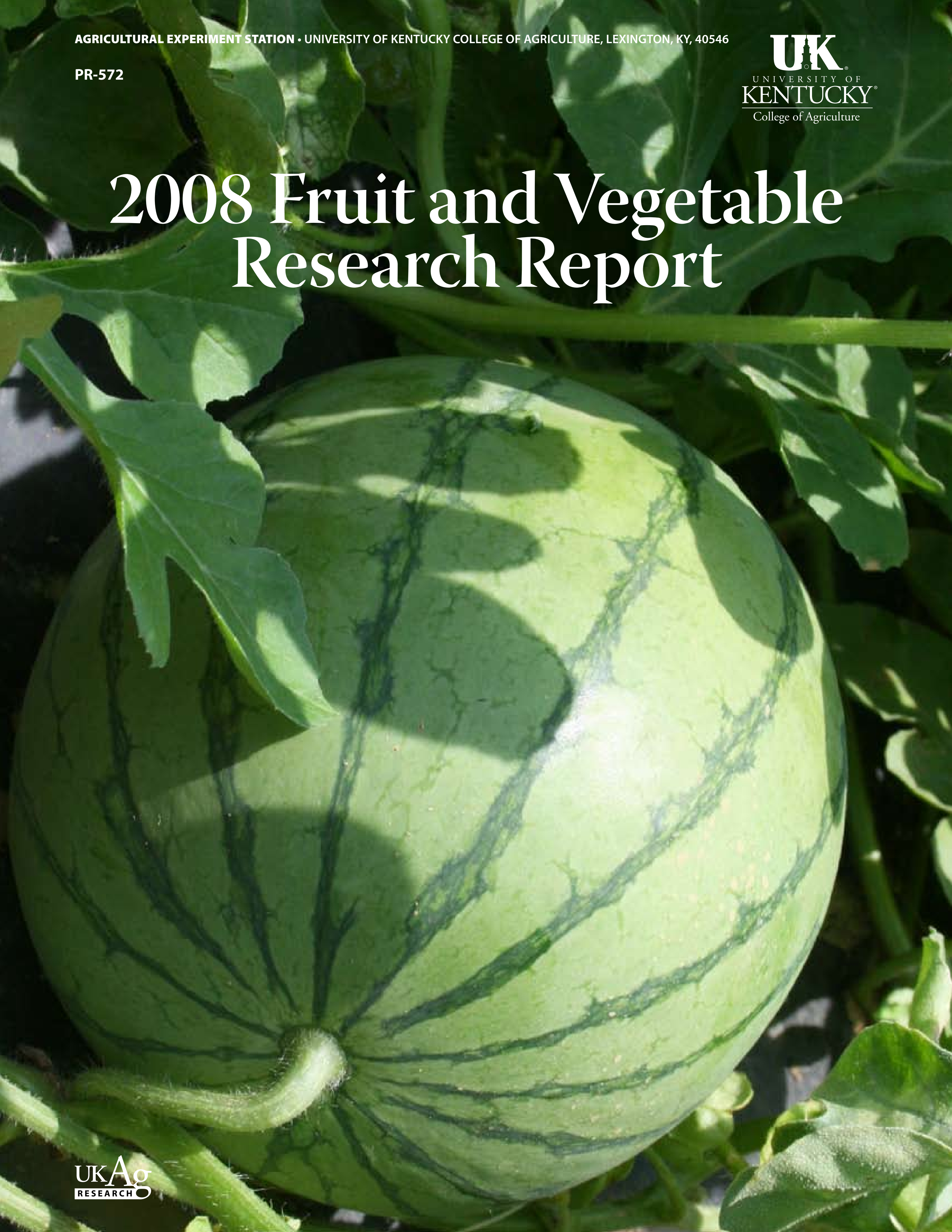
AGRICULTURAL EXPERIMENT STATION • UNIVERSITY OF KENTUCKY COLLEGE OF AGRICULTURE, LEXINGTON, KY, 40546

PR-572

UK UNIVERSITY OF KENTUCKY College of Agriculture

2008 Fruit and Vegetable Research Report



UK Ag RESEARCH

2008 Fruit and Vegetable Crops Research Report

Edited by Timothy Coolong, John Snyder, and Chris Smigell

Faculty, Staff, Students, and Grower/Cooperators

Horticulture

Faculty

Doug Archbold
Timothy Coolong
Tom Cottrell
Richard Durham
Dewayne Ingram
Terry Jones
Sahap K. Kurtural
Joseph Masabni
John Snyder
John Strang
Mark Williams

Area Extension Associates

Vaden Fenton, Princeton, western Kentucky (vegetables)
Nathan Howard, Green River, northwestern Kentucky (vegetables)
Nathan Howell, Mammoth Cave, south-central Kentucky (vegetables)
Bonnie Sigmon, Laurel and surrounding counties, southeastern Kentucky (vegetables)
Chris Smigell, Bluegrass, central Kentucky (small fruits)
Dave Spalding, Bluegrass, central Kentucky (vegetables)

Horticulture Farm Manager

Darrell Slone

Horticulture Farms Staff and Technical Staff

Sherri Dutton
Philip Ray Hays
Ryan Hays
Brandon Henson
June Johnston
Derek Law
Dave Lowry
Brandon O'Daniel
Janet Pfeiffer
Amy Poston
Kirk Ranta
Hilda Rogers
Crystal Sparks
Bonka Vaneva
David Wayne
Patsy Wilson
Dwight Wolfe

Graduate Students

Bob Caudle
Darby Harris
Audrey Law
Shawn Lucas
Janet Meyer
Patsy Wilson

Sustainable Agriculture Organic CSA Manager

Ben Abell

Horticulture Farm Temporary Staff and Student Workers

Matt Anderson
Katie Bale
Jessica Ballard
Sean Bessin
Ryan Capito
Jessica Cole
Jessica Dye
Meredith Hall
Lucas Hanks
Ellen Meyer
Julie Pfeiffer
Tyler Pierce
Kiefer Shuler
Matthew Simson
Joseph Tucker
Sarah Yates

Plant Pathology

Faculty

John Hartman
Kenny Seebold
Paul Vincelli

Professional Staff

Paul Bachi
Julie Beale
Ed Dixon
Sara Long

Agricultural Economics

Faculty

Wu Yang Hu
Tim Woods

Graduate Student

Emine Bayar

Extension Agents for Agriculture and Horticulture

(county research sites)

Anderson Co.—Tommy Yankey
Breathitt Co.—Lowell Hamilton
Christian Co.—Kelly Jackson, James Stone
Daviess Co.—Clint Hardy, Dr. Annette Heisdorffer
Fayette Co.—Jamie Dockery
Franklin Co.—Keenan Bishop, Kim Cowherd
Hancock Co.—Diane Perkins
Henderson Co.—Michael Smith, Jeff Porter
Jackson Co.—Jeff Henderson
Jessamine Co.—Robert Amburgey
Madison Co.—Brandon Sears, Amanda Ferguson Sears
McLean Co.—Greg Henson
Mercer Co.—Linda McClanahan
Metcalfe Co.—Brandon Bell
Nelson Co.—Ronald Bowman, Robert Smith
Powell Co.—Michael Reed
Rockcastle Co.—William Thomas Mills
Spencer Co.—Bryce Roberts
Union Co.—Rankin Powell
Warren Co.—Joanna Coles, Carol Schreiber
Whitley Co.—Phillip Meeks

Regulatory Services Soil Testing Lab

Frank Sikora

Kentucky State University

Faculty

George F. Antonious (Dept. of Plant and Soil Sciences)
Michael Bomford (Dept. of Plant and Soil Sciences)
Tejinder Kochhar (Dept. of Biology)
Kirk Pomper (Dept. of Plant and Soil Sciences)

Small Farm Outreach

Louie Rivers
Harold Eli

Professional Staff

Sherry Crabtree
Jeremiah Lowe
Zachary Ray

Grower/Cooperators

Joe and Sandy Adkins
Andrew Austin
Luther and Maxine Ball
Fred Chumbler
Stewart Curry
George and Sandy Deutsch
George's Place Mixed Vegetables
Joni Horne
Jewell Farms
Ronnie Knox
Don Liebfried
Robert Mayer
Jane McCauley
Need More Acres Farm
Harvey Rasnik
Carol Sigmon
Charles Silas
Josh Stephens
Paul and Betsy Stone
Scott Uzzle
Hiram Whitaker

Acknowledgments

Grants from the Agricultural Development Board through the Kentucky Horticulture Council have allowed an expansion of the field research and demonstration program to meet the informational and educational needs of our growing vegetable and fruit industries.

Important note to readers:
The majority of research reports in this volume do not include treatments with experimental pesticides. It should be understood that any experimental pesticide must first be labeled for the crop in question before it can be used by growers, regardless of how it might have been used in research trials. The most recent product label is the final authority concerning application rates, precautions, harvest intervals, and other relevant information. Contact your county's Cooperative Extension office if you need assistance in interpreting pesticide labels.

This is a progress report and may not reflect exactly the final outcome of ongoing projects. Please do not reproduce project reports for distribution without permission of the authors.

Mention or display of a trademark, proprietary product, or firm in text or figures does not constitute an endorsement and does not imply approval to the exclusion of other suitable products or firms.

Contents

continued

Vegetables

Diagnostic Laboratory

UK Fruit and Vegetable Program Overview—2008

Dewayne Ingram, Chair, Department of Horticulture

The UK Fruit Crops and Vegetable Crops Programs are the coordinated efforts of faculty, staff, and students in several departments in the College of Agriculture for the benefit of the Kentucky fruit and vegetable industries. Our 2008 report is divided into sections providing information on on-farm demonstrations, the Plant Diagnostic Laboratory, and the results of research projects involving small fruits, tree fruits, and vegetables. Research projects reported here reflect stated industry needs, expertise available at UK, and the nature of research projects around the world generating information applicable to Kentucky. If you have questions or suggestions about a particular research project, please do not hesitate to contact us.

Funds from the Agricultural Development Board through Kentucky Horticulture Council grants and the Kentucky Grape and Wine Council, as well as U.S. Department of Agriculture grants for the New Crop Opportunities Center, have allowed us to double the number of field research plots statewide in recent years. This has occurred during a time of rapid industry growth and emergence of vital questions about Kentucky's production and marketing systems. Important overarching questions include season extension (high tunnels and row covers), variety selection, understanding the consumer demand for locally grown produce, reduced inputs (fertilizers, pesticides, water, etc.) for profitability in sustainable systems, integrated pest management strategies, and organic production, as well as new crops and new packaging for targeted markets.

These grants have also funded Extension associates, located throughout the state, who are helping new and existing growers understand and apply the technologies of more profitable production and marketing systems. On-farm demonstrations, on-farm consulting, and collaboration with county Extension agents have been the hallmarks of this program. The investment in this approach is paying great dividends, as I think you will see in the results presented here.

Although the purpose of this publication is to report research results and summarize our Extension program results, here are a few highlights of our undergraduate and graduate degree programs.

Undergraduate Program Highlights

The department offers areas of emphasis in Horticultural Enterprise Management and Horticultural Science within a Horticulture, Plant and Soil Science Bachelor of Science degree. Following are a few highlights of our undergraduate program in 2007-2008.

The Plant and Soil Science degree program has 75 students in the fall semester of 2008, of whom more than one-half are horticulture students and another one-third are turfgrass students. Eleven horticulture students graduated in the 2007-2008 academic year.

We believe that a significant portion of an undergraduate education in horticulture must come outside the classroom. In addition to the local activities of the Horticulture Club and field trips during course laboratories, students have excellent off-campus learning experiences. Here are the highlights of such opportunities in 2008.

- Ten students interned at the student-run community-supported agriculture program at the UK Organic Farming Research and Education Unit at the University of Kentucky Horticultural Research Farm as part of the new curriculum in Sustainable Agriculture.
- Horticulture students competed in the 2008 Professional Landcare Network (PLANET) Career Day competition in Atlanta, Georgia, in March (Robert Geneve, faculty advisor).
- Students accompanied faculty to the following regional/national/international meetings, including the joint Eastern Region/Western Region of the International Plant Propagators' Society, the Kentucky Landscape Industries Conference, the Mid-States Horticultural Expo, the Ohio Florists Association Short Course, and the KNLA Summer Outing.

Graduate Program Highlights

The demand for graduates with M.S. or Ph.D. degrees in Horticulture, Entomology, Plant Pathology, and Agricultural Economics is high. Our M.S. graduates are being employed in the industry, Cooperative Extension Service, secondary and postsecondary education, and governmental agencies. Graduate students are active participants in the fruit and vegetable commodity teams and contribute significantly to our ability to address problems and opportunities important to Kentucky. The quality of our graduate students is illustrated by the awards they have won. Patsy Wilson and Derrick Hammons both received American Society for Enology and Viticulture scholarships, and Patsy Wilson won second place in the Southern Region-American Society for Horticultural Science graduate student competition. Janet Meyer, a graduate student working with Dr. John Snyder also won the first Kentucky Women in Agriculture Scholarship in 2008.

The 2008 Fruit and Vegetable Crops Research and Demonstration Program

Timothy Coolong, Department of Horticulture

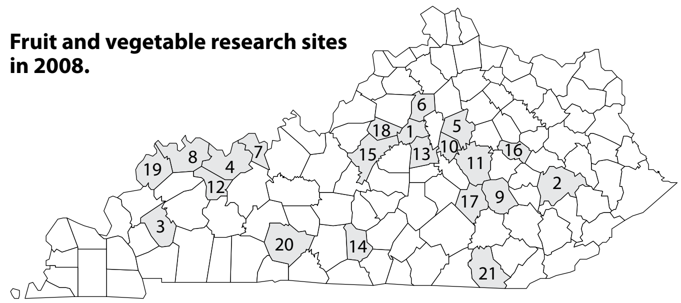
The 2008 Fruit and Vegetable Crops Research Report includes results for more than 40 field research and demonstration trials that were conducted in 21 counties in Kentucky (see map, below). Research was conducted by faculty and staff from several departments within the University of Kentucky College of Agriculture including Horticulture, Plant Pathology, Entomology, and Agricultural Economics. This report also includes collaborative research projects conducted with faculty and staff at Kentucky State University. Many of these reports include data on varietal performance as well as different production methods in an effort to provide growers with better tools that they can use to improve fruit and vegetable production in Kentucky.

Variety trials in this year's publication include fresh market tomatoes, pumpkins, specialty melons, onions, romaine lettuce, specialty peppers, strawberries, blueberries, raspberries, blackberries, and grapes. New varieties are continually being released, and variety trials provide us with much of the information necessary to update the recommendations in our publication *Vegetable Production Guide for Commercial Growers* (ID-36). However, when making decisions about what varieties to include in ID-36, we factor in performance of varieties at multiple locations in Kentucky over multiple years. We may also collaborate with researchers in surrounding states to discuss results of variety trials they have conducted. In addition, we consider such things as seed availability, which is often of particular concern for organic growers. Only then, after much research and analysis, will we make variety recommendations for Kentucky. The results presented in this publication often reflect a single year of data at a limited number of locations. Although some varieties perform well across Kentucky year after year, others may not. Here are some helpful guidelines for interpreting the results of fruit and vegetable variety trials.

Our Yields vs. Your Yields

Yields reported in variety trial results are extrapolated from small plots. Depending on the crop, individual plots range from eight to 200 plants. Our yields are calculated by multiplying the yields in these small plots by correction factors to estimate per acre yield. For example, if you can plant 4,200 tomato plants per acre (assuming 18 inches within row spacing) and our trials only have 10 plants per plot, we must multiply our average plot yields by a factor of 420 to calculate per acre yields. Thus, small errors can be greatly amplified. Furthermore, because we do not include factors such as drive rows in our calculations, our per acre yields are typically much higher than what is found on an average farm. Due to the availability of labor, research plots may be harvested more often than would be economically possible. Keep this in mind when reviewing the research papers in this publication

Fruit and vegetable research sites in 2008.



1. *Anderson*
2. *Breathitt*
3. *Caldwell*
4. *Daviess*
5. *Fayette*
6. *Franklin*
7. *Hancock*
8. *Henderson*
9. *Jackson*
10. *Jessamine*
11. *Madison*
12. *McLean*
13. *Mercer*
14. *Metcalfe*
15. *Nelson*
16. *Powell*
17. *Rockcastle*
18. *Spencer*
19. *Union*
20. *Warren*
21. *Whitley*

Statistics

Often yield or quality data will be presented in tables followed by a series of letters (a, ab, bc, etc.). These letters indicate whether the yields of the varieties are statistically different. Two varieties may have average yields that appear to be quite different but are actually not statistically significant. For example, if tomato variety 1 has an average yield of 2,000 boxes per acre, and variety 2 yields 2,300 boxes per acre, one would assume that variety 2 had a greater yield. However, just because the two varieties had different average yields does not mean that they are statistically or significantly different. In the tomato example, variety 1 may have consisted of four plots with yields of 1,800, 1,900, 2,200, and 2,100 boxes per acre. The average yield would then be 2,000 boxes per acre. Tomato variety 2 may have had four plots with yields of 1,700, 2,500, 2,800, and 2,200 boxes per acre. The four plots together would average 2,300 boxes per acre. The tomato varieties have plots with yield averages that overlap and therefore would not be considered statistically different, even though the average per acre yields for the two varieties appear to be quite different. This example also demonstrates variability. Good varieties are those that not only yield well but have little variation. Tomato variety 2 may have had similar yields as variety 1 but also had much greater variation. Therefore, all other things being equal, tomato variety 1 may be a better choice due to less variation in the field.

Statistical significance is shown in tables by the letters that follow a given number. For example, when two varieties have yields followed by completely different letters, then they are significantly different; however, if they share even one letter, then statistically they are no different. Thus, a variety with a yield that is followed by the letters "bcd" would be no different from a variety followed by the letters "cdef" because the letters "c" and "d" are shared by the two varieties. Yield data followed by the letters "abc" would be different from yield data followed by the letters "efg."

Finally, when determining statistical significance, we typically use a "*P*" value of 0.05. In this case, *P* stands for probability, and the 0.05 means that we have a 5% chance that our results are real and not simply due to chance or error. Put another way, if two varieties are said to be different at $P < 0.05$, then at least 95% of the time those varieties will be different. If the *P* value is 0.01, then 99% of the time those varieties will be different. Different *P* values can be used, but typically $P < 0.05$ is considered standard practice.

This may be confusing, but without statistics, our results would not be useful. Using statistics ensures that we can make more accurate recommendations for farmers in Kentucky.

On-Farm Commercial Vegetable Demonstrations in South-Central Kentucky

Nathan Howell, Department of Horticulture

Introduction

Three on-farm commercial vegetable demonstrations were conducted in south-central Kentucky. Grower/cooperators for the demonstrations were located in Metcalfe and Warren counties. The cooperator in Metcalfe County had a demonstration plot of approximately 0.36 acre consisting of mixed vegetables and herbs. The cooperator marketed his produce at the Southern Kentucky Regional Farmers' Market in Bowling Green, Kentucky, and other local farmers' markets including the one in Metcalfe County.

Two on-farm demonstrations were located in Warren County. One demonstration plot was approximately 0.25 acre consisting of Goliath, Mountain Fresh Plus, and several varieties of heirloom tomatoes along with watermelon and cantaloupe that were marketed at the Southern Kentucky Regional Farmers' Market and local restaurants in the Bowling Green area. The second demonstration was 0.42 acre of mixed vegetables from tomatoes, watermelon, cantaloupe, peppers, and greens. This cooperator also marketed through the Southern Kentucky Regional Farmers' Market, the Nashville Farmers' Market, and on-farm sales.

Table 1. Costs and returns from on-farm demonstrations of mixed vegetable crops in Metcalfe and Warren counties, 2008.

Inputs	Warren County (0.42 acre)	Warren County (0.25 acre)	Metcalfe County (0.36 acre)
Plants/Seeds	$25	$160	$100
Fertilizer/Lime	95	181	390
Black/Red plastic	68	60	86
Drip line	53	32	46
Tomato stakes, pea fence, etc.	0	202	0
Herbicides	46	15	0
Insecticides	53	52	0
Fungicides	58	76	0
Pollination	free	free	Free
Machine[1]	25	25	25
Irrigation/Water[2]	150	340	100
Labor[3]	40	20	0
Market fees	75	175	55
Total expenses	688	1338	802
Income—retail	2100	9454	400
Net income	1412	8116	(402)
Dollar return/Dollar input	3.05	7.07	0.50

[1] Machine rental, fuel and lube, repairs, and depreciation.
[2] Three-year amortization of irrigation system plus city water cost were applied.
[3] Does not include unpaid family labor.

Materials and Methods

Grower/cooperators for the demonstration plots were provided with production supplies such as black or red plastic mulch, drip irrigation lines, blue layflat tubing, and fertilizer injectors. Grower/cooperators were also able to use the University of Kentucky Horticulture Department's equipment for raised-bed preparation and transplanting. Field preparation was followed by fertilizer applications according to soil test results and recommendations provided by the University of Kentucky. Plastic for the demonstrations was laid in April and May. Red plastic mulch was used for the tomato demonstrations. The red mulch is reported to provide an enhanced growing environment for the tomato crops. The remaining plots used the standard black plastic mulch. All the demonstration plots used a municipal water source and a Mazzei-type injection system for fertilizer applications.

The Metcalfe County grower/cooperator produced his transplants, while the two Warren County grower/cooperators had local greenhouse managers produce their transplants. Demonstrations were planted from the last week of April through the end of May. The mixed vegetable demonstrations used 18-inch in-row spacing for their tomatoes and watermelon and 24-inch spacing for cantaloupes. Peppers and herbs were planted on 12-inch in-row spacing with two rows on each plastic row. Bed rows were typically 6 to 7 feet on center.

After plants were established, insecticides were applied to prevent damage from cucumber beetles and other insects. Imidacloprid, endosulfan, and permethrin were used for insect control. Imidacloprid (Admire) was used as a soil drench and was effective for three weeks; the remaining control was achieved by alternating insecticides on a weekly basis until harvest. The grower/cooperator in Metcalfe County elected not to use the recommended insecticides or fungicides; this was used as part of his marketing strategy. The other grower/cooperators used Bravo Weather Stick, Mancozeb, and Quadris, starting three weeks after transplanting. These fungicides were applied on the demonstration plots on an alternating weekly schedule for disease control. The University of Kentucky's recommendations in *Vegetable Production Guide for Commercial Growers* (ID-36) were used for insecticides and fungicides. Fixed coppers were also used in the tomato demonstrations for control of bacterial problems throughout the year. The demonstration plots were irrigated with at least 1 acre inch of water per week and fertigated weekly following the University of Kentucky's recommendations from ID-36. Harvest for the demonstration plots began in July and was completed by late October.

Results and Discussion

The 2008 season saw a moderate drought season in south-central Kentucky; temperatures overall were average throughout the production season. However, the late season did have cooler temperatures than average, and the region did not receive a killing frost until the last week of October. The grower/cooperator in Metcalfe County did suffer more extreme drought in his region of the state. Drip irrigation systems proved, yet again, to be a vital resource for grower/cooperators. All the demonstrators were able to have a lengthy harvest window that had surpassed their previous bare ground production methods.

Nevertheless, the year was not without obstacles and learning opportunities. Both demonstrations in Warren County used red plastic mulch for tomato production; in applying the mulch early, grasses were allowed to germinate beneath the plastic. However, it was noted that red plastic mulch applied later in the production year did not have this problem of weed pressures beneath the mulch itself. It was also noted that one of the grower/cooperators in Warren County underestimated the importance of timing in placing twine and staking his tomato and pepper crop. This increased the producer's labor by an estimated 25%. Improper staking and pruning decreased his yield by an estimated 10%.

The Metcalfe County demonstration plot experienced heavy pressure from insects, disease, and weeds. This was due to the decision not to use insecticides, fungicides, or herbicides on the plot; the grower/cooperator had used and marketed such methods of production in previous years on bare ground production. In addition to these problems, the grower/cooperator had problems in crop establishment due to planting transplants during periods of high temperatures on black plastic mulch.

Overall, it was a productive and profitable year for participants (Table 1). All the grower/cooperators are planning to continue the use of plastic mulch and drip irrigation, thus expanding on the knowledge gained in the demonstration plots. Grower/cooperators learned the importance of critical timing and the need to follow recommendations in a timely order. With that knowledge, all the demonstrators are projected to use the plasticulture system in 2009, and both of the Warren County demonstrators are projecting future growth in their 2009 production plans.

On-Farm Vegetable Demonstrations in Northwestern Kentucky

Nathan Howard, Department of Horticulture

Introduction

Seven on-farm commercial vegetable demonstration plots were conducted in northwestern Kentucky in 2008. Grower/cooperators were located in Daviess, Henderson, Hancock, McLean, and Union counties. None of the participants had used the plasticulture system for commercial production previously.

Materials and Methods

Each grower/cooperator was provided up to an acre of black plastic mulch and drip irrigation lines for production and use of the University of Kentucky Department of Horticulture's plastic mulch layer, waterwheel setter, and plastic mulch lifter. All grower/cooperators took soil tests and fertilized according to University of Kentucky recommendations. Fungicides and insecticides were applied according to recommendations in *Vegetable Production Guide for Commercial Growers* (ID-36). Also, the vegetable crops associate made regular visits and helped each individual grower/cooperator throughout the season.

Results and Discussion

Wet weather in April and early May pushed back the planting a couple of weeks for most early crops , as growers were not able to lay plastic on time. August and September had below-normal precipitation that reduced the productivity of many fall crops in the region. The drip irrigation system paid off for fall crops such as tomatoes and squash.

Two grower/cooperators in Daviess County raised mixed vegetables for retail sales. One grower/cooperator raised 0.25 acre of mixed vegetables. All of his production was sold from a roadside stand. The grower was an experienced producer but had problems with 2-4D drift on tomatoes early in the season and a spider mite buildup during harvest. The grower still was able to make it through the season showing a net profit, but his production was limited because of these issues. The second grower/cooperator in Daviess County raised 0.6 acre of mixed vegetables for sale at the Owensboro Regional Farmers' Market. The grower/cooperator is a high-school student who has raised vegetables for a few years for extra income for college. The grower/cooperator was able to lay his plastic earlier than most and capitalized on the early production. He was also able to make a net profit from this plot. Both grower/cooperators plan to continue their production next season.

The grower/cooperator located in Henderson County was a couple who had raised vegetables before but never for commercial sales. They sold at the Henderson Farmers' Market and had an outstanding season. They raised 0.35 acres of mixed vegetables. The growers/cooperators were able to produce two crops off the plastic by double cropping some of their area for fall crops as well, which is reflected in their income. They had an extremely good market and an excellent net profit for the plot. The grower/cooperators plan to expand production next season.

There were two grower/cooperators located in Hancock County. The first grower/cooperator raised 0.6 acre of mixed vegetables for sales at the Hancock County Farmers' Market in Hawesville. This plot was meant to give their children experience in raising and marketing a crop. The grower/cooperators were pleased with their production and income and plan on continuing production next season and emphasize earlier production. The second grower/cooperator raised 0.3 acre of mixed vegetables and also sold retail at the Hancock County Farmers' Market and wholesale to a local store. He is also a high-school student and wanted to earn extra money for college. This grower/cooperator made a net income for the season and plans to continue production next summer.

The grower/cooperator located in McLean County raised 0.4 acre of mixed vegetables for sales from a roadside stand on a heavily traveled road in the county. This grower/cooperator had raised commercial vegetables for a couple of years but had

Table 1. Costs and returns of seven vegetable demonstration plots in northwestern Kentucky in 2008.

	Daviess Co.		Henderson Co.	Hancock Co.		McLean Co.	Union Co.
Inputs	**0.25 acre**	**0.6 acre**	**0.35 acre**	**0.6 acre**	**0.3 acre**	**0.4 acre**	**1 acre**
Plants/Seed	$310	$360	$345	$123	$266	$90	$84
Fertlizer/Lime	79	428	85	344	126	91	15
Plastic	42	100	58	100	50	67	84
Drip lines	37	87	51	87	44	58	39
Herbicides	20	92	0	55	0	0	0
Insecticides	57	55	23	70	35	18	80
Fungicides	77	157	101	140	51	19	29
Irrigation/Water[1]	150	429	244	800	79	40	100
Field labor[2]	0	0	0	0	0	0	0
Machinery	20	180	35	400	25	40	50
Marketing	0	198	40	150	20	0	0
Total expenses	792	2086	982	2269	696	423	481
Income	3100	3466	11045	4553	1795	478	822
Net income	2308	1380	10063	2284	1099	55	341
Net income/A	9232	2300	28750	3426	3,330	140	341
Dollar return/Dollar input[3]	3.9	1.66	11.24	2.01	2.58	1.13	1.7

[1] Includes the cost of county water and five-year amortization of irrigation system.
[2] Does not include unpaid family labor.
[3] Dollar return/Dollar input = Income/Total expenses.

never used the plasticulture system. The net return was low due to decreased sales this season. Although the profit was not what he was hoping for, he plans to continue production next season and make some changes in his production and marketing plans.

The last grower/cooperator was in Union County. This cooperator got off to a late start and focused on direct marketing a fall mixed vegetable crop. The grower/cooperator raised 1 acre of tomatoes, squash, pumpkins, etc. He was pleased with his net returns and plans to focus on moving to a more organic approach in the future.

2008 On-Farm Commercial Vegetable Demonstrations in Southeastern Kentucky

Bonnie Sigmon, Department of Horticulture

Introduction

Six on-farm commercial vegetable demonstrations were conducted in southeastern Kentucky during 2008. Grower/cooperators were located in Jackson, Rockcastle, and Whitley counties. Two mixed vegetable plots were planted: one was 0.5 acre, and the other was 1 acre. Two fall tomato production plots utilized high tunnels. A 0.75-acre sweet corn plot and 0.33-acre sweet potato plot were also planted. All plots were soil tested in the spring, and fertilizer was applied according to test results. The grower/cooperators were supplied the plastic and irrigation supplies for their demonstration, as well as the use of the plastic mulch layer and waterwheel transplanter. The grower/cooperators were visited on a weekly basis to address any production problems that developed. All produce was marketed through local farmers' markets or directly off the farm to consumers.

The fall high tunnel tomato production plots are still in production, so they will be reported on at the annual Kentucky Fruit and Vegetable Conference in January 2009 and in the next research report.

Materials and Methods

Demonstration plot 1 was a 1-acre mixed vegetable plot. On 25 April, 4,000 feet of black plastic mulch and drip irrigation were laid using the Whitley County shared-use raised-bed plastic layer. A mixed variety of vegetables were transplanted by hand on 4 May that included tomatoes, squash, zucchini, okra, and several varieties of peppers, The remainder of the plot was planted in green beans and sweet corn using conventional methods. Roundup (glyphosate) was used for weed control using a no-drift applicator. Fungicides were applied on a preventative schedule every 10 days. Insecticides were used as needed for insect control. A drench of Admire 2F at transplanting was applied to the labeled vegetables.

Demonstration plot 2 was 0.5 acre of mixed vegetables. Plastic mulch and drip irrigation were laid on 22 April. Vegetables grown included tomatoes, peppers, cantaloupe, and green beans. The transplants were treated with a drench of Admire 2F at labeled rates for labeled vegetables for early insect control. Weed control was achieved with Roundup and a no-drift applicator. Fungicides were applied on a 10-day preventative schedule for tomatoes and cantaloupe. Insecticides were used as needed.

Demonstration plot 3 was 0.75 acre of sweet corn grown using conventional production methods. The grower/cooperator wanted to grow a mixed vegetable plot for the local farmers' market but did not have an adequate water source for plasticulture production; therefore. sweet corn was planted. Ambrosia, a sugar-enhanced bicolor sweet corn variety, was planted the last week in April. Dual Magnum 7.6E was sprayed for preemergent weed control. Nitrogen was sidedressed when the corn was about 18 inches tall, at a rate of 50 lb of actual nitrogen per acre. Insecticides were applied for worm control beginning at the silking stage on a 10-day schedule following the product labels.

Demonstration plot 4 consisted of 0.33 acre of sweet potatoes grown using conventional production methods. Sweet potato slips were ordered in early March with delivery scheduled for mid-May. Approximately 5,000 slips of the variety Beauregard were transplanted using a tobacco transplanter on 29 May. Devrinol 50 DF was sprayed for preemergent weed control.

Table 1. Costs and returns of three commercial vegetable demonstration plots conducted in eastern Kentucky in 2008.

Inputs	Plot No. 1 Mixed Veg. (1 acre)[1]	Plot No. 2 Mixed Veg. (0.5 acre)	Plot No. 3 Sweet Corn (0.75 acre)	Plot No. 4 Sweet Potato (0.33 acre)
Transplants/Seeds	$153.00	$193.00	$75.00	$653.00
Fertilizer	$400.00	$194.00	$574.00	$325.00
Fertilizer injector	$68.00	$68.00	$0.00	
Black plastic/Drip line	$173.00	$173.00		
Pesticides	$265.00	$195.00	$212.00	$57.00
Irrigation supplies[2]	$362.00	$480.00		
Stakes and twine	$36.00	$18.00		
Market fees/Advertising	$25.00	$25.00	$25.00	$75.00
Labor[3]	$0.00	$0.00	$0.00	$0.00
Machinery[4]	$250.00	$150.00	$250.00	$87.00
Total expenses	$1,732.00	$1,496.00	$1,136.00	$1,197.00
Income	$4,448.00	$4,325.00	$2,250.00	$2,800.00
Net income	$2,761.00	$2,828.00	$1,114.00	$1,603.00
Net income per acre	$2,761.00	$5,656.00	$1,392.50	$4,809.00
Dollar return/Dollar Input	$2.56	$2.89	$1.98	$2.33

1 Transplants produced by grower.
2 Five-year amortization on irrigation system plus water cost.
3 Does not include grower's labor.
4 Machinery depreciation, fuel and lube, and repair.

Results and Discussion

The 2008 growing season started out to be promising, but a severe drought late in the summer affected crops. The sweet corn plot was harvested before the negative effects of the drought were observed. The sweet potatoes yielded well without the use of irrigation. The cost and returns of all four plots are detailed in Table 1.

Grower/cooperators with demonstration plots using plasticulture methods were greatly impressed by the benefits of using plastic mulch and trickle irrigation. They were impressed with how easy the trickle irrigation was to set up and how efficiently it worked since both growers were using natural water sources to irrigate. They were very happy with the increased production and quality of the produce. They intend to use this production method next year.

The sweet corn grower/cooperator was happy with the yield and quality of the sweet corn produced but did not realize how difficult insects were to control in corn production. The grower had no problem marketing the sweet corn through the local farmers' market. He stated that he will be planting more next spring and plans to purchase better spray equipment.

The sweet potato grower/cooperator had some initial difficulty marketing the sweet potatoes but then advertised in the local paper and on the local radio station and eventually sold out. The grower used a potato plow to open the furrows and then dug and picked them up by hand. He found digging the potatoes to be a lot of work but said growing them was easy since there are few disease or insect problems with sweet potatoes in Kentucky.

On-Farm Commercial Vegetable Demonstrations

Dave Spalding, Department of Horticulture

Introduction

Seven on-farm commercial demonstrations were conducted in central and east-central Kentucky in 2008. Grower/cooperators were from Anderson, Jessamine, Madison, Mercer, Nelson, Powell, and Spencer counties. The grower/cooperators in Mercer, Nelson, Powell, and Spencer counties each grew about 1 acre of mixed vegetables, while the grower/cooperators in Jessamine and Madison counties each grew about 0.5 acre of mixed vegetables for on-farm markets and local farmers' markets. The grower/cooperator in Anderson County grew about 0.5 acre of pumpkins in raised beds with drip irrigation for the local market.

Materials and Methods

Grower/cooperators were provided with black plastic mulch and drip irrigation lines for up to 1 acre and the use of the University of Kentucky Horticulture Department's equipment for raised-bed preparation and transplanting. The cooperators supplied all other inputs, including labor and management of the crop. In addition to identifying and working closely with the cooperators, county Extension agents took soil samples from each plot and scheduled, promoted, and coordinated field days at each site. An Extension associate made regular weekly visits to each plot to scout the crop and make appropriate recommendations.

Table 1. Costs and returns of grower/cooperators.[1]

Inputs	Mercer Co. (1acre)	Nelson Co. (0.8 acre)	Powell Co. (1 acre)	Spencer Co. (1 acre)	Jessamine Co. (0.5 acre)
Plants and seeds	300.00	350.00	1,050.80	1,005.00	169.37
Fertilizer	200.00	50.00	514.37	458.00	34.98
Black plastic	125.00	100.00	125.00	125.00	62.50
Drip lines	175.00	145.00	175.00	175.00	82.50
Fertilizer injector	--------	75.00*	75.00*	85.00*	---------
Herbicide	--------	--------	334.00	--------	---------
Insecticide	130.00	100.00	189.69	115.00	---------
Fungicide	--------	50.00	469.80	153.00	---------
Water	80.00 (53,000 gal)	200.00 (60,000 gal)	320.00 (210,000 gal)	668.00 (225,000 gal)	501.47 (85,000 gal)
Labor	509.00** (65.0 hrs)	500.00** (100 hrs)	1,680.00** (1,500 hrs)	1,250.00** (600 hrs)	354.00 ** (150.0 hrs)
Machine	58.00 (6.0 hrs)	40.00 (4.2 hrs)	76.00 (8.0 hrs)	94.50 (10.5 hrs)	142.50 (16.0 hrs)
Marketing	25.00	200.00	100.00	1,191.00	201.60
Total expenses	1,602.00	2,810.00	5,109.66	5,319.50	1,548.92
Income	5,961.00	3,000.00	7,480.00	11,520.00	1,699.50
Net income	4,359.00	190.00	2,370.34	6,200.50	150.58
Net income/acre	4,359.00	237.00	2,370.34	6,200.50	301.16
Dollar return/Dollar input	3.7	1.1	1.5	2.2	1.1

1 Information from grower/cooperators in Anderson and Madison counties was not submitted at time of printing.
* Cost amortized over three years.
** Does not include unpaid family labor.

Six of the seven demonstration plots consisted of a mix of vegetables (tomatoes, peppers, squash, green beans, melons, and sweet corn), while the seventh plot consisted of pumpkins only. The mixed vegetable plots were planted into 6-inch-high beds covered with black plastic mulch and drip lines under the plastic in the center of the beds. The beds were planted at the appropriate spacing for the type of vegetable being grown (i.e., tomatoes were planted in a single row 18 inches apart; beans were planted in double rows 12 inches apart, etc.). The pumpkin plot was planted into 6-inch-high beds with trickle irrigation but no plastic mulch. The pumpkins were seeded 6 feet apart in the raised beds, and the beds were 6 feet apart. A preemergent herbicide was applied after seeding and prior to seedling emergence. Plots were sprayed with the appropriate fungicides and insecticides on an as-needed basis, and cooperators were asked to follow the fertigation schedules provided.

Results and Discussion

Weather conditions for the 2008 growing season were much improved from the previous couple of years, although drought conditions did occur in some growing areas late in the season, affecting late production. Most of the growing area had good-to-excellent growing conditions for much of the season, which allowed crops to be planted on time and harvest to begin in a timely fashion with good crop prices.

For most of the grower/cooperators, weeds were the biggest problem. The grower/cooperator in Jessamine County used hay mulch between the rows, which appeared to control the weeds fairly well. The grower/cooperators in Madison and Spencer counties sowed annual rye grass between the rows and mowed to keep the weeds under control for a while. The other grower/cooperators used a combination of cultivation and postemergent sprays to control the weeds with mixed results.

Effect of Training Systems on Vine Size, Yield Components, and Fruit Composition of European Grapevines

C. Smigell, S. K. Kurtural, J. Strang, P.E. Wilson, and S.B. O'Daniel, Department of Horticulture

Introduction

Kentucky growers have planted extensive grape acreage for wine production over the last 10 years. Roughly 50% of these grapes are *vinifera,* or European, cultivars that are prone to winter freeze and late spring frost damage. Additionally, this damage makes the European grapevines susceptible to crown gall infection (a bacterial disease, *Agrobacterium vitis*), which begins at wounds caused by freeze-induced trunk splitting or other injuries. Crown gall can severely weaken or kill the vines. The objectives of this study were to compare survival, vine size (pruning weight per foot of horizontal canopy), yield, and fruit quality between vertically shoot positioned (VSP) and fan-trained grapevine cultivars.

Table. 1. Effect of training system and cultivar on 2007 season's vine size and cropload and 2008 season shoot density.

	Factor					
Cultivar	Vine Size per Foot of Canopy (lb/ft)[1,2]	Crop Load (lb/lb)[3]	Count Shoots Retained	Non-Count Shoots Retained	Non-Count Shoots Removed	Total Shoots per Vine
Chardonnay	0.45 b	2.7 bc	40 a	7	26 a	47 ab
Cabernet Franc	0.53 b	3.9 b	40 a	9	20 a	48 a
Shiraz	0.66 a	2.0 c	40 a	6	11 b	46 ab
Vidal Blanc/own roots	0.48 b	8.0 a	38 b	6	11 b	45 b
Vidal Blanc/C3309	0.47 b	7.6 a	38 b	7	10 b	44 b
p<	0.0003	0.0001	0.0150	0.5405	<0.0001	0.1600
Training System						
Fan	0.51	4.9	39	6 b	13 b	45
VSP	0.53	4.8	39	8 a	17 a	47
p<	0.4419	0.3775	0.8976	0.0208	0.0416	0.0787
Cultivar x Training System	0.1247	0.6771	0.7510	0.2895	0.1852	0.7335

[1] Means within a column followed by the same letter are not significantly different (Duncan's multiple range test, Pr>F 0.05).
[2] Vine size is the amount (in pounds) of prunings per horizontal foot of canopy.
[3] Crop load is the ratio of a vine's yield for one season to the dormant pruning weight the following season.

Materials and Methods

One-year-old, dormant, bare-root grapevines of the *vinifera* cultivars Cabernet Franc clone No. 332 (fairly hardy), Chardonnay clone No. 76 (moderately hardy), Shiraz (least hardy), and the French-American hybrid Vidal Blanc (very hardy) were planted in the spring of 2002 at the University of Kentucky Horticultural Research Farm in Lexington on Maury silt-loam soil. All cultivars were grafted onto the C 3309 rootstock except one treatment of Vidal Blanc that was not grafted. Vines were spaced 8 feet within the row and 12 feet (454 plants/acre) between rows in a randomized block factorial design with six replications.

Half the grapevines were trained using the VSP system, in which vines are developed with two trunks, each becoming a cordon on the lowest wire (38 inches above the vineyard floor). From these cordons shoots are trained vertically between two sets of catch wires (spaced 12 inches above the training wire). The remaining grapevines were fan-trained, which consisted of up to six canes radiating out from the vine base or graft union in a fan pattern and tied to the trellis. In 2005, metal trellis post extensions were installed to increase leaf area, bringing the exposed height of the canopy to 5 feet and a total trellis height of 8 feet.

Vines were watered as needed until established, and weeds were controlled in a 3-foot-wide herbicide strip down the row beneath the vines. Mowed sod middles were maintained between rows. Graft unions were covered with soil annually in late fall to protect unions from freeze injury. Vines were trained during the first two seasons and balance pruned in 2004 and 2005 to adjust fruit load to vine size. In subsequent years, all vines were pruned to 40 nodes per vine to remove the confounding effects of crop level on the grapevines. Additional cluster and shoot thinning were performed on vines that had excessive crops and vine sizes, respectively. Insecticide, fungicide, and herbicide applications were made in accordance with the *Midwest Grape and Small Fruit Spray Guide* (ID-94).

Vines fruited for the first time in 2005. Results from the 2007 and 2008 growing seasons are reported here. Vine sizes (pruning weights) and crop loads (the ratio of a vine's yield for one season to its dormant pruning weight the following season) for the 2007 season are reported because they affected the 2008 crop. Spring shoot and cluster measurements, yields, cluster weights, berry weights, total soluble solids (TSS), juice pHs, and titratable acids (TA) for 2008 were measured.

