	89	4
OSM	1.97	0.13	0.11	0.61	0.18	0.83	15	541	65	3
OPS	2.01	0.13	0.11	0.54	0.21	0.5	15	1250	73	4
OPC	1.97	0.14	0.12	0.71	0.24	1.04	17	1170	85	4
CHM	1.96	0.13	0.12	0.56	0.22	0.8	18	789	113	4
Average	**1.96**	**0.13**	**0.11**	**0.62**	**0.21**	**0.80**	**16.60**	**916.00**	**85.00**	**3.80**
Normal Range	1.80 - 2.10	0.12 - 0.20	0.12 - 0.40	0.35 - 0.65	0.12 - 0.25	0.40 - 0.80	8 - 30	50 - 350	60 - 200	4 - 20

Foliar Analysis of Duke Bushes in Five Different Soil Treatments (August 2013)

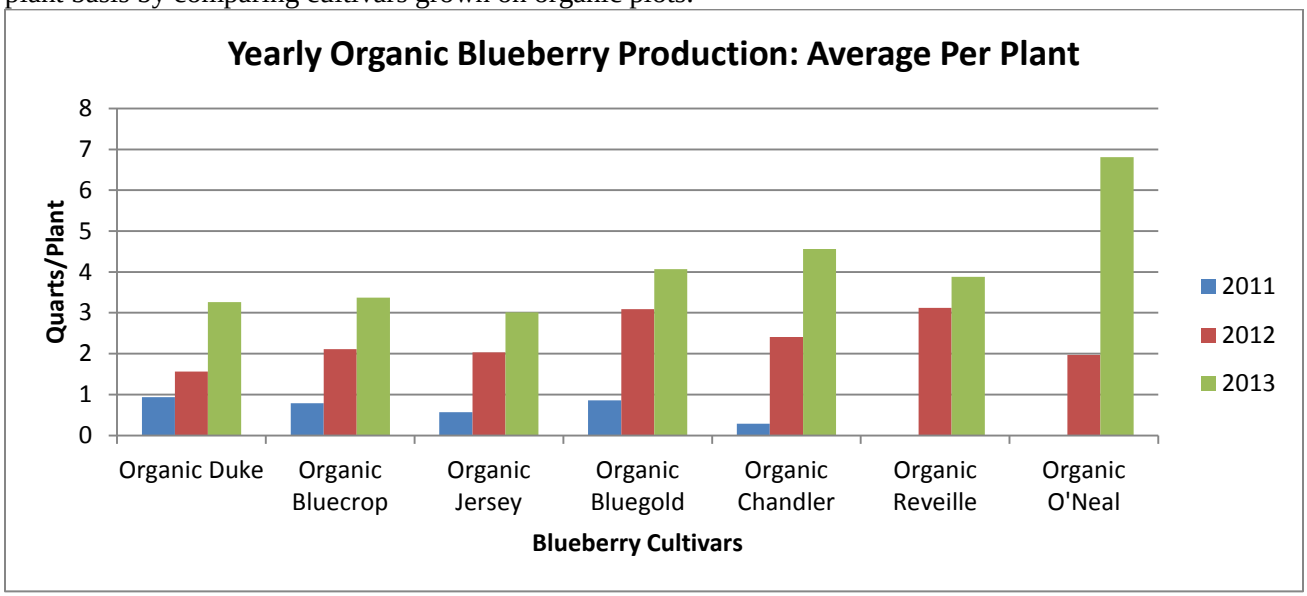
Plot	N %	S %	P %	K %	Mg %	Ca %	Zn ppm	Mn ppm	Fe ppm	Cu ppm
OHM	2.06	0.19	0.12	0.6	0.19	0.76	18	440	71	4
OSM	1.93	0.16	0.11	0.59	0.22	1	23	330	79	4
OPS	2.07	0.14	0.11	0.52	0.2	0.75	17	634	66	4
OPC	2.07	0.14	0.11	0.53	0.2	0.79	18	551	64	5
CHM	2.08	0.16	0.11	0.59	0.21	0.99	20	503	72	3
Average	**2.04**	**0.16**	**0.11**	**0.57**	**0.20**	**0.86**	**19.20**	**491.60**	**70.40**	**4.00**
Normal Range	1.80 - 2.10	0.12 - 0.20	0.12 - 0.40	0.35 - 0.65	0.12 - 0.25	0.40 - 0.80	8 - 30	50 - 350	60 - 200	4 - 20

Foliar Analysis of Seven Blueberry Cultivars (August 2013)

Plot	Type	N %	S %	P %	K %	Mg %	Ca %	Zn ppm	Mn ppm	Fe ppm	Cu ppm
OPC	**Duke**	2.07	0.14	0.11	0.53	0.2	0.79	18	551	64	5
OPC	**Bluecrop**	1.97	0.14	0.12	0.71	0.24	1.04	17	1170	85	4
OPC	**Jersey**	2.07	0.16	0.11	0.57	0.17	0.7	16	586	72	4
OPC	**Bluegold**	2.1	0.16	0.11	0.57	0.18	0.95	14	640	79	4
OPC	**Chandler**	1.99	0.14	0.1	0.51	0.16	0.76	18	635	73	4
OHM	**Reveille**	1.9	0.1	0.1	0.5	0.1	0.7	16	334	67	4

		2	5		8	6	1				
OSM	**O'Neal**	1.98	0.15	0.1	0.5	0.17	0.93	16	308	73.33	3
	Average	**2.01**	**1.04**	**0.11**	**0.57**	**0.18**	**0.84**	**16.43**	**603.43**	**73.33**	**4.00**
Normal or Expected Range		1.80 - 2.10	0.12 - 0.20	0.12 - 0.40	0.35 - 0.65	0.12 - 0.25	0.40 - 0.80	8 - 30	50 - 350	60 - 200	4 - 20

c) Plant berry production. The following graph summarizes average berry production on a per plant basis by comparing cultivars grown on organic plots.



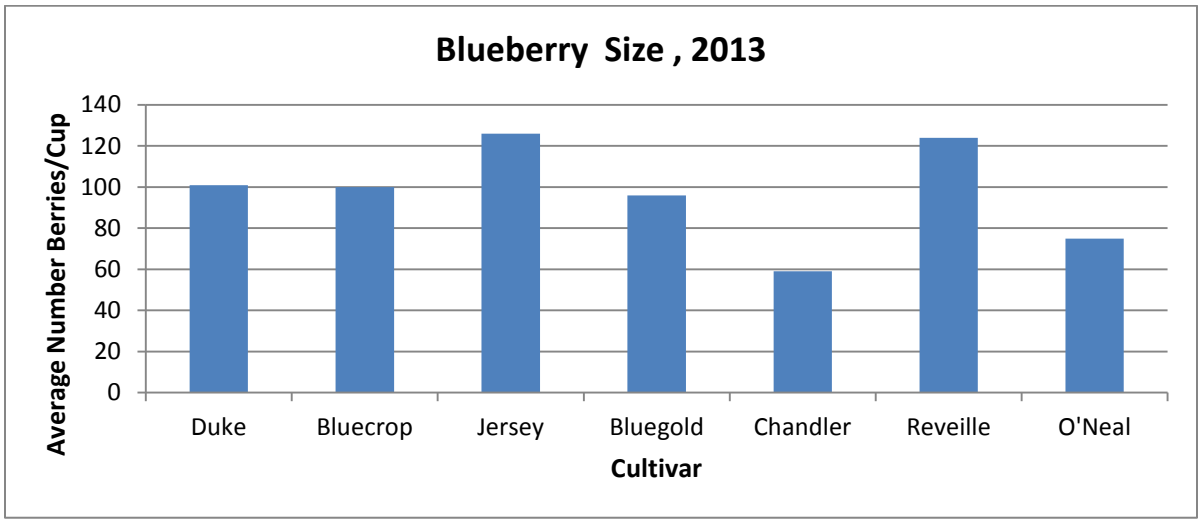
Summary of the data on the above graph show a healthy yearly yield increase in berry productivity. Significantly the O'Neal cultivar exceeds the others in productivity. The taste quality of the O'Neal berry exceeds the others also. Thus we are using O'Neal as our primary replacement plant. The graph, "Annual Average Blueberry Production 2011-2013" under objective one, clearly shows the blueberry bush production levels in the organic pine straw (OPS) plot and the organic planters choice (OPC) plot are significantly higher than in the other plots. That is an important learning. So in the future rather than trying to maintain the soil distinctions within the four organic plots, we will increasing enhance the weaker plots with supplemental nutrients to enhance their productivity. Thus currently and during the next years, replacement bushes will be planted in a soil mix that represents the best of the OPS and OPC plots. For example this past year, we have removed and replaced about a dozen bushes that were either dead, dying, or not thriving in the OHM, CHM, and OSM plots. In those cases we provided a soil planting mix that represented the best of the OPS and OPC plots.

Objective 4: ***Assess the quality and nutritional values of organic versus conventional blueberries representing five highbush cultivars***.

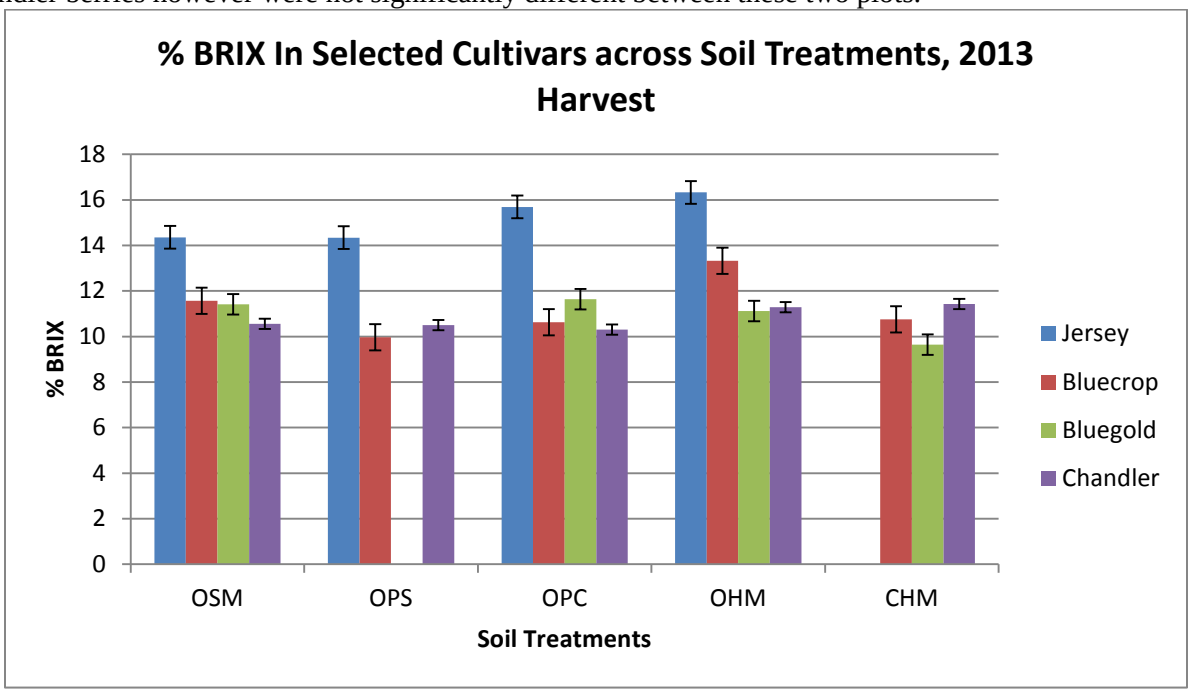
During the 2013 harvest season, we retained representative berry samples from various cultivars in the different soil treatment plots. As measures of quality, these samples were analyzed for their (1) berry size, (2) brix content (sweetness), (3) tasting quality, (4) antioxidant levels, and (5) phenolic content.

