FINAL Report to

USDA Agricultural Marketing Service

For

SPECIALTY CROP BLOCK GRANT PROGRAM
Agreement No. 12-25-B-0913

Revision 2
February 25, 2013

Submitted by

Connecticut Department of Agriculture
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January 25, 2013

PROJECT: *Establishing the USDA Good Agricultural Practices (GAP) Certification Program in CT*
SUBGRANTEE: Connecticut Department of Agriculture, Marketing Division

1. **An outline of the issue, problem, interest or need.**
The demand for a uniformly recognized certification program has increased as food safety becomes a more important purchasing factor for Connecticut residents, restaurants, hotels, schools, institutions, and wholesalers. In 2009, the Connecticut Department of Agriculture (DoAg) did not have a nationally recognized certification program and no way to respond to demand by the industry. As specialty crop producers nationwide were being required to have an on-farm food safety program and to undergo third party audits, Connecticut farmers only option was to utilize expensive third party audit companies. As a result, the agency felt the need to establish an on-farm food safety auditing program.

2. **How the issue or problem was approached via the project.**
The need for affordable on-farm GAP audits was brought to the attention of DoAg by many of Connecticut‘s specialty crop producers. DoAg investigated and addressed these concerns by working with USDA-AMS officials and surrounding states that were faced with similar situations. DoAg determined the best approach was to implement a USDA Audit Program through a new federal-state partnership. Through this partnership, a DoAg employee would be licensed by USDA-AMS to perform on-farm food safety audits. By offering this service, Connecticut specialty crop producers would have access to an in-state audit at a reduced cost in comparison to audits offered by out-of-state auditing firms. Utilizing SCBG funds to establish this program has been instrumental in the maintenance and future expansion of Connecticut specialty crop production and therefore specialty crop sales.

3. **How the goal of the project was achieved.**
Working with USDA-AMS, DoAg was able to outline the steps that needed to be taken to offer this federal-state cooperative program. DoAg selected a qualified employee to address the requirements and to apply for the license to perform USDA audits. This DoAg employee:

    - Attended new auditor training class (2009)
    - Worked with neighboring states to shadow other licensed auditors (2010)
    - Participated in on-going auditor education/training requirements (2010)
    - Performed as the lead auditor on two audits under USDA Federal Program Manager supervision (2011)
    - Participated in on-going auditor education/training requirements (2010)
    - Applied for and was approved as a licensed USDA-AMS auditor (2011)

    With the completion of all requirements, promotion of the program, and a slow start up phase that lasted over a year, 2012 brought on a true wave of GAP audit requests from Connecticut‘s specialty crop producers. Sixteen specialty crop producers successfully passed a USDA GAP/GHP audit performed by DoAg‘s USDA licensed auditor.

4. **Results, conclusions, and lessons learned.**
DoAg pursued the GAP audit program in response to and with expectations that specialty crop producers would be *required* to undergo third party GAP audits. The licensing requirements of USDA – AMS and start up requirements in the state were extensive, but DoAg persevered and

was fortunate to be prepared for the first significant wave of GAP audit requests which came in 2012.

At the conclusion of the project, the actual number of audits conducted was less than what was originally expected in the submitted expected measurable outcomes. The number of audits expected to be performed was very difficult to estimate due to the nature of it being a new program that is industry and customer driven. In 2011, two farms that passed a USDA GAP/GHP audit. However, in 2012, 16 farms passed the USDA GAP/GHP Audit - an 800% increase from 2011. DoAg originally expected and continues to expect this program to be an important part of Connecticut‘s specialty crop industry and continue to grow in popularity. It is not known when and if this program will produce the numbers DoAg initially had expected. DoAg also learned that specialty crop producers are not willing to voluntary request GAP/GHP audits unless they were required to do so by their customers. As more customers require specialty crop producers to participate in third party food safety audit programs, the program will continue to grow. We do not expect to see an 800% increase in numbers each year but do expect a significant amount of farms to start requesting audits. These numbers may also be driven by the upcoming FDA‘s Food Safety Modernization Act.

5. **How progress has been made to achieve long term outcome measures.**
This past year was an important year for DoAg‘s GAP program. DoAg saw a tremendous response from specialty crop producers requesting GAP audits between 2011 and 2012. These producers made a significant investment into the GAP program.

Overall the program is still in its infancy and will continue to expand as on-farm food safety continues to evolve. This project helped Connecticut‘s specialty crop producers to maintain their current market share with their customers. DoAg is hopeful that this program will help these same producers expand business in the future while satisfying any new federal mandates that may be implemented by the Food and Drug Administration‘s Food Safety and Modernization Act.

6. *Beneficiaries*
Specialty crop producers that sell to requesting wholesale operations benefitted from the GAP/GHP On Farm Food Safety Audit Program made possible through Specialty Crop Block Grant Funds. This program provided them with an in-state auditing firm that could be relied upon to remain in compliance with their customers‘ demands pertaining to on farm food safety. The number of producers that benefited from this audit program in 2012 is 16, however 18 audits, two of which were recertifications, were completed over the course of the program year(s). Without this program in place these specialty crop producers would have lost a valuable wholesale customer(s) and a significant portion of their business. Without this in-state program, the only other option these producers would have had would be to bring in an accredited auditing firm from out of state at an increased cost.

7. **Additional Information:**
Connecticut DoAg Audit Website:
http://www.ct.gov/doag/cwp/view.asp?a=3243&Q=465924&PM=1

List of businesses that have successfully passed a USDA Audit:

http://apps.ams.usda.gov/ReportServer05_69/Pages/ReportViewer.aspx?%2fGAP-GHP%2fG05+-+By+Location++-+Auditees+that+Meet+Acceptance+Criteria&rs%3aCommand=Render

8. **Contact person for each project with telephone number and e-mail address.**
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PROJECT: *Increasing specialty crop marketability with food safety expertise.*
SUBGRANTEE: UConn College of Agriculture and Natural Resources, Department of Extension

1. **An outline of the issue, problem, interest, or need for each project.**
In the last 15 years, foodborne disease outbreaks traced to produce have demanded the attention of consumers, the industry, regulators and public health community. Federal and state regulatory agencies have published guidance documents recommending the adoption of Good Agricultural Practices (GAP); industry has proposed/implemented marketing agreements that require adherence to GAP; and retailers are requiring that produce suppliers adopt GAP and submit to third party audits of their operations. Since 2008, a major produce distributor (part of a national corporation) in Connecticut have been asking farmers to work toward the development of GAP food safety plans, with the goal of participating in a third party audit by the summer of 2011. Increasingly, supermarket chains in Connecticut and the region have also been asking farmers to work toward the goal of preparing for a third party audit. To remain competitive, Connecticut specialty crop farmers need to meet the demand for GAP programs, documentation and audit requirements.

2. **How the issue or problem was approached via the project(s).**
A GAP Summit was planned and held, using a focus group approach. Representatives of stakeholder groups, including farmers, retailers, produce distributors, farm organizations, and regulators attended. Discussion points were reviewed and used to inform the development of the GAP training program. The Connecticut Extension GAP School curriculum was developed based on the United States Department of Agriculture (USDA) GAP audit criteria. The training materials included a set of power point presentations, a participant notebook that included presentation slides, resource materials, model food safety plans, sample record keeping forms, and GAP audit protocols. A USB flash drive containing all materials was also provided so that farmers could incorporate and personalize these materials as they developed their food safety plans. Three GAP School programs were offered for farmers planning to participate in a GAP audit (49 participants representing 45 farms/organizations); two GAP ―Lite" programs were offered for farmers who simply required an introduction to GAP concepts (14 people representing 11 farms/organizations). Project partners helped to market the programs and teach the courses: some attended the training programs as participants. A second set of Extension GAP School programs were provided. The series included three GAP ―Lite" programs (52 participants representing 38 farms or organizations, including 15 Master Gardeners) and one GAP two day school (9 participants representing 8 farms). Nine one on one farmer visits completed the training opportunities for farmers. These visits were held prior to audits for a review of food safety plans and farm tour, if requested.

   Results from training program evaluations indicated that well over 83% thought that they had learned something new or more about something they already knew. All participants were able to articulate at least one new concept they gained from the workshop, while all but a few (who were beginner farmers) were able to identify one or two practices they planned to adopt or change as a result of attending the programs. Many wanted to know more about how to write a food safety plan after attending the 2 day course. The team responded by offering a plan writing workshop in year 3 attended by 18 participants representing 10 farms and one produce distributor. 100% responded that the workshop provided them with the tools needed to write a food safety plan.

   Of 16 farms audited by the Connecticut Department of Agriculture in the 2012 growing year, 12 participated in the CT Extension GAP School. All passed the audit.

A final project activity was the distribution of an online GAP program survey to further identify farmer attitudes and program needs. An announcement of the availability of the survey was distributed by email to 1,000 farmers of all types. 127 farmers responded to the survey. Data from the survey provided updated information including farmer attitudes/opinions about GAP and produce safety; training and information preferences; possible influence of farm size, longevity, and past GAP program attendance on willingness to participate in/or to develop a GAP program.

Twenty-eight persons participated in the GAP Summit, including produce farmers, regulators, retailers, distributors and Extension program providers.

Discussion themes of the Summit focus groups included the safety of fresh produce and the role of participants in ensuring safety; training and education methods; organization of training sessions and the availability of GAP training and information resources.

Noteworthy discussion results included:

- Provide training that can meet a variety of producer needs, including varying times and locations
- Keep costs down
- Everyone must share the responsibility of delivering safe food to consumers
- Prefer a variety of GAP information/training delivery methods; offered in January/February; 2 hour sessions; traditional mailing still important; computers not ubiquitous
- Need to educate consumer and pick-your-own participants regarding GAP and produce safety
- Templates/models will be useful—record keeping and computer tools; ―field hardy” record systems
- Need more information regarding GAP and water, manure, food safety plans, micro testing, traceability
- Employee training issues: language; use of visuals; videos useful; time available for training

This information as well as training experiences and expertise of the planning group were used to inform the development of the GAP training program.

Over the course of the three year project, the University of Connecticut GAP School training program evolved. The initial program was based on results from the GAP Summit and included:
UConn GAP School: Training programs were offered in two locations and time periods: morning, weekday classes meet the needs of full time producers while night/weekend program allows part-time farmers more flexibility. The School consisted of four sessions:

- Session I: Introduction and GAP Foundation Programs
- Session II: In the Field/Harvest
- Session III: In the Packing Facility
- Session IV: Putting it All Together (training, food safety plans, record keeping)

All four sessions were again offered to provide flexibility for farmers who may have only needed to attend specific sessions (i.e., they did not need to participate in the packing house session). Over the next 2 years, we adjusted this program to meet farmer needs based on feedback, customer audit demands and evaluation results. We now offer the program in two full day sessions.

GAP Plan Writing Workshop: This program was developed during year two of the project to help farmers begin the process of writing their food safety plans with guidance from the training team. This process is a new one for farmers and though they responded that the GAP School provided the information they needed to write a plan, some needed more assistance. This one day hands-on workshop was developed to meet the need. Laptop computers were provided to those who did not have one. We took a step by step approach using a food safety plan template.

GAP Lite Workshop: A relatively small number of farmers actually participate in GAP third party audits as required by their customers. This was an effort to provide training that can meet a variety of producer needs (a GAP Summit result statement)—and some producers while not needing an audit, are interested in being proactive about growing fruits and vegetables using practices that reduce consumer risks. These half-day programs were primarily focused on GAP practices, with minimal attention to audit programs and formal plan writing.

GAP Farm visits: Farm visits were added as a final review of food safety plans and farm GAP practices in preparation for audits. These were provided as a result of farmer demand.

GAP Update: During the last program year, a GAP Update session was added to review last season's audit results, update on new knowledge, regulatory changes and audit program changes.

3. How the goals of each project were achieved.

The following goals are based on revisions in 2012.

Goal : To assess progress/intent of Connecticut farmers regarding GAP education and audit programs.

Activity: A 15 question online survey was distributed. Information gathered will inform future GAP program design and delivery.

Goal: To improve food safety literacy of Connecticut specialty crop farmers.

Activity	Target	Actual
GAP Food Safety Summit	Participants: 35	Participants: 28 representing multiple stakeholder groups
Farmers in GAP education programs	▪ 100 farmers trained in 3 years ▪ 80 will increase knowledge ▪ 80 farmers will identify planned changes in GAP practices	124 farmers/gardeners representing 102 farms/organizations were trained 83 % (66) reported gaining knowledge 100% of participants currently farming articulated at least one practice they planned to adopt as a result of attending the program.

Goal: To improve food safety literacy of Connecticut farm workers

Activity	Target	Actual
Training regarding employee training as part of basic GAP course	All (100%) of participants	All participants (58 farmers) in the CT GAP school full workshop received this training
Train the trainer for farmers regarding employee education	15 farmers	No farmers
Farmers will train employees regarding GAP	40 farmers	Farmers who completed audit - 17

Goal: To increase adoption of GAP/food safety plans

Activity	Target	Actual

Web site	Developed and launched	Developed
GAP plans developed	15 farmers	11 farms (17 farmers)
Self-audits by non-formal audit farms	20 farmers	0 farms
GAP third party audits completed	10 audits	11 audits completed by those who participated in CT GAP School programs

4. Results, conclusions, and lessons learned for each project.

The following results and conclusions are based on revisions in 2012.

Goal: To assess progress/intent of Connecticut farmers regarding GAP education and audit programs.
Discussion: A 15 question online survey was distributed. Information gathered will inform future GAP program design and delivery.

Goal: To improve food safety literacy of Connecticut specialty crop farmers.

Activity	Discussion
GAP Food Safety Summit	GAP food safety summit was conducted; focus groups identified training needs and design; including employee training and consumer education.
Farmers in GAP education programs	The numbers of farmers reached by GAP education programs, both GAP for farmers intending to participate in an audit and GAP Lite for those that did not, while meeting revised goals, were not as high as originally planned. At this time, only one distributor and two retail outlets are requiring GAP audits in Connecticut. A third retail store will require it next year. It appears that until required by a customer to undergo a GAP audit, farmers may want basic GAP practice information, but will be reluctant to formalize their activities with self-audits and written food safety plans.

Goal: To improve food safety literacy of Connecticut farm workers

Activity	Discussion
Training regarding employee training as part of basic GAP course	While all farmers in the 10 hour GAP school received information regarding training, there was not much interest in further programming on this issue. Farmers who participated in the audit (17 farmers, 11 farms) did need to provide employee training and documentation of that training, however. During the audit process employees were asked questions regarding personal hygiene. All farmers who participated in our GAP programs did pass the audit.
Train the trainer for farmers regarding employee education	
Farmers will train employees regarding GAP	

Goal: To increase adoption of GAP/food safety plans

Activity	Discussion
Web site	Waiting to complete development of other pages on UConn food safety web site so that all will be launched together.
GAP plans developed	Those that needed to participate in an audit wrote plans. In response to the need for additional help writing plans, project personnel provided a one day workshop attended by 15 farmers from 10 farms and 9 one-on-one education sessions to help farmers write their plans.
Self-audits by non-	Not done—likely due to the fact that it was not required.

formal audit farms	
GAP third party audits completed	While the revised goal was met, these numbers should be higher. Some customers who are want farmers to participate in a GAP audit have been lenient at first, moving farmers towards the goal in the next year or so. It is likely that as GAP becomes the way that business is done, more farmers will need to comply.

Right from the beginning, our biggest challenge was to draw in the farmers. At that point there was one distributor, a member of a national food supply corporation, who was requiring that farmers work towards preparing for a GAP third party audit. While there are upwards of 2500 farmers in Connecticut, the number of farms selling to a distributor or retailer requiring a third party audit is approximately 30-40. We learned that we needed to provide an alternative workshop for farmers who may not need to prepare for an audit, but wanted to learn the basics of GAP: GAP Lite was developed as this alternative. Some farmers will still not participate in any GAP programming unless required to. There are many demands on their time. Finally, we continue to struggle to help farmers understand that small operations carry the same risks (or in some cases, higher risk due to practices and facilities on the farm) as larger farms. Potential outbreaks will affect fewer people and will not garner the national attention the larger operations do. Any and all means of communication of the food-safe produce message needs to be used so that farmers hear, understand and incorporate that message into their business plans.

Below is a summary of participant's key points that contributed to the design of the training program.

Focus group key points	**How points affected program design**
What should program look like: One size does not fit all; variety of training times; hold in January/February; 2 hour sessions; videos for training employees; etc.	A variety of locations/times were offered; GAP Lite and regular GAP School developed; program held in January/February; resources provided for employee training
Address specific GAP practices (water, manure); how to write a food safety plan; SOP; traceability	Program agenda addressed all GAP practices; Plan Writing program offered.
Address operation specific issues-pick your own, small operations, etc.	Within the program, information specific to the needs of pick-your-own and smaller operations were addressed.
Have an annual GAP meeting/update	Annual update planned and provided.
Would like to learn about GAP using: person-person training on farm; reference guides, hard copies; on-line; educational walk-through; flexible training to meet needs of farmers; hands on; templates	The program included on-farm visits; hard copies of curricula and resources as well as a memory stick of all materials; hands on plan writing session with templates for plans and records provided.
How do you want to get information about GAP: traditional mailing, email, Dept. of Ag and other newsletters.	Program notification was accomplished using mail, email, newsletters, and a variety of farm organizations.

5. How progress has been made to achieve long term outcome measures for each project.

- Farmers (11 farms) who completed the course(s), prepared for and passed a third party audit are able to sell their product to distributors and retailers who require audits as a condition of purchase.

- Farmers (approx. 87 farms) who completed the course(s) who did not participate in the audit still benefited by the increased knowledge in safe food handling that the program provided. They learned skills and practices that they can adopt that may decrease the risk that their product will cause a foodborne illness.
- Future farmers will benefit from project outputs including course materials, a web site, and the development of an email list/listserv to continue communications to produce farmers.
- Distributors/retailers who require a third party audit (presently one large distributor and 4 retail supermarket chains with stores in Connecticut) benefit from having a pool of trained farmers who are providing a local product (increased consumer demand exists for local product) that is produced under a food safety plan, again, reducing consumer risk.
- Consumers of products produced by farmers who have adopted GAP practices will benefit from reduced risk for foodborne illness from locally grown produce.

6. Additional information available (e.g. publications, Web sites).

The survey summary can be found in Appendix A.

The web site will likely go live in three months. Once live it will be located at www.foodsafety.uconn.edu. Screen shots of the website are attached in Appendix A.

7. Contact person for each project with telephone number and e-mail address.

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PROJECT: *USDA Good Agriculture Practices (GAP) Certification Cost Share for Specialty Crop Producers*
SUBGRANTEE: Connecticut Department of Agriculture, Marketing Division

1. **An outline of the issue, problem, interest or need.**
   The Connecticut Dept of Agriculture (DoAg) established a Good Agricultural Practices (GAP) food safety certification program for Connecticut specialty crop farmers. However, the great expense associated with the certification was expected to be a turn off to many of the growers, possibly even preventing them from pursing an audit. To encourage participation, DoAg provided a financial incentive to specialty crop producers who successfully passed a GAP audit through the newly established GAP Certification Cost Share Grant Program. The program assisted with reducing the overall expenses associated with becoming USDA GAP certified and supported the newly established DoAg GAP certification program.

2. **How the issue or problem was approached.**
   DoAg established a food-safety GAP program in CT. The demand for a uniformly recognized certification program was and continues to increase as food safety becomes a more important as a purchasing factor. To fully utilize the GAP program, DoAg provided applicants the opportunity to be reimbursed the cost of becoming GAP certified through the GAP Certification Cost Share Grant Program.

   The program allowed specialty crop farmers to receive reimbursement for 100% of the total GAP audit cost <u>after</u> they successfully pass an accredited GAP third party audit. They also could receive reimbursement for up to two water tests per calendar year.

   To promote the program, any specialty crop grower who expressed interest in becoming GAP certificated received materials. Information was also available on our website, available from the DoAg GAP auditor and during any food safety training program. Knowledge of the grant also spread through word of mouth.

3. **How the goals of each project were achieved.**
   The goal of the project was to certify 100 specialty crop producers over three (3) years to participate and pass a third party food safety audit. We fell well short of our goal even with the added incentive of a cost share program to help alleviate the cost. Once an audit was passed, the new GAP auditor would inform the GAP Cost Share Grant Program manager so follow up could be done and the farm could submit for reimbursement.

4. **Results, conclusions, and lessons learned.**
   A total of 14 Connecticut specialty crop producers received the grant. While there was a total of 16 Connecticut specialty crop producers that participated and passed a third part food safety audit, two of them did not submit their paperwork prior to the grant ending. Overall we had expected a much higher participation rate during the program years however, we found that a lot of growers were reluctant to participate in this food safety program because of the paperwork and training requirements. The growers that did participate and passed the third party audit did so because one or more their buyers (wholesale, retailer store, school, etc) required it. Many growers assigned a person from the farm as a food safety specialist as their main job.

5. **How progress has been made to achieve long term outcome measures for each project.**
   There was significant interest in on farm third party audits. Around 87 specialty crop producers participated and completed a GAP food safety summit which focused training and education but did not participate in a third party food safety audit. They learned skills and practices that can be adopted in a future food safety audit that decreased their risk of a food borne illness outbreak at their farms. As more distributors/retail buyers require a third party food safety audits, these specialty crop producers may apply what they have learned and take part in the GAP audits.

6. **Additional information available (e.g. publications, Web sites).**
   http://www.ct.gov/doag/cwp/view.asp?a=3243&Q=465928

7. **Contact person for each project with telephone number and e-mail address.**
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PROJECT: *Enhancing the Competitiveness of Locally Grown Salad Greens Grown Under Protected Cultivation in Greenhouses*

SUBGRANTEE: Connecticut Agricultural Experiment Station

1. **An outline of the issue, problem, interest, or need for each project.**

   Protected cultivation in greenhouses extends the production season of vegetables in Connecticut beyond the few summer and fall months allowed by open field production. Greenhouses can provide locally grown, fresh vegetables to Connecticut consumers year-round. It is possible to increase the production of these crops, and the quality of specific compounds in plant tissue that are important for human nutrition, by manipulating the environment and fertilization within the greenhouse. Plants can be kept free of pesticides since most pathogens and diseases can be addressed using integrated pest management techniques in the contained environment. Hydroponics allows the control of the concentration and composition of fertilizer that plants take up, and thus provides another level of control of plant tissue composition.

   Locally grown vegetables are fresh and have a different nutritional composition than vegetables that have been in storage or transit for days or weeks before reaching the consumer. The greater content of vitamins and other metabolites is an appealing selling point to consumers for enhancing the consumption of locally grown food. They want to know the amounts of nutrients in representative samples of locally grown salad greens, such as spinach and lettuce, compared to the nutritional values to greens that have been transported from distant areas of the U.S. or other countries, and sold through nationally branded supermarkets and food outlets.