Results and Discussion

Vine size was not significantly affected by the training system treatments in 2007 (Table 1). Shiraz had a significantly greater vine size than the other cultivars. The average vine size for all cultivars was 0.52 lb per foot of canopy in 2007, indicating the vines were in balance going into the 2008 crop season. Crop load (ratio of yield to vine size) was also not affected by the training systems in 2007 (Table 1). However, the three European cultivars tested carried varying crop loads of less than 4 and were thus likely undercropped (Kliewer and Dokloozian, 2000). As expected, the Vidal Blanc grown on the C 3309 rootstock (Vidal Blanc/C 3309) and the Vidal Blanc on its own roots (Vidal Blanc/own) had significantly higher crop loads than the other cultivars. Still, the Vidal Blanc crop loads were low, and the vines were likely undercropped in 2007 (Wilson et al., 2008). Undercropping in 2007 was likely due mainly to

Table 2. Effect of training system and cultivar on yield components, 2008.

	Factor					
Cultivar/Harvest Date	**Total Clusters/ Vine[1]**	**Marketable Clusters/ Vine**	**Culled Clusters/ Vine[2]**	**Marketable Weight/ Vine (lb)**	**Marketable Yield (tons/A)[3]**	**Cluster Weight (g)**
Chardonnay —2 September	85 c	82 b	1.5 a b	32 d	7.4 d	180 c
Cabernet Franc—22 September	94 a b	93 a	1.0 b	43 b c	9.7 b c	210 b
Shiraz—23 September	87 b c	86 a b	1.0 b	40 c	9.1 c	213 b
Vidal Blanc/own—2 October	93 a b	92 a b	1.0 b	53 a	12.1 a	263 a
Vidal Blanc/C3309—2 October	96 a	89 a b	3.5 a	49 a b	11.0 a b	250 a
p<	0.0400	0.1485	0.0452	<0.0001	<0.0001	<0.0001
Training System						
Fan	88	85	2	42	9.5	224
VSP	93	91	1	45	10.1	222
p<	0.0736	0.0449	0.3109	0.1570	0.1570	0.6368
Cultivar x Training System	0.6460	0.2929	0.2545	0.9757	0.9757	0.0190

1 Means within a column followed by the same letter are not significantly different (Duncan's multiple range test, Pr>F 0.05).
2 Clusters that displayed >30% visual damage by fungal infection, bird damage, sunburn.
3 Based on 454 vines/A.

primary shoot loss in the April 2007 freeze but could also have been due to overcropping of the European cultivars in 2006.

The number of count shoots retained and the number of total shoots retained per vine were similar for the fan-trained grapevines and the VSP-trained ones (Table 1). However, the number of non-count shoots retained in the VSP-trained vines, regardless of cultivar, was 33% higher than in the fan-trained grapevines. Similarly, the number of non-count shoots removed in the VSP-trained grapevines was 31% higher than in the fan-trained grapevines.

Vidal Blanc/C 3309 and Vidal Blanc/own vines had significantly fewer count shoots retained than did any of the European cultivars (Table 1), even though the intent was to leave 40 count shoots on all vines. Thus, the Vidal Blanc vines may have produced fewer count shoots than the European cultivars. Vidal Blanc/C 3309 and Vidal Blanc/own vines and Shiraz had about half as many non-count shoots removed as were removed from Chardonnay and Cabernet Franc. The total numbers of shoots retained per vine were similar among all cultivars, although Cabernet Franc had significantly more total shoots retained than the Vidal Blanc vines on C 3309 rootstocks or their own roots.

The training system used did not affect any yield components in 2008 (Table 2). All of the cultivar yield component values were higher in 2008, compared to 2007, when crop loss was heavy, due to a heavy April freeze. Only the culled clusters per vine values were lower in 2008 versus 2007. Vidal Blanc tended to have slightly higher marketable yields per acre when on its own roots than when on the C 3309 rootstock. Vidal Blanc on either root system had significantly higher yields per acre than the three European cultivars, with the exception of Cabernet Franc, which had a similar yield to the Vidal Blanc/C 3309. Chardonnay had significantly lower yields than Shiraz and Cabernet Franc (Table 2). The numbers of marketable clusters per vine were similar for all cultivars in 2008. For all cultivars, numbers of marketable clusters per vine were higher than in any previous year.

Table 3. Effect of training system and cultivar on fruit composition, 2008.

	Factor			
Cultivar	**TSS**	**Juice pH**	**TA**	**Berry Weight (g)**
Chardonnay	20.5 b	3.62 b	6.2 b	1.83 b
Cabernet Franc	21.3 a	3.83 a	4.2 c	1.68 c
Shiraz	21.7 a	3.81 a	4.5 c	1.90 b
Vidal Blanc/own	21.5 a	3.28 c	7.3 a	2.27 a
Vidal Blanc/C3309	21.9 a	3.28 c	7.0 a	2.26 a
p<	0.0138	0.0001	0.0001	0.0001
Training System				
Fan	21.4	3.58	6.0	197
VSP	21.3	3.56	5.7	199
p<	0.7100	0.6286	0.0690	0.8838
Cultivar x Training System	0.2669	0.8591	0.0690	0.2581

The training system did not significantly affect fruit composition values in 2008 (Table 3). The TSS levels of all the cultivars were similar, except for Chardonnay, which was significantly less than all other cultivars. The juice pH values for Vidal Blanc/C3309 and Vidal Blanc/own were significantly lower than for the European cultivars. The TA values for Vidal Blanc on either root system were within recommended ranges. TA values for Vidal Blanc were significantly higher than for the other cultivars, as was expected. Berry weights were greatest for the Vidal Blanc/C 3309 and Vidal Blanc/own vines, followed by those of Chardonnay and Shiraz, and were smallest for Cabernet Franc.

Literature Cited

Kliewer, W.M., and Dokoozlian, N.K., 2000. Leaf area/crop weight ratios of grapevines: Influence on fruit composition and wine quality. Proc. ASEV 50th Anniv. Ann. Meeting, Seattle, Wash.

Wilson, P.E., Cottrell, T.H., Archbold, D.A., and Kurtural, S.K., 2008. Grapevine Sustainability and Wine Composition Ameliorated by Severity of Canopy Management. (In press).

Impact of Japanese Beetle Defoliation on First-Season Crop Yield and Berry Quality

Derrick L. Hammons, S.K. Kurtural, and Daniel A. Potter, Department of Entomology

Introduction and Rationale

Grapes are highly preferred food plants of the Japanese beetle [JB], *Popillia japonica*. In Kentucky, proximity of larval habitat (pasture) to vineyards results in severe damage to grapes. Growers typically manage JB with repeated cover sprays of insecticides. Varietal resistance and impact of JB defoliation on grapevines have not been studied for field-planted vines or for anything similar to the severity of damage that occurs in Kentucky. The goal of this research project is to quantify across a range of cultivars the cumulative "cost" of different levels of JB damage on aspects of vineyard establishment and production and the relative benefits of weekly versus biweekly cover sprays.

Data thus far indicate that while JB defoliation can reduce cordon growth (Hammons et al., 2006) and winter-hardiness (Hammons et al., 2007) of susceptible cultivars, growers can reduce frequency of cover sprays in newly planted vineyards by half and still receive the same benefits of JB management. This report highlights data from the third year of this project, evaluating the cumulative impact of JB defoliation on components of crop yield and fruit composition. Our goal is to develop IPM strategies for JB on grapes that support the sustainable production of grapes in Kentucky and other southeastern states under reduced spray regimes.

Table 1. Impact of JB defoliation on yield components.[1,2]

Cultivar	Treatment	Clusters/ Vine	Yield/ Vine (kg)	Cluster Weight (g)	Berry Weight (g)	Berries/ Cluster
Concord	7 d	57	5.4	96	2.7	35
	14 d	55	5.3	93	2.8	33
	NT	65	6.7	103	2.7	38
	$P < 0.05$					
Norton	7d	33 a	2.6 a	74 a	1.1 a	69
	14 d	33 a	2.2 a	64 a	1.0 a	64
	NT	9 b	0.6 b	48 b	0.8 b	61
	$P < 0.05$	*	*	*	*	
Cabernet Sauvignon	7 d	55 a	8.0 a	149 a	1.2	119
	14 d	62 a	8.3 a	134 ab	1.2	112
	NT	40 b	5.5 b	125 b	1.2	103
	$P < 0.05$	*	*			
Cabernet Franc	7 d	60 a	6.9 a	117	1.2	98
	14 d	61 a	7.0 a	113	1.2	95
	NT	41 b	4.5 b	111	1.2	95
	$P < 0.05$	*	*			
Chambourcin	7 d	71 a	8.8 a	124 a	2.1	59 ab
	14 d	71 a	8.3 a	120 a	2.0	62 a
	NT	56 b	5.8 b	102 b	1.9	53 b
	$P < 0.05$	*	*	*		

1 (*) denotes that comparisons within columns are significant when analyzed by a randomized complete block one-way ANOVA, with $P < 0.05$.
2 Means in the same column not followed by the same letter differ significantly when analyzed using Fisher's protected LSD, with $P < 0.05$).

Table 2. Impact of JB defoliation on berry composition.[1,2]

Cultivar	Treatment	TSS[3]	pH	TA[4]
Concord	7 d	17.8	3.6	5.55
	14 d	17.7	3.6	4.85
	NT	17.2	3.6	5.06
	$P < 0.05$			
Norton	7 d	22.0	3.43	10.73
	14 d	22.5	3.46	11.01
	NT	22.6	3.39	11.35
	$P < 0.05$			
Cabernet Sauvignon	7d	20.5	3.4	8.33
	14 d	19.9	3.4	7.96
	NT	19.4	3.4	8.43
	$P < 0.05$			
Cabernet Franc	7 d	21.0	3.6	5.26
	14 d	20.7	3.7	5.36
	NT	19.7	3.6	5.23
	$P < 0.05$			
Chambourcin	7 d	21.8	3.53	9.60
	14 d	22.2	3.47	9.42
	NT	22.5	3.49	10.0
	$P < 0.05$			

1 (*) Comparisons within columns significant by randomized complete block one-way ANOVA.
2 Means without letters not significant (Fisher's protected LSD, $P < 0.05$).
3 Total soluble solids reported as % brix in juice.
4 Titratable acidity in grams of tartaric acid/liter of juice.

Materials and Methods

A research vineyard was planted in May 2006 at the University of Kentucky Horticultural Research Farm. Two American (Concord and Norton), two European *vinifera* (Cabernet Franc and Cabernet Sauvignon), and one French-American hybrid (Chambourcin) were included in the planting. Vines were trained to a single high-wire bilateral cordon system and managed according to University of Kentucky viticulture guidelines. There were two vines per experimental unit, with treatment/cultivar combinations in an RCB design (eight replications). Vines were assigned one of three insecticide spray regimes to achieve varying levels of protection from JB defoliation. The three spray regimes were carbaryl sprayed every 7 or 14 days during the JB flight period or no treatment. This spray regime has been maintained for three consecutive years. Treatments within each cultivar were harvested on the same day and evaluated for the number of clusters, total yield, cluster and berry weight, and berries per cluster. Concentration of total soluble solids (TSS) was measured with a PAL-1 Digital Refractometer (Atago, Bellevue, WA). Juice pH was measured with a glass electrode and pH meter (model AR15; Fisher Scientific, Pittsburgh, PA). Titratable acidity (TA) was determined by titrating to pH 8.2 with 0.1N sodium hydroxide and expressed as grams of tartaric acid per liter of juice.

Results and Discussion

Impact of JB defoliation on yield components. Concord vines sustained relatively little JB defoliation (<10% on non-treated vines), and neither the weekly nor biweekly spray regimes provided any benefit insofar as yield (Table 1). For Norton grapes, both cover spray regimes significantly increased the number of clusters harvested, total yield, cluster weight, and berry weight of Norton grapes compared to non-treated vines (Table 1), but there was no difference between the 7-day and 14-day spray treatments for any of the yield components evaluated. Due to the heavy amounts of defoliation that occurred during the first two years of establishment, the non-treated vines lacked viable fruiting shoots capable of sustaining a crop load. This phenomenon was also expressed as significant reduction of clusters/vine and yield/vine for non-treated vines of Cabernet Franc, Cabernet Sauvignon, and Chambourcin (Table 1). The hybrid cultivar Chambourcin also had reduced cluster weight and berries/cluster on the non-treated vines, but this was not seen on either Cabernt Franc or Cabernet Sauvignon (Table 1).

Impact of JB defoliation on fruit composition at harvest. There were no apparent effects from variation in spray regime on TSS, juice pH, or titratable acidity at harvest.

Benefits to the Industry

This project contributes to research-based economic thresholds for JB management. Our work has now quantified the impact of JB defoliation from vineyard establishment through production and evaluated tolerance differences among several economically important cultivars. Our data indicate that growers can reduce cover spray frequency by half and still suppress defoliation below potential economic injury levels. Kentucky is on track in developing a medium-scale quality grape and wine industry. This research supports growers utilizing IPM strategies and other sustainable and organic production practices with reduced and alternative insecticide use.

Acknowledgments

This work was funded in part by the New Crop Opportunities Center at the University of Kentucky through a USDA Special Grant and a USDA Southern Sustainable Agriculture Research and Education Grant. We thank Cristina Brady, Jennie Condra, Brandon O'Daniel, Carl Redmond, Darrell Slone, and Patsy Wilson for technical assistance.

Literature Cited

Hammons, D.L., S.K. Kurtaral, and D.A. Potter. 2006. Evaluating host plant resistance and the impact of Japanese beetle defoliation on young grapevines. pp. 30-32. In: 2006 Fruit and Vegetable Crops Research Report (PR-538), University of Kentucky.

Hammons, D.L., S.K. Kurtural, and D.A Potter. 2007. Impact of Japanese beetle defoliation on the overwintering ability of first-year grapevines. pp. 35-36. In: 2007 Fruit and Vegetable Crops Research Report (PR-555), University of Kentucky.

Phenological Resistance of Grapes to Green June Beetle Damage

Derrick L. Hammons, S.K. Kurtural, and Daniel A. Potter Department of Entomology

Introduction

The green June beetle, *Cotinis nitida* L. (GJB), is a native insect pest that aggregates and feeds mainly on ripe fruits including figs, peaches, blackberries, and grapes. Convenience of larval habitat (e.g., pasture and other agricultural land) to vineyards results in heavy infestations of GJB on grapes. The flight period of the GJB peaks in midsummer, when early-season grape cultivars are harvested and mid-season cultivars are in the later stages of fruit ripening. The prevailing management strategy relies on repeated insecticide applications, and little information exists on alternative tactics. The goal of this research is to evaluate phenological resistance, i.e., planting of grape cultivars that ripen outside of the window of peak pest activity, as a sustainable strategy for reducing GJB injury to ripe fruit clusters close to harvest.

Materials and Methods

An experimental vineyard consisting of six early-, mid-, and late-season ripening cultivars of grapes planted in a randomized complete block was established at the University of Kentucky Research Farm in 2006. There were eight replications with vines planted in duplicate. Cultivars and their respective days to harvest were: early-ripening, Foch (90 d) and Jupiter (85 d); mid-ripening, Chancellor (100 d) and St. Croix (99 d); late-ripening, Norton (125 d) and Chambourcin (115 d). All have blue/black fruits to eliminate confounding effects of fruit color. The vines were not cropped during the 2006-07 growing seasons and were maintained according to Univeristy of Kentucky recommendations.

GJB flight was monitored with traps baited with attractant lures, and numbers of beetles present on all clusters on each vine were counted at least weekly throughout veraison. Representative berries were sampled weekly and analyzed for toughness (force to penetrate the berry skin in grams) and total soluble solids (TSS) to determine berry ripeness and harvest date. This report includes the number of clusters per vine, TSS and toughness (g) at harvest, and the percentage (%) of marketable clusters harvested per vine. Relative toughness of intact berries was measured using a digital force gauge with a pointed punch (Mark-10 Model EG-2, Hicksville, NY). Concentration of TSS was measured with a PAL-1 Digital Refractometer (Atago, Bellevue, WA). A cluster was considered marketable if it had sustained less than 25% GJB feeding damage at the time of harvest.

Results and Discussion

By 7 August, most of the clusters on Foch, Jupiter, and St. Croix had been entirely consumed by feeding aggregations of GJB leaving < 4% of marketable clusters on those vines. Chancellor had received significant damage by its date of harvest (14 August), but 73% of its clusters were marketable (Table 1). GJB flight had subsided by that time. Later-ripening Chambourcin, clusters of which were harvested on 5 September, had minimal damage, and 93% of those grapes were marketable. Norton, the latest-ripening cultivar (harvested 15 September) reached the highest level of TSS (22.1%) and next lowest toughness (414 g) but nevertheless received no visible damage from GJB feeding, and 100% of its clusters were harvestable.

Reduced susceptibility of grape cultivars to GJB feeding is based on phenological asynchrony. Grapes whose berries ripen outside of peak GJB activity are less susceptible to attack and therefore require minimal or no insecticidal control of this pest. Our data indicate that GJB can completely destroy an entire harvest of early-season ripening cultivars of grapes grown in Kentucky if the crop is not protected with sprays. Growers of highly susceptible cultivars should be aware of the potential damage that can occur, as well as the limited chemical control options available for near-harvest use.

Table 1. Susceptibility of grape cultivars to GJB damage.[1]

Cultivar	Harvest Date	Clusters/ Vine[2]	TSS[3]	Tough-ness[4] (g)	% Non-Marketable Clusters[5]
Foch	Aug-07	51 ab	19.6 b	582 b	96 c
Jupiter	Aug-07	43 b	16.6 c	489 c	97 c
St. Croix	Aug-07	49 ab	16.7 c	318 e	99 c
Chancellor	Aug-14	46 ab	17.1 c	653 a	26 b
Chambourcin	Sep-05	60 a	20.1 b	440 cd	7 a
Norton	Sep-15	39 b	22.1 a	414 d	0 a
P <		0.01	0.0001	0.0001	0.0001

1 Comparisons within columns by RCB one-way ANOVA; means not followed by same letter differ significantly (Tukey's HSD, $P < 0.05$).
2 Number of potentially harvestable clusters.
3 TSS reported as % brix in juice.
4 Force required to break berry skin in grams.
5 Clusters with > 25% damage considered non-marketable.

Acknowledgments

This work was funded in part by the New Crop Opportunities Center at the University of Kentucky through a USDA Special Grant and a USDA-Southern Region Sustainable Agriculture Research and Education Grant. We thank Katherine Akers, Cristina Brady, Randy Collins, Jennie Condra, Brandon O'Daniel, Carl Redmond, Darrell Slone, and Patsy Wilson for technical assistance.

Raspberry Cultivar Trial Results

John Strang and Chris Smigell, Department of Horticulture

Introduction

Raspberries are a potentially economically viable crop for Kentucky farms. Demand and prices are generally very good, and fall-bearing (also known as everbearing, or primocane-fruiting) raspberries can be harvested until the first hard fall freeze, allowing growers to get a premium price in the fall farm markets. Additionally, raspberries require little pesticide spraying, compared to many other fruit and vegetable crops. In the spring of 2006, a cultivar trial was established at the University of Kentucky Horticultural Research Farm in Lexington to compare survival, yields, and quality of five fall-bearing and two June-bearing raspberry cultivars.

Materials and Methods

The experimental design consisted of seven cultivars replicated five times, arranged in a randomized complete block design. Five fall-bearing cultivars were planted: Explorer, an experimental, black-fruited cultivar (P. Tallman, Nourse Farms); the red-fruited Caroline (Nourse Farms), Heritage (H. Schwartz, D. Stokes, OH), and Jaclyn (Nourse Farms); and the yellow-fruited Anne (Nourse Farms). The two black-fruited June-bearing cultivars were Jewel and Mac Black (both from Nourse Farms). Rows were spaced 10 feet apart, and each cultivar was planted in a 10-foot long plot, with 10 feet of buffer space between cultivar plots. Explorer, Jewel, and Mac Black were spaced 3 feet apart within a 10-foot section, and the remaining varieties were spaced 2 feet apart. Sixty pounds of N per acre as ammonium nitrate were applied preplant and tilled into the soil. Explorer, Jewel, Mac Black, Caroline, and Heritage were planted in the spring of 2006. Jaclyn and Anne were planted in the spring of 2007. Insecticide, fungicide, and herbicide applications were made in accordance with the *Midwest Grape and Small Fruit Spray Guide* (ID-94). Plants were trickle-irrigated as needed.

A three-wire T-trellis system was installed in the spring of 2007. In May, all plants were sidedressed with 0.8 lb of calcium nitrate per 10 feet of row, and floricanes were removed from Explorer, Heritage, and Caroline. All plots were mulched with 6 inches of mixed wood chips.

Harvesting began on 28 June and finished on 2 November. Berries were harvested once per week at the beginning and end of the harvest period and every two to three days during peak harvest. Yield and berry weight (weight of 15 berries per plot) data were collected at each harvest, and the per acre yields and average berry weights were calculated. Yields per acre were extrapolated from the average yields per 10-foot plot. Firmness and flavor ratings were made at each harvest. Firmness was determined by squeezing individual berries between thumb and finger and comparing firmness between cultivars. Flavor ratings were made by a single researcher the day of harvest. The total Jaclyn and Anne plants that survived until November were counted.

Results

The planting experienced temperatures in the mid- to low 20s (°F) on 7 to 10 April 2007. These low temperatures were preceded with a month with above-normal temperatures including 70s and low 80s just a few days before the cold period. Some floricane damage occurred from this combination of events. The remainder of the growing season was hot and dry.

Occasional cane dieback was first observed in July in Explorer, Anne, and Jaclyn. Diagnosis showed the cause to be *Phytophthora* root rot. This rot is typically associated with prolonged soil wetness. The weekly waterings lasted for 12 hours or more. Long watering periods and the bark mulch may have been sufficient to cause *Phytophthora* infections. Anne and Jaclyn may have been particularly stressed and thus more prone to infection because they were newly planted. In late October, rust pustules began to be observed on the leaves and fruit of all cultivars except for Anne. Its yellow color may have prevented detection of the pustules on the fruit; pustules were not observed on the leaves.

Caroline and Heritage had significantly higher yields than the other fall-bearing cultivars (Table 1). With yields of 4,995 and 4,699 lb/A respectively, they yielded six times as much as Explorer did. Jewel and Mac Black yielded 17 and 14 lb/A, respectively. These varieties only produce on floricanes. With the early spring warming and freezing events, floricane damage reduced yields considerably.

Anne yielded 62% more than Jaclyn. This is at least partly due to greater survival of the Anne plants than the Jaclyn plants. Of 50 Anne plants set in 2007, 44 survived until November, and 40 Jaclyn plants survived. Anne and Jaclyn were planted in 2007, and both still yielded more than the two-year-old Explorer.

Jaclyn had the largest average berry weight at 2.8 grams. Its average weight was significantly greater than that of any other cultivar except for Anne, which averaged 2.6 grams. Jewel, at

Table 1. Raspberry cultivar yields and berry characteristic measurements, 2007 harvest.

Variety[1]	Yield[2] (lb/A)	Berry Wt.[3] (grams)	Firmness[4]	Flavor[5]
Fall-Bearing				
Caroline	4995 a	2.3 b	3.1 c	4.2 a b
Heritage	4699 a	1.7 c d	3.5 a b	3.8 c
Anne	1441 b	2.6 a b	3.6 a	3.9 b c
Jaclyn	882 b	2.8 a	3.3 a b c	4.3 a
Explorer	751 b	1.3 e	3.2 b c	2.7 e
June-Bearing				
Jewel	17 [3]	2.0 c	_	3.3 d
Mac Black	14	1.6 d e	_	3.4 d

1 Listed in decreasing order of yield.
2 Weights followed by the same number are not significantly different (Duncan Waller LSD P = 0.05).
3 Yields of Jewel and Mac Black not statistically compared with other cultivars because of bud loss due to spring injury.
4 Based on average weight of 15 berries, which was measured at each harvest.
5 Flavor: 1 = poor, 5 = excellent.

2.0 grams, was significantly heavier than Mac Black, the other June-bearing black cultivar. The average berry weight for Explorer was significantly less than for any other cultivar, except for Mac Black. Average firmness ratings ranged from a high of 3.6 for Anne to a low of 3.1 for Caroline.

The red and yellow cultivars rated significantly higher in taste than any of the black ones. Jaclyn and Caroline had the highest flavor ratings of all the cultivars. They rated significantly higher than all other cultivars in the trial, with the exception of Anne, which rated slightly less than Caroline. Mac Black and Jewel had similar taste ratings. Both had significantly higher ratings than Explorer, which also had very hard seeds.

Overall, Anne performed very well. It ranked in the top three for yield, berry weight, flavor, and firmness. Jaclyn and Caroline were also top performers, ranking in the top three for flavor and berry weight. Jaclyn berries tended to adhere to the fruit receptacles, making them difficult to harvest. Although the standard variety, Heritage, was a top yielder, it had significantly smaller berries and lower flavor ratings than the other standard, Caroline, and the newer Jaclyn. Because of differences in plant age and the damage caused by the early spring weather, cultivar comparisons need to be made with caution. The spring damage to the June-bearing Mac Black and Jewel illustrates the advantage of fall-bearing cultivars: late spring freezes may reduce or eliminate a floricane crop, but the plants will still provide income with the fall crop.

Blackberry and Raspberry Trial at Princeton, Kentucky

Dwight Wolfe, Joseph Masabni, and June Johnston, Department of Horticulture

Introduction

Blackberries and raspberries are important small fruit crops grown in Kentucky. There is a strong demand for both berries at farmers' markets, and the demand for blackberries generally exceeds supply. Producers are looking for better cultivars that are productive and have berries with good size and flavor. Resistance to orange rust and rosette is also a consideration among growers. For this reason, a cultivar trial was initiated in the spring of 2006 at the University of Kentucky Research and Education Center (UKREC), Princeton, Kentucky, to evaluate five blackberry and four raspberry cultivars.

Materials and Methods

Twenty plants each of nine cultivars were planted in the spring of 2006. Plants were spaced 2 feet apart within 10-foot-long plots in rows spaced 20 feet between rows. Only one cultivar was allocated to each plot, and each row contained nine plots. The first five cultivars in each row were blackberry cultivars, and the last four cultivars were raspberry cultivars. Except for this restriction, cultivars were randomized in a randomized block design with each row being one block. Trickle irrigation was installed, and plants were maintained according to local recommendations (1, 2). Fruit was harvested twice weekly from mid-June through August 1. Fruit size was calculated as the average weight (oz) of 50 fruits. Data from the blackberry cultivars were analyzed separately from the raspberry cultivar data.

Results and Discussion

Among the blackberry cultivars, Anastasia was the first to reach petal fall stage during bloom (Table 1). Consequently, peak harvest was in June, ahead of the other blackberry cultivars (Table 2). A similar result was observed for OAM-W2 among the raspberry culitvars.

Yield, fruit size, and taste all differed significantly among both groups of bramble cultivars. The blackberry Chickasaw and the raspberry Georgia produced the most fruit in each of

Table 1. 2008 phenology of blackberry and raspberry cultivars at UKREC, Princeton, Ky.

Cultivar	1/4" leaf	Pre-Bloom	Bloom	Petal Fall
Blackberries				
Anastasia	April 7	May 1	May 8	May 28
Chesapeake	April 9	May 7	May 12	June 5
Chickasaw	April 1	May 1	May 8	June 1
Kiowa	April 9	May 1	May 8	June 5
OAL-W6	April 9	May 16	May 21	June 10
Raspberries				
Heritage	April 14	May 12	May 16	June 5
OAM-W2	April 7	May 8	May 12	May 20
PCS	April 14	May 21	May 23	June 5
Georgia	April 14	May 12	May 16	June 5

Table 2. 2008 harvest results from the blackberry and raspberry cultivar trial at UKREC, Princeton, Ky.

Cultivar	Peak Harvest	Yield[1] (lb /A)	Berry Size (oz/berry)	Taste Rating[2]
Blackberries				
Anastasia	June 23	1419	.32	1.00
Chesapeake	July 8	4360	.43	4.63
Chickasaw	July 8	9528	.37	4.63
Kiowa	July 13	7723	.50	4.75
OAL-W6	July 10	8844	.33	4.63
Mean	NA	6375	.37	3.93
LSD (0.05)[3]	NA	2450	.028	0.69
Raspberries				
Heritage	July 2	1097	.05	4.17
OAM-W2	June 22	700	.07	4.38
PCS	June 25	343	.07	4.88
Georgia	June 30	1177	.08	4.83
Mean	NA	785	.07	4.57
LSD (0.05)	NA	695	.013	0.54

[1] Based on a spacing of 20 between rows.
[2] Based on a scale from1 to 5 with 1 = very poor, 2 = marginal, 3 = fair, 4 = good, and 5 = excellent.
[3] LSD (0.05) = least significant difference at the 0.05 probability level.

their groups. Kiowa and Chesapeake had the largest berries among the blackberry cultivars. Berry size was similar among all the raspberry cultivars, except for Heritage, which produced the smallest berries. Berry flavor was generally good for all berries tasted in this trial, except for Anastasia, which is a cross between a blackberry and a raspberry. It had a markedly sour flavor.. However, this was the first year that we collected data from this trial, and flavor and other characteristics may be more distinguishable in subsequent years.

Literature Cited

1. Strang, J.G., J.G. Masabni, R.T. Jones, Kaan Kurtural, R.T. Bessin, and J.R. Hartman. *2008 Commercial Small Fruit and Grape Spray Guide*. University of Kentucky College of Agriculture Cooperative Extension Service, Publication ID-94.
2. ones, R.T., and J.G. Strang. *Growing Blackberries and Raspberries in Kentucky.* University of Kentucky College of Agriculture Cooperative Extension Service, Publication HO-15.

University of Arkansas Floricane-Fruiting Blackberry Trial in Kentucky

Jeremiah D. Lowe, Kirk W. Pomper, and Sheri B. Crabtree, Department of Plant and Soil Science, Kentucky State University; John R. Clark, Department of Horticulture, University of Arkansas; John G. Strang, Department of Horticulture, University of Kentucky

Introduction

The University of Arkansas Blackberry Breeding Program has developed many excellent blackberry cultivars including Apache, Arapaho, Cherokee, Comanche, Cheyenne, Chickasaw, Choctaw, Kiowa, Navaho, Ouachita, and Shawnee, and recently the selection Natchez was released (Clark and Moore, 2008). The objective of this study was to compare production characteristics from a number of advanced floricane-fruiting selections, including Natchez, developed by the University of Arkansas Blackberry Breeding Program to the commonly grown selections Chickasaw and Triple Crown in terms of yield and fruit quality under Kentucky growing conditions.

Materials and Methods

In June 2006, a blackberry variety trial was established at Kentucky State University (KSU). The variety trial included the commercially available cultivars Chickasaw (thorny erect) and Triple Crown (semi-erect, thornless) and the Arkansas (A) floricane-fruiting selections A-1937T, A-2215T, A-2241T, and A-2315T; the selection A-2241T was released in 2008 as Natchez after the start of the trial. All the advanced selections are thornless and erect in stature. The advanced selections and two commercially available cultivars were planted at the KSU Research and Demonstration Farm in Frankfort, Kentucky. Plants were arranged in a completely randomized design, with two replicate plots each containing five plants of each selection or cultivar (total of 10 plants of each selection or cultivar) in a 10-foot plot. Spacing was 2 feet between each plant and 5 feet between groups of five plants; each row was 70 feet long. Rows were spaced 14 feet apart. This trial was managed with organic practices following the National Organic Program standards. Weed control was achieved by placing a 6- to 8-inch-deep layer of straw around plants, adding straw when necessary, and hand weeding. Plants were irrigated weekly with T-tape laid in the rows. Flower buds of the floricanes of all blackberry selections were destroyed by the Easter freeze event of 2007. In 2008, selections flowered in June, and ripe fruit were harvested from plants each Monday and Thursday until August.

Table 1. Yield and berry weight in 2008 for three advanced floricane-fruiting selections from the University of Arkansas Blackberry Breeding Program and the selections Natchez, Chickasaw, and Triple Crown that were established at the Kentucky State University Research Farm in June 2006.

Selection	Yield (lb/A)	Berry Weight (g)	Brix	2008 Harvest Period
A-1937T	10430	4.3	8.0	6/30 – 8/3
A-2215T	8359	3.8	9.2	7/3 – 8/11
A-2315T	6526	5.5	7.8	7/3 – 8/3
Natchez	8924	6.8	8.7	6/26 – 8/3
Chickasaw	8259	5.4	9.2	6/30 – 8/3
Triple Crown	6782	4.6	11.3	7/17 – 8/14
Significance	ns	0.007	0.001	-
LSD (5%)	-	1.2	0.7	-

Results and Discussion

This was the first fruiting year for these advanced selections and cultivars due to the 2007 spring freeze event. All cultivars and advanced selections yielded well; however, there was not a significant difference in yield among the cultivars and advanced selections (Table 1). Brix were highest for Triple Crown and lowest for A-2315T. Berry weight was significantly larger for Natchez than for the other cultivars and advanced selections. This new cultivar release also had the earliest first harvest date of June 26. Triple Crown had the latest first harvest date, which was July 17. Natchez is the twelfth release in a series of erect-growing, high-quality, productive, floricane-fruiting blackberry cultivars developed by the University of Arkansas. Natchez has also been reported to ripen early in Arkansas, ripening slightly before or with the cultivar Arapaho, and seven days before Ouachita in the Arkansas trials. Natchez has been released for commercial production and could potentially be a popular new addition for blackberry production in Kentucky. The advanced selections noted in this trial are not commercially available. Year-to-year yield and fruit quality characteristics will need to be further evaluated for these advanced selections.

Literature Cited

Clark, J.R., and J. N. Moore. Natchez Thornless Blackberry. HortScience 43:1897-1899.

The Kentucky Primocane-Fruiting Blackberry Trial

Kirk W. Pomper, Jeremiah D. Lowe, and Sheri B. Crabtree, Department of Plant and Soil Science, Kentucky State University; John R. Clark, Department of Horticulture, University of Arkansas; John G. Strang, Department of Horticulture, University of Kentucky

Introduction

Primocane-fruiting blackberries have the potential to produce a niche-market crop for Kentucky growers from late summer until frost. This type of blackberry fruits on current-season canes (primocanes). The first commercially available primocane-fruiting blackberry varieties, Prime-Jim® and Prime-Jan®, were released by the University of Arkansas in 2004 (Clark et al., 2005). All previous blackberry varieties are floricane-fruiting; thus, the canes must be overwintered for fruiting the second year. This new type of blackberry has the potential to produce more than one "crop" per year, having the potential for the normal summer crop (floricane) and a later crop on the current-season primocanes. These primocane-fruiting blackberries flower and fruit from late summer until frost, depending on temperatures, plant health, and the location in which they are grown. Primocane blackberry selections can be pruned by mowing the canes down in the late winter; this also provides control of anthracnose, cane blight, and red-necked cane borer without pesticides.

Fruit size and quality of Prime-Jim and Prime-Jan are affected by the environment. Summer temperatures above 85°F can greatly reduce fruit set, size, and quality on primocanes; which results in substantial reductions in yield and fruit quality in areas with this temperature range in summer and fall (Clark et al., 2005; Stanton et al., 2007). The fruit of Prime-Jim and Prime-Jan also do not store well for shipping and are most suitable for home gardens and on-farm sales. A number of advanced selections are being developed that should have improved yield and berry size, as well as storage and shipping characteristics. The objective of this study was to determine if advanced selections developed by the University of Arkansas Blackberry Breeding Program were superior to Prime-Jim and Prime-Jan in terms of yield and fruit quality under Kentucky growing conditions.

Materials and Methods

In June 2006, a blackberry variety trial was established at Kentucky State University (KSU). Plants of two commercially available primocane-fruiting cultivars Prime-Jim and Prime-Jan (both thorny erect, primocane-fruiting) and the Arkansas Primocane-fruiting (APF) selections APF-27, APF-40, APF-41, APF-42, APF-46, and APF-77 (all thorny erect, primocane-fruiting) that are advanced selections from the University of Arkansas Blackberry Breeding Program were planted at the KSU Research and Demonstration Farm in Frankfort, Kentucky. Plants were arranged in a randomized complete block design, with four blocks, including five plants of each cultivar per block (total of 20 plants of each cultivar) in a 10-foot plot. Spacing was 2 feet between each plant and 5 feet between groups of five plants; each row was 70 feet long. Rows were spaced 14 feet apart. This trial was managed with organic practices following the National Organic Program standards. Weed control was achieved by placing a 6- to 8-inch-deep layer of straw around plants, adding straw when necessary, and hand weeding. Plants were irrigated weekly with T-tape laid in the rows.

Floricanes of the primocane selections began producing ripe fruit in mid-June 2008, and ripe fruit were harvested from floricanes each Monday and Thursday until the beginning of August, when primocane fruit harvest began (Table 1). Primocane harvest ended in late October. Primocanes were tipped on all selections at 1 meter in early June and again in September to promote lateral branching and flowering.

Results and Discussion

In 2007, an Easter freeze event destroyed all floricane flowers, and there was no floricane crop. However, the 2007 primocanes of all selections began bearing fruit in August. APF-40 had the greatest yield, and Prime-Jim had the smallest yield that year (Table 1). In 2008, there were both floricane and primocane crops on all selections. The selections APF-41 and APF-77 produced the largest floricane crop and APF-46 the smallest floricane crop. For the floricane crop, APF-41 and APF-40 had the largest berries of all selections. The 2008 primocane crop began ripening in August. APF-27 had the largest primocane crop in 2008; this selection had an almost two-fold increase in the yield of the previous year. Primocane production from APF-77 also increased almost two-fold in yield compared to the previous year's primocane crop. Although APF-41 had a large floricane crop in 2008, the primocane crop was only about one-quarter the size of the floricane crop and was about 60% that of the 2007 primocane crop. Primocane fruit of APF-41 were still large in size, but the primocane fruit of this selection were only 4.4 g on average compared to the 6.2 g on average for floricanes in 2008. APF-41 again had a later primocane crop compared to the other selections. Summer drought conditions may have negatively affected the primocane crop of all selections this year. Even with irrigation, it was difficult to satisfy the water demands of the plants. Year-to-year yield and fruit quality characteristics will need to be further evaluated, and none of these advanced selections have yet been released for commercial production.

Literature Cited

Clark, J.R., J. N. Moore, J. Lopez-Medina, C. Finn, and P. Perkins-Veazie. 2005. Prime-Jan (APF-8) and Prime-Jim (APF-12) Primocane-fruiting blackberries. HortScience 40:852-855.

Stanton, M.A., J. C. Scheerens, R. C. Funt, and J. R. Clark. 2007. Floral competence of primocane-fruiting blackberries Prime-Jan and Prime-Jim grown at three temperature regimens. HortScience 42 508-513.

Table 1. Yield and berry weight in 2007 and 2008 for six advanced primocane-fruiting selections from the University of Arkansas Blackberry Breeding Program and the primocane-fruiting cultivars Prime-Jan® and Prime-Jim® that were established at the Kentucky State University Research Farm in June 2006.

	Yield (lb/A)			Average Fruit Weight (g)			Harvest Dates (start and end)			
	2007	2008		2007	2008		2007		2008	
Selection	Primocane	Floricane	Primocane	Primocane	Floricane	Primocane	Floricane	Primocane	Floricane	Primocane
APF-27	1494 bc	1097 bcd	3005 a	3.0 b	3.6 c	3.5 bc	-	8/2 - 10/26	6/18 - 7/21	8/3 - 10/20
APF-40	2598 a	1999 b	1947 bc	4.0 a	5.0 b	3.9 ab	-	8/6 - 10/26	6/18 - 8/1	8/3 - 10/20
APF-41	1415 bc	4415 a	873 d	3.9 a	6.2 a	4.4 a	-	8/20 - 10/26	6/18 - 8/11	8/25 - 10/20
APF-46	1021 c	672 d	1179 cd	2.5 c	3.0 d	3.0 cd	-	8/2 - 10/26	6/18 - 7/24	8/11 - 10/20
APF-77	1104 c	3717 a	2229 ab	3.3 b	3.8 c	3.9 ab	-	8/2 - 10/26	6/18 - 7/28	8/3 - 10/20
Prime-Jan	1718 b	856 cd	2003 abc	3.3 b	4.0 c	3.2 cd	-	8/2 - 10/26	6/18 - 7/24	8/11 - 10/20
Prime- Jim	295 d	1856 bc	691 d	2.0 d	3.6 c	2.7 d	-	8/2 - 10/26	6/18 - 7/21	8/14 - 10/20

Means within a column followed by the same letter are not significantly different (Least Significant Difference P = 0.05).

Blueberry Cultivar Trial for Eastern Kentucky

Crystal Sparks, Ryan Hays, R. Terry Jones, and John C. Snyder, Department of Horticulture

Introduction

Although blueberries (*Vaccinium* spp.) are native fruits, Kentucky has limited commercial acreage. Blueberries have an excellent potential for local sales and U-pick operations. Recent research into the health benefits of small fruits, including blueberries, may help increase sales. Pharmaceutical companies are conducting more research on *Vaccinium* spp., with a particular emphasis on secondary metabolites such as anthocyanins. It is responsible for the blue color and is found only in the peel. Anthocyanins and other flavonoids could help limit cancer development, cardiovascular disease, glaucoma, and poor night vision. As consumers become more food-conscious, they are eating more blueberries.

Rabbiteye blueberries are varieties that are native to the southern United States. This type of blueberry is recommended for zones 7 to 9 but can be effectively grown in Kentucky (zone 6). Rabbiteye blueberries mature later than highbush blueberries and may prove useful in extending Kentucky's market window for retail sales. Rabbiteye blueberries have the same growing requirements as the more common highbush, although they tend to be larger plants and are planted in 12-foot-wide rows with 5 to 7 feet between plants in the row.

The high start-up cost for blueberries, approximately $4,000/A, is mainly due to land preparation, plants, and labor costs. However, after the plants reach maturity in approximately five years, profits should steadily increase to as high as $6,000/A per year. The longevity of a properly managed blueberry field is similar to that of a well-managed apple orchard. Blueberries require acidic soils with a pH of 4.5 to 5.2, with good drainage and high organic matter. It is best to plant more than one cultivar to ensure good pollination and a continuous harvest. Harvest usually begins in early June and lasts well into July for highbush but runs from mid-July to mid-August for most rabbiteye blueberries.

Table 1. Harvest measurements, berry measurements, and characteristics of rabbiteye blueberry cultivars, Quicksand, 2008.

Cultivar	Fruit Yield (lb/bush)[1]	Berry Size (oz/berry)[2]	Berry Size Rating[2]	Taste[3]	Appearance[4]	First Harvest Date	% Harvested[5] (first two harvest dates)
Ira	9.29	0.033	ML	ST	A	7/22	58.6
Tifblue	7.18	0.030	SM	ST	A+	7/22	43.8
Onslow	5.14	0.037	ML	ST	A	7/22	42.2
Powderblue	4.28	0.032	M	SB	A	7/22	48.8

1 In descending order of yield.
2 Size rated visually; S = small, M = medium, L = large, ML = medium large, VL = very large.
3 Taste rating: S = sweet, T = tart, B = bland.
4 Appearance rating: A = average, A+ = above average.
5 Harvest dates were 7/22, 7/28, 8/5, 8/12, and 8/18 over a 27-day harvest season.

Materials and Methods

A planting of rabbiteye blueberries was established at the University of Kentucky Robinson Station in eastern Kentucky in the spring of 2004. The planting consisted of two rows of four cultivars in a randomized complete block design. There were six replications of each cultivar. Plants were 4 feet apart in raised beds 14 feet apart, located next to the highbush variety trial of blueberries. Drip irrigation with point source emitters (2 gph/plant) was installed shortly after planting. In 2008, one application of sulfur-coated urea (5 lb/50 ft row) was made prior to bloom. Princep 4L+ Surflan 4AS at (3 qt + 2qt/A) was applied for weed control just before bud break. Netting was used to prevent loss from birds.