Berry size was determined by determining the number of berries required to fill a cup, i.e. the lowest number indicates the largest berries. In comparing the available cultivars at Knoll Acres, Chandler was the consistently largest berry while Jersey was consistently the smallest. The size of the O'Neal

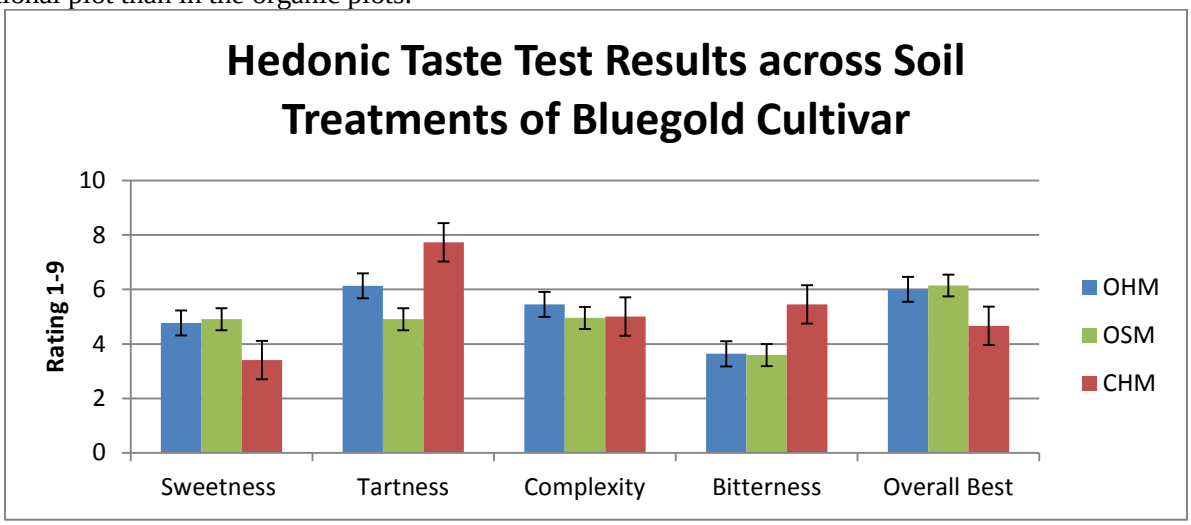
berries (in limited quantities) was larger than we expected; they compared favorably with the Chandler berries. The Reveille and O'Neal values seen here reflect a few sample bushes planted a couple of years ago; these two cultivars were purchased on a trial basis and were not part of the original five cultivars that formed the initiation of this project. Subsequently based on customer taste preferences who rated O'Neal berries as superior, we have decided to purchase more O'Neal bushes; consequently during the 2013 season we planted eight O'Neal blueberry bushes as replacement plants and plan to add more during the next year.



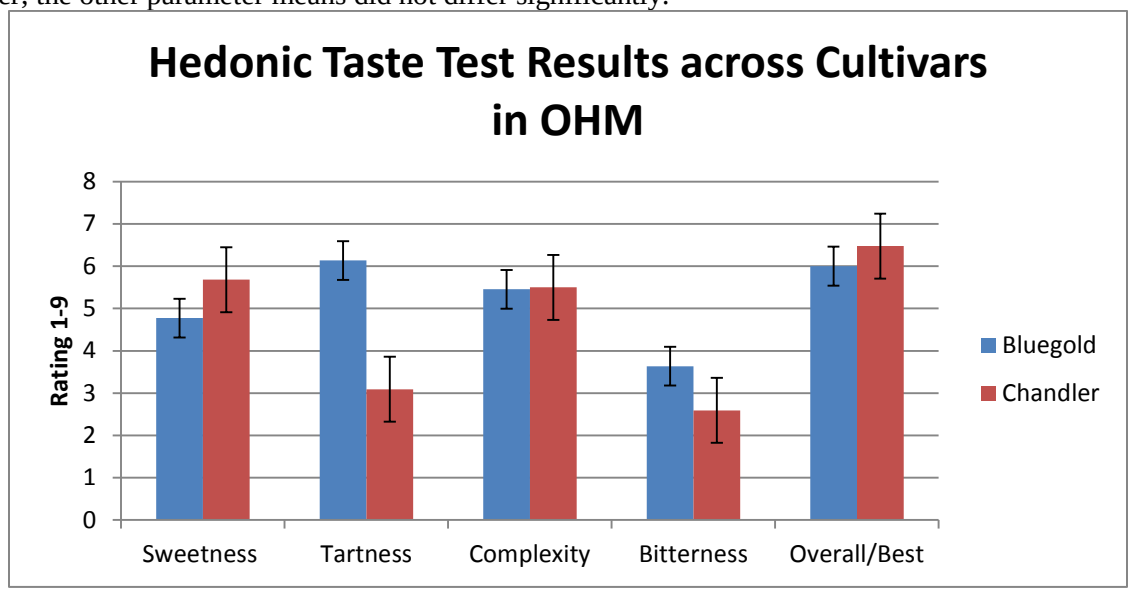
Brix content was determined in selected cultivars across soil treatments. While brix analysis reflects total solute particles in the berry juice, sugars provide the vast majority of those particles; hence brix values are positively correlated with berry sweetness. Brix was measured in four cultivars across the five soil treatment plots. (Jersey data are missing in the CHM, conventional horse manure plot.) Among the cultivars tested, Jersey berries consistently had the highest values within each of the soil plots while Chandler ranked among the lowest. Interestingly Bluecrop and Bluegold berries in the organic horse manure plot (OHM) was significantly higher than the comparable values in the CHM plot; the brix values for Chandler berries however were not significantly different between these two plots.



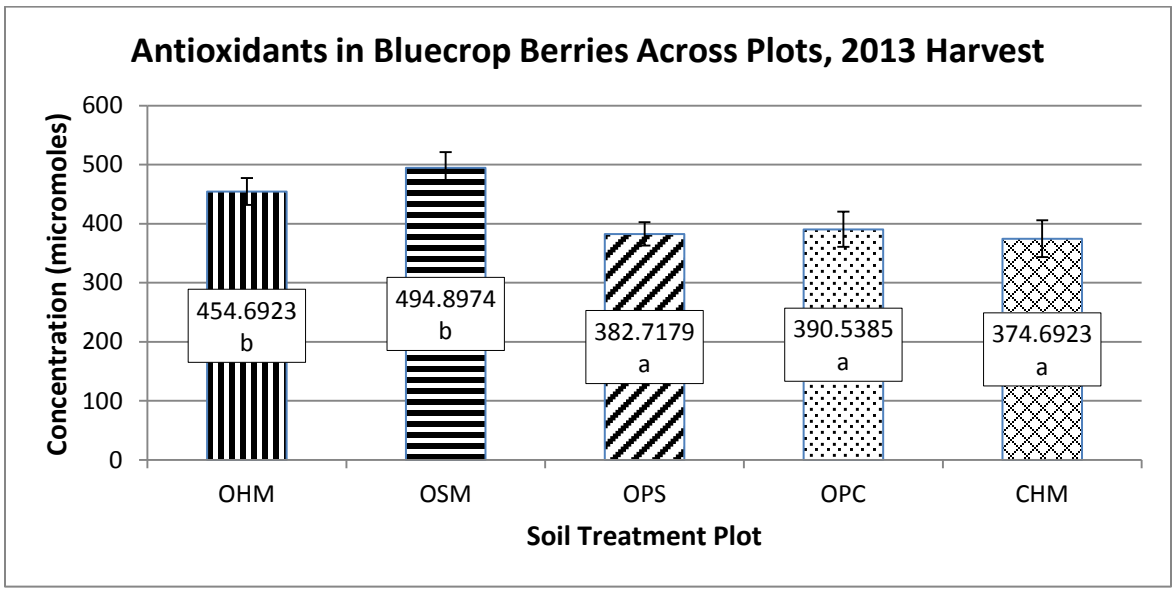
Tasting qualities were determined through taste testing with a class of 23 sustainable agriculture students. This hedonic taste test was administered as a single blind study. Five qualities were assessed (sweetness, tartness, complexity, bitterness, and overall best taste) in bluegold berries grown in three different soil profiles: OHM (organic horse manure), OSM (organic sheep manure), and CHM (conventional horse manure). In the two organic plots, bluegold blueberry sweetness and overall best taste was rated significantly higher than in the conventional plot. Conversely tartness was higher in the conventional plot than in the organic plots.



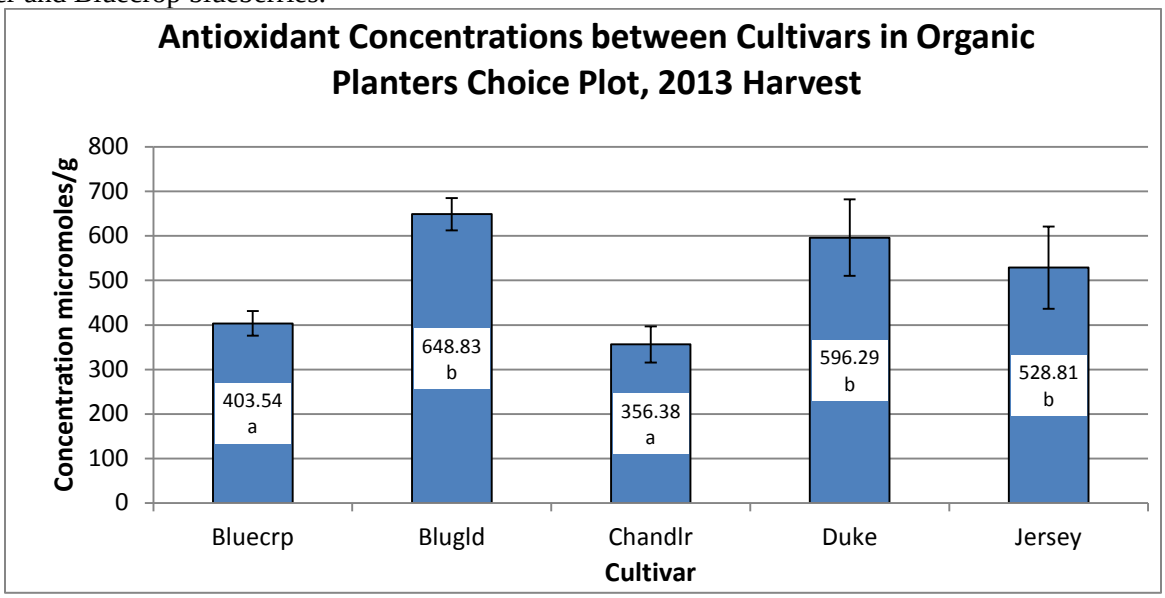
Two cultivars (Bluegold and Chandler) were comparatively analyzed within the organic horse manure plot (OHM). Only the value of tartness in the Bluegold was assessed at higher levels than in the Chandler; the other parameter means did not differ significantly.



