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2010 Fruit and Vegetable Research Report

UKAg RESEARCH University of Kentucky • Lexington, Kentucky 40546

2010 Fruit and Vegetable Crops Research Report

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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.

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The 2010 Fruit and Vegetable Crops Research and Demonstration Program

Timothy Coolong, Department of Horticulture

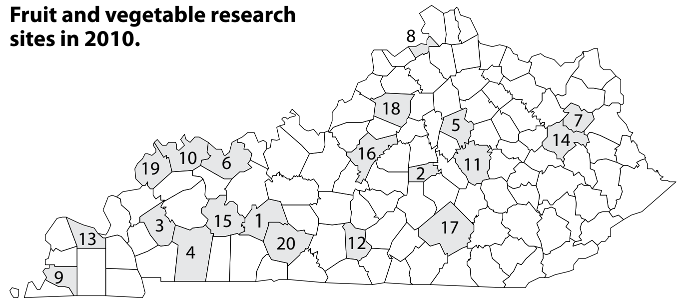
Fruit and vegetable production in Kentucky continues to grow. The 2010 Fruit and Vegetable crops research report includes results for more than 34 field research and demonstration trials that were conducted in 20 counties in Kentucky (see map, below). Research was conducted by faculty and staff from several departments within the University of Kentucky College of Agriculture including Horticulture, Plant Pathology, Entomology, Biosystems and Agricultural Engineering, and Nutrition and Food Science. This report also includes collaborative research projects conducted with faculty and staff at Kentucky State University and the University of Tennessee. Many of these reports include data on varietal performance as well as different production methods, in efforts to provide growers with better tools that they can use to improve fruit and vegetable production in Kentucky.

Variety trials included in this year's publication include fall squash, green beans, red onions, broccoli and cabbage, specialty melons and muskmelons, blueberries, raspberries, blackberries, apples, peaches, and grapes. New varieties are continually being released and variety trials provide us with much of the information necessary to update our recommendations in our *Vegetable Production Guide for Commercial Growers* (Publication 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 also 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 8 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" 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 2010.



1. Butler	*6. Davies*	*11. Madison*	*16. Nelson*
2. Boyle	*7. Elliot*	*12. Metcalfe*	*17. Pulaski*
3. Caldwell	*8. Gallatin*	*13. McCracken*	*18. Shelby*
4. Christian	*9. Hickman*	*14. Morgan*	*19. Union*
5. Fayette	*10. Henderson*	*15. Muhlenberg*	*20. Warren*

Statistics

Often yield or quality data will be presented in tables followed by a series of letters (a, ab, bc, etc.). These letters indicate if the yields of the varieties are statistically different. Two varieties may have average yields that appear to be quite different. For example, if tomato variety 1 has an average yield of 2000 boxes per acre and variety 2 yields 2300 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 1800, 1900, 2200, and 2100 boxes per acre. The average yield would then be 2000 boxes per acre. Tomato variety 2 may have had four plots with yields of 1700, 2500, 2800, and 2200 boxes per acre. The four plots together would average 2300 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 than a variety followed by the letters 'cdef,' because the letters 'c' and 'd' are shared by the two varieties. Yield data for followed by the letters 'abc' would be different than yield data followed by 'efg.'

Lastly, 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 wouldn't 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

Six on-farm commercial vegetable demonstrations were conducted in south-central Kentucky. Grower/cooperators for the demonstrations were located in Butler, Metcalfe and Warren counties. One of the demonstrations in Warren County was not completed due to extreme flooding within the region. The second cooperator in Warren County was able to establish a late crop of watermelon; the field consisted of 0.33 acres of seeded melon variety Sangria and was market through the Warren County School District.

One on-farm demonstration was conducted in Butler County. The plot was approximately 0.25 of mixed vegetables including peppers, tomatoes, and pumpkins. The cooperator marketed his produce at local farmers markets and direct from the farm. The remaining three on-farm demonstration plots were located in Metcalfe County. The first demonstration was approximately 0.33 acres of strawberries grown by the Metcalfe County FFA Chapter; the strawberries were marketed at the school greenhouse. The second demonstration consisted of 0.38 acres of mixed vegetables, primarily tomatoes, and were marketed direct from the farm. The final demonstration plot in Metcalfe County was 0.36 acres of mixed vegetables consisting primarily of hybrid tomatoes. This plot was marketed at the local farmers market, restaurants and direct from the farm.

Materials and Methods

Grower/cooperators for the demonstration plots were provided with production supplies such as black plastic mulch, drip irrigation lines, blue lay-flat 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. Black plastic mulch (1.0 mil) for the demonstrations was placed in April and May. All but one of the demonstration plots used a municipal water source with irrigation runs no longer than 350 ft; and all plots used a venture-type injection system for fertilizer applications.

The grower/cooperators had local greenhouse managers produce their transplants. Demonstrations were planted from the last week of April through the beginning of June. Tomato and mixed vegetable demonstration used 18 inch in-row spacing. Twenty-four-inch in-row spacing was used for muskmelons and 36-inch in-row spacing for watermelon. The pumpkin demonstration had in-row spacing of 24-36 inches depending upon the size pumpkin being planted. All the demonstration plots had bed rows 6-7 ft on center.

After transplant, insecticides were applied to prevent damage from the cucumber beetles and other insects. Imidacloprid, endosulfan, and bifenthrin were used for insect control. Imidacloprid (Admire) was used as a soil drench and was effective for three weeks after application. Control for the remainder of the season was achieved by alternating insecticides on a weekly basis until harvest. Three weeks after transplanting, Bravo Weather Stick, Mancozeb, Ralley and Quadris were applied on the demonstration plots on an alternating weekly schedule for disease control. The University of Kentucky's recommendations from *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 one acre inch of water per week and fertigated weekly following the University of Kentucky's recommendations from *Vegetable Production Guide for Commercial Growers* (ID-36). Harvest for the demonstration plots began in late June and was completed by October.

Results and Discussion

The 2010 was a unique growing season in south-central Kentucky; early May saw record flooding in the region. This was followed by moderate to extreme drought toward the end of the production year. Record high temperatures were also recorded throughout the summer. One demonstration plot was completely lost due to flooding; the field was located in a river bottom that had not been flooded in nearly 75 years. The remaining plots were not affected by flooding. The drip irrigation system employed in the remaining plots proved to be a vital resource as drought stress increased during the season. The demonstrations were able to have a lengthy harvest and surpassed previous bare ground production methods.

Virus pressure was significant during this growing season. Tomato spotted wilt virus was found throughout the demonstration plots. Nevertheless, most plots overproduced for their markets and had tomatoes that went unsold remaining in the fields. Nutrient deficiencies, particularly calcium (blossom end rot) and magnesium were also observed in several plots. The extreme fluctuation in weather and moisture played a part in the deficiencies along with improper irrigation timing.

Plants were grown on white and black plastic for the strawberry plot demonstration. The berries on the black mulch were a week to ten days earlier than those on the white. The plants on the white mulch also did not produce as much as did the ones on black mulch. Thus, based upon this information, the producer is going to use all black mulch in any future planting of strawberries. The purpose of using the white mulch was to look at following the strawberry crop with pumpkins; however, this planting did not occur.

Overall, it was a profitable year for half the demonstrators. All but one of the grower/cooperators are planning to continue the use of plastic mulch and drip irrigation, thus expanding upon the knowledge gained in the demonstration plots. Grower/cooperators learned the importance of the need to follow recommendations in a timely fashion, as well as having a viable market for selling harvested produce.

Table 1. Costs and returns from on-farm demonstrations of mixed vegetable crops in Butler, Metcalfe and Warren counties, 2010.

	Mixed Vegetables				Metcalfe Strawberries
	Butler	Warren	Metcalfe		
Inputs	(0.25 acre)	(0.33 acre)	(0.36 acre)	(0.38 acre)	(0.33 acre)
Plants/Seeds	$210	$123	$70	$200	$945
Fertilizer/Lime	60	300	275	214	185
Black plastic	40	54	58	62	54
Drip line	34	45	49	52	45
Tomato stakes, Pea Fence, etc.[1]	20	50	95	119	96
Herbicides	15	60	0	25	75
Insecticides	15	55	105	50	0
Fungicides	40	76	140	80	0
Pollination	Free	Free	0	Free	0
Machine[2]	75	50	50	55	50
Irrigation/Water[3]	190	125	600	30	320
Labor[4]	0	0	180	0	0
Total expenses	699	938	1622	887	1770
Income-retail	650	5500	3500	2189	1400
Net income	-49	4562	1878	1302	-370
Dollar return/Dollar input	0.93	5.86	2.16	2.47	.79

1 Three-year amortization of plastic harvest bins, backpack spray, stakes and row cover.
2 Machine rental, fuel and lube, repairs, and depreciation.
3 Three-year amortization of irrigation system plus city water cost where applied.
4 Doesn't include unpaid family labor.

On-Farm Commercial Vegetable Demonstrations

Dave Spalding and Tim Coolong, Department of Horticulture

Introduction

Five on-farm commercial demonstrations were conducted in central and northern Kentucky in 2010. Grower/cooperators were from Boyle, Gallatin, Madison, Nelson and Shelby counties. The grower/cooperator in Boyle County grew 1.0 acre of organic mixed vegetables for local markets, some local grocery stores and for CSA clients. The grower/cooperator in Gallatin County grew 0.75 acre of Roma-type tomatoes for a local wholesale market. The grower/cooperator in Madison County grew about 0.5 acre of mixed vegetables for the local and on-farm market. The grower/cooperator in Nelson County grew about 0.5 acres of heirloom tomatoes for the local market, and the grower/cooperator in Shelby County grew about 10 acres of mixed vegetables for local markets and CSA clients and 5.0 acres of bell peppers for the Central Kentucky Growers Co-operative in Georgetown, KY.

Materials and Methods

Grower/cooperators were provided with black plastic mulch and drip 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 cooperators, county Extension agents took soil samples of 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.

Three of the five demonstration plots consisted of a mix of vegetables (tomatoes, peppers, squash, melons, green beans, and sweet corn) while the other two plots consisted of tomatoes only. The 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 mixed vegetable plots were planted at the appropriate spacing for the 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 tomato-only plots were all planted into raised beds with the tomatoes planted 18 inches apart in the row. Except for the organic plot, the plots were sprayed with the appropriate fungicides and insecticides on an as-needed basis, and cooperators were asked to follow the fertigation schedule provided.

Results and Discussion

Weather conditions in 2010 were less than ideal for vegetable production. An abnormally warm and wet spring gave way to a very hot and, for most areas, a very dry summer and early fall. Generally, crops went in the ground on time and were growing well early in the season. Persistent warm and wet weather early in the season encouraged strong weed pressures for most growers and were a problem the whole season. The same warm and wet conditions were ideal for the development of disease and insect problems that persisted until the weather turned hot and dry, but by then much of the damage had been done. Those grower/cooperators selling in the farmer's markets and on-farm markets faired pretty well despite the conditions. The grower/cooperator in Gallatin County was late in getting his crop planted, but things turned out well, as most other growers in the area were through marketing their tomatoes by the time he started marketing, leaving him with little local competition. The heat and insect problems affected the bell pepper production in Shelby County and resulted in a substantial loss for that grower/cooperator. Also in Shelby County, there was sweet corn spacing observation in which the sweet corn of 2 varieties were planted at a spacing of 9 inches and 12 inches (Table 2.) The sweet corn was planted in double rows on each bed and there were 2 plants per transplant hole. Although the 9-inch spacing had 50 percent more plant population, it consistently yielded fewer marketable ears.

Table 1. Costs and returns of grower/cooperators.

Inputs	Boyle (1.0 acre)	Gallatin (0.75 acre)	Madison (0.25 acre)	Nelson (0.33 acre)	Shelby (1.0 acre)
Plants and Seeds	219.60	1,000.00	200.00	250.00	1,012.71
Fertilizer	550.00	400.00	75.00	150.00	184.00
Black Plastic	130.00	97.50	32.50	42.50	80.91
Drip Lines	180.00	135.00	45.00	49.50	124.79
Fertilizer Injector	------	75.00*	150.00*	35.00*	75.00*
Herbicide	------	45.00	15.00	-----	47.81
Insecticide	18.75	65.00	35.00	50.00	140.49
Fungicide	------	340.00	148.00	200.00	107.61
Water	180.00 (120,000 gal)	140.00 (140,000 gal)	550.00 (65,000 gal)	600.00 (72,000 gal)	109.00 (95,000 gal)
Labor	3,500.00 (390.0 hrs)	9,950.00 (995.0 hrs)	4,000.00 (485.0 hrs)	------ *** (250.0 hrs)	1,200.00** (188.0 hrs)
Machine	94.50 (12.25 hrs)	65.60 (8.50 hrs)	45.00 (4.75 hrs)	20.10 (2.50 hrs)	214.00 (16.5 hrs)
Marketing	-----	2,000.00	200.00	100.00	2,709.14
Total Expenses	4,872.25	14,313.10	5,495.50	1,497.10	6,005.47
Income	7,833.10	17,500.00	9,800.00	6,500.00	5,277.12
Net Income	2,960.85	3,186.90	4,304.50	5,002.90	(728.35)
Net Income/A	2,960.85	4,249.20	17,218.00	15,160.30	(728.35)
Dollar return/ Dollar Input	1.6	1.2	1.8	4.3	0.9

*Costs amortized over three years.
**Unpaid family labor not included.
***All labor unpaid family labor.