Results

Results are shown in Table 1. Ira had the highest yield in pounds per bush, while Powderblue had the lowest yield. Onslow had the largest berry, but there was little difference in average berry (size) weight between the cultivars. Ira berries were sometimes a little seedy and the skin was tough compared to the other rabbiteye and highbush cultivars. Tifblue had an above-average rating on appearance, while the remaining varieties had an average rating.

A variety's maturity is measured as the percent of the total season's yield that is harvested in the first two pickings. Ira (58.6%) was the earliest-maturing variety, followed by Powderblue (48.8%), Tifblue (43.8%), and Onslow (42.2%). Picking of the rabbiteye blueberries began on July 22 and ended on August 18, constituting a 27-day picking season. It is important to remember that these bushes have not reached maturity yet. It is hoped that they will continue to produce higher yields until they reach their fifth or sixth growing season in 2009 or 2010.

Blueberry Variety Evaluations

John Strang, Amy Poston, Chris Smigell, John Snyder, and Darrell Slone, Department of Horticulture

Blueberries are a profitable and rapidly expanding small fruit crop in Kentucky. Previous University of Kentucky trials have evaluated primarily highbush blueberries. Relatively recent releases of southern highbush varieties that have higher chilling hour requirements have performed well at the Robinson Station near Jackson, Kentucky. Home plantings of the less hardy rabbiteye blueberries, which are planted commercially from Tennessee southward, have done well in the Princeton and Henderson areas of Kentucky. This trial was established to evaluate six highbush, 10 southern highbush, and seven rabbiteye blueberry varieties for performance in the Lexington, Kentucky, area.

Table 1. Highbush and southern highbush blueberry yield, fruit size, taste, and appearance ratings, Lexington, Ky., 2008.

Variety	Type[1]	Yield (lb/A)[2]	Berry Wt. (oz/25 berries)	Berry Taste (1-5)[3]	Berry Appearance (1-5)[4]	First Harvest (date)	Harvest Midpoint (date)[5]
Chandler	HB	9814 a	1.8 a	3.2 ab	3.6 abcd	27 June	14 July
Pamlico	SH	9419 a	0.6 gh	3.9 a	3.8 abcd	27 June	4 July
Bluecrop	HB	8224 ab	0.8 efg	3.3 ab	3.8 abcd	27 June	14 July
Echota	HB	8223 ab	0.7 efgh	3.3 ab	4.3 a	27 June	16 July
Ozarkblue	SH	7743 ab	1.2 bc	3.2 ab	3.9 abc	29 June	21 July
Spartan	HB	7658 ab	0.8 efg	3.6 ab	3.4 bcd	27 June	2 July
NC-2927	SH	7048 ab	0.4 h	4.0 a	3.7 abcd	27 June	2 July
Star	SH	6706 abc	0.8 efg	3.6 ab	3.1 d	27 June	1 July
NC-3129	HB	5657 abc	0.7 fgh	3.3 ab	3.2 cd	1 July	6 July
Lenore	SH	5586 abc	0.7 ef	3.2 ab	4.0 abc	27 June	11 July
NC-1871	HB	4920 abc	0.6 gh	3.0 bc	3.7 abcd	27 June	29 July
Arien	SH	4850 abc	0.9 def	3.6 ab	4.1 ab	27 June	16 July
Misty	SH	3778 bc	0.9 de	3.6 ab	3.5 abcd	27 June	3 July
Aurora	HB	1542 c	1.1 cd	2.4 c	3.1 d	11 July	22 July
Sampson	SH	1451 c	1.4 b	3.7 ab	3.3 bcd	27 June	30 June

1 Type: HB = highbush; SH = southern highbush.
2 Numbers followed by the same letter are not significantly different (Duncan's multiple range test LSD P = 0.05).
3 Berry taste: 1 = poor; 5 = excellent.
4 Berry appearance: 1 = poor; 5 = excellent.
5 Date on which half of the berries were harvested, based on total yield weight.

Materials and Methods

Plants were acquired from Fall Creek Nursery, Lowell, Oregon; Finch Nursery, Bailey, North Carolina; DeGrandchamp's Farm, South Haven, Michigan; and from Dr. Jim Ballington at North Carolina State University, Raleigh, North Carolina. They ranged in age from rooted cuttings to two-year-old plants. This trial was established at the University of Kentucky Horticultural Research Farm in Lexington in the spring of 2004. Plants were set on raised beds of Maury silt loam soil into which peat and composted pine bark mulch had been incorporated and the soil pH had been adjusted from 5.6 to 4.6 by applying 653 lb of sulfur per acre. Five replications of individual plant plots were set in rows running east to west in a randomized block design. The southern highbush and highbush plants were randomized together at one end of the planting and spaced 4 feet apart in the row with 12 feet between rows. The rabbiteye blueberries were planted at the other end with 6 feet between plants and 12 feet between rows. All plants were mulched with a 3-foot-wide, 6-inch layer of wood chips.

Seventy pounds of phosphorus were applied per acre and incorporated into the field prior to bed shaping and planting. Plants showing iron chlorosis were fertilized with Peter's Professional Acid fertilizer (24-12-12) and iron chelate the first year. Plants were fertilized yearly with Osmocote Plus 5-6 month controlled release (15-9-12) fertilizer that contains six trace elements and magnesium at the rate of 1 oz per plant in March, April, May, June, and July.

Foliar insecticide applications included Sevin, Malathion, and Esteem. Fungicide applications included lime sulfur, Pristine, Cabrio, Elevate, and Captan. Herbicides for weed control included Surflan, Princep, Roundup, Gramoxone, and Poast.

Plots were drip irrigated using point source emitters (1 gph/plant), and netting was used over the rows for bird control. Flowers were removed annually in the spring from plants less than 3 feet tall. Larger plants were allowed to fruit for the first time in 2006.

The 2008 season was frost free. Rainfall was above normal over the winter, and in June the season turned dry and remained dry for the rest of the summer and fall. Winter, spring, and summer temperatures were normal. Fruit were harvested once a week. Twenty-five berries from each plant were weighed to determine average berry size at each harvest and were rated for taste and appearance.

Results and Discussion

At planting, most of the varieties were two-year-old, 18- to 30-inch plants. Columbus, Ira, Lenore, Pamlico, Powderblue, NC-3129, NC-1871, NC-2927, and NC-1827 were greenhouse forced, rooted hardwood cuttings. Essentially, all fruit were lost in 2007 due to a severe late spring freeze, resulting in a heavy flower set for 2008. Harvest and fruit size data for the highbush and southern highbush varieties are shown in Table 1. All of the Duplin and Legacy southern highbush plants in the plot have died. The Chandler (highbush) and Pamlico (southern highbush) varieties had the highest yields. Chandler, Sampson, and Ozarkblue tended to have the largest berries, while NC-2927 and Pamlico were rated as two of the best-tasting varieties. NC-2927, which had the smallest fruit in the trial, is being developed for machine harvest for the small-fruited lowbush blueberry baking market. Echota, Arlen, Lenore, and Ozarkblue were rated as having some of the more attractive fruit. Most of the varieties were first harvested on 27 June. While Aurora had the latest first harvest date, Star, Spartan, NC-2927, and Misty had the earliest harvest midpoints, and NC-1871 and Ozarkblue the latest.

Yields for the rabbiteye blueberries (Table 2) are considerably lower than those of the highbush blueberries because these plants have generally not grown as fast as the highbush blueberries. Powderblue and NC-1827 produced some of the higher rabbiteye blueberry yields. Columbus, Onslow, and Tifblue have had some of the larger berry sizes, while Tifblue and Onslow have been rated as some of the best-tasting berries. Onslow fruit were rated the best in appearance.

Rabbiteye blueberries are less sensitive to variations in soil pH, and the fruit generally mature later in the season than those of highbush and southern highbush varieties. Thus, rabbiteye blueberries could extend the Kentucky blueberry harvest season. Columbus had the earliest first harvest date of 7 July, and Ira had the latest of 23 July. Fruit harvest midpoints did not parallel first harvest dates, and NC-1827 had the earliest of 10 July, and Onslow the latest of 12 August.

These data should be considered preliminary, and several seasons will be required to determine how these varieties perform in central Kentucky.

Table 2. Rabbiteye blueberry yield, fruit size, taste, and appearance ratings, Lexington, Ky., 2008

Variety	Yield (lb/A)[1]	Berry Wt. (oz/25 berries)	Berry Taste (1-5)[2]	Berry Appearance (1-5)[3]	First Harvest (date)	Harvest Midpoint[4] (date)
Powderblue	2856 a	0.8 bcd	3.3 ab	3.4 b	12 July	3 August
NC-1827	2745 a	0.6 d	3.2 ab	3.7 ab	27 June	10 July
Climax	2154 ab	0.8 bcd	3.3 ab	3.6 ab	29 June	17 July
Onslow	1926 ab	1.1 ab	3.5 a	4.3 a	17 July	12 August
Tifblue	1147 ab	1.0 abc	3.6 a	3.6 ab	17 July	3 August
Columbus	840 ab	1.3 a	3.0 ab	3.6 ab	7 July	28 July
Ira	52 b	0.8 cd	2.5 b	3.2 b	23 July	31 July

1 Numbers followed by the same letter are not significantly different (Duncan's multiple range test LSD P = 0.05).
2 Berry taste: 1 = poor; 5 = excellent.
3 Berry appearance: 1 = poor; 5 = excellent.
4 Date on which half of the berries were harvested, based on total yield weight.

Acknowledgments

The authors would like to thank the following for their hard work and assistance in this year's trial: Matthew Anderson, Katie Bale, Jessica Ballard, Sean Bessin, Ryan Capito, Jessica Cole, Jessica Dye, Meredith Hall, Lucas Hanks, Ellen Meyer, Dave Lowry, Julie Pfeiffer, Tyler Pierce, Kirk Ranta, Kiefer Shuler, Matthew Simpson, Joseph Tucker, Bonka Vaneva, David Wayne, and Sarah Yates.

Evaluation of Strawberry Varieties as Matted Rows

John Strang, Amy Poston, John Snyder, Chris Smigell, and Darrell Slone, Department of Horticulture

Introduction

Strawberries continue to be popular with Kentucky consumers, and most growers have found that high-quality strawberries are readily marketable. This study was initiated to evaluate newer strawberry varieties planted in the matted row system at the University of Kentucky Horticultural Research Farm in Lexington, Kentucky. This is the third year of the study.

Materials and Methods

Nineteen dormant, bare-rooted strawberry varieties were planted on 11 April 2005. Earliglow, Honeoye, Allstar, and Jewel were included as standards. Each plot was 10 feet long and consisted of six plants set 2 feet apart in the row with 4 feet between rows. Plots were replicated four times in a randomized block design. Disease and weed control were conducted in accordance with the *Midwest Commercial Small Fruit and Grape Spray Guide* (ID-94). In 2008, Abound, Cabrio, Captan, Pristine, and Topsin M fungicides were used for disease control. Dacthal and Devrinol were used for weed control. No insecticides were used. Fifty-seven pounds of N per acre as ammonium nitrate and 104 lb of K as 0-0-60 per acre were applied preplant and tilled into the soil in 2005. In 2006, 50 lb of N per acre as ammonium nitrate were applied at renovation and an additional 8 lb of N per acre as ammonium nitrate were applied on 1 September. In 2007, 50 lb of N as ammonium nitrate were applied at renovation.

Ten-foot sections in each plot were harvested in the spring of 2006, 2007, and 2008. Yield, fruit size, flavor, and appearance data were collected. The 2005 season was hot and dry; the spring of 2006 was cool and wet; the spring of 2007 was hot and relatively dry with a spring freeze. The early spring of 2008 was wet, but rainfall began to drop below normal in June.

Data are shown for the 2008 harvest season. Fifteen berries were weighed at each harvest to determine average berry weight. Berry taste, firmness, and appearance were assessed on 23 and 27 May and 2, 5, and 9 June.

Results and Discussion

Yields and berry size were good. Sable and Mesabi had the highest yields, with 15,696 and 14,706 pounds per acre, respectively (Table 1). Cabot produced the largest berries. Sable, Darselect, Evangeline, Earliglow, and Bish were the earliest varieties to be harvested, on 23 May. Ovation and No. 88741 produced the latest fruit.

Fruit flavor was relatively poor throughout the season. Earliglow, Allstar, Evangeline, Sable, and Bish fruit were rated as having the best taste (Table 2). Clancy, Allstar, L'Amour, and Ovation were determined to have the firmest fruit, while Clancy, Evangeline, Mira, Honeoye, Bish, and Sable were rated as having the most attractive fruit. Most varieties had 20 or more days of harvest. Ovation and #8871 had the shortest harvest period.

Sable stood out in this trial for its high yield, good taste, and appearance, but it was at the bottom of the ratings for fruit firmness. Allstar, Clancy, Earliglow, and Evangeline were judged to have the most desirable fruit quality characteristics.

Table 1. Strawberry yield, berry weights, and harvest dates, 2008.

Variety	Yield[1] (lb/A)		Avg. Berry Wt.[2] (g/berry)		1st Harvest (date)		Harvest Midpoint[3] (date)		Days of Harvest	
Sable	15696	A	7.7	EF	23 May	D	31 May	A	23	ABCD
Mesabi	14706	AB	9.9	CDEF	25 May	BCD	04 Jun	DEF	25	ABCD
Honeoye	14541	AB	8.7	DEF	24 May	CD	02 Jun	ABCD	25	ABCD
Darselect	14538	AB	11.8	BCD	23 May	D	03 Jun	DEF	23	ABCD
Mira	13801	AB	9.7	CDEF	27 May	BC	06 Jun	H	23	ABCD
Primetime	12436	ABC	11.1	BCDE	24 May	CD	03 Jun	CDEF	25	ABCD
Evangeline	12166	ABC	8.3	DEF	23 May	D	01 Jun	AB	27	A
Kent	11472	ABCD	10.7	BCDEF	24 May	CD	04 Jun	FG	26	AB
Gurney's Whopper	10974	BCD	11.1	BCDE	24 May	CD	02 Jun	BCDE	25	ABCD
Earliglow	10460	BCDE	7.3	F	23 May	D	01 Jun	ABC	23	ABCD
Clancy	10357	BCDE	12.8	BC	28 May	B	06 Jun	GH	21	BCD
Allstar	10143	BCDE	11.4	BCDE	27 May	BC	04 Jun	EFG	20	CD
Cabot	10044	BCDE	18.7	A	27 May	B	07 Jun	H	19	DE
Bish	9043	CDE	10.0	CDEF	23 May	D	02 Jun	ABCD	26	ABC
L'Amour	8876	CDE	11.9	BCD	28 May	BC	04 Jun	FG	20	DE
Jewel	7729	CDE	10.6	BCDEF	28 May	B	07 Jun	H	20	BCD
#88741	6986	DE	13.1	BC	04 Jun	A	12 Jun	I	13	F
Eros	6927	DE	13.7	B	26 May	BCD	06 Jun	GH	24	ABCD
Ovation	5979	E	8.2	DEF	04 Jun	A	14 Jun	I	15	EF

[1] Means within a column followed by the same letter are not significantly different (Duncan's multiple range test LSD P = 0.05).
[2] Average berry weight based on the weight of 15 berries at each harvest.
[3] Date on which half of the berries were harvested, based on total yield weight.

Table 2. Strawberry flavor, firmness, and appearance ratings, 2008.

Variety	Taste[1] (1-5)	Firmness[2] (1-10)	Appearance[3] (1-10)	Comments
Sable	3.4	6.3	8.6	Uniform color and shape; intense flavor
Mesabi	2.9	7.3	8.2	Glossy fruit
Honeoye	3.3	6.6	8.7	
Darselect	3.3	7.4	7.7	Uniform color
Mira	3.1	7.1	8.8	Uniform color and shape; tart
Primetime	3.1	7.1	8.6	Uniform; conical shape; dark color
Evangeline	3.5	7.2	9.1	Large seeds
Kent	3.1	7.6	8.2	Dark fruit; variable shape
Gurney's Whopper	3.3	6.9	7.9	
Earliglow	3.8	7.1	8.8	
Clancy	2.9	9.2	9.2	
Allstar	3.8	8.8	8.3	Intense flavor
Cabot	2.9	7.3	7.7	Uniform color and shape
Bish	3.4	7.3	8.7	
L'Amour	3.0	8.1	8.3	
Jewel	3.3	7.5	8.1	Attractive
#88741	3.0	7.6	7.9	
Eros	3.2	7.2	7.9	Uniform color and shape; intense flavor, large, raised seeds
Ovation	2.8	7.9	7.8	Very attractive

[1] Taste rating: 1 = poor; 5 = excellent on 23 and 27 May and 2, 5, and 9 June.
[2] Firmness rating: 1 = poor; 10 = excellent on 23 and 27 May and 2, 5, and 9 June.
[3] Appearance rating: 1 = poor; 10 = excellent on 23 and 27 May and 2, 5, and 9 June.

Acknowledgments

The authors would like to thank the following for their hard work and assistance in this year's trial: Matthew Anderson, Katie Bale, Jessica Ballard, Sean Bessin, Ryan Capito, Jessica Cole, Jessica Dye, Meredith Hall, Lucas Hanks, Ellen Meyer, Dave Lowry, Julie Pfeiffer, Tyler Pierce, Kirk Ranta, Kiefer Shuler, Matthew Simpson, Joseph Tucker, Bonka Vaneva, David Wayne, and Sarah Yates.

Evaluation of Strawberry Varieties Using Plasticulture

John Strang, Amy Poston, Chris Smigell, John Snyder, and Darrell Slone, Department of Horticulture

Introduction

There is considerable interest in plasticulture strawberry production in Kentucky because of increased berry size, quality, cleanliness, earliness, and improved weed control compared to the matted row system. However, production costs, grower management skills, and frost protection needs are considerably higher for plasticulture production. Furthermore, the harvest periods and yields have been considerably less than those obtained in more southern production areas of the United States, making economics a serious concern for plasticulture production in Kentucky. This study was initiated to evaluate newer, potentially higher-yielding strawberry varieties at the University of Kentucky Horticultural Research Farm in Lexington, Kentucky.

Materials and Methods

Chandler and NCC99-27 from Dr. Jim Ballington's program were obtained from North Carolina State University in Raleigh, North Carolina.

Eight strawberry varieties were evaluated in this study. In the fall of 2006, runner tips for NCF94-17, NC99-13, Camerosa, and Sweet Charlie were obtained from the University of Illinois, Dixon Springs Agricultural Center, Simpson, Illinois, and B1033 Z22 plug plants were provided by Dr. Kim Lewers at the USDA ARS Beltsville Agricultural Research Center, Beltsville, Maryland. Darselect freshly dug plants were obtained from a research farm matted row study. A variety trial was established at the University of Kentucky Horticultural Research Farm in Lexington in the fall of 2006 but was severely damaged by a 2007 spring freeze.

Runner tips were harvested on 2 August 2007 from the 2006 plot, and plug plants were propagated in a lath house using overhead mist irrigation. Dr. Kim Lewers at the USDA ARS Beltsville Agricultural Research Center, Beltsville, Maryland, provided B1033 Z22 plug plants for the 2008 trial. Transplants were set using a waterwheel setter into raised black plastic covered beds on 6-foot centers on 7 September 2007. Beds were not fumigated. Each treatment consisted of 20 plants set in staggered double rows spaced 1 foot apart in the row with 1 foot between rows. There were four replications in a randomized block design. Each plant received a cup of 20-20-20 starter solution at planting. Guard rows were established on both sides of the plot. Annual rye grass was planted between the plastic strips and killed with Poast on 25 February 2008. The plot was drip irrigated as needed. Captan, Pristine, Topsin M, Cabrio, and Abound were applied for disease control. No insecticides were used. Dacthal and Devrinol were used for weed control. Zinc phosphide bait was used to control voles during the winter beneath a floating row cover (1.5 oz. per sq. yd.) that remained on the plot from 12 November to 20 March.

Sixty pounds of N per acre as ammonium nitrate were applied preplant and tilled into the soil. A total of 37 pounds of N as ammonium nitrate were fertigated in three irrigations on 22 and 29 April and 13 May 2008.

Ten-foot plot sections in each plot were harvested the spring of 2008. Yield, fruit size, flavor, and appearance data were collected. The 2008 winter was particularly wet, and temperatures were normal. In June, the weather turned dry and remained dry. Fifteen berries were weighed at each harvest to determine average berry weight. Berry taste, firmness, and appearance were assessed on 19, 23, and 27 May, and 2, 5, and 9 June 2008. Plants were rated for leaf diseases on 11 July.

Table 1. Strawberry yields, berry weights, and harvest dates, 2008.

Variety	Yield[1] (lb/A)		Avg. Berry Wt.[2] (g/berry)		1st Harvest (date)		Harvest Midpoint[3] (date)		Days of Harvest	
Chandler	12,347	A	12.4	B	16 May	B	28 May	B	28	D
B1033 Z22	11,453	AB	20.3	A	18 May	AB	28 May	AB	27	DE
NC99-13	10,546	ABC	9.9	B	15 May	BC	27 May	BC	29	CD
Camerosa	9,627	BCD	12.0	B	17 May	AB	28 May	AB	27	DE
NCC99-27	9,145	CD	8.5	B	19 May	A	30 May	A	25	E
Darselect	8,142	DE	8.7	B	12 May	D	26 May	D	32	B
NCF94-17	6,655	EF	12.2	B	17 May	AB	28 May	CD	31	BC
Sweet Charlie	5,962	F	8.0	B	9 May	E	21 May	E	35	A

1 Means within a column followed by the same letter are not significantly different (Duncan's multiple range test LSD P = 0.05).
2 Average berry weight based on the weight of 15 berries at each harvest.
3 Date on which half of the berries were harvested, based on total yield weight.

Table 2. Strawberry flavor, firmness, appearance, and foliar disease ratings, 2008.

Variety	Taste [1,2] (1-5)	Firmness[3] (1-5)	Appearance[4] (1-5)	Leaf Scorch[5] (% leaf surface affected)	Comments
Chandler	3.7 BC	3.2 C	3.9 A	8.1 A	
B1033 Z22	3.8 BC	3.5 C	3.9 A	1.7 CD	Glossy, attractive, sweet fruit; intense flavor
NC99-13	3.5 CD	3.3 C	3.9 A	1.1 D	Uniform size; dark color
Camerosa	3.8 BC	4.5 A	4.2 A	1.5 CD	Darker fruit color
NCC99-27	3.4 D	3.5 C	3.5 B	2.9 CD	
Darselect	4.0 AB	3.5 C	4.1 A	4.6 BC	
NCF94-17	4.2 A	3.8 B	3.5 B	6.2 AB	Very firm; intense flavor
Sweet Charlie	4.0 AB	3.5 C	4.0 A	7.1 AB	Uniform shape; intense flavor

1 Taste rating: 1 = poor; 5 = excellent on 19, 23, 27 May, and 2, 5, and 9 June.
2 Means within a column followed by the same letter are not significantly different (Duncan's multiple range test LSD P = 0.05).
3 Firmness rating: 1 = poor; 5 = excellent on 19, 23, 27 May, and 2, 5, and 9 June.
4 Appearance rating: 1 = poor; 10 = excellent on 19, 23, 27 May, and 2, 5, and 9 June.
5 Leaf scorch foliar disease rating: Three leaves were evaluated from three areas in each treatment on 11 July 2008. Value is the percent leaf surface infected.

Results and Discussion

Chandler, B1033 Z33, and NC99-13 were the highest-yielding varieties in the trial (Table 1). None of the new numbered varieties outyielded Chandler. B1033 Z22 had significantly larger berries than the other varieties. Berry flavor in general was not as good this season, but NCF94-17, Darselect, and Sweet Charlie were rated as being the better-tasting varieties, (Table 2). Camerosa stood out as being the firmest variety, and Camerosa, Darselect, and Sweet Charlie were rated as being the most attractive varieties. Leaf scorch was the only foliar disease noted, and NC99-13, Camerosa, and B1033 Z22 had the lowest leaf scorch levels. Sweet Charlie was the earliest-producing variety and NCC99-27 the latest. Sweet Charlie had the longest harvest period of 35 days, while NCC99-27 had the shortest of 25 days. B1033 Z22 was rated as being the best overall performer in this trial due to its yield, fruit size, taste, adequate firmness and appearance, and low leaf scorch rating.

Acknowledgments

The authors would like to thank the following for their hard work and assistance in this year's trial: Matthew Anderson, Katie Bale, Jessica Ballard, Sean Bessin, Ryan Capito, Jessica Cole, Jessica Dye, Meredith Hall, Lucas Hanks, Ellen Meyer, Dave Lowry, Julie Pfeiffer, Tyler Pierce, Kirk Ranta, Kiefer Shuler, Matthew Simpson, Joseph Tucker, Bonka Vaneva, David Wayne, and Sarah Yates.

High Tunnel and Field Plasticulture Strawberry Evaluation

Derek Law, John Strang, Amy Poston, John Snyder, Mark Williams, Chris Smigell, and Darrell Slone, Department of Horticulture

Introduction

Strawberry production in high tunnels should provide disease control due to the elimination of rainfall on the plants and berries and improves organic production potential. This study is intended to compare field and high tunnel strawberry production using plasticulture production techniques. It was conducted at the University of Kentucky Horticultural Research Farm in Lexington, Kentucky, in the certified organic section of the farm.

Materials and Methods

As reported in the 2007 research article "High Tunnel and Field Plasticulture Strawberry Evaluation" published in the *2007 Fruit and Vegetable Crops Research Report* (PR-555), three 4-foot by 100-foot raised plastic mulched beds were prepared inside and outside for the strawberry evaluation conducted during the 2006-2007 growing season. Only two of these beds inside and two outside were utilized during that trial, which allowed for the space of the third bed to be used for a second year of new data collection in 2008. To prepare the unused third beds, in the inside and outside plots, plastic mulch was removed, and compost at a rate of approximately 30 tons/A was applied 20 August 2007. The beds were then spaded with an Imants spading machine and were reformed and recovered with new plastic mulch on 26 August 2007. Transplanting took place on 7 September 2007, using a waterwheel setter.

Two strawberry varieties, Chandler and Camerosa, were evaluated in this study. The plants transplanted in 2007 for this 2008 study were propagated from tip cuttings from field plants started in 2006. Each treatment consisted of 20 plants set in staggered double rows, spaced 1 foot apart in the row with 1 foot between rows. There were four replications in a randomized block design. Plants were drip irrigated as needed. The area between the rows of plastic both in the Haygrove tunnel and the field plots was kept weed free using mechanical and hand cultivation.

Only two pest species, whitefly (*Trialeurodes vaporariorum)* and spider mite (*Tetranychus urticae).* were problematic in the spring and required action. An insecticidal soap (M-pede, Dow Agrochemical) and Pyganic spray were applied on alternate weeks between 13 March 2008 and 4 April 2008 to control these pests. The greenhouse plastic was initially raised over the Haygrove tunnels on 12 March 2008 and remained in place until October. As opposed to 2007, only the top plastic was put in place in 2008, and the side and end-walls were not used.

The 10-foot plot sections in each plot were harvested in the spring of 2008. Yield, fruit size, flavor, and appearance data were collected. The 2008 season started out wet, then turned dry in June and remained dry. Fifteen berries were weighed at each harvest to determine average berry weight. Berry taste, firmness, and appearance were assessed on 19, 23. and 27 May and 2, 5, and 9 June 2008. Plants were rated for leaf spot disease on 17 July 2008.

Results and Discussion

Production System

Average first harvest was a week earlier in the high tunnel strawberries compared to those grown in the field (Table 1). This was unexpected as the high tunnels were not managed in a manner to promote early season harvest by erecting side and end walls on the tunnels. Simply having the tunnel covered on the top allowed for an earlier first harvest. Total days of harvest were also significantly different between the production systems, as high tunnel berries were harvested for eight more days than the field-grown berries.

Neither total yield nor average berry weight was significantly different between the high tunnel berries and the field-grown berries when totaled over the entire harvest. This differs from results from the same experiment in 2007 when high tunnel berries yielded significantly higher, though this was likely due to being protected from a 2007 mid-spring hard freeze that occurred when the strawberries were in bloom. In addition, improved plant fertilization practices, based on the high rate of compost used in 2008, may have contributed to the lack of yield differences between the systems.

No differences in the taste, firmness, or appearance of berries from either the high tunnel or field-grown plants were observed. Quality overall was very good for berries produced in both production systems. However, by 17 July 2008 when the leaf scorch disease rating was conducted, differences in production system were present with hardly any high tunnel plants exhibiting leaf scorch symptoms, while the field plants did. Still, overall levels of this disease were exceptionally low due to the dryness of the summer period in central Kentucky.

Table 1. Strawberry yield, berry weight, and harvest date, 2008.

	Yield[1] (lb/A)		Avg. Berry Wt.[2] (g/berry)		1st Harvest (date)		Harvest Midpoint[3] (date)		Days of Harvest	
Variety										
Chandler	12,127	A	16.7	A	11 May	A	15 May	A	27	A
Camerosa	10,158	A	15.7	A	11 May	A	14 May	A	25	A
Production System										
High tunnel	12,025	A	15.9	A	5 May	B	14 May	B	30	A
Field	10,261	A	16.7	A	11 May	A	17 May	A	22	B

1 Means within a column followed by the same letter are not significantly different (Duncan's multiple range test LSD P = 0.05).
2 Average berry weight based on the weight of 15 berries at each harvest.
3 Date on which half of the berries were harvested, based on total yield weight.

Variety

Both strawberry varieties performed equally well compared to one another in all phases of the experiment. No significant differences in yield, average berry weight, first harvest date, harvest midpoint, or days of harvest were detected based on variety. There were no differences between the varieties in flavor or appearance, though Camerosa was rated as being slightly firmer than Chandler. Leaf scorch symptoms were more prevalent on Chandler than Camerosa, but neither variety was particularly infected with this disease.

However, neither variety yielded significantly different from each other. Variety choice is an important facet of plasticulture organic strawberry production, particularly if growers want to maintain a planting past the first year's harvest. Observations from this experiment when strawberry beds were carried over into a second year of harvest showed much better survival in the high tunnel plots than the field plots. If organic growers use varieties that are susceptible to disease such as Camerosa and Chandler, then producing them in a high tunnel environment should increase their chance of success.

Table 2. Strawberry flavor, firmness, appearance, and foliar disease rating, 2008.

	Taste[1,2] (1-5)	Firmness[3] (1-5)	Appearance[4] (1-5)	Leaf Scorch[5] (% leaf surface affected)
Variety				
Chandler	3.7 A	3.4 B	4.0 A	2.6 A
Camerosa	3.7 A	3.7 A	3.9 A	2.2 B
Production System				
High tunnel	3.7 A	3.5 A	4.0 A	0.2 B
Field	3.7 A	3.5 A	3.9 A	4.6 A

1 Taste rating: 1 = poor; 5 = excellent on 19, 23, 27 May and 2, 5, and 9 June.
2 Means within a column followed by the same letter are not significantly different (Duncan's multiple range test LSD P = 0.05).
3 Firmness rating: 1 = poor; 5 = excellent on 19, 23, 27 May and 2, 5, and 9 June.
4 Appearance rating: 1 = poor; 5 = excellent on 19, 23, 27 May and 3, 5, and 9 June.
5 Leaf scorch foliar disease rating: Three leaves were evaluated from three areas in each treatment on 17 July 2008. Value is the percent leaf surface infected.

Acknowledgments

The authors would like to thank the following for their hard work and assistance in this year's trial: Matthew Anderson, Katie Bale, Jessica Ballard, Charles Bobrowski, Sean Bessin, Ryan Capito, Jessica Cole, Jessica Dye, Meredith Hall, Lucas Hanks, Ellen Meyer, Dave Lowry, Julie Pfeiffer, Tyler Pierce, Kirk Ranta, Kiefer Shuler, Matthew Simpson, Joseph Tucker, Bonka Vaneva, David Wayne, and Sarah Yates.

Organic Small Fruit Production Using Haygrove Tunnels: Second-Year Update and Raspberry Production Yield Information

Derek Law and Mark Williams, Department of Horticulture

Introduction

The environmental difficulties in Kentucky for organic fruit production are well known. During the summer months, which are characteristically warm and often moist, insect and disease pests tend to flourish. In addition, insect and disease populations that can affect fruit production can build to difficult-to-manage levels over time when the climate is conducive. Organic growers have many techniques to profitably produce crops in such a difficult environment, including crop rotation, cover cropping, careful attention to cultural practices, use of disease-resistant varieties, release and attraction of beneficial insects, and, as a last resort, well-timed use of organically approved pesticides and fungicides. An additional technology that has the potential to revolutionize organic fruit production for Kentucky fruit producers is the use of high tunnels.

High tunnels are simply an unheated plastic-skinned, metal-framed structure covering a crop. In general, fruit crops grown under high tunnels are easier to manage, produce higher fruit yield, bear higher percentages of top-quality fruit, and decrease disease and insect pressure (Koester, 2003). High tunnels have allowed growers to expand their marketing window for small fruits and berries by extending their harvest season and have aided efforts to control troublesome disease and insect pests of crops like strawberries, raspberries, blueberries, blackberries, and cherries.

To evaluate and exhibit the use of high tunnels for Kentucky growers, an organically managed small fruit planting containing blueberries, blackberries, strawberries, and raspberries has been established at the University of Kentucky Horticultural Research Farm in Lexington, Kentucky. The small fruits are planted in two adjacent locations; one uncovered in the field, and one under an unheated Haygrove high tunnel structure. The following report will detail the progress of the blackberry and blueberry crops, report the yield information collected from the raspberries in the second year of this study, and detail the challenges and future concerns we have for the project. Information about the establishment year of this project can be found in the *2007 Fruit and Vegetable Crops Research Report* (PR-555).

Blueberries

Plastic was raised over all the tunnels on 12 March 2008. Spring soil tests indicated a pH around 6.5, so elemental sulfur was applied at the rate 5 lb per 4-foot by 100-foot long bed to bring the overall pH in the blueberry beds down to the pH target range of 4.2 to 5.5. A few individual plants that had died during the establishment year (2007) were replaced 21 April 2008. Two new late-maturing varieties, Chandler and Aurora, were added to the high tunnel and outside plots. A mix of Nature's Safe organic fertilizer (13-0-0 and 8-5-5) was applied to all blueberry plants in late April at the rate of approximately 60 lb/N per acre. At bloom, all flowers were removed by hand to delay the production of berries until at least their third season of growth. Weeds were controlled between rows using a tractor-pulled cultivator and in the raised bed mulched rows, by hand, throughout the season.

Blackberries

In spring 2008, a cedar and wire trellis support system was constructed. Pruning and fertilization with compost application at a rate of 35 tons per acre were performed in April. Second-year plants flowered and developed fruit, but yields from both inside and outside the high tunnel were negligible, and it was decided not to collect yield data this year. We focused on maintaining excellent weed control via cultivation and straw mulching, plenty of irrigation, and a high level of fertilization. Plants at the end of the season appeared to be in excellent condition.

Raspberries

Cultural Practices

Raspberries proved to be a very successful crop under this management system in this first year of study. Yield data from nine varieties planted in 2007—Boyne, Encore, K-81-6, Prelude, and Titan (June-bearing cultivars); Caroline, Autumn Britten, Polana, and Heritage (fall-bearing cultivars)—are presented here. All second-year plants were pruned (26 March 2008) in a manner to promote early summer fruiting. This required a normal pruning regimen for the June-bearing cultivars, but for the fall-bearing varieties. floricanes were thinned to four vigorous, healthy canes per foot and pruned to 4 feet in height rather than pruned to the ground. All plants received a heavy compost application in the spring at a rate of approximately 35 tons per acre. Three additional varieties—Jaclyn, Lauren (June-bearing cultivars), and Josephine (fall-bearing cultivar)—were planted (28 April 2008) this year to fill in both the inside and outside plots. A simple cedar and T-post trellis support was put in place for both the inside and outside plots.

Harvest, Insect, and Disease Observations

Harvest data collection began 9 June 2008 for both inside and outside plots. High tunnels do have the potential to allow growers to begin harvest at an earlier date than crops outside if the tunnel is kept sealed at the end walls and sides, particularly during early spring frost events. This was not done in 2008 as it was decided that increased airflow during the spring would be beneficial to decreasing plant disease pressure.. Thus, the plastic that was stretched over the tunnel 12 March 2008) was only over the top of the tunnel, and little to no season extension effect was expected. Early-season harvest, from 9 June 2008 to 25 July 2008, was conducted every four to five days; late-season harvest, from 31 July 2008 to 18 October 2008, was conducted once per week due to a shortage of harvest labor.

Both good ripe berries and cull berries were harvested and weighed at each picking. Cull berries were often just overly ripe berries that, if harvest had been conducted more regularly, could likely have been counted as good, edible berries. However, cull berries were found that could be traced to many other causes such as grey mold (*Botrytis cinerea*), late leaf rust (*Pucciniastrum americanum*), anthracnose (*Elsinoe veneta*), fruit feeding by Japanese (*Popillia japonica*) and green June beetles (*Cotinis nitida*), fruit probing by stink bug and tarnished plant bug, and sunburn. Nevertheless, increased harvesting frequency would have likely decreased cull percentages by a significant margin in both covered and uncovered plantings.

Despite the various disease and insect problems that manifested themselves on these plantings throughout the season, no pesticides or fungicides were used during the 2008 season. The reasoning for this was two-fold; invariably, the insect and disease pressure was substantially lower in berries grown in the high tunnel so we wanted to see what the effect of the tunnel alone might be, and in both plots a population of beneficial insects had been established. Identified beneficial insects in these plots included lacewings, lady beetles, and praying mantis, while populations of other insects including various ground beetles, spiders, stink bugs, flies, mites, and wasps were noticed and assumed to be either beneficial or neutral when they were not observed causing damage to fruit or foliage. In addition, two predatory mite species were released inside the high tunnels, *Phytosieulus persimilis* and *Neosiulus fallacis* (IPM Labs), to combat small infestations of spider mites found late in the growing season. Though no pest or beneficial insect population data were collected in 2008, field observations indicated that the protected environment of the high tunnel allowed for generally much lower levels of disease and pest insects and higher levels of beneficial insects in raspberries.

The fact that no insect or disease products were utilized during 2008 does not mean that there are no plans for their use in the future. It is expected in the spring in 2009, after pruning and removing all spent canes from the plot, a lime sulfur spray will be applied to combat any plant disease remaining from 2008. In addition, it is expected, along with continued releases of predatory mites, that additional generalist beneficial insects will be released in early 2009 to ensure pest populations remain low. However, for some insects, particularly Japanese and green June beetles, occasional use of organic pesticides may be justified in the future depending on their yearly infestation levels.

Results

Yield and cull data were recorded in grams from 24 row feet per variety but have been presented here in half pints per 10 row feet for ease of comparison for growers (Table 1). Highest early-yielding varieties were Boyne, Encore, and Autumn Britten inside the high tunnel and Autumn Britten, Boyne, and Prelude outside. Highest late-yielding varieties were Heritage, Caroline, and Polana in that order, in both inside and outside plots. Highest total yields were collected from Heritage, Caroline, Prelude, and Polana inside, while outside Autumn Britten, Prelude, Heritage and Caroline fared best. Titan and K-81-6, both June bearers with exceptionally large berries, fared the worst of all varieties both inside and outside. The effect of higher insect pressure, particularly by Japanese and green June beetle feeding, which began in early July, can be seen on the varieties Prelude, Caroline, Autumn Britten, and Heritage. All of these varieties had similar early-season yields, but late-season yields suffered greatly in the outside plots. The percent of berries that were culled shows a similar trend with the inside plots showing a much lower percent culled than those grown outside.

Potential yield is only given as a comparison between varieties. As this is not a replicated experiment and these are only data from a single year, such projected yield amounts should be viewed with caution. Still, the possibility of harvesting between 1,500 and 2,500 half pints from a single 25-foot by 100-foot high tunnel structure indicates the earning potential of using a high tunnel for raspberry production. Considerations for growers interested in organic raspberry production in high tunnels will include initial cost of high tunnel structure, choice of varieties based on desired timing of harvest, pruning management choices, insect and disease management options, and harvest labor cost and availability.

Table 1. Raspberry yield (half pints),[1] inside and outside a Haygrove high tunnel, by variety, 2008.

	Yield per 10 Ft of Row (half pts)	Culls (%)	Yield per 10 Ft of Row (half pts)		Potential Yield[3] (half pts per 288 row ft)
			Prior to 25 July 2008[2]	After 25 July 2008[2]	
Inside Haygrove Varieties					
Heritage	88	21.9	18	70	2535
Caroline	61	29.7	4	57	1762
Prelude*	54	20.5	24	30	1564
Polana	52	18.1	19	32	1494
Autumn Britten	48	24.2	27	20	1370
Boyne*	44	8.2	43	1	1279
Encore*	34	12.0	34	0	969
K-81-6*	24	12.6	24	0	695
Titan*	11	17.3	11	0	315
Outside Haygrove Varieties					
Heritage	32	42.1	9	23	920
Caroline	31	42.6	5	26	893
Prelude*	34	29.7	22	12	987
Polana	26	29.6	11	14	737
Autumn Britten	39	26.9	29	9	1113
Boyne*	23	11.5	23	0	651
Encore*	12	27.9	12	0	346
K-81-6*	19	22.8	19	0	550
Titan*	11	27.2	11	0	325

1 Half pint = 150 grams.
2 The date 25 July 2008 was chosen as a midpoint in the harvest season as four of the nine varieties had completed production by that date.
3 Potential yield refers to the area of one Haygrove high tunnel bay. Each bay is 25 feet by 100 feet. At 2 feet between plants, 7 feet between rows, and 5.5 feet from the edge row to the edge of the high tunnel, 288 row feet of raspberries can fit into a 2,500 square foot area.
* = June-bearing variety.

Literature Cited

Jones, T., and J. Strang. 2005. Growing Blackberries and Raspberries in Kentucky. University of Kentucky College of Agriculture Cooperative Extension, Publication HO-15.

Koester, K., and M. Pritts. 2003. Greenhouse Raspberry Production Guide. Cornell University Department of Horticulture, Publication 23.

Law, D., and M. Williams. 2007. Optimizing organic culture of select small fruits in Kentucky using Haygrove tunnels. 2007 Fruit and Vegetable Crops Research Report (PR-555). pp. 47-49. University of Kentucky Agricultural Experiment Station.

Rootstock and Interstem Effects on Pome Fruit Trees

Dwight Wolfe and Joseph Masabni, Department of Horticulture

Introduction

Apple is the principal tree fruit grown in Kentucky, although the hot and humid summers and heavy clay soils make apple production more difficult in Kentucky than in some neighboring apple-producing regions with more favorable conditions. The hot and humid summers also lead to high disease and insect pressure in Kentucky orchards. Despite these challenges, productive orchards offer high per acre income and are suitable for rolling hills and upland soils. Furthermore, orchards on these sites have less soil erosion potential.

Kentucky imports more apples than it produces. Identification of improved rootstocks and cultivars is fundamental for advancing the Kentucky apple industry. For this reason, Kentucky cooperates with 39 other states and three Canadian provinces in the Cooperative Regional NC-140 Project titled "Rootstocks and Interstem Effects on Pome Fruit." The NC-140 trials are critical to Kentucky growers, allowing them to gain access to and test new rootstocks from around the world. The detailed and objective evaluations allow growers to select the most appropriate rootstocks for Kentucky.

The 1999 apple rootstock trial compared eight dwarf and three semi-dwarf rootstocks that have not been tested previously at the University of Kentucky Research and Education Center (UKREC) at Princeton, Kentucky. The 2002 apple rootstock trial provided information on performance differences among newly released rootstock clones. The 2003 apple rootstock trial evaluated the adaptability of some new rootstocks to Kentucky climates and soils. The 2003 apple rootstock physiology trial primarily evaluated the relationship between different environments (sites), crop loads, and fruit size.