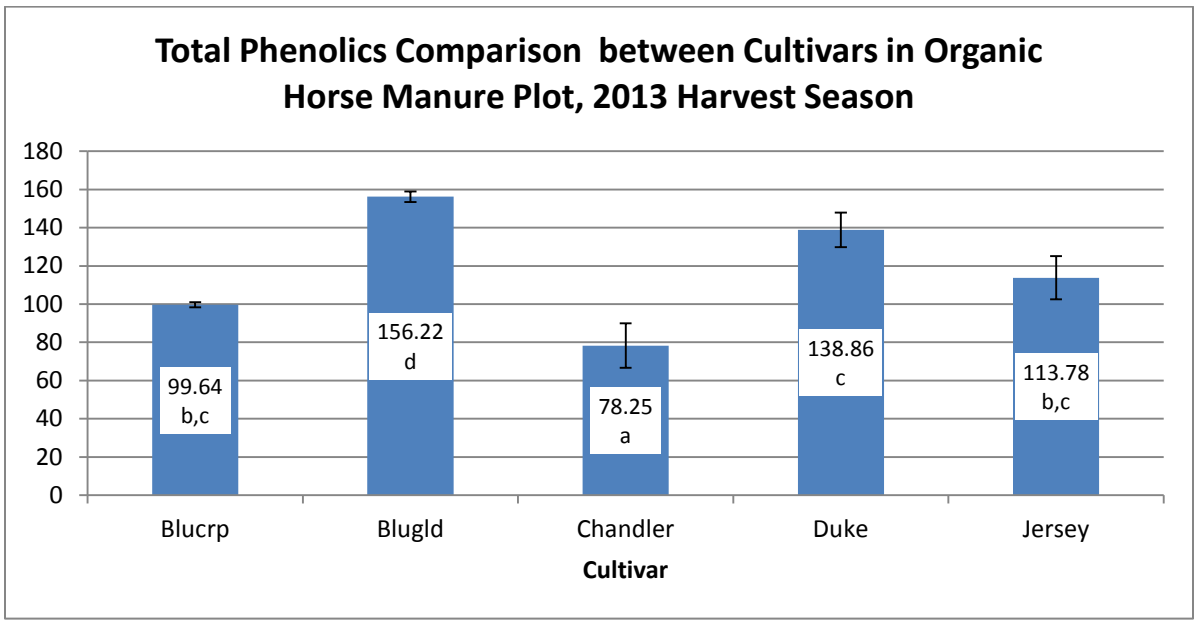
Antioxidant levels were measured via the FRAP (ferric reducing antioxidant power) assay. This colorimetric assay relies on the fact that many antioxidants are reducing agents and canbe measured in bulk plant samples by assessing their capacity to reduce ferric iron (Fe^{2+}). When comparing a given cultivar across the soil profiles, Bluecrop berries harvested from the OHM and OSM treatment plots had the highest values. A comparison of the organic horse manure (OHM) plot versus the conventional horse manure (CHM) plot demonstrated a significant difference between the organic and conventional berries with the organic berries showing higher antioxidant levels.



Comparing the antioxidant concentrations between cultivars within a given plot showed that Bluegold, Duke, and Jersey cultivars had significantly higher antioxidant concentrations than the Chandler and Bluecrop blueberries.



Phenolic content reflects the quantifiable presence of a cluster of highly pigmented compounds in blueberries, such as the prominent flavonoid anthocyanins. These were measured with a colorimetric assay (Folin-Ciocalteu). A comparison of organic cultivars within a given plot (organic horse manure plot) indicated that the phenolic levels in Bluegold were significantly higher than the other cultivars, while the Chandler levels were the lowest of the cultivars tested in this plot.



Objective 5: ***Enhance the educational development and involvement of undergraduate science students in agricultural related research***.

During the past years (2011-2013) the following eight students and their projects were supported by this grant. At the end of each project, the primary faculty mentor(s) is listed.

In the May 2013 meeting of the Virginia Academy of Sciences, two EMU students, **Emily Harnish** (a 2013 graduate of EMU) and **Andrew Kniss** (will graduate from EMU in 2014), shared their work on the blueberry project as a poster presentation which was titled "Analysis of Anthocyanins and Total Phenolic Compounds in Blueberries: Method Development and Preliminary Results." Andrew and Emily were primarily mentored by Steve Cessna.

Matthew Rhodes and **Ilya Pidroutchniak** worked during the summer of 2013 on the project. They assisted in weeding, picking berries, and conducting in field experimental work that included soil and foliar sampling for laboratory testing, chlorophyll measurements, plant growth measurements. Concurrently in the laboratory at EMU during the summer and fall they worked out the methodology for the antioxidant assays that were done on the sampled berries. They contributed to a joint presentation at the October Berry Conference with their presentation: "Organic Blueberry Differences: Antioxidants/Phenols". While the conference schedule listed Steve Cessna as the presenter, Steve introduced these two students who did the actual presentation. Steve Cessna, Tara Kishbaugh and Roman Miller collaborated in the mentorship of these two students. Matthew Rhodes is also presenting a paper in the Agricultural Division of the Virginia Academy of Sciences in May 2014.

Alejandra Gutierrez, initially started a blueberry project in 2012 but then had to drop out of school for financial reasons. She returned this fall (2013) and completed a project focusing on blueberry plant growth and vigor. She completed an oral presentation on this research, during our STEM Student Research Symposium on December 6th, 2013. Alejandra will graduate from EMU in December 2013. Roman Miller was the mentor for Alejandra.

Nicole Groff (scheduled to graduate from EMU in 2014) and **Janaya Sachs** (scheduled to graduate from EMU in 2016) worked together during the fall semester analyzing frozen berry samples from the 2013 harvest picking. They completed brix testing on the samples and also developed an experimental design for "taste-testing" berry juice from different cultivars. Their analysis of their single-blind taste-testing experiment was shown above. Nicole will present the brix and tasting data/information with berry production data in May at the Virginia Academy of Science meetings. Dr. Tara Kishbaugh was the primary mentor for Nicole and Janaya.

Finally **Brad Billings**, (2013 EMU graduate) who worked on this project during the summer of 2012, also gave an oral presentation at the EMU Berry Conference, October 21, 2013. The title of his talk

was "Netting at Knoll Acres: One Solution to Pest Invasion." Dr. Roman Miller was the mentor for Brad. Brad, along with Dr. Miller, is currently working on a manuscript detailing results from the 2012 season for the publication, *Acres USA*.

Objective 6: ***Assess organically allowable practices of post-harvesting handling, packaging, and marketing of fresh blueberries.***

For the second year during the summer of 2013, we marketed fresh blueberries based on cultivar type. Retail boxes (clamshell plastic pints) were labeled with cultivar type (i.e. Bluegold versus Duke versus Chandler, etc.), weight of contents, and an estimate of relative berry size (e.g. Chandler = 50 berries/cup versus Jersey = 95 berries/cup). Our retail approach was unique; other fresh blueberry sellers did not indicate the specific cultivar that they were selling. We experienced that some consumers came to realize that not all blueberries are the same. Some learned that a Chandler blueberry tastes different from a Bluegold blueberry which tastes different from a Jersey blueberry. O'Neal berries (which we had in limited supply) was by far the favorite and elicited many repeat customer requests for more.

During the 2013 market season, we experimented with several value-added blueberry products. These trial products that we marketed included blueberry sauce, blueberry muffins, blueberry chocolates, and blueberry vinegar.

Some Problems and Delays

Re-assessing objectives/goals. While progress has been made on objectives #1 and #6 during the period of the grant, it will not be possible to complete them entirely. For objective #1, a comprehensive quantitative outcome description of an economic model for sustainable organic blueberry production is currently not obtainable. Realistically this requires additional seasonal input beyond the scope of this grant proposal since blueberry production is not a short-term investment; currently, I estimate that our sales from two growing season have covered about 80% of the start-up and production costs. Start-up costs need to be prorated over a period of about four or five harvest seasons to show good profitability. We currently have had two market seasons (2012, 2013). However, that economic data is important; when completed will be an important factor in encouraging or discouraging others to venture into blueberry production. What we do have is information about sustainable organic practices that have emerged as best practices within our system. These have been and are continuing to be described in presentations, interviews, and publications. One early example of an economic sustainable practice is the November 2012 article in *Acres USA* that described our netting system that we use.

For objective #6, we had intended to create unique organic blueberry products based on dried blueberries, e.g. blueberry granola, blueberry snacks, etc. However, we have been unable to consistently dry blueberries in a quality fashion. Much more work needs to be done on this technique and remains as a future goal as we continue to develop blueberry value added products.

Website issues. During February through May 2013, our website analytics were mistakenly turned off. The consequence was that, although our website was available for visitors, we were unable to obtain reports on web traffic during that period of time. Consequently for this report I have shown the available data from the other months in 2012 versus 2013. I assume monthly web traffic was similar in the missing months.

Publication of Grant Outcomes. This remains a continuing effort, but is not yet completed. We have had a paper accepted by the *Journal of Applied Horticulture* (in press, schedule for the first issue in 2014) which details some of our early work on this project (2009-2011). During this spring semester, I am working with Brad Billings to write and submit a manuscript of the 2012 blueberry harvest season to a trade magazine (*Acres USA).* Dr. Stephen Cessna is working with Nicole Groff and Matthew Rhodes to complete a manuscript on production quality and quantity for submission to a peer review journal, such as *Virginia Journal of Science* or *Journal of Undergraduate Research*. As a composite group, we are currently working on a major paper that we intend to submit for publication to *HortScience*. This paper will highlight the overall project and contain comparative data from the past three years (2011-2013). The goal is to have this ready for submission by May 2014.

Overall assessment of current activities in meeting objectives.

Ob-jective	% Goal Obtained To Date	Current and Future Plans
1	90%	This is a "final" type objective that requires a summary of data information from multiple harvest years to show economic profitability. This objective was reached to a degree following the summer 2013 harvest, based on future projections. A preliminary article is planned for a trade magazine depicting cost-benefit of organic blueberry production over a five year period based on two harvest seasons with projections into the next three. A comprehensive article demonstrating economic sustainability is not possible at this time but remains a future goal.
2	100%	This objective has been well fulfilled and exceeded with numerous consultations, Knollacres blueberry website, the organic & sustainable berry conference, and trade magazine publications.
3	95%	Great progress has been made on this objective and efforts are continuing. Currently we are working on analyzing and summarizing data for publication in various venues. We anticipate submitting a major article to *HortScience* in 2014 that summarizes the findings from the past several years.
4	100%	We completed this objective based on berry samples obtained from the 2013 harvest with our analyses of production quantities, berry size, brix, taste tests, and antioxidant levels. During the next months working with student researchers, we anticipate submitting two publications from this work: one in a trade journal and the second in a peer-reviewed journal.
5	100%	The projects of eight different students have been partially or fully supported by this grant project. Multiple student presentations have been made especially in two venues: Virginia Academy of Sciences and in our Regional Organic and Sustainable Blueberry and Brambleberry conference. Two students will be presenting talks at the Virginia Academy of Sciences in May 2014. Two articles are in preparation for submission to trade or peer reviewed journals. If these on-going efforts are completed, we will have exceeded our goal.
6	75%	The marketing issue needs further development. Some successful marketing was done during the summers of 2012 & 2013, including cultivar specific packaging of fresh berries to retail customers. However, additional research in marketing and cost-effective ways of delivering a final berry product to the consumer remains to be determined. While we have demonstrated the ability to provide successfully some value added products (blueberry sauce, blueberry vinegar) to the retail market, the consistent ability to prepare and market dried blueberry products has not be possible yet. We intend to work on that protocol during the 2014 season which is beyond the time of this grant.

IV. Beneficiaries

Who benefited? At least four targeted groups: (1) area and regional agriculturalists who were interested or involved in growing blueberries, especially using organic horticulture techniques; (2) eight undergraduate science students who worked on research projects related to this project; (3) three university professors who advanced their research agendas and interests; and finally (4) area consumers who benefited by purchasing and enjoying fresh organic blueberries or blueberry value added products during the summer Farmer Markets in Harrisonburg and Broadway, Virginia.

V. Lessons Learned

V. Lessons Learned

The following identifies six lessons learned as related to the six grant objectives:

· Economic sustainability for a small organic blueberry production requires several years of preparation, nurture, and adjustment to balance costs and income. I estimate that the third year of harvest (summer of 2014) will be the "tipping point" for economic sustainability. Our bushes are still maturing and production has been increasing by 30-50% each year. Thus a system is now in place that can readily be sustained with minimal expense for the next 10-15 years.

· Farmer contacts continue to provide opportunities to enhance berry production; most of the conversations have dealt with general aspects of blueberry production, only a few focus on the organic portion. The blueberry conference was an important and helpful time of sharing and learning.

· We are still learning the best organic practices. Based on production and berry quality it is clear that planting blueberries in a pine needle/straw compost is fair superior to planting them in a horse manure/sawdust compost. In our experience the production of the pine needle blueberries was at least 3 times greater than the horse manure blueberries. Also the loss of bushes in the horse manure plot was far greater than the loss in the pine need plot. The consequence is that all of our replacement blueberry bushes are now being planted in a pine needle/soil mix which enhances their growth and survival.

· We have found that the quality of blueberries (depending a bit on the specific cultivar) varies between the conventional and organic plots, so that the organic berries generally rate a bit more superior then the conventional ones. Also we have found great differences between specific highbush cultivars both in quality, taste, size, nutrient content, etc. So for example, Bluegold berries have the highest concentration of antioxidants; Jersey berries are the sweetest; Chandler berries are the largest; each cultivar has its characteristic taste.