Table 2. Sweet corn spacing observation results.

Variety	Bed	Row	Nine-inch Spacing Ear Number	Twelve-inch Spacing Ear Number
Incredible	A	1	916	1,006
Incredible	A	2	923	1,072
Incredible	B	1	943	1,032
Incredible	B	2	964	1,125
Serendipity	A	1	723	817
Serendipity	A	2	731	804
Serendipity	B	1	719	796
Serendipity	B	2	698	782

On-Farm Vegetable Demonstration Program in Western Kentucky

Vaden Fenton, Department of Horticulture

Introduction

Seven on-farm commercial vegetable demonstration plots were conducted in Western Kentucky in 2010. Grower/cooperators were located in Union County Crittenden, McCracken, Davies County, Hickman, Henderson and Muhlenberg Counties. None of the growers had used the plasticulture system for commercial production before. In Union County 3700 onion plants were planted. Watermelons were planted on 1.5 acres in Hickman County. The four other plots contained a mixture of vegetables. There was one acre of production in McCracken County, two acres in Muhlenberg County, 0.25 acres in Davies County and two- 0.25 acre plots in Henderson County. The grower cooperator did not submit any data for the Davies County plot.

Material and Methods

Each grower was provided up to one acre of plastic mulch and drip lines for the production season. Growers with more than one acre in production provided the extra plastic and drip tape. The University of Kentucky Department of Horticulture bed shaper and waterwheel setter were used to establish the plantings. All the growers were asked to conduct a soil test and make any soil amendments according to the University of Kentucky recommendations. Regular visits were made to each grower and where necessary fungicides and insecticides recommendations were made in accordance with UK V*egetable Production Guide for Commercial Growers* (ID-36).

Results and Discussion

The grower in McCracken County had one acre of mixed vegetables. The distance to the local market made it unfeasible to market small quantities of produce. Labor costs were fairly high as well. In this plot, red plastic mulch was used instead of the traditional black plastic. The amount of light passing through the plastic cause some weeds to emerge under the plastic and increasing labor costs associated with weeding and also reduced yields. The grower/cooperator in Hickman County had 1.5 acres of watermelons. This was his first time growing melons on plastic; however it was not his first time growing melons. As an experienced grower, his transition to plastic production was smooth and yields increased. The grower in Union County had 0.06 acres of onions, 'Sweet Vidalia' and 'Candy' planted on 5 April 2010. Onions were planted on black plastic with in-row spacing 6 inches apart. Two rows were planted on plastic mulch, one with 'Candy' and the other with 'Sweet Vidalia.' Onions were sold at the local farmers market at $1.00/lb and averaged 0.5 lb each. The grower in Muhlenberg County had two acres of mixed vegetables. The management of this plot proved to be difficult. The grower, after initially planting at least half of the plot, left the plot unmanaged for the rest of the season.

Table 1. Cost and returns of five commercial vegetable demonstration plots in six counties in Western Kentucky.

Inputs	McCracken (1 acre)	Hickman (1.5 acre)	Muhlenberg (2 acres)	Davies (0.25 acre)	Union (0.06 acre)	Henderson (0.25 acre)	Henderson (0.25 acre)
Plants/seeds	$750	$224.25	0	0	114.8	129	85
Fertilizer	450	210	0	0		95	190
Plastic	180		0	0	10	42	42
Drip lines	144	306	0	0	8	37	37
Herbicides	100	32.81	0	0		48.47	0
Insecticides	75	450	0	0	50	10	30
Irrigation	0	18.75	0	0	40	10	160
Field labor	4800	510	0	0	0	400	150
Machinery		37.5	0	0		100	25
Total expense	6499	1789.31	0	0	222.8	871.47	719
Income	3700	7042.5	0	0	1400	750	270
Net income	-2799	5253.19	0	0	1177.2	-121.47	-449
Net Income/A		3502.12	0	0	7063.2		
Dollar return/ Dollar input	$0.57	$3.9	0	0	$6.28	$0.86	$0.37

Places where labor equals $0 is unpaid family labor.
Dollar return/Dollar input = income/total expenses.
No data in Muhlenberg County = abandon plot
No data in Davies county = grower/cooperator did not provide data in time for publication.

High Tunnel Tomato Demonstration in Southwest Kentucky

Timothy Coolong, Lucas Hanks, Darrell Slone, UK Department of Horticulture; Kelly Jackson, UK Cooperative Extension Service, Christian County; and Harold Eli, Kentucky State University, Small Farm Assistant

The popularity of high tunnels with vegetable producers has increased significantly in recent years. High tunnels are plastic covered hoop house structures, similar to greenhouses, though they typically have no exhaust fans or sources of heat. High tunnels are proving to be worthwhile for vegetable growers because they represent a relatively low-cost investment (ranging from $0.50-$1.00 per square ft), while allowing out-of-season vegetable production. The ability to extend the production schedule for vegetables has allowed growers to capitalize on higher early and late season prices as well as extend their marketing opportunities. For example, some growers are able to market to restaurants on a year-round basis due to having high tunnels. Additionally, high tunnels have proven to be worthwhile for organic farmers as they generally cut down on foliar diseases due to lack of rainfall in the tunnels and in some instances have been reported to decrease insect pressures for plants grown in the tunnels.

In Kentucky high tunnels are typically utilized in the spring for early season tomato production and then in the fall and winter for the production cool-season crops such as leafy greens. It is not uncommon for successful growers to gross up to $2 or more per square ft when producing spring tomatoes. The University of Kentucky's Department of Horticulture has helped install low-cost, rudimentary demonstration high tunnels in several counties over the past three years as a way to increase awareness of the benefits of high tunnels. In spring 2010 a high tunnel was installed in Fairview, Kentucky to demonstrate the benefits of high tunnels for spring tomato production.

Materials and Methods

A 100-ft-long by 12-ft-wide high tunnel was installed on 31 March 2010 on a level site in Fairview, Kentucky. The high tunnel was assembled over two existing raised beds covered in black plastic mulch with drip irrigation. The 12-ft width allowed it to cover two raised beds that were placed on six-ft centers. The bows of the tunnel were constructed from 20-ft-long by 1.5-inch diameter schedule 40 pvc pipe spaced eight ft apart along the length of the tunnel. Anchors 24 inches in length were made from one-inch-diameter steel pipe with a single revolution of auger flight welded to the base. The tunnel was covered with a single layer (24 ft wide by 100 ft long) of 4 mil thick clear plastic. A publication detailing the complete construction of this low-cost high tunnel can be found at eXtension.org under "Low Cost High Tunnel Construction" or by pasting the following link of the web site: http://www.extension.org/article/18356. High tunnel assembly took approximately five hours with a cost estimated between $450-$500, not including labor.

Tomatoes, variety 'Mountain Fresh,' were planted both inside and outside of the tunnel on 12 April 2010. Tomatoes were spaced 18 inches apart within each row. Plants were grown according to standard growing practices for Kentucky (Coolong et al., 2009). Plants were harvested beginning 24 June 2010 continuing until 23 July 2010 for a total of six harvests.

Results and Discussion

Tomatoes grown inside the high tunnel produced 1155 lb (per 100 plants) of marketable fruit compared to 519 lb for plants grown outside the tunnel (Table 1). Yields inside the tunnel were higher than outside. Much of this was due to a lack of virtually any foliar diseases for plants grown under the tunnel compared to those grown outside. Plants grown outside the tunnel displayed symptoms from early blight (*Alternaria solani*) despite being on a regularly schedule fungicide spray program. The higher productivity of plants in the tunnel was not necessarily related to significantly earlier production of fruit. Due to the warm weather following planting date of 12 April, there was minimal advantage to the tunnel versus field-grown tomatoes with regard to earliness. Based on historical data and empirical observations, it is likely that tomatoes could have been planted into the tunnel three to four weeks earlier than the 12 April date chosen in this demonstration. Profits for tunnel tomatoes would have been significantly higher if tomatoes were harvested just two weeks earlier. For example, on 10 June 2010 average prices at the Fairview produce auction were nearly $1.60/lb (http://www.uky.edu/Ag/NewCrops/).

Despite not producing earlier fruit, tunnel-grown plants were much more productive than those grown in the field. In an average 12 x 100 ft tunnel such as the one used in this demonstration one can plant approximately 133 tomato plants. Using the values and yields presented in Table 1, one would expect the full value of the tunnel used in this experiment to be $763. On a square-ft basis the return for this tunnel (1200 ft^2) would be $0.63 per square ft. If calculations are based on a shift in production so that plants were harvested beginning on 10 June 2010 (based on earlier planting) the value of the tunnel would have been much greater, at $0.83 per square ft (Table 2).

It is worthwhile to note the plants grown in the tunnel displayed virtually no symptoms of disease when compared to field-grown plants. The ability of the tunnel to protect plants from foliar diseases suggests that tunnels could be a useful tool for organic farmers to employ to prevent diseases in some crops.

Table 1. Yields and values for tomatoes grown in a high tunnel in Fairview, Kentucky in spring 2010.

	Per 100 Plants:				
Harvest Date	Inside Tunnel (lb)	Total Income ($)	Outside Tunnel (lb)	Total Income ($)	Average Price/lb[a]
24 June	23	$33.12	10	$14.40	$1.44
2 July	53	$40.81	64	$49.28	$0.77
5 July	281	$182.65	130	$84.50	$0.65
13 July	322	$154.56	196	$94.08	$0.48
19 July	389	$132.26	105	$35.70	$0.34
23 July	87	$30.45	14	$4.90	$0.35
Totals	1155	$573.85	519	$282.86	

[a] Average price/lb determined from average prices obtained at the Fairview Produce Auction for a 20-lb box of tomatoes on the harvest dates indicated. Price reports are available at the UK New Crops Opportunities Center http://www.uky.edu/Ag/NewCrops/.

Table 2. Projected yields and values for tomatoes grown in a high tunnel in Fairview, Kentucky if planted in the last week of March 2010.

Projected Harvest Date[a]	Inside Tunnel (lb/100 plants)	Total Income ($/100 plants)[b]
10 June	23	$36.34
18 June	53	$82.68
21 June	281	$365.30
1 July	322	$193.20
5 July	389	$252.85
9 July	87	$66.12
Totals	1155	$996.49

[a] Yields and harvest dates are projected in this case for a high tunnel planted and yielding two weeks earlier than the demonstration high tunnel in 2010.
[b] Average price/lb determined from average prices obtained at the Fairview Produce Auction for a 20-lb box of tomatoes on the harvest dates indicated. Price reports are available at the UK New Crops Opportunities Center http://www.uky.edu/Ag/NewCrops/.

Previous trials conducted at the UK Horticulture Research Farm in Lexington, KY suggest that inexpensive tunnels can be helpful when used in the production of a variety of organic fruits and vegetables (data not shown).

High tunnels continue to grow in popularity with growers in Kentucky. High early-season prices obtained at markets and some produce auctions have been shown to justify the cost of tunnels for growers. In many cases growers have been able to pay for their high tunnel structure in less than two growing seasons. As farmers markets and produce auctions continue their growth in Kentucky, high tunnels are sure to become more popular.

Acknowledgements

We would like to acknowledge David Weaver for participating in this demonstration program and maintaining the tomato plants.

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Day-Neutral Matted Row, Field and High Tunnel Plasticulture Strawberry Management Systems

Vaden Fenton, Department of Horticulture

Introduction

Strawberries are a very important high-value cash crop for Kentucky growers. The profit potential is greatly affected by the cultural management system selected for the crop. This article provides a comparison of three different management systems used by growers in three different western Kentucky counties.

Material and Methods

Three different strawberry management systems were established on grower/cooperator farms in Union, Muhlenberg, and McCracken counties. Three hundred Albion, 300 Seascape, and 300 Tribute day-neutral or everbearing dormant bare root strawberry plants were set in Union county at a spacing of 2' X 4' in the spring of 2009 using a matted-row, bare ground management system. Roughly 800 of these plants survived. Two thousand Chandler plug plants were set in double rows spaced 12" apart in the row, 12" between rows on 6' centers on black plastic covered raised field beds in Muhlenberg County on 8 September 2009 using a conventional plasticulture management system. Eight hundred Chandler plug plants were set in double rows using the same plant spacing in a high tunnel on 30 September 2009 in black plastic-covered raised beds. The field plasticulture and high tunnel management systems both had drip irrigation, while the day-neutral, matted row production system was not irrigated.

Table 1. Strawberry production input costs and returns for three management systems on grower/cooperator farms.

Inputs	Union	Muhlenberg	McCracken
Production system	**Matted Row Bare Ground**	**Raised Bed Plasticulture**	**High Tunnel Raised Bed Plasticulture**
Plants established (no)	800	2,000	800
Plant cost		$727	$232
Fertilizer		4	50
Plastic		190	17
Miscellaneous		223	
Herbicides		20	10
Marketing expense		400	
Irrigation		95	
Field labor		900	560
Machinery		120	
Total expense		2727	896
Income		3450	1875
Net income		723	979
Total yield (qt)	100	1380	500
Yield/2,400 sq ft[1] (qt)	38	552	500
Gross income[2]/2,400 sq ft	$114	$1,656	$1,500
Yield/A (qt)	686	10,019	9075
Gross income[2]	$2058	$30,057	$27,225

1 1/18 acre.
2 Grower harvested, @$3/qt.