   Consumers also want to know the conditions under which their vegetables are grown rather than purchasing produce from anonymous farms, under unknown conditions. Research in hydroponic production of salad greens in Connecticut has the potential to significantly increase the economic returns for Connecticut greenhouse operations, owned by farmers and local growers, involved in vegetable production. Topics related to this research area include extending the season for vegetable production using high tunnels and greenhouses; and the change in composition of plants due to fertilization or season.

2. **How the issue or problem was approached via the project(s).**

   We determined the nutritional value of locally-grown salad greens and compared these values to those of the same crops that were produced in distant regions and sold in supermarkets. Samples were obtained from all sources in each season of the year. Locally grown produce had higher concentrations of sucrose and starch, and lower concentrations of free amino acids than produce shipped from distant regions. Sugars were increased in summer in lettuce, and in winter in spinach. The local produce likely retained more of the sugars found in plants immediately after harvest. The high amino acids in non-local produce may be an early sign of tissue breakdown due to prolonged storage. However, we found no instances in which mineral- or organic acid composition differed between local compared to distance production. These concentrations were not affected by seasonal changes in environment. Most differences in composition could be attributed to production conditions and/or the size of the plants, and not to the source or place of origin.

3. **How the goals of each project were achieved.**
Goal 1: Develop greenhouse environment and fertilizer protocols to maintain high nutrition values of vegetable crops grown in various seasons of the year.
    - Consecutive plantings of spinach in hydroponics, grown by Dr. Martin Gent & technician
    - Spinach was grown in hydroponics from Feb to June 2010
    - Plants were harvested every 3 hours to observe day/night variation in composition of plant tissue, June 2010.
    - Composition of plant tissue samples, analyzed by Technician & assistant, Aug – Sept 2010

    Goal 2: Determine how changes in nutrient solution composition will affect the value of salad greens for human nutrition.
    - Spinach grown in hydroponics from Feb to June 2010, grown by Dr. Martin Gent & technician
    - Plants were harvested daily to observe changes in composition due to nitrate depletion or resupply in the nutrient solution, May 2010.
    - Composition of plant tissue samples, analyzed by Technician & assistant,Jun – Oct 2011

    Goal 3. Determine the nutrition value of locally grown salad greens and compare these values to those of the same crops available in supermarkets that were produced in distant regions.
    - Collected samples of salad greens from two local growers, Dr. Martin Gent, Dec 2009 to Dec 2010, Five sample dates.
    - Analysis of composition of plant tissue samples, Dr. Martin Gent & technician, Mar 2010 to Mar 2011

    Goal 4. Disseminate this information to the agricultural and farming community, to the general public, and to interested stakeholder organizations.
    - Analysis and write-up of results of prior work on diurnal variation in lettuce, by Dr. Martin Gent, Jan 2010 - Dec 2010.
    - Analysis and write-up of results of prior work on nitrate nutrition of lettuce, by Dr. Martin Gent, Jan – Oct 2011.
    - Analysis and write-up a CT Agr. Exp. Stn. Bulletin _Composition of salad greens: A comparison of locally-grown and supermarket produce.' by Dr. Martin Gent, March - May 2011.

4. **Results, conclusions, and lessons learned for each project.**
Greenhouse production is extremely important to Connecticut agriculture. Connecticut leads New England in net farm income. In 2004, the cash value of all vegetable crops grown on approximately 10,000 acres in Connecticut increased to $24.8 million. Agriculture in Connecticut has diversified, leading to smaller farms and more farmers growing food crops;.64% of farms are less than 50 acres in size. Many such operations use greenhouses to grow vegetables to sell. Currently, there are only a few growers who use hydroponics to produce salad greens. The ability to influence the nutritional value of these crops will help to expand the popularity of hydroponics. This will translate into increased consumer appeal and potential increased sales of greenhouse-grown vegetables. This research project, which will publicize the nutritional value of CT grown crops, and will improve the retail value and income of growers who produce salad greens.

    Only some of the differences in tissue composition of salad greens could be attributed to the source (local or distant) and to the time of year of production. There were also variations that could not be ascribed to these factors. A more comprehensive study involving more growers and sources, and more years of data would be required to more clearly define all the sources of variation in tissue nutrient content. Vitamin content is of great interest to consumers. It was not possible to analyze for these chemicals within the budget and time constraints of this project.

Goal-specific results:
Goal 1. Develop greenhouse environment and fertilizer protocols to maintain high nutrition values of vegetable crops grown in various seasons of the year.

- The diurnal variation in composition of lettuce leaves was analyzed and a report was written, submitted to, and accepted by, the Journal ‗Science of Food and Agriculture'.

Goal 2. Determine how changes in nutrient solution composition will affect the value of salad greens for human nutrition.

- The effect of withdrawal or resupply of nitrate in the nutrient solution on composition of lettuce was analyzed and a report written and submitted to the Journal ‗Science of Food and Agriculture'.

Goal 3. Determine the nutrition value of locally grown salad greens and compare these values to those of the same crops available in supermarkets that were produced in distant regions.

- Salad greens were collected from local growers on five dates between Dec 2009 and Dec 2010 to determine seasonal variation in composition of plant tissue. All data were analyzed and written up as a CT Agricultural Experiment Station bulletin. This bulletin is available to the public, including CT farmers and growers. There were no fact sheets produced other than the bulletin.

Goal 4. Disseminate this information to the agricultural and farming community, to the general public, and to interested stakeholder organizations.

- Provided advice on lettuce production in greenhouses (9 growers)
- Talked to a Community Garden Club on ―Season Extension" (25 people)
- Talked to Farm to Chef on ―Effect of Environment and Fertilizer on Composition of Vegetables" (25 people)
- Talked at the New England Vegetable and Fruit Growers Conference on ―Changes with Season of Nutrients in Salad Greens Grown in High Tunnels" (approx 100 growers).
- Talked to a Farm Bureau meeting on ‗Vegetable production in high tunnels, greenhouses, and in hydroponics' (50 people).

During the calendar year 2012 there were 3 unique views/downloads of the bulletin.

5. How progress has been made to achieve long term outcome measures for each project.
Consumers – They'll have more information about the nutritional value of locally grown salad greens.
Local growers – Connecticut's growers will have a better idea of the nutritional value of their crops, and how this varies with time of year and method of production.
Growers nationwide – They have the opportunity to benefit from knowledge of the diurnal variation in tissue composition and the time course of change due to depletion and resupply of nitrogen, in order to harvest their crop at a time of optimal nutritional value.

There were two local growers made significant contributions to this project: ‗Two Guys from Woodbridge' in Hamden CT, is a grower that uses hydroponics to produce lettuce and other greens according to organic standards and ‗Starlite Gardens' of Durham CT, is a grower that produces year –round a wide variety of salad greens grown in organic soil in high tunnels or under row covers. Both of these growers provided sampled for tissue analysis when requested, (five times over the course of a year). They also provide details on timing of crop production and cultivars used.

6. **Additional information available (e.g. publications, Web sites).**
Analysis and write-up of results of prior work on diurnal variation in lettuce, by Dr. Martin Gent, Jan 2010 - Dec 2010. Gent, M.P.N. 2012. Composition of hydroponic lettuce: Effect of time of day, plant size, and season. J. Sci. Food. Agric. 92:542-550.
http://onlinelibrary.wiley.com/doi/10.1002/jsfa.4604/abstract

Analysis and write-up of results of prior work on nitrate nutrition of lettuce, by Dr. Martin Gent, Jan – Oct 2011. Gent, M.P.N. 2012. Rate of change of composition of lettuce in response to nitrogen depletion or resupply. J. Sci. Food. Agric. 92:3007-3015.
http://onlinelibrary.wiley.com/doi/10.1002/jsfa.5716/abstract

*Analysis and write-up a CT Agr. Exp. Stn. Bulletin „Composition of salad greens: A comparison of locally-grown and supermarket produce."by Dr. Martin Gent, March - May 2011.*Gent, M.P.N. 2011. Composition of salad greens: A comparison of locally-grown and supermarket produce. Connecticut Agric. Experiment Station Bulletin 1032. 5 pp.
http://www.ct.gov/caes/lib/caes/documents/publications/bulletins/b1032.pdf

Talked to a Community Garden Club on "Season Extension" (25 people)
http://www.ct.gov/caes/lib/caes/documents/publications/record_of_the_year/record_of_the_year_2009-2010.pdf page 49

Talked at a Farm to Chef on "Effect of Environment and Fertilizer on Composition of Vegetables" (25 people)
http://www.ct.gov/caes/lib/caes/documents/publications/record_of_the_year/record_of_the_year_2009-2010.pdf page 49

Talked at the New England Vegetable and Fruit Growers Conference on "Changes with Season of Nutrients in Salad Greens Grown in High Tunnels" (approx 100 growers).
http://www.ct.gov/caes/lib/caes/documents/publications/record_of_the_year/record_of_the_year_2009-2010.pdf page 49

Talked to a Farm Bureau meeting on „Vegetable production in high tunnels, greenhouses, and in hydroponics"(50 people).
http://www.ct.gov/caes/lib/caes/documents/publications/record_of_the_year/record_of_the_year_2010-2011.pdf page 45

7. **Contact person for each project with telephone number and e-mail address.**
Dr. Martin Gent, Dept of Forestry and Horticulture
The Connecticut Agricultural Experiment Station
Telephone Number: 203-974-8489 Email Address: martin.gent@ct.gov

PROJECT: *Enhancing Asparagus Production in Connecticut's Agriculture*
SUBGRANTEE: Connecticut Agricultural Experiment Station

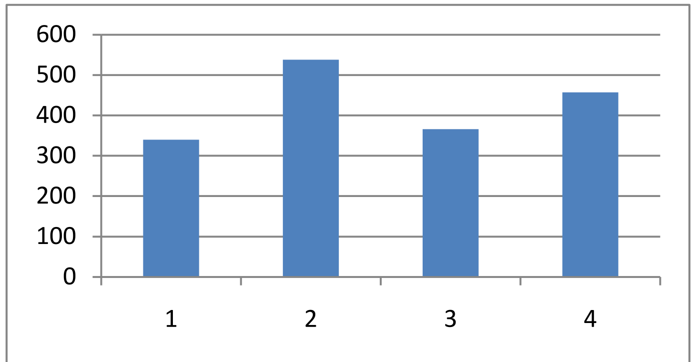
1. **An outline of the issue, problem, interest, or need for each project.**
   - The Issue: Growers in Connecticut have long since realized the need to diversify their operations and extend the market season to stay economically viable. Asparagus crop that can serve two functions: It is a cash crop generating between $10,000-15,000 /A As a late spring crop, growers can use asparagus sales to attract consumers to their operations in May instead of June when many markets open.
   - The Problem: Asparagus is labor intensive and is susceptible to Fusarium crown and root rot, a disease caused by the soilborne fungi, Fusarium spp. To manage this disease, growers must establish a strong and vigorous planting the first year is one of the most important aspects to ensure a productive planting.
   - The Interest: Consumers perceive asparagus as a highly nutritious delicacy with health benefits and anticancer properties, which translates into a willingness among consumers to pay high retail prices. Rising energy costs favor local production of agricultural commodities, such as asparagus. Connecticut growers stand to profit from increased production. Growers who have small fruit plantings can also benefit from asparagus production because they already have the labor and markets established.

2. **How the issue or problem was approached via the project(s).**
   The long term strategy for reducing damage from Fusarium crown and root rot disease was to increase soil quality with earthworms (Lumbricus terrestris) and the use of biochar, a fine-grained charcoal produced from the pyrolysis of plant tissue. Strong correlations exist between the earthworm densities and the physical and biological health of soils. However, earthworm densities in asparagus fields are not usually high due to toxic asparagus root residues. Biochar has tremendous absorptive capacities and may function by irreversibly binding toxic compounds in soil. As biochar facilities increase in the US, costs for biochar will decline.

3. **How the goals of each project were achieved.**
   Greenhouse and field experiments were established in 2010. Field plots were planted at Lockwood farm (Hamden) Windsor valley laboratory (Windsor) and at Griswold research farm (Voluntown). Greenhouse experiments were set up with earthworm and biochar applied alone and in combination. The work plan proceeded according to schedule except additional biochar was not available in 2010 so the biochar treatments were applied in the spring 2011 for the Griswold and Windsor planting only. Yield and disease measurements were taken in 2012.

4. **Results, conclusions, and lessons learned for each project.**
   During 2011, we researched and demonstrated the effects of biochar and earthworms on the health, yield, and disease suppression of asparagus in three experimental plantings in Hamden, Griswold, and Windsor, CT. Growth and disease evaluations have been collected from these plots which show significant and positive effects of earthworms on asparagus health and yield. Earthworms increased yield by 58%. Biochar did not have a significant effect in the first year harvest and the combination of earthworm and biochar did not increase yield over earthworms alone.

The goal to increase awareness amongst people interested in asparagus culture and those involved in asparagus research worldwide of the use of earthworms and biochar has been difficult to measure. However, field days, ―Farm to chef" programs, presentations, along with manuscripts and fact sheets has been delivered to the stakeholders of Connecticut and researcher abroad in attempt to increase awareness of the crop and new management strategies. In a survey, 11 individuals followed up with queries on starting asparagus plantings in Connecticut (4.8 % response in interest). Proceedings from an International symposium were published in Acta Horticulturae , an online fact sheet and a refereed article have been submitted and published in Plant Disease. This manuscript was chosen as The Editor's Pick of the month (out of 18 articles). Fact sheets on using earthworm and asparagus culture were published and available on line.



Effect of earthworms and biochar on yield of marketable yield (g/plot) asparagus 1 = control, 2 = earthworms, 3 = biochar, and 4 = earthworms and biochar. Values represent the means from all three locations: Hamden Griswold, and Windsor,

Locally, field days were held in in 2011 in Griswold, CT and Hamden, CT on Jun 16 and Aug 3, respectively, and on 4 Aug 2010 and 1 Aug 2012 in Hamden, CT to show growers the benefits of using biochar and earthworms. Field plots were label according to treatment and data on previous yields was provided along with a fact sheet on asparagus culture.

- In Griswold 51 adults attended the field plots, but most were home gardeners.
- In 2010 approximately 900 people attended and 12 growers visited the field plots
- In 2011, 555 adults attended the field day and 11 growers made inquiries at the asparagus plots
- In 2012, 687 adults and 192 kids attend the field and 17 growers made inquiries at the asparagus plots.

I participated in two farms to chef presentation during the grant period

I moderated one of the ―speed talk tables" at the ―Farm-to-Chef" program in Old Saybrook, CT on Jan 31, 2010, where I discussed and distributed information on growing asparagus to over 225 attendees. Eleven individuals followed up with queries on starting asparagus plantings (4.8% response in interest). Their names and addresses have been saved for inclusion into a data base for asparagus production in CT.

On April 5th, 2010 I spoke to 22 attendees to the Farm-to-Chef Program in Jones Auditorium, New Haven, CT. ―Managing asparagus crown rot for Connecticut markets. The participants included local farmers, growers, chefs, restaurant owners and journalists.

On March 3 2010. 1 I gave the invited seminar ―Use of Biochar to increase mycorrhizal colonization and suppress Fusarium crown rot of asparagus in replant soils to the Biochar Course: Climate Energy, Biochar and Agriculture at the University of Massachusetts, Amherst, MA

On 4 October 2010 I presented the presernation Use of Biochar to increase mycorrhizal colonization and suppress Fusarium crown rot of asparagus in replant soils " at the Annual meeting of the Northeastern Division of the American Phytopathological Society in Northampton, MA

EMO results:

Increase number of research sites to 3 and increase the number of demonstration plots at each site. Provide grower management strategies for establishing healthy asparagus plantings at 3 locations and under different environments

The extra field in Griswold was established in May 2010 and treatments were applied. In addition, a field day was held at this research site on June 1. The other fields that were anticipated did not occur.

Increase yields and potential sales of asparagus by 20-25 percent and extending the season of farmers" markets by assisting asparagus sales to start in May

We were able to demonstrate that earthworms would increase marketable yield by an averaged 58%, but we were unable to determine that sales of asparagus were increased by 20-25 percent. This was due, in part, to some growers did not establish their fields until 2011 and yield information would not be available till 2013 time to achieve this goal

Survey CDA registered farms stands and farmers" markets to determine if growing asparagus is allowing growers to begin selling this crop earlier

We did a survey online of farmer market on line and found over 80% of them will not open their market till June (See http://www.farmersmarketonline.com/fm/Connecticut.htm) In a few conversations, we learned that one reason given was that they claimed they lack enough vendors to attract consumer, they did not access to the site till June or July, and that asparagus growers alone could not supply enough to maintained market opening earlier. Our original object was to use asparagus grower along with vegetable and bedding plant grower to field to early opening of these markets. Many of these growers do not use farmers markets yet because they are not open and they have other ways of marketing their plants through big box stores

Track and report professional contact with foreign and domestic growers and industries

Attendance at an international asparagus symposium in in 2009 gathered much attention on the use of these treatments in overcoming the replant problems among international researcher. Since then I have received four email queries from International asparagus researcher and growers. I also presented these data in Chillan, Chile in 2009 and in Dalian, China and Beijing, China in 2009 and 2012. We have had no contact form foreign industries .

Increase the awareness of CT farmers and growers of new developments in asparagus production by 20 percent.

Given that there are less that 50 wholesale vegetable growers in CT the interest among 11 new growers who suffice the 20% awareness. However we recognize that there are hundreds of retail growers in the State so we would defer to our outreach efforts

Monitor and record the number of site visits to the CAES web site posting results of asparagus research

The two fact sheet prepared as a result of this grant were

Elmer, Wade H. 2012. Using earthworm to improve soil health and suppress diseases. The Connecticut Agricultural Experiment Station Fact Sheet.

http://www.ct.gov/caes/lib/caes/documents/publications/fact_sheets/plant_pathology_and_ecology/using_earthworms_to_improve_soil_health_and_suppress_diseases_01-27-12.pdf

Elmer, Wade H. 2010. Asparagus in Connecticut and diseases to watch out for. Connecticut Weekly Agricultural report (June 23, 2010) http://www.ct.gov/caes/lib/caes/documents/publications/fact_sheets/plant_pathology_and_ecology/asparagus_in_connecticut_06-11-10.pdf

Both fact sheets were view as unique page views in 2012 448 times .

5. **How progress has been made to achieve long term outcome measures for each project.**
These finding have demonstrated the importance or maintaining soil health in asparagus plants. Given that asparagus is a long term crop, we will continue to monitor yield and plant health. The project has also spurned two Greenwich high school science projects that will result in presentations at science fairs.

6. **Additional information available (e.g. publications, Web sites).**
Elmer, W. H. 2012. Influence of biochar and earthworms on plant growth, Fusarium crown and root rot, and mycorrhizal colonization of asparagus. Acta Horticulturae 950:263-270. Publication can be found in Appendix B.

Elmer, W. H., and Pignatello, J. J, 2011. Effect of biochar amendment on arbuscular mycorrhizae and Fusarium crown and root rot of asparagus in replant soils. Plant Disease. 95:960-966. DOI: 10.1094/PDIS-10-10-0741. Publication can be found in Appendix B.

Elmer, Wade H. 2012. Using earthworm to improve soil health and suppress diseases. The Connecticut Agricultural Experiment Station Fact Sheet. http://www.ct.gov/caes/lib/caes/documents/publications/fact_sheets/plant_pathology_and_ecology/using_earthworms_to_improve_soil_health_and_suppress_diseases_01-27-12.pdf

Elmer, Wade H. 2010. Asparagus in Connecticut and diseases to watch out for. Connecticut Weekly Agricultural report (June 23, 2010) http://www.ct.gov/caes/lib/caes/documents/publications/fact_sheets/plant_pathology_and_ecology/asparagus_in_connecticut_06-11-10.pdf

7. **Contact person for each project with telephone number and e-mail address.**
Wade Elmer
Phone: 203 974 8503 Email: Wade.Elmer@ct.gov

PROJECT: *Economic Analysis of Grape Production for Wine Making in Connecticut*
SUBGRANTEE: University of Connecticut, Dept. of Agricultural and Resource Economics

1. **An outline of the issue, problem, interest or need.**
The general objective of this study is to examine how specialty crop production can contribute to the profitability and sustainability of farming in Connecticut and thus to preserving farmland. Specifically the study looks at wine grape production in the state, where wineries rely heavily on imported grape juice for their wines. There is an interest in examining alternative crop production on land previously dedicated to farming. Wine grapes are a good candidate for such lands and the models used for grapes may be adjusted to other crops.

2. **How the issue or problem was approached via the project.**
Project efforts began with a review of the relevant literature for other states and by working with state vineyards to examine the costs and challenges associated with grape production. Vineyards were contacted and interviewed accordingly. The next step was to develop a representative farm budget generator given a reasonable set of assumptions. The budget generator allows the researchers to test the profitability of grape growing for a range of assumptions and uncertainty. The budget generator may also be adjusted for other crop enterprises and even multi-enterprise farms.

3. **How the goal of the project was achieved.**
CT vineyards were contacted about the study and asked to participate. Those that elected to participate were interviewed and provided data for the representative farm models. The budget generator was developed and adjusted for CT wine grape production. Thus the profitability of wine grapes was estimated for the state of Connecticut.

4. **Results, conclusions, and lessons learned.**
Results of the study are provided in Jeremy Jelliffe‘s Plan A M.S. Thesis ―An Economic Analysis of Wine Grape Production in the State of Connecticut". Preliminary results were presented at extension meetings during the study period and final results were presented in August 2012. The paper describes the various difficulties and challenges facing wine grape producers in CT. A major factor for the project was the amount of time and effort required to get information from farmers, as they tend to be particularly busy. The findings of the study suggest that the profitability of wine grape production in Connecticut is very limited. Wine grape production is likely to be most successful in cases where the farm also shares in the benefits of the value added product of wine. Also, multi-enterprise farms are likely to absorb some of the risk associated with wine grapes by relying on several income-generating crops. CT wineries may also encourage wine grape production by working with farmers and agreeing to purchase a set amount of grapes at a set value. Along the same line, wineries may work together to support or establish a large vineyard and benefit from risk sharing and economies of scale associated with wine grape production.

Taken directly from Jeremy Jelliffe's M.S. Thesis:

> *Financial Analysis Results:* Under the assumption of CT prices over the investment IRR (internal rate of return) of 13% and a PP (payback period) of 15 years. When all grapes are assumed to receive the premium price of $2000 per ton, the investment is projected to

return a NPV of $199,847, an IRR of 25% and a PP of 7 years. However, when the lower New York State prices are used the NPV goes down to a negative ($73,367) for which the IRR is undefined. When the cash inflow, based on CT grape prices, is varied by 25% for the best/worst-case analysis, the results indicate that the NPV is ($55,542) with an IRR of 3% and a PP of more than 20 years in the worst-case, and a NPV of $141,452, an IRR of 21% and a PP of 9 years in the best case.