· Using this project as an educational tool for science students has been a rewarding experience. Students have learned a lot about science, horticulture, and research which has been illustrated in their public presentations and in published papers.

· Organically allowable practices of harvesting, handling, packaging, and marketing of fresh blueberries remains under-developed. While we currently have a good retail market system in our local farmers market and consumers are learning about berry quality and cultivar distinctives, we still have more work to do in this area. We have found that our marketing strategy of emphasizing berry quality (rather than large quantities at discount rates) has resulted in many consumers willing to pay a bit more for our organically certified blueberries rather than other blueberries available in the farmers market. That consumer idea is slowly growing.

#13 FINAL
Local Food Hub Specialty Crop Grant Progress Report

I. Project Summary

With the support of this grant, Local Food Hub utilized its 75-acre, certified organic farm to provide educational opportunities for established, beginning, and aspiring farmers -- specifically around growing specialty crops using sustainable methods.

This project was intended to address two issues: attracting and training the next generation of specialty crop producers, and promoting the use of organic and sustainable farming methods. It included a comprehensive workshop series, a farm site visit program, and the evolution of its apprenticeship program into an on-site Farm Worker Training Program.

This program builds upon specialty crop grant 2010-587, which allowed the educational farm to get up and running, develop pilot workshops, and host its initial apprentices.

II. Project Approach

To develop, teach, and promote organic and sustainable growing methods, Local Food Hub:

- Hosted a series of workshops and seminars on proven organic and sustainable growing methods.
- Developed a Farm Worker Training Program in partnership with the International Rescue Committee.
- Conducted Farm Site Visits with our partnering specialty crop producers, providing one-on-one consultation and personalized technical assistance
- Tested organic and sustainable growing methods including experimental cover cropping methods, trap crops, mulching methods, and season extension techniques.
- Researched organic and sustainable growing methods that may help solve problems that are specific to our region.

Project Activity	# of participants	Project Staff/Partners	Date
Survey existing specialty crop producers to determine desired workshop topics for 2012	n/a	*LFH Staff:* Adrianna Vargo, Lisa Reeder	December 2011
Develop effective curriculum for workshop series in 2012	n/a	*LFH Staff*: Adrianna Vargo, Steve Vargo, Emily Manley	December 2011
Workshop #1: Financial Management for Small Farms	15	*LFH Staff:* Adrianna Vargo, Steve Vargo *Contractor:* Richard Bean/Double H Farm	February 2012
Develop strategy for Farm Site Visit Program	n/a	*LFH Staff:* Adrianna Vargo, Lisa Reeder	February 2012
Workshop #2: Sustainable	15	*LFH Staff:* Adrianna	March 2012

Soil Management		Vargo, Steve Vargo, Anna Emery *Contractor:* Mark Shonbeck/VABF	
Begin Farm Worker Training Program	4 trainees	*LFH Staff:* Adrianna Vargo, Steve Vargo	March 2012
Workshop #3: Beginning Beekeeping	25	*LFH staff:* Adrianna Vargo, Steve Vargo, Anna Emery *Contractor:* Central VA Beekeepers	April 2012
Begin Farm Site Visit Program	30+	*LFH Staff:* Adrianna Vargo, Lisa Reeder, Emily Manley	April 2012
Workshop #4: Permaculture for Farm and Garden	20	*LFH Staff:* Adrianna Vargo, Steve Vargo, Anna Emery *Contractors:* Lee and Dave O'Neill/Radical Roots	June 2012
Workshop #5: Pests and Their Natural Enemies	22	*LFH Staff:* Adrianna Vargo, Steve Vargo, Anna Emery, Emily Manley *Contractor:* Don Weber/USDA	July 2012
Workshop #6: Cover Crops and Permanent Bed Systems	28	*LFH Staff:* Adrianna Vargo, Steve Vargo, Anna Emery, Emily Manley *Contractor:* Ron Morse/VT	September 2012
High Tunnel Field Day	25	*LFH Staff:* Adrianna Vargo *Contractor:* Susan Hill, Hill Farm	October 2012

During the course of this grant Local Food Hub transitioned from an apprenticeship program to a Farm Worker Training Program, as the ratio of resources to outcomes in the apprenticeship program did not meet expectations. Local Food Hub developed a partnership with the International Rescue Committee to provide organic and specialty crop training to recent refugees – providing them with a job, a steady paycheck, fresh food, and hands-on agricultural experience. At the same time, the program helped build a skilled farm labor workforce in our region – something local farmers say is severely lacking. All of this took place at the Educational Farm at Maple Hill.

Strong partnerships have been integral to all aspects of Local Food Hub's work under this grant.

Key partnerships include:

- International Rescue Committee (IRC): The IRC has been our connection to Farm Worker Training candidates and provided translation services and other program guidance.
- Va. Polytechnic Institute has assisted with curriculum development and publicity, and will benefit from research and findings, through the Beginning Farmers and Ranchers Coalition.
- Va. Cooperative Extension has facilitated the transfer of current resources / updates to farmers, and connected Local Food Hub with new partner producers.

III. Goals and Outcomes Achieved

One stated goal of this project was to increase the number of specialty crop farmers who utilize certified organic and sustainable growing methods by providing training for at least **15 farmers per year**. At the beginning of this project period we conducted a detailed survey with our partnering farms to determine the most relevant workshop topics to them, and we used this data to develop a useful and innovative curriculum. By targeting these topics, we saw a marked increase in the number of established specialty crop producers attending. More than 50 farmers attended at least one workshop in 2012, and many attended two or more. Of note was the assistance provided to two farms as they transitioned to Certified Organic status and prepared for their inspections.

Another stated goal was to train at least five new farmers through an apprenticeship program conducted at the Educational Farm at Maple Hill. Under the newly minted Farm Worker Training Program, Local Food Hub was able to provide on-site, hands-on training **four refugee farmers in 2012.**

To meet the goal for direct technical assistance for existing farmers, farm site visits were conducted at farms partnering with Local Food Hub. These visits provided an opportunity for LFH staff to assess growing practices currently in use, learn about challenges and successes, and offer suggestions and follow-up as needed. As the farm site visit program has grown, it has provided an opportunity for LFH to act as a bridge between farms – sharing successful production strategies from one farm to another. In addition, we have been able to promote the services available to farmers through government agencies such as Virginia Cooperative Extension and Natural Resources Conservation Service.

We expect that 50% of participants in the workshop series will utilize the organic and sustainable practices taught. This year we have reached full capacity of attendance in each workshop, serving more than 90 participants. We ask them to fill out an evaluation survey at the end of each workshop - and if we receive this grant we will ask them to rate the likelihood that they will utilize the organic/sustainable practices taught.

In surveys completed at the end of each workshop, participants responded regarding the likelihood that they would implement practices/knowledge gained. All workshops scored above the 50% goal for intended utilization of skills and practices taught, with a composite of 69% across all workshops within the series.

In tandem with our efforts to reach more farms directly through the CIG grant, we hope to be able to reach at least 38 established farmers and provide them with resources, cost comparisons, and means necessary to choose organic and/or more sustainable growing practices. We expect 50% of these farms to incorporate these practices in the current or subsequent season (depending on the practice discussed). This will be evaluated with a "mid-season" check-in.

Our initial survey of conservation practices in place (40 respondents), showed a higher rate of existing utilization of organic practices than we had anticipated. While we were not able to complete an official mid-year check in with all original respondents, we did design our workshop series to address areas that were highlighted though our initial survey. Given that participants at our workshop series were primarily small farmers and we were able to determine a composite rate of 69% for the indented utilization of practices taught, it stands to reason that our partner producers intended to increase the adoption of sustainable and organic practices throughout the course of this project. Determining 'actual' versus 'intended' adoption of practices was not possible due to the length of the project period.

IV. Beneficiaries

The beneficiaries of this project include:

- The more than 125 existing, beginning, and aspiring farmers who attended the workshops, witnessed first-hand the concepts and methods being discussed, and make long-lasting connections with one another. We had several farmers attend multiple workshops throughout the season.

- The more than 30 farmers who received one-on-one technical assistance related to sustainable farming methods. This was accomplished through farm visits and direct inquiries via phone, email, or in person. In addition to the assistance we offer our partner producers, we are often contacted by individuals outside our network with questions or resource needs related to sustainable farming practices.

- The four refugee farm workers who received hands-on training in organic specialty crop production

V. Lessons Learned

As we continued to refine our workshop series in 2012, we learned several key lessons. These included the need to schedule workshops when farmers have more time to attend events during the off-season, and the value of having experienced farmers as workshop presenters. Given that we have many farmers who attend multiple workshops during the year, it is also helpful to have topics that are complementary and build on each other. This year we successfully augmented workshops held at Maple Hill Farm with workshops held at partnering farms, allowing for more diverse field demonstrations.

Our Farm Worker Training Program proved to be a more successful model than our Apprenticeship Program with the participation of agricultural refugees who were accustomed to

agricultural work, yet needed hands-on instruction on regional farming practices. Language barriers made formal instruction time challenging, but the hands-on portion of the training was successful.

As an innovative, organic farm, Maple Hill continued to use cutting-edge sustainable and organic practices that were “on-display” to visiting farmers and the public. Given the dual roles of the farm as training ground and production farm, it was difficult to conduct formalized trials on specific farming strategies, however results of employed practices such as cover cropping, strip tilling, mulch types, and varietal trials were able to be assessed more generally.

VI. Additional Information

Kristen Suokko
Local Food Hub
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#14 FINAL
Commercial Green Production in Underused Industrial Sites in Martinsville, VA
J. Fields
Patrick Henry Community College

I. PROJECT SUMMARY:

The Martinsville Virginia area has been severely affected by the loss several major industries resulting in high unemployment and a number of underused manufacturing structures that have been vacated by the loss of these industries. The Commercial Greens Production Study was initiated to evaluate the use of LED lights and a hydroponic production of various salad greens in these vacant structures. Studies were to include the evaluation of several LED lighting systems, the use of an affordable hydroponic system, and a survey of several varieties of greens to evaluate their suitability to this type of production.
This project has the potential to provide a boost to the local economy by providing a use for these vacant buildings, providing a year round source of fresh greens that would be suitable for sale to an assortment of local consumers and to provide employment for an area with very high unemployment. A new industry of this type has the potential to provide employment for a number of growers, packers, shippers, persons responsible for the logistics, marketers, and managers.