Results and Discussion

The field plasticulture management system tended to yield the best, with 552 qt per 2,400 sq ft with a gross return of $1,656 at $3.00 per qt or on a per-acre basis, 10,019 qt with a gross return of $30,057. This was closely followed by the high tunnel plasticulture management system, which produced 500 qt and a gross return of $1,500 per 2,400 sq ft, or 9,075 qt with a gross return of $27,225 on a per acre basis. These are both excellent yields for Midwest strawberry production using the plasticulture system. The day-neutral, matted-row cultural system had very poor yields of 38 qt per 2,400 sq ft, or 686 qt per acre, for a gross return of $2058 at $3.00 per qt. Yield on these plants was intermittent, and the yield was reduced by the lack of irrigation in a very dry season. In this study, Tribute contributed over half the total yield, and Seascape had yields that were less than half that of Tribute.

High-tunnel management system strawberries mature before the field plasticulture berries and a few weeks before June-bearing strawberries, providing the grower with a premium price for early berries. However, the cost of the construction of the high tunnel may make it difficult for some growers. This grower was able to convert a high-tunnel house from ornamental plant sales because of a market slump and increased his early cash flow with strawberries. Thus, the use of a preexisting high tunnel can be a source of income for growers who already have these structures in place, with very little input cost for construction.

Peach Variety Demonstration

Dwight Wolfe, June Johnston, Ginny Travis, Department of Horticulture

Introduction

Due to the perennial nature of the crop, one of the 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 UK Research and Education Center at Princeton, Kentucky (1). This planting consisted of two trees per variety spaced 6 ft apart within rows 18 ft apart. The phenology (timing of flowering, etc.) of each cultivar was recorded in 2005 (1), in 2006 (2), and again in 2007 and 2008 (3). In spring of 2009, one tree per variety was removed in order to allow adequate spacing for future growth. Yield, fruit size (average weight of 25 fruits), and Brix readings of three fruits were recorded at harvest in

Table 1. Results of the 2008, 2009, and 2010 harvest from the 2004 peach cultivar trial at Princeton, Kentucky.

Cultivar	Date of Harvest			Cumulative Yield[1] (lb/tree)	Yield (lbs/tree)			Fruit Wt (oz)			Brix (%)			Bacterial Spot[2]
	2008	2009	2010		2008	2009	2010	2008	2009	2010	2008	2009	2010	
Allstar	Aug 4	July 27	July 22	287	111	30	90	5.1	6.8	4.0	12.3	9.9	11.9	1.0
Blushingstar	Aug 7	July 30	July 21	215	56	78	34	4.8	7.1	5.9	12.4	9.2	14.3	1.0
Contender	Aug 4	July 26	July 21	312	119	45	100	4.5	6.8	4.5	12.0	10.6	12.9	1.0
Coralstar	Aug 1	July 21	July 15	187	90	29	32	5.4	9.6	7.1	14.8	11.3	14.4	2.0
Cresthaven	Aug 18	Aug 7	Aug 9	184	49	40	61	7.1	7.6	5.9	12.0	11.9	12.8	1.5
Crimson Rocket	July 30	July 30	July 29	25	8	7	7	3.7	.	3.1	14.8	12.3	.	1.0
Encore	Aug 26	Aug 17	Aug 16	198	80	26	41	6.9	7.1	6.8	12.7	13.0	15.0	1.0
Ernie's Choice	July 30	July 24	July 21	20	3	8	8	3.4	5.1	4.5	16.8	10.9	16.3	2.0
Flat Wonderful	July 14	June 20	July 15	55*	17	17	21	3.8	3.4	2.3	12.0	13.5	13.3	2.0
Galaxy	Aug 21	July27	July 15	190*	72	1	117	4.9	.	3.7	13.8	18.0	13.4	3.0
Glowingstar	Aug 7	July 30	July 21	281	112	75	25	5.6	6.2	5.1	10.9	11.6	13.7	1.0
John Boy	July 28	July 22	July 15	203	47	105	36	6.0	6.1	8.5	13.7	11.9	14.7	1.5
John Boy II	Aug 1	July 27	July 12	132	74	22	9	4.8	5.4	5.1	12.5	9.3	16.2	1.5
Klondike White	July 30	July 24	July 22	220	107	3	92	4.7	5.6	2.5	16.0	12.8	15.1	1.0
Laurol	Aug 28	Aug 28	Aug 16	237	87	46	47	6.2	7.9	5.1	12.7	12.9	14.8	2.0
PF 1	June 29	June 24	June 10	188	57	49	57	3.4	5.2	4.2	8.2	.	9.4	1.5
PF 15A	July 28	July 2	July 20	148	75	11	25	3.5	4.9	5.2	8.0	10.9	12.7	2.0
PF 17	Aug 4	July 28	July 21	263	76	75	69	5.4	5.9	4.5	10.7	10.7	12.5	2.0
PF 20-007	Aug 1	July 20	July 21	301	87	32	125	6.5	9.6	4.8	10.1	10.4	10.7	2.0
PF 24C	Aug 11	Aug 5	July 29	126	42	58	0.4	6.2	4.5	.	11.1	.	.	1.0
PF 25	Aug 21	Aug 7	Aug 16	200	80	29	72	4.9	8.0	3.7	13.2	12.6	13.1	1.0
PF 27 A	Aug 15	Aug 7	Aug16	179	58	2	106	4.5	.	4.0	12.3	.	13.7	1.0
PF 35-007	Aug 15	Aug 13	July 12	194	37	55	77	5.1	10.2	4.8	13.8	12.7	13.0	2.0
PF 5B	June 29	June 10	June 10	120	60	18	18	3.4	4.4	4.0	10.0	9.8	11.2	2.0
PF 7	July 11	June 30	June 30	99	51	33	5	3.8	5.6	.	10.2	8.3	10.1	2.0
PF Lucky 13	July 21	July 2	July 1	151	86	8	20	3.1	4.2	5.1	11.0	11.5	11.0	2.0
PF Lucky 21	Aug 4	July 4	July 29	241	84	58	69	6.5	5.6	3.4	11.8	10.3	.	2.0
Redhaven	July 22	July 15	July 12	151	81	8	21	3.7	4.9	13.9	11.5	11.7	13.9	2.0
RedStar	July 22	July 16	July 12	94	49	14	3	4.0	5.4	14.1	12.1	9.7	14.1	2.0
Reliance	July 14	July 14	July 15	108*	28	8	72	4.2	4.8	4.8	11.0	11.9	13.3	3.0
Snow Brite	July 14	no	harvest	28	26	0	0	2.5	.	.	10.6	.	.	3.0
Snow Giant	Aug 25	Aug 25	Aug 16	189	82	55	35	7.9	7.9	6.5	13.3	10.5	16.8	3.0
Spring Snow	June 27	June 5	June 18	37*	5	8	24	3.1	3.8	5.2	9.6	13.1	11.7	2.5
Sugar Giant	Aug 15	July 27	July 29	41	17	1	22	5.4	.	4.5	11.3	10.9	.	4.0
Sugar May	July 8	June 5	June	26*	21	4	1	2.5	4.4	.	9.2	11.9	13.4	3.0
Summer Breeze	July 25	July 18	July 15	163	70	28	41	5.0	5.4	3.7	10.8	9.9	16.6	2.0
Sweet-N-Up	Aug 7	July 30	Aug 9	46	30	16	0.9	7.3	8.5	.	14.7	11.8	16.8	1.0
True Gold	Aug 11	Aug 10	July 21	188	66	48	4	7.2	6.5	5.9	11.7	10.0	13.3	
White Lady	Aug 7	July 20	July 21	126	77	9	1	3.1	5.6	.	10.1	11.7	21.7	2.0

1 2006, 2008, 2009 and 2010. There was no harvest in 2007 due to the spring freeze.
2 Bacterial spot rating for 2009 is based on a scale from 1 to 5, with 1 representing negligible number of leaves with symptoms of infection to 5 representing half or more of the leaves showing signs of infection.
*Indicates first harvested in 2008.

2006, 2008, 2009 and 2010. 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. In July of 2009, trees were rated on the degree to which they showed signs of bacterial spot infection.

Results and Discussion

The date of harvest averaged about 11 days earlier in 2010 than it did in 2009 (Table 1). 'Contender,' 'PF20-007,' 'Allstar,' and 'Glowingstar' have the highest cumulative yields to date. Among these, only 'Contender,' and 'PF 20-007' were among the top four in yield per tree in 2010. 'Allstar,' 'Coralstar,' 'Glowingstar,' and 'Klondike' averaged the highest yields per tree in 2008, while 'John Boy,' 'Blushingstar,' 'Glowingstar,' and 'PF 17' were the highest in 2009.

About two-thirds of the cultivars had the same or higher yields in 2010 than in 2009. But about a third of the cultivars had little or no yield in 2010, due to poor winter flower bud survival and possibly due to poor pollination for those cultivars. Fruit averaged about 4.6 oz per fruit in 2010, versus 6.2 oz per fruit in 2009, and 4.8 oz in 2008. Brix readings averaged 13.8 in 2010, versus 11.4 in 2009 and 11.9 in 2008. The hot, dry weather resulted in both a decrease in fruit size and a concentration of sugars during fruit development. The hot dry weather in this year resulted in bacterial spot being less of a problem than in previous years to the extent that we were not able to rate this disease in 2010. Bacterial spot was more of a problem in 2009 as a result of the wet rainy growing season during that year, when this disease was rated. The majority of the varieties grown at UKREC appear to be fairly resistant to bacterial spot.

All peach cultivars in this trial generally have good flavor. 'Flat Wonderful' and 'Galaxy' are peento (flat-shaped) peach cultivars. 'Crimson Rocket' has a pillar or columnar growth habit, while 'Sweet-N-Up' has an upright 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.

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Rootstock Effects on Apple and Peach Tree Growth and Yield

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Introduction

Apple and peach are the principal tree fruits grown in Kentucky, although the hot, humid summers and heavy clay soils make apple and peach production more difficult in Kentucky than in some neighboring tree fruit producing regions. The hot, humid summers 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.

Identification of improved rootstocks and cultivars is fundamental for advancing the Kentucky tree fruit industry. For this reason, Kentucky cooperates with 39 other states and three Canadian provinces in the Cooperative Regional NC-140 Project entitled, "Improving Economic and Environmental Sustainability in Tree Fruit Production through Changes in Rootstock Use." The NC-140 trials are critical to Kentucky growers, allowing access to and testing of new rootstocks from around the world. The detailed and objective evaluations allow growers to select the most appropriate rootstocks for Kentucky.

The NC-140 orchard trials are research trials that also serve as demonstration plots for visiting fruit growers, extension personnel, and researchers. The data collected from these trials helps establish baseline production and economic records for the various orchard system/rootstock combinations that can be used by Kentucky fruit growers.

Materials and Methods

Grafts of known cultivars on the various rootstocks were produced by nurseries and distributed to cooperators. NC-140 rootstock plantings at the UK Research and Education Center (UKREC) at Princeton:

1. 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 end of each row. A trellis was constructed and trickle irrigation installed a month after planting. Trees were planted on 8 ft x 15 ft spacing.
2. The 2003 apple rootstock trial compares eleven rootstocks with 'Golden Delicious' as the scion. Two trees of each rootstock were planted in a randomized complete block design with four replications (blocks). Trees were planted on 8 ft x 15 ft spacing.

3. The 2009 peach rootstock trial compares fourteen rootstocks with 'Redhaven' as the scion cultivar. Eight trees of each rootstock were planted in a randomized complete block design with eight replications (blocks). Trees were planted on 16 ft x 20 ft spacing.
4. A planting of 'Aztec Fuji' apple on thirty-one different rootstocks with four blocks per rootstock and up to 3 trees per rootstock per block (256 trees for Princeton, KY) was established in March 2010. The experimental design was a randomized complete block design, and trickle irrigation was installed a month after planting. Heavy spring rains resulted in many of the graft unions sinking below ground level. Many of the trees were replanted and allowed to resettle through the summer. The height of the graft unions above the soil line now average 5 inches (12.7 cm) with a range of 3 to 7 inches (7.6 to 17.8 cm).

Orchard floor management consists of a 6.5 ft 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 for apple and 6 inches above the graft union for peach. 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

January and February temperatures were 3° and 6.9° F below normal, respectively. Temperatures for April through August ran consistently 3 to 4.8° F above normal. Louisville had 82 days, Bowling Green 75 days, Paducah 74 days, Lexington 44 days, Cincinnati 34 days, and Jackson 22 days above 90° F this summer. This was the second warmest year for Kentucky on record,

Table 1. 2002 NC-140 apple rootstock trial, UKREC, Princeton, Kentucky.

Rootstock[1]	Percent Survival (no. trees planted)	2005-2010 Cumulative Yield (lb/tree)	Yield (lb/tree)	Fruit Weight (oz)	Trunk Cross-Sectional Area (sq in)	Cumulative Yield Efficiency (lb/sq in)
P.14	43 (7)	1023	308	5.5	22.0	32.6
M.9 Burgmer 756	14 (7)	816	227	5.9	15.6	38.2
M.9 NAKB T337	43 (7)	636	157	5.9	12.9	34.9
M.26 NAKB	57 (7)	576	157	4.9	11.9	34.5
M.9 Nic29	57 (7)	440	92	6.1	8.0	51.5
Supporter 4	43 (7)	389	57	6.0	7.6	50.2
M.26 EMLA	29 (7)	297	43	5.3	8.4	34.9
B.9 Treco	86 (7)	194	17	5.2	3.8	51.2
B.9 Europe	71 (7)	106	5	3.7	2.2	46.7
Mean	49	429	97	5.5	9.0	48.5
LSD (5%)	NS	279	121	NS	5.0	NS

1 Arranged in descending order of cumulative yield.

Table 2. 2003 NC-140 apple rootstock trial, UKREC, Princeton, Kentucky.