Another significant result is the effect of farm size and discount rate on expected returns. Assuming that operating costs per unit produced are constant for farms of different sizes and that the machinery compliment is fixed but capable of covering additional acreage, per unit cost of production would be lower with a larger farm size. Thus, prospective investors would likely reap greater benefits by expanding their operation. It is assumed that the base case acreage can go from 10 to 15 acres without additional machinery investments, and that a decrease in acreage from 10 to 5 acres will also require the same machinery compliment. The effect is such that NPVs range from ($31,730) for the 5-acre plot to $71,933 for the 15-acre plot, at the 10% discount rate.

The discount rate is another important consideration for prospective investors, since it greatly affects the expected return on the investment. For the 10-acre representative plot size the range in NPV is $131,192, from $140,420 to $9,228 with the lower to upper limit discount rate of 4% and 12% respectively. For the 5-acre plot the NPV is only positive when the discount rate is dropped to 4%, and for the 15-acre plot the NPV is positive for the entire range in discount rates.

The financial impact of optional practices (i.e., irrigation, deer fencing, and bird netting), not included in a results table, indicate that for the base case scenario irrigation and deer fencing both lead to a decrease in IRR from 13% to 11%; bird control measures are slightly more costly with a reduction in IRR from 13% to 9%.

The performance of individual grape varieties is also analyzed. NPVs and IRRs are calculated for both the CT grape prices as well as for the average New York State prices. The results illustrate which grape varieties are likely to contribute most to farm profitability. Thus, the mean NPV at the upper limit is for Chardonnay at $126,033 but at the lower limit is ($47,187) for Vidal Blanc, given CT prices. When the average NYS prices are used the most profitable variety is Lemberger with an NPV of $13,194, and Vidal Blanc remains the least profitable with an NPV of ($147,511) in this case.

Monte Carlo Simulation Results: Simulation incorporating yield variability and fixed CT prices produce similar results to those in the initial analysis. Chardonnay, the most profitable grape variety, has a mean NPV of $120,530 and a 95% confidence interval from $33,799 to $199,935, whereas, Traminette, the lease profitable grape variety in this case, has a mean NPV of ($40,663) and a 95% confidence interval from ($159,489) to $74,800. Simulation incorporating yield variability and historical NYS price variability also produces consistent results with the initial analysis. Lemberger generates the greatest mean NPV of $10,703 and a 95% confidence interval from ($81,585) to $102,871, and as in the initial analysis Vidal Blanc generates a net loss in all cases with a mean NPV of ($133,491) and a 95% confidence interval from ($211,997) to ($37,294).

Additional Qualitative Findings: When it comes to a discussion of grape growing one of the first points to be raised is what kind of grapes to grow and how to grow them. Aside from discussion of the various pros and cons for specific varieties, trellis systems, plant spacing, etc., the discussion tended to focus on some of the deeper underlying concerns for choosing the best grapes to grow. The debate is essentially about how to determine what grape varieties are *really* suitable for Connecticut. Though some farmers have been relatively successful growing varieties popularized in other established wine producing regions, like Chardonnay and Cabernet, it is suggested that a better choice is to produce varieties that are best suited to the state's climate. The development of the industry would benefit from an identification of emblematic wines, characterized by new varieties and blending options that are uniquely Connecticut. At the regional level such instances contribute to the further establishment of the character of the greater New England vineyard and wine industry.

Furthering the argument for alternative varieties, some growers are quick to point out that there is a major quality difference between popular varieties grown in Connecticut versus the region they are typically associated with, such as California. One may go as far as to say a Connecticut Chardonnay is inferior to the Californian counterpart and if such varieties are desired for winemaking then by all means import the *superior* product. On the other hand, growers of such varieties argue that such remarks are misguided. Indeed a Connecticut chardonnay is different than its west-coast cousin, but it is the difference that makes it stand out. In the same vain as the argument for producing alternative varieties, so goes the one for producing popular ones, with a Connecticut twist. There is no clear *right* answer to this debate, though some experts would give reason to believe the contrary. The observation is that established wineries achieve a balance by producing some combination of popular and alternative varieties.

From a marketing standpoint, offering a diverse wine selection makes good sense. For many state wineries the majority of their income comes through their tasting rooms. Wineries usually employ some variation of a familiar strategy, which is to give the customer something to compare with what they already know followed by something less familiar. Similarly, a typical scenario is to present products across a spectrum where tastings proceed incrementally from the familiar to the unknown. In this way tasting rooms are educational, providing patrons some new knowledge about wine. Though the subject of this study is wine grapes, and not wineries, it is difficult to make a clear separation between the two activities since the majority of grape growers in Connecticut also produce wine. Furthermore, the particular focus of this study is the profitability associated with growing wine grapes; the connection between grape and wine production is also observed through the issue of which varieties are best suited for the industry, which is largely determined by the entities that demand them, wine producers.

The current state of the Connecticut wine industry is another topic that was discussed during the interviews. Again, since the growing of grapes and making wine in Connecticut go hand-in-hand, it is difficult to treat grape and wine production separately. An observation that was reiterated by several industry representatives is that state wineries tend to range from one extreme to another in terms of the nature of their operation. On one end there are the vineyards that are particularly passionate about local viticulture, growing CT grapes, and this is reflected in the grapes and wines they produce. On the other side there are vineyards that treat the operation as a unique type of business, one that may employ several strategies to enhance financial success.

Visiting a farm vineyard and winery tending more towards the former end of the spectrum, one is likely to find a well cared for vineyard composed of several varieties of grapes selected for the particular agronomic attributes of the farm. The tasting room is likely to sell other state or regionally produced products, such as cheeses, sauces, and textile goods. On the other hand, one might attend a wedding at a vineyard leaning towards the latter end of the spectrum, and the wines they produce are likely to include a larger portion of imported grape juice. In some cases the state of the vineyard may be less than ideal, with multiple vine gaps in the rows and limited varieties, which are not particularly suited to the local growing conditions.

Of course there are always limits to such categorizations, and state vineyards do not fall directly into either category. As indicated above, the production of wine grapes is highly variable, so in order to deal with such variability vineyards and wineries implement different strategies. Some focus mostly on their product in an attempt to beat the odds; others look to unique opportunities that are consistent with the industry; some host farmers markets, or have a restaurant on the premise, and hosting events and weddings works for some, and sometimes wine grape production is simply one of several enterprises that contribute to the overall profitability of the whole farm.

Claiming that one strategy is better than another is generally a matter of opinion when it comes down to the profitability of the business. Faced with the bottom line, managers must come up with creative alternatives to boost cash flows. Quality wine requires quality fruit and therefore best practices for producing such fruit is critical. The reputation of Connecticut wine is essential for the future success of the industry; and, moving forward the industry requires that all growers work to produce the best quality grapes possible.

Altogether the message from the interviews is clear; the future of the Connecticut wine industry depends on what is being done now. Smart choices by growers and the continual work to produce better wines with grapes that are well suited to the climate is likely to lead to the best result for everyone involved. Although it was particularly difficult to explicitly measure the market for state grapes, the response from most growers who produce wine is that they would be interested in purchasing state grapes so long as the quality and price are reasonable. These conditions may seem pretty straight forward, though they require serious consideration by prospective growers. The market demand for wine grapes is unclear, meaning it is all the more important for newly established grape growers to employ different strategies for securing buyers.

One suggestion is the cooperative model, where a group of wineries work together to support the establishment of a vineyard, agreeing to purchase the fruit at an economically sustainable price. Similarly, a prospective grower may reach out to wineries to establish relationships before entering into the industry. Since the initiation of this research project, several farm vineyard and winery establishments have been started, and are awaiting their initial crop. The expansion of the industry and new wineries are likely to increase the demand for state produced grapes. Farmers with large tracts of suitable land for grape production may also reap the benefit of increased returns to size, as indicted in the results. However, a large enterprise without a committed group of buyers could be financially problematic. Yet, if the proper strategies are implemented the prospective investment could be successful for all parties involved.

Over the past several years there has been a growing interest in Connecticut wine, which parallels the general market trend for locally produced goods, agricultural and otherwise (Carpio and Isengildina-Massa, 2009 & 2010). Programs like the Connecticut Wine Trail and ―passport program" couple nicely with the addition of wine festivals throughout the summer, the culmination of which is the Connecticut wine fest. If there is one sentiment that was shared by all industry representatives it was that state and regional wine production is a growing industry and is likely to have a bright future. This is not to suggest that every winery or vineyard established will be successful, but that the industry as a whole is moving forward. The components that will contribute to the success of individual firms are the same that hold for all sorts of companies; a consistent high quality product, good management that with creative solutions and foresight can keep costs down; stable yields through the selection of suitable grape varieties; and, of course, continued support from local consumers. Similar points are made throughout the associated literature for wine grape production, as illustrated in Chapter II, and to some extent most of the qualitative results are intuitive and based on common sense. As a final note, most farmers indicated that a genuine passion for the enterprise is essential to the success of the farm. Those who are deeply committed to the work, who go beyond the bottom line, are the ones who are more likely to brave the tougher times and come out all the wiser on the other end.

Unfortunately we did not keep track of excatly how many grape growers and other speicalty crop stakeholders attended the various sessions we‘ve reported at. It is estimated to be less than 50, however, we have yet to present to the CT Vineyard and Winery Association and the CT Farm Wine Development Council, or host extension meetings. Currently, there is work being done to produce an article for the Journal of Extension and to disseminate those results to stakeholders. It is estimated that roughly a dozen growers have received information on the results and access Jeremy Jelliffe's final thesis report.

5. **How progress has been made to achieve long term outcome measures.**
Additional efforts are underway to condense the results into extension materials and to hold meetings with state farmers to share the findings of the study. Also, the results of the study and thesis paper will be condensed into a journal article, which will be submitted for publication in the coming months. We are working to set a date to give a short presentation to the CT Farm Wine Council to share and discuss the results of the study.

6. **Additional Information:**
J. Jelliffe M.S. Thesis:
http://digitalcommons.uconn.edu/cgi/viewcontent.cgi?article=1393&context=gs_theses

7. **Contact person for each project with telephone number and e-mail address.**
Boris Bravo-Ureta, Boris.Bravoureta@uconn.edu; 860-486-1918
Jeremy L. Jelliffe, Jeremy.Jelliffe@uconn.edu, 860-486-1918

PROJECT: *Connecticut GardenStars*
SUBGRANTEE: Connecticut Nursery and Landscape Association and the Connecticut Greenhouse Growers Association

1. **An outline of the issue, problem, interest or need.**
The Connecticut GardenStars campaign was created as a way to increase sales of Connecticut-grown ornamental plants by focusing consumers' attention on 39 specific plants, one or two each month, over a 30-month period. Two state associations—Connecticut Nursery & Landscape Association (CNLA) and Connecticut Greenhouse Growers Association (CGGA)—have partnered together for maximum impact.

2. **How the issue or problem was approached via the project.**
Each month of the campaign, we focused on marketing different plants, such as Primrose, Potted Tulips, Lenten Rose, Coral Bells, Lilies, Columbine, Geranium, Mountain Laurel, Hosta, Blueberry, Black-eyed Susan, Fall Blooming Aster, Sweetspire, Ornamental Kale/Cabbage, Alberta Spruce and more. A committee of growers and retailers came together and spent a lot of time deciding which plants had lagging demand or sales, but which could be augmented by a campaign such as this. They were also plants that we knew could have ramped-up production by our growers and would garner strategic support from our garden retailers.

3. **How the Goals of the Project Were Achieved.**
We maintained a project web site to promote the plants: www.CTGardenStars.com. Our project logo emphasized our state, Connecticut, and the joy of the plants we were recommending to our residents and our retailers. We informed each of our plant growers—both nursery and greenhouse—about the campaign and asked for their participation. We supplied many promotional materials: bench tape to go around benches in retail garden centers, greenhouses, etc.; plant tags to go in each pot of the featured plants; adhesive labels with the GardenStars logo; large vinyl banners for display at retail points of sale (one each for the 30 featured plants); and paper brochures showing all the 30 plants along with acetate display stands for store countertops. We also issued press releases to all the Connecticut news media on the plants featured each month. We have asked the Connecticut growers for their figures and those who have replied report mostly increased sales of the plants we featured. Here are some overall results we received:
    - Andromeda: up 40%
    - Pansy: up about 10%
    - Lilac: down less than 5%
    - Phlox: up 62%
    - Shrub roses: up between 50-61%
    - Tomatoes: up about 10%
    - Delphinium: up 19%
    - Coneflower: up 67%
    - Hydrangea: up overall 53%
    - Garden mums: up over 10%
    - Winterberry: up 23%
    - Poinsettia: up 10%

   Some nurseries have promoted the GardenStars project to their customers, such as Imperial Nurseries (Connecticut's largest farm) which placed ads. We have done many news media interviews with reporters who were doing stories on the plants promoted in the press releases they received. There was even a statewide television show, *Better Connecticut*, on WFSB-TV-CBS that featured one of our tradespeople promoting the Connecticut GardenStars campaign. We placed a full color ad our state‘s major glossy magazine, *Connecticut* magazine. Each year we made GardenStars a central part of our Connecticut green industry exhibit at the Connecticut Flower and Garden Show in February, which some 30,000 people saw.

4. **Results, Conclusions, and Lessons Learned.**
Although we are still feeling the big effects of the great recession here in Connecticut on the green industry, the sales figures we‘ve received on the plants featured show that our campaign had a strong impact. It‘s almost impossible for us to measure the impact of, say, how many Connecticut retailers bought cheaper featured plants from outside the state‘s borders, OR, how many fewer retailers in other states did not buy featured plants exported there from our Connecticut growers because of those distressed sales. The promotion of the GardenStars plants has been valuable in that it kept consumption of plants on top of people‘s minds, regardless of whether they were in a buying mood.

5. **How progress has been made to achieve long term outcome measures.**
We‘re hopeful the campaign made thousands of consumers return to loving the 39 plants we featured in the project. Also, this was the first time our industry rallied around a marketing campaign that was focused on specific plants. So, the effort has taught all of us at grower, wholesale, and retail/landscape levels that cooperation can produce results to benefit everyone. We may reactivate the campaign again using internal resources, and a new list of plants.

6. **Additional Information.**
The Garden Stars logo and website screenshots can be found in Appendix C.

7. **Contact person for each project with telephone number and e-mail address.**
Robert V. Heffernan, Executive Director
Connecticut Greenhouse Growers Assocation
Telephone Number: 800-562-0610   Email Address: conngreen@aol.com

PROJECT: *50th Anniversary of the Connecticut Christmas Tree Growers Association, Inc.*
SUBGRANTEE: Connecticut Christmas Tree Growers Association, Inc

1. **An outline of the issue, problem, interest or need.**
The 50th Anniversary of the Connecticut Christmas Tree Growers Association, Inc. (CCTGA) was celebrated at the Jones Family Farm, the site of the first meeting of CCTGA 50 years ago, on August 6-7, 2010 with 311 people in attendance, 226 who were Christmas tree growers. Located in Fairfield County, Jones Family Farm is nestled in the White Hills of Shelton, CT. The purpose of this event was to:
    a. do research and furnish information on the production and marketing of Christmas trees
    b. to encourage and promote cooperation among the tree growers regarding raising, handling and marketing of Christmas trees
    c. to educate Christmas tree growers on how increase sales, solve growing problems, and listen to the scientists and professionals as they shared their areas of expertise.

    Fifty years later, at this anniversary meeting, CCTGA continued their commitment to its constitution.

2. **How the issue or problem was approached via the project**
The Executive Director, along with a steering committee and individual committees, created a timeline two years before the expected anniversary meeting. Designated tasks were assigned and tracked as the tasks were completed. All New England associations were notified, including the National Christmas Tree Growers Association to "save the date" eight months prior to the meeting and subsequent notices were sent and printed in the green industry publications monthly newsletter thereafter. Members, associated growers, and the general public were invited to attend to promote the awareness and importance of the real CT grown Christmas tree and its competitiveness in today's market. It provided current education information to:
    1. grow a quality tree
    2. to identify issues associated with pesticides and the effective control methods to manage insect pests
    3. to assist growers with conservation ideas
    4. teach proper weed control maintenance
    5. promote awareness and help to sustain a productive farm
    6. to discuss product development and environmental concerns
    7. to promote the farm experience
    8. most importantly, to increase sales of the real Christmas tree

    The meeting began with a 90 minute walking tour demonstrating weed management, cover and aisle crops, tree and seedling culture and other Jones Farm operations led by the farm staff and featuring CAES scientist Dr. John Ahrens, Dr. Todd Mervosh and Tom Rathier. A 90 minute riding tour demonstrating insect management, disease management and other Jones Farm operations led by the farm staff and featuring CAES scientists Dr. Richard Cowles and Mary Inman completed the morning activities.

    During lunch break, attendees visited with the 17 vendors at the Trade show.

The afternoon lectures were given by Dr. Sharon Douglas, CAES Chief Plant Pathologist, New Haven, on disease management for Christmas trees and Dr. Richard Cowles, Windsor CAES Entomologist, continued with arthropod management. Approximately 200 attendees were on tour including seasoned growers.

Exhibitor demonstrations were given prior to the wine tasting, awards dinner, recognition ceremony and entertainment provided by the CT Troubadour.

The meeting continued on the second day, beginning with State association meetings and announcements. The morning progressed with educational talks on weed management by Dr. Larry Kuhns, Retired Professor of Ornamental Horticulture, from Pennsylvania State University. Dr. Mel Koeling, Emeritus Forestry Professor, Michigan State University continued with ―Innovations in Christmas tree culture". Over 90 growers attended these talks.

Farm tours continued after lunch led by Jaime Jones. A conservation tour, led by Terry Jones and Tom Rathier, included water and pest management conservation efforts made at the Jones Farm.

The meeting concluded with an informal ―ask the experts" forum.

Nine educational units were offered to members for recertification requirements and licensing. Local Connecticut Agricultural Experiment Station Scientists were on hand to "ask the experts" and share their findings on research that has been done and continues to be done through Grants donated by CCTGA. A special highlight of this meeting included a CT grown picnic much like the one enjoyed by members and guests 50 years ago.

3. **How the Goals of the Project Were Achieved**

The goal of this event was to increase CT grown real Christmas tree sales by 20% over a period of 8 - 10 years, the life cycle of a Christmas tree. Through better seedling selections offered by the vendors attending, more effective weed and pest management taught by the guest scientists and programs speakers, the use of new machinery and tools exhibited by the vendors and enhanced marketing measures detailed in the Jones Family Farm tours, promoted the importance and awareness of the Christmas tree industry to even the most inexperienced grower. In conjunction with the New England Tree Alliance, CCTGA was able to reach out to growers from all over New England, NY, PA and Canada to share information and increase awareness to enhance the real Christmas tree industry. An evaluation instrument was distributed in all the registrant's tote bags to reflect all criteria covered during this event.

About 15% of surveys were returned which help to validate the valuable information needed to enhance and promote the Christmas tree industry. These results were provided to the scientists to see what areas needed the most attention. At the January Board of Directors meeting in 201 1 all the county Directors reported tree saleifrom members who had - attended the meetina in their individual counties. At the Januarv 2012. Directors "reported again the previous selling season. On an average there was a 4%+ increase of sales by year two.

Statistics will continue to be compiled over the next 10 years to see if the graph continues to climb to reach the anticipated goal. By promoting and sustaining open space in our state, growing Christmas trees in Connecticut will eliminate the importing of trees from Canada and other states to meet the supply and demand locally.

4. How progress has been made to achieve long term outcome measures

By having the unique opportunity to hold a commemorative event at the original farm site, to offer educational information and recertification credits, attendees had the opportunity to experience how a Christmas tree farm can be a successful business yesterday, today and tomorrow. Jones Family Farms believes that "they grow the best agricultural crops in an environmentally sustainable way by keeping the soils healthy and productive".

Continuing with their family philosophy they "are stewards of the land, sewing to pass the land on to the next generation in better condition that they inherited it. Jones Family Farm is a true inspiration to all Christmas tree growers and CCTGA. This event was a tribute not only to Philip Jones and his family but to all the growers in Connecticut and their dedication to the Christmas tree industry.

5. Results, Conclusions, and Lessons Learned

As any event is planned, there are always lessons to be learned from successes and mistakes. For all those that did attend, the educational piece, the camaraderie, and the venue were ideal. For those who did not attend, wished they did. The strongest attributes of our members is their willingness to share information. Tips, pointers and experiences were shared at this commemorative meeting between the most experienced growers to the newcomer on the block which are more valuable than manuals, instructions and labels read. Our commitment is the promotion of the CT grown real Christmas tree industry to anyone who hears our voices. CCTGA was proud to be 50 years old in 2010 and will continue to "grow" strong in commitment to its members and the 4000 + acres of Christmas trees presently planted in the state of Connecticut.

Tips, pointers and experiences were shared at this commemorative meeting between the most experienced growers to the newcomer on the block which are more valuable than manuals, instructions and labels read.

6. Beneficiaries

By having the unique opportunity to hold a commemorative event at the original farm site, to offer educational information and recertification credits, 226 growers and 85 attendees had the opportunity to experience how a Christmas tree farm can be a successful business yesterday, today and tomorrow. A commemorative issue of the Real Tree Line (CCTGA‘s quarterly newsletter) was sent to all 286 members and included in the attendee‘s gift bags. A total of 597 newsletters were distributed with valuable information presented at the meeting.

Jones Family Farms believes that ―they grow the best agricultural crops in an environmentally sustainable way by keeping the soils healthy and productive”. Continuing with their family philosophy they ―are stewards of the land, serving to pass the land on to the next generation in better condition that they inherited it. Jones Family Farm is a true inspiration to all Christmas tree growers and CCTGA. This event was a tribute not only to Philip Jones and his family but to all the growers in Connecticut and their dedication to the Christmas tree industry.

7. Additional Information.

Promotional information and follow up articles from the event can be found in Appendix D.