The NC-140 orchard trials are demonstration plots for visiting fruit growers, extension personnel, and researchers. The data collected from these trials will help establish base-line production and economic records for the various orchard system/rootstock combinations that can be used later by Kentucky apple growers.

Materials and Methods

Grafts of known cultivars on the various rootstocks were produced by nurseries and distributed to cooperators for each planting. The University of Kentucky has three NC-140 rootstock plantings at the University of Kentucky Research and Education Center (UKREC) at Princeton, Kentucky:

I. The 1999 dwarf and semi-dwarf apple rootstock trial consists of two groups (both have Fuji as the scion cultivar):
   i) 11 dwarfing rootstocks with six replications per rootstock. Trees are planted on 10-foot x 16-foot spacing.
   ii) 6 semi-dwarfing rootstocks with six replications per rootstock. Trees are planted on 13-foot x 20-foot spacing.

Eight of the dwarfing and three of the semi-dwarfing rootstocks have not been tested previously at UKREC.

II. The 2002 apple rootstock trial compares nine rootstocks: three clones of M.9, two clones each of B.9 and M.26, and one clone each of Supporter 4 and of P.14. All have Buckeye Gala as the scion. Seven replications of each rootstock were planted in a randomized complete block design. The planting has seven rows with a pollenizer tree at the ends of each row. A trellis was constructed and trickle irrigation installed a month after planting. Trees are spaced 8 feet apart within rows 15 feet apart.

III. The 2003 apple rootstock trial compares 11 rootstocks with Golden Delicious as the scion cultivar. Two trees of each rootstock were planted in a randomized, complete block design with four replications (blocks). Trees are planted on 8-foot x 15-foot spacing.

Orchard floor management consists of a 6.5-foot bare-ground herbicide-treated strip with mowed sod alleyways. Trees are fertilized and sprayed with pesticides according to local recommendations (1, 2). Yield and trunk circumference measurements are recorded for all of the rootstock trials, and trunk cross-sectional area is calculated from the trunk circumference measurements taken 10 inches above the graft union. Cumulative yield efficiency is the cumulative yield divided by the trunk cross-sectional area of the tree. It is an indicator of the proportion of nutrient resources a tree is putting into fruit production relative to vegetative growth. Tree height and canopy spread (the average of the within-row and across-row tree widths) are recorded at the end of the fifth and final (usually the tenth) seasons of each trial. Fruit size is calculated as the average weight (oz) of 50 fruits.

Results and Discussion

As reported in 2007 (3), all of our NC-140 apple plantings at UKREC sustained damage that severely reduced yield in that year due to a series of devastating freezes from 5 April through 10 April 2007, that affected all fruit crops in Kentucky. This year, Hurricane Ike blew through western and northern Kentucky on 14 September 2008. At UKREC, some fruit was blown off trees, and some trees were broken at either the graft union or at their roots just below the soil line. Nevertheless, the heavy bloom this past spring and a generally excellent growing season resulted in excellent yields at harvest.

I. 1999 Dwarf and Semi-Dwarf Apple Rootstock Trial

Cumulative yield, yield in 2008, trunk cross-sectional area, and cumulative yield efficiency varied significantly only among the dwarf rootstocks (Table 1). In the dwarf trial, scions on CG.3041 (also known as CG.41) had the highest cumulative yield, and those on CG.4013 were largest in terms of trunk cross-sectional area. Scions on Supporter 1 had the highest cumulative efficiency.

In the semi-dwarf trial, scions on CG.30N were the largest trees and also had the highest cumulative yield. However, trees on M.7 EMLA had the highest cumulative efficiency.

Neither tree mortality nor fruit size varied significantly by rootstock for either the dwarf or semi-dwarf group. In dwarf trial, two trees with Supporter 3 rootstocks and one tree with M.9 NAKBT337 were broken off at their roots just below the soil line due to Hurricane Ike. In the semi-dwarf trial, one tree with CG.5202 was broken at its graft union. Between the two trials, scions on Supporter 4 have sustained the highest mortality with only 17% of these trees still alive.

Table 1. 2008 results for the 1999 NC-140 dwarf and semi-dwarf apple rootstock trial, UKREC, Princeton, Ky.

Rootstock[1]	Percent Survival (no. trees planted)	Cumulative Yield (2001-2008) (lb/tree)	Yield (lb/tree)	Fruit Weight (oz)	Trunk Cross-Sectional Area (sq. in.)	Cumulative Yield Efficiency (lb/sq. in.)
Dwarf						
CG.3041	50 (2)	755	228	5.6	14.3	52.9
CG.4013	100 (4)	750	215	5.7	21.5	35.1
G.16T	100 (5)	735	242	5.3	14.5	51.3
CG.5179	83 (6)	717	251	5.4	13.8	51.7
CG.5202	60 (5)	680	253	5.4	14.8	47.4
G.16N	100 (4)	668	214	5.1	14.8	45.6
M.9NAKBT337	67 (6)	597	196	5.3	12.7	48.9
Supporter 2	100 (6)	243	178	4.9	10.3	53.2
Supporter 1	100 (6)	497	151	4.6	8.1	62.2
Supporter 3	67 (6)	488	160	5.0	9.2	52.7
M.26 EMLA	83 (6)	485	177	4.8	11.8	41.5
Mean	91	611	201	5.1	12.8	49.8
LSD (5%)	NS	182	65	NS	3.6	13.6
Semi-Dwarf						
CG.30N	100 (2)	942	284	6.8	19.9	47.3
CG.7707	60 (5)	652	178	6.7	17.6	37.3
CG.4814	80 (5)	612	226	6.0	15.4	39.6
M.26 EMLA	67 (6)	510	177	6.2	14.2	35.2
M.7 EMLA	100 (6)	488	146	5.9	16.6	33.1
Supporter 4	17 (6)	178	48	4.8	3.2	56.3
Mean	67	572	182	6.3	15.7	38.0
LSD (5%)	NS	NS	NS	NS	NS	NS

[1] Arranged in descending order of cumulative yield.

II. 2002 Apple Rootstock Trial

Sixty-three trees of Buckeye Gala were planted. A few trees have been lost to fire blight and wind breakage, but significant differences in tree mortality have not been observed to date (Table 2). Significant differences were observed for cumulative yield, yield in 2008, fruit size, fall trunk cross-sectional area, and cumulative yield efficiency (Table 2). The cumulative yield and tree size were greatest for trees on P.14, and M.9 Burgmer 756. P.14 and B.9 Europe rootstocks have produced the largest and smallest trees, respectively, in this trial. Trees with scions on the two B.9 rootstock strains (Treco and Europe) have the highest cumulative yield efficiencies.

Table 2. 2008 results from the 2002 NC-140 rootstock trial, UKREC, Princeton, Ky.

Rootstock[1]	Percent Survival (no. trees planted)	Cumulative Yield (2004-2008) (lb/tree)	Yield (lb/tree)	Fruit Weight (oz)	Trunk Cross-Sectional Area (sq. in.)	Cumulative Yield Efficiency (lb/sq. in.)
P.14	57 (7)	368	192	6.3	17.4	21.3
M.9 Burgmer 756	29 (7)	300	118	6.3	11.5	26.1
M.9 NAKB T337	43 (7)	231	69	5.9	9.7	23.2
M.26 NAKB	71 (7)	222	85	5.9	9.2	23.7
M.9 Nic29	71 (7)	212	75	5.5	7.1	29.8
Supporter 4	57 (7)	211	81	5.9	6.3	32.9
M.26 EMLA	57 (7)	199	56	5.8	7.2	27.4
B.9 Treco	86 (7)	128	34	4.9	3.5	37.2
B.9 Europe	71 (7)	77	16	4.5	2.1	36.2
Mean	60	203	75	5.6	7.6	29.5
LSD (5%)	NS	88	48	1.1	3.0	5.9

[1] Arranged in descending order of cumulative yield.

III. 2003 Apple Rootstock Trial

Mortality, cumulative yield, yield in 2008, fruit size, trunk cross-sectional area, and cumulative yield efficiency all varied significantly among the rootstocks in this trial (Table 3). Cumulative yield and tree size were greatest for trees with scions on PiAu56-83, but cumulative yield efficiency was highest for scions on CG.5935. Mortality has been greatest for scions on G.16 and CG.5935.

Literature Cited

1. Bessin, R.T., R.T. Jones, J.G. Strang, J.G. Masabni, and J.R. Hartman. *2008 Commercial Tree Fruit Spray Guide*. University of Kentucky College of Agriculture Cooperative Extension Service, Publication ID-92.
2. *Midwest Tree Fruit Pest Management Handbook*. University of Kentucky College of Agriculture Cooperative Extension Service, Publication ID-93.
3. Masabni, J.G., and D.E. Wolfe. 2007. Rootstock and interstem effects on pome fruit trees. 2007 Fruit and Vegetable Crops Research Report (PR-555). pp. 50-52. University of Kentucky Agricultural Experiment Station.

Table 3. 2008 results for the 2003 NC-140 apple rootstock trial, UKREC, Princeton, Ky.

Rootstock[1]	Percent Survival (no. trees planted)	Cumulative Yield (2005-2008)[2] (lb/tree)	Yield (kg/tree)	Fruit Weight (oz)	Trunk Cross-Sectional Area (sq. in.)	Cumulative Yield Efficiency (lb/sq. in.)
PiAu56-83	100 (8)	372	232	7.0	21.8	17.2
PiAu51-4	100 (7)	360	247	6.7	19.0	19.3
J-TE-H	100 (8)	351	224	6.1	8.9	39.7
CG.5935	50 (8)	330	197	7.1	8.1	40.4
M.9 Pajam2	100 (8)	307	219	6.5	9.8	30.9
Bud.62-396	100 (8)	273	232	6.7	7.9	34.5
CG.3041	88 (8)	271	182	6.0	7.1	38.1
G.16	50 (8)	259	174	5.7	7.7	33.8
M.9 NAKBT337	88 (8)	253	165	6.5	7.8	32.0
M.26	88 (8)	240	168	6.3	8.3	29.2
B.9	63 (8)	72	45	4.2	2.2	32.6
Mean	84	288	189	6.3	10.4	31.1
LSD (5%)	31	86	57	0.6	2.3	6.2

1 Arranged in descending order of cumulative yield.
2 There was no yield in 2007 due to a spring freeze and extensive bird damage during that season.

Assessing Lime Sulfur as an Organic Fruit Thinning Agent for Apples

Douglas D. Archbold, Department of Horticulture

Introduction

Of all the cultural practices involved in apple production, fruit thinning is one of the most critical. Without fruit thinning, a large proportion of the fruit crop would be undersized and of poor quality, and the trees would be thrown into a biennial bearing pattern with alternating heavy and light crop years. Thinning is conventionally done with synthetic chemicals like Sevin (carbaryl) or NAA, because hand thinning is very labor intensive and cost prohibitive. In a survey of organic apple growers in the United States, fruit thinning was listed as a major issue with no clear solution (Clark and Evans, 2002). Unfortunately, there are no thinning agents that are recommended for use in organic apple production. Lime sulfur (LS) may have potential as an organic thinning agent and could be used by conventional apple growers as well. While it has been known for a number of years that the material has thinning potential, it is only as the need for organic alternatives has grown that more attention has been paid to it (Koike and Ono, 1998; McArtney et al., 2000; Robinson et al., 2002). The LS has been combined with fish oil (FO), with the oil acting as a surfactant to increase LS uptake. Fruit thinning after petal fall (PF) is commonly performed in Kentucky so that the chance of frost has passed since frost can also thin fruit. Though it was evident from early work that LS application 7 to 10 days after petal fall thinned the crop and increased fruit size at harvest, it has not been studied under Kentucky growing conditions. The objective of this research was to assess the ability of the organically approved LS/FO to fruit thin apple trees under Kentucky growing conditions to achieve acceptable fruit size and quality

Materials and Methods

In 2004, one or two sprays of LS/FO (Crocker's Fish Oil, Quincy, WA) were applied as branch treatments to five cultivars: Royal Gala, Red Fuji, Golden Glory Golden Delicious, and Redchief Delicious on M7 or M7a rootstocks planted in 1993 at the University of Kentucky Horticultural Research Farm in Lexington. The LS/FO was applied until dripping with a hand-pump sprayer once at 4%/2.5% (v/v) on three dates: PF, PF + 5 days, PF + 10 days, or twice at PF plus 5 or 10 days. There were five replicate branches per treatment on each of three trees per cultivar. Foliar and fruit phytotoxicity were assessed periodically after treatments.

LS/FO (4%/2.5%) was applied with an air-blast sprayer once at PF + 7 days to entire trees of Redfree, Royal Gala, and Golden Glory Golden Delicious apple in 2005, and once in 2006 at PF + 7 days to the same cultivars as in 2005 plus Redchief Delicious, Red Fuji, and Stayman Winesap. The effect of the LS/FO both years was compared to trees receiving a single application of Sevin at the commercial rate of 1,000 ppm on the same date, and untreated control trees were included for comparison in 2006. Fruit per 100 fruit clusters on four branches per tree were counted 6 to 8 weeks after the treatments both years. In 2006, fruit were harvested when ripening was evident in each cultivar, and mean fruit weight was derived from the weight of 50 fruit per tree. There were three trees per cultivar and treatment each year.

Results and Discussion

In 2004, leaf phytotoxicity was evident on most LS/FO treatments, with more damage from two applications than a single one, but no fruit damage was observed by mid-season.

Most leaf injury occurred on leaves that were immature at the time of application. Leaves with severe symptoms eventually dropped from the trees, but most leaves survived. As the season progressed, leaf injury symptoms were not evident.

Compared to Sevin applications for fruit thinning, the results were promising in 2005, as LS/FO application reduced fruit load almost 60% across the three cultivars (Table 1). Leaf and fruit phytotoxicity symptoms were evident but minimal, suggesting that the LS/FO rate could be an effective technique for Kentucky growers.

In 2006, leaf phytoxicity from LS/FO was severe on Gala and Redfree but was less on the other cultivars. Two cultivars, Golden Delicious and Fuji, showed no significant response to either thinning compound, less than a 10% reduction in fruit/100 clusters, so they were omitted from the analysis; means in Table 1 are from the cultivars showing a significant response. While Sevin reduced fruit number by 20%, the LS/FO application reduced fruit number more than 50% across those cultivars responding. Fruit size at harvest was greater on those trees receiving thinning compounds, though there were no differences in fruit sizes when comparing LS/FO to Sevin. However, russeting on Gala and Redfree fruit skin was observed in the LS/FO treatments.

This work indicated that LS/FO could effectively thin some apple cultivars with a single application at 5 to 10 days after petal fall. In addition to cultivar variation in the thinning response to LS/FO, leaf injury and fruit russeting also varied among cultivars. Seasonal variation in injury symptoms was also noted, suggesting drying conditions after LS application may be important. Lower rates and/or split applications of LS, and perhaps use of surfactants other than FO, need to be assessed before commercial recommendations on use of LS as a post-bloom fruit thinner in apple can be developed.

Table 1. Comparing Sevin and lime sulfur plus fish oil (LS/FO) for post-bloom fruit thinning of apple. Means followed be different letters are significantly different by Tukey's test at α = 0.05.

Treatment	2005 Fruit/100 Clusters	2006 Fruit/100 Clusters	Mean Fruit Weight (g)
Untreated	-	112 a	132 b
Sevin	140a	79 b	154 a
LS/FO	58b	52 c	158 b

Acknowledgments

The author would like to thank Darrell Slone, Dave Lowry, Marta Nosarzewski, Valeria Sigal Escalada, and Federica Galli for contributions to this work.

Literature Cited

Clark, J.R., and M.R. Evans. 2002. Horticultural studies 2001. Arkansas Agricultural Experiment Station Research Report, University of Arkansas, Research Series 494.

Koike, H., and T. Ono. 1998. Optimum crop load for apples in Japan. Compact Fruit Tree 31:13-16.

McArtney, S., J. Campbell, K. Foote, and H. Stiefel. 2000. Thinning options for organic apple production. The Orchardist 10:32.

Robinson, T., et al. 2002. Progress Report for Toward Sustainability Foundation, Cornell University, Ithaca, New York.

Peach Variety Demonstration

Dwight Wolfe, Joseph Masabni, and June Johnston, Department of Horticulture

Introduction

One of the initial and most important decisions every fruit grower makes is the choice of cultivars. Although cultivar performance and fruit quality information is very useful, obtaining this information is time consuming, due to the time required for fruit trees to begin bearing fruit. It is also expensive due to the large number of cultivars available. One way of reducing this cost is to conduct a variety trial of the most recent cultivars with potential of performing well in Kentucky.

Materials and Methods

In 2004, a block of 37 peach cultivars was planted in the orchard of the University of Kentucky Research and Education Center at Princeton, Kentucky (1). This planting consisted of two trees per variety spaced 6 feet apart within rows 18 feet apart. The phenology (timing of flowering, etc.) of each cultivar was recorded in 2005 (1) and 2006 (2) and again in 2007 and 2008. Yield, fruit size (average weight of 25 fruits), and Brix readings of three fruits were recorded at harvest in 2006 and 2008. No fruit was harvested in 2007 due to a series of freezes from April 5 through April 10, 2007, that affected all fruit crops in Kentucky.

Results and Discussion

Phenology of each peach cultivar for 2007 and 2008 is presented in Table 1. Although one might expect later-blooming cultivars to escape spring freezes, none of these cultivars did so during the April freeze of 2007. Yield, average weight per fruit, and average brix (sugar) reading are presented in Table 2. Allstar, Coralstar, Glowingstar, and Klondike averaged the highest yields per tree this year, but yield comparisons between any two cultivars in only one year should not be used as evidence that one is a better yielder than the other. All peach cultivars in this trial generally have good flavor. Flat Wonderful and Galaxy are peento (flat-shaped) peach cultivars, and Crimson Rocket and Sweet-N-Up are columnar cultivars that have an upright pillar-type growth habit. Blushingstar, Galaxy, Flat Wonderful, Klondike White, Snowbrite, Snow Giant, Spring Snow, Sugar Giant, Sugar May, and White Lady are white-fleshed cultivars. Numbered cultivars beginning with PF are Paul Friday selections.

Literature Cited

1. Masabni, Joseph, Dwight Wolfe, June Johnston, and Hilda Rogers. 2005. Asian pear, apple, and peach variety demonstrations. In: *2005 Fruit and Vegetable Crops Research Report*. PR-521:44-45.
2. Masabni, Joeseph, Dwight Wolfe, June Johnston, and Hilda rogers. 2006. Asian pear, apple, and peach variety demonstrations. In: *2006 Fruit and Vegetable Crops Research Report*. PR-538:41-425.

Table 1. Dates of phenological stages for peach cultivars at Princeton, Ky., for 2007, and 2008.[1]

Cultivar	Swollen Bud	Half-Inch Green	Pink	Bloom	Petal Fall	Fruit Set
Allstar	March 6, 21	March 14, 26	March 19, 28	March 21, 30	March 28, April 7	March 30, April 14
Blushingstar	March 6, 21	March 16, 26	March 19, 28	March 21, 30	March 28, April 7	March 30, April 14
Contender	March 6, 21	March 14, 26	March 21, 28	March 23, April 1	March 28, April 9	March 30, April 14
Coralstar	March 6, 21	March 14, 26	March 19, 28	March 21, 30	March 28, April 7	March 30, April 14
Cresthaven	March 6, 21	March 16, 26	March 21, 28	March 23, April 1	March 28, April 7	April 2, 14
Crimson Rocket	March 12, 26	March 14, 28	March 19, 30	March 21, April 7	March 28, April 14	April 2, 21
Encore	March 6, 21	March 14, 26	March 19, 28	March 21, April 1	March 28, April 11	April 2, 14
Ernie's Choice	March 6, 26	March 16, 28	March 21, 28	March 23, April 7	March 28, April 11	March 30, April 21
Flat Wonderful	March 14, 19	March 16, 21	March 19, 26	March 21 , 28	March 28, April 1	March 27, April 9
Galaxy	March 6, 17	March 9, 19	March 12, 21	March 14, 26	March 23, April 1	March 27, April 9
Glowinstar	March 6, 21	March 14, 26	March 21, 28	March 23, 30	March 28, April 7	March 30, April 14
John Boy	March 6, 21	March 14, 24	March 16, 26	March 21, 28	March 28, April 11	March 30, April 14
John Boy II	March 6, 21	March 16, 26	March 19, 26	March 21, 30	March 28, April 11	March 30, April 14
Klondike	March 6, 21	March 14, 24	March 16, 26	March 19, 28	March 28, April 7	March 30, April 14
Laurol	March 6, 21	March 14, 26	March 19, 28	March 21, 30	March 28, April 7	March 30, April 14
PF 1	March 12, 26	March 14, 28	March 21, 30	March 23, April 7	March 28, April 11	March 30, April 14
PF 15A	March 6, 19	March 12, 21	March 19, 28	March 21, 30	March 28, April 11	March 30, April 14
PF 17	March 6, 19	March 12, 21	March 16, 28	March 19, 30	March 28, April 9	March 30, April 14
PF 20-007	March 12, 21	March 16, 26	March 21, 28	March 23, April 7	March 28, April 9	March 30, April 14
PF 24C	March 12, 21	March 21, 26	March 23, 28	March 25, April 7	March 28, April 9	March 30, April 21
PF 25	March 12, 19	March 13, 21	March 14, 26	March 16 , 28	March 28, April 7	March 30, April 14
PF 27A	March 12, 19	March 13, 21	March 14, 26	March 16, 28	March 28, April 7	March 30, April 14
PF 35-007	March 12, 21	March 14, 26	March 19, 28	March 21, 30	March 28, April 9	March 30, April 14
PF 5 B	March 12, 21	March 14, 26	March 21, 28	March 23, 30	March 28, April 7	March 30, April 14
PF 7	March 12, 21	March 14, 26	March 21, 28	March 23, 30	March 28, April 7	March 30, April 14
PF Lucky 13	March 6, 21	March 12, 24	March 14, 26	March 16, 28	March 28, April 1	March 30, April 14
PF Lucky 21	March 6, 19	March 12, 21	March 14, 26	March 19, 28	March 28, April 7	March 30, April 14
Redhaven	March 6, 21	March 14, 26	March 19, 28	March 23, 30	March 28, April 11	March 30, April 14
RedStar	March 6, 21	March 16, 26	March 21, 28	March 23, April 4	March 28, April 11	April 2, 14
Reliance	March 14, 26	March 23, 28	March 24, April 1	March 25, April 7	April 2, 14	April 4, 21
Snow Brite	March 6, 21	March 16, 26	March 21, 28	March 23, 30	March 28, April 11	April 2, 14
Snow Giant	March 6, 21	March 14, 24	March 19, 26	March 21, 28	March 28, April 7	March 30, April 14
Spring Snow	March 6, 19	March 14, 21	March 16, 24	March 19, 26	March 28, April 7	March 30, April 11
Sugar Giant	March 6, 21	March 16, 24	March 21, 26	March 23, 28	March 28, April 7	March 30, April 14
Sugar May	March 6, 21	March 14, 24	March 16, 26	March 19, 30	March 28, April 11	March 30, April 14
Summer Breeze	March 6, 21	March 16, 26	March 21, 28	March 23, 30	March 28, April 7	March 30, April 14
Sweet-N-Up	March 12, 21	March 14, 26	March 19, 28	March 21, 30	March 28, April 7	March 30, April 14
White Lady	March 6, 21	March 14, 26	March 16, 28	March 21, 30	March 28, April 11	March 30, April 14

[1] For each stage of development and for each cultivar, the date for 2007 is listed first followed by the date for 2008.

Table 2. Results of the 2008 harvest from the 2004 peach cultivar trial at Princeton, Ky.

Cultivar	Date of Harvest	Cumulative Yield[1] (lb/tree)	2008 Yield (lb/tree)	Fruit Wt. (oz)	Brix (%)
Allstar	August 4	166.4	111.1	5.1	12.3
Blushingstar	August 7	103.0	55.9	4.8	12.4
Contender	August 4	166.7	119.2	4.5	12.0
Coralstar	August 1	126.4	89.9	5.4	14.8
Cresthaven	August 18	82.8	48.8	7.1	12.0
Crimson Rocket	July 30	10.6	8.1	3.7	14.8
Encore	August 26	131.4	80.0	6.9	12.7
Ernie's Choice (NJ 275)	July 30	3.0	2.6	3.4	16.8
Flat Wonderful	July 14	-	17.4	3.8	12.0
Galaxy	August 21	-	71.9	4.9	13.8
Glowingstar	August 7	180.7	112.2	5.6	10.9
John Boy	July 28	62.4	46.6	6.0	13.7
John Boy II	August 1	100.4	73.5	4.8	12.5
Klondike White	July 30	125.0	107.3	4.7	16.0
Laurol	August 28	143.7	87.3	6.2	12.7
PF 1	June 29	82.1	56.5	3.4	8.2
PF 15A	July 28	112.0	75.0	3.5	8.0
PF 17	August 4	118.3	75.6	5.4	10.7
PF 20-007	August 1	143.6	86.7	6.5	10.1
PF 24C	August 11	67.4	41.8	6.2	11.1
PF 25	August 21	99.5	79.5	4.9	13.2
PF 27 A	August 15	71.5	58.3	4.5	12.3
PF 35-007	August 15	60.8	36.9	5.1	13.8
PF 5B	June 29	85.2	59.8	3.4	10.0
PF 7	July 11	61.1	51.3	3.8	10.2
PF Lucky 13	July 21	123.0	86.0	3.1	11.0
PF Lucky 21	August 4	114.4	84.0	6.5	11.8
Redhaven	July 22	121.6	80.6	3.7	11.5
RedStar	July 22	77.0	49.2	4.0	12.1
Reliance	July 14	-	27.5	4.2	11.0
Snow Brite	July 14	27.7	26.2	2.5	10.6
Snow Giant	August 25	99.0	81.8	7.9	13.3
Spring Snow	June 27	-	5.1	3.1	9.6
Sugar Giant	August 15	18.5	16.7	5.4	11.3
Sugar May	July 8	-	21.3	2.5	9.2
Summer Breeze	July 25	94.7	70.0	5.0	10.8
Sweet-N-Up	August 7	29.6	29.5	7.3	14.7
White Lady	August 7	116.0	76.6	3.1	10.1

[1] Values are the sum of the yield in 2006 and 2008. There was no harvest in 2007 due to the spring freeze during that year. A "-" within this column indicates cultivars first harvested in 2008.

Romaine Lettuce Cultivar Trial

Dave Spalding and Timothy Coolong, Department of Horticulture

Introduction

Although romaine lettuce is not currently grown on a commercial scale in Kentucky, high fuel costs have sparked an interest in romaine lettuce production east of the Mississippi River to lessen transportation costs to eastern United States markets. Romaine lettuce production could be an early/short season crop for Kentucky growers looking to extend their growing season. This trial was designed to evaluate some of the varieties that are currently being grown in our region to determine which, if any, of these cultivars perform well in our area.

Materials and Methods

The trial was conducted at the University of Kentucky Horticultural Research Farm. Seed of 17 romaine lettuce cultivars and one green leaf cultivar were seeded in the greenhouse in 98-cell trays on 27 February 2008. Plants were transplanted to the field on 4 April 2008, in a randomized complete block design with four replications. Plants were transplanted into raised beds with black plastic mulch and trickle irrigation. Each cultivar in each replication had 20 plants planted in double rows with 12 inches between plants within the rows. The plot received a preplant application of 50 lb/A of N, 50 lb/A of P_20_5, and 50 lb/A of K_20, as indicated by soil samples. An additional 30 lb/A of N were applied through the trickle irrigation during the growing season. The plot was scouted regularly for disease and insects and sprays applied accordingly. The plot was harvested on 5 June. Ten plants from each cultivar and each replication were harvested and evaluated for color, leaf texture, plant frame, head weight, head length, core length, and overall rating. The green leaf cultivar BOS9115-GLX was planted for observation purposes only and proved to be a very acceptable green leaf lettuce cultivar.

Table 1. Average head weight, height, core length, and overall evaluation of romaine lettuce cultivars.

Cultivar	Avg. Weight[1] (lb)		Avg. Height[2] (in.)		Avg. Core Length[3] (in.)		Overall Evaluation of Cultivar[4]	
Jericho	2.37	a	14.8	a	3.8	ab	4.0	b
Plato II	2.34	ab	12.3	f	3.9	a	4.4	ab
Coastal Star	2.26	abc	13.7	bc	3.5	abc	4.7	a
BOS 9021-G	2.14	abc	13.0	cde	3.2	abcd	4.7	a
Green Forest	2.07	abc	13.2	cd	2.8	cde	4.9	a
EXP T12	2.03	abcd	12.7	def	2.8	de	4.6	a
Green Towers	2.00	abcd	12.6	def	2.8	cde	4.9	a
Rubicon	1.98	abcd	12.5	ef	2.7	de	4.6	a
Torrento	1.97	abcd	12.4	ef	2.8	cde	4.7	a
PIC 714	1.89	bcd	12.5	f	2.7	de	4.9	a
Ideal	1.87	cd	14.0	b	3.1	bcd	4.9	a
Fresh Heart	1.85	cd	12.6	def	3.1	bcd	4.5	ab
Parris Island	1.84	cd	12.2	f	2.6	de	4.4	ab
Nautilus	1.83	cd	12.6	def	2.7	de	4.7	a
Mirella	1.82	cd	12.6	def	2.8	cde	4.5	ab
Paragon PIC	1.80	cd	12.3	f	2.5	de	4.4	a
PIC-A	1.60	c	12.1	f	2.2	e	4.5	ab

* Treatments followed by different letters within a column are statistically different with $P<0.05$.
1 Weight is for the whole cut head.
2 Head height is measured from the cut base to the tip of the leaves.
3 Core length is measured from the cut base to the apex of the growth point.
4 The overall rating is a composite of rating factors and general appearance.

Results and Discussion

Color, leaf texture, and headshape were consistent within the cultivar in each replication (Table 1). The color of each cultivar was essentially the same except for Jericho which was a yellowish green and for Ideal which was a noticeably lighter green. Plant frame for the different cultivars was nearly indistinguishable except for Jericho which was noticeably taller. The leaf texture of most cultivars tended to be crinkled and Savoy-like in appearance except for the cultivar Ideal which was smoother and noticeably less Savoy-like in texture.

With the exception of the color of Jericho, all the cultivars were acceptable for color, plant frame, and leaf texture. Other characteristics of commercially acceptable romaine lettuce cultivars are head weights of about 1.5 pounds, head height or length of 10 to 12 inches, and a core length of less than 3.5 inches. Based on these characteristics, PIC 714, Green Forest, Ideal, and Green Towers were the highest-rated cultivars.

Weather conditions this spring were near normal as opposed to last spring when record cold temperatures in early April were followed by near record high temperatures in late April and most of May. With more normal weather conditions this spring, the results of this study should be more indicative of the characteristics of the cultivars examined.

Romaine Lettuce Spacing Study

Dave Spalding and Timothy Coolong, Department of Horticulture

Introduction

Although varieties of romaine lettuce have been tested for production in Kentucky, optimum within-row plant spacing has yet to be determined This study is intended to look at plant spacing as a means to maximize marketable production using the raised bed, plastic mulch, and trickle irrigation production system.

Materials and Methods

The study was conducted at the University of Kentucky Horticultural Research Farm. Seed of the Green Towers romaine lettuce cultivar was seeded in the greenhouse in 98-cell size trays on 27 February. Plants were transplanted to the field on 4 April, in a randomized complete block design with four replications. Plants were transplanted into raised beds with black plastic mulch and trickle irrigation. There were three treatments each planted in double rows in 10 feet of row with 15 inches between rows. In Treatment I, plants were spaced 12 inches apart in the row; Treatment II plants were spaced 9 inches apart in the row; and Treatment III plants were spaced 6 inches apart in the row. The plot received a preplant application of 50 lb/A of N, and P and K were applied preplant as indicated by soil samples. An additional 30 lb/A of N were applied through the trickle irrigation during the growing season. The plot was scouted regularly for disease and insects and sprays applied accordingly. The plot was harvested on 9 June. Ten plants from each treatment and each replication were harvested and evaluated for head weight, head height, core length, and yield per acre.

Table 1. Evaluation of plant spacing on romaine lettuce production.

In-Row Spacing	Avg. Head Weight (lb)	Avg. Head Height (in.)	Avg. Core Length (in.)	Yield (lb/A)
12-inch	2.37 A[1]	13.85 A	3.52 A	34,143 B
9-inch	2.03 B	13.45 A	4.07 A	43,837 A
6-inch	1.42 C	12.79 B	4.12 A	40,926 A

[1] Numbers in the same column followed by different letters are significantly different at *P<0.05*.

Results and Discussion

Average head weight was highest for the 12-inch spacing at 2.37 lb/head, and lowest for the 6-inch spacing at 1.42 lb/head. Average head height was not significantly different for the 12-inch and 9-inch spacing at 13.85 inches and 13.45 inches, respectively, but both were significantly taller than the 6-inch spacing at 12.79 inches. The average core length was not significantly different for the three treatments but, as seen in Table 1, core length decreased as the spacing increased. Average yield per acre was highest for the 9-inch spacing and lowest for the 12-inch spacing due to fewer plants per acre for the 12-inch spacing. Overall, it appears that the optimum spacing for the raised bed, plastic mulch, trickle irrigation production system would be between 9 and 12 inches to maximize yields and produce an acceptable quality product.

Spring Onion Cultivar Evaluation in Central Kentucky

Timothy Coolong, Janet Pfeiffer, and Darrell Slone, Department of Horticulture

Introduction

Although onions are grown on a limited basis in Kentucky, they represent a potentially profitable crop for those who grow them. Farmers who are currently growing onions in Kentucky generally limit plantings to an acre or less. However, by using retail markets and produce auctions to sell their product, these growers are able to command prices ranging from \$0.40 to \$0.50/lb. This represents a profit potential of many thousands of dollars per acre. A variety trial was conducted using primarily medium and long day cultivars to determine which varieties would be best suited for farmers in Kentucky.

Materials and Methods

Eleven onion varieties were seeded into 200-cell trays on 11 January 2008. Seedlings were greenhouse grown and fertilized with 150 ppm N of 20-10-20 twice weekly. Seedlings were transplanted on 2 April 2008 into flat beds spaced on 6-foot centers on the University of Kentucky Horticultural Research Farm in Lexington, Kentucky. Black plastic mulch (4 feet wide) and drip tape were put down prior to planting. Each bed contained five rows of onions spaced 6 inches within and between rows. Plots contained 200 plants each (20 feet) and were separated from adjacent plots within the same row by 6 feet. This would result in a per acre population of 72,000 plants. The varieties were arranged in the field in a randomized complete block design with four replications. Approximately 50 lb N/A was broadcast prior to planting. Supplemental potassium and phosphorous were not necessary according to soil tests. Starting two weeks after transplanting, N was applied at a rate of 20 lb/A through the drip irrigation. This continued every other week until approximately 80 lb N/A had been applied through the drip irrigation. Lorsban 15G was applied at planting to control onion maggots. Thereafter, Pounce was sprayed for thrip control in June and July. No fungicides were applied. Harvested began 2 July 2008 and continued through 30 July 2008. Bulbs were weighed and graded according to USDA size and quality standards for onions. Ten bulb samples were sliced to determine the percentage of bulbs with multiple centers and for percent dry matter. Statistics were performed using SAS statistical software. Data were tested for normality and transformed, if necessary. Yield data are presented as units per acre, with a unit defined as a 50-lb bag. Results were considered significantly different if $P< 0.5$.

Results and Discussion

The yellow-skinned varieties with the largest marketable yields included Expression, Peso, and Candy, all yielding greater than 800 units (50-lb bags) per acre (Table 1). The majority of the bulbs produced by these varieties were either colossal or jumbo. A white variety, Super Star, also yielded well. Two red varieties, Red Line and Red Beauty, tended to produce a large percentage of medium bulbs. Both red varieties also had the highest dry matter and tended to have thicker outer scales. Two large bulbed varieties, Walla Walla and Ailsa Craig, produced lower marketable yields than expected. In a separate study, these two varieties were planted in the fall and overwintered

Table 1. Days to harvest, total yield, colossal, jumbo, medium, small, and cull onions is given in 50-lb bag units per acre as well as percentage of doubles and dry matter for 11 varieties of onion. Varieties are ordered based on total marketable yield (highest to lowest).[1]

Variety	Days to Harvest[2]	Total Marketable Yield (units/A)		Colossal (units/A)		Jumbo (units/A)		Medium (units/A)		Small (units/A)		Cull (%)[3]		Multi-Center (%)[4]		Dry Matter (%)	
Expression	113	885	a*	138	abc	511	ab	230	bcd	5	bc	1.5	c	13	cde	6.5	def
Peso	120	874	a	164	ab	551	a	156	cde	3	cd	4.3	c	3	de	7.0	cde
Superstar	110	830	a	129	abc	499	abc	199	bcde	4	bcd	1.8	c	0	e	7.0	cde
Candy	110	810	a	159	ab	507	ab	142	de	2	cd	3.8	c	3	de	8.0	bc
Sweet Spanish	122	752	ab	69	bcd	451	abcd	227	bcd	6	bc	3.0	c	15	ab	7.8	cd
Olympic	100	630	bc	25	d	364	bcde	234	abcd	6	bc	2.5	c	35	ab	8.3	bc
Red line	113	626	bc	17	d	315	de	288	ab	6	bc	6.8	c	25	bc	11.0	a
Walla Walla	113	623	bc	194	a	332	cde	96	e	1	d	29.0	b	48	a	6.0	ef
Red Beauty	113	589	c	2	d	240	ef	338	a	8	b	1.5	c	8	de	9.3	b
Ailsa Craig	120	427	d	55	cd	270	e	100	e	2	cd	51.8	a	8	de	5.3	f
WI 131	92	363	d	0	d	95	f	254	abc	15	a	2.3	c	15	dc	5.5	f

* Treatments followed by different letters are statistically different with $P<0.05$.
1 Onion yields are based on populations of 72,000 plants per acre and presented in units of 50-lb bags/acre.
2 Days to harvest from transplanting during the spring 2008 growing season.
3 Percentage culls were based on weight.
4 Percentage of doubles is the number of bulbs with multiple centers (growing points) in 10 bulb samples from each replication.

in central Kentucky, producing reasonable yields of very large bulbs. However, while both varieties continued to produce large bulbs, their marketable yield was down due to a high number of culls, which were the result of the presence of several diseases in these spring-planted cultivars. Perhaps these two cultivars are better suited to fall planting and overwintering in Kentucky, while other varieties such as Expression, Peso, and Candy are better suited to spring planting.

Overwintering Potential of Onion Varieties in Kentucky

Timothy Coolong, Janet Pfeiffer, and Darrell Slone, Department of Horticulture

Introduction

In many parts of the United States, onions are grown through the winter for harvest in late spring and early summer. Traditionally, farmers in the mid-Atlantic region plant onions in early spring months; however, there would be advantages to growing onions through the winter in Kentucky. Overwintered onions would mature earlier than spring-planted bulbs and would not be exposed to high temperatures early in the summer, which can increase disease and insect pressure on crops. In addition, fields are often wet and difficult to work during the late winter and early spring when onions are typically planted. However, winter temperatures may prevent onions from being successfully overwintered in central Kentucky. Thus, several onion varieties were chosen with varying degrees of overwintering ability and grown using two types of protection (floating row covers and straw mulch) to determine the overwintering ability of onions in Kentucky.

Materials and Methods

Onions were seeded into 200-cell flats on 22 August 2007 and were greenhouse grown until 2 November 2007. Transplants were fertilized twice a week with 20-10-20 fertilizer at a rate of 150 ppm N. On 9 November 2007, seedlings were transplanted into raised beds on 6-foot centers at the University of Kentucky Horticultural Research Farm in Lexington, Kentucky. Black plastic mulch (4 feet wide) and drip tape were put down prior to planting. Each bed contained five rows of onions spaced 6 inches within and between rows. Plots contained 200 plants each (20 feet) and were separated from adjacent plots within the same row by 6 feet. This would result in a per acre population of 72,000 plants. The varieties were arranged in the field in a randomized complete block design with three replications of 200 plants each. Approximately 25 lb N/A in the form of ammonium nitrate were broadcast prior to planting. Supplemental potassium and phosphorous were not necessary according to soil tests. Plants were fertigated every other week with additional N at a rate of 20 lb/A beginning in late March and continuing until late May for a season total of 125 lb N/A. A floating row cover (Remay) or straw mulch was applied in three replications on 13 December 2007. The covers and mulch were removed on 10 March 2008. Lorsban 15G was applied at planting to control onion maggots. No fungicides were applied. Harvests began on 2 June 2008 and continued through 8 July 2008. Varieties were weighed and graded according to USDA size and quality standards for onions. Ten bulb samples were taken and sliced to determine the percentage of bulbs with multiple centers and percent dry matter. In addition, 10 bulb samples of varieties that successfully overwintered were analyzed for sugars, onion lachrymator factor, and bulb pungency using the method of Randle and Bussard (1993) and Schmidt et al. (1996) at the National Onion Labs, Collins, Georgia. Yield data are presented as 50-lb bag units per acre.

Table 1. Days to harvest, mean and standard deviation for percent survival, flowering (bolting) percentage total yield, colossal, jumbo, medium, small, and cull onions is given in 50-lb bag units per acre for seven varieties of onions overwintered in Lexington, Ky.[1]

Variety with Remay (R) or Straw (S)[2]	Days to Harvest[3]	Percent Survival (%)		Flowering (%)		Total Marketable Yield (units/A)		Colossal (units/A)		Jumbo (units/A)		Medium (units/A`)		Small (units/A)		Cull (%)[4]	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Ailsa Craig (R)	241	94	2.8	13	2.4	614	120	107	36	363	67	133	30	10	10	13	2
Ailsa Craig (S)	241	43	16.7	1	0.9	272	99	77	60	148	50	47	14	0	0	3	3.0
Candy (R)	241	89	4.5	61	3.4	153	11	0	0	55	2	93	10	5	4	15	3
Candy (S)	241	34	14.0	12	10.3	157	19	7	12	105	19	46	15	0	0	24	7
Expression (R)	241	89	2.3	67	17	113	76	0	0	52	39	58	38	2	2	59	21
Expression (S)	241	7	3.1	0	0	29	2.6	0	0	22	2	6	3	0	0	11	18
Olympic (R)	216	94	1.0	1	0.8	705	40	46	15	421	23	233	17	5	3	1	1
Olympic (S)	216	76	6.6	0	0.0	492	33	19	19	299	82	171	72	3	2	0	0
Super Star (R)	241	85	8.8	41	20.0	261	75	0	0	113	32	146	53	2	4	37	14
Super Star (S)	241	12	6.4	3	4.7	46	19	0	0	22	12	24	9	0	0	24	10
Walla Walla (R)	241	97	1.0	11	3.9	604	60	203	78	312	70	88	64	1	1	13	8
Walla Walla (S)	241	79	11.0	1	0.6	594	156	322	154	222	8	48	11	1	1	8	4
WI 131 (R)	203	69	6.2	11	3.9	124	17	0	0	9	5	80	20	36	10	16	6
WI 131 (S)	203	3.2	4.2	1	0.6	2	2	0	0	0	0	2	1	1	1	0	0

1 Onions yields are based on populations of 72,000 plants per acre and presented in units of 50-lb bags/acre.
2 Each variety was grown under a floating row cover (Remay) or straw mulch.
3 Days to harvest from transplanting.
4 Percentage culls were based on weight of culls divided by total harvested weight.