II. PROJECT APPROACH:

The initial portion of the project began with research into the availability of LED lights that would be suitable for use in our planned systems. It was discovered that affordable lights were difficult to obtain, but three models were purchased and one was built in-house to provide the required light in the color spectrum that was needed for the growth of the greens to be used.
The hydroponic systems were designed using components purchased from local building material suppliers. A mixture of vermiculite and perlite was used as a growing media with a commercial water soluble formulation of a 20-10-20 fertilizer used as the source of nutrition. The nutrient mixture of water and fertilizer was added using a timed pump system applied to the upper levels and allowed to flow by gravity to the lower levels. The excess nutrient solution was captured and recycled for use again after the nutrient levels were evaluated and returned to the original concentrations.
Seeds of an assortment of lettuce varieties, kale, spinach, radish, chives, basil and cilantro were purchased from a commercial seed source.
The initial Test 1 planting was done and a light period of 14 hour day and 10 hour night was established to begin the evaluation of the suitability the various varieties. We used a Split Plot design to achieve more random results and avoid any problems that might exist from the planting design. During this portion of the study we were evaluating three different LED lights that were being grown on three different towers with 8 different varieties of greens being tested. We found that all varieties of the lettuce, kale and greens mix performed well the basil was not suited to this type of production. A marketable crop of greens was ready for harvest in 31 days from the time of seeding.
Our second planting, Test # 2, we were trying to confirm our results from our initial study by using the same light day length and four varieties of lettuce that had performed well in Test #1. We added the Spinach, another lettuce variety and two varieties of radish to this test. In this test, we were also looked at a reduced room temperature which had an effect upon our germination and a slower plant growth. A concern had been expressed by some of our contributors about the

cost of heating so an effort was made to evaluate this during our colder season. The reduced temperature resulted in a slower plant growth and resulted in the 55 days to harvest from planting. The crop was a success, but it took considerably longer to reach a marketable size.
In Test # 3 of the study, we used the same day length and looked at four additional varieties of lettuce and to compare their growth to the ones that had shown to be suited to this type of production. We returned to the original temperature setting for this study and found that again we able to achieve a marketable crop in 31 day on all of the varieties in this phase of the test. The growth rates are a key to this type of production as we need to "Turn" as many crops as possible to increase our potential profitability. Future tests will look at a different light scenario in an effort to reduce growing times.
In all three tests we found that there were marked differences in the growth of the plants under the three lighting systems. Light intensity was a determining factor in the growth rates achieved. We used three different LED lights in each of these tests and found that those emitting the greatest amount of light in the situations that we presented preformed the best with a more rapid growth rate. The commercial light made by Sunshine Systems preformed best in these tests followed by our "In-House" constructed LED light and then a T-8 type of tube LED light preforming the poorest. The T-8 tube light was a product that was made in China and it failed to provide adequate light in our situation with all lights being at the same level above the growing media.
A search was conducted for packaging for the greens produced. We found that a variety of "Clam-Shell" type containers were available that would be well suited for the handling of greens should it be decided that a retail sale of the greens was an option. Greens that were to be sold to restaurant or food service outlets could be packaged in less expensive plastic bag containers. Handling of the greens at harvest will require a skilled labor force with the harvest and handling being done under strict sanitary conditions. This is a very "Clean" type of production without outside contaminants—but sanitary handling conditions are essential.
Plants grown during this project were evaluated by faculty members, staff and students during a "Salad Lunch" at the end of Test # 3. All participants completing a survey commented favorably as the quality, flavor, and crispness of the greens that we produced. All stated that the quality was equal to or greater than other commercially produced greens. A scaled down model of the system that was chosen for use in our production was displayed at the local regional trade show called "Fast Track 2013" in effort to increase the awareness of the community to the work that was being done at the College. A presentation of the results was made to the VCCS New Horizons Conference in Roanoke, Virginia in April of this year and was greeted by numerous questions and interest.

III. GOALS AND OUTCOMES ACHIEVED:

A search of buildings that were available for use in our study was able to yield a vacant store front that was very suitable for our research project. The building was in downtown Martinsville, Virginia on East Main Street and was easily accessible to college personnel, Governors School students and was a face for the public as we worked on this project. The building had only 6 windows that were darkened to insure that light used by plants was from our test lighting.
Considerable time was spent evaluating the LED lights that were available for inclusion in our studies. We purchased two models from a distributor in Chicago, Illinois. One of the lights was called a UFO, the other was called a Glow Panel. As we continued to source lightning that we would be suitable for inclusion, we found that it was difficult to find products that would meet our needs. We were able to source a supplier of individual LED lamps that produced light in the

400 to 700 nm. range that we required for plant growth. We were able to acquire the LED lamps needed to build four 2 ft. X 8 ft. panels and purchase the necessary power supplies that were need to provide one of the light treatments to be included in the study. The last model that was purchased was a T-8 tube LED light which had to be built in and imported from China. All lights were mounted at 11 to 13 inches above the growing media.

The growing structures were constructed from re-cycled metal shelving that provided the structural support for the shelving that was used to hold our growing troughs. The growing troughs were regular 5 ½ inch plastic gutters filled with a mixture of 2/3 perlite and 1/3 vermiculite. The troughs were placed at 20 degree slope to allow gravity to move the nutrient solution through the media and to allow it to move to end of the trough and fall to the next level below. The hydroponic watering system was an assembly of ½ inch plastic pipe and ¼ inch tubing as emitters that was elevated to the top of the structures and a nutrient solution was pumped to the upper most level using a small submersible pump in a 35 gal. plastic can. The nutrient was a commercial grade soluble 20-10-20 fertilizer at a rate of ½ cup per 35 gallons of water. The nutrient solution was allowed to flow by gravity through the sloped troughs and fall from one level to the one below to insure through wetting of the media. At the end of the lowest level, the nutrient was captured, tested for nutrient concentration and then re-cycled to the original nutrient container.

The seeds for the study were purchased from a commercial seed source that had a large selection of varieties of the crops that were needed to be included. The plants in Test 1 were started in "Plug" trays and then transferred to the growing systems. Seeds for Tests 2 & 3 were direct seeded into the growing troughs to reduce the shock of transplanting. The direct seeding resulted in very high plant populations requiring a selective thinning to create the desired spacing. Visual observation were taken daily and plants measured on a two day schedule with the data being used to make decisions for subsequent tests. Observations from Test #1 were used in the determination of varieties to be included in Test # 2 and Test # 3.

We were able to include 3 different LED lighting systems in our study. We purchased a fourth type of LED light, but upon arrival we recognized that the light pattern from the "UFO" light was not suited to this application as it must be mounted at a much higher level to get the desired area of illumination. The light intensity in the growing zone of the lights tested is critical to efficient plant growth. The growth rates were dependent upon the intensity with the "Grow-Panel" providing the most rapid growth followed by the "In-House" being the second best while the "T-8 tube" being the slowest. This correlates with the light intensity at the level of the growing media. The "Grow-Panel" produced a marketable crop in Test # 1 in 31 days, the "In-House" light produced a marketable plant in 36 days while the "T-8" tube does not produce a marketable plant. The "T-8" tube plant is very small, weak and not marketable. Test # 2 and Test # 3 confirmed the results from Test # 1 with the light intensity from the various lights determining both growth rate and plant quality.

The survey of varieties determined that there was a difference in the suitability of varieties to this type of production. The lettuce varieties "Buttercrunch", "Salad Bowl", "Red Sails", and "Grand Rapids" grew well in Test # 1. "Kale", "Greens Mix", and "Spinach also showed well in Test # 1 with all producing a marketable plant in the 29 to 31 days after planting. Basil was included in this Test # 1 and it was found to fail in this production.

Test # 2 confirmed the varieties that showed well in Test # 1, "Buttercrunch", "Salad Bowl", "Grand Rapids", "Red Sails", and "Spinach". We added "Simpson Elite", "Cherry Red" and "Easter Egg" radishes to this test. The additions did very well with the Radishes producing a salable radish. This test was conducted during the coldest part of the winter and our building

temperatures were much lower than in Test # 1 resulting in much slower plant growth, but salable plants were produced. This added to our confidence about our growing system. The LED light systems preformed as they had done in Test # 1.

Test # 3 was done using the same production system with the addition of four additional lettuce varieties. “Green Oakleaf Tango”, “Red Firecracker Grand Rapids”, “Oakleaf Salad Bowl”, and “Outredgeous Romaine” were used in this Test # 3. All of these varieties preformed as the lettuce varieties had done in the previous Tests. Marketable plants were harvested in 30 days from seeding and the same performance of the lights was confirmed. Greens from this were used for a “Salad Lunch” for Faculty and Staff to evaluate the quality of plants that were grown using this system. Surveys that were completed by those participating in the lunch showed very positive responses as to “Freshness”, “Flavor”, and “Over-all Quality”. A majority stated that they would purchase these greens if they were available to them.

An attempt was made to develop a results paper of the project. However, the results were incomplete without the continuation of the Phase II grant. The paper will be published toward the completion of the Phase II grant to show complete data and connection with possible entrepreneurs toward the unique growing process.

IV. BENEFICIARIES:

The beneficiaries of this project have been the Horticulture and Agribusiness students of Patrick Henry Community College, students from Henry County Governors School, Virginia Cooperative Extension, and several entrepreneurs from the local area. The students involved were able to witness the use of LED lights, the unique hydroponic system, some of the various types of greens that could be produced in a system of this type and to gain an understanding to this type of plant production for fresh market uses.

V. LESSONS LEARNED:

This project has enabled the Horticulture and Agribusiness students to become involved in a possible new agricultural enterprise in an area of Virginia that needs new industry by using vacant buildings and inexpensive low energy using LED lights in the production of fresh greens that could be used locally by restaurant, food service, or sold through fresh market channels. We were able to evaluate three different LED lights and to find one that was suited to this plant production using an inexpensive hydroponic system. It was found that most lettuce varieties tested worked well in this system, while the herbs that were included did not fare as well. Surveys taken by those that sampled these greens proved that the greens were well received and would be considered for purchase if they were offered at a competitive price.

Future plans are to consider using different light periods in an effort to reduce the time taken to produce a marketable crop. Using the current “Day Length” of 14 hour day and 10 night, we should be able to harvest 10 crop cycles per calendar year. With further study, it is hoped to increase the crop cycles to enable 12 harvests and thus increase potential profit from a system of the type. Our next study will consider a cycle of 7 hours of light, 5 hours of dark, 7 hours of light and 5 hours of dark in an attempt of achieve 2 days of growth from a single 24 hour calendar day.

VI. CONTACT PERSON

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Northern Neck Vegetable Growers Association
Ensuring Future Farm Profits with innovative Specialty Crop Education Opportunities
FINAL Report

Project Summary: The Northern Neck Vegetable Growers Assoc., Inc. (NNVGA) is a regional group of producers representing approx. 50 member farms in the Northern Neck region of the Commonwealth. Their purpose is to facilitate the marketing of production and to provide education to the producer members and the general public. The NNVGA has a long-standing record of support for educational activities and events which outline the parameters for this grant. Willing learners, this group will travel near and far to get information and ideas, but they also realize the opportunities to share are just as important if not more so. Extension research shows that farmers learn best from other farmers. This project facilitated both of these methods of learning: attending educational programs for formal content as well as informal transfer, the human side.

Many of the growers are direct markets and developing a clientele is important when trying to figure out how much and what to plant then to get it ready to go all takes time. As the ethnicity of the clientele base changes so does the definition of a profitable mix that can draw in the customers and keep them coming back. Growers also need to stay abreast of the changing food business, the regulations and improved production methods and varieties all to improve the bottom line; the profits.

This project builds on another funded project by the same name through an amended project with similar goals that wasn't able to meet implementation and approval from VDACS. But it is still a very viable method that yields high returns to the producer members, the family farms.

Project Approach: Several educational opportunities were identified as being worthwhile and of interest to the group. Then local Extension Agents made arrangements for transportation and accommodations for the producers as well as tours to see local producers in and on the way to the areas of the educational events. This process makes the trip very appealing but also allows producers to have plenty of time to facilitate the cohesion that this group has developed. What was once a splintered and at times even fractious Board of Directors now makes decisions that transact 10's of thousands of dollars. All the field trips included a formal conference portion as well.

Goals and Impacts
Increase the members' awareness of new/alternative food safety practices and marketing techniques of specialty crops for the Northern Neck and Middle Peninsulas region of Virginia.

Performance Measures: implementation of practices/enterprises added.
Targets: 5 farm operations will implement at least one change of practice by the year 2015.
Baseline 2011: zero.
Results: At the end of the growing season of 2014, a year ahead of schedule, the members of the NNVGA reported to the agent via focus group, interview and letters that 10 farms had adopted 16 new practices. Those practices included changing processing protocols for food safety purposes or adopting new technology to make compliance easier, adopted new varieties to

enhance pest and disease resistance and therefore reducing pesticide use, added a new crop to their production, bought improved implements to allow for more timely and accurate application of crop protectants and to implement other production practices as seen/learned on these trips. The economic impact of the program while seemingly significant proved elusive to calculate when much of the benefits realized were cost savings or market access related. Of the crops implemented, some were perennial plantings that have not come into full production yet and their full potential not yet attained. The annual new crops were much more readily available data for production and a total net increase in production of nearly $5,000 total over 5 farms the first year was calculated with the potential of this impact being more in the future as their confidence and proficiency increased along with customer base and awareness rises.

Five (5) participating farms reported no significant impact as a result of the project.