8. **Contact person for each project with telephone number and e-mail address.**
   Kathy Kogut, Executive Director
   Phone: 203-237-9400 Email: wkogut@cox.net

UConn Extension GAP School Planning

SurveyMonkey

1. Please check all that apply to you.

	Response Percent	Response Count
This farm/garden sells the vegetables/fruits that are grown here	**95.9%**	**118**
This is an institution (school, restaurant, hospital) that grows products used in meals that we sell/deliver	0.8%	1
This farm/garden donates the vegetables/fruits grown here to a food bank, pantry, school, or other community agency	26.0%	32
	answered question	**123**
	skipped question	**4**

2. How long have you been farming/gardening/growing produce for sale or donation?

	Response Percent	Response Count
Up to 5 years	27.6%	34
6-10 years	22.8%	28
11-20 years	13.8%	17
Over 20 years	**35.8%**	**44**
	answered question	**123**
	skipped question	**4**

3. How many acres of fruits/vegetables do you have under production?

	Response Percent	Response Count
Up to 5 acres	**62.6%**	**77**
6-10 acres	11.4%	14
11-25 acres	9.8%	12
26-50 acres	5.7%	7
51-100 acres	1.6%	2
More than 100 acres	8.9%	11
	answered question	**123**
	skipped question	**4**

4. How many employees do you have, including yourself and family members, full time or part time?

	Response Percent	Response Count
One	30.9%	38
2-4	**43.9%**	**54**
5-10	13.8%	17
11-20	7.3%	9
More than 20	4.1%	5
	answered question	**123**
	skipped question	**4**

5. If your employees use a primary language other than English, what is that language? (Check all that apply.)

	Response Percent	Response Count
Spanish	26.8%	15
French	0.0%	0
Creole	0.0%	0
Vietnamese, Hmong or other South Asian languages	0.0%	0
Italian	1.8%	1
Other (please specify)	**73.2%**	**41**
	answered question	**56**
	skipped question	**71**

6. Please check all of the ways you sell/distribute your products. (Check all that apply)

	Response Percent	Response Count
On-farm market or stand	**61.8%**	**76**
On-farm market or stand	12.2%	15
Farmers' market	54.5%	67
Farmers' market	12.2%	15
CSA operation	25.2%	31
CSA operation	4.9%	6
Direct to restaurants	33.3%	41
Direct to restaurants	6.5%	8
Direct to schools	5.7%	7
Direct to schools	0.0%	0
Direct to hospitals or other institutions	2.4%	3
Direct to hospitals or other institutions	0.0%	0
Wholesaler/distributor	17.1%	21
Wholesaler/distributor	1.6%	2
Direct to retail outlets, grocery stores, other farm stands	34.1%	42
Direct to retail outlets, grocery stores, other farm stands	4.9%	6
Donate to soup kitchens, pantries, community agencies	24.4%	30
Donate to soup kitchens, pantries, community agencies	6.5%	8
Other (please specify)	7.3%	9

answered question	**123**
skipped question	**4**

7. What vegetable/herb crops do you grow? (Check all that apply)

	Response Percent	Response Count
Asparagus	21.1%	26
Beans, green or yellow	57.7%	71
Broccoli, Brussels spouts, cabbage	46.3%	57
Beets, carrots, parsnips, potatoes, radishes, turnips	59.3%	73
Chard, collards	43.1%	53
Corn	28.5%	35
Cucumbers	**69.9%**	**86**
Eggplant	61.0%	75
Herbs	53.7%	66
Lettuce, spinach and other salad greens	59.3%	73
Onions, scallions, leeks, garlic	56.9%	70
Peppers	62.6%	77
Summer squash, zucchini, patty pan	64.2%	79
Tomatoes	**69.9%**	**86**
Winter squashes, pumpkins (edible)	60.2%	74
I do not produce vegetables or herbs	14.6%	18
Other (please specify)	17.9%	22
	answered question	**123**

skipped question	**4**

8. What fruit crops do you grow? (Check all that apply)

	Response Percent	Response Count
Apples, pears	34.1%	42
Berries (blackberries, raspberries, strawberries, blueberries, currants, gooseberries)	**43.1%**	**53**
Grapes	12.2%	15
Melons (watermelon, cantaloupe, honeydew)	22.0%	27
Peaches, nectarines	27.6%	34
I do not produce fruits	34.1%	42
Other (please specify)	8.1%	10
answered question		**123**
skipped question		**4**

Appendix A Cont.

9. How do you feel about GAP, GAP training and developing a food safety plan?

	Response Percent	Response Count
I don't really know enough about GAP...I am a bit confused about it all.	**42.9%**	**48**
I have decided not to sell to someone who requires a GAP audit.	6.3%	7
If my customer requires me to have a GAP audit, I will do it. It is part of business.	10.7%	12
I am glad it is voluntary...if no customer makes me do it, I am not going to do it.	9.8%	11
I think all produce farmers should have a food safety plan-whether they are being audited or not.	20.5%	23
Small farms produce safer product than large farms-we don't need a food safety plan.	14.3%	16
It's just too much, we do not have the time or resources to do this.	16.1%	18
If you do not agree with these options, describe here how you feel about GAP:	15.2%	17
	answered question	**112**
	skipped question	**15**

Appendix A Cont.

10. Have you written and implemented a food safety plan?

	Response Percent	Response Count
I have a GAP food safety plan and have implemented it because I am selling to someone who requires an audit	9.8%	11
I have a GAP food safety plan and have implemented it even though no one is requiring me to have an audit	4.5%	5
I have written a GAP food safety plan, but have not implemented it	2.7%	3
I have not written a GAP food safety plan	**83.0%**	**93**
	answered question	**112**
	skipped question	**15**

11. What GAP programs/activities would you participate in? (Check all that apply)

	Response Percent	Response Count
A basic GAP course	**43.8%**	**49**
Annual GAP refresher/update for those who have attended the basic course	24.1%	27
On farm mock audit	16.1%	18
GAP food safety plan writing workshop	20.5%	23
Packing house sanitation workshop	10.7%	12
Employee/worker training workshop	15.2%	17
Individual farm visit to help with plan writing/audit preparation	19.6%	22
Email list/FAX list for regular GAP and produce food safety updates	23.2%	26
I am not interested in any of these	32.1%	36
	Other (please specify)	15
	answered question	**112**
	skipped question	**15**

Appendix A Cont.

12. What kinds of training/education programs or methods do you prefer? (Check all that apply)

	Response Percent	Response Count
Workshops, talks, lectures, discussions	**50.9%**	**57**
On-line courses	30.4%	34
Webinars	20.5%	23
Half day programs	33.0%	37
Full day programs	11.6%	13
Two or three sessions held on consecutive days	5.4%	6
Two or three sessions over a period of weeks	12.5%	14
Evening options	22.3%	25
Saturday morning options	6.3%	7
I am not interested in any of these	24.1%	27
Other (please specify)	3.6%	4
	answered question	**112**
	skipped question	**15**

13. How would you like to receive news or information about produce safety and GAP? (Check all that apply)

	Response Percent	Response Count
Traditional mailings or newsletters	30.4%	34
Email newsletters	**66.1%**	**74**
Email distribution list or listserv	21.4%	24
Twitter, Facebook or other social media applications	1.8%	2
UConn GAP/Produce Safety web page	15.2%	17
I do not want to receive information about produce safety or GAP	17.9%	20
Other (please specify)	0.9%	1
answered question		**112**
skipped question		**15**

14. What types of GAP training/implementation tools would you use? (Check all that apply)

	Response Percent	Response Count
Posters to remind workers re: personal hygiene practices; on farm and /or packing house sanitation practices	30.4%	34
Model food safety plans	31.3%	35
Food safety plan template	36.6%	41
Model record keeping forms	32.1%	36
Record keeping form templates	**39.3%**	**44**
Model protocols for sanitation and other food safety practices ("how to")	25.0%	28
Customer/consumer GAP/produce safety information brochures, fact sheets or posters	18.8%	21
Flip charts for employee training	19.6%	22
GAP course binders with course information (powerpoint slides, supporting information)	14.3%	16
Memory sticks or "thumb drives" with templates and additional resources	18.8%	21
I would not use any of these	25.0%	28
Other (please specify)	4.5%	5
	answered question	**112**
	skipped question	**15**

15. Have you attended a GAP workshop or course? (Check yes or no)

	Response Percent	Response Count
Yes	27.7%	31
No	**72.3%**	**81**
	answered question	**112**
	skipped question	**15**

16. What GAP workshop(s) did you participate in?

	Response Percent	Response Count
UConn full GAP course	**45.2%**	**14**
UConn GAP "Lite"	16.1%	5
UConn food safety plan writing workshop	12.9%	4
UMass sponsored workshop	16.1%	5
Cornell sponsored workshop	6.5%	2
Cornell online course	3.2%	1
Other (please specify)	19.4%	6
	answered question	**31**
	skipped question	**96**

17. Did the workshop provide you with all of the tools and resources you needed in order to develop your food safety plan?

	Response Percent	Response Count
Yes	**87.1%**	**27**
No	12.9%	4
Comments? What was lacking? What would make it better?		3
answered question		**31**
skipped question		**96**

18. Did you develop a food safety plan after completing the workshop?

	Response Percent	Response Count
Yes	48.4%	15
No	**51.6%**	**16**
answered question		**31**
skipped question		**96**

19. Did you participate in a GAP audit ?

	Response Percent	Response Count
Yes	35.5%	11
No	**64.5%**	**20**
answered question		**31**
skipped question		**96**

20. What were the results of your GAP audit? (Please choose only one)

	Response Percent	Response Count
I passed the audit	35.5%	11
I failed the audit, then passed after making corrections	0.0%	0
I failed the audit	0.0%	0
I did not participate in an audit	**64.5%**	**20**
answered question		**31**
skipped question		**96**

21. Would you be interested in attending any of these ? (Check all that apply)

	Response Percent	Response Count
A half day GAP "Lite", just the basics, not a lot of detail	**49.4%**	**40**
A regular 2 day GAP course	6.2%	5
An online course	35.8%	29
Not interested in attending a GAP workshop or course	29.6%	24
Other (please specify)	7.4%	6
answered question		**81**
skipped question		**46**

22. What is your gender?

	Response Percent	Response Count
Female	44.8%	47
Male	**55.2%**	**58**
	answered question	**105**
	skipped question	**22**

23. Which category below includes your age?

	Response Percent	Response Count
18-25	2.8%	3
26-35	6.5%	7
36-50	24.3%	26
51-65	**53.3%**	**57**
Over 65	13.1%	14
	answered question	**107**
	skipped question	**20**

24. Are you White, Black or African-American, American Indian or Alaskan Native, Asian, Native Hawaiian or other Pacific islander, or some other race?

	Response Percent	Response Count
White	**96.2%**	**100**
Black or African-American	0.0%	0
American Indian or Alaskan Native	0.0%	0
Asian	0.0%	0
Native Hawaiian or other Pacific Islander	0.0%	0
From multiple races	3.8%	4
	answered question	**104**
	skipped question	**23**

25. Are you Hispanic or Non-Hispanic?

	Response Percent	Response Count
Hispanic	1.0%	1
Non-Hispanic	**99.0%**	**99**
	answered question	**100**
	skipped question	**27**

26. Please add any additional comments or suggestions that would help the UConn Extension GAP school meet your needs for produce safety education, training and information.

	Response Count
	26
answered question	**26**
skipped question	**101**

University of Connecticut

College of Agriculture and Natural

Cooperative Extension System

Food Safety in Connecticut for Farmers and Growers

Courses and Workshops

Food safety for:

Consumers/ Home cooks

Farmers/ Growers

Processors/ Specialty foods

Food Service/ Retail

Teachers/ Educators

Who regulates our food?

Helpful websites

UConn Food Safety Contacts

(Scrolling food pictures)

Produce Safety and Good Agricultural Practices (GAP)

Fruits and vegetables add color, variety and important nutrients to our diet. Most of us enjoy them raw in salads, as a snack or desert. However, in the last few years there has been an uptick in the numbers of foodborne illness outbreaks associated with fresh fruits and vegetables: spinach, cantaloupe, tomatoes, cilantro, and green onions have been on the outbreak list.

The use of Good Agricultural Practices is one way that farmers and gardeners can reduce the risk of microbial contamination of the fruits and vegetables they sell. GAP programs address the safety of water, manure use, sanitation, and personal hygiene practices on the farm, in the field, during harvest, packing, and transportation.

Sign up here to be added to our GAP mailing list--be informed about the produce safety issues, GAP workshop, and more.

What is GAP?

UConn Extension Produce Safety Programs, Workshops and GAP School

Produce safety guidance and regulations

How are you doing? Conduct a GAP self audit

Write a food safety plan: models, templates and record keeping forms

USDA and other third party GAP audit information

Connecticut Department of Agriculture

GAP Resources and Links

This article is from the
August 2011 issue of

plant disease

published by
The American Phytopathological Society

For more information on this and other topics
related to plant pathology,
we invite you to visit APS*net* at
www.apsnet.org

APS
Healthy Plants • Healthy World

Effect of Biochar Amendments on Mycorrhizal Associations and Fusarium Crown and Root Rot of Asparagus in Replant Soils

Wade H. Elmer, Department of Plant Pathology and Ecology, and **Joseph J. Pignatello**, Department of Environmental Sciences, The Connecticut Agricultural Experiment Station, New Haven 06504

Abstract

Elmer, W. H., and Pignatello, J. J. 2011. Effect of biochar amendments on mycorrhizal associations and Fusarium crown and root rot of asparagus in replant soils. Plant Dis. 95:960-966.

Pyrolyzed biomass waste, commonly called biochar, has attracted interest as a soil amendment. A commercial prototype biochar produced by fast pyrolysis of hardwood dust was examined in soils to determine if it could reduce the damaging effect of allelopathy on arbuscular mycorrhizal (AM) root colonization and on Fusarium crown and root rot of asparagus. In greenhouse studies, biochar added at 1.5 and 3.0% (wt/wt) to asparagus field soil caused proportional increases in root weights and linear reductions in the percentage of root lesions caused by *Fusarium oxysporum* f. sp. *asparagi* and *F. proliferatum* compared with a control. Concomitant with these effects was a 100% increase in root colonization by AM fungi at the 3.0% rate. Addition of aromatic acids (cinnamic, coumaric, and ferulic) that are known allelopathic agents affecting asparagus reduced AM colonization but the deleterious effects were not observed following the application of biochar at the higher rate. When dried, ground, asparagus root and crown tissues infested with *Fusarium* spp. were added to soilless potting mix at 0, 1, or 5 g/liter of potting mix and then planted with asparagus, there was a decrease in asparagus root weight and increase in disease at 1 g/liter of potting mix but results were inconsistent at the higher residue rate. However, when biochar was added at 35 g/liter of potting mix (roughly 10%, vol/vol), these adverse effects on root weight and disease were equal to the nontreated controls. A small demonstration was conducted in field microplots. Those plots amended with biochar (3.5% [wt/wt] soil) produced asparagus plants with more AM colonization in the first year of growth but, in the subsequent year, biochar-treated plants were reduced in size, possibly due to greater than average precipitation and the ability of biochar to retain moisture that, in turn, may have created conditions conducive to root rot. These studies provide evidence that biochar may be useful in overcoming the deleterious effects of allelopathic residues in replant soils on asparagus.

Biochar is a charcoal-like carbonaceous byproduct of biomass pyrolysis (25,27). It is produced from crop residue, wood chips, manure, or other wastes at temperatures between 400 and 700°C in the near absence of oxygen. Although the initial interest in biomass pyrolysis was the value of distilled gases and fuels that could be collected, the biochar byproduct itself has gained much more attention as a potentially beneficial soil amendment and as a means of sequestering carbon in a form that can withstand decomposition to CO_2 in soil over centuries. Advocates have argued that there is potential for the annual sequestration of atmospheric CO_2 at the billion-ton scale within 30 years (38). If massive-scale deployment does occur over the next few decades, biochar may be available for widespread use as a soil amendment at levels ranging from a few tenths to several percent of soil by weight in the rhizosphere. However, many claims regarding the usefulness of biochar have not been experimentally validated.

Addition of biochar to soil results in increased nutrient retention and water-holding capacity in soil (5,26). Although some studies have shown positive effects of biochar on yields of maize, several legumes, and several species of trees (28,38), in other studies, biochar either had no value or was harmful toward plants (14). Generalizations about the utility of biochar are confounded by the wide variability in composition, texture, and adsorptive properties of biochar depending on the feedstock, temperature, and other conditions used in its preparation.

Depending on source stock and formation conditions, charcoals can be strongly adsorptive toward organic compounds (4,42). Rotting asparagus crowns release allelopathic toxins, notably aromatic acids such as coumaric, caffeic, and ferulic acids (19,21). Asparagus is also susceptible to Fusarium crown and root rot caused by *Fusarium oxysporum* Schltdl. and *F. proliferatum* (Matsush.) Nirenberg (synanamorph = *F. moniliforme* J. Sheld.). These two factors contribute to the asparagus decline problem (2,11) and to the subsequent replant problem that occurs when old fields are replanted with asparagus (15). Thus, the potential of biochar to adsorb allelochemicals makes it attractive for mitigating the replant problem in asparagus. There have been varying opinions as to whether these allelochemicals actually affect disease severity (1,20,34). It is documented that *Fusarium* spp. are not affected by the allelochemicals, which may allow them to proliferate in the absence of competitors (3). These toxins have been shown to inhibit beneficial microorganisms such as vesicular arbuscular mycorrhizae (AM) (29,33), *Trichoderma* spp., and *Gliocladium* spp. (3), causing reduced plant vigor and increased susceptibility to Fusarium crown and root rot (9). The addition of activated carbon to asparagus soils improved growth and increased AM colonization in greenhouse studies (30). Injecting flowable activated charcoal into the root zones of established plants increased growth and performance in young fields but was less effective in older fields (32). However, in studies on other plants, activated carbon improved plant growth while reducing AM colonization, possibly by improving the availability of phosphorus which, in turn, inhibited AM colonization (41). Increased AM colonization has also been closely associated with the suppression of Fusarium crown and root rot (40) and tolerance to allelopathy (31). Other beneficial microbes such as fluorescent pseudomonads are implicated in the suppression of Fusarium crown and root rot of asparagus and may be a useful indicator of soil and root health (8,10).

The structure and properties of biochar are similar to those of activated carbon in some respects; therefore, it is reasonable to expect that biochar will influence soil biology and affect crop health. However, the mechanisms by which biochar may affect crop health are still obscure. Elad et al. (6) reported that biochar can elicit the systemic acquired resistance pathway in plants and

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Accepted for publication 18 March 2011.

doi:10.1094/PDIS-10-10-0741
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provide disease protection against *Botrytis cinerea* (gray mold) and *Leveillula taurica* (powdery mildew) on pepper and tomato.

Biochar amendments may reduce damage from Fusarium crown and root rot of asparagus in replanted asparagus soils. The disease-suppressing mechanism may be associated with increasing AM colonization and mineral nutrition of the plant. Therefore, the objectives of this study were to determine the effect of biochar on asparagus growth, disease, AM colonization, and elemental composition of asparagus in soils where allelochemicals were artificially added.

Materials and Methods

Greenhouse study I. The first greenhouse study examined the effect of biochar on asparagus in soil naturally infested with *Fusarium* spp. and artificially supplemented with allelochemicals. Seed of susceptible 'Mary Washington' were agitated for 1 h in 20% household bleach (0.105% $NaHClO_2$) and rinsed three times with distilled H_2O to eliminate seedborne pathogens. Seed were soaked in distilled water at 30°C for 72 h, germinated in trays with 36 cells filled with potting mix (ProMix BX; Premier Brand Inc., New Rochelle, NY), and held for 10 to 12 weeks in the greenhouse. Seedlings received Hoagland's solution at 50 ml/cell (22) after 4 weeks and were irrigated as needed. Seedlings were removed and the soil was washed from the roots. Seedlings with no root lesions that weighed between 5 and 7 g were selected for the experiments. Soil (pH 6.4) for the experiment was removed from a field where asparagus had been grown for many years. Soil was shaken loose from exhumed asparagus root systems, air dried, and passed through a 0.5-cm sieve. The soil contained small pieces of asparagus roots. Serial dilution onto selective agar revealed *Fusarium* spp. at approximately 5×10^3 CFU/g of soil but the actual fraction capable of causing disease was not determined. Half of the soil was autoclaved at 121°C for 1 h. The autoclaved or nonautoclaved batches were mixed 1:1 with autoclaved sand (bulk density = 1.25), amended with biochar (CQuest Biochar; Dynamotive Energy Systems Corp., McLean, VA) at the rate of 1.5 and 3.0% (wt/vt), and then placed into 10-cm plastic pots (350 cm^3). Each pot contained 440 g of soil mix. The manufacturer's analysis of CQuest Biochar revealed that it was composed of 74% C, 3.2% H, 11.2% O, and 11% ash that may have provided small amounts of essential nutrients. Soil not treated with biochar served as a control. To ensure that AM fungi were present in sufficient densities, endomycorrhizal inoculant (BEI Bio/Organics, La Pine, OR), which contained spores of *Glomus brasilianum* Spain & J. Miranda, *G. clarum* T.H. Nicolson & N.C. Schenck, *G. deserticola* Trappe, Bloss & J.A. Menge, *G. intraradices* N.C. Schenck & G.S. Sm., *G. monosporum* Gerd. & Trappe, *G. mosseae* (T.H. Nicolson & Gerd.) Gerd. & Trappe, and *Gigaspora margarita* W.N. Becker & I.R. Hall, was mixed into the soil at 1 g/liter of soil mix. One 12-week-old asparagus transplant was planted into each pot. The next day, each pot was supplemented with 50 ml of distilled water containing 0, 5.0, or 50.0 µg of caffeic, coumaric, and ferulic acids per milliliter (equivalent to 0, 0.57, or 5.7 mg of each acid per gram of soil). Acids were initially dissolved by heating at 60°C in a small amount of ethanol and brought to volume with deionized water (final liquid composition, 2.0% ethanol by volume). Plants were grown at 15 to 20°C (night) and 20 to 25°C (day) under sodium vapor lamps set for 12-h-day, 12-h-night photoperiods. Plants were irrigated as needed and fertilized twice a month with 50 ml of Hoagland's solution per pot. This experiment consisted of 18 treatments (three [biochar rates] × two [infested or autoclaved] × three [allelochemical concentrations]) with 12 replicates per treatment. Pots were set on greenhouse benches in a randomized blocked design (three blocks, four replicates/block). The experiment was repeated the following year.

After 12 weeks, plants were removed from the pots and the soil was shaken off. Rhizosphere soil was sampled by shaking each root system into a plastic bag and refrigerating it at 4°C. Roots were then washed with tap water to remove soil, and the fresh weights of the ferns and roots plus crown were recorded. Fern tissue was dried and reweighed. Tissue from plants grown in autoclaved soil was used in tissue analyses described below. Root systems were divided in half. One half was assayed for disease as described below, while the other half was placed in formalin-acetic acid-alcohol (FAA) (35) until the root systems could be assayed for AM colonization. Feeder roots (1 to 2 cm long) were assayed using modifications of Phillips and Haymans (35) as described by Elmer (9). Between 150 and 200 intersects were counted from each root system, scored as colonized or not, and expressed as a percentage of the total intersects colonized by AM. Disease severity (percentage of roots with lesions) and colonization by *Fusarium* spp. (CFU per centimeter of root) were determined as described previously (7). Rhizosphere soils were assayed for total bacteria, fluorescent pseudomonads, and total *Fusarium* populations as described previously (10) and expressed as log CFU per gram of soil (over dry weight equivalent).

Dried fern samples from each block were bulked and treated as replicates. Samples were ground in a Wiley mill and passed through a 20-mesh sieve. The dried plant tissue was analyzed for total nitrogen by combustion using a LECO FP-528 nitrogen Analyzer (FP-528; Leco Corp., St. Joseph, MI). For analysis of elements K, P, Ca, Mg, S, Fe, Mn, Zn, Cu, and B, dried plant tissue (0.5 g) was digested in 50-ml polypropylene digestion tubes with 5 ml of concentrated nitric acid at 115°C for 45 min using a hot block (DigiPREP System; SCP Science, Champlain, NY). The digested samples were diluted to a 50-ml volume with distilled deionized water. Digested plant tissues were analyzed for the nutrient elements by inductively coupled plasma atomic emission spectroscopy (iCAP 6500; Thermo Fisher Scientific, Waltham, MA).