Results and Discussion

There were large differences among cultivars in overwintering ability (Table 1). In addition to large varietal differences, there were differences in plant survival within the same cultivar when comparing the Remay and straw mulch treatments. For example, 89% of Expression plants survived under Remay, while just 7% survived when grown under straw mulch. Across all varieties, survival was much greater when plants were grown under the floating row covers. However, the percentage of plants that bolted (flowered) was also significantly higher in those plants grown under Remay. Since those bulbs that flower must be culled, there was actually little benefit to growing many of the varieties under Remay because even though more plants survived, they flowered and had to be culled. Of the varieties tested, only Ailsa Craig would have actually benefited from being grown under Remay. Total marketable yields for Ailsa Craig grown under the Remay were 614 units (50-lb bags) per acre, which would be a fair yield for a grower. The Ailsa Craig bulbs grown under the straw mulch yielded only 272 units per acre, which would be unacceptably low. Two varieties, Olympic and Walla Walla, yielded well under straw and the row cover. These varieties produced a large percentage of jumbo and colossal bulbs, with Walla Walla producing an average of 544 units of colossal and jumbo bulbs per acre. Because both Walla Walla and Olympic yielded well when grown under straw as well as Remay, it would be difficult to justify the additional cost of the row cover when even growing a limited quantity of onions. It should be noted that the coldest temperature experienced at the Horticultural Research Farm during the winter of 2007-2008 was 5°F, and growers should be aware that in many winters, temperatures in Kentucky are much lower.

Table 2. Percentage dry matter, soluble sugars, lachrymatory factor (expressed in umol/ml juice), pungency (umol pyruvic acid/ml juice), and percentage of multiple centers for seven varieties of onions overwintered in Lexington, Ky.

Variety with Remay (R) or Straw (S)[1]	Dry Matter (%)		Sugars (%)		Lachrymatory Factor (umol/ml juice)[2]		Pungency (umol/ml juice)[3]		Multiple Centers (%)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Ailsa Craig (R)	8.0	3.6	7.8	0.20	4.5	0.51	5.1	0.21	40	10.0
Ailsa Craig (S)	6.0	1.0	NA[4]	NA	NA	NA	NA	NA	40	10.0
Candy (R)	8.0	1.0	9.3	0.12	6.6	1.15	6.2	0.55	47	11.5
Candy (S)	8.0	1.0	9.5	0.12	8.4	1.67	6.9	0.38	67	20.8
Olympic (R)	9.3	0.6	9.2	0.20	3.4	0.87	3.4	0.40	7	5.8
Olympic (S)	9.3	0.6	9.2	0.20	3.5	0.10	3.3	0.46	7	5.8
Super Star (R)			9.0	0.20	9.5	2.67	7.2	0.15	80	10.0
Super Star (S)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Walla Walla (R)	4.3	0.6	7.1	0.12	4.3	0.47	4.8	0.49	77	23.1
Walla Walla (S)	4.7	0.6	7.2	0.20	5.2	0.95	7.2	0.20	77	5.8
WI 131 (R)	7.0	0.0	6.8	0.20	2.7	0.38	2.3	0.23	0	0.0
WI 131 (S)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Expression (S)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Expression (R)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

1 Each variety was grown under a floating row cover (Remay) or straw mulch.
2 Lachrymatory factor (LF) expressed in umol LF/ml of onion juice from crushed onions.
3 Pungency is expressed as umol of pyruvic acid /ml of onion juice from crushed onions.
4 NA = not analyzed due to insufficient bulbs remaining after harvest and grading.

Pungency, sugars, and the lachrymatory factor (LF),the volatile chemical in onions that makes people cry when cutting them, were tested as well (Table 2). Typically for sweet mild onions, pungency and LF values of less than 5 are desirable. Higher values indicate a hotter, more pungent bulb. The varieties tested ranged from very pungent to mild and sweet. Of those varieties that overwintered, Olympic had the lowest pungency (3.4 umol/ml juice) and high sugars (9.2%). This suggests that Olympic would be a sweet and mild bulb similar in flavor to the popular Vidalia onions produced in Georgia. Our results indicate that there are some onion varieties that could be successfully overwintered in central Kentucky during a relatively mild winter when low temperatures only reached 5ºF; however, more research needs to be conducted to determine the feasibility of overwintering onions on a routine basis in Kentucky.

Literature Cited

Randle, W.M., and Bussard, M.L. 1993. Streamlining onion pungency analyses. Hortscience 28:60-60.

Schmidt, N.E., Santiago, L.M., Eason, H.D., Dafford, K.A., Grooms, C.A., Link, T.E., Manning, D.T., Cooper, S.D., Keith, R.C., Chance, W.O., Walla, M.D., and Cotham, W.E. 1996. Rapid extraction method of quantitating the lachrymatory factor of onion using gas chromatography. J. Agric. Food Chem. 44:2690-2693.

Muskmelon and Specialty Melon Variety Evaluations

John Strang, Amy Poston, Chris Smigell, Darrell Slone, and John Snyder, Department of Horticulture

Forty-two melon varieties were evaluated in a replicated trial for their performance under Kentucky conditions. These included ananas, Asian, canary, eastern muskmelons, galia, gourmet, honeydew, and muskmelon galia crosses.

Materials and Methods

Varieties were seeded on 23 and 29 April into Styrofoam plug trays (72 cells per tray) at the University of Kentucky Horticultural Research Farm in Lexington. Plug trays were set on a greenhouse bench to germinate, and seedlings were subsequently thinned to one per cell. Plants were set into black plastic mulched, raised beds using a waterwheel setter on 29 May. Each plot was 21 feet long, with 7 plants set 3 feet apart within the row and 6 feet between rows. Each treatment was replicated four times in a randomized complete block design. Thirty pounds per acre of nitrogen, phosphorus, and potassium as 19-19-19 were applied beneath the plastic mulch as the beds were formed. This is equivalent to a field broadcast rate of 50 pounds per acre of nitrogen, phosphorus, and potassium. Drip irrigation was used to provide water and fertilizer as needed. The plot was fertigated with a total of 68 lb N/A as ammonium nitrate divided into six applications over the season. The systemic insecticide Admire 2F was applied with a hand sprayer as a drench to the base of each plant after transplanting, using the maximum rate of 24 fl oz/A. Foliar insecticide applications included Pounce, Capture, and Malathion. Weekly foliar fungicide applications included Maneb, fixed copper, Bravo, Quadris, T-methyl, and Nova. Strategy preemergent herbicide was applied as a banded spray between the rows, just as the vines began to grow off the plastic mulch. One fruit from each replication was measured and evaluated for flavor, soluble solids, interior color, rind color, and net type.

Results and Discussion

The growing season temperatures were normal, and the season was very dry. Fruit were harvested twice a week. Harvest and variety evaluation data are in Tables 1 and 2. Flavor was exceptional due to the dry season, and most melon varieties evaluated previously performed well. Varieties are grouped by melon type and listed in order of declining yield within the grouping.

Weed control was excellent, but plant injury from the Command component of Strategy was severe as evidenced by plant bleaching immediately after application. Plants gradually regained their chlorophyll as the season progressed, but vine growth was reduced. Yield was reduced by roughly half, when compared to the 2007 season. This was most probably caused by the Command injury and a reduction in water application to the plot due to a restriction in the irrigation line that was not noted until most of the harvest was completed. Both of these factors tended to increase melon sugar contents.

Bacterial wilt and powdery mildew were the primary diseases (Table 3). No virus was observed. Bacterial wilt caused the loss of more plants than in previous seasons. This was possibly due to the plot location which was close to a railroad right of way, where wild cucurbits prosper. Sunrise, Dorado, Orange Sherbet, NUN 7225, and Mini Ananas lost the most plants, but except for Mini Ananas, their yields were surprisingly good in comparison with other varieties. Powdery mildew was a serious disease this season, and no varieties were immune to its effects. However, there was a large difference in infection levels between varieties. Sweetie, Green Flesh, and Sweet Delight had the highest levels of infection, while HSR 4347 and Mini Ananas had some of the lowest powdery mildew infection levels.

Eastern muskmelon. Orange Sherbet, Ambrosia, Atlantis, Eclipse, Earlichamp, and Wrangler were the top eastern muskmelons in this trial. Orange Sherbet had the highest yield and largest excellent-tasting melons. Ambrosia is an older variety known for its excellent taste but is soft and has poor shelf life. Atlantis and Eclipse also performed well. Earlichamp is notable for its earliness and quality. Wrangler is a very distinctive Tuscan melon with very attractive dark green sutures and a smaller size, and it had the highest flavor rating. Lil Loupe is notable for its very small size, high flavor, and the potential for a specialty niche market. All of the above-mentioned varieties were superior to Athena, the industry standard in flavor and sugar content.

Table 1. Specialty melon variety trial yield and fruit characteristics, Lexington, Ky., 2008.

Variety	Melon Type[1]	Seed Source	Days to Harvest	Yield (cwt/A)[2]	Avg. No. Melons/A	Avg. Wt./ Fruit (lb)	Culls (%)[3]	Outside Measurements		Flesh Thickness (in.)	Seed Cavity	
								Length (in.)	Width (in.)		Length (in.)	Width (in.)
Orange Sherbet	MM	SW	83	549 a	7,606	7.2	4	8.9	6.5	1.7	6.2	3.2
Ambrosia	MM	SW	86	477 abc	12,186	3.9	5	6.5	5.9	1.9	3.9	2.6
Atlantis	MM	SW	74	420 abcd	7,433	5.7	2	7.8	6.6	1.9	5.1	2.8
Cruiser	MM	HR	74	408 abcd	9,594	4.1	3	6.5	5.9	1.6	3.8	2.9
CS823819	MM	CF	85	406 abcd	6,741	6.0	2	8.0	6.5	2.0	4.8	2.7
Aphrodite	MM	SW	80	402 abcd	6,136	6.7	1	7.7	6.9	1.6	5.2	3.5
Jaipur	MM	SW	86	391 abcd	8,038	4.9	1	7.8	6.4	1.8	5.0	2.8
Eclipse	MM	SW	85	365 abcd	6,914	5.4	2	7.4	6.9	2.0	4.7	3.1
Primo	MM	ST	79	359 abcd	6,396	5.6	4	7.8	6.6	1.8	5.0	2.9
Diva	MM	SW	81	356 abcd	5,013	7.1	2	8.0	7.0	1.9	5.5	3.3
Earlichamp	MM	HL	78	344 bcd	6,655	5.1	1	7.7	6.3	2.1	4.8	2.7
Athena	MM	SW	79	323 bcd	6,914	4.6	4	7.4	6.9	1.9	4.7	3.2
Lil Loupe	MM	RU	80	317 cd	17,113	1.9	2	4.8	4.6	1.4	2.9	2.0
Wrangler	MM	HL	85	305 cd	9,161	3.3	1	6.2	5.5	1.6	4.0	2.3
Goddess	MM	SW	70	244 d	4,754	5.1	14	7.3	6.5	1.9	4.8	2.8
HSR 4347	HD	HL	85	514 ab	8,556	5.8	1	7.2	7.4	2.2	4.2	3.2
Honey Brew	HD	RU	90	482 abc	7,260	6.4	1	8.3	7.0	1.7	5.3	3.6
Earlidew	HD	ST	75	462 abc	9,939	4.6	3	6.2	6.2	1.7	3.6	2.9
Honeymoon Hyb.	HD	PK	80	458 abc	9,334	4.9	0	7.9	7.0	2.0	5.1	3.0
Summer Dew	HD	HM	90	451 abc	7,174	6.3	0	7.4	7.0	1.8	4.4	3.3
Temptation #1	HD	SK	85-90	434 abcd	7,174	6.0	3	8.1	6.9	2.0	5.2	3.0
Honey Gold	HD	HM	85	426 abcd	8,124	5.2	1	8.1	7.0	1.7	5.4	3.3
HSR 4333	HD	HL	88	424 abcd	6,482	6.5	1	7.8	7.1	2.0	4.4	3.2
Honey Yellow	HD	JS	71	424 abcd	14,347	2.9	3	5.7	5.3	1.5	3.5	2.5
NUN 7225	HD	NU	85	415 abcd	7,865	5.4	0	7.3	6.8	2.0	4.5	2.8
Sweet Delight	HD	RU	90	369 abcd	5,359	7.0	0	8.3	7.3	1.7	5.3	4.0
Snow Mass	HD	PK	90	343 bcd	7,865	4.4	0	7.2	6.4	2.0	4.4	2.6
Green Flesh	HD	RU	90	298 cd	4,926	6.0	2	8.6	7.5	1.8	5.6	4.0
Dorado	CA	ST	85	461 abc	7,346	6.2	0	8.8	6.8	1.8	6.3	3.4
Camposol	CA	SW	80	425 abcd	7,346	5.8	1	8.9	6.5	2.0	5.9	2.8
Sonora	CA	CF	80	421 abcd	8,729	4.8	1	7.8	6.3	1.6	5.2	2.9
Sugar Nut	CA	JS	77	399 abcd	13,137	3.0	0	6.6	5.7	1.7	3.9	2.2
Sunrise	AS	EV	72	472 abc	16,508	2.8	3	5.2	5.1	1.5	3.3	2.5
Sprite	AS	CF	80	463 abc	34,917	1.3	1	4.7	3.9	1.0	3.2	2.1
Napoli	AS	EV	72	404 abcd	13,915	2.8	3	4.9	4.8	1.6	2.6	2.0
Venice	AS	EV	80	338 bcd	9,248	3.6	1	6.3	5.8	1.5	4.1	2.8
HSR 4310	GA	HL	74	467 abc	19,274	2.4	2	5.0	4.9	1.6	2.9	1.9
HSR 4377	GA	HL	70	339 bcd	14,693	2.3	2	4.9	4.9	1.5	2.8	2.3
Sweetie	MG	KU	85	434 abcd	10,907	4.0	0	6.8	5.6	1.7	4.2	2.4
Pixie	MG	HL	80	392 abcd	14,952	2.6	0	5.4	5.3	1.6	3.1	2.3
Sensation	GO	HL/RU	80	459 abc	10,112	4.5	5	6.6	6.2	1.7	4.1	2.9
Mini Ananas	AN	RU	65-75	317 cd	11,236	2.8	6	6.4	4.9	1.3	4.2	2.5

1 Melon type: AN = ananas, AS = Asian melon, CA = canary, GA = galia; GO = gourmet, HD = honeydew, MG = muskmelon galia cross, MM = eastern muskmelon.
2 Numbers followed by the same letter are not significantly different (Duncan's multiple range test LSD P = 0.05). Cwt/A = hundredweights (100-lb units) per acre.
3 Cull percent by weight.

Table 2. Specialty melon trial fruit characteristics, Lexington, Ky., 2008.

Variety	Flavor (1-5)[1]	Sugar (%)	Interior Color[2]	Rind Color[3]	Fruit Shape	Net Type[4]	Comments
Orange Sherbet	4.4	14.8	or.	str.	oblong	co.	Very large melon; attractive exterior & interior; sutures turn from dark green to straw color when ripe; smooth firm flesh; nice flavor; harv. at slip
Ambrosia	4.7	13.3	or.	lt. or. str.	oblong	md.	Nice flavor; soft, smooth melting flesh; short harv. window; harvest at slip
Atlantis	4.6	14.2	bor.	str.	oblong	md.	Attractive exterior & interior; smooth firm flesh; harv. at slip
Cruiser	3.7	11.9	or.	lt. str.	oblong	hv. co.	Attractive exterior & interior; v. firm dry flesh; harv. at slip
CS823819	3.8	12.1	or.	str.	oblong	md. hv.	V. large; attractive exterior & interior; some surface cracking; harv. at slip
Aphrodite	3.9	12.5	or.	str.	round	co.	Not symmetrical; variable in size; smooth soft flesh; harv. at slip
Jaipur	3.8	13.2	or.	str.	oblong	md. hv.	Attractive exterior & interior; firm smooth flesh; harv. at slip
Eclipse	4.1	13.1	or.	str.	round	hv. co.	Attractive interior; soft, smooth flesh; harv. at slip
Primo	4.5	14.5	lt. or.	str.	oblong	fi.	Nice flavor; a little surface cracking and dry decay; harv. at slip
Diva	3.7	12.2	or.	str.	oblong	co.	V. large, variable in size; soft, smooth flesh; harv. at slip
Earlichamp	4.1	13.3	or.	str.	oblong	md.	Slightly green shallow sutures; some cracking; fine, soft flesh; harv. at slip
Athena	3.8	13.4	or.	str.	sl. oblong	md. fi.	Industry standard; attractive exterior & interior; harv. at slip
Lil Loupe	4.6	14.2	or.	str.	round	co.	V. small; rough exterior; excellent smooth, firm flesh; harv. at slip
Wrangler	4.8	14.5	or.	str.	oblong	md.	Attractive rind; has dk. gr. sutures; smooth, firm flesh; harv. at slip
Goddess	3.7	12.0	or.	str.	oblong	co.	Some rind scarring; cracks when overripe; fine-textured flesh; harv. at slip
HSR 4347	4.8	17.0	lt. gr.	cr.	round	md.	Excellent flavor; medium-firm flesh; may or may not have diffuse netting; harv. just prior to slip when exterior is a yellowish cream color or at full slip
Honey Brew	4.7	15.4	lt. gr.	cr.	oblong	diffuse	Surface netting; crisp flesh; harv. when rind is cream color & waxy
Earlidew	4.7	15.9	lt. gr.	cr. yl.	round	co.	Difficult to pick at high sugar without serious exterior checking and cracking
Honeymoon Hyb.	4.7	17.8	lt. gr.	cr.	oblong	na	Surface checking; diffuse netting; some cracking; crisp, crunchy flesh; harv. when rind cream-colored and waxy
Summer Dew	4.4	16.2	lt. gr.	cr. yl.	round	na	Free of netting; v. firm flesh; harv. when cream-colored & waxy
Temptation #1	4.5	15.2	or.	cr.	oblong	na	Some surface checking; firm crisp flesh; harv. when cream-colored & waxy
Honey Gold	4.4	15.7	lt. or.	cr. gr.	almond	na	Attractive exterior; no checking; most but not all melons slip
HSR 4333	4.2	14.9	lt. gr	cr. gr.	oblong	na	V. smooth attractive exterior; soft, slightly grainy flesh; some split in field, harv. when cream-colored & waxy
Honey Yellow	4.5	15.9	lt. or.	dk. yl.	round	na.	Attractive; may crack across blossom end; harvest when dark yellow
NUN 7225	4.6	17.2	lt. gr.	cr.	oblong	na	Medium-crunchy, nice-flavored flesh; harv. when cream-colored & waxy
Sweet Delight	4.2	15.4	lt. gr.	cr.	oblong	na	Smooth exterior; harv. at yellowish cream exterior & cream ground spot
Snow Mass	4.7	16.6	lt. gr.	cr. gr.	oblong	na	Attractive, slightly crisp flesh; cracks; harv. when cream-colored & waxy
Green Flesh	4.2	14.7	lt. gr.	cr.	round	na	Late maturity; coarse, crunchy; harv. when exterior yellowish cream-colored
Dorado	4.7	13.8	gr.-cr.	bt. yl.	almond	na	Attractive exterior & interior; soft, melting flesh; harv. when dark yellow
Camposol	4.6	13.9	gr.-cr.	bt. yl.	almond	na	Attractive exterior & interior; soft, slightly chewy flesh; harv. when dark yellow
Sonora	4.4	14.1	gr.-cr.	bt. yl.	almond	na	Uniform longitudinal checking; crisp flesh; harv. when golden yellow
Sugar Nut	4.8	15.9	lt. gr.	bt. yl.	almond	na	Attractive exterior & interior; soft, smooth flesh; harv. when dark yellow
Sunrise	4.7	16.0	lt. or.	str.	round	hv. co.	Uniform size; soft, melting flesh; harv. when rind turns yellow before slip
Sprite	4.4	16.8	cr.	cr.	oval	na	Attractive, crisp flesh; harv. when rind becomes slightly waxy; develops a yellowish tinge and minute concentric checks appear around blossom end
Napoli	4.7	16.5	cr. gr.	cr. gr.	round	hv. fi.	Excellent flavor; soft, smooth flesh; harv. at first slip when rind colors
Venice	4.3	15.2	or.	bl. gr.	oblong	hv. co.	Dark green sutures; difficult to harv.; look for cream-colored ground spot
HSR 4310	4.3	13.2	lt. gr.	dk. yl.	round	md.	Attractive, smooth firm flesh; harv. just prior to slip at full color or at slip
HSR 4377	4.5	15.3	gr.	str.	round	md.	Attractive exterior & interior; uniform size; smooth flesh; harv. at slip
Sweetie	4.4	15.4	or.	lt. bl. gr.	oval	md. co.	Crisp flesh; harv. when rind develops yellow highlights
Pixie	4.5	17.3	or.	lt. gr. yl.	round	hv. co.	Uniform size; v. firm sweet flesh; harv. with yellow highlights in rind
Sensation	4.3	13.3	cr.	or. str.	round	lt. co.	Attractive; soft, melting flesh; ripens rapidly; harv. as rind yellows or at slip
Mini Ananas	4.3	13.7	cr.	dk. str.	elongated	md.	Attractive exterior & interior; ripens rapidly; harv. at slip

1 Flavor: 1 = poor; 5 = excellent, sweet taste, pleasant texture.
2 Interior color: o = orange; cr = cream; lg = light green; wh = white; pk = pink.
3 Rind color: lg = light green; gr = green; dg = dark green; yl = yellow; bor = bright orange; by = bright yellow; wh. = white; str = straw; tn = tan; or = orange; gd = gold; cr = cream; bl = blue.
4 Net type: na = none; lt = light amount of netting; md = medium amount of netting; hv = heavy amount of netting; fi = fine textured; co = coarse.

Honeydew. HSR 4347, an experimental numbered variety, was the highest-yielding and best-tasting honeydew of those evaluated. Honey Brew, our standard recommendation which has done well in previous trials, also performed very well. Temptation No. 1, an orange-fleshed honeydew that develops some surface checking, looked good for a second season. Honey Gold, the second orange-fleshed honeydew in the trial, and Summer Dew were excellent varieties that were essentially free of surface netting and checking. Finally, NUN 7225, noted for its consistent size and outstanding flavor, looked very good.

Canary. All of the canary melons performed exceptionally well and had few culls. Dorado trended toward having the highest yield and had outstanding flavor. Sugar Nut, a small canary melon, again performed exceptionally well and produced high-quality, attractive melons. Camposol and Sonora both tasted very good, and Camposol fruit developed small longitudinal checks at maturity that were attractive.

Asian. Sunrise and Napoli have produced consistently high-quality, excellent-tasting, uniformly sized melons over the last three seasons. Sprite is an outstanding Asian melon and has been consistent in our trials over the years. It is a small cream-colored melon with crisp flesh that has a strong consumer following.

Galia. HSR 4310 and HSR 4377 were both exceptional small, personal-sized galia melons with excellent flavor.

Muskmelon galia crosses. Both Sweetie and Pixie were excellent-quality melons and had very firm orange flesh that was attractive and excellent in flavor. Pixie was the smaller of the melons and was rated as having a slightly better flavor, while Sweetie was a larger melon with a slightly higher yield tendency.

Gourmet. Sensation is an outstanding melon in terms of appearance, flavor. and sugar content and has been consistent in quality from year to year. It ripens rapidly, must be harvested frequently. and produces melons over a long period.

Ananas. The Mini Ananas variety was a very nice melon and was small compared to other melons of this type that we have tested over the years. Ananas melons should be harvested daily because of their rapid ripening, short harvest window, and short storage life.

Acknowledgments

The authors would like to thank the following for their hard work and assistance in the successful completion of this trial: Matthew Anderson, Katie Bale, Jessica Ballard, Sean Bessin, Ryan Capito, Jessica Cole, Jessica Dye, Meredith Hall, Lucas Hanks, Ellen Meyer, Dave Lowry, Julie Pfeiffer, Tyler Pierce, Kirk Ranta, Kiefer Shuler, Matthew Simpson, Joseph Tucker, Bonka Vaneva, David Wayne, and Sarah Yates.

Table 3. Specialty melon trial disease ratings, Lexington, Ky., 2008.

Variety	Dead Plants (%)[1,2]		Powdery Mildew[3] (%)	
Orange Sherbet	18	bc	45	bc
Ambrosia	0	c	42	cd
Atlantis	7	c	20	fghij
Cruiser	4	c	22	fghi
CS823819	0	c	6	kl
Aphrodite	0	c	48	bc
Jaipur	4	c	27	efgh
Eclipse	0	c	41	cd
Primo	0	c	16	ghijk
Diva	7	c	17	ghijk
Earlichamp	4	c	39	cde
Athena	0	c	53	b
Lil Loupe	0	c	45	bc
Wrangler	0	c	15	hijkl
Goddess	4	c	23	fghi
HSR 4347	18	bc	2	h
Honey Brew	4	c	50	bc
Earlidew	7	c	56	bc
Honeymoon Hyb.	7	c	15	hijkl
Summer Dew	0	c	9	ijkl
Temptation #1	0	c	43	cd
Honey Gold	7	c	47	bc
HSR 4333	7	c	20	fghij
Honey Yellow	4	c	28	efgh
NUN 7225	18	bc	7	jkl
Sweet Delight	0	c	72	a
Snow Mass	7	c	39	cde
Green Flesh	0	c	73	a
Dorado	29	ab	30	defg
Camposol	0	c	32	def
Sonora	0	c	23	fghi
Sugar Nut	0	c	31	def
Sunrise	39	a	22	fghi
Sprite	4	c	6	kl
Napoli	11	bc	24	fgh
Venice	0	c	56	b
HSR 4310	0	c	4	kl
HSR 4377	4	c	21	fghij
Sweetie	14	bc	76	a
Pixie	14	bc	10	ijkl
Sensation	0	c	22	fghi
Mini Ananas	18	bc	2	l

1 Percent dead plants, primarily due to bacterial wilt on 18 August.
2 Numbers followed by the same letter are not significantly different (Duncan's multiple range test LSD P = 0.05).
3 Powdery mildew rating as percent leaf area infected, rated1-4 September.

Grafted Watermelon Performance in Kentucky

Nathan Howell, Amy L Poston, Nathan Howard, and Timothy Coolong, Department of Horticulture

Introduction

Although not often utilized in the United States, grafting of vegetables is relatively common in much of Asia and parts of Europe. In some Asian countries such as South Korea, more than 80% of melons are grafted (Lee and Oda, 2003). Although labor intensive, grafting allows farmers in these countries to overcome many soil-borne pathogens such as *Verticillium* wilt, *Fusarium* wilt, and nematodes without the use of large amounts of synthetic pesticides. In addition to disease resistance, grafting of vigorous rootstocks to traditional vegetable cultivars often increases yield and water and nutrient uptake. Recently, the practice of grafting watermelons has increased in popularity in the southeast United States. Growers in South Carolina are successfully using disease-resistant cucurbit rootstocks to double-crop watermelons. While labor intensive, the practice has been shown to be economically viable for growers who wish to double-crop melons on the same land in one year. This study was undertaken to determine the performance of grafted melons in Kentucky.

Materials and Methods

The watermelon Sugar Baby was used as the scion for grafting and two rootstocks. Shintosa Camel, an interspecific hybrid squash, and Macis, a *Lagenaria* (gourd), were used as rootstocks. Both rootstocks were made available from Nunhem's Seeds. The watermelon Sugar Baby was seeded into 128-cell trays on 24 April 2008. The two rootstocks were seeded approximately one week later into 128-cell trays. The grafts between the Sugar Baby scion and the Shintosa Camel rootstock were performed on 5 May 2008, while the Sugar Baby to Macis grafts were performed on 19 May 2008, and Sugar Baby self-grafts were performed on 20 May 2008. Grafts were performed as follows: the rootstock and scion stems were cut at 45º angles, put together, and held in place using commercially available plastic grafting clips (Johnny's Seeds). Immediately after grafting, plants were placed on a mist bench and covered with plastic and heavy black shade cloth. This was done to keep the humidity high, without having water sitting on the plants. Shade cloth was used to prevent heat stress on the grafted plants. After 10 days, plants were removed from the mist environment and placed in a greenhouse.

Plants were transplanted to the field on 13 June 2008; transplants were placed on black plastic mulch with drip irrigation. The study was arranged as a randomized complete block design with four replications of seven plants each for each treatment with the exception of the self-grafted treatment. Due to a lack of plant materials, the self-grafted treatments consisted of four replications of five plants each. Plants were spaced 24 inches apart in rows, and rows were on 6-foot centers. Weed control was accomplished by broadcasting annual ryegrass at the rate of 100 lb per acre with a mixture of 50 lb per acre of sorghum sudangrass prior to laying plastic. The grass mixture was then sprayed post-transplant with Gramoxone Max 3L at the rate of 2 pt per acre with a shielded spray; an additional application of 2 pt per acre of Strategy 2.1 E was applied three weeks after transplanting. Preplant fertilizer was applied at the rate of 500 lb of 10-20-20 per acre; the remaining required nitrogen was applied on a weekly basis through the drip irrigation at the rate of 32 lb/A per week in the form of calcium nitrate. The plants were watered by an automated system that watered once a day; the plot was watered at the rate of 1 acre inch of irrigation water per week. For control of insects, Capture 2 EC and Endosulfan 3 EC were used in rotation on a weekly basis from transplant until a week before projected harvest. Capture 2 EC was used at the rate of 4 fl oz per acre, while Endosulfan 3 EC was used at the 2 pt per acre rate. Once vines began to run, plants were sprayed with fungicides on a weekly rotation of 11 fl oz per acre of Quadris, 2 pt per acre of Chlorothalonil, and/or Mancozeb at the rate of 2 lb per acre. Melons were first harvested 21 August 2008, and a second harvest was needed on 29 August 2008. Maturity was determined by the presence of a dead tendril at the point where the fruit attaches to the vine, along with a yellow ground spot on the melon. At harvest. fruit were counted and weighed, external measurements were taken, and the internal sugars were measured both near the rind and near the center of the fruit.

Statistics were performed using SAS statistical software. Data were tested for normality and transformed, if necessary. Results were considered significantly different if $P < 0.5$.

Results and Discussion

Grafted plants using the commercially available rootstock Shintosa Camel had greater yields than the other treatments (Table 1). Although the self-grafted plants yielded fewer fruit per acre than the other treatments, there was no significant difference among the treatments with regard to fruit number per acre. Average fruit weight was highest in all of the grafted treatments. While plants grafted to the commercial rootstocks had slightly higher average fruit weights than the self-grafted plants, they were not significantly different. This suggests that the act of simply grafting the Sugar Baby melons increased fruit yield, regardless of the rootstock used. Soluble solids (sugars) were also significantly higher in all the grafted treatments when compared to the non-grafted control plants. Although the vigor of the commercially available rootstock seedlings was greater than that of the Sugar Baby seedlings, it seems as if the act of grafting the plant may have had more of an effect on traits such as fruit size and sugar content than the actual rootstock that was used. However, it should be noted that during the grafting process. the Sugar Baby plants grafted to the commercial rootstocks had a much higher percentage of success (90%; data not shown) than those Sugar Baby seedlings that were self-grafted (50% success rate). Nonetheless, those plants grafted to the Shintosa Camel rootstock did yield significantly more per acre than the other treatments. The higher yield of this treatment was likely a combination of rootstock vigor and the act of grafting, which seems to promote larger fruit. Similar results have been reported elsewhere (Cohen et al., 2005; Lee and Oda, 2003).

Table 1. Performance of grafted melons in 2008.

Treatment	Yield (cwt/A)[1]		Avg. No. (melons/A)		Avg. Fruit Wt. (lb)		Avg. Length (in.)		Avg. Width (in.)		Sugars (close to rind) (%)		Sugars (interior) (%)	
Non-grafted	434	b*	8571	a	5.4	b	20.5	b	20.0	b	7.9	b	8.7	b
Self graft	488	b	6960	a	6.7	a	21.7	a	22.4	a	8.3	ab	9.1	ab
Macis rootstock	542	b	8572	a	7.3	a	22.8	a	22.2	a	8.8	a	9.4	a
Shintosa Camel rootstock	654	a	8614	a	7.6	a	23.0	a	22.2	a	8.4	a	9.1	ab

* Treatments followed by different letters are statistically different with *P<0.05*.
[1] cwt/A = 100 pound units/acre.

The hot, dry weather encountered during this growing season resulted in large numbers of spider mites. To determine if there was an effect of the treatments on mite damage, ratings were taken on 13 August and 20 August 2008. Interestingly, while the non-grafted control plants were severely infested with spider mites (Table 2), spider mite levels were relatively low on the grafted treatments. This suggests that regardless of rootstock used, the act of grafting made those plants either more resistant to spider mites or simply less attractive. It is plausible that the act of grafting the Sugar Baby melons may have initiated a stress response in those plants.

The results from this trial suggest that grafting may be used to increase fruit yield and quality in some melons. However, more research is necessary since it is possible that the high levels of mite damage on the non-grafted melons could have confounded our results. Average numbers of fruit per plant were the same among treatments, but average fruit weights were highest in the grafted treatments, which happened to be relatively unaffected by mites compared to non-grafted treatments. It is possible that the damage caused by the mites was enough to reduce plant vigor, resulting in smaller fruit. This study was conducted only on one variety of melon, under one set of environmental conditions and, although results were interesting, much more research is necessary to determine if grafting melons would be a viable production alternative for Kentucky farmers.

Table 2. Spider mite damage on grafted melons in 2008.

Treatment	Mite Damage Ratings 13 Aug. (1-5)[1]		Mite Damage Ratings 20 Aug. (1-5)	
Non-grafted	4.0	a*	5.0	a
Self graft	1.5	b	2.0	c
Macis rootstock	1.0	b	2.25	bc
Shintosa Camel rootstock	1.5	b	2.75	b

* Treatments followed by different letters are statistically different with *P<0.05*.
[1] 1 = little or no visible infestation, 5 = severe infestation.

Literature Cited

Cohen, R., Y. Burger, C. Horev, A. Porat, and M. Edelstein. 2005. Performance of Galia-type melons grafted on to *Curcurbita* rootstock in *Monosporascus cannonballus*-infested and non-infested soils. Ann. Appl. Biol. 146:381-387.

Lee, J.M., and M. Oda. 2003. Grafting of herbaceous vegetable and ornamental crops. Hort. Rev. 28:61-125.

Pumpkin Cultivar Trial in Eastern Kentucky

R. Terry Jones, Crystal Collins Sparks, and Ryan Hays, Department of Horticulture

Introduction

Over 50% of Americans spend $50 or more on Halloween and fall decorations. Pumpkins are not only a way to find a niche in an ever-growing, popular holiday but also a way to extend the marketing season. A pumpkin trial was conducted at the University of Kentucky Robinson Station in eastern Kentucky. Sixteen cultivars were evaluated: two small varieties (under 10 pounds) and14 medium and large varieties (over 10 pounds).

Materials and Methods

Seeds were planted directly into the field on 11 June 2008. Each cultivar was replicated four times in a randomized complete block design. Each replication consisted of a single row 16 feet long containing eight plants (two/hill). Seeds were hand-sown 4 feet apart in the row with 5 feet between the pumpkin cultivars in a row. Seeds were planted about 1 inch deep. A sidedressing of urea containing 28 lb N/A was made on 20 June 2008. An additional 50 lb N was applied through the drip lines during irrigation. A tank-mix of Curbit 3EC + Command 3ME at (2 pt and 1 pt/A, respectively) was applied immediately after planting on 12 June 2008. In late June, 52 lb N/A was added as a sidedress to the planting. Pest control sprays were followed as outlined in *Vegetable Production Guide for Commercial Growers* (ID-36) as conditions warranted. Trickle irrigation was used throughout the season. Growing conditions this season were hot and very dry. Despite the use of trickle irrigation, the extremely dry conditions probably reduced fruit set and size at harvest on 29 September 2008.

Results and Discussion

Seven of the 14 large-fruited jack-o'-lantern cultivars showed fruit numbers greater than 2,200 fruit/acre. The four top-yielding large pumpkin varieties were Camaro, Magic Lantern, Gladiator, and Gold Medallion. Camaro, Spartan, and Super Herc produced more immature fruit than the other cultivars

(21%, 17%, and 17% of their total yields). World of Color Mix had the largest average pumpkin fruit weight (22.7 lb), but the yield/acre was so low (510 fruit/A) that economically, it was not desirable. High temperatures and dry weather may have prevented or delayed fruiting on the heirloom cultivar World of Color Mix. Aladdin was the largest jack-o'-lantern pumpkin (21.8 lb), followed by Gold Medallion (21.6), then Camaro (21.2) and Gold Medal (21.0). The pumpkin cultivars in this variety trial ranged from 11.9 pounds to 22.7 pounds. All the large-fruited pumpkin cultivars in this trial had good stem quality except for Gold Medal, which had only an average stem quality.

In the small pumpkin trial, Rockafellow produced 5,062 small 2.6 lb pumpkins per acre. Prankster produced 3,871 small 4 lb fruit per acre. Both Rockafellow and Prankster were very attractive small-fruited pumpkins. Stem quality was excellent on both of these small-fruited cultivars.

Table 1. Seed source, fruit number per acre, yield, average weight, and quality evaluations for large pumpkin cultivars, 2008.

Cultivar	Seed Source[1]	Mature Fruit (no./A)	Immature Fruit (no./A)	Avg. Wt. (lb)	Shape[2]	Smooth[3]	Ribbing[4]	Color	Stem Quality[5]
Camaro	Ru	2850	597	21.2	1	1.5	2.5	medium orange	3
Magic Lantern	Hm	2765	299	14.9	1	2.3	2.75	dark orange	3
Gladiator	Hm,Sw	2552	85	16.2	1	2.5	2.75	dark orange	3
Gold Medallion	Ru	2510	299	21.6	1	2.3	3	dark orange	3
Aladdin	Ru	2467	213	21.8	1	2.3	2.5	dark orange	3
Magician	Hm,Sw	2382	299	16.4	1.5	2	2.75	dark orange	2.8
Gold Challenger	Ru	2297	171	17.4	1.5	2.3	2.5	dark orange	2.8
Spartan	Sw	2084	427	19.1	1	2.5	2.75	dark orange	3
Super Herc	Hm,Sw	2042	427	16.3	1	2.5	2.5	dark orange	2.3
20 Karat Gold	Ru	1957	299	13.92	1	3.25	2.5	dark orange	3
Phantom	Sw	1957	384	14.5	1.3	2.3	2.75	dark orange	3
Gold Medal	Ru,Sw	1829	213	21	1	2	2	dark orange	1.5
Warlock	Hm,Sw	1744	213	11.9	1	3.3	1.75	dark orange	3
World of Color Mix	Ru	510	85	22.7	3.5	4	1	grayish white	2.8

1 Seed sources are found in Appendix A.
2 Shape rating: 1 = oblate, 2 = blocky, 3 = round, 4 = flat, hv = highly variable.
3 Smoothness rating: 1 = rough, warty skin, 5 = very smooth.
4 Ribbing rating: 1 = no ribbing, 5 = heavy ribbing .
5 Stem quality rating:1 = poor stem quality, 3 = excellent stem quality.

Table 2. Seed source, fruit number per acre, yield, average weight, and quality evaluations for small pumpkin cultivars, 2008

Cultivar	Seed Source	Mature Fruit No./A	Immature Fruit No./A	Avg. Wt. (lb)	Shape[1]	Smooth[2]	Ribbing[3]	Color	Stem Quality[4]
Rockafellow	SK	5062	510	2.6	2	4.25	1.13	dark orange	3
Prankster	Ru	3871	255	4.0	2.75	2.25	1.5	dark orange	3

1 1 = oblate, 2 = blocky, 3 = round, 4 = flat, hv = highly variable.
2 1 = rough, warty skin, 5 = very smooth.
3 1 = no ribbing, 5 = heavy ribbing.
4 1 = poor stem quality, 3 = excellent stem quality.

Evaluation of Powdery Mildew Tolerance in Pumpkin in Central Kentucky

Timothy Coolong, Department of Horticulture, and Kenneth Seebold, Department of Plant Pathology

Introduction

Powdery mildew is a serious disease of cucurbits in Kentucky. The effects of powdery mildew in pumpkins can be devastating, as hot and dry conditions in summer and early fall are generally favorable for outbreaks that can be quite severe. Large outbreaks of powdery mildew can destroy foliage resulting in plants that are unable to support large fruit loads, thus reducing yields. In addition, powdery mildew can spread from foliage and vine to the handles, compromising keeping quality and resulting in unmarketable fruit. As a result, pumpkin growers must rely on regularly scheduled fungicide sprays to reduce damage from powdery mildew. The cost of fungicide programs can be relatively high depending on the materials used and the number of times they are applied. In addition, many seed companies offer a number of pumpkin varieties with varying degrees of resistance to powdery mildew. When used in combination with fungicide sprays, these varieties enable growers to effectively control powdery mildew on pumpkins. Growers may be able to reduce the number of fungicide sprays required for adequate control of powdery mildew, along with the associated expense, if they choose a variety with high resistance to powdery mildew compared to a variety with minimal resistance. Also, effective disease control can be achieved with less-expensive protectant fungicides if varieties with good resistance to powdery mildew are planted. To gain a better understanding of the inherent resistance to powdery mildew in commercially available and experimental pumpkins, 24 varieties of medium and large pumpkins with at least some resistance to powdery mildew were tested without fungicide sprays to determine the level of resistance in each when subjected to high disease pressure. Four pumpkin varieties without any reported powdery mildew resistance were included as positive controls.

Table 1. Seed source, average fruit weight, stem ratings, and color evaluations for 28 varieties of pumpkins grown in Lexington, Ky., in 2008.

Variety	Seed Source[1]	Avg. Fruit Wt. (lb)		Stem Rating (1-5)[2]		Color
Conestoga Giant	SI	23.2	a*	3.2	bcde	medium orange
Super Herc.	HM	23.2	a	1.3	h	medium orange
Dependable	AC	22.1	ab	3.3	abcd	yellow orange
Summit	OS	20.8	abc	2.3	defg	medium orange
HSR 4710	HL	20.3	abcd	3.3	abcd	yellow orange
Aladdin	HM	19.5	bcd	3.7	ab	medium orange
Checkmate	OS	19.5	bcd	2.0	fgh	medium orange
King Midas	SI	18.8	bcde	3.3	abcd	medium orange
Camaro	HL/SW	17.2	cdef	2.6	cdef	yellow orange
Spartan	SW	17.0	def	2.3	efgh	dark orange
Howden	SW	16.8	def	2.8	bcdef	medium orange
ACX7302	AC	15.5	efg	3.7	ab	medium orange (variable)
ACX6501	AC	15.2	fgh	3.5	abc	yellow orange
Warlock	HM	15.1	fgh	2.3	efgh	dark orange
20 Karat Gold	RU	14.6	fgh	2.8	bcdef	medium orange
Hannibal	SI	14.3	fghi	3.0	bcde	medium deep orange
Magic Lantern	HM	14.2	fghi	2.3	efgh	medium deep orange
Sorcerer	HM	14.1	fghij	2.9	bcdef	medium orange
Gladiator	HM	14.1	fghij	1.7	gh	dark orange
ACX7301	AC	13.9	fghij	3.6	ab	medium orange
Superior	OS	13.9	fghij	3.1	Bcde	medium orange
Merlin	HM	13.7	fghij	2.8	bcdef	medium orange
Magic Wand	HM	13.2	ghij	1.6	gh	medium deep orange
Charisma	JS	11.7	hijk	3.5	abc	yellow orange
Magician	HM	11.7	hijk	3.0	bcde	medium deep orange
Capital	OS	11.0	ijk	2.9	bcdef	medium orange
Pankow's Field	H	10.6	jk	4.1	a	yellow orange
HSR4721	HL	9.5	k	3.2	bcde	yellow orange

* Means in the same column followed by different letters were significantly different at *P>0.05*.
1 Seed sources are found in Appendix A.
2 Stem rating (1 = best, 5 = worst) based on stem color, architecture, thickness, attachment, and overall attractiveness.