Rootstock[1]	Percent Survival (no. trees planted)	2005-2010 Cumulative Yield[2] (lb/tree)	Yield (lb/tree)	Fruit Weight (oz)	Trunk Cross-Sectional Area (sq in)	Cumulative Yield Efficiency (lb/sq in)
PiAu56-83	100 (8)	691	213	7.6	34.1	20.3
PiAu51-4	100 (7)	653	226	7.2	29.1	22.6
M.9 Pajam2	88 (8)	550	181	7.5	15.5	35.8
J-TE-H	100 (8)	543	187	7.2	13.2	41.2
Bud.62-396	100 (8)	495	137	7.4	11.2	44.3
CG.3041	88 (8)	464	158	7.4	10.7	43.4
G.16	50 (8)	453	164	7.4	12.1	37.2
CG.5935	25 (8)	451	107	6.9	9.6	45.8
M.26	75 (8)	436	157	7.2	13.7	32.5
M.9 NAKBT337	88 (8)	418	145	7.5	11.6	36.2
B.9	50 (8)	143	36	6.3	2.9	49.9
Mean	88	506	165	7.3	16.2	36.0
LSD (5%)	33	141	59	NS	4.1	7.9

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.

Table 3. 2009 NC-140 peach rootstock planting, Princeton, Kentucky.

Rootstock[1]	Tree Mortality (% lost)	Trunk Cross-Sectional Area (sq in)	Julian Date of 90% Bloom
Microbac	0	18.5	91.1
Krymsk 86	0	17.8	91.1
Bright's Hybrid	50	17.6	91.2
Viking	12.5	17.5	91.2
Atlas	0	17.1	91.5
Guardian	0	16.7	91.1
Lovell	0	16.0	91.4
KV010-127	0	15.8	91.3
P. american	0	15.1	91.5
KV010-123	12.5	14.9	91.3
HBOK 32	12.5	14.7	91.4
Controller	0	14.2	91.4
HBOK 10	0	13.8	91.9
Krymsk 1	0	12.2	92.0
Mean	7.1	15.8	91.4
LSD (5%)	22.2	2.3	0.6

1 Arranged in descending order of trunk cross-sectional area for each rootstock.

only surpassed by 1936. Fruit size was generally good, but fruit color was only fair due to high temperatures throughout the growing season.

1. 2002 Apple Rootstock Trial

Sixty-three trees of 'Buckeye Gala' were planted in 2002. A number of trees have been lost to fire blight and wind breakage, but significant differences in tree mortality have not been observed to date (Table 1). There were no significant differences in the number of root suckers and in cumulative yield efficiency. Significant differences were observed for cumulative yield, yield, fruit size, and trunk cross-sectional area (Table 1). The cumulative yield was greatest for scions on P.14 and M.9 Burgmer 756. The P.14 and the two B.9 rootstock strains have produced the largest and smallest trees, respectively.

2. 2003 Apple Rootstock Trial

Mortality, cumulative yield, yield, trunk cross-sectional area, and cumulative yield efficiency varied significantly among the rootstocks in the 2003 apple rootstock trial (Table 1). Trees on B.9, G.16 and CG.5935 rootstocks have the highest mortality (50 to 75%) in this trial. The highest cumulative yield and highest yield for 2010 were observed for scions on Pi Au 56-83, which also had the largest fruit size and trunk cross-sectional area. Biennial bearing in this trial was evident in that yield in 2010 averaged about three times that obtained in 2009.

Table 4. 2010 Results of the 2010 NC-140 apple rootstock trial, Princeton, Kentucky.

Rootstock[1]	Number of Trees Planted	Tree Mortality (% lost)	Initial TCSA (in^2)	Fall TCSA (in^2)	TCSA Growth (in^2)	Number of Branches at Planting
PiAu 9-90	7	43	0.46	1.15	0.69	10.8
G.202 N	8	0	0.40	0.90	0.50	10.3
B.70-20-20	12	0	0.30	0.88	0.58	4.0
PiAu 51-11	12	0	0.38	0.86	0.48	6.6
G.5202	8	0	0.39	0.80	0.41	6.0
G.3001	3	0	0.21	0.79	0.58	6.0
G.935 N	11	9	0.40	0.78	0.38	11.0
M.9 Pajam2	12	10	0.28	0.75	0.47	4.1
M.26 EMLA	12	0	0.29	0.74	0.44	6.8
G.4814	8	50	0.34	0.73	0.39	10.0
B.7-3-150	12	0	0.33	0.72	0.40	3.8
B.70-6-8	12	0	0.31	0.71	0.39	7.2
B.67-5-32	12	0	0.24	0.67	0.43	1.5
G.202 TC	12	0	0.35	0.66	0.31	7.6
G.11	9	11	0.24	0.65	0.41	5.0
M.9 NAKBT337	10	0	0.24	0.62	0.38	3.5
B.10	12	0	0.31	0.61	0.31	4.4
Supp.3	5	0	0.24	0.59	0.35	3.2
B.64-194	8	0	0.26	0.56	0.30	3.3
G.935 TC	5	20	0.36	0.55	0.19	9.3
G.4004	4	0	0.27	0.52	0.26	9.5
G.41 TC	1	0	0.21	0.51	0.30	2.0
G.5087	2	0	0.27	0.49	0.22	3.0
B.9	12	0	0.25	0.46	0.21	2.1
G.4214	5	20	0.25	0.46	0.20	4.5
G.4003	7	0	0.26	0.45	0.20	5.4
G.4013	4	50	0.16	0.41	0.25	2.0
G.41 N	6	50	0.30	0.38	0.08	3.3
G.2034	3	33	0.21	0.34	0.13	1.0
B.7-20-21	12	0	0.16	0.26	0.10	0.9
B.71-7-22	10	0	0.11	0.22	0.10	0.0
Means	NA	7	0.29	0.64	0.35	5.0
LSD (0.05)	NA	30	0.07	0.23	0.20	4.8

[1] Arranged in descending order of the fall trunk cross-sectional area for each rootstock.

3. 2009 Peach Rootstock Trial

Mortality and trunk cross-sectional area varied significantly among the fourteen rootstocks in the rootstock trial (Table 3). Only 50% of the trees with Bright's Hybrid rootstock have survived. Redhaven on Microbac rootstock are the largest trees in this trial. Some root suckers were reported in the 2009 data, but none have been observed in 2010. Ninety percent bloom occurred on 1 April for all trees except those on Krymsk 1 rootstock, which occurred a day later.

4. 2010 Apple Rootstock Trial

Mortality and trunk cross-sectional area varied significantly among the thirty-one rootstocks in this trial (Table 4). Only 50% of the trees with G.4013, G.41N, and G.4814 rootstocks have survived. Trees with PiAu 9-90, G.202N, and B70-20-20 rootstocks are the largest trees, and trees on B.7-20-21 and B.71.7-22 are the smallest. Trees with PiAu 9-90 and B70-20-20 rootstocks have made the most growth. After planting and initial pruning, trees with B.70-20-20, G.202N, G.4814, G.935N, and PiAu 9-90 rootstocks averaged ten or more branches.

Literature Cited

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National Plum Pox Virus (PPV) Survey in Kentucky, 2010

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Background

Plum Pox Virus (PPV) is one of the most devastating diseases of stone fruits worldwide. Peach, nectarine, plum, apricot and related ornamental plants can become infected with this disease. A wide range of symptoms are apparent with PPV infection, including ring spots, blotching and malformation of the leaves and fruit. Aphids are the primary tree-to-tree vector of this pathogen, while transport of nursery stock likely contributes to long distance spread.

Although common in Europe since the early 1900s, this disease has only been confirmed in the United States three times. It was first detected in a Pennsylvania orchard in 1999. In 2006, it was found in a commercial orchard in New York and in a single tree in Michigan. Eradication programs were implemented in all of these locations to stop the spread of the virus and its aphid vector. However, because of the most recent finds, funding of a national survey in 2010 was a high priority for the USDA-APHIS.

Nature of the Work

Implementation of this survey for Kentucky was a collaborative effort between the Department of Plant Pathology and the Office of the State Entomologist (Department of Entomology) at the University of Kentucky. Procedures for collecting and testing followed protocols established by the USDA-APHIS-PPQ. Samples were collected in June from seven orchards from across the state. Orchards sampled were located in Bourbon, Caldwell, Daviess, Scott, Trimble, Warren and Woodford counties. Nonsymptomatic peach leaves were collected from 25 percent of the trees at each orchard in the survey. These samples were bagged and delivered to the Plant Disease Diagnostic Lab (PDDL) in Lexington for testing. An immunological assay (ELISA) was used to detect the presence of the virus.

Results

A total of 804 foliar samples were collected and submitted to the PDDL. Each of these samples was tested via ELISA for the presence of PPV. All of the samples collected within the state were negative for PPV.

Literature Cited

"Plum Pox." USDA-APHIS-PPQ Fact Sheet. March 2009. <http://www.aphis.usda.gov/publications/ plant_health/content/printable_version/fs_rev_plumpox_2009.pdf.>

Organic Apple Production Update

Delia Scott, Mark Williams, Doug Archbold, John Strang; Department of Horticulture, Ric Bessin; Department of Entomology

Introduction

The vast majority of organic apples produced in the U.S. are grown in western states, which enjoy relatively lower insect and weed pressure compared to eastern states. Climatic conditions are also much less favorable for plant disease pathogens; thus, organic apple production requires fewer inputs than apples grown in eastern states. Currently, apple production in Kentucky is only a small part of the U.S. total at 4.5 billion tons, although it is still the most important tree fruit crop grown in the state. It annually accounts for an $8 million gross return to Kentucky fruit growers. The UK Horticulture Research Farm Organic Apple Orchard was established in 2007 to identify the limiting factors to organic apple production in Kentucky and test possible solutions.

Materials and Methods

In March 2007, 200 trees were planted using the vertical axis system, in which trees are trained to a 'Christmas-tree' shape with strong, near-horizontal lower scaffold branches and weak, fruitful upper branches. This system helps promote good light penetration and air circulation while reducing the amount of pruning needed as well as improving spray penetration. The trees are staked with 10-ft tall metal T-posts, 6 inches from the trunk, and are planted 6 ft apart. The rows are 270 ft long and spaced 18 ft apart.

The varieties planted were chosen because they are resistant to major apple diseases such as apple scab, powdery mildew, and fire blight. Three varieties, including Redfree, Crimson Crisp, and Enterprise, are represented in the main experimental area with twelve replicated blocks, each with three tree sub-blocks. Guard row varieties include Sir Prize, William's Pride, Splendour, Freedom, Liberty, Goldrush, Akane, Wolf River, Sundance, Pristine, Priscilla, Rezista Releika, Rezista Rajka, Rezista Resi, and Rezista Goldstar. All cultivars are grafted onto rootstocks chosen for controlling mature tree size and enhancing insect and disease resistance. The three experimental varieties are grafted onto B.9 dwarf rootstock (20-30% standard size), while guard row varieties are on M.9 (30-40% standard size) or G.11 (30-40% standard size) dwarf rootstocks.

Cultivation is done using the WeedBadger®, a side-mounted rotary cultivator that spins angled tines at a predetermined depth of 2 to 4 inches and cultivates across a 30-inch swath. A permanent groundcover between rows consists of creeping red fescue, subterranean clover, and a low-growing wildflower mix.

Discussion

Organic apple growers in Kentucky face numerous insect and disease problems; thus, adhering to a strict spray schedule is important. The most serious insect pests seen in the organic orchard include codling moth and plum curculio; diseases include fire blight, cedar apple rust, sooty blotch, and flyspeck. The spray schedule for the organic apple orchard begins when trees are still dormant and before growth begins in spring and continues until apples are at first and second cover. Subsequent sprays may be applied later in the season to help protect developing fruit.

Physical exclusion methods of insects and diseases are also being tested and include the use of two types of bags, Japanese apple bags and deli-style bags. Bags are placed over the developing fruits when they are 5/8 inch in diameter and left on until 3 weeks before harvest, when they are removed to allow coloration of the fruits. Data are currently being collected on the bagging experiment, which will be repeated in subsequent years.

A thinning experiment using a mixture of liquid lime-sulfur and fish oil is also being conducted in the organic orchard. Conventional apple growers typically use chemical thinners to remove unwanted fruits. Organic apple growers often hand-thin unwanted fruits, which is very labor intensive. The orchard was divided into 3 blocks in spring, with one block receiving one thinning spray, a second block receiving two thinning sprays, and the third block receiving no sprays. Data are being collected on the thinning experiment, which is to be repeated in subsequent years. Harvesting in the organic orchard began in 2009, with preliminary data collected on insect and disease incidence and severity. Grading was also done in accordance with USDA standards.