Beneficiaries: The primary beneficiaries of the project were the members of the NNVGA. This portion identifies some of things we (NNVGA) have learned and were able to apply at our farms from three educational trips we have taken with the Northern Neck Vegetable Growers Association Inc. that were funded by the USDA Grant. They are as follows,

- How to plant sweet corn in double rows under clear plastic for corn two weeks earlier than normal. Increased the value of that early Sweet Corn by 35%. It cost 20% more for the planting process for a net profit of 15%.
- Learned about food safety and GAPs certification. How other farms approach those things and how it can be best applied to our farm. GAPs certification opens more marketing opportunities for possible increased profits.
- New Strawberry growing, harvesting, and post harvest handling practices that lead to better a yield of good quality salable fruit, and an extended season. Increased yield an average of 18%. Added cost of the new practices of about 5% left a net profit of 13%
- New pest management chemicals and practices that are more environmentally and user friendly, safer for honey bees, increases yields, and profit margins.

There are also other informal learning experiences that take place during these trips. You get to meet farmers, extension agents, and agricultural trade reps from other regions to compare what they are doing with what you are doing. Some very useful information and agricultural practices are learned from this type of informal discussions that can be applied back home to improve bottom lines.

To date, reporting a cumulative economic impact of $40,000.

Lessons Learned/ unexpected outcomes: In addition due to the sharing of fixed travel expenses I was able to include, outside of grant funds, a small group of new Cooperative Extension Agents. Their participation in one of the major trips allowed me to spread fixed costs of travel over more people but not allocating grant funds to them. Their participation allowed them to witness firsthand how to organize a trip, interact with producers, conduct focus group interviews and gain technical information along the way.

As for the producers, the lessons they learned are reflected in the above results section.

A lesson reiterated for me was 1. You don't impress everyone all the time 2) not everyone experiences a "wow moment" 3) some folks are just going to be contrary and not put for the effort despite your own efforts.

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#16 FINAL
Promoting Specialty Crops in VA: Increasing Fresh Food Access and Sales of Fruits and Vegetables to SNAP Clients at Fredericksburg Area Farmers Markets

I. Project Summary

Promoting Specialty Crops in VA: Increasing Fresh Food Access and Sales of Fruits and Vegetables to SNAP Clients at Fredericksburg Area Farmers Markets is designed to increase sales of fresh, local specialty crops to low-income populations in the Fredericksburg, Virginia region, improving food access to undeserved communities. The project promotes the competitiveness of specialty crops sold at the Fredericksburg, Spotsylvania and King George Farmers Markets and benefits 65 specialty crop producers. The program provides additional access to fresh fruits and vegetables to low income families; provides additional revenue for farmers by accessing new customers; and supports market sales by offering centralized card services as a convenience to all customers.

Objectives include:
(1) Create a targeted, multilingual community marketing plan and materials to increase awareness and consumption of specialty crops by SNAP clients;
(2) Provide on site staff resources and program oversight for SNAP redemption at three Farmers Markets;
(3) Demonstrate the effectiveness of "matching incentives" or bonus tokens at driving SNAP shoppers to use the famers markets.

The project is a collaboration of George Washington Regional Commission and the Fredericksburg Region Farmers Market Coalition (The Farmers Market.Co).

II. Project Approach

The Farmers Market.Co is a regional farmers market network that operates a token program at four regional markets in the Fredericksburg VA region. The markets work collaboratively to offer SNAP EBT, Nutrition Incentives and centralized Credit Card services to build market sales through increased access and affordability. The project solely supports the sale of Specialty Crops by directing $10 weekly Nutrition Incentives towards purchase of fresh fruits and vegetables.
In the grant period (Oct 2011-Sept 2012), the following activities have been performed:

1) Doubled total token sales over 2011, with two months remaining in 2012 market season. 2011 total token sales were $60,000 at three markets; current sales are $123,292 at four markets (as of 9/29/12). This is significant new income for small and mid sized family farms. So far this season, we have conducted 3,045 credit transactions (worth $91,857); 1,324 SNAP EBT transactions (worth $18,670); matched by $12,765 in Nutrition Incentives.
2) The breakdown is fairly consistent across markets, with one third of token sales from EBT/Bonus, two thirds from Credit. Token sales represent 8 to 10% of total Market sales.
3) To build farmers market sales through SNAP/EBT, worked with community stakeholders including Regional Government, Social Services, Health Dept., Virginia Cooperative Extension, Economic Development, local Healthcare Foundation and Regional Hospital.

4) To build farmers market sales through SNAP/EBT, worked with community stakeholders including Regional Government, Social Services, Health Dept., Virginia Cooperative Extension, Economic Development, local Healthcare Foundation and Regional Hospital.

5) With University of Mary Washington (UMW), issued 2012 Producer Survey to obtain updated sales data for each market and to determine producer's continued attitudes towards Incentive program. UMW Sociology students also currently compiled and analyzed demographic data collected on SNAP shoppers at four regional markets.

6) Established a new market at a regional hospital, addressing an existing food desert and providing a new weekday venue of local producers.

7) Spotsylvania Farmers Market participated in Wholesome Wave's National Cluster Evaluation with producers and consumers to drill down on impacts of nutrition incentives. Three other markets participated in standard Wholesome Wave data collection, fielding Producer and Consumer surveys.

8) Planned and Implemented Vegucation, Fresh Food Education program to increase awareness and consumption of fruits and vegetables, in partnership with Virginia Cooperative Extension. The planning team included Market Managers, Social Services, Health Dept., Extension, Germanna Community College Nursing program, Headstart, Food Bank, SNAP representatives, and a local Pediatrician. Obtained UMW intern to support program implementation. At each market, provided monthly market-based education about seasonal fresh foods. Market Managers and Extension Nutritionists worked with Master Food Volunteers, Germanna Community College Nursing students and other volunteers to support program implementation.

9) Delivered new outreach material reflecting needs of Social Services for simplified, market specific fliers (handouts and posters) and mailers (which are included in Notice of Action letters). Outreach materials were widely distributed by Market Managers to many community partners, including Social Services, WIC, Community Health Centers, Food Bank and Pantries, YMCA, Thrift stores, Schools, Faith Based Organizations.

10) Hosted market visits by Virginia Department of Agriculture and Consumer Services Commissioner Matt Lohr; and Congressman Rob Wittman. USDA Under Secretary Edward Avalos visited two regional markets in July to highlight successful use of FMPP and SCBG funds. Conducted a follow up farm visit with Undersecretary Avalos to Ochoa Produce in Warsaw, Virginia in September.

11) Received several positive newspaper stories, and an endorsement from the local paper on Nutrition Incentives. Also mentioned in the Richmond Federal Reserve News. (See attached).

12) Spoke to numerous groups about Local Foods and EBT, including national Buy Fresh Buy Local chapters; Fredericksburg Area Food Bank affiliates, Headstart; Central Virginia Farm Bureau Women's Committee.

13) Notified regional FNS office that there is a plan to continue to offer incentives to encourage SNAP customers to purchase food at Farmers Markets. Sent End Of Season report reflecting number of SNAP transactions and incentives in 2011.

14) Established Internal Controls and reporting processes for grant management.

15) Outlined new fiscal agent processes for merchant services to support timely payments to producers for SNAP and credit card transactions. Hired new CPA to manage program books.

16) Managed Spotsylvania and King George Farmers Markets.

17) Established new market site for Spotsylvania Farmers Market at Spotsylvania Regional Medical Center (Wednesday 3-7 PM) and hired a UMW intern as site manager for weekday market.

18) Added new market days for SNAP EBT sales at the Fredericksburg Farmers Market (Tues & Wed, 11 am – 1 pm).

19) Developed and implemented advertising and promotion plans for jointly promoting the four markets.

20) Arranged for Social Services tours at each market site to educate Caseworkers about the SNAP EBT program.

21) Supported development of Virginia Farmers Market Managers Association to build professionalism and support SNAP EBT at Virginia farmers markets. Served as steering committee member and interviewer for facilitator position to lead effort.

- In Fredericksburg-area farmers markets, the majority of farmers market vendors are Specialty Crop producers, who benefit directly from market token programs that increase fruit and vegetable consumption. Specialty crop farmers are the primary beneficiaries of new revenues produced by the Market Token Program. Prior analysis shows that fruit and vegetable producers receive 80% to 85% of SNAP token sales and close to 100% of Nutrition Incentive token sales at Fredericksburg area farmers markets.
- SCBG provided a portion of funding for the 2013 Market Token Program. Other funding came from a variety of sources, including Farmers Market Promotion Program and local Community Benefit Funds. Project staff time was allocated to ensure that work paid for by SCBG focused solely on Specialty Crop producers and did not benefit other market sellers. The benefit to Specialty crop growers was significantly greater than the percent of funding provided by SCBG funds. Total program staff expense was $56,000; SCBG contributed $20,000.
- Funds from this grant were used for the Vegucation program by supporting additional market days for this fresh fruit and vegetable education program. Vegucation is foccused solely on increasing awareness and consumption of Specialty crops by educating consumers on how to identify, select, prepare and store fresh fruits and vegetables.

III. Goals and Outcomes Achieved

The expected measureable outcome is that farmers selling at three participating farmers markets will increase sales through SNAP by 3% and overall sales by 8%. Actual sales increased by

upwards of 50% in the grant period at four participating markets. New SNAP shoppers (411) visited the four farmers markets, and conducted 1459 SNAP transactions.

With the addition of a new weekday farmers market, additional specialty crop producers were also able to sell locally and benefit from market token sales.

Specialty crop farmers are the primary beneficiaries of new revenues produced by the Market Token Program. Prior analysis shows that fruit and vegetable producers receive 80 to 85% of SNAP token sales and close to 100% of Nutrition Incentive token sales at Fredericksburg area farmers markets.

The target measurable outcome was 3% growth in SNAP sales and 8% growth overall. The actual measurable outcome was 13% growth in SNAP sales and 13% total token program sales. Specialty Crop farmers were the direct beneficiaries of 10.45 of the growth in 2013.

IV. Beneficiaries

65 specialty crop farmers that sell at Spotsylvania, Fredericksburg and King George farmers markets in Central Virginia are the intended beneficiaries. Through this program, 17,460 federal nutrition benefit recipients are able to use SNAP EBT to purchase seasonal locally grown produce at area farmers markets. By effectively doubling federal benefit dollars, Nutrition Incentives help both the consumers and farmers. SNAP shoppers reported that Nutrition Incentives increased their consumption of a variety of fresh fruits and vegetables. Many SNAP shoppers came from surrounding counties, affirming the need for SNAP EBT to be available at more farmers markets to meet the growing demand for fresh food.

Specialty crop farmers were the primary beneficiaries of the increased market sales. In addition, the individual farmers markets benefited by increased awareness and foot traffic as a result of collaborative regional outreach and promotion.

V. Lessons Learned

- Increasing low-income access and affordability through SNAP EBT and Nutrition Incentives at farmers markets is a viable strategy to build local and regional food systems. More support is required for local food organizations to fully leverage this opportunity.
- A regional network is an effective approach to administering farmers market token programs. Small markets can band together for increased impact through outreach, producer training, fiscal management, data collection and reporting.
- Specialty Crop Producers reap the benefits of increased promotion, new customers brought to market and direct sales increases through token program sales.
- Continual outreach is required to reach federal benefit recipients with the message that they can use SNAP EBT at farmers markets. This places new requirements on farmers market staff, who may lack capacity to undertake this community outreach.
- Partnerships are particularly important in promoting access and affordability - community partners such as Social Services and Community Health that have frequent and direct contact with low-income residents must be engaged to act as agent for farmers market programs.
- Exponential growth in token sales is possible but not sustainable across many seasons.