Materials and Methods

Pumpkins were direct seeded into bare-ground raised beds on 6 June 2008. Beds were spaced on 12-foot centers, and plants were seeded at 4 feet within row spacing. Four seeds were placed in each hole (hill) and later thinned to two plants per hill. Each plot consisted of eight plants (four hills) and plots were separated by 12 feet within rows. Drip irrigation tape was placed on the surface of each bed to provide supplemental water. Approximately 50 lb/A N was incorporated preplant using ammonium nitrate. Plants were watered as needed during growth. After seedling establishment, plants were fertigated weekly with ammonium nitrate at a rate of 10 lb/A until mid-August, such that the total (preplant + fertigation) N application for the season was 110 lb/A. Based on soil tests, no additional phosphorous or potassium fertility was necessary.

Weed control. Plots were sprayed using rates recommended in *Vegetable Production Guide for Commercial Grower* (ID-36), with a combination of Command (clomazone) and Curbit (ethalfluralin) herbicides between rows shortly after plant emergence to control weed growth. Plots were spot-sprayed with Paraquat (gramoxone) herbicide to control some weeds near plants. Rows were hand-cultivated as needed after vines began to run.

Fungicide sprays. No fungicides were used during this study.

Insecticide sprays. Admire (imidacloprid) was applied to the soil surrounding seeds at the time of seeding for control of cucumber beetles. Capture (bifenthrin) was applied at approximately 10 and 12 weeks after seeding to control squash bugs and cucumber beetles.

Plants were routinely monitored for the presence of powdery mildew after seedling emergence. The first signs of powdery mildew infection were detected on 28 July 2008. Subsequently, powdery mildew evaluations were conducted weekly beginning 6 August 2008 and concluding on 22 August 2008. The upper and lower canopies of plants were separately evaluated using a 0 to 5 scale where 0 = no symptoms, 1 = 1%, 2 = 10%, 3 = 30%, 4 = 60%, and 5 = 100% of the upper and lower canopy with symptoms of powdery mildew. Ratings for each plot were converted to percent diseased leaf area using the following transformation: $1.5625 - (5.625*x) + (5.0625*x^2)$, where x = assigned rating. Stems were evaluated for powdery mildew at harvest using the same 0 to 5 scale; however, data were not transformed to percent diseased area.

Fruit were harvested on 8 September 2008. Fruit were counted and weighed, and unmarketable fruit were culled. Yields and fruit per acre were based on an estimated plant population of 1,800 plants per acre. Fruit color was matched to color chips from the Royal Horticultural Society color chart from the "greyed-orange" group. Stem quality was also assessed at this time. Stem quality was evaluated on a scale of 1 (best) to 5 (poor). Stem quality was composed of an aggregate of traits including stem color, thickness, attachment, and overall attractiveness.

Table 2. Total yield, fruit per acre, marketable yield, marketable fruit per acre, and percentage of culls for 28 medium-large sized pumpkin cultivars grown in Lexington, Ky., in 2008. Varieties are ordered based on marketable yield (highest to lowest).

Variety	Total Yield (cwt/A)[1]		Avg. No. Fruit/A		Marketable Yield (cwt/A)		Marketable Yield (Fruit/A)		Culls (%)[2]	
Merlin	483	a*	3600	ab	461	a	3375	a	6	defg
Magic Lantern	473	ab	3450	abc	447	a	3150	ab	5	efg
HSR4721	293	de	3225	abcd	291	bcde	3150	ab	2	fg
Gladiator	423	abcd	3000	abcdef	423	ab	3000	abc	0	g
Capital	320	cde	2925	abcdefg	298	bcde	2700	abcd	6	defg
Warlock	398	abcd	2643	cdefghi	385	abc	2531	bcde	4	efg
Magic Wand	338	bcde	2588	cdefghi	327	abcd	2475	bcdef	3	efg
Superior	435	abcd	3543	ab	330	abcd	2419	bcdefg	23	abcde
Sorcerer	418	abcd	3318	abc	337	abcd	2363	cdefg	21	abcdef
ACX6501	480	ab	3675	a	349	abcd	2325	cdefgh	28	abc
Magician	328	cde	3038	abcde	258	cde	2138	cdefghi	24	abcde
Summit	477	ab	2400	defghi	424	ab	2025	defghij	12	bcdefg
ACX7301	440	abc	3600	ab	275	cde	1969	defghij	38	a
20 Karat Gold	307	cde	2325	efghi	280	cde	1950	defghijk	8	cdefg
HSR 4710	405	abcd	2193	fghi	379	abc	1913	efghijk	5	efg
Charisma	305	cde	2868	abcdefg	223	de	1913	efghijk	27	abcd
Camaro	315	cde	1856	i	301	bcd	1744	fghijk	5	efg
ACX7302	393	abcd	2775	bcdefgh	268	cde	1725	fghijk	31	ab
Spartan	338	bcde	2138	fghi	286	bcde	1688	ghijk	15	bcdefg
Howden	303	cde	1875	i	257	cde	1575	hijk	13	bcdefg
Pankow's Field	198	e	2081	ghi	156	e	1519	ijk	21	abcdef
Super Herc.	423	abcd	1950	hi	351	abcd	1500	ijk	18	abcdefg
Aladdin	350	abcd	1875	i	292	bcde	1500	ijk	17	abcdefg
Hannibal	310	cde	2250	efghi	220	de	1500	ijk	31	a
Dependable	440	abc	2306	efghi	302	bcd	1463	ijk	29	abc
King Midas	417	abcd	2625	cdefghi	266	cde	1425	ijk	30	ab
Checkmate	340	abcde	1912	hi	248	cde	1294	jk	29	abc
Conestoga Giant	410	abcd	1875	i	275	cde	1200	k	17	abcdefg

* Means in the same column followed by different letters were significantly different at $P>0.05$.
[1] cwt/A = 100 lb weight/acre, based on a plant population of 1,800 plants per acre.
[2] % cull based on weight of nonmarketable pumpkins/total yield of pumpkins.

Results and Discussion

Yield and quality. Yield and quality of all of the varieties tested were likely affected by the high levels of powdery mildew present in this study. However, the following results demonstrate the relative performance of one variety compared to another when grown under high powdery mildew pressure.

Conestoga Giant, Super Herc, Dependable, and Summit all had an average fruit weight of greater than 20 pounds (Table 1). This was expected as all are marketed as larger fruited pumpkins. Of these larger pumpkins, Summit and Super Herc had the highest marketable yields per acre (Table 2). Merlin, a medium-sized pumpkin (13.7 lb/fruit), had the greatest marketable yields. This was primarily due to the large number of fruit (3,600) per acre that it produced. Magic Lantern, a very popular variety in Kentucky, is another medium-sized (14.2 lb/fruit) pumpkin that yielded well, produced a low number of culls, and had moderate powdery mildew resistance. Other noteworthy varieties were Gladiator and Warlock. Both varieties had good yields, a relatively low percentage of culls, excellent dark orange color, and high-quality stems, in addition to displaying moderate resistance to powdery mildew. Some fruit from Warlock can be a little "warty," which may or may not be suitable for some markets.

Other varieties that yielded well and had a moderate-high level of resistance to powdery mildew (see below) included HSR4710 and Camaro. Camaro and HSR4720 produced medium/large fruit, 17.2 and 20.3 lb/fruit, respectively; had excellent resistance to powdery mildew; and had good stem ratings. The colors of both pumpkins, however, were a pale yellow-orange in contrast to a more typical medium-orange color of a Howden type pumpkin.

Powdery mildew resistance. The varieties tested in the study showed varying levels of resistance to powdery mildew, ranging from none to moderate-high (Table 3). At the earliest evaluation (August 6), eight varieties, including Camaro, HSR 4710, Gladiator, Warlock, and Magic Wand, had 20% or less of total leaf area (diseased leaf area, or DLA) affected by powdery mildew. By the final evaluation (August 22), all varieties had 50% or more DLA; Camaro showed 59% DLA, making it the variety with the greatest resistance to powdery mildew in the trial. Season-long severity of powdery mildew, determined by calculating the area under disease progress curves (AUDPC) for each variety, was lowest for Camaro, HSR 4710, HSR 4721, Gladiator, and Warlock. Varieties such as Checkmate, ACX 7301, ACX 7302, ACX 6501, Dependable, Howden, and King Midas showed the least resistance to powdery mildew in the trial. Severity of powdery mildew on pumpkin stems appeared to be linked to foliar disease severity. In general, varieties with

Table 3. Severity of powdery mildew on 28 medium-large sized pumpkin varieties grown in Lexington, Ky., in 2008. Varieties are ordered based on overall disease severity (lowest to highest).

Variety	PM[1] Res.	Powdery Mildew (PM) Severity[2] % DLA (8/6/08)		% DLA (8/15/08)		% DLA (8/22/08)		Overall PM Severity (AUDPC)[3]		Stem Rating (0-5)[4]	
Camaro	HR	7	k[5]	22	i	59	g	464	n	1.25	k
HSR 4710	HR	10	k	39	h	75	ef	684	m	1.75	jk
HSR4721	HR	14	jk	40	gh	71	f	730	lm	1.75	jk
Gladiator	HR	17	hij	35	h	74	ef	740	klm	1.25	k
Warlock	IR	11	ijk	53	fg	82	de	841	jkl	1.50	jk
Magic Wand	IR	19	hi	52	fg	86	cd	939	ijk	1.75	jk
Magician	IR	17	hij	67	def	89	bcd	1039	hij	1.75	jk
Superior	IR	20	gh	62	ef	95	abc	1059	g-j	1.50	jk
Magic Lantern	IR	23	gh	67	b-f	97	abc	1140	ghi	1.75	jk
Summit	IR	29	gh	63	fg	90	a-d	1157	hij	1.63	jk
Capital	IR	35	efg	62	c-f	94	abc	1226	fgh	1.88	ijk
Spartan	IR	30	fg	83	a-d	100	a	1355	efg	2.13	hij
Aladdin	IR	39	def	83	abc	100	a	1458	def	1.88	ijk
Merlin	IR	41	def	81	a-e	100	a	1469	def	1.88	ijk
Charisma	IR	44	b-f	81	a-e	100	a	1502	def	1.75	jk
Super Herc.	IR	56	a-e	77	a-e	97	ab	1597	cde	2.50	ghi
20 Karat Gold	IR	42	c-f	99	a	97	ab	1612	b-e	3.25	c-f
Sorcerer	NR	51	a-e	93	a	99	a	1681	a-e	2.75	fgh
Conestoga Giant	IR	56	a-e	86	ab	99	a	1686	a-e	2.50	ghi
Hannibal	IR	55	a-e	90	a	97	ab	1693	a-e	3.88	abc
King Midas	IR	57	a-e	100	a	100	a	1809	a-d	3.0	d-g
Howden	NR	69	a-d	94	a	100	a	1895	a-d	3.50	a-e
Pankow's Field	NR	74	ab	94	a	100	a	1949	abc	4.0	ab
ACX6501	UN	70	abc	100	a	100	a	1954	abc	3.63	a-d
Dependable	MT	80	a	97	a	100	a	2043	ab	3.38	b-f
ACX7302	UN	84	a	92	a	99	a	2048	ab	3.63	a-d
ACX7301	UN	83	a	95	a	99	a	2059	ab	4.13	a
Checkmate	NR	84	a	97	a	100	a	2089	a	2.88	efg

1 Reported resistance to powdery mildew (PM) according to seed company sources. UN = unknown, NR = no resistance, MT = mild tolerance, IR = intermediate resistance, and HR = high resistance.
2 Severity of powdery mildew assessed as the percentage of diseased leaf area (DLA).
3 Overall (season-long) severity of powdery mildew as determined by the area under disease progress curves (AUDPC) calculated from severity ratings taken on 8/6, 8/15, and 8/22.
4 Severity of powdery mildew on stems evaluated at harvest using a 0 to 5 scale where 0 = no disease, 1 = 1%, 2 = 10%, 3 = 30%, 4 = 6%, and 5 = 100% of stem area diseased.
5 Means in the same column followed by the same letter do not differ significantly as determined by Fisher's protected LSD test (*P≤0.05*). Statistics for foliar disease severity were calculated on arcsin-transformed means; non-transformed means are reported in the table.

greater resistance to powdery mildew on foliage tended to have less powdery mildew on stems than varieties with lower foliar resistance to the disease.

For many of the pumpkin varieties tested, our results appear to agree with the resistance ratings reported by seed companies. For example, varieties reported to be "highly resistant"—Camaro, HSR 4710, HSR 4721, and Gladiator—ranked as the most resistant in our trial. Varieties reported to have intermediate resistance, however, showed a wide range of powdery mildew resistance in the current study that ranged from moderate-high (Warlock, Magic Lantern) to low (Hannibal, King Midas). One variety, Hannibal, was described as "moderately tolerant" to powdery mildew but performed no better than completely susceptible varieties. Those varieties reported to be completely susceptible to powdery mildew, for the most part, tended to have the highest severity of disease in this trial. These results demonstrate the variability between advertised and actual resistance to powdery mildew in the varieties that were evaluated. It is important to remember that disease pressure will be different between years and locations, and our findings represent a single trial in a high-pressure year. Variety performance could be better or worse, depending on disease pressure, but the relative rankings between varieties would not be expected to change greatly.

Our results suggest that there are varieties with good yields and moderate levels of powdery mildew resistance. Growing these varieties might enable a grower to reduce fungicide inputs and associated costs while still producing good marketable yields of pumpkins.

Producing No-Till Pumpkins with a Rye/Vetch Cover Crop in Kentucky with Conventional, Low-Input, and Organic Practices

Derek Law, Mark Williams, Timothy Coolong, Department of Horticulture; Kenny Seebold, Department of Plant Pathology

No-till vegetable production systems continue to foster interest with Kentucky vegetable growers. The benefits of no-till systems include reduced energy use, lower soil erosion, reduced fertility inputs, higher soil moisture holding capacity, and increased earthworm and beneficial soil microbial populations. Most no-till crop production is accomplished by planting into residues remaining from a previous crop. However, some growers, particularly those interested in organic no-till vegetable production, are planting into a killed grass/legume mulch of winter or summer grown cover crops planted specifically in preparation for the following vegetable crop. Pumpkins are a good candidate for no-till production with cover crops as developing fruit rests on a bed of residue allowing for a clean crop at harvest. This experiment tested three production systems, conventional, low-input, and organic pumpkins grown using no-till practices on a winter cover crop of rye and hairy vetch in central Kentucky.

Materials and Methods

Plots used for this experiment were located at the University of Kentucky Horticultural Research Farm in Lexington, Kentucky. The plot area had been in a long-term crop science trial comparing conventional, low-input, and organic vegetable production systems since 2003. Twelve 40-foot by 60-foot plots were planted 13 September 2007 with rye/hairy vetch cover crop (60/30 lb/A). The cover crop was knocked down 27 May 2008 using a Buffalo rolling stalk chopper when the rye was in early head stage and the vetch at about three-quarters bloom.

Pumpkin transplants were started 1 May 2008 using organically approved practices in a controlled environment greenhouse. Magic Lantern (HS), a powdery mildew-resistant, 115-day pumpkin that has performed well in past trials in Kentucky, was selected for use. Seeds were planted in Sun-gro Sunshine certified organic potting media mixed with a local product, Prathers worm castings (1 part castings to 5 parts media). One additional fertilization using Omega 6-6-6 (one-third cup per 2 gallons water) was applied when the plants were moved to outside benches to harden off.

Transplanting was performed 4 June using a RJ Equipment no-till vegetable transplanter. Four rows of pumpkins at 10-foot spacing between rows and 4 feet between plants were planted in each 40-foot by 60-foot plot. Drip irrigation was applied to each row, and plots were irrigated as needed throughout the growing season.

Conventional inputs. Directly after the cover crop was rolled in late May, Roundup (glyphosate) was applied at 32 oz/A to ensure cover crop kill and to eliminate any small weeds growing under the canopy. One additional Roundup herbicide treatment was conducted 24 June using a backpack sprayer to spot-treat certain problematic areas of the conventional plots. In early June, just prior to transplanting, ammonium nitrate (Green Charger 33-0-0, Southern States) was broadcast in each plot at a rate of 80 lb N/A. Directly after transplanting, the herbicide Strategy was applied at the rate of 6 pt/A to the plots in 2-foot bands on either side of the plant row, and Admire, a systemic insecticide, was applied to the transplants at 24 fl oz/A. Applications of chlorothalonil (Bravo Weather Stik) at 3 pt/A were sprayed on June 5, June 12, June 19, July 3, July 17, July 24, August 7, and August 22. On June 26, July 10, and July 31, applications of strobilurin (Quadris) at 15.5 fl oz/A were used. Pounce, a pyrethroid-based insecticide, was applied at a rate of 8 oz/A July 17, July 31, and August 14.

Low-input inputs. The inputs in this production system were identical to the conventional inputs, but most were utilized at lower rates (except Admire and Quadris) than the conventional. After the cover crop was rolled in late May, Roundup at 16 oz/A was applied to ensure cover crop kill, and in early June, just prior to transplanting, ammonium nitrate (Green Charger 33-0-0, Southern States) was broadcast in each plot at a rate of 40 lb N/A. Directly after transplanting, the herbicide Strategy was applied at the rate of 3 pt/A to the plots in 2-foot bands on either side of the plant row, and Admire, a systemic insecticide, was applied at 24 fl oz/A. Applications of chlorothalonil (Bravo Weather Stik) at 1.5 pt/A were sprayed on June 5, June 19, July 3, and July 17. On July 31, an application of strobilurin (Quadris) at 15.5 fl oz/A was applied. Pounce, a pyrethroid based insecticide, was applied at a rate of 4 oz/A July 17, July 31, and August 14 .

Organic inputs. Organic inputs are often less effective than conventional inputs when faced with particular disease and insect pests, and organic growers must therefore be deliberate when making management choices. Over 30 consecutive years of cucurbit research have been conducted at the University of Kentucky Horticultural Research Farm, resulting in very high populations of overwintering cucumber beetles and squash bugs. These high pest populations present difficult challenges to organic pumpkin production at this research farm. Nevertheless, for this experiment, a vigorous spray regimen was followed with the intention that these inputs would ameliorate the heavy insect and disease challenges present in this location.

After the cover crop was rolled in late May, Matratec AG, an organic herbicide used at 6% dilution, was applied to ensure cover crop kill and to eliminate any small weeds growing under the canopy. In early June, just prior to transplanting, Nature's Safe 13-0-0, an organic fertilizer, was broadcast in each plot at a rate of 50 lb N/A. Directly after transplanting, the herbicide Matratec AG was applied at 8% dilution to the plots in 2-foot bands on either side of the plant row. One additional Matratec AG herbicide treatment was conducted 24 June using a backpack sprayer to spot-treat certain problematic areas of the organic plots.

The main organic insect and disease inputs used were weekly sprays of tank-mixed Surround, Pyganic, and either stylet or neem oil. Surround is a kaolin clay product that imparts a white particle film to the surface of plant leaves which is purported to discourage insect movement and feeding. It was used at a rate of 25 lb/A. Pyganic is a botanical pyrethrum-based non-selective contact insecticide that quickly kills exposed insects but rapidly loses effectiveness once exposed to the sun. It was used at a rate of 16 oz/A. Stylet oil is a petroleum product that has both fungicidal and insecticidal properties, and it was used at the rate of 5 qt/100 gallons. Neem oil is a natural oil cold pressed from seeds of the tropical tree (*Azadirachta indica*) and was added to the tank-mix at a 0.05% dilution rate. Sprays of these tank-mixed products were applied weekly beginning 5 June until 7 August. Surround and Pyganic were used in every spray, while stylet oil and neem oil were used on alternate weeks. On two occasions (26 June and 24 July), Entrust, an organically approved spinosad-based insecticide, was used in place of Pyganic.

Results and Discussion

The 2008 growing season started well with good rains, but during the height of the summer, little rain fell in Lexington, making the presence of drip irrigation vital to the success of the experiment. Conventional and low-input pumpkin yields were good, while the organic pumpkin yields were disappointing. Issues relating to each facet of the experiment are addressed below.

Timing of harvest. The two harvest dates of this experiment of 21 August and 10 September were too early to secure good wholesale pumpkin prices in central Kentucky. The original seed planting date of 1 May for the pumpkin transplants was too soon and in hindsight should have been delayed until late May. Total time from seed sowing to first harvest (112 days) and to second harvest (121 days) agreed with time-to-maturity expectations listed by Harris Seeds. Most of the mature marketable pumpkins were harvested on the first harvest date, and average number of pumpkins, average total weight of pumpkins, percent of total that was culled, and the average size of each pumpkin were all significantly higher than those harvested on the second harvest (data not shown).

Weed pressure. Only subjective observations of weed pressure were noted during the growing season which indicated overall weed pressure was highest in the organic treatment and lowest in the conventional. The main problem weeds were red root pig weed (*Amaranthus retroflexus*) and green foxtail (*Setaria viridis*) in terms of overall weed coverage, but other weeds such as morning glory (*Ipomoea* spp.), prickly sida (*Sida spinosa),* and lambsquarters (*Chenopodium album*) were present. It was estimated that weed control was satisfactory to good in the conventional and low-input treatments, while the organic treatments exhibited generally poor weed control over the four replicated plots. The conventional herbicides, coupled with the weed-reducing effect of the rolled down cover crop and a single herbicide spot treatment for large weeds at mid-season, provided adequate to good weed control for the season. The organic herbicide used was effective against very small weed seedlings, but any weeds over 3 inches in size seemed to recover from treatment, resulting in lower weed control by the end of the season. The relatively poor weed control in the organic treatment may have contributed to low yields.

Insect and disease pressure. Both the low-input and the conventional pumpkin plantings appeared to have been adequately protected from insect and disease attack throughout the year. Some weed pressure, a small amount of powdery mildew toward the end of the season, and some minor insect pressure were observed, but during this year, it seemed both spray regimens protected the crop enough to allow a very good marketable yield. Cucumber beetle and squash bug feeding is probably the main cause of poor yields in the organic plots. Neither insect appeared to be deterred by the use of the kaolin clay product Surround, and though individual insects were observed to die following application of the Surround/Pyganic/oil tank- mix spray treatment, it is likely there was not enough residual activity of this insecticide mix to keep the insect population in check over time. Major feeding damage began to occur in late June, and by the first harvest, many plants in the organic plots were heavily damaged, and nearly all were completely dead by the second harvest. Insect damage to pumpkin stems was the primary cause for culling pumpkins grown using organic methods (Table 1).

None of the three treatments appeared to have any real problem with powdery mildew. The combination of the use of a disease-resistant variety and the application of fungicides or stylet and neem oil in the spray regimens allowed this disease to be adequately controlled for the majority of the season. By the second harvest, evidence of this disease was present in all three treatments, but it was unlikely to have contributed to any kind of yield decline in any of the production systems for this year.

A concern going forward, however, is how the low-input regimen that worked well this year could be adapted in future years to respond to yearly environmental differences and other concerns about managing disease resistance, In addition, when using a low-input spray regimen, questions will arise as to whether overwintering pest populations will increase due to the use of lower amounts of insecticide or will increase resistance to fungicides by disease organisms as a result of lower overall use of fungicides.

Total yield. The conventional pumpkins, managed with herbicides and a weekly spray program of insecticides and fungicides applied at the highest recommended rates, had the highest yield. However, the low-input program during this year that also utilized conventional herbicide, fungicides, and

Table 1. Yield of marketable and cull pumpkins from three no-till production systems, 2008.

	Marketable Pumpkins			Cull Pumpkins			Percent of Total Yield That Was Cull (%)
Treatment	(lb/A)	(no./A)	Average Weight (lb)	(lb/A)	(no./A)	Average Weight (lb)	
Conventional	41109 A[1]	2867 A	14.34 A	6316 B	580 B	10.65 A	13.32 B
Low-input	36027 A	2522 A	14.29 A	6316 B	653 B	9.63 A	14.92 B
Organic	15772 B	1125 B	14.23 A	13176 A	1361 A	9.59 A	45.52 A

1 Means within a column followed by the same letter are not significantly different, as determined by Duncan-Waller LSD (5%).

insecticides but with fewer applications using the lowest possible rates yielded an amount that was not statistically different from that produced in the conventional treatments. Organic yields were significantly lower than either of the other treatments likely due primarily to insect feeding, disease pressure, and weed competition.

That the total conventional and low-input yields are not statistically different from one another cannot be too surprising when considering the climate during the growing season for pumpkin production. The weather during the majority of the summer was excellent for irrigated pumpkins with warm, dry weather that encouraged plant growth and restricted disease pathogen spread. With conventional plant protection practices like systemic and contact conventional insecticides that are highly effective and possess some residual activity, pumpkins produced high yields. Use of less-effective organic insecticides played a major role in the reduced yield from that production system.

Cost of inputs. Information regarding the cost of inputs only includes the variable cost of inputs that were different from system to system (Table 2). These costs do not include fixed costs like fuel and tractor maintenance costs, transplant or harvesting costs, or any kind of land use or opportunity costs that might be included in a standard crop budget. What is included is the cost of herbicides, fertilizers, insecticides, and fungicides used in each system on a per acre basis.

Table 2. Variable input costs per acre for no-till pumpkins, Lexington, Ky., 2008.

		Conventional	Low-Input	Organic
Herbicide		**$90.30**	**$45.25**	**$374.00**
Fertilizer		**95.00**	**47.38**	**140.00**
Insecticides	Admire	228.00	228.00	
	Pounce	24.00	12.00	
	Pyganic			716.00
	Surround			350.00
	Entrust			105.00
Fungicides	Bravo	222.00	92.50	
	Quadris	122.00	41.00	
	Neem Oil			250.00
	Stylet Oil			160.00
Totals		$781.30	$466.13	$2,095.00

Conclusion

Given the challenges noted above about the insect and disease pressure associated with cucurbit research at the University of Kentucky Horticultural Research Farm, it should not be a surprise that the organic treatment performed so poorly. Even when all the principles utilized by successful organic farmers such as long crop rotations, cover cropping, soil inputs of organic matter sources, use of disease-resistant plant varieties, and diligent attention to use of the best cultural techniques are put into practice, the inherent pressures of the surrounding environment can defeat these measures. Organic insecticides can play a role in management when environmental pressures overwhelm all other choices, but usually these botanically based products are less effective than synthetic conventional products, and, as such, it is likely they should not be counted on in the situation of extreme pest pressure. Despite the high cost of the organic inputs used, they were ineffective in protecting this crop in this environment. The production of organic pumpkins, particularly on a site where cucurbits have been commonly grown for a long period of time and pest and disease populations are well established, is probably not profitable in Kentucky.

The use of the rolled down rye/vetch cover crop was a successful feature of all three systems. The killed cover crop provided nitrogen to the growing crop, kept the soil cool which likely helped with transplant survival, allowed for increased water retention in the soil which was important in this dry year, and kept the harvestable crop clean prior to picking. Low-input and conventional-input strategies resulted in good yields. However, growers should be aware that in years with higher disease pressure, more protective chemical sprays may be necessary to ensure adequate production.

Literature Cited

Jones, R. Terry. 2002. Pumpkin Cultivar Evaluation in Eastern Kentucky.

Jones, T., Rowell, B., Strang, J., Bessin, R., and Nesmith, B. 1998. Kentucky Pumpkin Integrated Pest Management Grower Manual. IPM-12.

Fresh Market Tomato Variety Performance in 2008

Timothy Coolong, Janet Pfeiffer, Darrell Slone, and Amy L. Poston, Department of Horticulture

Introduction

Fresh market tomatoes represent one of the most valuable vegetable crops in Kentucky. Kentucky farmers grow nearly 1,000 acres of fresh market tomatoes for wholesale and farmers' markets.Several new varieties released recently have not been tested in Kentucky. Therefore, a variety trial was designed using many new varieties and some existing varieties that are commonly grown in Kentucky.

Materials and Methods

The trial was conducted at the University of Kentucky Horticultural Research Farm in Lexington, Kentucky, during the spring and summer of 2008. Tomato varieties were seeded into 200-cell trays on 14 March 2008. Seedlings were moved into 72-cell trays on 25 April 2008. Seedlings were greenhouse grown using standard production techniques. Seedlings were transplanted into the field on 7 May 2008. Plants were set into raised beds covered with black plastic mulch with drip tape.

Beds were spaced on 6-foot centers, and plants were spaced at 18 inches within rows. Plots consisted of eight plants of each variety replicated four times in a randomized complete block design. Borders containing several tomato varieties surrounded the test plots. The field received approximately 50 pounds of preplant nitrogen with no additional phosphorous or potassium applied per soil test results. Tomatoes were grown using University of Kentucky standard procedures recommended in *Vegetable Production Guide for Commercial Growers* (ID-36).

Plants were first harvested on 14 July 2008. Plants were harvested once or twice weekly until 11 September 2008. Fruit were graded for quality and size according to USDA standards for U.S. No. 1 tomatoes. For storage data, five tomatoes at the mature green or breaker stage were weighed from each replication of the 23 varieties and stored in boxes at 60ºF for 18 days and re-weighed to determine weight loss in storage. Yield data were calculated based on a plant population of 4,800 plants/acre. Statistics were performed using SAS statistical software. Data were tested for normality and transformed, if necessary. Results were considered significantly different if $P<0.5$.

Results and Discussion

Mountain Fresh Plus, a very popular main season variety in Kentucky, had the highest marketable yield for fresh tomatoes (Table 1). Mr. Ugly, an indeterminate hybrid, also had high yields; however, due to the misshapen fruit that this variety produces, it would only be suitable for farmers' market production and *not* for commercial wholesale production. Other high-yielding varieties included BHN 602, a new variety from BHN Seeds, and two numbered selections, NC 086 and NC 07425, from Dr. Randy Gardner's breeding program in North Carolina which have not been released yet. The high marketable yield observed in Mt. Fresh Plus was the result of having the largest yield of medium and large fruit and one of the lowest cull percentages of those varieties tested. Several numbered varieties from the North Carolina program had very high yields of extra large fruit, but they had relatively high percentages of culls, which brought down the marketable yield of some of them. The top three varieties in terms of average fruit weight were NC numbered selections (Table 2). BHN 602 had the highest average fruit weight of those varieties that are currently available. Two other new releases, Nico and Red Defender, did well also, with Red Defender having high yields of medium fruit and Nico having higher yields of large fruit. While fruit of Red Defender had a deep red color, Nico tended to be more orange. Two new releases that previously performed well in other trials, Fletcher and Mt. Glory, had relatively low marketable yields this year. This may be related to the relatively high percentage of fruit that were culled due to damage or other surface defects. It is interesting that Mt. Fresh Plus, a main season variety that has

Table 1. Marketable yield and yields of small, medium, large, and extra large tomatoes as well as % of culls and total harvested weights per acre for 23 fresh market tomato varieties grown in Lexington, Ky., in 2008. Varieties are ordered based on marketable yield (highest to lowest).[1]

Variety	Marketable Yield (lb/A)		Small (lb/A)		Medium (lb/A)		Large (lb/A)		Extra Large (lb/A)		Culls (%)[2]		Total Harvested (lb/A)	
Mt. Fresh +	61376	a*	3117	a	24483	a	18987	A	14789	ef	34	lm	93779	bcd
Mr. Ugly[3]	60716	a	1818	abcdef	12173	ghi	11697	bcdef	35028	a	43	defghi	106100	a
NC 07245	60000	ab	2112	abcde	16515	def	14823	B	26550	bc	34	m	91113	cde
BHN 602	54756	abc	1314	bcdef	16104	efg	14337	Bc	23001	cd	37	ijklm	86376	defg
NC 086	53984	abcd	816	ef	14627	fgh	13749	bcde	24792	bcd	47	bcd	102515	ab
Nico	53676	abcd	1719	abcdef	17049	def	13635	bcde	21273	d	41	efghij	91938	cde
Red Defender	52257	bcde	1713	abcdef	23292	abc	14790	B	12462	efg	35	klm	80463	fghij
NC 0694	49521	cdef	1839	abcdef	20007	cde	11430	bcdef	16245	e	45	cdefg	89268	cdef
NC 0821	49392	cdef	441	f	11478	hi	8721	Fg	28752	b	50	ab	98922	abc
Mt. Crest	49047	cdefg	1584	abcdef	20310	bcd	11349	bcdef	15804	e	40	ghijkl	81723	efghij
Rocky Top	48906	cdefg	1026	cdef	18687	def	14046	bcd	15147	ef	36	klm	76275	ghijk
Crista	48675	cdefg	1572	abcdef	18060	def	13449	bcde	15594	e	36	jklm	76491	ghijk
Carolina Gold	47229	cdefg	2925	ab	24195	ab	11409	bcdef	8700	gh	38	hijklm	75849	hijk
NC 07235	46254	defgh	789	ef	9750	ij	10107	ef	25608	bcd	46	bcdef	85752	defg
Solar Fire	44412	efgh	2499	abcd	24822	a	10062	ef	7029	h	43	defghi	76821	ghijk
BHN 640	44112	fgh	1428	bcdef	16140	efg	11703	bcdef	14841	ef	46	bcde	82506	fghij
BHN 543	43932	fgh	2904	ab	23439	abc	10461	cdef	7128	h	41	fghijk	73845	jk
BHN 871	43785	fgh	2649	abc	18357	def	10356	def	12423	efg	48	bc	84669	defghi
Finish Line	43707	fgh	1512	abcdef	17571	def	11997	bcdef	12627	efg	44	cdefg	77697	ghijk
Amelia	43326	fgh	1605	abcdef	16956	def	13734	bcde	11031	fgh	43	cdefgh	75405	ijk
Mt. Glory	41232	gh	2118	abcde	19470	cde	10464	cdef	9180	gh	34	m	62493	lm
Fletcher	38871	h	873	def	14652	fgh	11163	bcdef	12183	efg	43	cdefgh	68550	kl
Applause	26355	i	992	cdef	7101	j	5439	g	12824	efg	54	a	57873	m

* Means in the same column followed by different letters were significantly different at $P>0.05$.

1 Yield values based on a per acre population of 4,800 plants, grading based on USDA size and quality standards.

2 % cull based on weight of nonmarketable fruit/total harvested fruit.

3 Mr. Ugly is an indeterminate variety with an "heirloom-like" appearance that would not conform to typical USDA standards for round tomatoes.

been commonly grown for some time in the tomato industry in Kentucky, had the highest marketable yields. Many of early-season varieties, Applause, Mt. Glory, and Fletcher, had lower yields. This is likely due to the high numbers of culls in early harvests. Due to unusually cool spring weather, fruit that was developing early tended to be of poor quality, leading to high cull numbers in early- and mid-season varieties. Main season varieties tended to yield better, as they produced more fruit during the warmer temperatures in late July and August. It is likely that results may have been different in a season with warm spring weather.

Weight loss in storage ranged from 8% for Rocky Top to 2.3% for Mt. Crest, with most varieties losing between 3 and 4% fresh weight during storage (Table 2). Soluble solids were fairly similar among varieties tested (Table 2).

Growers should be aware that this trial tested varieties in one location for one year and that performance of varieties can vary-from one year to the next. A concurrent trial using the same varieties was performed in Crossville, Tennessee, this year. Results of that trial are pending and may be considered when future recommendations are made.

Table 2. Seed source, average days to first harvest, average fruit weight, percentage of weight loss in storage, and soluble solids content of 23 tomato varieties grown in Lexington, Ky., in 2008. Varieties are ordered based on average fruit weight (highest to lowest).[1]

Variety	Seed Source[2]	Days to First Harvest[3]	Average Fruit Weight (oz)		Weight Loss in Storage (%)		Soluble Solids (%)	
NC 0821	NA	-	12.1	a*	3.6	cdefg	4.30	ab
NC 07235	NA	-	11.6	ab	3.5	defg	4.10	ab
NC 086	NA	-	11.5	b	3.8	cdef	4.15	ab
BHN 602	SI/SW	77	10.6	c	5.2	bc	4.10	ab
NC 07245	NA	-	10.5	c	3.4	defg	4.20	ab
Applause	SW	67	10.4	cd	6.7	ab	4.20	ab
Nico	SW	76	10.0	de	2.3	fg	3.80	b
Rocky Top	RU	74	9.9	def	8.1	a	4.15	ab
BHN 640	SI	76	9.9	def	3.5	defg	3.93	ab
Crista	SW	74	9.8	ef	4.7	cde	4.50	a
Fletcher	SW	74	9.8	ef	3.6	cdef	4.40	ab
NC 0694	NA	-	9.7	ef	3.3	defg	4.30	ab
Amelia	SW	80	9.6	efg	3.6	cdef	4.30	ab
Mt. Crest	SW/SI	74	9.6	efgh	2.3	fg	4.15	ab
Finish Line	SI	77	9.5	fgh	3.9	cdef	4.23	ab
Mr. Ugly	SR	70	9.5	efgh	2.0	g	4.25	ab
Mt. Fresh +	SW	77	9.4	fgh	3.9	cdef	4.20	ab
Red Defender	SW	80	9.2	ghi	3.4	defg	4.05	ab
BHN 871	SI	76	9.1	hij	4.1	cde	4.10	ab
Mt. Glory	SW/SI	70	8.7	ijk	3.4	defg	4.40	ab
Carolina Gold	SI	75	8.7	ijk	3.1	efg	4.25	ab
BHN 543	SW	72	8.6	jk	4.9	cd	4.15	ab
Solar Fire	SW	73	8.5	k	4.6	cde	3.88	ab

* Means in the same column followed by different letters were significantly different at *P>0.05*.
1 Average fruit weight in ounces based on total marketable yield/total number of marketable fruit.
2 See Appendix A for seed sources; NA = not yet commercially available.
3 Average days to harvest according to seed company data.

Consumer Taste Preference for Vine-Ripened Heirloom and Hybrid Tomatoes

Timothy Coolong, Richard Durham, and Janet Pfeiffer, Department of Horticulture

Introduction

Many gardeners and consumers have expressed a preference for the taste of heirloom-type tomatoes compared to newer hybrid varieties. However, some argue that hybrid varieties do not have inferior flavor attributes, but they are often picked green, whereas many heirloom varieties are picked and sold vine ripened. Therefore, the type of tomato may affect flavor less than the time of harvest. To determine consumer taste preferences between vine-ripened hybrid and heirloom tomato varieties, a taste test was conducted comparing 12 varieties of heirloom and hybrid tomatoes.

Materials and Methods

Mature red-ripe tomatoes were harvested from 12 hybrid and heirloom varieties grown as part of a fresh market tomato variety trial conducted on the University of Kentucky Horticultural Research Farm in Lexington, Kentucky, in the summer of 2008. Fruit were graded, and those with any defects/disorders were culled. Fruit were then washed in a 150 ppm bleach solu-

Table 1. Flavor and texture ratings for 12 hybrid and heirloom tomato varieties.

Variety	Heirloom-Type or Hybrid[1]	Flavor (1 = best, 7 = worst)		Texture (1 = best, 7 = worst)	
NCO514[2]	Hybrid	2.2	a[3]	2.2	a
Brandywine Red	Heirloom	2.7	b	2.5	ab
Mr. Ugly	Heirloom	2.8	b	2.6	bc
Cour de Bue Oxheart	Heirloom	2.9	bc	2.6	bc
BHN 543	Hybrid	2.9	bc	2.7	bc
Gremlin	Heirloom	2.9	bc	2.6	bc
Amelia	Hybrid	3.1	bc	3.0	cd
Conestoga	Heirloom	3.1	bc	2.8	cde
Garden Peach	Heirloom	3.1	bc	2.8	cde
Mt. Glory	Hybrid	3.3	cd	3.1	de
Carolina Gold	Hybrid	3.6	de	3.4	e
Sophya	Heirloom	3.8	e	3.4	e

1 Not all heirloom-type varieties are true heirlooms by definition but are modern selections with heirloom characteristics and are sold as such, whereas hybrids are marketed for wholesale production.
2 NCO514 is expected to be released in 2009 as Mountain Magic.
3 Numbers within the same column followed by different letters are significantly different at *P<0.05.*

tion and stored at 60°F overnight until tasting. Taste evaluations were conducted as part of the University of Kentucky Arboretum Tomato Festival on 9 August 2008. For tasting, tomatoes were sliced and quartered and placed on white foam plates labeled 1 through 12. Participants were not told what varieties they were tasting. After the taste test, participants were asked to rate each variety for flavor and taste on a scale of 1 to 7 with 1 = like extremely, 7 = dislike extremely. Demographic and tomato consumption data were also collected from each participant (data not shown). Data were collected from 111 participants, though six data sets were removed because they were incomplete. Data were analyzed using SAS statistical software.

Results and Discussion

Interestingly, a new hybrid selection, NCO514, a large cherry-type tomato, rated highest in terms of flavor and texture. This variety is expected to be released in 2009 as Mountain Magic. Three heirloom types, Brandywine Red, Mr. Ugly, and Cour de Bue, and one hybrid, BHN 543, came in behind NCO514. Sophya, an heirloom type, and Carolina Gold, a yellow hybrid tomato, rated the lowest of the 12 varieties. These results suggest that there are no clear differences between heirloom- and hybrid-type tomatoes in terms of flavor quality. Perhaps consumer preferences for heirloom-type tomatoes may be due to flavor differences resulting from harvesting heirloom and hybrid fruits at different stages of ripeness.

2008 Fresh Market Specialty Pepper Evaluation for Yield and Quality in Eastern Kentucky

Crystal Collins Sparks, R. Terry Jones, and Ryan Hays, Department of Horticulture, Robinson Station, Quicksand, Kentucky

Introduction

Market opportunities for new or ethnic vegetable crops are becoming greater as a result of an increasingly diverse population and changes in eating habits. As a result of these trends, there has been more demand for various types of hot and sweet specialty peppers. Specialty peppers have culinary, nutritional, and/or health benefits and may provide some growers the opportunity to capitalize on a niche market.

Due to hot, humid summer weather, peppers grown in Kentucky are often under heavy disease pressure. The most devastating pepper disease in Kentucky is bacterial leaf spot (*Xanthomonas campestris* pv. *vesicatoria* or *Xcv*). Therefore, most peppers recommended for planting in Kentucky have been shown to be resistant to at least three races of bacterial leaf spot. To determine the performance of specialty peppers in Kentucky, several varieties of specialty peppers were tested in the summer of 2008 in Quicksand, Kentucky.

Materials and Methods

Twelve specialty and one bell pepper cultivar (Table 1) were evaluated for yield, quality, and appearance (Table 3). Immature green or mature colored fruit were harvested three times from early July to mid-August. Mature green or colored fruit were counted, graded, and weighed. Small fruit or fruit with visual defects were culled. Mature fruit were graded, weighed, and evaluated for taste and appearance. The 13 pepper cultivars (Table 1) were seeded in 72-cell trays in the greenhouse at the Robinson Station on 25 March 2008 and were transplanted to the field on 13 May 2008. Fifty pounds per acre of N and 100 pounds K_2O/A were applied several days before planting based on soil test results. One hundred additional pounds of N/A were applied to the peppers through the drip irrigation lines during the growing season for a total of 150 lb actual N/A. Each cultivar replication contained 12 plants per replication in double rows with eight plants per row. The in-row spacing was 14 inches with 14 inches between rows.

Fruit appearance ratings. Hand harvest started too early for some of the specialty peppers to display optimum color. All pepper cultivars were harvested on two separate occasions (7/01 and 7/08), laid out on the ground, and evaluated. Overall appearance ratings were the result of several factors listed in order of decreasing importance: overall attractiveness, shape, smoothness, color, and uniformity.

Results and Discussion

The 2008 growing season was very dry and temperatures were hot with clear, sunny skies on most days. In 2008, Sweet Diablo was the top-yielding pepper with 31,310 lb/A followed by Ringo Yellow with 25,852 lb/A, Aristotle with 24,658 lb/A, and Marachi with 24,574 lb/A (Table 2). Zavory, the sweet Habanero, had the lowest early yields because it was much slower to flower and produce fruit than the other cultivars. In fact, the plants of Zavory were also very slow to germinate and develop in the greenhouse and were much smaller at the time of setting. Jalapeno (Sax 7603) at 342,153 fruit/A; Zavory at 329,413 fruit/A; and Telica at 285,491 fruit/A produced the most fruit per acre. The bell pepper Aristotle had the largest average fruit size, and Zavory had the smallest average fruit size. Many of these peppers were very attractive and had excellent taste. Mariachi, Ringo Yellow, and Yummy Mix performed well.