This ongoing project is attempting to solve many of the known challenges faced by organic apple growers and is identifying new or lesser known problems. Collaborative efforts are being made from across the College and include faculty and staff from the Departments of Horticulture, Entomology, and Plant Pathology.

Wine and Table Grape Cultivar Evaluation Trial in Kentucky

Patsy Wilson, Jeff Wheeler, and Sean Lynch, Department of Horticulture

Introduction

The climate in Kentucky is well suited to produce a variety of wine and table grape cultivars. However, cold winters and fluctuating spring temperatures as well as long, warm, humid summers pose challenges to growing grapes in KY. Successful production is determined by the use of proper cultural practices and matching variety and rootstock to a specific site. The primary types of grapes grown in Kentucky are *Vitis vinifera* (European), interspecific hybrids, and *Vitis aestavalis* (Norton). Although interspecific hybrids and Norton are less sensitive to the continental climate in Kentucky, European varieties often produce more desirable wines and potentially have the highest economic gain for grape growers and winemakers. However, European varieties are more susceptible to winter injury and diseases, often resulting in a low yields and increased labor inputs. A cultivar trial consisting of interspecific hybrid, European, and table grape varieties was conducted to assess and improve fruit and wine quality rootstock and clone selection. The following research update is intended to provide the 2010 season production and cultivar performance results.

Table 1. Yield components for the 2010 American/hybrid winegrape cultivar trial, UK Horticulture Research Farm.

Cultivar/ Rootstock	Harvest Date	Yield per Acre[1] (tons)	Yield per Foot[2] (lb)	Shoots Per Foot of Cordon[3]	% Culled Clusters[4]	Cluster Weight (g)
White						
NY76.084	Aug. 11	5.6	2.4	8.5	11	96
Cayuga	Aug. 14	8.3	3.8	6.9	1	190
Seyval blanc	Aug. 14	4.3	2	7.9	1	219
Vignoles	Aug. 27	4.1	1.9	7.3	3	85
Chardonel/C-3309	Sept. 1	6.1	2.7	6.3	5	223
Chardonel/OR	Sept. 1	5.4	2.4	6.1	4	187
Vidal/5C	Sept. 8	6.7	3.1	7.1	0	189
Vidal/OR	Sept. 8	6.6	3	6.3	0	199
Villard	Sept. 9	8.3	3.8	6.6	0	179
Traminette	Sept. 10	5.8	2.5	7.7	11	140
Traminette/5C	Sept. 10	6.3	2.7	7.3	12	148
Red						
Foch	Aug. 23	5.3	2.3	7.6	3	76
Corot Noir	Aug. 26	8.4	3.8	7.1	2	142
Frontenac	Aug. 31	5.2	2.2	7.6	3	114
GR7	Sept. 1	6.1	2.6	9.5	2	90
Chancellor	Sept. 3	5.8	2.6	9.2	3	158
Noiret	Sept. 4	4.8	2.2	6.9	3	142
Chamb/101-14	Sept. 9	6.7	3.1	7.4	0	221
Norton	Sept. 11	5.2	2.4	7.9	0	64
St. Vincent	Sept. 18	7.9	3.6	7.9	0	185

1 Yield/A calculated using 8ft x 10ft vine/row spacing, with 545 vines/A.
2 Total yield divided by the total length of cordon = yield per linear ft of cordon.
3 Total number of shoots divided by the total length of cordon = shoots per linear ft of cordon.
4 Percentage of harvested clusters having ≥ 30% damage caused by cluster rot.

Table 2. Yield components for the 2010 table grape cultivar trial, UK Horticulture Research Farm.

Cultivar/ Rootstock	Harvest Date	Yield per Acre[1] (tons)	Yield per Foot[2] (lb)	Shoots Per Foot of Cordon[3]	% Culled Clusters[4]	Cluster Weight (g)
Einset	Aug. 1	2.4	1.0	6.0	32	89
Reliance	Aug. 1	6.4	2.3	5.1	36	204
Jupiter	Aug. 3	7.0	3.1	5.5	15	189
Marquis	Aug. 11	11.4	5.2	6.4	0	215
Neptune	Sept. 8	8.8	3.9	5.6	3	340

1 Yield/A calculated using 8ft x 10ft vine/row spacing, with 545 vines/A.
2 Total yield divided by the total length of cordon = yield per linear ft of cordon.
3 Total number of shoots divided by the total length of cordon = shoots per linear ft of cordon.
4 Percentage of harvested clusters having ≥ 30% damage caused by cluster rot.

Materials and Methods

Two research vineyards were planted in the spring of 2006 at the UK Horticulture Research Farm in Lexington, KY. Twelve varieties within these vineyards were planted in 2008 as part of the NE-1020 Multi-State Evaluation of Winegrape Cultivars and Clones. Hybrid cultivars planted in 2008 are Chambourcin 101-14, Vidal blanc 101-14, Frontenac Gris, Frontenac, Marquette, Corot Noir, NY76.0844, and Vignoles. European varieties planted in 2008 are Cabernet Sauvignon #8, Malbec, Petite Verdot, Rkatsitelli, Touriga, Tinto Cao, and Pinot Noir.

Vineyard one consists of five table grape and 20 American/hybrid cultivars. Each cultivar in vineyard one has four replications with three vines per replication (12 vines total) in a randomized complete block design. All cultivars were planted at 545 vines/A (8 ft between vines and 10 ft between rows) and trained to a 6-ft single high wire bilateral cordon. Vines were own-rooted with the exception of Chambourcin, Chardonel, Vidal Blanc and Traminette. Chambourcin and Chardonel were planted on the 101-14 and 3309 rootstocks, respectively, while Vidal Blanc and Traminette were planted on the 5C rootstock.

Vineyard two consists of 15 European varieties and 21 different clones (Table 3). Each cultivar and clone of cultivar has four replications with four vines per replication (16 vines total) in a randomized complete block design. All vines were planted on the rootstock 101-14, spaced at 622 vines/A (7 ft between vines and 10 ft between rows) and trained to vertically shoot positioned (VSP) bilateral cordons.

Standard commercial cultural management practices were implemented in both vineyards. In March of 2010 vines were spur pruned and de-hilled. Tractor-mounted tillage (Weed Badger) was used to smooth soil under vines and control winter annual weeds in May. Summer annual weeds were controlled with a single-banded application of post-emergent herbicide (glyphosate) in July and followed by single spot spray where necessary. Vines less than three years of age were irrigated during July, August, and September. Split applications of nitrogen fertilizer totaling 50 lb/A were applied as ammonium nitrate in late May and again in June on vines less than three years of age. Disease and pest control were in accordance with the *Midwest Commercial Small Fruit and Grape Spray Guide* (ID-94).

Polyethylene bird netting was applied in mid-July and removed in late October. Crop and vine balance were achieved by shoot thinning to 4-6 shoots per ft of cordon (European) and 5-7 shoots per ft of cordon (hybrid) in mid-May and cluster-thinned to appropriate crop loads post fruit set (berries bb size). Vines on the VSP trellising system were manually hedged in late July before the onset of veraison. Fruit maturity and harvest dates were determined by taking 100 berry samples starting at veraison to monitor the progression of total soluble solids (TSS) (Atago Digital Refractometer), pH (Hannah 222 pH meter), and titratable acidity (TA) (end point titration of pH 8.2 using .100 N sodium hydroxide) until harvest. Each vine was harvested separately to determine the number of clusters and yield/vine. A final 100-berry sample was taken at harvest to determine fruit chemistry (TSS, pH, and TA) and berry weight.

Results and Discussion

Decreased winter temperature fluctuations reduced risks of cold injury with little to no trunk or bud injury observed during the months leading up to the 2010 season. Very low incidences of fungal infections were observed due to the lower-than-average rainfall. All hybrid varieties showed < 15% incidence of bunch rot (Table 1) and of the European varieties, only Riesling (clone 9, 12, 17) had significant incidence of bunch rot (Table 3). All table grape varieties with the exception of Marquis and Neptune had >15% bunch rot that is most likely due to earlier season grape berry moth damage (Table 2).

Yield, shoots per ft of cordon and cluster weight for all hybrid (Table 1), European (Table 3) and table grape (Table 2) varieties were within commercially acceptable ranges with the exception of the vines that were planted in 2008. These vines will carry a full crop in the 2011 season and harvest data will better represent commercial production in 2011.

Below-average rainfall and above-average temperatures in 2010 allowed all grape varieties to ripen fully and reach desired fruit chemistry and varietal flavor profile. TSS, juice pH and TA for hybrid (Table 4), European (Table 6) and table grape (Table 5) varieties were all within commercially acceptable ranges.

Table 3. Yield components for the 2010 Vinifera winegrape cultivar trial, UK Horticulture Research Farm.

Cultivar / Clone	Harvest Date	Yield per Acre[1] (tons)	Yield per Foot[2] (lb)	Shoots Per Foot of Cordon[3]	% Culled Clusters[4]	Cluster Weight (g)
White						
Pinot Grigio #146	Aug. 24	4.2	1.9	6.6	4	77
Pinot Grigio #152	Aug. 24	3.3	1.5	6.6	1	74
Pinot Grigio #4	Aug. 24	3.6	1.6	6.5	2	76
Chardonnay #15	Aug. 25	2.9	1.3	5.1	0	74
Chardonnay #37	Aug. 25	3.9	1.8	5.8	0	90
Chardonnay #4	Aug. 25	5.8	2.6	5.2	0	160
Chardonnay #43	Aug. 25	4.1	1.9	5.7	1	97
Chardonnay #76	Aug. 25	4.1	1.9	5.7	0	101
Viognier	Aug. 26	3.9	1.8	5.4	0	152
Rkatsiteli	Sept. 4	1.5	0.7	5.3	0	159
Riesling #12	Sept. 10	4.6	1.6	5.2	29	121
Riesling #17	Sept. 10	3.8	1.4	5.6	29	99
Riesling #9	Sept. 10	3.8	1.2	5.3	41	97
Red						
Limberger	Aug. 26	5.5	2.5	5.4	2	151
Petite Verdot #2	Sept. 4	2.2	1.0	5.6	1	88
Tinto Cao	Sept. 4	3.1	1.4	4.8	0	134
Touriga	Sept. 4	2.7	1.1	4.6	2	95
Sangiovese #12	Sept. 11	6.0	2.7	5.2	5	252
Cabernet Franc #1	Sept. 17	3.7	1.7	5.8	0	112
Cabernet Franc #214	Sept. 17	3.1	1.4	5.3	9	95
Cabernet Franc #312	Sept. 17	4.1	1.8	5.7	3	135
Cabernet Franc #4	Sept. 17	4.0	1.8	5.8	2	109
Cabernet Franc #5	Sept. 17	4.7	2.2	6.1	2	120
Cabernet Sauvignon #337	Oct. 17	3.5	1.6	6.3	0	75
Cabernet Sauvignon #8	Oct. 17	1.9	0.9	5.4	0	89

1 Yield/A calculated using 7ft x 10ft vine/row spacing, with 622 vines/A.
2 Total yield divided by the total length of cordon = yield per linear ft of cordon.
3 Total number of shoots divided by the total length of cordon = shoots per linear ft of cordon.
4 Percentage of harvested clusters having ≥ 30% damage caused by cluster rot.

Table 4. Fruit composition for the 2009 American/hybrid winegrape cultivar trial, UK Horticulture Research Farm.[1]

Cultivar/ Rootstock	Berry Wt. (g)	TSS[2] (%)	Juice pH	TA[3] (g/L)
White				
NY76.084	198	17.5	3.21	8.5
Cayuga	304	20.2	3.27	7.1
Seyval blanc	194	23.7	3.39	7.1
Vignoles	169	24.3	3.48	8.4
Chardonel/C-3309	269	23.1	3.44	6.8
Chardonel/OR	274	23.3	3.46	6.6
Vidal/5C	210	22.8	3.60	5.6
Vidal/OR	213	22.7	3.51	6.2
Villard	301	22.0	3.36	7.8
Traminette	174	21.5	3.30	5.5
Traminette/5C	178	21.3	3.43	5.5
Red				
Foch	134	23.1	3.71	5.8
Corot Noir	240	19.0	3.57	5.8
Frontenac	112	24.6	3.67	10.3
GR7	170	23.3	3.67	6.4
Chancellor	205	21.9	3.56	6.0
Noiret	211	19.4	3.50	5.2
Chamb/101-14	256	23.7	3.43	6.8
Norton	112	24.3	3.49	7.5
St. Vincent	328	21.3	3.38	7.2

1 Fruit samples were collected and analyzed on harvest dates listed in Table 1.
2 TSS = total soluble solids measured as °Brix in juice.
3 TA = Titratable acidity measured as grams of tartaric acid per liter of juice.

Results of the 2010 growing season represent a better-than-average year for the production of grapes in Kentucky. The vineyards at the UK Horticulture Research Farm are planted in an excellent site where most varieties can reach full production potential. All sites in Kentucky will not be able to sustain an economically viable crop of all varieties. It is imperative to evaluate each grape growing site and match variety and rootstock to that specific site.