Greenhouse study II. A second study examined the effect of biochar on Fusarium crown and root rot in soilless potting mix amended with increasing amounts of dried *Fusarium* spp.-infested asparagus residues. Asparagus roots and crowns collected above were air dried, blended in a Waring blender for 30 s, and passed through a 0.5-cm sieve. Dried ground asparagus crowns and roots were also incorporated into biochar-amended potting mix and the nonamended mix at the rate of 0, 1, and 5 g of residues per pot. Asparagus plants were transplanted into potting mix (ProMix BX; Premier Brand, New Rochelle, NY) supplemented with or without CQuest Biochar at 3.5 g/liter of potting mix. After 12 weeks, plants were removed, washed, and weighed, and the roots were assayed for disease severity as described above. There were 12 replicate plants per treatment combination, and the experiment was repeated the following year.

Field demonstration. A field demonstration was established in Hamden, CT (sandy loam soil, 1% organic matter) in 2008 to test the practical application of biochar on asparagus growth. Eighteen black plastic pots with five drainage holes (0.45 m in diameter by 0.35 cm deep) each were set into soil 1 m apart in a row. The experiment consisted of three treatments: non-asparagus soil (healthy control), asparagus soil containing 5% asparagus residues, and asparagus soil containing 5% asparagus residues with biochar (3.5% [wt/wt], 10% [vol/vol], approximately 150 metric tons/ha mixed 35 cm deep). There were six replicates per treatment. Asparagus residues were obtained from recently dug crowns that had been chopped into 5- to 10-cm pieces. Microplots were planted with 1-year-old crowns ('Mary Washington') and fertilized with N-P-K fertilizer at 50 kg/ha.

In August 2008 and 2009, asparagus stems were rated by size: small (0.1 to 0.5 cm in diameter), medium (0.6 to 1.0 cm in diameter), and large (>1.0 cm in diameter), and counted. In August 2009, roots were sampled from each microplot by removing soil cores (22.5 by 3 m in diameter) with a soil auger. Five soil cores per microplot were removed approximately 12 to 15 cm from the crown and bulked. Roots were extracted from the soil cores by passing the soil through a 2.8-mm sieve with a slow stream of water and collecting the roots with forceps. Roots were washed in tap water, fixed in FAA, and assayed for mycorrhizae as described above. Marketable yield (22 cm) was harvested three times weekly for 3 weeks in spring 2010.

Statistical methods. Data were subjected to analysis of variance and means were separated using Tukey's test at $P = 0.05$. Percent data were transformed to arcsine of the square root before analysis to achieve homogeneity of variance. Regression analyses were done where appropriate.

Results

Greenhouse study I. The effects of biochar on asparagus root weight and root lesions in *Fusarium* spp.-infested asparagus soil are shown in Figure 1. No significant effects of the allelochemicals were found. The results in Figure 1, therefore, represent combined data from both trials, given that no interactions were noted between the treatment and the two trials. The addition of biochar up to 3% (wt/wt) increased asparagus root weight and suppressed disease in the infested soil, both approximately linearly with biochar rate. Biochar also improved root weight in the autoclaved soil when added up to 1.5% (wt/wt) but further changes at 3% biochar rate were not significantly different (Fig. 1).

Biochar had a positive, linear effect on percent root colonization by AM, independent of whether allelochemicals were added at 5.7 µg/g of soil (Fig. 2). Allelochemicals applied at 5.7 µg/g of soil significantly suppressed root colonization by AM compared with the soil without biochar ($P = 0.03$). Allelochemicals applied at a lower rate (0.57 µg/g of soil) also reduced AM colonization compared with the soil without biochar but the reduction was not significant (*data not shown*). When biochar was added at 1.5 or 3.0%, the allelochemicals had no statistically significant impact on AM colonization.

The rhizosphere pH increased slightly with biochar rate but, because replicates were bulked, it was not possible to determine whether or not trends were statistically significant (Table 1). When compared with the control, rhizosphere densities of fluorescent pseudomonads were significantly increased at the higher biochar rate but not at the lower rate. The density of *Fusarium* spp. in the rhizosphere samples (Table 1) and the bulked soil samples (*data not shown*) was unaffected by biochar rate or allelochemicals.

Biochar amendment was associated with increases in K, S, Mn, and B and with reductions in N, Mg, and Fe (Table 2). The allelochemicals decreased N and P and increased Ca, S, and B. Significant interactions between biochar and the allelochemicals were occasionally observed and were the result of unexpected peaks of S, Mn, Zn, and Cu in the tissue of plants treated with the lower rate (0.57 µg/g of soil) of the allelochemicals that was not observed at higher rate of biochar.

Greenhouse study II. In the second set of experiments, the effect of biochar added at constant rate (0 or 3.5 g/liter) was examined for impact on disease and growth of asparagus grown in soilless potting mix supplemented with variable amounts of dried and ground asparagus residues. This experiment was repeated and significant interactions between treatments and experimental repetition prevented the two data sets from being combined. In the first trial, root weights declined with increasing asparagus residues but these deleterious effects were not observed when biochar was added (Fig. 3A). The lowest residue rate (1 g/liter of potting mix) was associated with the highest amount of root lesions, and biochar significantly reduced the disease at this rate. The repetition of this experiment produced plants that were much smaller in size than in the first study (Fig. 3B). The lowest residue rate (1 g/liter of potting mix) produced the smallest plants but the effect was not observed when residues were added at the higher rate (5 g/liter of potting mix), where an unexpected increase in root weights was observed. The inclusion of biochar produced plants that did not differ from nontreated control plants. As before, the percentage of roots with lesions was highest at the lowest residue rate (43%; 1 g/liter of potting mix), and plants grown with biochar at this same rate did not differ from the control (12%; Fig. 3B).

Microplot demonstration. There was no AM colonization in the sampled roots from non-biochar-treated asparagus soils; however, a low amount (4.4%) was detected in the biochar-treated soils in 2009. In the healthy non-asparagus soil, AM colonization had risen to 14%. Stand counts during summer 2009 revealed no differences in vigor between the treatments but there was a downward trend for the microplots treated with biochar (Table 3). Spear yield recorded in 2010 was similar to stand count data for the three treatments but there were no significant differences for any of the yield components. However, it was noted in July 2010 that three of six replicate microplots treated with biochar had died as opposed to only one microplot of the infested control. The average rainfall

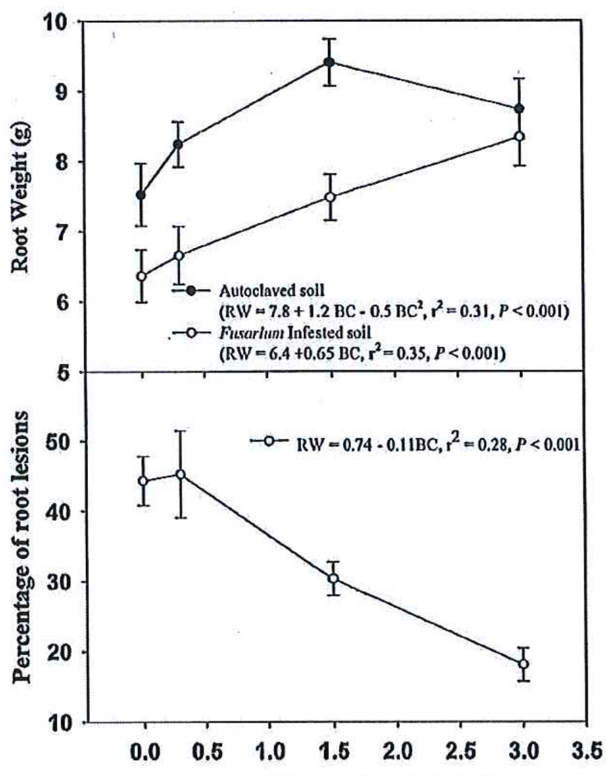

Fig. 1. Effect of biochar rate on root weights or roots with lesions of asparagus grown in autoclaved asparagus soil or asparagus soil naturally infested with *Fusarium oxysporum* f. sp. *asparagi* and *F. proliferatum*. Error bars represent the standard error of the means ($n = 20$) from two combined trials.

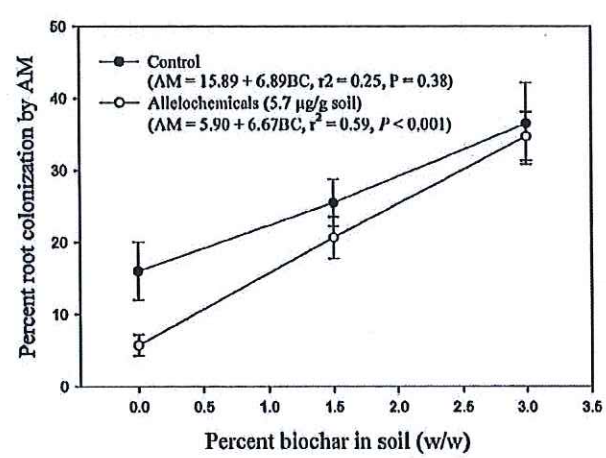

Fig. 2. Effect of biochar rate on colonization of asparagus roots by arbuscular mycorrhizae (AM) grown in soil that was spiked or not with an allelochemicals mixture (caffeic, coumaric, and ferulic acids, each acid at 5.7 µg/g of soil). Error bars represent the standard error of the means from two combined experiments.

during the period of fern production (June and July) in 2009 was excessive (36.2 cm) compared with the past 10 years, which averaged 21.0 cm for the same time period. Biochar-treated microplots were noted to hold water longer and dried down more slowly than untreated microplots.

Discussion

Failure of asparagus to establish in abandoned asparagus fields is attributed to several factors, one of which is the release of aromatic acids and other allelochemicals from plant residues. The main toxins are the aromatic acids: coumaric, caffeic, and ferulic acids (19). These toxins make plants more susceptible to Fusarium crown and root rot disease (34). Given that the removal of these residues remains impractical, our objectives were to determine whether biochar could be useful to overcome the replant problem. Addition of the above aromatic acids to the soil in the current study was an attempt to reproduce the conditions found in a replant situation. The aromatic acids had no effect on the percentage of root lesions or on root weights but they did reduce root colonization by AM. In previous studies, filtrates of asparagus residues containing these compounds inhibited growth of asparagus (1,21) but it is likely that the filtrates contained other toxins. In fact, in greenhouse study II, root weight was negatively affected by ground dried asparagus residues added to soilless potting mix. In both repetitions of that study, disease was unexpectedly greatest at the lowest residue rate.

In the first set of greenhouse experiments, most growth and disease responses were proportional to the biochar rate but thresholds were occasionally observed at the lower rate, suggesting that biochar interactions with soil properties may exist. A clear reduction in the percentage of root lesions caused by *Fusarium* spp. was observed following the addition of biochar to soil along with an increase in AM colonization. Both Wacker et al. (40) and Matsurba et al. (31) observed that disease suppression was closely associated with an increase in AM colonization. The current study supports that observation and may suggest that increased AM colonization may suppress infection and disease development in asparagus (9).

The present study is in qualitative agreement with Matsubara et al. (30), who found coconut charcoal amendments suppressed Fusarium crown and root rot and increased AM colonization of asparagus seedlings (from 32 to 55%). However, the conditions of that study and the current one differ enough that different mecha-

Table 1. Soil pH and densities of *Fusarium* spp. and fluorescent pseudomonads associated with rhizosphere asparagus roots treated with allelochemicals and grown in soil amended with different rates of biochar[y]

Treatment	Rhizosphere pH	*Fusarium* counts (log CFU/g of soil)	Fluorescent pseudomonads (log CFU/g of soil)
No biochar			
No allelochemicals	6.87	3.72	5.60
Allelochemicals (5.7 μg/g)	7.11	3.86	5.74
Mean	6.99	3.80	5.67
Biochar 1.5% (wt/wt)			
No allelochemicals	7.24	4.29	5.44
Allelochemicals (5.7 μg/g)	7.19	3.88	5.45
Mean	7.22	4.13	5.45
Biochar 3.0 (wt/wt)			
No allelochemicals	7.26	3.80	5.97
Allelochemicals (5.7 μg/g)	7.27	3.56	5.95
Mean	7.27	3.70	5.96
ANOVA for tissue, source *P*			
Biochar	ns[z]	ns	0.008
Allelochemicals	ns	ns	ns
Biochar × allelochemicals	ns	ns	ns

[y] Abbreviations: ANOVA = analysis of variance and ns = not significant.
[z] Significant at $P = 0.078$.

Table 2. Mineral composition of asparagus ferns treated with allelochemicals and grown in soil amended with biochar[w]

	Minerals (μmol/g of tissue)										
Treatment[x]	N[y]	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	B
No biochar											
No alleo.	1.37	65	816	114	68	69	1.76	0.32	0.26	0.08	3.62
Allelo. 0.57 μg/g	1.31	60	860	127	68	73	1.35	0.35	0.22	0.08	4.32
Allelo. 5.7 μg/g	1.32	63	865	112	62	67	1.43	0.35	0.28	0.08	3.87
Mean	1.33	63	847	118	66	70	1.51	0.34	0.25	0.08	3.94
Biochar 1.5% (wt/wt)											
No alleo.	1.31	65	879	107	63	70	1.48	0.37	0.23	0.07	4.14
Allelo. 0.57 μg/g	1.19	58	926	118	63	71	1.26	0.36	0.27	0.08	4.33
Allelo. 5.7 μg/g	1.06	59	853	121	65	69	1.32	0.39	0.24	0.09	4.67
Mean	1.19	61	886	115	63	70	1.35	0.38	0.25	0.08	4.38
Biochar 3.0 (wt/wt)											
No alleo.	1.27	65	905	111	58	72	1.16	0.37	0.24	0.09	4.24
Allelo. 0.57 μg/g	1.19	62	925	119	59	74	1.24	0.45	0.26	0.09	5.03
Allelo. 5.7 μg/g	1.07	56	891	101	57	66	1.09	0.37	0.24	0.06	3.94
Mean	1.18	61	907	110	58	70	1.16	0.39	0.25	0.08	4.40
ANOVA, source *P*											
Biochar	*[z]	ns	0.001	ns	0.001	0.023	0.0	0.001	ns	ns	0.046
Allelo.	0.001	0.023	ns	0.024	ns	0.01	0.03	ns	ns	ns	0.003
Biochar × allelo.	ns	ns	ns	ns	ns	0.001	ns	0.049	0.03	0.02	ns

[w] Values represent means of six replicates; three bulked samples from each experimental repetition; Alleo. = allelochemicals, ANOVA = analysis of variance for tissue, and ns = not significant.
[x] A 50-ml mixture of allelochemicals containing caffeic, coumaric, and ferulic acids at 0, 5.0, or 50.0 μg/ml was applied to 440 g of soil.
[y] Nitrogen concentrations are expressed a mmol/g tissue.
[z] Significant at $P = 0.062$, Kruskal Wallace test at $P = 0.025$.

nisms may be operative. No allelopathy was imposed in the Matsubara et al. (30) study; therefore, the increase in AM colonization and disease suppression observed may have been due to other effects, such as changes in soil structure that favor survival of the AM fungi. Moreover, soil pH in their study was acidic (pH 5.4) and rose to pH 6.3 following the addition of coconut charcoal. Although pH was not considered to be important in affecting germination of the AM fungi, the alkalization effect of their soils may have suppressed Fusarium disease severity and promoted root health and beneficial microbes, which, in turn, increased AM colonization.

Soil nutrient levels were not measured in the present study but it has been documented that biochar enhances nutrient retention and water-holding capacity of soil (5,26) along with supplying a small amount of nutrients. This may explain the growth-promoting effects observed in autoclaved soil where disease was minimized. Another possible mechanism for growth promotion is the possible production of ethylene, a plant hormone, from biochar amendment (39). Ethylene at concentrations less than 2 ppm can increase AM germination and hyphal growth (23). The evolution of ethylene from biochar and its role on root growth remains an interesting mechanism to be investigated.

Warnock et al. (41) discussed several ways that biochar could affect AM colonization in plants: (i) alteration of nutrient availability or soil properties, (ii) stimulation of soil microbial populations that favor AM colonization, (iii) disruption of chemical signaling or detoxification of allelochemicals that inhibit AM colonization, and (iv) creation of a physical refuge from AM predators. Although the present study was not designed to elucidate the relative importance of the aforementioned mechanisms, there is evidence that biochar may function through at least two of them: alteration of nutrient availability and stimulation of soil microbes that favor AM colonization.

Increasing biochar rate increased K, S, Mn, and B uptake whereas N, Fe, and Mg uptake decreased. Analysis of the CQuest biochar revealed that all of these elements except B were present in the biochar; however, because the choice of procedures to estimate elemental composition of biochar in soil can drastically affect the results (J. Lehman, Cornell University, *personal communication*), the actual amount available to plants is difficult to predict. The

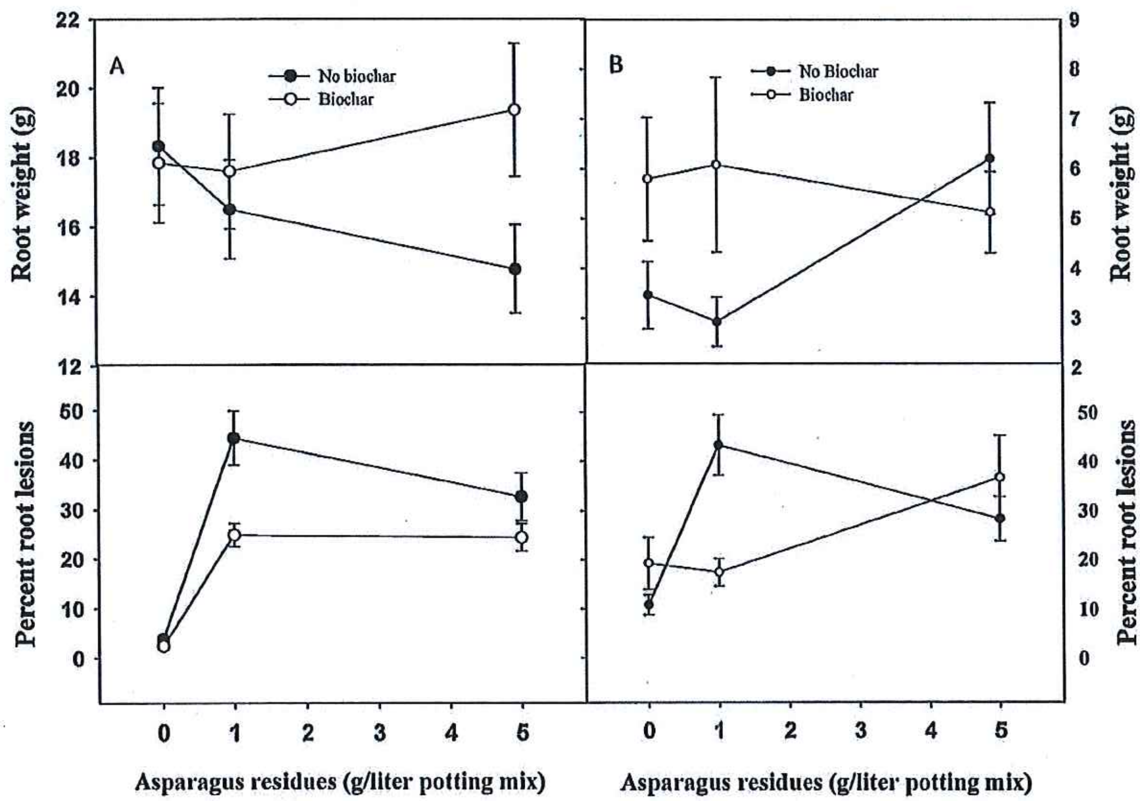

Fig. 3. Effect of increasing rates of dried asparagus residues in soilless potting mix amended with and without biochar (3.5 g/liter of potting mix) on root weight and the percentage of roots with lesions caused by *Fusarium oxysporum* f. sp. *asparagi* and *F. proliferatum*. A, Experiment 1 and B, experiment 2. Error bars represent the standard error of the means ($n = 20$).

Table 3. Stand counts, marketable yield, and arbuscular mycorrhizal (AM) colonization of asparagus roots from microplots treated with biochar[x]

Treatments[y]	Marketable yield: Number of spears	Marketable yield: Spear weight (g)	Stand counts	Disease rating (1–5)[z]	AM colonization (%)
Control (CK)	2.1 a	19.4 a	5.7 a	3.0 a	0.0
Biochar	1.3 a	17.1 a	5.0 a	2.5 ab	4.4
Healthy CK	3.3 a	45.0 b	5.7 a	1.9 b	14.1

[x] Values represent the means of six replicates; values followed by differing letter are significant different by Tukey's test at $P = 0.05$; AM colonization data represent one bulked sample from six replicate plots.

[y] Control = untreated asparagus soil, Biochar = asparagus soil treated with biochar at 10% (vol/vol) (3.5% wt/wt), untreated non-asparagus soil.

[z] Disease rating based on the scale 1 = green and robust ferns, 2 = slightly less vigorous ferns, 3 = yellowing in the fern tissue, 4 = yellow and wilts, or 5 = dead or near dead.

reduction in N uptake was unexpected because the root systems were larger in the biochar-amended pots. Potassium and S are active in host defense metabolism by influencing osmotic relations and the production of defense products (18,36), and the increased uptake of these elements may have contributed to disease suppression. The increase in Mn levels is interesting, given past research associating disease suppression with an increase in the availability of Mn in asparagus following NaCl application to soils (8,10) and in surveys associating low Mn in field soils where Fusarium crown and root rot was severe (17). Past studies on asparagus (7) found disease suppression to be associated with a reduction in Mg in the fern tissue, also observed in the current study. In addition, the slight increase in soil pH may have contributed to reduced disease by decreasing the availability of Fe to the pathogen (24). The linear reduction in Fe concentration in the asparagus tissue with biochar concentration in the soil (Table 2) lends support to this mechanism. These nutrient alterations may have promoted a more disease-resistant plant. In other studies, biochar applied at 20 t/ha (which approximates 1% [wt/wt] in the top 15 cm of soil) increased the nutrient-holding capacity of the soil, boosted the yield of maize, and increased tissue levels of Ca and Mg (28). Lehmann et al. (26) reported that biochar amendment to tropical soils initially increased K, P, and Zn availability and, to a lesser extent, Ca and Cu. The differences in soil types and the different types of biochar used in these studies make comparisons difficult.

Biochar also increased the density of beneficial fluorescent pseudomonads. Esfchani et al. (13) found that fluorescent pseudomonads alone could enhance mycorrhizal colonization in wheat. In addition, competition, antibiosis, and induced resistance are well-documented methods by which fluorescent pseudomonads can suppress disease and increase root health (16). Elad et al. (6) suggested that biochar induced resistance to *Botrytis* spp. and powdery mildew on pepper and tomato.