VI. Additional Information (Include contact information)

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Articles

Richmond Federal Reserve
http://www.richmondfed.org/publications/research/region_focus/2012/q2-3/pdf/upfront.pdf

Free Lance-Star Article
http://fredericksburg.com/News/FLS/2012/092012/09292012/728121

Program helps families buy fresh, local produce
Food stamp recipients use benefits at local farmers markets
Date published: ***9/29/2012***

Free Lance-Star Editorial
With a Neighbor
Buying locally produced food at area farmers markets can pay big dividends
Date published: ***7/2/2012***

JULY IS here, and while the downside might be heat and humidity, the very tasty upside is the arrival of local corn and tomatoes, along with the other produce that's as fresh as it gets at area farmers markets.
People are more than ever looking to buy food that's been produced locally--many of them growing it themselves whether as a hobby or to save money. It's a "growing" movement, actually, and one that's about as nonpartisan as it gets. It's also a habit that presents a bounty of benefits by:

- Reducing the need to transport food over long distances, reducing pollution and fuel consumption
- Strengthening the local economy
- Supporting local family farms
- Improving everyone's nutrition by putting fresh, healthy food on the table
- Helping to keep open space and farmland in production rather than development

Establishing a sustainable local community-food system.
Some people are making a commitment to local commodities by joining CSAs, or Community Supported Agriculture programs, offered by local farmers. These are a good way to share the local bounty and boost the local economy all season long. Based on figures prepared for the Fredericksburg area, if each household spent $10 a week on local food that would be otherwise spent in the Fredericksburg area, if each household spent $10 a week on local food that would be otherwise spent in the supermarket, the regional economy would gain $57 million per year. According to localharvest.org, only 18 cents of each dollar you spend at the supermarket trickles back to the grower, wherever he might be.

And when you buy directly from a local grower, you can learn more about how that food was produced--organically or with chemicals. Part of the value of buying local is that artificial methods of preserving freshness are largely unnecessary.
To further advance the buy-local movement, patronize restaurants that use locally produced foods and encourage school officials to bring local foods into the cafeteria. What better way to boost good nutrition at a young age?
If there is any silver lining to the ongoing economic stress, it's that more people are inclined to buy local and grow their own. It's the sort of trend that can continue once the economy recovers--good news for local growers, and everyone's health and pocketbook.

#17 FINAL

Phase II - Marketing Expansion Initiative Promoting Virginia Grown Trees

Jeff Miller, VA Christmas Tree Growers Association, secretary@virginiachristmastrees.org

PROJECT SUMMARY

The purpose of the FY2010 USDA Specialty Crop Competitive Grant is to allow the Virginia Christmas Tree Growers Association (VCTGA) to take a more proactive approach to better connect the growers and potential buyers by focusing primarily, but not exclusively, on civic, community and non-profit organizations and groups. Project "Marketing Expansion Initiative Promoting Virginia Grown Christmas Trees" will help in the sale of Virginia Christmas trees by establishing greater visibility and marketing opportunities for its growers within the Commonwealth by sponsoring marketing expos in each region or by combining regions of Virginia as a vehicle to connect growers and buyers. This project has not been submitted to or funded by another Federal or State grant program.

Phase II, Marketing Expansion Initiative Promoting Virginia Grown Christmas Trees, built on the successes of the Phase I program with three mutually supporting activities. The first activity was to schedule winter meetings. We annually hold summer meetings which consist of structured discussions (e.g. new growers' seminar and wreath making workshop), formal presentations (e.g. pest control, marketing, management etc.) and a business meeting. In terms of marketing discussions and presentations, we tend to focus on the pending holiday season and plan new approaches based upon what we learn during the summer meeting. Further, our first marketing expo was planned and scheduled around our summer 2011 meeting. But, as currently scheduled at the end of that selling season, we have not had any formal opportunity for another eight months to compare notes, consider "lessons learned," evaluate the results of the marketing expos or critique our innovations. With a winter meeting, changes in marketing techniques learned at the summer meeting/expos and implemented during the selling season would be current, relevant and primed for discussion. As an association, we, the growers will have a more timely opportunity to learn from each other about how to increase the visibility of our Virginia Christmas trees. With the addition of subject matter experts as guest speakers, we have had a better opportunity to understand which marketing techniques were successful, how to increase those successes and why other innovations fell short of our goals.

In consideration of the potential travel limitations of winter weather and to include both our 110+ association members and the 200+ other growers in the Commonwealth, we proposed a total of four winter meetings, two in January 2012 and two in January 2013. Each year, one meeting would be scheduled in the Waynesboro/Staunton/Harrisonburg area for the convenience of those geographically located growers. The second meeting would be scheduled in the Blacksburg/Wytheville/Marion area. With two winter meetings, geographically apart, we can offer an exchange of information and assistance to all growers and benefit the entire Christmas tree industry in Virginia.

Funding to enhance the Association's internet site was the second initiative of this proposal. Christmas trees are an important part of Virginia's agriculture industry, contributing more than $35 million to the Commonwealth's total sales. The size of Christmas tree farms ranges from less than an acre to as large as several hundred acres, with a few growers having a thousand or more acres; and all are in competition with large, non-agricultural retailers, many of which feature trees grown beyond our borders. In terms of marketing, one opportunity to "level the playing

field" lies with the power of the internet. VCTGA has owned a website for several years. Like many other businesses, our growers have attracted new customers and sold our products as a direct result of the Association's site. But the site was dated and we believe an update will increase the effectiveness of internet marketing. A rewrite of the VCTGA page with better mapping links; social networking links; modern, animated graphics and search techniques is envisioned. Funds are available through the FY2010 USDA Specialty Crop Competitive Grant to upgrade our site, but we evaluated those changes and a further upgrade was in order to take best advantage of the marketing opportunities over the internet.

Virginia Christmas tree growers across the state are experiencing a steady decline in sales that is leaving quality trees standing in our fields. Far too many of the Christmas trees purchased in Virginia are bought from sources outside the state and marketing efforts must be implemented to change this trend, increase overall competitiveness and to build pride in our Virginia Grown products. If we can narrow the gap between our growers and Virginia buyers, it would increase overall sales and provide Virginia consumers with a locally grown, freshest tree possible. As our third initiative in this proposal, we are seeking funding to purchase display banners that will advertise our Virginia Grown products at the points of sale. We propose to purchase banners in sufficient quantity to provide retailers, of each grower's choice, for prominent display on retail lots and choose and cut farms.

VCTGA continues to refocus in order to gain more support from buyers within our home state. At the same time, we need to work harder to improve the competitive edge for our growers and secure the financial stability of the Virginia Christmas tree growers.

PROJECT APPROACH

- **In November 2011, we distributed marketing signs and banners to each member** (114) to help promote their business and “Experience a Real Tree” Christmas. These were used at choose-and-cut farms, retail lots, farmers markets and at meetings.
- **In the Spring of 2012, Additional work was done on the VCTGA website** www.VirginiaChristmasTrees.org to enhance the consumer experience and to serve as an asset for members and potential members for information resources and marketing their individual tree businesses through their mini-page on the VCTGA website.
- **At the Annual Meeting and Conference**, August 23-25, 2012, speakers were brought in to discuss marketing and advertising subject matter. See attached program.
- **In 2012, we continued to distribute marketing signs and banners** to new members to help promote their business and “Experience a Real Tree” Christmas. They were also made available to members at the Winter Meetings, at the Annual Membership Meeting/Conference and updates in the VCTGA News Journal. These were used at choose-and-cut farms, retail lots, farmers markets and at meetings.
- **Throughout 2012-2013, additional work was done on the VCTGA website** www.VirginiaChristmasTrees.org to enhance the consumer experience and to serve as an asset for members and potential members for information resources and marketing their individual tree businesses through their mini-page on the VCTGA website. Consumer-friendly updates were made to the farm Locator. A training manual for the development and maintenance of the mini-pages for members to update their information and mini-web pages

online for themselves, anytime, was developed and added to the member's only section of the website.

- **Two Winter education meetings** were held on February 22, 2013 in Waynesboro and February 23, 2013 in Hillsville. The first meeting, in central Virginia, was oriented more towards choose-and-cut farms and retail outlets and some wholesale growers. The second meeting, in Southwest Virginia, was oriented more towards wholesale growers. See attached program schedules.
- **At the Annual Meeting and Conference**, August 15-16, 2013, speakers were brought in to discuss marketing and advertising subject matter. See attached program.
- **State Fair** – The VCTGA joined the Virginia Green Industry exhibits at the 10-day State Fair of Virginia with support from the Virginia Department of Agriculture & Consumer Affairs who provided 700 copies of the "Virginia Grown Christmas Trees Guide" (http://www.virginia.org/VirginiaTreeFarms/__as well as VCTGA promotional material. The exhibit was staffed by VCTGA members at key traffic times.
- **Another consumer event, the Virginia Christmas Show,** we had similar and marketing materials on November 8-10.
- **A Winter Workshop was held on March 8, 2014,** in Wytheville, VA was oriented towards growers with the latest information on Boxwood Blight by by Norm Dart, VDACS State Plant Pathologist. A representative from the Virginia State Police explained the rules and regulations regarding trucks, trailers and farm vehicles on Virginia roads, which have created issues for growers trying to get their product to market in a timely fashion. The manager of the Virginia Logo program explained how the Tourist Oriented Directional Signs Program (TODS) could benefit choose-and-cut farms to help consumers easily find their location. (See attached program.)
- **A mobile version of our website locator service has been published** so that consumers could simply plug in their zip code on a mobile device and locate choose-and-cut and retail farms closest to their location. It will also give them the option of going to the full mobile-friendly website for additional selections and care instructions.
- **A half-page color ad was inserted in the 2014 Guide to Virginia Growers,** published by the Virginia Nursery & Landscape Association, which is distributed to over 4,000 buyers in the Virginia and Mid-Atlantic region.
- The VCTGA display promoting "Real Virginia Grown Christmas Trees" was on display at the **National Christmas Tree Association Annual Conference** in Washington, DC, to let potential buyers know about Virginia grown trees.
- **WVPT – Public Radio** provided recognition of the Virginia Christmas tree industry as well as several interviews with growers that were broadcast around the state.

Other significant contributors to the project are the Mount Rogers Christmas Tree Growers Association (MRCTGA) and the Virginia Department of Agriculture and Consumer Services (VDACS). The MRCTGA help disseminate "Experience a Real Virginia Grown Tree" and "Buy and Sell a Real Virginia Christmas Tree" information to their members. VDACS Marketing representatives provide marketing advice, promotion of the program, speakers for programs and staffing at the Mid-Atlantic Nursery Trade Show (MANTS) in Baltimore.

GOALS AND OUTCOMES ACHIEVED

Monitoring fulfillment:

Subsequent to the 2011 Christmas season, we measured our outcomes via an informal poll. At our Board of Director's meeting on January 23, 2012, we discussed those results in terms of both our personal experiences, as well as those of our associates, and generally concluded that the brochures (complete with new logo), banners and static displays increased the visibility and marketability of not only the member tree farms, but that of all tree farmers across the Commonwealth. When asked, our members agreed that the website was a positive influence on sales and eagerly anticipated the pending rewrite as most were finding new customers arriving at our farms and tree lots as a direct result of internet research.

In assisting all tree farmers to locate civic and non-profit groups, we did not fare as well as hoped. We can only monitor the members of our Association. It was ambitious to think we could monitor the fulfillment of outcomes from non-member tree farmers. As it turned out, the expos did not generate the anticipated activity and we soon learned the logistics of hosting an expo exceeded the capacity of our Association. Learning from that lesson, we began seeking other opportunities, such as regional agri-business festivals, the State Fair and the Virginia Christmas Show where we could promote our product as vendors at a lower cost and significantly less labor.

With our annual survey now in place, we look forward to being able to better monitor the fulfillment of outcomes.

Highlight the major successful outcomes of the project in quantifiable terms.

Additional measures to monitor the fulfillment of outcomes include employment of Google Analytics. While we are just getting familiar with this process, we can report that during the period of November 15, 2013 to December 24, 2013, we had 7,823 visits to our website, 19,759 page views, the average visit was 2 minutes and 18 seconds and 85% of the visitors to the website were new visitors. During the same period the previous year, we had 5,410 visits, 13,773 page views, duration was 2 minutes and 20 seconds and 83% of the visitors were new visitors.

BENEFICIARIES

Along with the 106 Virginia Christmas Tree Growers Association (VCTGA) the Mount Rogers Christmas Tree Growers Association (MRCTGA) also were beneficiaries of this grant promotional program.

LESSONS LEARNED

Beyond the "Lessons Learned" that were previously reported and discussed in earlier progress reports, there were two unexpected results.