Table 5. Fruit composition for the 2010 table grape cultivar trial, UK Horticulture Research Farm.[1]

Cultivar/ Rootstock	Berry Wt. (g)	TSS[2] (%)	Juice pH	TA[3] (g/L)
Einset	270	20.6	3.38	5.7
Reliance	258	20.7	3.34	5.5
Jupiter	435	20.3	3.53	5.7
Marquis	591	19.2	3.53	4.1
Neptune	583	21.8	3.39	5.3

1 Fruit samples were collected and analyzed on harvest dates listed in Table 1.
2 TSS = total soluble solids measured as °Brix in juice.
3 T.A. = Titratable acidity measured as grams of tartaric acid per liter of juice.

Table 6. Fruit composition for the 2010 vinifera winegrape cultivar trial, UK Horticulture Research Farm.[1]

Cultivar/Clone #	Berry Wt. (g)	TSS[2] (%)	Juice pH	TA[3] (g/L)
White				
Pinot Grigio #146	152	18.9	3.79	4.0
Pinot Grigio #152	147	18.0	3.69	3.8
Pinot Grigio #4	152	21.6	3.66	3.6
Chardonnay #15	163	20.2	3.54	6.5
Chardonnay #37	164	20.5	3.56	6.5
Chardonnay #4	184	20.9	3.54	6.5
Chardonnay #43	172	21.3	3.55	5.8
Chardonnay #76	168	20.3	3.60	5.8
Viognier	178	21.4	3.70	4.3
Rkatsiteli	206	20.3	3.36	5.8
Riesling #12	171	19.9	3.37	5.8
Riesling #17	180	19.7	3.39	6.2
Riesling #9	184	19.2	3.37	5.9
Red				
Limberger	207	21.6	3.53	5.6
Petite Verdot #2	115	24.8	3.55	4.9
Tinto Cao	160	22.5	3.58	4.3
Touriga	156	22.3	3.54	4.5
Sangiovese #12	295	22.1	3.48	4.7
Cabernet Franc #1	184	20.1	3.64	4.3
Cabernet Franc #214	155	23.9	3.67	4.4
Cabernet Franc #312	184	22.7	3.62	5.2
Cabernet Franc #4	173	24.2	3.57	4.4
Cabernet Franc #5	190	23.5	3.68	4.4
Pinot Noir #13	124	23.0	3.66	4.0
Cabernet Sauvignon #337	143	23.6	3.63	4.5
Cabernet Sauvignon #8	138	24.3	3.58	3.8

1 Fruit samples were collected and analyzed on harvest dates listed in Table 3.
2 TSS = total soluble solids measured as °Brix in juice.
3 T.A. = Titratable acidity measured as grams of tartaric acid per liter of juice.

Blackberry Cultivar Trial at Princeton, KY

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Introduction

The demand for fresh blackberries at farmers markets is strong and 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 UKREC, Princeton, KY, to evaluate five blackberry cultivars.

Materials and Methods

Twenty plants each of five cultivars, Anastasia, Chesapeake, Chickasaw, Kiowa, and OAL-W6, were planted in the spring of 2006. Plants were spaced 2 ft apart within ten-ft-long plots in rows spaced 20 ft between rows. Only one cultivar was allocated to each plot and each row contained five plots. Cultivars were planted in a randomized block design with each row being one block. Trickle irrigation was installed, and plants were

Table 1. 2008 through 2010 phenology of blackberry cultivars at UKREC, Princeton, Kentucky.

	1/4" leaf			Pre-bloom			Bloom			Petal Fall		
Cultivar	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
Anastasia	April 7	April 6	March 29	May 1	April 24	April 16	May 8	April 27	April 22	May 28	May 5	April 29
Chesapeake	April 9	April 8	March 28	May 7	April 27	April 28	May 12	May 1	April 30	June 5	May 15	May 9
Chickasaw	April 1	March 31	March 26	May 1	April 24	April 16	May 8	April 27	April 22	June 1	May 8	May 2
Kiowa	April 9	April 8	March 25	May 1	April 24	April 22	May 8	April 27	April 28	June 5	May 8	May 6
OAL-W6	April 9	April 8	March 29	May 16	May 10	April 28	May 21	May 15	May 2	June 10	June 2	May 24

Table 2. 2008 through 2010 harvest results from the blackberry cultivar trial at UKREC, Princeton, Kentucky.

Cultivar	Peak Harvest			Yield (lb/Acre)[1]			Berry Size (oz/berry)			Taste Rating[2]		
	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
Anastasia	June 23	June 24	June 7	1,419	374	2,081	0.32	0.24	0.26	1.00	1.88	2.50
Chesapeake	July 8	July4	June 29	4,360	4,949	7,253	0.43	0.30	0.37	4.63	3.87	4.00
Chickasaw	July 8	July 13	June 29	9,528	10,952	9,295	0.37	0.27	0.31	4.63	3.71	3.50
Kiowa	July 13	July 13	June 25	7,723	11,356	6,798	0.50	0.34	0.37	4.75	4.17	4.50
OAL-W6	July 10	July 8	July 1	8,844	9,269	4,901	0.33	0.23	0.26	4.63	3.83	5.00
Mean	NA	NA	June 24	6,375	7,382	6,065	0.37	0.27	0.31	3.93	3.49	3.83
LSD (0.05)[3]	NA	NA	3 days	2,450	4,438	1,216	0.03	0.02	0.03	0.69	2.18	1.38

1 Based on a spacing of 20 ft between rows.
2 Based on a scale from 1 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.

maintained according to local recommendations (1, 2). Fruit was harvested twice weekly from mid-June through 1 August in 2008 and 2009. The harvest season end in mid-July in 2010 due to a warm spring. One of the cultivars in the trial, Anastasia, is a tayberry, a cross between blackberry and raspberry. It was harvested during the month of June in 2010. Fruit size was calculated as the average weight (oz) of 25 fruits.

In 2010, fruit from Chickasaw and Kiowa from this trial location, fruit from Chester and Triple Crown in Lexington trials, and fruit from Apache from Caludi's Fields in Lexington, KY, were rated for sweetness and flavor in order to determine whether there is any significant difference in taste between the thorny and thornless blackberry cultivars. A panel of thirteen *Lexington Herald-Leader* editors was assembled as taste testers on 12 July.

Results and Discussion

The quarter-inch leaf stage ranged from five days to two weeks earlier in 2010 than in 2009. But except for OAL-W6, this resulted in a one-to-five-day difference in time of bloom from 2009 (Table 1). OAL-W6 was about two weeks earlier in bloom than in 2009. Depending on variety, petal fall occurred from two to nine days earlier in 2010 than it did in 2009.

Yield, fruit size, and taste all differed significantly among cultivars (Table 2). Chickasaw produced significantly more fruit in 2010 than did the other cultivars in this trial. Kiowa and Chesapeake again had the largest berries in 2010, as they did in 2008 and 2009. Berries were generally sweeter in 2010 than last year, but tended to be less juicy. Both characteristics were a consequence of the relatively dry 2010 growing season. OAL-W6 berries were the sweetest tasting in 2010. All cultivars were generally pruned more vigorously this spring than last year. Anastasia was pruned the most and harvested at an earlier stage during ripening than last year. This improved its flavor somewhat, but it still tended to be tarter than the other blackberry cultivars.

There were no statistically significant differences detected in sweetness and flavor among the five cultivars that were rated by the panel of *Lexington Herald-Leader* newspaper taste testers (Table 3). The thorny cultivars, Chickasaw and Kiowa were not statistically different in taste from the thornless cultivars, Apache, Chester, and Triple Crown.

Table 3. Blackberry cultivar taste ratings[1] on July 12, 2010.

Cultivar	Sweetness	Flavor
Apache	3.31	3.54
Chester	2.77	3.46
Chickasaw	2.61	2.85
Kiowa	3.31	3.23
Triple Crown	2.85	3.08
Mean	2.97	3.23
LSD (0.05)[2]	0.84	0.76
Contrast thorny vs. thornless[3]	N.S.	N.S.

1 Rating scale: 1 = poor, 2 = fair, 3 = good, 4 = very good, 5 = excellent. Taste panel consisted of 13 Lexington Herald-Leader employees.
2 Least significant difference at 0.05 probability level.
3 N.S. = Not significant at the 0.05 probability level.

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University of Arkansas Thorny and Thornless Primocane-fruiting Blackberry Trial in Kentucky

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Introduction

Blackberry plants are unusual among fruit crops in that they have perennial root systems but have biennial canes. There are two cane types. Primocanes, or first year canes, are usually only vegetative. In the second season these same canes are called floricanes, and they flower and produce fruit. Floricanes die after fruiting. Primocane-fruiting blackberries can produce two crops per year, with a typical summer crop on the floricanes and a later crop on the current-season primocanes. Primocane-fruiting blackberries flower and fruit from midsummer until frost, depending on temperatures, plant health, and plant location. Growers can reduce pruning costs by mowing canes in late winter to obtain only a primocane crop. This also provides anthracnose, cane blight and red-necked cane borer control without pesticides. Relying only on a primocane crop also avoids potential winter injury of floricanes.

Table 1. Yield and berry weight for seven advanced primocane-fruiting selections from the University of Arkansas Blackberry Breeding Program and the primocane-fruiting cultivar 'Prime-Jan®', Kentucky State University, 2010.

	Yield (lb/A)[1]		Average Fruit Weight (g)		Harvest Dates (start to end)	
Selection	**Floricane**	**Primocane**	**Floricane**	**Primocane**	**Floricane**	**Primocane**
APF-140T	-	19 d	-	1.8 cd	-	9/7 - 10/21
APF-120T	-	30 d	-	1.4 d	-	8/12 - 10/21
APF-136T	-	42 d	-	2.0 bcd	-	8/19 - 10/21
APF-138T	-	126 cd	-	1.8 cd	-	8/19 - 10/21
APF-132	-	129 cd	-	2.6 ab	-	8/9 - 10/21
APF-139T	-	295 bc	-	2.0 bcd	-	8/9 - 10/21
APF-146T	-	432 b	-	2.9 a	-	8/9 - 10/21
'Prime Jan®'	-	950 a	-	2.4 abc	-	8/9 - 10/21

[1] Numbers followed by the same letter are not significantly different (Duncan's multiple range test Least Significant Difference P = 0.05).

The first commercially available primocane-fruiting blackberry varieties, 'Prime-Jim®' and 'Prime-Jan®', were released by the University of Arkansas (UARK) Blackberry Breeding Program in 2004 (Clark et al., 2005; Clark, 2008). 'Prime-Ark®45' was released commercially in 2009. Fruit size and quality of primocane-fruiting blackberries can be affected by the environment. Summer temperatures above 85° F can greatly reduce fruit set, size and quality on primocanes, resulting in substantial yield reductions (Clark et al., 2005; Stanton et al., 2007). The objective of this study was to determine if thorny and thornless advanced selections developed by the UARK blackberry breeding program yielded better and had better fruit quality than 'Prime-Jan®' under Kentucky growing conditions.

Materials and Methods

In June 2009, a blackberry variety trial was established at the Kentucky State University (KSU) Research and Demonstration Farm in Frankfort. The primocane-fruiting cultivar 'Prime-Jan®' (thorny erect) and the Arkansas primocane-fruiting (APF) advance selections APF-146T (thorny) and APF-120T, APF-132, APF-136T, APF-138T, APF-139T, and APF-140T (all thornless) from the UARK blackberry breeding program were included in the trial. Selections APF-120T and APF-132 are dwarf types that do not reach over one meter high. 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-ft plot. Spacing was two ft between each plant, and five ft between groups of five plants, with each row being 70 ft long. Rows were spaced 14 ft apart. This trial was planted on certified organic land and managed with organic practices following the National Organic Program standards. Weeds were controlled with a 6-8 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.

There were few fruit on primocanes in the fall of 2009 or on floricanes in the spring of 2010, so fruit were not harvested from these canes. Primocanes began producing fruit in early August, 2010. Fruit were harvested each Monday and Thursday until a killing frost on October 22.

Results and Discussion

Primocane fruit production began in early August for most selections and continued until frost. However, yields were quite low (Table 1) and likely reflected the poor growing conditions of 2010. 'Prime-Jan®' had the highest yield at 950 lbs/A. This is far lower than yields obtained previously in a similar trial of 'Prime-Jan®' at KSU. Yields of 1,718, 2,003, and 2,517 lbs/A were obtained in 2007, 2008, and 2009, respectively, from 'Prime-Jan®' primocanes in that trial. The average fruit weight of 'Prime-Jan®' was only 2.4 g/fruit in 2010, compared to 3.3, 3.2, and 4.9 g/fruit in 2007, 2008, and 2009, respectively. May and June 2010 had above-average rainfall, but a drought began in August and continued until frost. Even with supplemental irrigation, the drought conditions reduced yields and fruit sizes. Temperatures were also above normal for much of the summer and fall. There were 85 days out of 122 with a daily high above 85° F from June through September. This likely reduced fruit and druplet set, fruit size, and yields. APF-140T in particular had reduced fruit set, with very few fruit harvested despite frequent flowering and vigorous primocane growth. Some selections, mainly 'Prime-Jan®' and APF-146T, had vigorous primocane growth. Selections APF-120T and APF-132 are dwarf selections and faced greater weed competition than the other selections in this trial. Yield and fruit quality characteristics will need to be further evaluated, and none of these advanced selections have yet been released for commercial production.