Table 1. 2008 specialty pepper cultivar trial.

Cultivar	Source[1]	Days to Maturity	Comments[2]
Aristotle	SW, HM	72	Very large green to red bell pepper, resistant to BLS Xcv 1,2,3 and PVY, TMV
Telica	HS	75	X-large jalapeno with excellent yields; very attractive; BLS tolerant
Holy Mole	HM	85	Pasilla type; dark green; 7-9 in. long; fruit that become chocolate brown at maturity; mildly hot
Mariachi	HM	85	AAS winner; hot pepper Santa Fe Grande type; fruit 3-4 in. x 1.5 in.; medium hot; pale cream to creamy orange fruit; resistant to TMV
Carmen	HM	75	AAS winner; Italian sweet; 7 in. x 2 in. fruit that mature from green to brown red
Ringo Yellow	SW	70	Italian Bull's Horn; 9 in. x 2 in.; green to yellow fruit; great frying combined with Diablo Sweet
Yummy Mixed	SW	73	Snack pepper; orange, red, or yellow fruit; 2¼ in. x 1½ in.
Sweet Diablo	SW	70	9 x 2 in.; very large; Italian roasting pepper; green to red fruit; very sweet; thick walled
Zavory	SW	90	Sweet habanero; 2¼ in. x 1¾ in.; light green to red; lots of flavor; touch of heat
Key West X3R	SW	67	Cubanelle; 7½ in. x 2 in.; light green to red fruit; resistant to BLS Xcv 1, 2, 3
Hot Spot	SW	72	Hot banana; light yellow to red fruit; 8½ in. x 1½ in.; resistant to BLS Xcv 1, 2, 3
Sweet Spot	SW	72	Sweet banana pepper; resistant to BLS Xcv 1, 2, 3
Jalapeno (SAX 7603)	SW	75-80	Attractive green to red jalapeno; 2.5 in. x 3 in. long fruit; little cracking

1 Information on seed source is listed in Appendix A.
2 Pepper disease key: PVY = Potato Virus Y, TMV = Tobacco Mosaic Virus, BLS Xcv = Bacterial Leaf Spot caused by specific races of *Xanthomonas campestris* pv *vesicatoria.*

Table 2. 2008 specialty pepper yield and fruit number per acre from three harvests.

Cultivar	Seed Source[1]	Total No. Fruit/A	Total Fruit Yield (lb/A)	Avg. Fruit Wt. (oz)	Total No. Cull Fruit (fruit/A)	Fruit Color	Comments
Aristotle	SW, HM	60183	24658	6.56	1676	green	Sweet bell; good flavor
Telica	HS	285491	17002	0.95	3185	dark green	Hot to taste; equal to Hot Spot
Holy Mole	HM	103266	9609	1.5	0	chocolate brown/green	No heat; had a bell pepper taste; good fryer
Mariachi	HM	235031	24574	1.7	1509	bright green/ yellow	Hot; not as hot as Hot Spot; a good fryer with some heat
Carmen	HM	146350	22742	2.5	503	bright green	No heat; has a bell pepper taste; Italian sweet pepper with a "nice" mild flavor
Ringo Yellow	SW	131430	25852	3.1	3353	dark yellow	Mild to taste; adds beautiful color to dishes and has a nice flavor
Yummy Mixed	SW	157246	8764	0.9	1676	green, red, orange, & yellow	These little peppers had the best flavor; very pretty pepper that was sweet as candy
Sweet Diablo	SW	110911	31310	4.5	2347	medium green	Attractive pepper; had a pleasant taste; no heat; not as strong as the other Cubanelle
Zavory	SW	329413	8416	0.4	2179	green	Very nice little pepper; had nice color and a hint of heat after eating; pleasant
Key West X3R	SW	86838	19098	3.5	0	bright /medium green.	Attractive Cubanelle; mild flavor; good stuffed pepper
Hot Spot	SW	191445	16848	1.4	838	light green	Very good fryer, but it was extremely hot
Sweet Spot	SW	164958	19595	1.9	335	light green	Good fryer; mild kick
Jalapeno (SAX7603)	SW	342153	21029	1.0	3520	dark green	Burns for a while after eating

1 Information on seed source is listed in Appendix A.

Screening *Capsicum chinense* for Antioxidant Contents

George F. Antonious and, Lauren Lobel, Department of Plant and Soil Science, Land Grant Program, Kentucky State University, Frankfort, Kentucky; Tejinder Kochhar, Department of Biology, Kentucky State University, Frankfort, Kentucky; Terry Berke, Seminis Seed Co., State Highway, Woodland, California; and Robert L. Jarret, USDA/ARS Plant Genetic Resources Conservation Unit, Griffin, Georgia

Introduction

The search for beneficial phytochemicals is growing worldwide. Many hot pepper species (*Capsicum* spp.) and cultivars have not been analyzed for their concentrations of capsaicin, ascorbic acid, and phenol compounds, which are important antioxidants with a number of benefits for human health. The USDA pepper (*Capsicum* spp.) germplasm collection contains several thousand members or accessions.

There is a growing interest in the enhancement of compounds in food that possess health-promoting attributes such as antioxidant properties and which were previously regarded as non-nutritive (Van der Sluis et al., 2002). Plants contain numerous non-nutritive bioactive compounds known as "phytochemicals." Many of these compounds, including phenols, are antioxidants in nature (Shahidi 2000). Plant phenols may interfere with stages of the cancer process, potentially resulting in a reduction of cancer risk. They might prevent oxidative damage to biomolecules such as DNA, lipids, and proteins which play a role in chronic diseases such as cancer and cardiovascular disease (Holman, 2001). Plant phenols include simple phenols, flavonoids, anthocyanins, lignans and lignins, stilbenes, and tannins. The role of phenols as antioxidants with properties similar to vitamins C, E, and ß-carotene has prompted a number of studies of these compounds. A wide variety of phenolic compounds derived from spices like hot pepper possess potent antimutagenic and anticarcinogenic properties (Surh and Seoul, 2002). Some mammalian metabolites of polyphenols and tannins (PPT) may be able to protect the vascular endothelium. Diets rich in PPT may have the ability to protect against Type II diabetes and the metabolic syndrome through effects on glucose absorption and associated hormones (Clifford, 2004). Hot pepper also contains significant concentrations of ascorbic acid. A few derivatives of ascorbic acid were tested on cancer cells, among them ascorbic acid esters, revealing promising anti-cancer activity (Naidu, 2003). Ascorbic acid, found in most vegetables and fruits, protects against heart disease, high cholesterol, high blood pressure, and cancer (University of Maryland, 2008).

Capsicum chinense has been referred to as the most frequently cultivated pepper in South America (DeWitt and Bosland, 1996). Capsaicinoids, the pungent component of pepper, exhibit antioxidant activity and antimutagenic and anticarcinogenic properties (Surh and Seoul, 2002). Pungent chili varieties are grown for their food value, health-promoting properties (Padilla and Yahia, 1998), and as a source of capsaicinoids that have a variety of medicinal uses (Sicuteri et al., 1990). The USDA *Capsicum* germplasm collection contains many thousands of accessions of *Capsicum* spp.; however, limited information is currently available on their composition. Variability in the presence and concentration(s) of phytochemicals in pepper species can be a factor affecting the selection of pepper for breeding programs. The objectives of this investigation were to: 1) determine the concentration of phenols, ascorbic acid, and capsaicin in 63 hot pepper accessions of *Capsicum chinense* and 2) identify accessions of hot pepper having great concentrations of ascorbic acid, total phenols, and total capsaicinoids among countries of hot pepper origin for use as a source of antioxidants or as parents in USDA breeding programs.

Materials and Methods

Seeds of 63 accessions of hot pepper, *Capsicum chinense* were obtained from USDA/ARS in Griffin, Georgia. The accessions of *C. chinense* represented germplasm originally acquired from a variety of locations including: Belize (n = 9), Brazil (n = 7), Colombia (n = 8), Ecuador (n = 6), Mexico (n = 10), Peru (n = 10), Puerto Rico (n = 6), and United States (n = 7). Seeds were sown on March 16, and the seedlings were transplanted in the field on May 3, 2006, into rows about 1.5 m apart and 0.25 m between plants within rows. Plants were fertilized and weeded as needed. Randomly selected fruits of each accession were harvested at full maturity.

Representative fruit samples (20 g) were blended with 150 mL of ethanol to extract phenols. Homogenates were filtered through Whatman No. 1 filter paper, and one mL aliquots of filtrate were used for determination of total phenols using a standard calibration curve (1 to16 µg mL^{-1}) of chlorogenic acid (Fisher Scientific Company, Pittsburgh, PA). Ascorbic acid was extracted by blending 20 g of fruit with 100 mL of 0.4 % (w/v) oxalic acid solution (Antonious and Kasperbauer, 2002) and was determined using the 2,6-dichlorophenolindophenol method.

Capsaicinoids were extracted by blending 50 g of homogenate (n = 3) of fresh fruits with 100 mL of methanol for 1 minute. The solvent extracts were decanted through 55 mm Whatman 934-AH glass microfiber filter discs (Fisher Scientific, Pittsburgh, PA) and concentrated in a rotary vacuum evaporator (Buchi Rotovapor, Model 461, Flawil, Switzerland) at 35°C, chased with nitrogen gas (N_2), and reconstituted in 10 mL of methanol. One µL (n = 3) of this filtrate was injected into a gas chromatograph (GC) equipped with a nitrogen-phosphorus detector (NPD). GC separations were accomplished using a 25 m × 0.20 mm ID capillary column with 0.33 µm film thickness (HP-1). Quantifications were based on average peak areas of 1 µL injections obtained from external standard solutions of capsaicinoids prepared in methanol. Under these conditions, retention times (R_t) were 11.50 and 11.75 min for capsaicin and dihydrocapsaicin, respectively. A HP gas chromatograph (GC) model 5890A equipped with a mass spectrometer (GC/MS) operated in total ion monitoring with electron impact ionization (EI) mode and 70 eV electron energy was also used for identification and confirmation of individual peaks. Purified standards of capsaicin (N-vanillyl-8-methyl-6-noneamide) and dihydrocapsaicin were obtained from Sigma-Aldrich Inc. (Saint Louis, MO) and used to obtain calibration curves.

Results and Discussion

Among the 63 accessions analyzed (data not shown), concentrations of total phenols were significantly higher in PI 438648 and PI 159248 (Table 1). Concentrations of ascorbic acid in PI 152452 and PI 360726 were significantly higher than in other accessions analyzed (Table 1). These accessions may be useful as parents in hybridizations to produce high phenol and ascorbic acid containing varieties. On the contrary, PI 224445 and PI 281424 had the lowest contents of both phenols and ascorbic acid, respectively (data not shown).

Pronounced differences in total capsaicinoids (capsaicin plus dihydrocapsaicin) concentrations were found among accessions. Fruits of *C. chinense* accessions PI-640900 (USA) contained the greatest concentration ($P< 0.05$) of capsaicin (1.52 mg g^{-1} fresh fruit) and dihydrocapsaicin (1.16 mg g^{-1} fresh fruit), while total major capsaicinoids in the fruits of PI-438648 (Mexico) averaged 2 mg g^{-1} fresh fruit. PI-152452 (Brazil) and PI-360726 (Ecuador) contained the greatest concentrations of ascorbic acid (1.2 and 1.1 mg g^{-1} fresh fruit, respectively), while PI-438648 (Mexico) contained the greatest concentration of total phenols (349 µg g^{-1} fresh fruit) among the other 63 accessions tested. Table 3 summarizes the concentrations of capsaicin and dihydrocapsaicin among countries of hot pepper origin. Hot pepper fruits grown from seeds originating in Mexico contained the greatest concentration of total capsaicinoids. These accessions were identified as potential candidates for mass production of major antioxidants that have health-promoting properties. The great variability within and between *C. chinense* accessions for these phytochemicals suggests that these selected accessions should be included in plant breeding programs or other research approaches to produce fruits with value-added traits.

Acknowledgments

We thank Jami Rogers and Yoon Hu for their assistance in preparing hot pepper extracts. This investigation was supported by the KY-WVA LSAMP Program and grant No. KYX-10-08-43P from USDA/CSREES to Kentucky State University.

Literature Cited

Antonious, G.F., and M.J. Kasperbauer. 2002. Color of light reflected to leaves modifies nutrient content of carrot roots. Crop Sci. 42:1211-1216.

Clifford, M.N. 2004. Diet-derived phenols in plasma and tissues and their implications for health. Planta Medica 70:1103-1114.

DeWitt, D., and P.W. Bosland. 1996. Peppers of the World: An Identification Guide. Ten Speed Press, Berkeley, CA,

Hollman, P.C.H. 2001. Evidence for health benefits of plant phenols: Local or systemic effects? J. Science Food Agriculture 81:842-852.

Naidu, K.A. 2003. Vitamin C in human health and disease is still a mystery? An overview. Nutrition Journal 2:2-7.

Table 1. Concentrations of ascorbic acid and total phenols (µg g-1 fresh weight) in 10 accessions of *Capsicum chinense* grown from seeds originated from different countries of origin; Mexico (ME), United States (US), Ecuador (EC), Peru (PE), Brazil (BR), and Colombia (CO) having greatest concentrations of ascorbic acid and total phenols among 63 accessions. Values within a column for each compound accompanied by different letter(s) indicate significant differences (P< 0.05) using Duncan's multiple range test.

Accession	Ascorbic Acid	Accession	Total Phenols
PI 152452 (BR)	1224.0 a	PI 438648 (ME)	349.3 a
PI 360726 (EC)	1138.9 b	PI 159248 (US)	337.7 ab
PI 257165 (PE)	972.8 c	PI 460900 (US)	324.8 abc
PI 355817 (EC)	951.3 cd	PI 360726 (EC)	317.6 bc
PI 441605 (BR)	938.5 cd	PI 257165 (PE)	309.2 cd
PI 355819 (EC)	902.3 d	PI 438622 (ME)	292.8 de
PI 441629 (BR)	900.3 d	PI 152452 (BR)	292.8 de
PI 441625 (BR)	898.5 d	PI 257124 (CO)	267.1 ef
PI 281338 (EC)	838.4 e	PI 438631 (ME)	263.1 ef
PI 159248 (US)	833.2 e	PI 438636 (ME)	261.9 ef

Table 2. Concentrations of capsaicin, dihydrocapsaicin, and total capsaicinoids (µg g^{-1} fresh weight) in 11 accessions of *Capsicum chinense* grown from seeds originated from different countries of origin (BR = Brazil, CO = Colombia, ME = Mexico, US = United States) having greatest concentrations of capsaicinoids among 63 accessions tested. Values within a column for each compound accompanied by different letter(s) indicate significant differences ($P< 0.05$) using Duncan's multiple range test.

Accession	Capsaicin	Dihydrocapsaicin	Total
PI 152452 (BR)	842 cd	455 e	1297 bcd
PI 257124 (CO)	1126 c	257 g	1383 bcd
PI 435917 (ME)	775 cde	501 e	1276 bcd
PI 435918 (ME)	758 cde	484 e	1242 bcd
PI 438622 (ME)	875 cd	711 b	1586 bc
PI 438631 (ME)	766 cde	513 e	1279 bcd
PI 438636 (ME)	993 c	656 bc	1649 bc
PI 438648 (ME)	1338 b	636 bc	1974 b
PI 441603 (BR)	854 cd	367 f	1200 bcde
PI 441629 (BR)	892 cd	593 bcd	1485 bcd
PI 640900 (US)	1518 a	1160 a	2678 a

Table 3. Concentrations of capsaicin, dihydrocapsaicin, and total capsaicinoids (µg g^{-1} fresh weight) in *Capsicum chinense* grown from seeds originated from different countries of origin (BR = Brazil, CO = Colombia, ME = Mexico, US = United States) having greatest concentrations of capsaicinoids among 63 accessions tested. Values within a column for each compound accompanied by different letter(s) indicate significant differences ($P< 0.05$) using Duncan's multiple range test.

Country of Origin	Capsaicin	Dihydrocapsaicin	Total
Mexico	797 a	563 a	1360 a
U.S.	655 a	309 b	964 b
Brazil	621 a	304 b	925 b
Colombia	315 b	88 c	404 c
Ecuador	306 b	96 c	402 c
Peru	300 b	135 c	436 c
Belize	206 b	142 c	348 c
Puerto Rico	125 b	58 c	183 c

Padilla, M.C., and E.M. Yahia. 1998. Changes in capsacinoids during development, maturation, and senescence of chili peppers and relation with peroxidase activity. J. Agric. Food Chem. 46:2075-2079.
Shahidi, F. 2000. Antioxidant factors in plant foods and selected oilseeds. BioFactors 13:179-185.
Sicuteri, F., M. Fanciullacci, M. Nicolodi, P. Geppetti, B.M. Fusco, M. Marabini, M. Alessandri, and V. Campagnolo. 1990. Substance P theory: A unique focus on the painful and painless phenomena of cluster headache. Headache 30:69-70.
Surh, Y.J., and S.K. Seoul. 2002. Anti-tumor promoting potential of selected spice ingredients with oxidative and anti-inflammatory activities. Food Chem Toxicol. 40:1091-1097.
University of Maryland Medical Center-2008, Vitamin C (ascorbic acid), www.umm.edu/altmed./articles/vitamin-c-000339.htm.
Van der Sluis, A.A., M. Dekker, G. Skrede, and W.M. Jongen. 2002. Activity and concentration of polyphenolic antioxidants in apple juice. J. Agric. Food Chem. 50:7211-7219.

Growing *Brassica* Species for Glucosinolates Content

George F. Antonious and Michael Bomford, Department of Plant and Soil Science, Land Grant Program, Atwood Research Center, Kentucky State University, Frankfort, Kentucky; Paul Vincelli. Department of Plant Pathology, University of Kentucky

Introduction

Glucosinolates (GSLs), a group of compounds found in *Brassica* plants, are toxic to some soil-borne plant pathogens because of the toxicity of their hydrolysis products, isothiocyanates. Plants in the *Brassicaceae* that contain the secondary metabolites of GSLs have been used in suppression of soil-borne organisms. Incorporation of allelopathic cruciferous tissues into the soil can suppress soil-borne pests due to the biofumigant properties of the highly toxic isothiocyanates and moderately toxic non-glucosinolate S-containing compounds (Bending and Lincoln, 1999). Isothiocyanates, physiologically active compounds, are the major products of hydrolysis of GSLs that are released when myrosinase (thioglucosidase), a degradative enzyme, comes into contact with GSLs in plant-damaged tissues. In addition to isothiocyanates other less toxic breakdown products of GSLs (e.g., nitriles, thiocyanates, and oxazolidinethiones) can also be released. More than 120 different GSLs have been described in the literature (Fahey et al., 2001; Wittstock and Halkier, 2002). When plants containing GSLs are physically disrupted, the hydrolytic enzyme myrosinase (thioglucoside glucohydrolase) is released from ruptured cells, hydrolyzing GSLs to primarily isothiocyanate, glucose, and nitrile products. GSLs and their hydrolysis products are responsible for the sharp or biting taste of condiments (horseradish or mustard) and contribute to the characteristic flavors of plants whose leaves (brussels sprouts, cabbage), floral buds (broccoli, cauliflower), stems (kohlrabi), or roots (radish, turnip) are consumed by humans (McGregor et al., 1983). The pungency, flavor, and many undesirable toxic manifestations of different crucifer materials are associated with GSLs. When consumed by humans and animals in moderate amounts, some GSLs, or their enzymatically released products, can reduce the risk of cancer (Song et al., 2006; Moreno et al., 2007). On the other hand, GSLs are significant factors impairing the nutritional quality of rape seed and restricting its use as high-quality protein animal feed (Jezek et al., 1999).

Interest in the fate of GSLs in soil derives from recent research on the use of *Brassica* plants as natural fumigants (biofumigants) due to the release of isothiocyanates upon their hydrolysis. GSLs by themselves are not biologically active but must be enzymatically hydrolyzed by the enzyme myrosinase to isothiocyanates capable of suppressing soil pathogens. Myrosinase is produced by plants, insects, and fungi and is frequently found in soil (Gimsing et al., 2005). Kleinwächter and Selmar (2004) reported that a distinctive characteristic of myrosinase is its activation by ascorbic acid; in some cases. myrosinase is completely inactive in the absence of ascorbic acid. Consequently, the concentration of ascorbic acid in plant tissues that releases isothiocyanates by the action of myrosinase should be investigated.

Plant phenols are among the factors that improve the efficacy of biofumigants for soil disinfestation. Phenols had a strong antimicrobial effect against *Phytophthora capsici* (*Phytophthora* blight) (Hwang et al., 2005).

Consistent and reliable soil-borne pest management with *Brassica* GSL-containing amendments would not be achieved in field application without simple, accurate, and fast methods of GSL separation and quantification. The objectives of this investigation were to: 1) develop a simplified procedure for quantification of glucosinolates in *Brassica* accessions; 2) determine variation in total glucosinolate concentration among plants grown under greenhouse, winter high tunnels, and field conditions; and 3) identify *Brassica* accessions with the greatest levels of GSLs and total phenols for future research on fumigant potential of their crude extracts. Our major goal is to select *Brassica* species and accessions within species with improved levels of GSLs and phenols for future use as soil biofumigants to fight *Sclerotinia* white mold in winter vegetables grown in unheated high tunnels and *Phytophthora* blight in summer-grown peppers.

Materials and Methods

The experimental studies were conducted in 2006-07 at the Kentucky State University Research Farm in Franklin County, Kentucky, and replicated in three climatic conditions (fall greenhouse, winter high tunnel, and spring field). Seven accessions of Indian mustard, *Brassica juncea* (Ames 8660, Ames 8674, Ames 8709, Ames 8887, PI 120923, PI 603015, and Pacific Gold); one accession of oilseed rape, *Brassica napus* (PI 169083); one accession of *Brassica campestris* (Ida gold field mustard); and one accession of arugula, *Eruca sativa* (PI 633215) were grown from seed.

Greenhouse-grown plants were direct-seeded on 26 July 2006 in a greenhouse with active heating and cooling systems set to maintain a temperature of 20°C. Each accession was represented by 10 seeds grown in a 3.6 L (16.5 cm diam × 16.5 cm high) bench-top nursery container filled with a mixture of equal parts of peat-based potting soil and aged compost. High tunnel and field-grown accessions were planted at 5 cm spacing in 1 m rows 15 cm apart in Elk silt loam amended with aged compost at 25 L m^{-2}. Each row contained a different accession, with locations randomly assigned within two complete blocks. Seeds were planted in the unheated high tunnel on 7 December 2006 and in the field on 11 June 2007. All aboveground biomass from each accession was collected and weighed when >50% of plants had initiated flowering (7-10, 17-21, and 7 weeks after seeding in the greenhouse, high tunnel, and field, respectively). Representative samples of five plants from each accession were collected for extraction of GSLs. Shoots (stems and leaves) were cut into 1 to 3 cm, and 100 g subsamples were dropped into boiling methanol (300 mL) on a steambath in 1-L wide-mounted Erlenmeyer flasks (covered with a watch glass) for 15 min. After cooling, the material was blended and vacuum filtered. The methanol extracts were concentrated by rotary vacuum evaporator (Buchi Rotavapor Model 461, Switzerland) at 40°C to remove methanol. The contents were centrifuged (10,000 ×g for 10 min). Ten mL of the extract was filtered through an open glass chromatographic column of 1.5 × 20 cm containing 4 g of celite to give a purified homogeneous aqueous extract.

Separation of total GSLs was accomplished by adsorption on DEAE-Sephadex A-25 (2-[diethylamino] ethyl ether) ion exchange resin of 40-125 µm bead size. We simplified the GSL separation procedure by using 10 mL disposable pipette tips filled with DEAE, a weak base, that has a net positive charge when ionized and therefore binds and exchanges anions (anion-exchange resin). Five mL of the purified plant extracts were applied to disposable pipette tips (10 × 1.2 cm) containing a small glass wool plug, ion-exchange Sephadex (pre-swelled overnight with 2M ammonioum acetate) to give a settled resin height of 5 cm, and the resin was washed with 10 mL of deionized water. Two mL of myrosinase (thioglucosidase in 5 mM phosphate buffer of pH 7) were added to the contents of the pipette tip (column). When the enzyme solution had completely entered the column, the column flow was stopped, capped, and incubated at 37°C for 18 hrs. After incubation, the columns were allowed to stand at room temperature and eluted with 10 mL of deionized water. A fraction of water extract that contains the hydrolysis products of the GSLs was subjected to a glucose determination procedure (Antonious et al., 1996). Extracts without addition of purified horseradish myrosinase were used as controls.

Quantification of GSLs was based on measurement of enzymatically released glucose. Moles of glucose released into the aqueous medium are equivalent to the moles of total GSLs. A calibration curve was carried out with each group of samples using 10 – 100 µg mL^{-1} glucose. The activity of myrosinase was optimized using sinigrin as substrate. Standard materials of sinigrin monohydrate (allylglucosinolate), thioglucosidase, and pure glucose were obtained from Sigma Chemical Co. (St. Louis, MO).

Representative samples of the shoots (20 g) were blended with 100 mL of 0.4% oxalic acid solution for ascorbic acid extraction. The homogenate was filtered through a Büchner funnel containing Whatman filter paper No. 1. Ascorbic acid was determined by the potassium ferricyanide method (AOAC, 1970). L-ascorbic acid of 100% purity (Sigma Chemical Company, St. Louis, MO) was used to establish a calibration curve.

Representative samples of the shoots (20 g) were blended with 150 mL of ethanol to extract phenols. Following filtration through Whatman No. 1 filter paper, an aliquot was used for phenol determination. Total phenolic constituents were determined by Folin-Ciocalteu colorimetric method (McGrath et al., 1982). A standard calibration curve was obtained using pure tannic acid in the range of 1 to 16 µg mL^{-1}. Aboveground biomass yield and concentrations of total glucose equivalent to GSL, ascorbic acid, and total phenol contents in *Brassica* shoots of the different accessions grown in the three environments (greenhouse, high tunnels, and field) were statistically analyzed using the analysis of variance (ANOVA) procedure (SAS Institute, 2003). Tukey's honestly significant difference test was used to compare means. Pearson correlation coefficients were calculated to test for correlations between yield and concentrations of GSLs, phenols, and ascorbic acid.

Results and Discussion

Environmental variables such as ultraviolet radiation (Antonious et al., 1996), temperature (Zhao et al., 2007), and water availability (Estiarte et al., 1994) affect the chemical composition of plants through induction of general stress responses. *Brassica* yields (shoot weight) were lower for plants grown in field than those grown in the other environments, but GSL, phenol, and ascorbic acid concentrations in the shoots were higher (Table 1); aboveground biomass production was negatively correlated with concentration of GSLs and phenols (Table 2). It is difficult to predict the fumigant potential of a particular *Brassica* accession on the basis of GSL concentration in its tissue because other factors may increase or decrease the activity of myrosinase. Larkin and Griffin (2007) noted that soil-borne disease reductions were not always associated with higher GSL-producing crops. Ascorbic acid, for example, enhances myrosinase activity (Kleinwächter and Selmar, 2004; Van-Eylen et al., 2008). Myrosinase activity is also influenced by intrinsic (e.g., pH, ascorbic acid) and extrinsic (e.g., temperature, pressure) factors. Ascorbic acid concentration in plant shoots varied among accessions tested in this study (Table 3) and was positively correlated with the concentration of GSLs and phenols (Table 2). *B. juncea* accessions Ames 8660, Ames 8674, and Ames 8709 contained more ascorbic acid than Pacific Gold, Ida Gold, or Ames 8887 (Table 3).

Brassica juncea accessions Ames 8660, Ames 8674, and Ames 8709 had a higher phenol concentration than Pacific Gold in this study (Table 3). The greatest concentrations of GSLs, phenols, and ascorbic acid were consistently found among the *B. juncea* accessions, but only Ames 8887 had a significantly higher GSL concentration than the *E. sativa* accession PI 633215 across the range of environments tested (Table 3). This accession had a lower biomass yield than the *B. napus* accession and a lower ascorbic acid concentration in its shoots than three other *B. juncea* accessions tested (Table 3). The *B. juncea* accession Pacific Gold, recently released as cover crop for biofumigation, did not differ significantly from other accessions in its biomass production or GSL concentration but tended to have a higher GSL yield across the three environments (greenhouse, high tunnel, and field) (Table 3). Our results suggest that *B. juncea* cultivar Pacific Gold and *B. napus* accession PI 169083 are the most promising biofumigation cover crops among those tested. The promise of the *B. napus* accession is surprising, given its low GSL concentration, but its superior biomass production made it the only accession to give a consistently high yield per unit area for GSLs, phenols, and ascorbic acid across environments.

GSL concentration of greenhouse, high tunnel, and field-grown shoots (leaves and stems) averaged 24, 40, and 76 μmoles g^{-1} fresh weight, respectively. Accessions of *B. juncea* generally had the highest GSL content. A comparison of accessions revealed that Ames 8887 of *B. juncea* contained the greatest GSL concentration but had the lowest biomass yield and ascorbic acid concentration, in part because phytochemical concentration tended to be negatively correlated with biomass yield. More promising was *B. juncea* accession Pacific Gold which coupled high biomass yield with above-average GSL production but had low phenol and ascorbic acid concentration. We concluded that environmental stress on growing plants can increase the concentration of GSLs, ascorbic acid, and total phenols in *Brassica* shoots but does not increase yields of these phytochemicals per unit area.

Table 1. Aboveground biomass and phytochemical production by 10 *Brassica* accessions grown under greenhouse, winter high tunnel, and spring field conditions.

Environment	Shoot Wt. (kg m^{-2})	Glucosinolates (μmoles g^{-1})	Phenols (μg g^{-1})	Ascorbic Acid (mg g^{-1})
Greenhouse	6.3 ± 0.6 a	23 ± 7 b	0.26 ± 0.14 b	2.4 ± 1.4 c
High tunnel	4.5 ± 2.5 a	40 ± 15 b	0.43 ± 0.17 ab	4.2 ± 1.9 b
Field	1.7 ± 0.3 b	76 ± 7 a	0.51 ± 0.04 a	5.2 ± 0.9 a

Values in the table indicate means ± standard error. Values within each column followed by the same letter do not differ significantly (Tukey, $P < 0.05$).

Table 2. Pairwise correlations between aboveground biomass production and tissue concentration of three phytochemicals that may contribute to biofumigation potential of *Brassica* accessions.

	Pearson Correlation Coefficients, N = 30		
	Shoot Wt.	GSLs	Phenols
GSLs	-0.57**	-	
Phenols	-0.40*	0.41*	-
Ascorbic acid	-0.32	0.49**	0.79***

*$P < 0.05$; **$P < 0.01$; ***$P < 0.005$.

Acknowledgments

We thank Eric Turley and Brian Geier for their kind help in growing the plants and processing the samples. This investigation was supported by a southern SARE (Sustainable Agricultural Research and Education) grant LS-06-185 and USDA/CSREES Evans-Allen project No. KYX100843P from USDA/CSREES to Kentucky State University.

Literature Cited

Antonious, G.F., M.J. Kasperbauer, and M.E. Byers. 1996. Light reflected from colored mulches to growing turnip leaves affects glucosinolate and sugar contents of edible roots. Photochemistry and Photobiology 64:605-610.

AOAC (Association of Official Analytical Chemists). 1970, Official Methods of Analysis of the Association of Analytical Chemists, 11th Edition. Washington, D.C.

Bending, G.D., and S.D. Lincoln. 1999. Characterization of volatile sulphur-containing compounds produced during decomposition of *Brassica juncea* tissues in soil. Soil Biol. Biochem. 31:695-703.

Estiarte, M., I. Filella, J. Serra, and J. Penuelas. 1994. Effects of nutrient and water stress on leaf phenolic content of peppers and susceptibility to generalist herbivore *Helicoverpa armigera* (Hubner). Oecologia 99:387-391.

Fahey, J.W., A.T. Zalcmann, and P. Talalay. 2001. The chemical diversity and distribution of glucosinolates and isothiocyanate among plants. Phytochemistry 56:5-51.

Gimsing, A.L., J.A. Kirkegaard, and H.C.B. Hansen. 2005. Extraction of glucosinolates from soil. J. Agric. Food Chem. 53:9663-9667.

Hwang, U.H., Y.I. Matsushita, K. Sugamoto, and T. Matsui. 2005. Antimicrobial effect of the wood vinegar from *Crytomeria japonica* sapwood on plant pathogenic microorganisms. J. Microbiol. Biotechnol. 15:1106-1109.

Jezek, J., B., G.H Haggett, A. Atkinson, and D.M. Rawson. 1999. Determination of glucosinolates using their alkaline degradation and reaction with ferricyanide. J. Agric. Food Chem. 47:4669-4674.

Table 3. Aboveground biomass and phytochemical production by *Brassica* accessions, averaged across three environments.

Accession	Shoot Wt. (kg m-2)	Glucosinolates (μmoles g^{-1})	Phenols (μg g^{-1})	Ascorbic Acid (mg g^{-1})
B. campestris, Ida Gold	4.0 ± 1.4 ab	44 ± 11 ab	0.38 ± 0.09 ab	2.7 ± 0.8 c
B. juncea, Ames 8660	3.4 ± 0.7 ab	53 ± 15 ab	0.67 ± 0.16 a	6.3 ± 2.2 a
B. juncea, Ames 8674	3.3 ± 1.3 ab	59 ± 28 ab	0.64 ± 0.19 a	5.2 ± 1.9 a
B. juncea, Ames 8709	3.3 ± 1.6 ab	44 ± 22 ab	0.61 ± 0.13 a	5.4 ± 1.7 a
B. juncea, Ames 8887	2.8 ± 1.3 b	66 ± 26 a	0.21 ± 0.04 ab	2.7 ± 1.4 c
B. juncea, Pacific Gold	5.7 ± 1.7 ab	50 ± 2 ab	0.14 ± 0.05 b	2.2 ± 0.8 c
B. juncea, PI 120923	5.2 ± 2.3 ab	37 ± 8 ab	0.28 ± 0.05 ab	3.2 ± 1.0 bc
B. juncea, PI 603015	3.3 ± 1.4 ab	49 ± 14 ab	0.34 ± 0.03 ab	3.2 ± 1.2 bc
B. napus, PI 169083	7.7 ± 3.4 a	27 ± 14 ab	0.41 ± 0.07 ab	4.2 ± 1.4 abc
E. sativa, PI 633215	3.7 ± 1.8 ab	35 ± 5 b	0.35 ± 0.07 ab	4.3 ± 1.6 abc

Values in the table indicate means ± standard error. Values followed by the same letter do not differ significantly (Tukey, $P < 0.05$).

Kleinwächter, M., and D. Selmar. 2004. A novel approach for reliable activity determination of ascorbic acid depending myrosinases. J. Biochem. Biophys. Methods 59:253-265.

Larkin, R.P., and T.S. Griffin. 2007. Control of soil-borne potato diseases using *Brassica* green manure. Crop Protection 26:1067-1077.

McGrath, R.M., W.Z. Kaluza, K.H. Daiber, W.R. Van der Riet, and C.W. Glennie. 1982. Polyphenols of sorghum grain, their changes during malting, and their inhibitory nature. J. Agric. Food Chem. 30:450-456.

McGregor, D.I., Mullin W.J., and G.R. Fenwick. 1983. Analytical methodology for determining glucosinolate composition and content. J. Assoc. Anal. Chem. 66:825-849.

Moreno, D.A., B.C. Lopez, and V.C. Garcia. 2007. Effects of stir-fry cooking with different edible oils on the phytochemical composition of broccoli. J. Food Sci. 72:S064-S068.

SAS Institute. 2003. SAS/STAT Guide, Version 9.1.3. SAS Inc., SAS Campus Drive, Cary, N.C.

Song, L., R. Ioril, and P.J. Thornalley. 2006. Purification of major glucosinolates from *Brassicaceae* seeds and preparation of isothiocyanate and amine metabolites. J. Sci. Food Agric. 86:1271-1280.

Van-Eylen, D., I. Oey, M. Hendrick, and A. Van-Loey. 2008. Behavior of mustard seed (*Sinapis alba* L.) myrosinase during temperature /pressure treatments: A case study on enzyme activity and stability. Eur. Food Res. Technol. 226:545-553.

Wittstock, U., and B.A. Halkier. 2002. Glucosinolate research in the *Arabidopsis era*. Trends in Plant Sci. 7:263-270.

Zhao, X., T. Iwamoto, and E.E. Carey. 2007. Antioxidant capacity of leafy vegetables as affected by high tunnel environment, fertilisation, and growth stage. J. Sci. Food Agric. *87*:2692-2699.

Indicators of Biological Activity in Soil Amended with Sewage Sludge

George F. Antonious, Department of Plant and Soil Science, Land Grant Program, Kentucky State University, Frankfort, Kentucky

Introduction

Microorganisms, despite their relatively low amounts, play the crucial role of keeping the main nutrient (C, N, P, S) in soil through recycling from organic matter. Microbial biomass is very dynamic in soil and responds to weather, crop input, season, soil type, and landscape (Rice et al., 1996). Microbial biomass is a sensitive indicator of changes in climate, tillage systems, crop rotations, and pollutant toxicity. Quantification of microbial biomass in soil is a rapid, reliable, and fast way for the appraisal of fundamental biological and biochemical activities in soil, i.e., microbial respiration and enzymatic activities. Soil fungi often make up at least 75 to 95% of the soil microbial biomass and, together with bacteria, are responsible for about 90% of the total energy flux of organic matter decomposition in soil (Paul and Clark, 1996). Saprotrophic fungi and mycorrhiza are among the main groups of microorganisms associated with plant roots.

There is a continuing search for inexpensive, locally available sources of organic matter for use in growing horticultural crops. Composting provides an organic amendment useful for improving soil structure and nutrient status (Antonious, 2003) and generally stimulates soil microbial activity (Straton and Rechigl, 1998; Antonious, 2003). Among the major parameters of soil fertility and biological properties, special emphases are given to the enzyme activity. As more sewage treatment districts turn to composting as a viable means of sludge stabilization, sewage sludge as a source of organic matter will become available in increasing quantities. With the increased interest in recycling waste and integrated soil bioecosystem studies, there is a need to quantify the three enzymes involved in the C, N, and P cycles as indicators of increased soil microbial populations and activity. Soil microorganisms (bacteria, fungi, protozoa, algae) excrete a variety of enzymes (ureases, invertases, dehydrogenases, cellulases, amylases, phosphatases) that have long been recognized as a primary means of degrading xenobiotics in soil and water ecosystems. Microorganisms also produce sticky substances (polysaccharides) that help soil particles adhere to one another and help the soil resist erosion that can diminish agriculture productivity (Reganold et al., 1990). In recent years, more specific emphasis has been given to soil enzymes in relation to reclamation management and the enzymatic processes that play a significant role in bioremediation. Remediation of contaminated soils is based on the degrading activity of soil microbiota. Accordingly, remediation technologies should enhance the growth of native and/or introduced microorganisms in soils.

Soil enzymatic measurements can be used to provide a biological index of soil fertility, and the activity of soil enzymes can be used as an indicator for many soil biological processes. Urease (urea amidohydrolase, EC 3.5.1.5) is the enzyme that catalyzes the hydrolysis of urea to CO_2 and NH_4 ions by acting on C-N non-peptide bonds in linear amides. It is an important enzyme in soil that mediates the conversion of organic nitrogen to inorganic nitrogen by hydrolysis of urea to ammonia (Byrnes and Freney, 1995). Invertase (β-D-fructofuranosidase) is a ubiquitous enzyme in soils (Gianfreda et al., 1995). The activities of urease and invertase are important in soil for releasing simple carbon and nitrogen sources for the growth and multiplication of soil microorganisms. Considerable literature has accumulated on phosphomonoesterases in soils. Most of the literature, however, is related to acid phosphatase. Consequently, this enzyme has been given a prominent place in a number of soil enzyme studies. Soil acid and alkaline phosphatases catalyze the hydrolysis of organic phosphate esters to orthophosphate, and thus constitute an important link between biologically unavailable and bioavailable P pools in the soil. Phosphatases are ubiquitous in soil and are produced by microorganisms in response to low levels of inorganic P. Accordingly, soil enzymes can be tracked as indicators of soil quality following the addition of soil amendments to monitor the presence and activities of soil microorganisms throughout the growing season. The main objective of this investigation was to study the impact of sewage sludge or yard waste compost addition on the activities of urease, invertase, and acid and alkaline phosphatases in the rhizosphere of broccoli plants during two growing seasons (spring and fall).

Materials and Methods

A study was conducted on a Lowell silty loam soil (2.7% organic matter, pH 6.9) at Kentucky State University Research Farm, Franklin County, Kentucky. The soil has an average of 12% clay, 75% silt, and 13% sand. Eighteen plots of 22 × 3.7 m each were established. Plots were separated using metal borders 20 cm above the ground level to prevent cross contamination between treatments. Three soil management practices, replicated six times, were used: 1) municipal sewage sludge treated with lime and pasteurized for land farming (class-A biosolids) obtained from Nicholasville Wastewater Treatment Plant, Nicholasville, Kentucky, was mixed with native soil at 30 t acre^{-1} on a dry weight basis; 2) yard waste compost made from yard and lawn trimmings, and vegetable remains (produced at Kentucky State University Research Farm in Frankfort, Kentucky, was also mixed with native soil at 30 t acre^{-1} on a dry weight basis with a plowing depth of 15 cm; and 3) no-mulch (NM) treatment (roto-tilled bare soil) was used for comparison purposes. Broccoli (*Brassica oleracea* L. cv. Packman F1) seeds were obtained from Holmes Seed Company (Canton, OH) and planted in the greenhouse. Seedlings that were 45 days old were planted in April (spring broccoli) and August (fall broccoli) at 10 rows/plot and 10 plants/row. Plants were irrigated using overhead sprinklers, and no mineral fertilizer was applied.

Soil samples (six replicates per treatment) were collected from the rhizosphere (a zone of increased microbial and enzyme activity where soil and root make contact) of broccoli plants to a depth of 15 cm at different time intervals following transplanting. Soil samples were air-dried, passed through a 2-mm sieve, and kept at 4°C up to 24 hours before use. Soil urease activity was determined by the method of Tabatabi and Bremner (1972). Invertase activity in soil samples was estimated by the method described by Balasubramanian et al. (1970). Acid and alkaline phosphatase activities in soil were determined by the method developed by Tabatabai and Bremner (1969) which determines *p*-nitrophenol released when soil is incubated with buffered sodium *p*-nitrophenol phosphate solution (pH 6.7 for acid phosphatase assay and pH 11 for alkaline phosphatase assay). Activities of urease, invertase, and acid and alkaline phosphatases in soil samples collected from the three soil treatments were compared using analysis of variance procedure (SAS Institute, 2003) and Duncan's multiple range test for mean comparisons.

Results and Discussion

Soil urease and invertase activities increased with addition of sewage sludge which provided evidence of increased soil microbial population. Urease increase was more pronounced in spring broccoli than fall broccoli (Table 1). Application of yard waste compost did not alter urease or invertase activities. Urease activities in sewage sludge varied from 5.6 to 38.5 mg NH^4-N g^{-1} dry soil. Soil urease is produced by both plants and microorganisms (Gould et al., 1973), and therefore soil urease activity might arise from the two sources. Urease and invertase showed fluctuating means with sampling time (Tables 1 and 2). This is consistent with Longo and Melo (2005) who found that enzyme activities were affected by time of sampling with the greatest activity during hot and rainy months.

Table 1. Impact of mixing native soil with municipal sewage sludge or yard waste compost on soil urease activity in the rhizosphere of spring and fall broccoli plants grown at Kentucky State University Research Farm, Franklin County, Ky.