The effect of biochar on adsorption or detoxification of toxins was not examined in the current study but data are forthcoming. Similarly, the fourth mechanism proposed by Warnock suggests that biochar can provide refuge of AM propagules from predation. Matsubara et al. (29) and Saito (37) both suggested that carbonized material could enhance the growth of AM fungi in soil by providing optimum air and water permeability while excluding antagonists. This hypothesis also needs validation.

The water-holding capacity of biochar-treated soils may offer potential benefits in nutrient-poor sandy soils that are prone to moisture deficits. Asparagus is relatively drought tolerant but moisture deficits can promote disease (12). In heavier clay soils, it is conceivable that biochar may be a detriment to root health by promoting root rot. This may explain the poor asparagus growth we observed in microplots on loam soil. Studies are underway to examine the role of biochar on asparagus grown in sandy soils.

Based on these studies, there appears to be a potential role for biochar in the asparagus replant problem. Its applicability to other replant problems on apple and nut trees needs to be determined. However, until more is known about how biochar rates and different biochar types interact in different soils and on different crops, caution should be exercised in making any specific endorsements of the use of biochar for disease suppression.

Acknowledgments

We thank Dynamotive Energy Systems for donating the CQuest Biochar; C. Musante for tissue analyses; and P. Thiel, C. Connelly, and C. Steckler for technical assistance.

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INFLUENCE OF BIOCHAR AND EARTHWORMS ON PLANT GROWTH, FUSARIUM CROWN AND ROOT ROT, AND MYCORRHIZAL COLONIZATION OF ASPARAGUS

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Key words: *Asparagus officinalis*, replant problem, disease management, *Fusarium oxysporum* f. sp. *asparagi, F. proliferatum*

ABSTRACT

Biochar and earthworms were two treatments examined alone and in combination for their influence on increasing asparagus root health in old asparagus soils by reducing Fusarium crown and root rot (FCRR) and increasing colonization by vesicular arbuscular mycorrhizae (VAM). Earthworms (*Lumbricus terrestris*) were added to pots filled with soil infested with the pathogenic *Fusarium* spp. and planted with asparagus. Earthworm activity was associated with a 66% increase in root weight and a 50% reduction in FCRR disease. When biochar, a fine-grained activated charcoal, was added to pots at 0, 1.6, and 3.2% (w/w), planted to asparagus, and then drenched with a mixture of the inhibitory allelochemicals (caffeic, coumaric, and ferulic acids), root weights increased and FCRR disease ratings declined with increasing rates of biochar. The allelochemicals alone did not affect plant growth or FCRR, but reduced VAM colonization. However, biochar reduced the negative effect of the allelochemicals on VAM. A series of studies examined the combination of earthworms and biochar in soils heavily amended with dried asparagus residues. When these treated soils were later planted to asparagus, no interactions were observed between biochar and earthworms on growth or FCRR. In autoclaved soils, biochar reduced root weights. Earthworms were not effective in the studies possibly due to the high rate of residues added. The beneficial effects of both treatments appear to directly influence the pathogenic and beneficial microbes, their interactions with each other, and with the allelochemicals and plants roots possibly by interrupting signals between roots and microbes.

INTRODUCTION

Replanting old asparagus fields presents many obstacles to growers. Soil densities of pathogenic *Fusarium* spp. are usually very high, and the decomposing crown and root residues release allelochemicals that inhibit the growth of young transplants (Elmer et al., 1996; Blok and Bollen, 1993; 1996a). The initial release of allelochemicals is very rapid the first year, but slowly continues for an indefinite amount of time (Schofield et al., 1997). Although the allelochemicals inhibit most soil microorganisms including beneficial microbes like vesicular arbuscular mycorrhizae (VAM), the pathogenic *Fusarium* spp. are unaffected by the toxins (Blok and Bollen, 1996b; Pedersen et al., 1991) so they can proliferate in the absence of competitors. Partial success in overcoming the replant problem was achieved with NaCl applications and beneficial nonpathogenic *F. oxysporum* isolates. Disease suppression and marketable yields were increased when these treatments were applied (Elmer, 2004; 2008). However, the beneficial *Fusarium* strains are not registered for use and many growers have reservations about using NaCl. Alternatively, research in The Netherlands has shown that anaerobic decomposition of green manures in abandoned asparagus fields can reduce densities of *Fusarium* spp. and possibly accelerate microbial decomposition of asparagus residues (Blok et al., 2008). The creation of anaerobic conditions requires that fields are first cropped with a suitable grass to provide biomass and then covered with airtight plastic sheeting to create the low oxygen environment. Although effective, these activities require costly inputs, including machinery and labor that may not be options for many growers. Given these hindrances, other strategies need to be developed.

Biochars are fine-grained activated charcoals produced from the pyrolysis of plant wastes at temperatures between 400 and 700 C (Lehman, 2007). Biochars possess tremendous absorptive properties that may be able to reduce the damaging effects of allelopathic compounds from asparagus. Biochar is currently touted as a beneficial soil amendment useful in increasing nutrient exchange and water-holding capacity in nutrient poor soils (Lehman, 2007). However, the properties of biochar can vary widely depending on feedstocks, pyrolysis temperatures, and syngas removal. In addition, biochar's usefulness in plant disease management has not been thoroughly assessed. It has been hypothesized that biochar will have a qualitatively positive effect on growth by detoxifying allelochemicals involved in plant-mycorrhizal fungi signaling processes. This assumption is supported by Matsubara et al. (2002) who found activated carbon increased growth of asparagus grown in soil with allelochemicals and increased colonization by VAM fungi and by Wacker et al. (1990a; 1990b), who reported that the allelochemical, ferulic acid, had little effect on the growth of asparagus, but it essentially eliminated mycorrhizal colonization and reduced plant weight by 40%. Elmer (2003) also observed that certain soil treatments that promoted a three-fold increase in mycorrhizal colonization enhanced growth of asparagus by 16%. Amendment of asparagus soil with different forms of biochar was examined by Motoki and colleagues (Motoki et al., 2002; 2005; 2008). Flowable biochars were able to increase growth and marketable yield, but the age of the field and size of the root systems were believed to influence the response (Motoki et al., 2008). Another limitation for the asparagus system would be the delivery of biochar in established fields. Motoki et al. (2008) experimented with injecting flowable biochars into the root zones, but found the larger root systems may have escaped the ameliorating effect of the biochar.

One possible means to distribute biochars to the root zones where the allelochemicals are being released might be through the burrowing activity of earthworms (Edwards and Bohlen, 1996; Scheu, 2003). The Canadian nightcrawler (*Lumbricus terrestris* L) burrows to depths of over 1 m opening up channels for water infiltration and possibly the movement of biochar (Ehlers, 1975). In addition, earthworms might redistribute biochars throughout the root systems through ingestion and release in the castings. Earthworms have also been associated with decreased incidence of many root diseases (Davoren, 1994; Elmer, 2009; Elmer and Ferrandino, 2009; Stephens and Davoren, 1997). Rhizosphere soils augmented with earthworms had 10- to 12-fold increases in fluorescent *Pseudomonas* spp. and filamentous actinomycetes (Elmer, 2009). Strong correlations also exist between earthworm densities and the physical soil health parameters like bulk density, pore size, water infiltration rate, soil water content, and water-holding capacity (Edwards and Bohlen, 1996). Earthworm activity increases nutrient availability and plant biomass (Scheu, 2003). Given that earthworms have been used to remediate and restore soils that are contaminated with toxins (Butt, 1992), it is reasonable to assume they might also aid in decomposition and detoxification of asparagus root residues. The objectives of this study were to determine if earthworms or biochar amendments alone or combined could improve growth, suppress Fusarium crown and root rot, and increase VAM colonization.

MATERIALS AND METHODS

Effect of earthworms

Asparagus (cv. Mary Washington) seeds were disinfested by exposing them to 20% household bleach (1.05% $NaHClO_2$) for 30 min, and then rinsing them in tap water to remove seedborne *Fusarium* spp. Seedlings were fertilized every 2 weeks with 20-10-20 (N-P-K) Peter's soluble fertilizer (1.0 g/L) (Scotts Inc., Lincoln, NE). Soil (Cheshire fine sandy loam) that was naturally infested with *F. oxysporum* f. sp. *asparagi* and *F. proliferatum* was removed from around the rotting crowns of asparagus plants in a field in Hamden, CT. Soil was air-dried, passed through a 0.5 cm sieve, and mixed 1:1 with peat along with 10 g dolomitic limestone/L soil. Plants were grown in 2-L plastic pots that were set into Styrofoam containers to prevent large fluctuations in temperature. The rims of each pot were wrapped with aluminum foil to reflect light and prevent warming and to prevent earthworms from crawling out. The bottoms of all pots were also securely wrapped and taped with nylon cloth to prevent escape. One 2-mo-old asparagus transplant was placed into each pot. Adults of *L. terrestris* were purchased from a fishing supply house (N.A.S. Inc., Marblehead, OH) and washed in tap water before use. There was an earthworm treatment and a control with 12 replicates/treatment. Earthworms were added at 4/pot to approximate an upper field limit of 250 earthworms/m^2 (Edward and Bohlen, 1996). Every 2 wks, all pots received 40 ml of dehydrated cow manure that was passed through a 4 mm sieve (Agway, Inc., North Haven, CT). Soil temperatures were measured with soil thermometers placed 10 cm deep and averaged 19 $\pm$ 3°C. In addition, 1-2 g of ground alfalfa was sprinkled on the soil surface of all pots once a week to serve as a food source for the earthworms. Pots were irrigated as needed with deionized water. After 2 mo., plants were removed from the pots, the number of earthworms was recorded, and the root systems were weighed and assayed for disease severity and colonies of *Fusarium*/cm root as described before (Elmer, 2002; 2004).

Effect of biochar

Biochar was obtained from Dynamotive-USA, Arlington, VA. Dynamotive biochar is prepared anaerobically from hardwood by fast pyrolysis at 450-500 °C. It contains 70.5% C, 3.32% H, <0.5% N, and 10.9% ash. Experiments were conducted using a Cheshire fine sandy loam from an abandoned asparagus field that was mixed 1:1 with sand. Half of the soil was autoclaved for 1 hour at 121 C. Biochar was mixed by hand into the soil at 0, 1.6, or 3.2% (w/w) equivalent to 0, 5, or 10% (v/v), respectively. Roots of 3 mo-old 'Mary Washington' transplants were lightly dusted with the Endomycorrhizal Inoculant (BEI Bio/Organics, La Pine, OR) that contained mycorrhizal spores of seven different mycorrhizal species. Seedlings were transplanted into 10-cm plastic pots filled with the soil mix (one plant/pot). Pots were fertilized with soluble 20-10-20 N-P-K fertilizer at planting and one month later and irrigated at other times with tap water. Fifty ml of an aqueous solution containing ferulic acid, caffeic acid, and coumaric acid (0, 5.0 or 50.0 µg/ml) was poured around the plant one week after planting. The allelochemicals were first dissolved in 20 ml of 95% ethanol. The 18 treatment (two soil treatments x three allelochemicals x three biochar treatments) were arranged as factorial experiment in a randomized block design with 6 replicates per treatment. After 3 months, plants were washed, weighed, and root systems were assayed for disease severity and root colonization by *Fusarium* spp. as described before. Mycorrhizal colonization was assayed by staining a total of 1 and 2 m of feeder roots (Elmer 2002; Kormanik and McGraw, 1982; Phillips and Haymans, 1970)

Effect of biochar and earthworms.

Mineral top soil (Agway, Inc.) was autoclaved for 1 hr at 121 C. Half of the soil was amended with ground, dried asparagus roots and crowns that had been dug from an infested field (10 g residues/L soil), and the other half was left untreated. Each of these soil treatments was divided and one half was amended with 35 g/L biochar to yield a 10% (v/v) rate and the other half was not amended. Each soil treatment was then dispensed into two 3.9-L pots. Half of the pots were augmented with 10 *L. terrestris* adults. The drainage holes had been sealed with 100 µm mesh cloth to prevent escape. One g of mycorrhizae spore inoculum was added to the surface of all pots. Pots were kept moist. Twice a week, 1-2 g of ground alfalfa was sprinkled on the surface of all pots to provide a food source for the earthworms. After 2 mo, each pot was emptied, earthworms were counted, and the thoroughly mixed soil was dispensed into twelve 10-cm plastic pots and planted with one 2 mo-old asparagus seedling. After another two months, plants were removed, washed, weighed, and roots were assayed for disease severity and for colonization by VAM and *Fusarium* spp. as described above. The experiment was repeated.

Statistical Analyses.

Data from the greenhouse studies were analyzed using the ANOVA tests for a randomized factorial design. Arcsine transformation of percent data was done when needed to establish data homogeneity.

RESULTS

Effect of earthworms

Adding earthworms to pots containing asparagus increased root weight by 66% when compared to controls (Table 1). Disease severity was reduced by half when earthworms were added, but no difference was detected in root colonization by *Fusarium* spp. between earthworm-treated soil and the controls. This may be due to the inability to distinguish the colonies of *Fusarium* sp. that are pathogenic from the nonpathogenic ones. Earthworms survived well in these pots with minor reproduction.

Effect of biochar

Root weight was significantly reduced in infested soil compared to autoclaved soil ($P < 0.001$). Applications of biochar produced significant increases in root weights in infested and autoclaved soil (Figure 1). The rate of 1.6% produced the largest root systems in autoclaved soil, but there was a linear increase in root weight as biochar was added to infested soil. The addition of allelochemicals reduced root weights in autoclaved soil, but the negative effect was partially removed when biochar was added. The allelochemicals did not affect root weights in infested soils. Biochar rate was inversely proportional to disease severity and to the root colonization by *Fusarium* spp. (Figure 2). The addition of allelochemicals had no significant effect on disease severity or root colonization by *Fusarium* spp. However, the allelochemical rate of 50 µg/ml reduced the amount of VAM colonization of the roots when compared to controls. When the allelochemicals were added along with biochar at 1.6 and 3.2%, the VAM colonization increased and approached the level that was observed in the non-allelochemical control. Biochar rate was associated with a linear increase in VAM in both the allelochemical treatment and the control.

Effect of earthworms and biochar

When earthworms and biochar were combined in asparagus residue-amended soil for 2 mo then planted to asparagus, there were no statistical interactions for the root weight, disease severity, or root colonization by *Fusarium* spp. In autoclaved soils, biochar reduced root weights and did not increase weight in soil infested with asparagus residues. However, in infested soils biochar significantly reduced the estimates of disease severity and increased the colonization by VAM fungi. The earthworms tended to reduce disease severity, but they also negated the beneficial effects of biochar on increasing VAM fungi.

CONCLUSIONS

Applications of biochar and earthworms were two strategies that were explored to reduce the allelopathic and pathological effects of old *Fusarium*-infested asparagus residues on young crowns planted in old asparagus soils. It was hypothesized that the absorptive properties of biochar and the burrowing activity of earthworms would act to absorb allelochemicals, accelerate the decomposition of roots, and improve root health. Although we found that both treatments were beneficial on asparagus health, many unanswered questions arose when the two products were combined in the asparagus residue-amended soils.

Biochar alone increased plant growth in infested soils, reduced root disease, and increased the colonization of VAM. Our results support the findings of Matsubara et al. (2002) who also found increased VAM colonization when activated carbon was added to soil, and those of Motoki et al. (2002; 2008), who observed greater yield when flowable activated carbon products were used. However, in the current study, biochar also reduced growth in autoclaved soil. This suggests biochar may operate by interfering with plant root signals between microbes. Absorption of toxic compounds could explain the increased root colonization by VAM and the current study provides evidence that increasing rates of biochar can increasingly negate the damaging effects of allelochemicals when they were added to soil. Enhanced mycorrhizae colonization provides many health benefits to asparagus including suppression of FCCR (Arriola et al., 2000; Matsubara et al., 2001; Wacker et al., 1990). We also have noted that the addition of biochar to soil raises the pH 0.4 units, which may promote better growth if soils are slightly acidic (unpublished). One limiting factor governing the use of biochars is the cost and availability of large quantities. However, the production of biochar is predicted to increase dramatically on a global scale due to its potential use in agriculture and the carbon-negative generation of fuels and energy (Lehman, 2007).

It was also hypothesized that earthworms might provide a mode of delivery by actively ingesting and transporting biochar to lower soil horizons and by opening up burrows that might allow biochar to channel down in percolation water. Our findings show that earthworm activity alone in *Fusarium*-infested asparagus soils was associated with larger plants and healthier roots. Other studies with earthworms found that they increase beneficial microbes like fluorescent pseudomonads and filamentous actinomycetes (Elmer, 2009). It was not clear why earthworms did not improve asparagus growth in soils that were heavily amended with dried crown residues. Furthermore, in these studies, earthworms negated the beneficial effect of biochar. Since the asparagus residues were added at very high rates (10 g dried residue/liter soil), it is possible that there was too much residue for earthworms to process in the two-month incubation time.

Given that earthworm densities in asparagus fields are typically not high, presumably due to chemical inputs, toxic root and crown residues, and a general lack of suitable plant debris research aimed at increasing their numbers by mulching, companion planting, and reducing chemical inputs would also need to be studied further. The cost of manually applying adult earthworms is currently prohibitive. Similarly, it is not clear that the cost of biochar could be justified in terms of future yield benefits. However, field studies are in progress to address the hypothesis that these treatments might be applied only once at planting. As technology continues to advance on encapsulating live earthworm cocoons and on the large-scale production of biochar, these treatments may become economically obtainable to asparagus growers.

Acknowledgements
The author gratefully acknowledges Peter Thiel for technical assistance.

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Table 1. Influence of earthworms (*Lumbricus terrestris*) on asparagus root weight, disease severity, and root colonization by *Fusarium oxysporum* spp.

Treatment	Roots weights (g)	Percent Root Lesions	*Fusarium* colonies/ cm root	Earthworms recovered
Control	18.5	14.0	0.34	0
Earthworms[x]	30.7***[y]	7.0**	0.38	4.15***

[x] Earthworms (*Lumbricus terrestris*) added to pots at 4 adults per pot.
[y] *, **, or *** indicates statistically significant differences between sample means based on t-test at $P < 0.05$, < 0.01 or < 0.001, respectively.

Table 2. Effect of combining earthworms and biochar in soil supplemented with asparagus residues on asparagus root weight, disease severity, and root colonization by *Fusarium* spp. and vesicular arbuscular mycorrhizae (VAM).

Asparagus residues[z]	Earth worms[y]	Biochar[x]	Root Weight(g)	% Disease severity	*Fusarium* spp. colonies /cm root	% VAM
No	No	No	5.2	4.0	0.11	1.6
No	Yes	No	6.4	6.4	0.25	1.2
No	No	Yes	3.9	6.1	0.16	1.3
No	Yes	Yes	3.8	2.4	0.13	1.8
Yes	No	No	4.4	28.0	0.72	17.0
Yes	Yes	No	4.2	18.0	0.52	28.3
Yes	No	Yes	4.6	11.0	0.47	63.0
Yes	Yes	Yes	4.8	10.0	0.46	44.0
ANOVA (*P*)						
Asparagus residues			NS	>0.001	>0.001	>0.001
Earthworms			NS	NS	NS	NS
Biochar			0.008	0.01	NS	0.01
AR x BC			>0.001	NS	NS	0.02
BC x EW			NS	NS	NS	0.04

[z] Residues consisted of dried, ground root and crown tissue, applied at 10 g residue/L soil.
[y] Earthworms (*Lumbricus terrestris*) added to pots at 10 adults per pot.
[x] Biochar added at 3.2 g/liter soil.

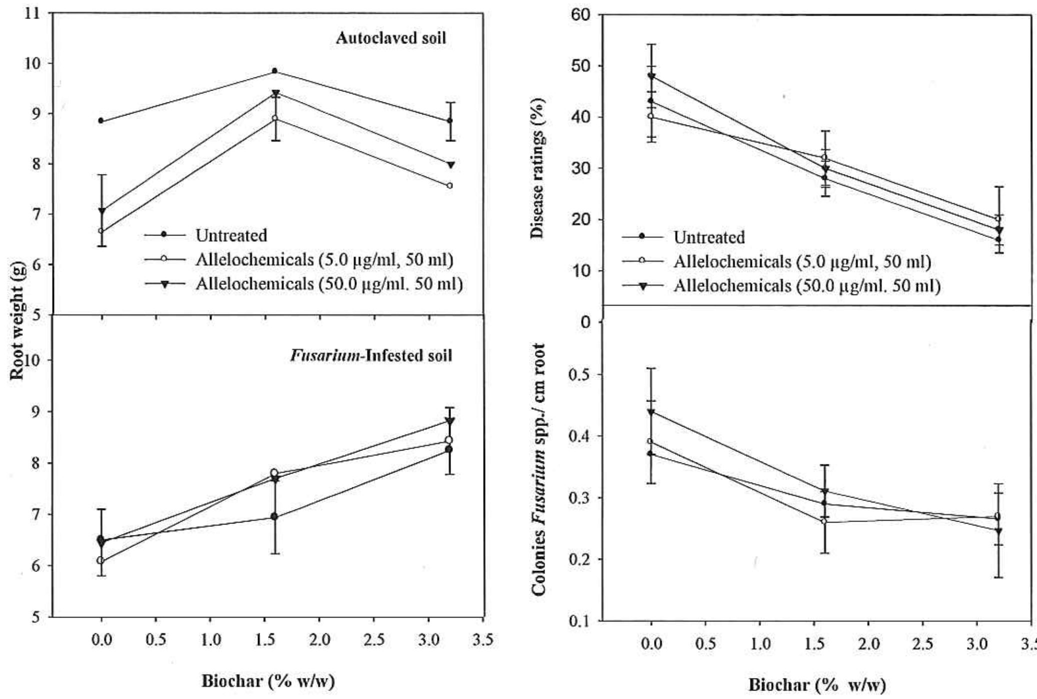


Figure 1. Left - Asparagus root weights in autoclaved soil (top graph) or soil infested with *Fusarium* pathogens (bottom graph) amended with increasing rates of biochar and treated with allelochemicals. Right – Disease severity (%) (top graph) and colonization by *Fusarium* spp. (bottom graph) of asparagus root grown in soil with increasing rates of biochar and treated with allelochemical. Error bars represent the standard error of the mean.