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The Influence of Primocane Mowing Date on Flowering, Ripening, and Stink Bug Populations on Primocane-fruiting Blackberry Selections in Kentucky

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Introduction

Primocane-fruiting blackberries, such as 'Prime-Jim®' and 'Prime-Jan®', fruit on current-season canes (primocanes) (Clark et al., 2005; Clark, 2008). Primocane-fruiting blackberries can produce more than one "crop" per year, with a typical summer crop on floricanes, which are the previous year's primocanes, and a later crop on the current season's primocanes. Primocane blackberry varieties flower and fruit from late summer until frost. Thus, this multi-cropping blackberry type is very attractive to farmers. Primocane blackberries can be pruned by mowing the canes down in the late winter; this provides anthracnose, cane blight and red-necked cane borer control without pesticides. Mowing during specific times in the growing season could also potentially allow the scheduling of fruit production. Summer temperatures above 85° F can greatly reduce fruit set, size and quality on primocanes. Strategies to delay primocane growth, such as spring mowing of primocanes, could also delay flowering and fruit harvest until fall when cooler temperatures could enhance fruit set and quality.

Stink bugs such as *Euschistus* species and *Acrosternum hilare* (Hemiptera: *Pentatomidae*) have become pests of organic blackberries in Kentucky and the surrounding region (Johnson and Lewis, 2005). Brown, one-spotted, green, and other species of stink bugs cause damage by feeding on blackberry drupelets, discoloring the fruit, and imparting foul odors. Producers have set very low tolerance levels for the presence of insects or damage to meet consumer demand for blemish and insect-free blackberries. Stink bug populations have not been studied in Kentucky, and the number of generations per year has not been quantified; however, fruit damage has been noted often by growers and researchers.

Managing blackberry insect pest infestation is challenging to small and organic farmers. Concerns about pesticide efficacy, timing, impact on beneficial insects and the environment, social factors, and economics determine which pest management system is selected. Strategies to delay primocane growth, such as spring mowing of primocanes, could not only delay flowering and fruit harvest until the cooler temperatures of fall to improve fruit set and quality, but also allow growers to avoid the greatest concentrations of stink bugs and resulting fruit damage. The objectives of this study were to 1) examine the influence of primocane mowing date on flowering and fruiting of the blackberry varieties 'Prime-Jim®' and 'Prime-Jan®' and 2) identify pest stink bug species and frequency of occurrence in organically produced blackberries.

Materials and Methods

In June 2006, plants of the primocane-fruiting blackberry cultivars 'Prime-Jim®' and 'Prime-Jan®' (both thorny erect) were planted at the KSU Research and Demonstration Farm in Frankfort, KY. Plants were arranged in a completely randomized design, with three plots including five plants of each cultivar per treatment combination in a 10-ft plot. Rows were spaced 14 ft apart. This trial was managed with organic growing practices following the National Organic Program standards. Weeds were controlled by hand weeding.

Ten ft plots either of 'Prime-Jim®' or 'Prime-Jan®' were initially mowed to ground level on March 30, 2010 (control). Three replicate plots of each variety were then either mowed once on May 24 (treatment 1) or mowed on May 24 and then again on July 6 (treatment 2). Percent flowering canes and number of ripe fruit per plot were determined weekly. Stink bugs were sampled weekly by hand picking them from blackberry bushes and with 6 in x 6 in yellow sticky traps. Data collection began on May 24 and ended on October 6, 2010.

Results and Discussion

Primocane mowing in May delayed flowering by approximately three weeks in both 'Prime-Jim®' and 'Prime-Jan®' plants (Figs. 1, 2, 3, and 4). When primocanes were mowed in March (control) in either variety, ripe fruit production peaked 9-20

Figure 1.

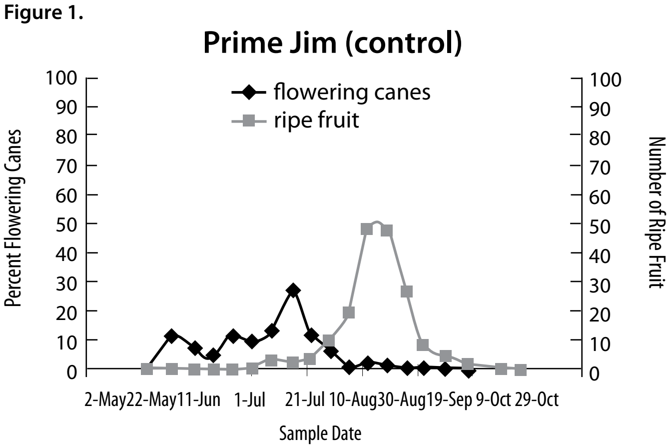
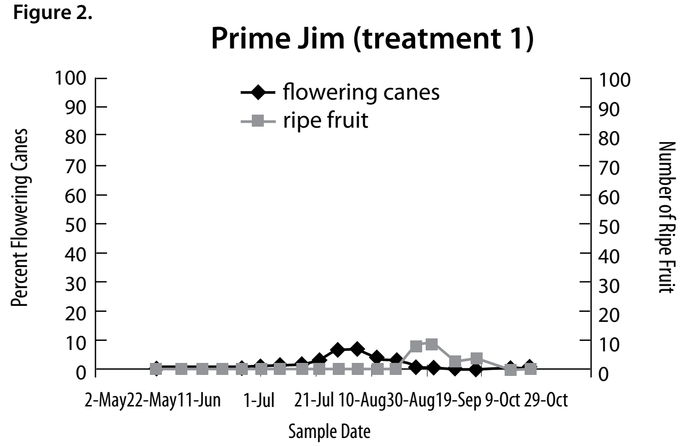


Figure 2.



weeks after mowing. When primocanes were mowed in May (treatment 1) in either variety, ripe fruit production peaked 21-22 weeks after mowing. Average fruit weights for the control and treatment 1 were 1.8 and 0.7 g/fruit, respectively, for 'Prime-Jim®' and 2.7 and 1.6 g/fruit, respectively, for 'Prime-Jan®' plants. Mowing primocanes in July (treatment 2) for either variety delayed growth and primocanes did not flower. Extremely hot summer and fall temperatures, coupled with drought conditions starting in August and extending into the fall, likely negatively affected all treatments, especially plots that were mowed in May and July.

The stink bug species caught during the study were the brown stink bug, *Euschistus servus*; one-spotted stink bug, *E. variolarius*; green stink bug, *Acrosternum hilare*; twice-stabbed, *Cosmopepla lintneriana*; rice, *Oebalus pugnax*; and the red-shouldered stink bug, *Thyanta custator*. The brown stink bug was the most abundant species caught, followed by the green stink bug and rice stink bug with 38%, 17% and 15% of the total number captured, respectively. One-spotted and twice-stabbed stink bugs each accounted for 14% of the total stink bugs caught. The red-shouldered stink bug represented less than 3% of the total caught. Stinkbugs were found throughout the sampling period. Almost all ripe fruit, approximately 70%, harvested from both cultivars, showed some berry drupelet feeding. The average number of damaged drupelets on ripe fruit for control and treatment 1 was 1.7 and 0.9 drupelets/fruit, respectively, for 'Prime-Jim®' and 2.7 and 2.4 drupelets/fruit, respectively, for 'Prime-Jan®' plants. Stink bugs may not have been the only insects feeding on the fruit; Japanese beetles and June beetles were also seen in the plantings. Yellow sticky traps were not satisfactory for sampling stink bugs in blackberries. Earlier treatment mowing dates may be required for optimal fruit production and stink bug management.

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Figure 3.

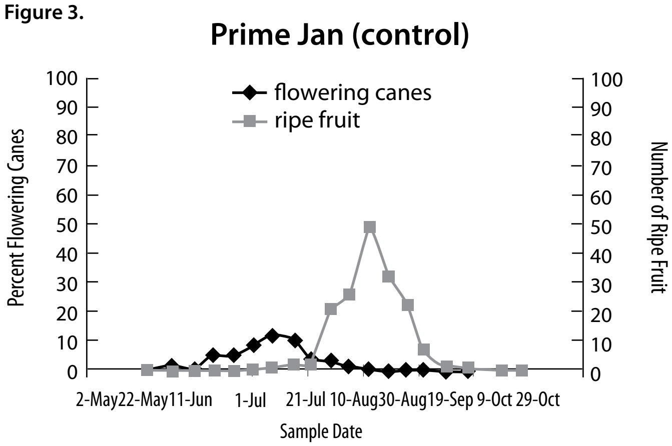
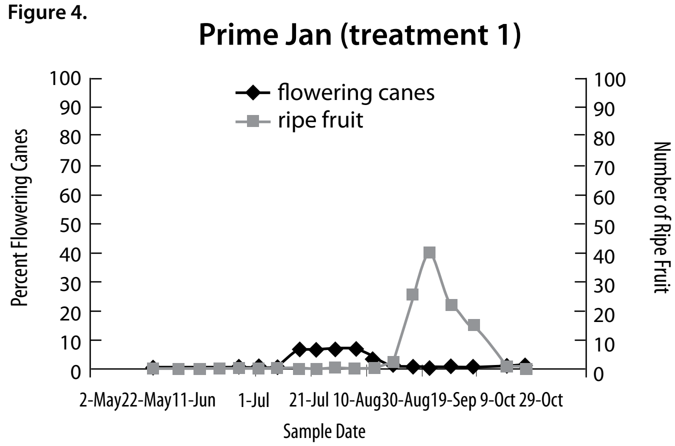


Figure 4.



Kentucky-Grown Berry Crops are Rich Sources of Health-Beneficial Phytochemicals

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Introduction

There is an increasing awareness across the U.S. that locally-grown produce provides optimum quality and greatest freshness. Tied to this is a growing understanding of the health benefits of eating fresh fruits and vegetables. While these health benefits are due in part to the general nutritional value of fresh produce, much of their impact is due to their specific, unique phytochemical content. The dominant phytochemicals in a particular crop may be species-specific, such as anthocyanins in berries, resveratrol in grapes, and lycopene in tomato, though many different types of phytochemicals may occur in any one species. These phytochemicals are usually inclusively termed antioxidants. Diets rich in these antioxidants can have significant positive impacts on human health, including reductions in heart disease and reduced incidence of many types of cancers (Schreiner and Huyskens-Keil, 2006). Berry crops exhibit some of the highest levels of antioxidants of all fruits and vegetables (Halvorsen et al., 2002). So, increased consumption of berries and berry-derived products can provide some of the greatest health benefits.

The primary phytochemicals in berry crops are polyphenolic flavonoids and include proanthocyanidins, anthocyanins, flavones, and flavonols. Anthocyanins are the pigments giving many fruit their red to purple to nearly black (lowest to highest anthocyanin content) color. The phenolic and anthocyanin content of berry crops is determined by both genetics and the production environment. The production environment is comprised of both site traits, like soil type and seasonal climate patterns, as well as specific production techniques.

There is a growing body of studies from around the U.S. and the world comparing phytochemical content of berries of different species and of cultivars within each species. Blackberries, black raspberries, and blueberries commonly show some of the highest phytochemical levels. However, due to both genetic and environmental effects, a rather wide range of values has been reported. As a result this study was undertaken to assess and compare the phytochemical content of a number of cultivars of blackberries, black, red and yellow raspberries, blueberries, strawberries, and table grapes grown in Lexington to see how Kentucky-grown berries compare to those grown elsewhere.

Materials and Methods

Thorny and thornless blackberries, black raspberries, red raspberries, yellow raspberries, blueberries, strawberries, and table grapes were harvested from cultivar trial plots at the UK Horticulture Research Farm in 2009 and 2010. All plots were managed by conventional techniques. In 2009, 'Caroline' red raspberries were also harvested from both the open field and under a Haygrove tunnel on the certified organic section of the research farm. In 2010, strawberries were harvested from the field of a Lexington-area berry grower, and plastic clamshell

Table 1. Bramble (*Rubus* spp.) phytochemical and antioxidant values. Fruit grown at the UK Horticulture Research Farm, Lexington, Kentucky, 2009 and 2010.

2009 Cultivar	Total Phenolics[z]	Total Anthocyanins[y]	FRAP[x]	TEAC[w]
Blackberry				
Triple Crown	346	126	12	41
Hull	462	143	36	55
Chester	452	172	25	55
Black Raspberry				
Mac Black	991	631	13	77
Jewel	527	370	15	71
Red Raspberry				
Heritage	242	67	6	17
Polana	246	60	6	22
Jacklyn	414	70	12	32
Autumn Britten	261	62	6	21
Caroline				
Conventional	283	66	9	25
Organic	240	59	6	21
Tunnel	242	66	9	24
Yellow Raspberry				
Anne	168	0	3	14
LSD[v]	135	52	4	8
2010 Cultivar	**Total Phenolics[z]**	**Total Anthocyanins[y]**	**FRAP[x]**	**TEAC[w]**
Blackberry				
Triple Crown	469	184	38	69
Hull	562	219	46	75
Chester	451	184	38	66
Chesapeake	223	102	30	53
OAL W-6	333	159	30	57
Chickasaw	242	115	28	46
Kiowa	413	207	34	64
Black Raspberry				
Mac Black	1112	637	49	121
Jewel	918	562	47	106
Red Raspberry				
Heritage	277	97	19	34
Caroline	264	72	19	36
Yellow Raspberry				
Anne	154	6	17	25
LSD	116	60	5	11

[z] Total phenolics expressed as mg chlorogenic acid/100 g fresh weight.
[y] Anthocyanins expressed as mg cyanidin 3-glucoside/100 g fresh weight.
[x] FRAP total antioxidant activity expressed as µmol ascorbic acid equivalents/g fresh weight.
[w] TEAC total antioxidant activity expressed as µmol Trolox equivalents/g fresh weight.
[v] Mean separation within years by Fisher's LSD at P = 0.05.

containers representing three commercial producers from California were purchased from local retailers on the same date. Upon harvest, all fruit were placed in reclosable bags, and frozen and stored at -20° C.