First, the rewrite of our VCTGA website resulted in more attention than we anticipated. In recognition of the power and popularity of the internet, many growers have gotten into the habit of asking new customers how they learned of our businesses. Often, the reply was "from the internet." What could not be pinpointed was the specific site the customers were referencing as there are many opportunities to shop for Christmas trees on the web. When we familiarized ourselves with Google Analytics, we were very pleasantly surprised to learn of the popularity of

our Association website as Google was providing an analysis of that specific website. We were gratified to confirm that the marketing firm that we employed to rewrite the site provided sound recommendations and published a product that exceeded our expectations as measured by Google.

The second result concerns measurable outcomes. We recognized and reported that many of our members are small businesses or part-time operators. As such, they do not have the automated resources to capture, sort, retrieve or produce reports. Many have a very limited capability to produce customer lists, determine trends, or calculate useful sales data. Many have no background or inclination relative to information technology. When we began asking for sales data, in the form of surveys, the response was somewhat disappointing. In follow-up requests, it became apparent that we, as an Association, needed to be educated in "point of sale" technology. We scheduled a subject matter expert to present available, affordable options during our summer meeting this past August. The presentation was well received and ran over the allotted time. Thoughtful questions were received and fielded by the presenter. Subsequent to the presentation, members were actively discussing employment of different resources. Clearly, the topic was long overdue we are proud to include this outcome in this report.

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ADDITIONAL INFORMATION

Copy of ad that ran in the 2014 issue of the Virginia Nursery & Landscape Association's "Guide to Virginia Growers".

#18 FINAL
Buying Virginia Grown Produce: Workshops for Private Schools, Senior Centers and other Community Institutions

I. Project Summary

This project organized by the Piedmont Environmental Council (PEC) addressed a strategic opportunity to expand market share and profits for Virginia specialty crop producers by connecting them to local institutional food purchasers such as primary and secondary private schools, senior centers, independent living communities, food service buyers and other community-based institutions. While there has been growing interest among administrators and food service buyers in purchasing locally grown food, there are few examples of Virginia specialty crop producers who are tapping into this market. Officials at community institutions need help in charting a path toward shifting some of their food purchases toward local products. Other institutions which are already on this path can help their peers navigate the issues and take steps toward sourcing more locally grown food. The project focused on the nine-county region of Virginia's northern Piedmont that comprises PEC's service area (Loudoun, Fauquier, Clarke, Culpeper, Rappahannock, Orange, Madison, Greene and Albemarle).

II. Project Approach

The project approach focused on participatory learning through open exchange among peers. PEC held a series of four workshops to help institutions assess their food procurement and preparation practices, featuring speakers from institutions that have successfully incorporated Virginia-grown specialty crops. PEC Agriculture and Rural Economy program director Sue Ellen Johnson facilitated the workshops.

Following the workshop series, PEC organized five site visits to local food aggregators and community institutions so participants could establish contacts, increase their familiarity with local food distributors, and directly see, ask questions about, and be inspired by current best practices among their peers. The site visits were organized in response to post-workshop feedback from the surveys in which participants expressed a need for hands-on tours and networking opportunities.

Participants were surveyed at the beginning, middle and end of the grant period to measure increases in local food purchasing and to help identify other kinds of activities and resources that would best stimulate more local food purchasing in the target audience.

The workshops and site visits were held on the following dates at the following locations:

- February 21 2012, 9:00 – 3:00 – Charlottesville Cooking School
- February 28 2012, 9:00 – 3:00 – Airlie Conference Center in Warrenton
- March 26 2012, 9:00 – 3:00 – Albemarle County Office Annex (follow-up to first workshop)
- March 27 2012, 9:00 – 3:00 – Airlie Conference Center (follow-up to first workshop)
- August 9, 2012 – Site visit to Local Food Hub, Charlottesville
- October 10, 2012 – Site visit to Blue Ridge Produce, Culpeper
- November 8, 2012 – Site visit to Fauquier Hospital, Warrenton

- January 31, 2013 – Site visit to Jefferson Area Board for Aging and Vinegar Hill Café, Charlottesville
- March 1, 2013 – Site visit to DC Central Kitchen, Washington DC

In organizing the workshops, PEC identified and recruited leading practitioners from 9 community institutions to speak and share best practices. The speakers ranged from small-sized institutions such as St. Anne's Belfield School and Jefferson Area Board for Aging in Charlottesville to large-sized institutions such as INOVA Health Services in Loudoun County and the Veterans' Affairs Medical Center in Martinsburg, WV. These institutional speakers, as well as representatives of a local food aggregator, Local Food Hub, and the VA Department of Health offered a wide range of experience and resources for our workshop participants. The institutions profiled included Jefferson Area Board for Aging, The Charlottesville Cooking School and St. Anne's-Belfield School in Charlottesville, Veterans' Affairs Medical Center in Martinsburg, WV, Grafton Integrated Health Network in Leesburg, Inova Hospital in Loudoun and Fairfax, and DC Central Kitchen.

To promote the workshops, PEC first created a list of community institutions and began to identify contacts at each (e.g. food service directors, dieticians, chefs, school principals). We sent e-mails and made follow-up phone calls to more than 80 institutions. Most of these calls were "cold calls" and helped us identify contacts.

The workshops and site visits identified a pattern of key issues that practitioners often confront when seeking to shift to more local sourcing. These include the need to educate, engage and sometimes re-train food service personnel; the challenges of advocating within the institution to senior administrators; the relative complexity of working with multiple local vendors compared to wholesale distributors; the tendency for local products to be more expensive and the need for institutions to stay within their budget; the difficulty of working with seasonality of local products when many institutions must create menus months in advance; the need to ensure high quality and consistency of local products institutions order.

Much of the discussion during the workshops focused on how to address and overcome these obstacles, based on real-life experiences and strategies adopted by the presenting organizations. Through this series of activities and networking, participants began to build a community of practice for sharing experiences, learning how to incorporate local food in their services and building relationships with local food aggregators. At the end of each workshop, each participant was asked to identify one action they would take once they returned to their institutions to help advance local food purchasing.

The workshops were attended by representatives of 21 institutions. This exceeded our goal of 10-20 community institutions. A total of 13 individuals representing 10 institutions participated in the site visits. The full participant list is attached. In addition, PEC directly engaged with more than 20 institutional representatives who were not able to attend the workshops or site visits but with whom we engaged in one-on-one conversations on their food purchasing. The workshop, online and phone surveys provide baseline and impact data from 52 of the more than 80 institutions from our original contact list. We also captured impact data through follow-up communications with participants.

The workshops, site visits and pre-/post-program survey content focused exclusively on purchasing local produce. The project director instructed workshop presenters and the site visit hosts to focus their presentations on local produce. All of the recruitment for the workshops and post-workshop follow-up communications and evaluation conveyed that the purpose of the program was to increase local produce purchasing. As a result, the discussions and learnings shared by the participants were all restricted to this topic.

III. Goals and Outcomes Achieved

Our principal activities were organizing and promoting the workshops and site visits; communicating one-on-one with program participants to learn more about their institutions' situations and needs, and connect them with helpful resources; producing, collecting and analyzing the post-workshop and online surveys; and conducting the phone survey.

Our goals were to reach 10-20 community institutions through the workshops; enable participants to identify where opportunities exist to incorporate Virginia-grown fruits and vegetables; increase new purchases of specialty crops among participating institutions; and build our organizational capacity to better assist institutional purchasers in buying local.

A total of 21 institutions participated in the workshops, exceeding our goal. As documented in our curriculum, the program provided substantive learnings and best practices for participants to better understand the challenges and opportunities for incorporating Virginia-grown fruits and vegetables. For example, participants were connected to the two major local food aggregators in the region. Many participants have built relationships with these aggregators, and some have entered into contracts. Before the program, many participants were unaware that these local food aggregators existed.

The program has demonstrably increased purchasing of Virginia-grown food by some community institutions. Particular successes include INOVA and Woodberry Forest. INOVA has increased its spending on local produce from 3.95% to 6.47% of produce expenditures at its flagship hospital in Falls Church. Although our contact at INOVA is not allowed to disclose actual cash figures, the hospital serves more than 4,400 meals per day so the economic impact is sizable. Woodberry Forest, a private school in Madison County, serves 1,300-1,500 meals a day during the school year and also runs a summer sports program served by its food service. Before participating in the program, the school's annual purchase of local food was in the $250-$1,000 range. It has increased its local food purchasing by an estimated $200/week. Now, about 10-15% of the school's food is from local farms.

IV. Beneficiaries

The primary beneficiaries are Virginia specialty crop producers. The local food aggregators have increased their institutional purchasers' base. As a result, they have been able to enter into more contract growing arrangements with Virginia specialty crop producers. Secondary beneficiaries are clients of the participating institutions, as well as the institutions themselves.

The impacts on the primary beneficiaries are demonstrated by our survey data on local food purchasing increases by participating institutions and by reported increases in the institutional

client base for local food aggregators. Among respondents to the online survey, two institutions expect to increase their purchases of local produce by $1,000-$5,000 during their next fiscal year, while two expect to increase local purchases by less than $1,000. Another institution has increased local food purchasing by an estimated $8,000/year. INOVA's purchases of local produce have increased 39% since participating in the program.

Impact on secondary beneficiaries is demonstrated through anecdotal evidence. Food service directors have noticed the improved quality of the local food they buy. For example, the food service director at Woodberry Forest School has observed that, "People like knowing that the food is fresher and better for you. Many have noticed that it is a better product."

V. Lessons Learned

This was PEC's first extended outreach project to community institutions. As expected, we learned a great deal about what was successful and what did not work so well. Below are some of the main successes, and key strategies that we would adjust in the future.

Successes/Positive results

- Participatory learning works: Face-to-face exchange and relationship-building were critical to building participants' comfort level. Participants were able to hear peers talk about how they had incorporated local food, and then interact with them afterward in small-group settings. This made local food purchasing seem much more achievable. As one participant whose institution eventually made a significant increase in local purchasing attested, "All the networking and information sharing was wonderful." Participants agreed that continued networking is the most important next step for the program.
- Positive reinforcement works: Participants also appreciated the emphasis on identifying short-term actions they could take right away, such as starting to plan a community garden. Sharing these initial successes with PEC staff and their peers in follow-up communications and during the site visits helped build their confidence and self-identification as advocates for local food within their institutions.
- Local food aggregators are critical: Engaging the Local Food Hub and Blue Ridge Produce in the program was central to our successes. Participants were able to engage in discussion with aggregators, get answers to detailed questions, exchange business cards and develop relationships. Through the site visits, they got to know the operations intimately and gained confidence that they would be solid partners. In end-of-program phone surveys, respondents repeatedly identified the instrumental role of the aggregators for starting or increasing local purchasing programs.

Lessons learned

- Must engage senior leadership: Our outreach targeted food service and nutrition staff. To some extent, we also tried to engage key administrators such as CFOs. Our learning is that we need to work harder to encourage senior administrators to participate in the program along with food service personnel. For example, one program participant reported that a buying arrangement she established with a local CSA, though very popular with the clientele, could not be sustained after a new CFO was hired and was not supportive. Organizations pursuing a program like this should strongly encourage participation by senior administrators *and* food service personnel.

- Government reimbursement standards play a significant role even in private institutions: We learned that many private institutions rely on government programs that reimburse them on a per-meal/per-plate basis, and this poses a significant constraint to adding local food. If we were to organize this program again, we would prompt our presenters to speak more to this issue and focus more of the discussion on how to make local food work within this constraint.
- Scheduling matters: It is difficult for the target audience to sacrifice a full workday for workshops or site visits. In general, they have limited funds or time allowances for professional development. We need to weigh the value of the full-day workshops in enabling networking and participatory learning against the real-life time constraints for our target audience.
- Individual vendor partnerships are not practical for many institutions: While some highly dedicated food service directors are forging connections with individual farmers, for most institutions the opportunity costs are too high to make this feasible. We are finding the local food aggregators to be much more pragmatic options for significantly expanding the local food footprint in community institutions.

VI. Additional Information

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