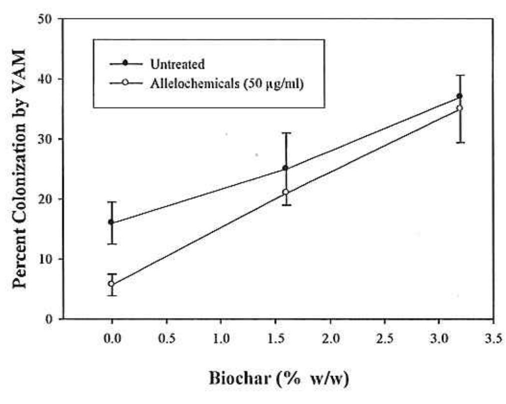
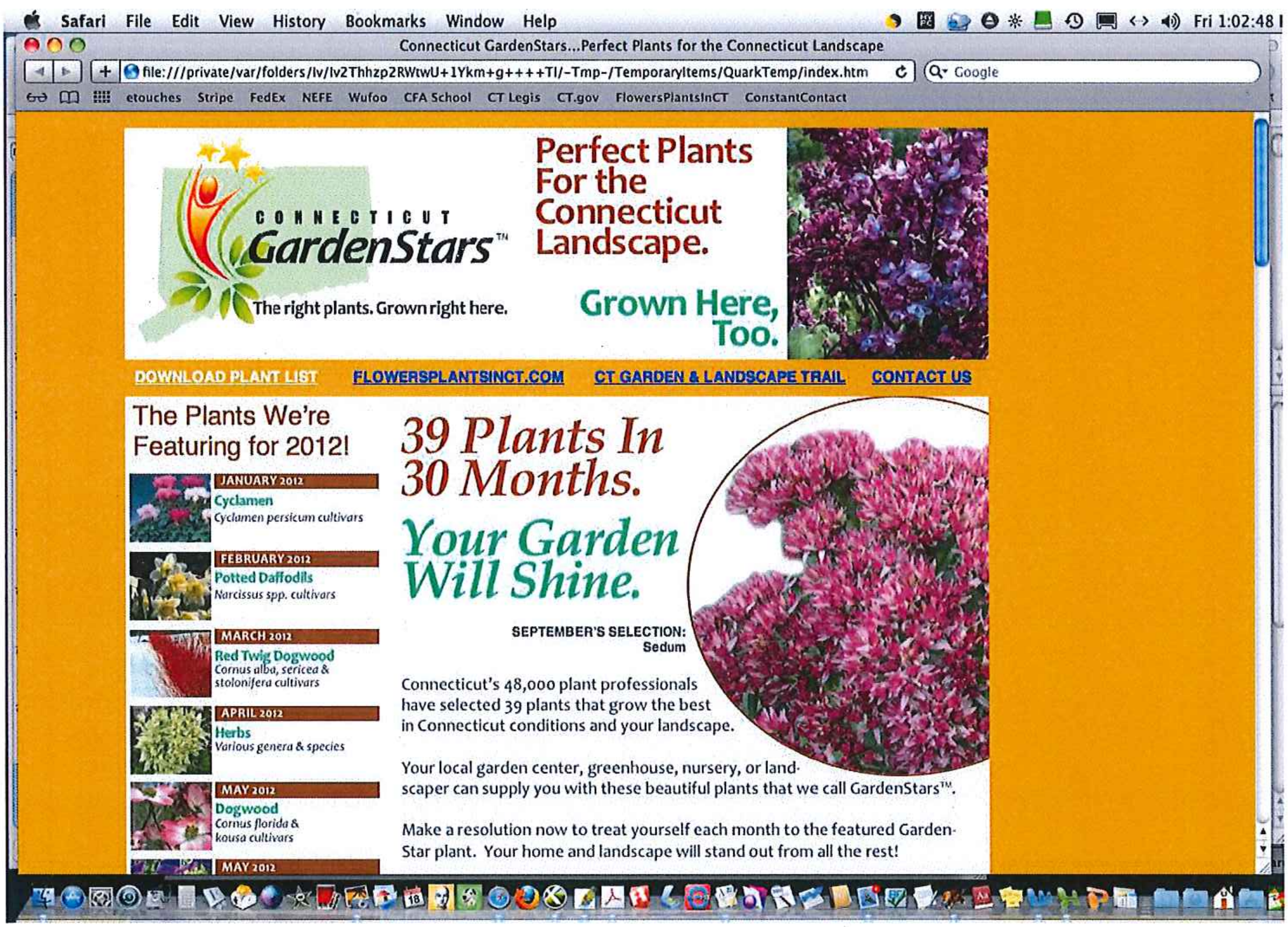


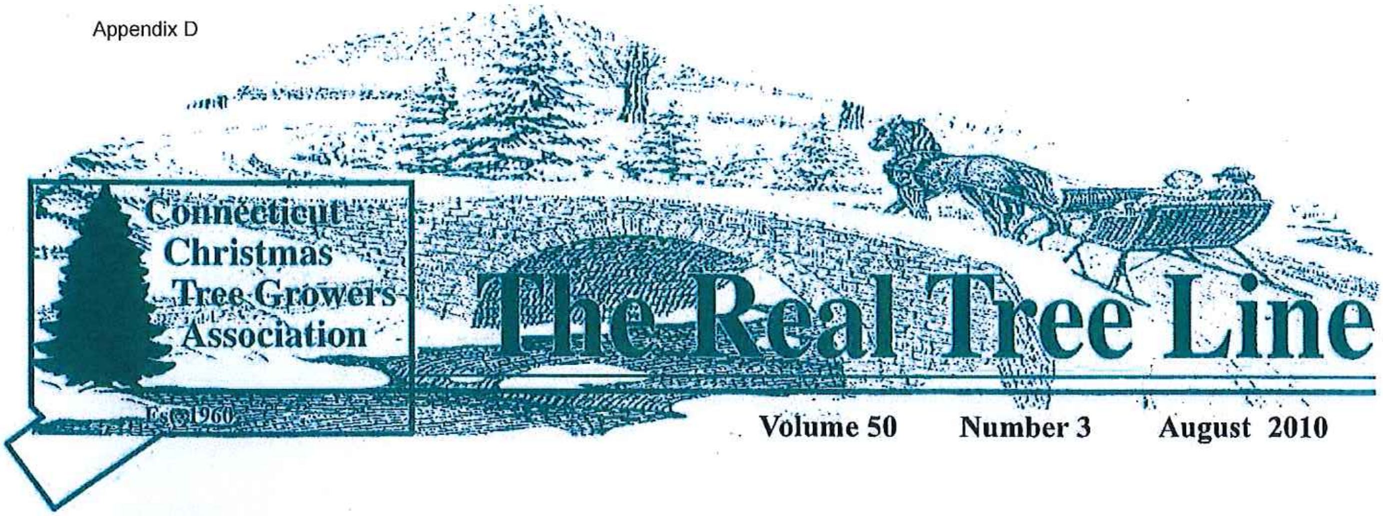
Figure 2. Effect of allelochemicals on colonization of the asparagus roots by vesicular arbuscular mycorrhizae (VAM) in soil amended with increasing rates of biochar. Error bars represent the standard error of the mean.

Appendix C

CONNECTICUT
GardenStars™
The right plants. Grown right here.

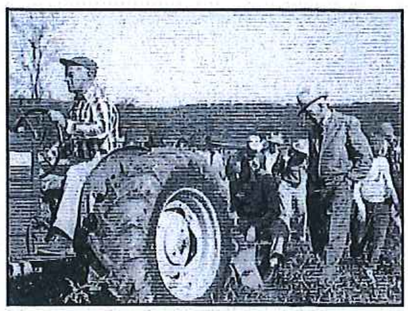


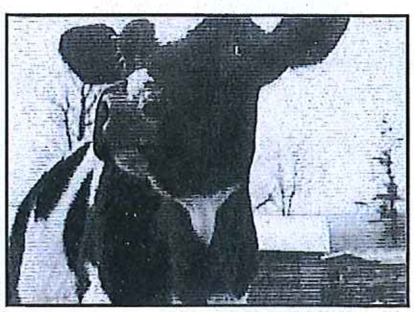
Appendix D



Volume 50 Number 3 August 2010

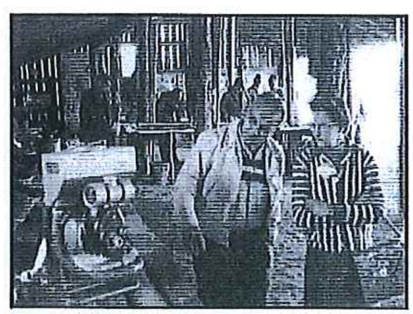
CCTGA Celebrates it's 50th Anniversary!





Photographs from CCTGA's first field meeting at Jones Family Farm October 1960

See pages 18, 19 & 20 for information on the upcoming 50th annual meeting at the Jones Family Farms in Shelton



The Real Tree Line is the official magazine of the Connecticut Christmas Tree Growers Association. Issued in February, May, August and November.

Attendee Registration Form

August 6 -7, 2010

Connecticut Christmas Tree Growers Association 50th Anniversary Meeting

In association with the biennial conference of the

New England Christmas Tree Alliance

Hosted by Jones Family Farms, 606 Walnut Tree Hill Rd. Shelton, CT 06484

www.jonesfamilyfarms.com

*Name*__________ *Farm Name*__________

*Address*__________ *City*__________ *State*_____ *Zip* _____

*Phone Number*__________ *E-Mail*__________ *Web Site* __________

Additional Attendees:

Name:

*1.*__________ *2.* __________ *3.* __________ *4.*__________

Registration Options:					
Friday & Saturday trade show and seminars	*# attending*_____	@	*$75.00*	=	__________
Friday Only – trade show and seminars	*# attending*_____	@	*$50.00*	=	__________
Saturday Only – trade show and seminars	*# attending*_____	@	*$50.00*	=	__________
Friday Lunch (12:00 – 1:30 PM)	*# attending*_____	@	*$10.00*	=	__________
Friday Wine tasting (5:30 – 6:30 PM)	*# attending*_____	@	*$5.00*	=	__________
Friday Night Dinner (6:30 PM)	*# attending*_____	@	*$25.00*	=	__________
Saturday Picnic (12:00 – 1:30 PM)	*# attending*_____	@	*$10.00*	=	__________

All events and seminars including the banquet will be held at the farm.

If you wish to make a donation to support CCTGA please do so here- *donation amount*__________

*Total $*__________

Please make checks payable to CCTGA (US Dollars)

For registration questions call (203)237-9400 or email wkogut@cox.net

Please mail check and registration form to: Kathy Kogut 304 Parker Ave. Meriden, CT 06450

Lodging Information

Special hotel rates have been negotiated with **The Courtyard by Marriott Shelton** and **Hilton Garden Inn Shelton.** Both hotels are offering $79.00 charge per night. The rooms are 2 queen beds or 1 king bed with free parking. All reservations need to be made by Friday, July 23, 2010, for this special rate.

To make your reservation at the **Courtyard Marriott,** 780 Bridgeport Ave., Shelton, CT 06484, call 800-228-9290 or 203-929-1500. Please refer to: http://cwp.marriott.com/bdrcy/ctchristmastreegrowers

To make your reservation at the **Hilton Garden Inn,** 25 Old Stratford Road, Shelton, CT 06484, call 203-447-1000. Please refer to: www.shelton.stayhgi.com/ctctga

Also, for those who wish to camp, there are sever campgrounds within 30 miles.

Kettletown State Park in Southbury, CT
Tel: 203-264-5678

Webb Mountain Park in Monroe, CT
For more information, call Monroe Park a Recreation Department at 203-452-2806.

Black Rock State Park in Watertown, CT
Tel: 860-283-8088

Please refer to http://www.campconn/directory.ht for more information on CT campgrounds.

For complete information please visit www.ctchristmastree.org

Program Schedule

THURSDAY- AUGUST 5TH

4:00 PM - 6:00 PM
Pre-registration
Vendor set up

FRIDAY- AUGUST 6TH

8:00 - 9:30 AM Check in/registration
8:30 - 12 Noon Tours
Walking tour (1.5 hrs) - CAES Scientists: Todd Mervosh, John Ahrens, Tom Rathier*
Riding tour (1.5 hrs) - CAES Scientists: Mary Inman, Rich Cowles*
Discussions will include weed management, cover and aisle crops, tree and seedling culture, tree diseases, and sustainability
12:00 Noon - 1:30 PM Lunch and trade show
1:30 PM - 2:00 PM Welcome & Jones Family Farm Story
2:15 PM - 3:15 PM Session One
A. Guest Speaker - Sharon Douglas - Disease management in Christmas Trees *
B. Alternate Program -Kathy Angevine -Christmas Gift Shops makes "cents"
3:15 PM - 4:30 PM Session Two
A. Guest Speaker - Rich Cowles - Pest control in Christmas trees*
B. Alternate program - Dick Jaynes/Andy Brand - "Wreath making", as demonstrated on the Martha Stewart Show
4:30 PM - 5:00 PM Exhibitor demonstrations
5:30 PM - 6:30 PM Wine tasting
6:30 PM Dinner /Awards / recognition / entertainment

SATURDAY- AUGUST 7TH

8:00 AM - 9:30 AM Registration - trade show opens
8:30AM - 9:30 AM State meetings
9:30 AM - 9:45 AM Announcements
10:00 AM - 11:00 AM Session One
A. Guest Speaker-Larry Judson Kuhns-State College, PA Weed management in Christmas trees *
B. Alternate Program-Kathy Angevine -Christmas Gift Shops make "cents"
11:00 AM - 12 Noon Session Two
A. Guest Speaker-Mel R. Koelling, Retired Professor from Michigan State University - Tannenbaum Farms *
B. Alternate Program-Dick Jaynes/Andy Brand - "Wreath making", as demonstrated on the Martha Stewart Show
12 Noon - 1:30 PM Picnic Lunch
1:30 PM - 3:30 PM Farm Tours -JJF's operations and points of interest (Vineyard, Philip's Saw mill, etc.)- Jaime Jones Conservation Tour- Terry Jones, Tom Rathier
3:30 PM - 4:00 PM Wrap-up/pick up Pesticide credits

*Recertification credits for pesticide applicator licenses will be available

Directions to The Homestead Farm: includes the Christmas Tree Farm, Winery and Harvest Kitchen 606 Walnut Tree Hill Road Shelton, CT 06484

FROM LOWER FAIRFIELD COUNTY

Travel north on Merritt Parkway (Route 15) to Exit 49N or I-95 to Exit 27A. Follow Route 25 North to stop light. Take a right at light on Route 111 and go for 3.3 miles. Then turn right onto Route 110 and go 2 miles. Turn right on Israel Hill Road/Walnut Tree Hill Rd and follow signs for the Homestead Farm and Winery parking lot on your right.

FROM HARTFORD AREA

Follow I-91 to Route15, Wilbur Cross Parkway Exit. Continue on Route 15, Wilbur Cross Parkway for 21 miles. Take Exit 58 - Route 34 to Derby. Turn right onto Route 34 and go West for 3.5 miles. Turn left on Bridge St. and go 0.2 miles. Turn right on Route 110/ Howe Avenue and travel 4.5 miles. Take a left on Israel Hill Road/Walnut Tree Hill Rd and follow signs for the Homestead Farm and Winery parking lot on your right.

FROM DANBURY AREA

Follow I-84 to Exit 11 Derby/ New Haven and Route 34. Turn right off exit onto Mile Hill Road and go 800 ft. At light, turn right onto Route 34 and go 5 miles. Turn right on Route 111 to Monroe - approx. 4 miles. Then turn left onto Route 110 and go 2 miles. Take a right on Israel Hill Road/Walnut Tree Hill Rd and follow signs for the Homestead Farm and Winery parking lot on your right.

FROM WATERBURY AREA

Follow I-84 to Exit 19 - Route 8 South to Naugatuck/ Bridgeport. Bear left on Route 8 and go south for 18 miles. Take exit 14 - Route 110/ Howe Ave. to Shelton. Turn right on Route 110 and go for 5 miles. Take a left on Israel Hill Road/Walnut Tree Hill Rd and follow signs for the Homestead Farm and Winery parking lot on your right.

FROM NEW HAVEN AREA

Take Route 34 West, turn left on Bridge St. (street is not labeled; it is the next left after the Twisted Vine Restaurant) and go 0.2 mi. Turn right on Route 110/ Howe Ave. and travel 4.5 miles. Take a left on Israel Hill Road/Walnut Tree Hill Rd and follow signs for the Homestead Farm and Winery parking lot on your right.

JONES
FAMILY FARMS

Appendix D Cont.

About our program speakers

By Fabienne Audette

Dr. Larry J. Kuhns, Professor Emeritus, Penn State University. Owner/Grower, Kuhns Tree Farm.

Larry spent 30 years at Penn State as Professor of Ornamental Horticulture beginning in 1977. He conducted educational programs for Christmas tree growers, plants men in the nursery and landscape and garden center managers. His research focused on the proper selection and use of herbicides and low maintenance grasses in Christmas tree plantations, along roadsides and in nursery and landscape plantings.

As owner of Kuhns Tree Farm in State College, PA, Larry runs a 45 acre Christmas tree and nursery operation and also consults on tree-related issues as well as herbicide research. He will speak on weed management in Christmas trees, Saturday, August 7, at 11:00 a.m.

Dr. Melvin R. Koelling, Professor, Forest Extension, Physiology, Department of Forestry, Michigan State University.

Dr. Koelling received his Ph.D. in Physiological Ecology from the University of Missouri.His research interests include biological and economic aspects of Christmas tree production, Christmas tree marketing and market trends.

His work on evaluation of true firs (Abies sp.) for Christmas tree production, soil fertility management for Fraser fir and environmental implications of Christmas tree production has been reported in both the Michigan (MCTJ) and American (ACTJ) Christmas Tree Journals. They include "Environmental Concerns and Christmas Tree Producers" MCTJ, 1991; "Christmas Trees Do Not Cause Fires - Some Facts" ACTJ, 1998; "Fertilization Recommendation for Fraser Fir - Part I: Before Planting" MCTJ, 2001 and "Fertilization Recommendation for Fraser Fir - Part II: Established Plantings" MCTJ, 2002.

Mel and his wife Laurie own and operate Tannenbaum Farms in Mason, MI. They grow and sell pumpkins and Christmas trees and have a Christmas gift shop, along with wreath and garland sales.

Dr. Mel Koelling will discuss the business of running Tannenbaum Farms and the future of the Christmas tree industry, Saturday, August 7 at 11:00 a.m.

Dr. Sharon Douglas, Agricultural Scientist and head, Deppartment of Plant Pathology and Ecology, The Connecticut Agricultural Experiment Station, New Haven, CT

Sharon received her Ph.D. in Plant Pathology from the Pennsylvania State University.She started at CAES as Assistant Scientist in 1982, became Associate Scientist in 1993 and has held her current position as Agricultural Scientist since 2000. Among her responsibilities include the Plant Information Office which involves diagnosis of plant health problems for commercial growers, plant care professionals, and homeowners. Her office is the official seed testing laboratory for Conn.

Her expertise in diagnosis and management of disease in conifers has been invaluable to Connecticut Christmas tree growers. Her Fact Sheets are currently being published in the official magazine of the Connecticut Christmas Tree Growers Association *The Real Tree Line*.

Dr. Sharon Douglas will speak on disease management in Christmas trees at 2:15 PM on Friday, August 6, 2010.

Dr. Richard S. Cowles, Agricultural Scientist, Valley Laboratory, The Connecticut Agricultural Experiment Station, Windsor, Conn.

Dr. Cowles received his Ph.D. in Entomology from Michigan State University. His station career started as Assistant Scientist in 1994. and has since been promoted to his current position as Agricultural Scientist.

His current research directed toward improved management of various Christmas tree pests and his experience in the uses of conventional and new insecticides is of great benefit to Connecticut Christmas tree growers. Richard regularly presents research findings and new developments with insecticides at CCTGA meetings.

He is currently involved in CCTGA's research project on evaluation of resistance to Phytophthora root rot in different species of firs. His grant proposal titled "Genetic Improvement of Christmas Trees for Connecticut Farms" won a major award for the project.

Dr. Richard Cowles will speak on pest control in Christmas trees at 3:15 PM on Friday, August 6, 2010.

FOR SALE: Commemorative 50th Anniversary T-Shirts

Please place your order as follows:

Size:
small ____ medium_____ large_____ex.large______1X______2X______

Amount ordered ______x $12.00______ = total amount $________

Please make your check payable to CCTGA and mail to:
Kathy Kogut, Executive Director
304 Parker Ave.
Meriden, CT 06450

Shirts will be sent to you directly. Please be sure to include your mailing address.

Front and back designs for T-shirts

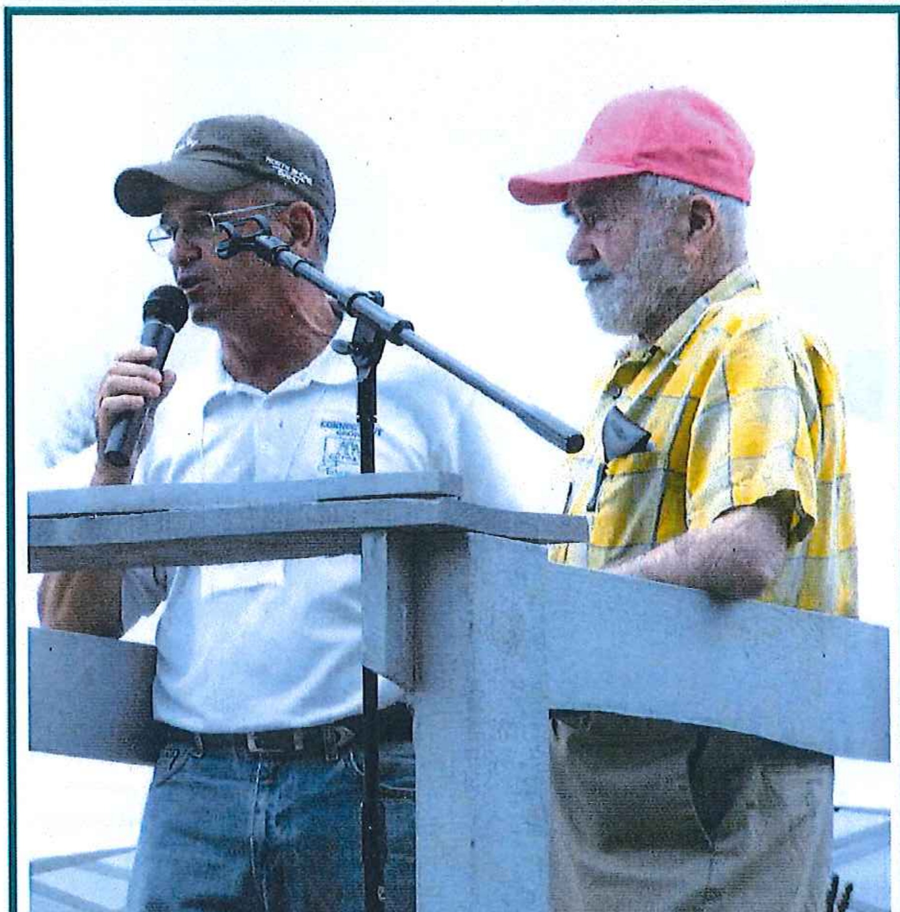
Appendix D Cont.

Connecticut Christmas Tree Growers Association

Est. 1960

The Real Tree Line

Volume 50 Number 4 November 2010



50 Years and Growing

Over 200 people turned out for CCTGA's Golden Anniversary field meeting August 6 and 7 at the Jones Family Farms in Shelton. Pictured above are Charlie Langevin, our current president, and Philip Jones, one of the founders and first president. Go to page 3 and also pages 6 and 22, and pages 16 & 17 to read what took place at this event.