Days Following Soil Treatment	Sewage Sludge Incorporated with Native Soil	Yard Waste Incorporated with Native Soil	Native Soil
Spring Broccoli			
1	38.6 ± 9.7 a	3.2 ± 1.3 b	0.9 ± 0.4 b
2	14.7 ± 5.6 a	3.1 ± 1.0 b	4.3 ± 2.5 b
5	8.1 ± 3.4 a	1.2 ± 0.8 b	1.1 ± 0.6 b
8	10.4 ± 5.2 a	1.2 ± 0.6 b	0.6 ± 0.2 b
12	13.6 ± 6.1 a	4.6 ± 2.2 b	0.7 ± 0.4 c
19	14.4 ± 5.7 a	0.9 ± 0.4 b	1.3 ± 0.8 b
30	31.0 ± 7.6 a	1.4 ± 0.7 b	0.6 ± 0.2 b
50	23.2 ± 5.2 a	2.1 ± 0.9 b	3.6 ± 0.9 b
Fall Broccoli			
1	7.6 ± 3.5 a	1.4 ± 0.3 b	0.8 ± 0.2 b
2	10.3 ± 4.3 a	0.5 ± 0.1 b	0.5 ± 0.3 b
5	12.1 ± 4.1 a	0.5 ± 0.2 b	0.5 ± 0.2 b
12	8.9 ± 3.2 a	0.4 ± 0.1 b	0.4 ± 0.1 b
16	4.1 ± 1.4 a	0.4 ± 0.1 b	0.4 ± 0.1 b
22	5.3 ± 1.2 a	0.6 ± 0.2 b	0.4 ± 0.0 b
24	4.8 ± 2.0 a	0.7 ± 0.4 b	0.4 ± 0.2 b
26	2.5 ± 0.6 a	0.5 ± 0.2 a	0.4 ± 0.1 a
28	6.9 ± 3.1 a	0.5 ± 0.1 b	0.5 ± 0.2 b
30	4.1 ± 0.9 a	0.5 ± 0.1 b	0.3 ± 0.1 b
34	3.0 ± 1.1 a	0.4 ± 0.2 b	0.4 ± 0.2 b
36	4.5 ± 1.5 a	0.4 ± 0.2 b	0.3 ± 0.2 b
42	4.8 ± 1.2 a	0.5 ± 0.1 b	0.4 ± 0.1 b
48	4.0 ± 0.9 a	0.5 ± 0.2 b	0.2 ± 0.0 b
52	6.5 ± 1.2 a	0.4 ± 0.1 b	0.3 ± 0.1 b
56	3.7 ± 1.8 a	0.4 ± 0.2 b	0.2 ± 0.1 b
60	2.3 ± 1.0 a	0.4 ± 0.1 a	0.3 ± 0.2 a

Each value in the table is an average of six replicates. Statistical comparisons were carried out between three soil management practices for each sampling date. Values in each row accompanied by the same letter are not significantly different from each other ($P > 0.05$) using Duncan's multiple range test (SAS Institute, 2003).

This increase in urease activity associated with sludge addition may also be explained by the presence of urea, the substrate of the enzyme. According to Garcia et al. (1993), sewage sludge contains high amounts of enzymatic substrates. These easily available substrates stimulate microbial growth and enzyme production. Results indicated that the addition of sewage sludge to native soil has increased broccoli yield and total marketable head compared to yard waste and no-mulch treatments (data not shown). Antonious et al. (2005) reported that broccoli grown in sewage sludge-amended soil meets broccoli quality marketing opportunities. Compared to other two treatments, acid and alkaline phosphatases were stimulated only

Table 2. Impact of mixing native soil with municipal sewage sludge or yard waste compost on soil invertase activity in the rhizosphere of spring and fall broccoli plants grown at Kentucky State University Research Farm, Franklin County, Ky.

Days Following Soil Treatment	Sewage Sludge Incorporated with Native Soil	Yard Waste Incorporated with Native Soil	Native Soil
Spring Broccoli			
1	41.1 ± 9.4 a	11.1 ± 3.2 b	13.7 ± 4.5 b
2	33.4 ± 8.2 a	14.8 ± 5.4 b	12.6 ± 2.8 b
5	34.5 ± 6.6 a	11.1 ± 6.4 b	8.6 ± 1.5 b
8	33.1 ± 8.5 a	15.0 ± 7.1 b	13.4 ± 4.1 b
12	28.3 ± 8.1 a	13.7 ± 3.6 b	16.8 ± 4.4 b
19	25.8 ± 7.3 a	12.2 ± 3.5 b	10.4 ± 1.2 b
30	24.9 ± 6.6 a	10.8 ± 4.4 b	12.6 ± 2.6 b
50	32.7 ± 4.4 a	15.9 ± 5.3 b	17.8 ± 4.3 b
Fall Broccoli			
1	26.7 ± 5.2 a	27.9 ± 8.2 a	18.7 ± 5.5 a
2	34.5 ± 4.4 a	11.3 ± 3.3 c	20.7 ± 5.7 b
5	33.5 ± 6.1 a	39.3 ± 4.9 a	23.4 ± 4.3 b
12	28.7 ± 3.3 a	32.1 ± 4.5 a	17.9 ± 6.6 a
16	30.9 ± 5.6 a	27.3 ± 7.2 a	20.8 ± 5.1 a
22	26.1 ± 7.3 a	24.6 ± 6.5 a	20.0 ± 4.5 a
24	29.5 ± 4.2 a	26.5 ± 5.4 a	16.9 ± 4.1 b
26	30.7 ± 4.5 a	27.6 ± 6.6 a	23.0 ± 6.0 a
28	31.6 ± 2.6 a	22.6 ± 9.0 a	30.7 ± 4.5 a
30	35.6 ± 2.7 a	22.8 ± 3.4 b	18.5 ± 3.2 b
34	30.7 ± 4.4 a	21.5 ± 4.4 a	11.8 ± 1.5 b
36	35.7 ± 3.7 a	19.5 ± 6.8 b	17.6 ± 2.6 b
42	25.5 ± 5.5 a	24.0 ± 8.2 a	25.5 ± 4.4 a
48	31.0 ± 4.1 a	27.3 ± 4.9 a	24.2 ± 5.1 a
52	32.3 ± 5.0 a	26.7 ± 6.5 ab	17.5 ± 3.8 b
56	31.0 ± 4.6 a	12.5 ± 7.1 b	8.3 ± 1.5 b
60	25.8 ± 2.9 a	14.2 ± 5.5 b	13.6 ± 2.2 b

Each value in the table is an average of six replicates. Statistical comparisons were carried out between three soil management practices for each sampling date. Values in each row accompanied by the same letter are not significantly different from each other ($P > 0.05$) using Duncan's multiple range test (SAS Institute, 2003).

Table 3. Impact of mixing native soil with municipal sewage sludge or yard waste compost on soil acid phosphatase activity in the rhizosphere of spring and fall broccoli plants grown at Kentucky State University Research Farm, Franklin County, Ky.

Days Following Soil Treatment	Sewage Sludge Incorporated with Native Soil	Yard Waste Incorporated with Native Soil	Native Soil
Spring Broccoli			
1	13.8 ± 3.5 b	21.7 ± 6.6 a	14.2 ± 3.0 b
2	21.9 ± 5.6 b	31.5 ± 4.0 a	23.8 ± 2.9 b
5	16.3 ± 2.8 b	23.1 ± 3.1 a	18.1 ± 1.3 b
8	10.9 ± 5.2 b	34.2 ± 7.8 a	13.2 ± 3.1 b
12	11.5 ± 3.9 c	32.4 ± 5.8 a	19.7 ± 4.8 b
19	17.4 ± 4.4 b	27.1 ± 4.1 a	17.3 ± 1.4 b
30	20.4 ± 5.4 b	31.4 ± 4.4 a	19.9 ± 4.1 b
50	21.2 ± 4.9 b	35.8 ± 6.8 a	22.8 ± 2.7 b
Fall Broccoli			
1	14.8 ± 3.4 a	17.5 ± 1.5 a	14.4 ± 1.9 a
2	14.5 ± 3.1 a	18.1 ± 3.2 a	13.9 ± 2.4 a
5	14.8 ± 3.9 a	18.5 ± 3.2 a	13.7 ± 1.7 a
12	18.9 ± 4.6 b	26.9 ± 3.0 a	20.2 ± 1.7 b
16	16.9 ± 5.0 b	25.2 ± 3.9 a	16.7 ± 2.2 b
22	11.2 ± 1.3 b	16.0 ± 3.7 a	7.9 ± 2.6 b
24	12.7 ± 4.2 b	17.6 ± 4.1 a	12.3 ± 2.8 b
26	9.6 ± 2.1 b	14.1 ± 3.4 a	9.2 ± 1.6 b
28	12.9 ± 3.4 a	15.6 ± 1.9 a	12.9 ± 6.4 a
30	19.7 ± 1.4 b	26.8 ± 4.3 a	16.6 ± 2.1 b
34	15.6 ± 4.3 b	25.1 ± 5.3 a	14.0 ± 3.7 b
36	14.3 ± 2.6 b	21.4 ± 4.4 a	12.5 ± 2.9 b
42	14.9 ± 3.7 b	23.5 ± 3.8 a	14.1 ± 1.7 b
48	13.2 ± 1.6 b	17.5 ± 2.3 a	10.8 ± 1.6 b
52	17.7 ± 5.1 a	20.4 ± 3.7 a	15.7 ± 2.6 a
56	23.3 ± 2.6 b	28.9 ± 3.9 a	17.8 ± 2.5 b
60	23.5 ± 2.3 b	32.5 ± 5.6 a	18.9 ± 3.3 c

Each value in the table is an average of six replicates. Statistical comparisons were carried out between three soil management practices for each sampling date. Values in each row accompanied by the same letter are not significantly different from each other ($P > 0.05$) using Duncan's multiple range test (SAS Institute, 2003).

when soil was incorporated with yard waste compost (Tables 3 and 4). Generally, the positive effects on the activities of the three enzymes involved in the C, N, and P cycles as well as on the biomass C, suggested that adding sewage sludge might be a suitable technique to restore or improve soil quality. The U.S. Environmental Protection Agency (EPA) promotes beneficial use of municipal sewage sludge (biosolids) and yard waste because it decreases dependence on chemical fertilizers and provides significant economic advantages.

With increasing cost and shortage of nitrogen fertilizer, there is increased emphasis on use of sewage sludge rather than on its disposal. In addition to organic matter, there are 16 elements in sludge that plants require. The USEPA (1993) has defined acceptable sludge in terms of its heavy metal content (mg kg^{-1}; Zn 1400, Cu 1500; Ni 420, Cd 39; Pb 300; Cr 1200; Mo 75). Sewage sludge could be added to land if all these metals were below their limit. Sewage sludge safety data sheet (Nicholasville Wastewater Treatment Plant) indicated that the seven heavy metals in soil amended with sewage sludge were all below the allowable limits, and therefore this sludge has potential for agricultural use. This investigation has focused on one type of sludge and soil in two broccoli growing seasons. Accordingly, these results cannot be generalized to different sources of sludge and different soil types. Soil incorporation of sewage sludge compost increased significantly urease and invertase activities in soil, indicating their stimulation and production by soil microflora. With increasing emphasis on fertility sustainability and environmental friendliness, restoration of soil microbial ecology has become important. Further studies to reveal the effects of heavy metals on soil microorganisms and the enzymes they produce with chemical metal speciation are necessary for sewage sludge application to agricultural soils. Application of organic amendments to agricultural soils makes good use of natural resources and reduces the need for artificial fertilizers.

Acknowledgments

The author would like to thank Eddie Reed and Hank Schweickart for their help in the KSU field trial. This investigation was supported by two grants from USDA/CSREES to Kentucky State University under agreements No. KYX-10-08-43P and No. KYX-2006-1587.

Table 4. Impact of mixing native soil with municipal sewage sludge or yard waste compost on soil alkaline phosphatase activity in the rhizosphere of spring and fall broccoli plants grown at Kentucky State University Research Farm, Franklin County, Ky.

Days Following Soil Treatment	Sewage Sludge Incorporated with Native Soil	Yard Waste Incorporated with Native Soil	Native Soil
Spring Broccoli			
1	44.9 ± 10.9 a	51.5 ± 9.2 a	27.8 ± 4.5 b
2	45.3 ± 7.5 a	51.6 ± 3.0 a	37.6 ± 6.2 b
5	38.1 ± 3.2 b	50.4 ± 6.2 a	22.6 ± 1.9 c
8	42.7 ± 8.8 a	49.9 ± 2.7 a	34.2 ± 5.4 b
12	18.6 ± 4.3 b	34.2 ± 5.0 a	20.3 ± 2.1 b
19	30.1 ± 4.4 b	42.8 ± 6.2 a	16.3 ± 2.1 c
30	20.2 ± 2.8 b	39.7 ± 10.3 a	18.4 ± 3.9 b
50	27.4 ± 3.1 b	43.9 ± 6.8 a	18.2 ± 2.3 c
Fall Broccoli			
1	21.7 ± 8.0 a	28.5 ± 2.9 a	7.7 ± 0.8 b
2	22.9 ± 3.4 b	32.6 ± 6.1 a	10.5 ± 0.7 c
5	34.2 ± 9.1 a	41.9 ± 11.4 a	18.5 ± 1.6 b
12	35.9 ± 5.2 a	41.3 ± 8.7 a	20.2 ± 2.1 b
16	21.2 ± 3.5 b	31.4 ± 2.8 a	8.7 ± 1.5 c
22	31.3 ± 5.8 a	36.2 ± 2.8 a	17.7 ± 3.1 b
24	21.6 ± 6.7 a	26.4 ± 3.6 a	13.5 ± 4.8 b
26	15.7 ± 2.7 b	21.5 ± 2.8 b	30.6 ± 7.5 a
28	17.4 ± 2.9 b	22.9 ± 3.2 b	37.3 ± 8.3 a
30	18.2 ± 2.9 b	30.4 ± 4.2 a	37.1 ± 12.3 a
34	18.9 ± 2.7 b	27.4 ± 5.9 a	33.4 ± 6.2 a
36	16.3 ± 9.7 b	31.2 ± 12.5 a	37.5 ± 13.3 a
42	16.9 ± 3.3 b	29.9 ± 9.7 a	18.1 ± 2.9 b
48	8.1 ± 1.2 b	16.4 ± 7.1 a	23.8 ± 3.2 a
52	11.2 ± 2.8 b	17.3 ± 6.5 a	21.8 ± 4.3 a
56	7.9 ± 1.4 c	17.5 ± 6.6 b	26.2 ± 8.6 a
60	12.7 ± 3.0 a	16.7 ± 3.5 a	12.4 ± 5.0 a

Each value in the table is an average of six replicates. Statistical comparisons were carried out between three soil management practices for each sampling date. Values in each row accompanied by the same letter are not significantly different from each other ($P > 0.05$) using Duncan's multiple range test (SAS Institute, 2003).

Literature Cited

Antonious, G.F. 2003. Impact of soil management and two botanical insecticides on urease and invertase activity. J. Environ. Sci. Health 38:479-488.

Antonious, G.F., M.A. Patterson, and J.C. Snyder. 2005. Impact of soil amendments on broccoli quality and napropamide movement under field conditions. Bull. Environ. Contam. Toxicol. 75:797-804.

Balasubramanian, D., D.J. Bagyaraj, and G. Rangaswami. 1970. Studies on the influence of foliar application of chemicals on the microflora and certain enzyme activities in the rhizosphere of *Eleusine coracana* Gaertn. Plant Soil 32:198-206.

Byrnes, B.H., and J.R. Freney. 1995. Recent development on the use of urease inhibitors in the tropics. Fertilizer Res. 42:251-259.

Garcia, C., T. Hernandez, C. Costa, B. Ceccanti, G. Masciandaro, and C. Ciardi. 1993. A study of biochemical parameters of composted and fresh municipal wastes. Bioresource Technology 44:17-23.

Gianfreda, L., F. Sannino, and A. Violante. 1995. Pesticide effect on the activity of free, immobilized, and soil invertase. Soil Biol. Biochem. 27:1201-1208.

Gould, W.D., F.D. Cook, and G.R.Webster. 1973. Factors affecting urea hydrolysis in several Alberta soils. Plant Soil 38:393-401.

Longo, R.M., and W.J. Melo. 2005. Urease activity in soils as influenced by vegetation cover and sampling time. Revista Brasileira de Ciencia do Solo 29:645-650.

Paul, E.A., and F.E. Clark. 1996. Soil Microbiology and Biochemistry. Academic Press, San Diego, CA,

Reganold, J.P., R.I. Papendick, and J.F. Parr. 1990. Sustainable agriculture. Scientific American 262:112-120.

Rice, C.W., T.B. Moorman, and M. Beare. 1996. Role of microbial biomass carbon and nitrogen in soil quality. In: Doran J.W., Jones A.J. (eds.) Methods for Assessing Soil Quality, vol. 49. Madison, WI, SSSA Special Publi., pp. 203-215.

SAS Institute Inc. 2003. SAS/STAT Guide, Version 9.1.3. SAS Inc., Cary, NC 27513;

Straton, M.L., and J.E. Rechcigl. 1998. Organic mulches, wood products, and compost as soil amendments and conditioners. In *Handbook of Soil Conditioners*. Wallace, A., Terry, R., eds.; Marcel Dekker Inc., New York, pp. 43-95.

Tabatabai, M.A., and J.M. Bremner. 1969. Use of p-nitrophenol phosphate for assay of soil phosphatase activity. Soil Biol. Biochem. 1:301-307.

Tabatabi, M.A., and J.M. Bremner. 1972. Assay of urease activity in soils. Soil Biol. Biochem. 4:479-487.

United States Environmental Protection Agency. 1993. Standards for disposal of sewage sludge; final rules: part II. Federal Register (2-9-93), 9247-9415.

Kentucky Consumer Interest in Different Sweet Potato Varieties and Products

Timothy Woods, Emine Bayar, and Wu Yang Hu, Department of Agricultural Economics

Introduction

Part of the recent Kentucky Food Consumers Panel, which targets over 600 Kentucky consumer households on food preferences and issues, included an investigation on interest in innovative sweet potato products and varieties. The Web-based survey collected demographic information on the respondents and their households, as well as general shopping behavior and food preferences. The objective of the survey was to determine if there may be opportunities to develop and position some of these products within certain Kentucky markets for stronger commercial acceptance.

There are numerous variations for niche varietal production, distinct production systems, and value-added products. We just looked at a sample. Specifically, consumers were asked to indicate their interest in organically produced sweet potatoes, white and purple cultivars, and then products made from sweet potatoes, including fries, flour, and dried. Participants were asked to indicate their interest level in the product as one of "none," "might try," "interested," or "very interested."

Only consumers who indicated they consumed sweet potatoes at all were asked their interest in the products, so the results reflect interest among current consumers. A total of 356 sweet potato consumers participated in the panel and provided usable data.

An ordinary least squares regression was used to examine if there might be demographic determinants helping to explain differences in interest level across products.

Table 1. Summary of interest expressed in sweet potato products.

	Sweet Potato Products					
Rate Your Interest in These Products	**White Sweet Potato**	**Purple Sweet Potato**	**Sweet Potato Fries**	**Sweet Potato Flour**	**Dried Sweet Potato**	**Organic Sweet Potato**
None	26.6%	33.1%	13.0%	34.2%	39.0%	20.9%
Might try	39.3%	40.4%	30.5%	39.0%	37.0%	34.2%
Interested	22.6%	17.8%	33.6%	19.2%	15.3%	26.8%
Very interested	11.6%	8.8%	22.9%	7.6%	8.8%	18.1%

Table 2. OLS results for significant signs for demographic terms.

Demographic Variables	Product Categories					
	White	**Purple**	**Fries**	**Flour**	**Dried**	**Organic**
Constant	+	+	+	+	+	+
Male	+	-				-
Age	+	+				-
Household size	-					+
Children						-
Education						
Full-time						
Income						
White						
R^2	0.04	0.03	0.01	0.01	0.02	0.05

Results and Discussion

Table 1 summarized the interest across products in simple percentage responses. There was relatively strong interest expressed for organic sweet potatoes (44.9% at least interested). There was slightly more interest expressed for white versus purple cultivars and considerable interest in products like sweet potato fries with lesser interest in flour or dried products.

Table 2 summarizes the regression results, reporting the sign of the specific coefficients where the regression reported at least an 85% significance level. For flesh color, males appear to show higher interest in white, with less interest in purple. Homes where adults are fully employed outside the home showed greater interest in both types. Consumers with higher incomes showed less interest in white-fleshed types. Differences in demographics did not appear to explain much of the difference in interest for the value-added products. For organic sweet potatoes, older consumers and consumers with higher incomes expressed less interest, while consumers with higher education expressed greater interest.

Fruit and Vegetable Disease Observations from the Plant Disease Diagnostic Laboratory—2008

Julie Beale, Paul Bachi, Sara Long, Kenny Seebold, and John Hartman, Department of Plant Pathology

Introduction

Diagnosis of plant diseases and providing recommendations for their control are the result of University of Kentucky College of Agriculture research (Agricultural Experiment Station) and Cooperative Extension Service activities through the Department of Plant Pathology. We maintain two branches of the Plant Disease Diagnostic Laboratory, one on the University of Kentucky campus in Lexington, and one at the University of Kentucky Research and Education Center in Princeton. Of the nearly 3,000 plant specimens examined annually, approximately 15 to 20% are commercial fruits and vegetables (1). Although the growers are not charged for plant disease diagnoses at UK, the estimated direct annual expenditure to support diagnosis of fruit and vegetable specimens by the laboratory is $25,000, excluding UK physical plant overhead costs. During recent years, we have acquired Kentucky Integrated Pest Management funds to help defray some of these additional laboratory operating costs. We have greatly increased the use of consulting on plant disease problems, including solving fruit and vegetable issues through our Web-based digital consulting system. In 2008, approximately 20% of digital cases involved fruit and vegetable diseases and disorders.

Materials and Methods

Diagnosing fruit and vegetable diseases involves a great deal of research into the possible causes of the problems. Most visual diagnoses include microscopy to determine what plant parts are affected and to identify the microbe(s) involved. In addition, many specimens require special tests such as moist chamber incubation, culturing, enzyme-linked immunosorbant assay (ELISA), polymerase chain reaction (PCR) assay, electron microscopy, nematode extraction, or soil pH and soluble salts tests. Diagnoses which require consultation with UK faculty plant pathologists and horticulturists and which need culturing, ELISA, or PCR are common for commercial fruits and vegetables. The Extension plant pathology group has tested protocols in our laboratory for PCR detection of several pathogens of interest to fruit and vegetable growers. These include the difficult-to-diagnose pathogens causing bacterial wilt of cucurbits, bacterial leaf spot of pepper, cucurbit yellow vine decline, and Pierce's disease of grape. The laboratory also has a role in monitoring pathogen resistance to fungicides and bactericides. These exceptional measures are efforts well spent because fruits and vegetables are high-value crops. Computer-based laboratory records are maintained to provide information used for conducting plant disease surveys, identifying new disease outbreaks, and formulating educational programs. New homeland security rules now require reporting of all diagnoses of plant diseases to USDA-APHIS on a real-time basis.

The 2008 growing season was better than the 2007 season. January had lower-than-normal temperatures and precipitation. February began with destructive severe weather that produced one of the highest tornado totals for a single weather event that the Commonwealth has experienced. A couple of winter weather systems that created an icy situation across the state caused significant branch breakage to many trees and larger woody plants. In March, there were several heavy rainfall events which created periodic flooding across the Commonwealth, especially along the Ohio River. The first part of April continued with above-average rainfall (the period from October 1, 2007, through April 19, 2008, was the wettest ever recorded during that time in Louisville with 41.28 inches of rain), but the latter half of the month was relatively dry. Temperatures for April were average. May saw below-normal temperatures and normal rainfall. In June temperatures were above normal and rainfall below normal There were below-normal temperatures and above-normal rainfall in July, but the end of the month saw the beginning of a significant dry period across the state which continued through October. The period of August 1 to September 30, 2008, was the second driest for that time frame in the past 114 years.

The abundant rainfall at bud break and beyond provided optimum conditions for many diseases such as scab, cedar-apple rust and bitter rot of apple, black rot of grape, anthracnose of strawberry, leaf curl of peach, and plum pockets to be widespread. In vegetable crops, foliar diseases were also quite common early to mid-season but tapered off significantly during the dry weather in mid- to late summer.

Results and Discussion

New, Emerging, and Problematic Fruit and Vegetable Diseases in Kentucky

Grape crown gall caused by *Agrobacterium vitis* continues to affect vineyards, particularly in vines with freeze injury or other wounding.

Plum pockets disease (*Taphrina communis*) was an unusual find. Although the related disease, peach leaf curl, is a common occurrence, plum pockets is seen less often in Kentucky, and leaf/twig infections, as were found this year, are seen even more infrequently. Leaves and developing shoots become thickened, curled, and deformed; infected fruits are much larger than normal and hollow.

Some cucurbit crops, particularly cucumber and summer squash, had poor fruit production and uneven development due to poor pollination. Although certain environmental conditions can adversely affect pollination, the most likely scenario for many commercial growers and home gardeners this year was inadequate pollinator populations.

Tomato yellow leaf curl virus was diagnosed for only the second time in Kentucky. This virus is vectored by *Bemesia* species of whitefly, and both vector and virus are not known to overwinter in Kentucky. Prompt destruction of infected plants is needed to prevent possible overwintering of this disease in greenhouses.

Tobacco mosaic virus (TMV) is being seen in tomato plantings more frequently due to the rise in popularity of heirloom tomato varieties, most of which have no resistance to TMV. Some commercially grown tomato varieties are also susceptible to TMV. The virus spreads easily via mechanical transmission. At least one commercial producer saw extensive TMV infection throughout a large planting.

Spinach white rust (*Albugo occidentalis*) was diagnosed from a home garden planting. This disease is favored by cool temperatures and high humidity. It is not common in Kentucky.

Sclerotinia fruit rot (*Sclerotinia sclerotiorum*), favored by cool, moist weather, was found in a commercial cucumber planting.

Tree Fruit Diseases

Pome fruits. Common foliar diseases of apple were abundant this year, particularly apple scab (*Venturia inequalis*), cedar-apple rust (*Gymnosporangium juniperi-virginianae*), and frog-eye leaf spot (*Botryosphaeria obtusa*). Botryosphaeria branch cankers were also common on apple. Most fire blight (*Erwinia amylovora*) infections of apple and pear occurred on April 9 and 10 with symptoms appearing about one month later. A number of cases of bitter rot (*Glomerella cingulata*) were diagnosed as late-season apple fruit rot symptoms became visible.

Stone fruits. Scab (*Cladosporium carpophilum*) and brown rot (*Monilinia fruticola*) were diagnosed on apricot and peach, while brown rot was also seen on cherry. Spring rains favored the development of peach leaf curl (*Taphrina deformans*), and the related disease plum pockets (*Taphrina communis*) was also diagnosed (see above).

Small Fruit Diseases

Grapes. Foliar diseases were common due to wet spring weather and high humidity throughout the season. Black rot (*Guignardia bidwellii*) was quite common; anthracnose (*Elsinoe ampelina*), Phomopsis cane and leaf spot (*Phomopsis viticola*), powdery mildew (*Uncinula necator*), and downy mildew (*Plasmopara viticola*) were diagnosed. Crown gall (*Agrobacterium vitis*) continues to damage certain plantings.

Brambles. Cane blight (*Leptosphaeria coniothyrium*) and spur blight (*Didymella applanata*) were both diagnosed on blackberry canes. Double blossom disease, also known as rosette (*Cercosporella rubi*), was diagnosed in a number of blackberry samples. Enlargement of the sepals and flower buds is a characteristic, early-season symptom of the disease; infected canes fail to fruit and eventually die back.

Blueberries. Root and collar rot caused by *Phytophthora* spp. and twig blight (*Botryosphaeria dothidea*) were diagnosed.

Strawberries. Diseases were common, including leaf spot (*Mycosphaerella fragrariae*) as well as a case of black seed disease caused by the same fungus, leaf blight (*Phomopsis obscurans*), anthracnose (*Colletotrichum acutatum*) causing foliar symptoms, crown rot and fruit decay, angular leaf spot (*Xanthomonas*), black root rot (various fungi), and crown rot (*Phytophthora cactorum*).

Vegetable Diseases

Vegetable transplants. Pythium (*Pythium* sp.) root rot and/or damping off were seen in vegetable transplants, including cabbage, lettuce, and tomato.

Beans. Foliar diseases including Ascochyta leaf spot (*Phoma exigua*), Cercospora leaf spot (*Cercospora* sp.), and common bacterial blight (*Xanthomonas phaseoli*) and foliar and pod infections of anthracnose (*Glomerella lindemuthianum*) were favored by wet weather early in the growing season and high humidity throughout the summer. Root diseases (*Rhizoctonia* sp., *Fusarium* sp., *Pythium* sp.) and southern blight (*Sclerotium rolfsii*) were also observed on bean.

Cucurbits. Bacterial wilt (*Erwinia tracheiphila*), which is vectored primarily by the striped cucumber beetle (*Acalymma vittatum*), was problematic in cucurbit crops this year, particularly in cucumber and melon fields. Anthracnose (*Colletotrichum orbiculare*), Alternaria leaf blight (*Alternaria cucumerina*), and powdery mildew (*Podosphaera xanthii* and *Erysiphe cichoracerarum*) were common foliar diseases in all cucurbit crops. Powdery mildew pressure was extremely high on pumpkin, squash, and even watermelon. Gummy stem blight (*Didymella bryoniae*) was problematic in certain fields, particularly in watermelon and cantaloupe. Aphid-vectored viruses (zucchini yellow mosaic virus and the potyvirus complex) were also diagnosed on cucurbits.

Tomatoes. Diseases of tomato were abundant in 2008. Foliar diseases such as early blight (*Alternaria solani*), Septoria leaf spot (*Septoria lycopersici*), bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*), and bacterial speck (*Pseudomonas syringae* pv. *tomato*) were common this year even though dry conditions starting in midsummer prevented high levels of late-season disease. Timber rot (*Sclerotinia sclerotiorum*) was diagnosed from several locations, as were southern blight (*Sclerotium rolfsii*) and root knot nematode (*Meloidogyne incognita*). Bacterial canker (*Clavibacter michiganensis* subsp. *michiganensis*) was found in some commercial plantings. Fusarium wilt (*Fusarium oxysporum* f. sp. *lycopersici*) was diagnosed a number of times, most often in home garden plantings and heirloom or older varieties lacking wilt resistance. Tobacco mosaic virus (see above), tomato spotted wilt virus, and tomato yellow leaf curl virus (see above) were diagnosed.

Peppers. Bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) was the most common disease of pepper this year. Anthracnose (*Colletotrichium gloeosporioides*), southern blight (*Sclerotium rolfsii*), and alfalfa mosaic virus were also seen.

Other vegetables. Drop (*Sclerotinia* sp.) and gray mold (*Botrytis cinerea*) were diagnosed on lettuce in high tunnel production systems. Bacterial soft rot (*Erwinia chrysanthemia* var. *zeae*) was diagnosed on sweet corn from several home gardens. Common scab (*Streptomyces scabies*) and Verticillium wilt (*Verticillium* sp.) were diagnosed on potato. Spinach white rust (*Albugo occidentalis*) was an unusual find (see above).

Because fruits and vegetables are high-value crops, and many of them are new or expanding crops in Kentucky, the Plant Disease Diagnostic Laboratory should be an important resource for Cooperative Extension agents and the growers they assist. Several new vegetable diseases are being investigated this year due to the teamwork of Extension personnel and growers. The information gained from diagnostic experiments will help to improve production practices and reduce disease in the future. We urge county Extension agents to stress in their programming the need for accurate diagnosis of diseases of high-value crops and the importance of timely sample submission. In this way, Kentucky fruit and vegetable producers can have the best possible information on diseases and their management.

Literature Cited

1. Bachi, P., J. Beale, J. Hartman, D. Hershman, S. Long, K. Seebold, and P. Vincelli. 2009. Plant Diseases in Kentucky—Plant Disease Diagnostic Laboratory Summary, 2008. University of Kentucky Department of Plant Pathology (in press).

Appendix A: Sources of Vegetable Seeds

We would like to express our appreciation to these companies for providing seeds at no charge for vegetable variety trials. The abbreviations used in this appendix correspond to those listed after the variety names in tables of individual trial reports.

AAS .... All America Selection Trials, 1311 Butterfield Road, Suite 310, Downers Grove, IL 60515
AS/ASG .... Formerly Asgrow Seed Co., now Seminis (see "S" below)
AC.................. Abbott and Cobb Inc., Box 307, Feasterville, PA 19047
AG.................. Agway Inc., P.O. Box 1333, Syracuse, NY 13201
AM.................. American Sunmelon, P.O. Box 153, Hinton, OK 73047
AR.................. Aristogenes Inc., 23723 Fargo Road, Parma, ID 83660
AT.................. American Takii Inc., 301 Natividad Road, Salinas, CA 93906
B..................... BHN Seed, Division of Gargiulo Inc., 16750 Bonita Beach Rd., Bonita Springs, FL 34135
BBS................. Baer's Best Seed, 154 Green St., Reading, MA 01867
BC.................. Baker Creek Heirloom Seeds, 2278 Baker Creek Rd., Mansfield, OH 65704
BK.................. Bakker Brothers of Idaho Inc., P.O. Box 1964, Twin Falls, ID 83303
BR.................. Bruinsma Seeds B.V., P.O. Box 1463, High River, Alberta, Canada, TOL 1B0
BS.................. Bodger Seed Ltd., 1800 North Tyler Ave., South El Monte, CA 91733
BU.................. W. Atlee Burpee & Co., P.O. Box 6929, Philadelphia, PA 19132
BZ.................. Bejo Zaden B.V., 1722 ZG Noordscharwoude, P.O. Box 9, The Netherlands
CA.................. Castle Inc., 190 Mast St., Morgan Hill, CA 95037
CF.................. Cliftons Seed Co., 2586 NC 43 West, Faison, NC 28341
CG.................. Cooks Garden Seed, P.O. Box C5030, Warminster, PA 18974
CH.................. Alf Christianson, P.O. Box 98, Mt. Vernon, WA 98273
CIRT................ Campbell Inst. for Res. and Tech., P-152 R5 Rd 12, Napoleon, OH 43545
CL.................. Clause Semences Professionnelles, 100 Breen Road, San Juan Bautista, CA 95045
CN.................. Canners Seed Corp. (Nunhems), Lewisville, ID 83431
CR.................. Crookham Co., P.O. Box 520, Caldwell, ID 83605
CS.................. Chesmore Seed Co., P.O. Box 8368, St. Joseph, MO 64508
D..................... Daehnfeldt Inc., P.O. Box 947, Albany, OR 97321
DN.................. Denholm Seeds, P.O. Box 1150, Lompoc, CA 93438-1150
DR.................. DeRuiter Seeds Inc., P.O. Box 20228, Columbus, OH 43320
EB.................. Ernest Benery, P.O. Box 1127, Muenden, Germany
EV.................. Evergreen Seeds, Evergreen YH Enterprises, P.O. Box 17538, Anaheim, CA 92817
EX.................. Express Seed, 300 Artino Drive, Oberlin, OH 44074
EW.................. East/West Seed International Limited, P.O. Box 3, Bang Bua Thong, Nonthaburi 1110, Thailand
EZ.................. ENZA Zaden, P.O. Box 7, 1600 AA, Enkhuisen, The Netherlands 02280-15844
FED................ Fedco Seed Co., P.O. Box 520, Waterville, ME 04903
FM.................. Ferry-Morse Seed Co., P.O. Box 4938, Modesto, CA 95352
G..................... German Seeds Inc., Box 398, Smithport, PA 16749-9990
GB.................. Green Barn Seed, 18855 Park Ave., Deephaven, MN 55391
GL.................. Gloeckner, 15 East 26th St., New York, NY 10010
GO.................. Goldsmith Seeds Inc., 2280 Hecker Pass Highway, P.O. Box 1349, Gilroy, CA 95020
GU.................. Gurney's Seed and Nursery Co., P.O. Box 4178, Greendale, IN 47025-4178
HL/HOL......... Hollar & Co. Inc., P.O. Box 106, Rocky Ford, CO 81067
H/HM............ Harris Moran Seed Co., 3670 Buffalo Rd., Rochester, NY 14624
HMS.............. High Mowing Organic Seeds, 76 Quarry Rd., Walcott, VT 05680
HN.................. HungNong Seed America Inc., 3065 Pacheco Pass Hwy., Gilroy, CA 95020
HO.................. Holmes Seed Co., 2125-46th St., N.W., Canton, OH 44709
HR.................. Harris Seeds, 60 Saginaw Dr., P.O. Box 22960, Rochester, NY 14692-2960
HS.................. Heirloom Seeds, P O Box 245, W. Elizabeth, PA 15088-0245
HZ.................. Hazera Seed, Ltd., P.O.B. 1565, Haifa, Israel
JU.................. J. W. Jung Seed Co., 335 High St., Randolph, WI 53957
JS/JSS........... Johnny's Selected Seeds, Foss Hill Road, Albion, MA 04910-9731
KS.................. Krummrey & Sons Inc., P.O. 158, Stockbridge, MI 49285
KY.................. Known-You Seed Co., Ltd. 26 Chung Cheng Second Rd., Kaohsiung, Taiwan, R.O.C. 07-2919106
KZ.................. Kitazawa Seed Co., P.O. Box 13220, Oakland, CA 94661-3220
LI..................... Liberty Seed, P.O. Box 806, New Philadelphia, OH 44663
LSL................. LSL Plant Science, 1200 North El Dorado Place, Suite D-440, Tucson, AZ 85715
MB.................. Malmborg's Inc., 5120 N. Lilac Dr., Brooklyn Center, MN 55429
MK.................. Mikado Seed Growers Co. Ltd., 1208 Hoshikuki, Chiba City 280, Japan 0472 65-4847
ML.................. J. Mollema & Sons Inc., 4660 East Paris Ave. SE, Grand Rapids, MI 49507
MM................. MarketMore Inc., 4305 32nd St. W., Bradenton, FL 34205
MN.................. Dr. Dave Davis, Univ. of Minnesota Horticulture Dept., 305 Alderman Hall, St. Paul, MN 55108
MWS.............. Midwestern Seed Growers, 10559 Lackman Road, Lenexa, KS 66219
NE.................. Neuman Seed Co., 202 E. Main St., P.O. Box 1530, El Centro, CA 92244
NI.................... Clark Nicklow, Box 457, Ashland, MA 01721
NU.................. Nunhems (see Canners Seed Corp.)
NS.................. New England Seed Co., 3580 Main St., Hartford, CT 06120
NZ.................. Nickerson-Zwaan, P.O. Box 19, 2990 AA Barendrecht, The Netherlands
OE.................. Ohlsens-Enke, NY Munkegard, DK-2630, Taastrup, Denmark
ON.................. Osbourne Seed Co., 2428 Old Hwy 99 South Road, Mount Vernon, WA 98273
OS.................. Outstanding Seed Co., 354 Center Grange Road, Monaca, PA 15061
OLS................ L.L. Olds Seed Co., P.O. Box 7790, Madison, WI 53707-7790
OT.................. Orsetti Seed Co., P.O. Box 2350, Hollister, CA 95024-2350
P..................... Pacific Seed Production Co., P.O. Box 947, Albany, OR 97321
PA/PK............ Park Seed Co., 1 Parkton Ave., Greenwood, SC 29647-0002

PARA.............. Paragon Seed Inc., P.O. Box 1906, Salinas CA, 93091
PE..................... Peter-Edward Seed Co. Inc., 302 South Center St., Eustis, FL 32726
PF..................... Pace Foods, P.O. Box 9200, Paris, TX 75460
PG.................... The Pepper Gal, P.O. Box 23006, Ft. Lauderdale, FL 33307-3006
PL..................... Pure Line Seeds Inc., Box 8866, Moscow, ID
PM.................. Pan American Seed Company, P.O. Box 438, West Chicago, IL 60185
PR................... Pepper Research Inc., 980 SE 4 St., Belle Glade, FL 33430
PT..................... Pinetree Garden Seeds, P.O. Box 300, New Gloucester, ME 04260
R....................... Reed's Seeds, R.D. #2, Virgil Road, S. Cortland, NY 13045
RB/ROB......... Robson Seed Farms, P.O. Box 270, Hall, NY 14463
RC.................. Rio Colorado Seeds Inc., 47801 Gila Ridge Rd., Yuma, AZ 85365
RE..................... Reimer Seed Co., P.O. Box 236, Mt. Holly, NC 28120
RG.................... Rogers Seed Co., P.O. Box 4727, Boise, ID 83711-4727
RI/RIS............. Rispens Seeds Inc., 3332 Ridge Rd., P.O. Box 5, Lansing, IL 60438
RS..................... Royal Sluis, 1293 Harkins Road, Salinas, CA 93901
RU/RP/RUP.. Rupp Seeds Inc., 17919 Co. Rd. B, Wauseon, OH 43567
S....................... Seminis Inc. (may include former Asgrow and Peto cultivars), 2700 Camino del Sol, Oxnard, CA 93030-7967
SE..................... Southern Exposure Seed Exchange, P.O. Box 460, Mineral, VA 23117
SHUM............ Shumway Seed Co., 334 W. Stroud St. Randolph, WI 53956
SI/SG.............. Siegers Seed Co., 8265 Felch St., Zeeland, MI 49464-9503
SIT.................... Seeds From Italy, P.O. Box 149, Winchester, MA 01890
SK..................... Sakata Seed America Inc., P.O. Box 880, Morgan Hill, CA 95038
SN.................... Snow Seed Co., 21855 Rosehart Way, Salinas, CA 93980
SO .... Southwestern Seeds, 5023 Hammock Trail, Lake Park, GA 31636
SOC................ Seeds of Change, Santa Fe, NM ,www.seedsofchange.com
SST .... Southern States, 6606 W. Broad St., Richmond, VA 23230
ST..................... Stokes Seeds Inc., 737 Main St., Box 548, Buffalo, NY 14240
SU/SS............. Sunseeds, 18640 Sutter Blvd., P.O. Box 2078, Morgan Hill, CA 95038
SV .... Seed Savers Exchange, 3094 North Winn Rd., Decorah, IA 52101
SW.................. Seedway Inc., 1225 Zeager Rd., Elizabethtown, PA 17022
SY..................... Syngenta/Rogers, 600 North Armstrong Place (83704), P.O. Box 4188, Boise, ID 83711-4188
T/TR .... Territorial Seed Company, P.O. Box 158, Cottage Grove, OR 97424
TGS................. Tomato Growers Supply Co., P.O. Box 2237, Ft. Myers, FL 33902
TS..................... Tokita Seed Company, Ltd., Nakagawa, Omiya-shi, Saitama-ken 300, Japan
TT..................... Totally Tomatoes, P.O. Box 1626, Augusta, GA 30903
TW.................. Twilley Seeds Co. Inc., P.O. Box 65, Trevose, PA 19047
UA.................... U.S. Agriseeds, 3424 Roberto Court, San Luis Obispo, CA 93401
UG .... United Genetics, 8000 Fairview Road, Hollister, CA 95023
US.................... U.S. Seedless, 12812 Westbrook Dr., Fairfax, VA 22030
V....................... Vesey's Seed Limited, York, Prince Edward Island, Canada
VL..................... Vilmorin Inc., 6104 Yorkshire Ter., Bethesda, MD 20814
VS .... Vaughan's Seed Co., 5300 Katrine Ave., Downers Grove, IL 60515-4095
VTR................. VTR Seeds, P.O. Box 2392, Hollister, CA 95024
WI .... Willhite Seed Co., P.O. Box 23, Poolville, TX 76076
WP .... Woodpraire Farms, 49 Kinney Road, Bridgewater, ME 04735
ZR .... Zeraim Seed Growers Company Ltd., P.O. Box 103, Gedera 70 700, Israel