The Real Tree Line is the official magazine of the Connecticut Christmas Tree Growers Association. Issued in February, May, August and November.

Penn State and Michigan State Scientists addressed growers at CCTGA's 50th Anniversary field meeting

By Fabienne Audette

It was a bright clear morning as we all filed into the historical barn of Jones Family Farms on Saturday, August 7. The hayloft had been set up for two guest speakers: Dr. Larry J. Kuhns, Professor Emeritus, Penn State University, and Dr. Melvin R. Koelling, Professor, Michigan State University.

Dr. Kuhns told the growers about his research on vegetation management in Christmas tree plantations, along roadsides and in nursery and landscape plantings, with an emphasis on the proper selection and use of herbicides and low maintenance cover crops. In addition to owning Kuhns Tree Farm in State College, Penn, Dr. Kuhns consults on a wide range of tree-related issues as well as herbicide research.

His opening comments pointed out the difference in Connecticut growing sites and those in Pennsylvania. He did not hesitate to point out the slopes, boulders, ledges and obstacles present on Jones Farm. Since his research was conducted on very different sites, his conclusions are drawn for similar sites and may not apply to the soils and growing conditions of Connecticut.

Kuhns Tree Farm lies on 45 level acres. His marketing strategy has evolved over the past 30 years from "2/3 retail 1/3 wholesale" to "2/3 wholesale 1/3 retail." This occurred after a competitor opened down the road from him and priced his trees at $25, less than the wholesale price received at Kuhns Tree Farm....

After eight years of evaluating numerous cover crops, he concluded endophyte enhanced hard fescue, one of the fine fescue varieties with slow bunch grass growth habit, was the best low maintenance cover crop for his plantation. Fungal endophytes may reduce the use of pesticides. He showed us with slides how his fields are set up: the rows of fescue are 6 feet apart and the trees within the vegetation free rows are planted 5 feet apart. He noted that Fraser firs are rather intolerant to competition and soil conditions. He remarked that the trees in the Jones Farm site were surprisingly healthy considering the grass cover.

An experiment he conducted revealed significant growth reduction in Fraser firs with grass growing up to the trunk of the tree versus growing in a vegetation free strip of 30inches. Another experiment showed reduction in growth rate of Douglas fir but not as much as Fraser fir.

Dr. Kuhns fertilizes with a Vicon® spreader which has an oscillating broadcast attachment he uses on small trees. For large trees he uses a band attachment which targets the area in the vegetation free strip. He recommends the cover crop strip for erosion control, addition of organic matter, weed control, and cleaner paths for customers and staff resulting in cleaner trees. He adds that the strips are also environmentally friendlier than bare ground. Asked what his opinion was on mulch, Dr. Kuhns responded that mulch does not control weeds. It does help in retaining moisture and moderating soil temperature but so does the fescue strip. He reiterated his experience with the erosion prevention properties of the fescue strip as an advantage to mulch.

As he turned to discussion on herbicides for the vegetation free strip, he emphasized a number of herbicide properties that would affect the way we use them for Christmas tree cultivation. Glyphosate is the active ingredient of the herbicides he prefers using. He cautioned us, however, on those containing a crop oil concentrate/surfactant which improves assimilation of the active ingredient by the weed as well as the tree. The crop oil concentrate component is

(continued on page 22)

Tips offered to wholesale producers and retailers on preventing moisture and needle loss in yule trees

By Dr. John F. Ahrens

Emeritus Plant Scientist, Connecticut Agricultural Experiment Station

Valley Laboratory, Windsor

Keepability facts

Cut Christmas trees can lose 25 to 30 percent of their original moisture and fully recover when held in a _continuous_ water supply indoors. Moisture losses begin the moment a tree is cut, but are accelerated as temperatures increase and humidity decreases.

Moisture loss and needle loss are directly related, but not all shedding trees are necessarily dry (and not all dry trees shed!). Cool, shaded, moist conditions reduce moisture loss in cut trees.

A fresh cut on the butt enables best water uptake, but several hours delayed setup after recutting butts is better than not recutting them.

Water additives in tree stands are not essential and some are harmful to trees. Hot tap water in tree stands can be beneficial to water uptake in some trees, but ample clean water is essential. Cut trees can use about one quart of water for each inch of basal stem diameter. However, fully hydrated fresh trees may use less water when first displayed.

Conifer species differ in moisture and needle retention after cutting. Fraser fir is the best true fir in the East for needle retention. Colorado is best among spruces. Canaan and balsam firs appear equivalent requiring more care than Fraser fir to reduce moisture and needle loss. The pines and Douglas firs have excellent needle retention.

Clean, fresh Christmas trees do not support combustion. A sustained open flame is required to ignite them.

Tips for wholesale producers

Cut trees as late in the season as possible. Note: Remember that cutting at subfreezing temperatures can result in lower moisture content and excessive needle and branch breakage.

If possible, shake trees to remove dead inner needles before baling.

Bale trees right away (preferably above freezing) and get them out of the sun and wind.

Store trees in moist shaded areas. Upright storage with butts on wet mulch is excellent. Sprinkle if necessary.

Provide tree care information to retailers.

Tips for retailers

Avoid storing trees in sun, wind or on dry blacktop. High overhead lath or other shade is excellent. Plastic covers that touch trees will heat and should be avoided.

Display only trees expected to be sold on a given day; store the rest in shade. Sprinkle trees if necessary. If displayed indoors, hold trees with butts in water. Shake trees to clean them.

Cut butts of trees for customers who don't have saws.

Make available tree stands that hold at least one gallon of water. Emphasize frequent watering of trees to buyers.

Baling helps buyers transport, handle and setup trees and enhances customer satisfaction.

Provide tree care information to customers.

Replace without question any tree a customer claims is shedding or dry.

Appendix D Cont

In Memoriam

Hampton
Warren Arnold Stone

Warren Arnold Stone, 84, a lifelong resident of Hampton passed away at his home on July 15, 2010. Warren owned and operated Evergreen Farm of Hampton. He was well known for growing high quality Christmas trees and creating beautiful wreaths. He was an active member of the Connecticut Christmas Tree Growers Association, serving as treasurer for several years.

Warren entered his wreaths at many of the area fairs as well as The Big E in Westfield, Mass. He earned many blue ribbons for his efforts. For many years at Christmas time his wreaths decorated the Congregational Church of Hampton, The Edward Tiel Homestead, the Historical Society and the Hampton Library. He was generous with his resources, time and effort.

A memorial wreath was made in his honor and entered at the Hebron Harvest Fair. This wreath was later placed on his grave at the Litchfield Cemetery in Hampton.

Warren was also an avid golfer and enjoyed the sport. A golfball was placed at his burial site by one of his friends.

He will be remembered and greatly missed by his many friends.

Riverton
Marguerite Lamont

Marguerite Lamont of Riverton passed away on May 4, 2010. Mrs. Lamont and her late husband Thomas (Red) Lamont were charter members of the Connecticut Christmas Tree Growers Association when it formed in 1960.

Willington
Daniel William Talmadge

Daniel William Talmadge, 91, passed away July 25, 2010. Dan was a longtime Christmas tree grower at his Hyde Acres Tree Farm in Willington and was also a member for many years of the Connecticut Christmas Tree Growers Association.

A highly decorated U.S. Army Captain in World War II, he was an Associate Professor of Poultry Science at the University of Connecticut from 1949 to 1979. He taught courses in poultry science, physiology, genetics and management. He also conducted research and supported the College of Agriculture and Natural Resources' Cooperative Extension program.

Woodstock
Paul Breton

Paul Breton of Woodstock passed away on May 26, 2010. In the 1980's he opened Breton Tree Farm in Woodstock and is still in operation today.

Executive Director's Report - November 2010

By Kathy Kogut
CCTGA Executive Director

Choose & Cut brochures

About 14,000 copies of the Choose & Cut brochures have been printed and distributed throughout the state and at the local agricultural fairs. Wholsale brochures were also printed and mailed out to potential customers hoping to promote the CT Grown tree throughout New England. Anyone who needs a supply please let me know.

Scholarship winners announced

CCTGA awarded two $500.00 scholarships to qualifying students this year. It takes long hours, perseverance and dedication to successfully obtain their goals in the "green industry" and we are honored to help with that effort. The recipients are Josh Miller from Durham and Mark Popolizio from Wallingford.

Twilight meetings held

Sincere thanks go out to Will Jones and Tom Rathier and all the CAES scientists for organizing the three informative and inspirational twilight meetings. Approximately 60 attendees were present at the first two meetings even though it was a rainy night at Bergan's Farm. I thank all of those who did brave the elements to attend the meetings. The third meeting was held at Michael Keiltys Maple Springs Farm, concentrating on farm sustainability. Anyone who attended any or all of these meetings can attest to the beautiful farms and gracious hosts.

USDA Specialty Crop Block Grant

CCTGA was awarded a grant totaling $3,847.00 for the education portion of the 50th Annual Field meeting. We received official word that the Tree Improvement Project has been accepted by the USDA. The first check will be here by year's end. This award will be for $36,092.00 over 3 years.

Membership dues due

Membership dues for 2011 are in the mail to our 303 members. Please advise me of any changes (farm names, owners, addresses, phone numbers, etc.) so we can keep an updated mailing list. We are currently working on an email list of all of our members. New members who paid for membership after September 1, 2010 will be considered paid for 2011.

Coloring Contest entries sought

Our 9th annual coloring contest is open to children in grades K through 3 in all public and catholic elementary schools in Connecticut. For the rules and the "picture" to color please refer to the website @ www.ctchristmastree.org or pages 23 and 24 in this magazine. All entries must be postmarked by November 17th and the winner will be announced by November 21st. Eight winners will be chosen - two from each grade. The recipients will receive a gift certificate (value up to $45.00) redeemable for a real tree at any Choose & Cut farm. CCTGA will reimburse that farm for the tree value or the farm may choose to donate it. Gift certificates must be sent back to me with the farm name on it. Pictures of the winning trees will be posted on the website after the gift certificates are distributed.

Logo Items

There are still some t-shirts, padfolios, and wine glasses available for sale from the 50th anniversary. Any logo item or special order items are always available year round.

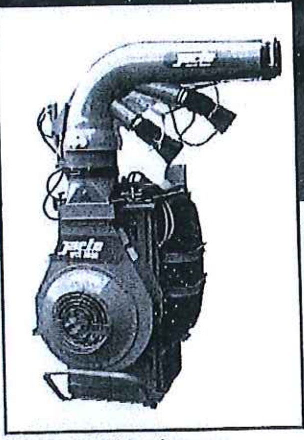
Thanks to our volunteers

My personal thanks to all the volunteers who gave their time and talents to make the Christmas tree/wreath exhibits at the fairs informative and attractive. Special thanks to all the fair supervisors and their "teams" who diligently worked so hard. Congratulations to our members who took home prizes for their winning trees and wreaths.

Merry Christmas

I wish you and your families a very Merry Christmas and a happy and healthy New Year. Take some time to relax and enjoy what makes you the happiest.

If you're not spraying with a Jacto Cannon Sprayer, you're competing with someone who does!



Wide-swath spraying with Cannon Sprayers can cut your spraying time by up to 75% and your chemical usage by up to 50%. Jacto Sprayers are proven producers that save you time and money. Six models to choose from.

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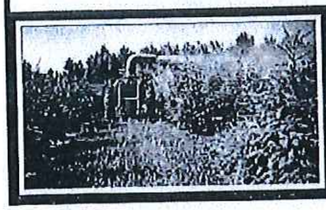


Jacto® No Sprayer Delivers More

Member National Christmas Tree Association

Penn State and Michigan State

(continued from page 6)

harmful to fish and other animals, not the active ingredient. The list of trademarked products on his slides mostly contain Glyphosate. The difference between the products is in the amount of the active ingredient and the surfactant. Therefore, the application concentrations and rates need to be adjusted to the product as the standard dilutions cannot be used. As a result, he strongly recommends using the original products containing Glyphosate unless one is willing to do the calculations.

He has used Roundup® original and compared it to Roundup®Pro with a surfactant. His conclusions are Roundup®Pro is safer than Roundup®, if animal toxicity is of concern but it is costlier. The effectiveness of Roundup®Pro may be better but caution has to be taken in applying it to prevent damage to the tree crop.

Application time and rate also depend on the goals of the application. Rates can be higher for site preparation versus established fields. Control of annual weeds can be done almost anytime during the life cycle of the weed whereas perennial weed control is more effective close to maturity of the weed. To complicate things, perennial weeds also mature at different times.

In general for site preparation, application is best in late summer and early fall. The use of Glyphosate is fine but one may use Garlon® or 2,4-D to improve perennial weed control. Dicamba, with residual properties, may also be used but planting is recommended only after six months from application. The extremely long residual property of Arsenal® can kill new plantings and should never be used for site preparation.

Dr. Kuhns listed some general dos and don'ts for success in growing Christmas trees.

1. Calibrate, calibrate and calibrate for each broadcast application of herbicide.
2. Do not allow grass to grow under trees.
3. Do not plant in well established grass areas.
4. Control both grasses and broadleaf. If only one is controlled the other will take over.

Dr. Kuhns mentioned some other products which could be used in addition to Glyphosate for both grass and broadleaf control: Goal® and SureGuard™, Westar®, Oust® and Pendulum®; also Pennant for its effectiveness on yellow nutsedge. He clearly stated all the cautions in the use of all these products. He also recommended for reducing costs, the generic version of the active ingredients in these products.

Due to the complexity associated for the effective use of the herbicides, Dr. Kuhns strongly recommended that growers contact Connecticut Agricultural Experiment Station scientists for information pertinent to your situation. (See CAES scientist Dr. John Ahren's article on the update on Westar and Glyphosate in local Christmas tree plantations on page 18 in this magazine.)

Dr. Mel Koelling, our second guest speaker, said that his research includes biological and economic aspects of Christmas tree production; Christmas tree marketing and market trends; and evaluation of Abies sp. for Christmas tree production.

In 1977, he purchased a 160 acre cornfield in Mason, Mich. and named it Tannenbaum Farms. He sold his first trees, 50 to be exact, in 1983 and continues to provide his customers with easy access, parking, clear directional signage and high quality trees for a memorable experience. He grows and sells pumpkins and Christmas trees at his full-service choose and cut operation. He also has a Christmas gift shop where wreaths and garlands are sold, among other holiday items.

The layout of the farm is on a half square mile of fertile, relatively flat land with sandy loam to clay soils. The pH ranges from 4.5 to 7. He uses 50 pounds per acre of ammonium sulfate to lower the pH of 7, which is neutral and not ideal for the conifers he uses in his plantation. He does not fertilize transplants in the first year but provides a 19-19-19 fertilizer in the second and third years. He uses different and compatible varieties of trees for different soils and conditions maximizing their marketability.

His best selling variety is Fraser Fir. He also sells Canaan Fir, Blue Spruce, and other fir varieties.

Glyphosate is used for weed management specifically in the weed free strips and for spot treatments in all his fields. A section of his plantation is dedicated to 10 feet or larger trees. He has a significant and profitable business for his large trees. They, mostly Fraser firs, present different maintenance challenges than the 8 feet or less trees. Cone removal is one example; spraying for pest management is another. He uses a German sprayer for its accuracy in calibration and efficiency in spraying. It has an attachment specifically for spraying the underside of the lower branches of the tree.

He uses hand pruners for the large trees versus shears for the smaller ones except for Douglas fir because of the Swiss Needlecast disease.

The fields at Tannenbaum Farms are tiled. In addition, Mel Koelling continues to use a mix of species and varieties of trees compatible with the soil and environmental conditions to maximize productivity. Canaan firs are planted in the more moist soils and Frasers in the drier soils.

The Christmas selling season starts the day after Thanksgiving. The farm is accessible to customers through only one entrance. Mel has only one entrance and exit. Customers are directed with signs to the different areas: choose and cut fields, pre-cut tree yard and gift shop.

In the pre-cut area, a post is used to measure the tree for pricing. Potted trees are also available for customers. Mel recommends adding a bow on the tree. Customers going out to the 'choose and cut' fields are told that only trees with pricing tags are saleable. Mel uses a stapling technique for the price tags which makes it almost impossible to remove or switch tags. Signage also informs customers of blocks not ready for cutting. Customers are directed to the exit area where they are asked to pay for their tree in the gift shop. Wreaths, garlands, greens and a selection of gift items are for sale including a Tannenbaum Farms tree ornament.

Mel believes in providing service and quality to the customer. The staff he employs have other jobs. He strongly believes that the best personnel are employed people. Service to the customer is of utmost priority. He practices the adage "The customer is always right".

Advertising by word of mouth is golden when positive, devastating when negative. He maintains and uses a mailing list for reaching his customers. And as a closing comment he recommends a flagpole!

Reviewer's comments: this article covers only a few highlights of the slide presentations given by Dr. Mel Koelling and Dr. Larry Kuhns. We thank both speakers for their valued time and for reaching out to the growers of Connecticut. We are truly grateful for their participation in making our 50th Anniversary field meeting such a success.



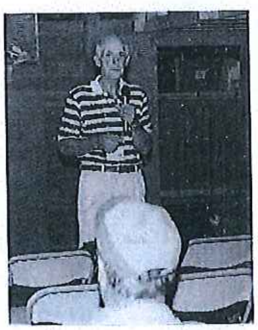
Phil Jones smiles as his picture is taken. His son Terry and his grandson Jamie nod their approval. All three Jones and their staff rolled out the green carpet as they hosted our 50th Anniversary field meeting.
Jeremy Pollack photos


Dick Jaynes owner and operator of Broken Arrow Nursery in Hampton explains the art of wreath making. Kathy Angevine talks on how she orders and sells items in her gift shop at Angevine Tree Farm in Warren.
Fabienne Audette photos

CCTGA celebrates its Golden Anniversary Field meeting in grand style: A Pictorial



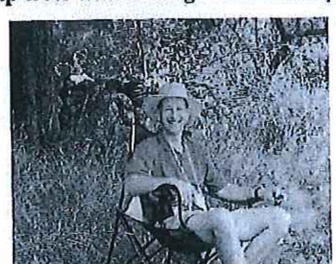
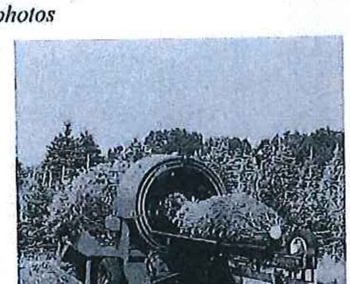
State Agricultural Commissioner Phil Prelli extends greetings to CCTGA members. John and Phyllis Ahrens were among the visitors who attended our 50th Anniversary field meeting. Pizza is hand made before putting in the oven for Friday's night meal.
Jeremy Pollack photos





***From top left:* Guest Speaker Dr. Larry Kuhns, emeritus professor, Penn State University, reported on his research in weed management. Peter Godiere shows multi-color ribbons at his B.T.F. Wholsale vendor stand. OESCO,Inc., sold Christmas tree production equipment at its vendor stand. Attendees eat lunch inside tent area. *From bottom left:* Co-chairman Dick Slimak greets growers from stand. A roadway through part of Jones Family Farms Christmas tree plantation. Dr. Richard Cowles takes a break before he speaks on insects and control. Balers like this one are used to wrap up trees with netting.** *Bud Gavitt photos*



Appendix D Cont.

An Event of a Lifetime

By Fabienne Audette

A simple review cannot give justice to the success of the CCTGA 50th Anniversary Celebration and even less to the tireless efforts of so many volunteers who planned two days of activities for over 200 participants on August 6 & 7, 2010. From the moment you entered Jones Family Farms in Shelton, you sensed this was a special place. You had already experienced the rolling hills on Route 110 and seen the signs to Pumpkin Hill, Strawberry and Blueberry Fields.

You wondered what those huge piles of wood chips were doing behind a row of well tended grape vines in the field across the road where you were turning onto Walnut Tree Hill Road. And to top all this you were welcomed to Jones Winery with a beautiful sign inviting you to taste their wines in the restored historic dairy barn. You were now truly out of breath and wondering how in two days you were going to attend the meetings, go on the tours and still have time to take in all the beauty of this farm.

Many of you did and from early morning to noon on Friday, you were driven around to the upper fields to tree plantations, including an original stand of pines planted by Phil Jones, a pond created by his father as a gift to his mother for water at the farm house and the winery, on an old NIKE control/radar site, started by Jamie Jones.

It was a well planned tour with pesticide recertification credit talks from the CAES scientists Dr. John F. Ahrens, Mary Inmann, and Dr. Rich Cowles. We saw shearing demonstrations, listened to pest control management programs and were witness to the successful control at Jones Family Farms due to the IPM program diligently followed by the staff.

Concurrently, Tom Rathier was leading attendees to the well designed Mailbox Nursery (so called as it actually lies below the farm's mailbox) on an east facing slope providing the perfect exposure for successful seedling growth. The secret of the chip dunes was revealed along with information on cover crops, fertilizing, weed control and mulching.

As we walked to where Todd Mervosh and Jamie Jones were speaking we passed through the courtyard bustling with vendors, registration, and a refreshment area. It was a fair like atmosphere among the many equipment lean-tos where the vendors had set up their booths and bales of hay had been assembled for attendees of workshops on Christmas wreath making and Christmas gift shop marketing and management.

We all gathered back at the courtyard where we were welcomed by Phil Jones and had a delicious lunch prepared by Jean Jones and her staff. Jean masterminded The Harvest Kitchen and the educational farm food programs for young and old.

The afternoon programs included our very own CAES Scientists Dr. Sharon Douglas and Dr. Cowles. As always the information they present is crucial to our goal of growing the best trees in Connecticut so essential for the profitability of the businesses we run.

Alternate programs ran. "Christmas Gift Shops Make Cents" was lead by Kathy Angevine of Angevine Farm in Warren. Kathy established a very successful gift shop and urged us to do the same recommending cautiousness in the beginning until you know your customers and their desires.

Dr. Richard Jaynes, geneticist and horticulturist, along with Andy Brand demonstrated the craftsmanship and art of making one-of-a-kind wreaths with an amazing assortment of greens from Broken Arrow Nursery. The demonstration had been previously aired on The Martha Stewart Show.

The evening proved to be most memorable, delightful, and flawlessly orchestrated, beginning with wine tasting in the splendidly

(continued on page 20)

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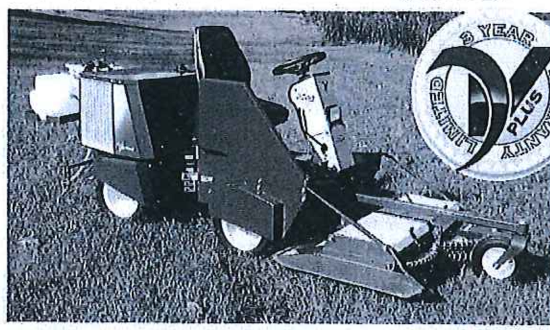

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