Subsamples of berries from each cultivar were extracted once with 80% methanol at a 3:4 weight/volume ratio in a Waring blender. The resulting mixture was first filtered through a Büchner funnel with Whatman No. 1 filter paper, then through a Gelman Laboratory 0.45 µm Acrodisc LC PVDF syringe filter. A portion of the filtered extract was then diluted for use. There were three replicate extractions from each fruit sample. To determine and adjust values for extraction efficiency, selected samples were extracted 4 times, and replicate extracts for each sample were pooled.

To measure total phenolics and anthocyanins, a modified version of the Glories' method was used (Fukumoto and Mazza, 2000). To do this, 0.05 ml of the diluted berry extract was combined with 0.05 ml of 0.1% HCl in 95% ethanol, and then 0.91 ml of 2% HCl was added. The solution was vortexed, held for 10 min, and absorbance was read spectrophotometrically at 280 nm for total phenolics and 520 nm for total anthocyanins. Chlorogenic acid was used for the phenolic standard; results are expressed as mg chlorogenic acid/100 g FW. Anthocyanin was quantified using the molar extinction coefficient of the major anthocyanin for each berry crop.

To measure antioxidant activity of the samples, the ferric ion reducing antioxidant power (FRAP) and Trolox equivalent antioxidant capacity (TEAC) assays were performed. The FRAP assay was performed by adding 0.05 ml of diluted extract to 0.05 ml of 3 mM ferric chloride in 5 mM citric acid (Arnous et al., 2002). This solution was vortexed in a 2 ml Eppendorf tube and incubated for 30 minutes in a 37° C water bath. The mixture was then added to 0.90 ml of 1 mM 2, 4, 6-Tris (2–pyridyl)–1, 3, 5–triazine (TPTZ) solution in 0.05 M HCl. This solution was immediately vortexed and allowed to sit for 10 minutes. Absorption was then read at 620 nm. Reducing power was determined by comparing absorbance to ascorbic acid standards. Results are expressed as µmol ascorbic acid equivalents/g FW. The TEAC assay was performed by mixing 10 µL of diluted extract with 1 mL of 2,2'-azinobis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS*) solution adjusted to ~0.7 absorbance at 734 nm (Huang et al., 2005). The solution was vortexed, incubated for 15 min, and absorbance read at 734 nm. A standard curve using Trolox (a vitamin E derivative) was developed, and results are reported as µmol Trolox equivalents/g FW.

Table 2. Blueberry (*Vaccinium* spp.) phytochemical and antioxidant values. Fruit grown at the UK Horticulture Research Farm, Lexington, KY, 2009 and 2010.

2009 Cultivar	Total Phenolics[z]	Total Anthocyanins[y]	FRAP[x]	TEAC[w]
Highbush				
Bluecrop	308	156	9	25
Chandler	282	144	17	32
Echota	382	191	12	34
Spartan	515	221	16	48
Southern Highbush				
Arlen	462	248	11	36
Lenore	439	259	10	26
Misty	441	211	12	34
Ozarkblue	346	96	10	28
Pamlico	647	376	18	21
Sampson	516	240	8	31
Star	376	177	10	29
Rabbiteye				
Climax	519	247	14	26
Columbus	489	190	14	35
Ira	526	222	16	41
Onslow	560	214	11	40
Powderblue	584	200	15	31
Tifblue	462	164	9	38
LSD[v]	109	59	4	4
2010 Cultivar	**Total Phenolics[z]**	**Total Anthocyanins[y]**	**FRAP[x]**	**TEAC[w]**
Highbush				
Chandler	275	139	9	42
Southern Highbush				
Lenore	448	212	14	55
Ozarkblue	468	202	20	60
Pamlico	943	536	31	76
Sampson	1332	715	36	75
NC1827	2315	1078	72	316
Rabbiteye				
Columbus	789	324	19	60
LSD	206	112	17	23

z Total phenolics expressed as mg chlorogenic acid/100 g fresh weight.
y Anthocyanins expressed as mg malvidin 3-glucoside/100 g fresh weight.
x FRAP total antioxidant activity expressed as µmol ascorbic acid equivalents/g fresh weight.
w TEAC total antioxidant activity expressed as µmol Trolox equivalents/g fresh weight.
v Mean separation within years by Fisher's LSD at P = 0.05.

Results and Discussion

Of the bramble crops, black raspberries had the highest phenolic and anthocyanin content each year (Table 1). These were followed by blackberries, red raspberries, and yellow raspberry. Cultivars within each group varied, and there were clear differences between years as well. The 2 antioxidant assays yielded somewhat different results if ranking from high to low each year, which is not uncommon due to the unique chemistries of each, but both black raspberries and blackberries generally had the highest activities in both assays. In 2009, 'Caroline' red raspberry showed similar values for phytochemical traits whether from conventional, organic, or tunnel production.

All blueberries had high phenolic and anthocyanin content (Table 2). The values were generally equal to or higher than those for black raspberries and blackberries. Antioxidant activities also varied among cultivars. In 2009, 'NC1827' stood out with very high phenolic and anthocyanin content and the highest antioxidant activity. The 'NC1827' berries are very small. The skin of a blueberry is the primary source of phytochemicals in each berry, and it contributes a greater proportion of the weight on a per g basis in a small versus a large berry. Thus, more of each g comes from the phytochemical-rich skin, accounting for the high values with 'NC1827'.

Strawberry cultivars showed a range in phenolic and anthocyanin content in 2009 (Table 3). The anthocyanin content was similar to that for red raspberries. Total antioxidant activity also varied among cultivars with values lower than for most brambles and blueberries. In 2010, locally-grown 'Camerosa' and 'Sweet Charlie' strawberries had greater phytochemical content than two of the strawberries purchased at local retailers. This may be due to the fact that shipped fruit are harvested before they are fully ripe or red, unlike locally-grown fruit that are most often picked fully ripe. Cultivar and production environment differences may have played important roles in creating these differences as well. Notably, antioxidant activities did not generally differ among the two groups of fruit.

Both phenolic and anthocyanin content of table grape cultivars varied both years (Table 4). In 2009, Sunbelt had the highest content of both phytochemical groups and the greatest antioxidant activities. There was no detectable anthocyanin from three cultivars in 2009, but it was detectable yet very low in them in 2010. Grapes with higher phenolic and anthocyanin content also exhibited higher antioxidant content. Overall, antioxidant activities were comparable to strawberry and lower than most brambles and blueberries.

In prior work with blackberries, we had found that some cultivars may show some increase in phenolic and/or anthocyanin content during a 7-day cold storage and a subsequent 3 days at room temperature (Table 5) (Fulkerson, 2004). However, total antioxidant activity changed very little. The results confirmed findings from other studies that a short-term cold storage, such as in a home refrigerator, will not significantly affect the nutritional value of the berries. Although nutritional value did not change, quality of the stored blackberries did significantly decline.

This study is but a snapshot of the phytochemical content of some Kentucky-grown berry crops. However, it is clear that berry crops grown in Kentucky rival those grown elsewhere in their content of health-beneficial phytochemicals. While one can see important genetic differences among cultivars within a species in this study, as well as production environment effects, the darker colored fruit (those purple to black) were generally the richest source of phytochemicals and antioxidant activity. Given that the quality of fresher, locally-grown berry crops is considered superior to those shipped and held in cold storage before reaching the consumer, these crops should be a high priority to consumers for both eating quality and nutritional value.

Table 3. Strawberry (*Fragaria X ananassa* Duch.) phytochemical and antioxidant values. Fruit grown at the UK Horticulture Research Farm, Lexington, KY, in 2009, and from either a local grower or purchased from a grocery in 2010.

2009 Cultivar	Total Phenolics[z]	Total Anthocyanins[y]	FRAP[x]	TEAC[w]
Earliglow	263	56	7	27
Mesabi	252	57	8	28
Camerosa	174	34	3	13
Redchief	216	28	2	13
Darselect	248	23	3	13
Allstar	184	24	4	16
Honeoye	202	38	4	18
Evangeline	209	46	3	19
LSD[v]	NS	12	1	5
2010 Cultivar	**Total Phenolics[z]**	**Total Anthocyanins[y]**	**FRAP[x]**	**TEAC[w]**
Locally-grown				
Earliglow	522	90	5	49
Camerosa	680	123	5	46
Sweet Charlie	645	95	4	42
Grocery-bought				
Company 1	566	84	5	46
Company 2	450	38	6	52
Company 3	408	55	5	48
LSD	203	38	1	NS

[z] Total phenolics expressed as mg chlorogenic acid/100 g fresh weight.
[y] Anthocyanins expressed as mg pelargonidin 3-glucoside/100 g fresh weight.
[x] FRAP total antioxidant activity expressed as µmol ascorbic acid equivalents/g fresh weight.
[w] TEAC total antioxidant activity expressed as µmol Trolox equivalents/g fresh weight.
[v] Mean separation within years by Fisher's LSD at P = 0.05. NS indicates no significant difference.

Table 4. Table grape (*Vitis* spp.) phytochemical and antioxidant values. Fruit grown at the UK Horticulture Research Farm, Lexington, KY, 2009 and 2010.

2009 Cultivar	Total Phenolics[z]	Total Anthocyanins[y]	FRAP[x]	TEAC[w]
Sunbelt (B)[v]	407	180	10	35
Mars (B)	154	27	3	10
Reliance (R)	84	0	5	6
Marquis (W)	74	0	3	9
Neptune (W)	91	0	3	10
LSD[u]	NS	0	3	2
2010 Cultivar	**Total Phenolics[z]**	**Total Anthocyanins[y]**	**FRAP[x]**	**TEAC[w]**
Jupiter (B)	125	15	5	27
Mars (B)	167	32	6	28
Reliance (R)	60	4	2	12
Marquis (W)	61	2	3	13
Neptune (W)	89	4	4	24
LSD	27	4	1	4

[z] Total phenolics expressed as mg chlorogenic acid/100 g fresh weight.
[y] Anthocyanins expressed as mg malvidin 3-glucoside/100 g fresh weight.
[x] FRAP total antioxidant activity expressed as µmol ascorbic acid equivalents/g fresh weight.
[w] TEAC total antioxidant activity expressed as µmol Trolox equivalents/g fresh weight.
[v] Berry color: B = black, R = red, and W = white.
[u] Mean separation within years by Fisher's LSD at P = 0.05. NS indicates no significant difference.

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Table 5. Total phenolics, anthocyanins, and antioxidant activity of blackberries at harvest, after 7 days of 4° C cold storage, after 3 additional days at room temperature, and change from 0-7 (Δ0-7) and 7-10 (Δ7-10) days (Fulkerson, 2004).

Variety	Day 0	Day 7	Day 10	Δ 0-7	Δ 7-10
Total phenolics[z]					
Hull	317 ay	352 a	423 a	35 NS	71 NS
Chester	254 b	265 b	322 b	11	57
Triple Crown	326 a	297 b	332 b	- 29	35
Total anthocyanins[x]					
Hull	151 b	143 NS	140 NS	-8 ab	-3 NS
Chester	134 c	138	149	3 b	11
Triple Crown	165 a	131	136	-34 a	5
Total antioxidant activity[w]					
Hull	49 b	47 b	51 b	-2 NS	4 NS
Chester	55 a	51 a	55 a	-4	4
Triple Crown	54 a	51 a	52 ab	-4	1

z Total phenolics expressed as mg chlorogenic acid/100 g fresh weight.
y Mean separation among cultivars within traits by Fisher's LSD at P = 0.05. NS indicates no significant difference.
x Anthocyanins expressed as mg cyanidin 3-glucoside/100 g fresh weight.
w Total antioxidant activity from the FRAP assay expressed as μmol ascorbic acid equivalents/g fresh weight.

Blueberry Variety Evaluations

Chris Smigell, John Strang, John Snyder, Joseph Tucker 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 Center for Appalachian Resource Sustainability 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, ten southern highbush, and seven rabbiteye blueberry varieties for performance in the central Kentucky area.

Table 1. Highbush and southern highbush blueberry yield, fruit size, taste, appearance ratings and harvest dates, Lexington, KY, 2010.

Variety	Type[1]	Yield (lbs/A)[2]		Berry Weight (oz/25 berries)		Berry Taste (1-5)[3]		Berry Appearance (1-5)[4]		First Harvest Date	Harvest Midpoint[5] Date
Chandler	HB	16,760	a	2.5	a	3.3	def	4.2	bcde	11 June	07 July
Ozarkblue	SH	11,240	b	1.6	b	3.4	de	4.6	a	16 June	10 July
Pamlico	SH	9,070	bc	0.7	f	4.1	ab	4.1	bcde	8 June	24 June
Bluecrop	HB	8,780	bc	1.2	cd	3.4	d	4.2	bcde	8 June	23 June
Star	SH	7,510	bc	1.0	de	3.8	bc	4.0	de	8 June	17 June
Arlen	SH	7,410	bcd	1.5	bc	3.4	de	4.3	abcd	14 June	06 July
Lenore	SH	7,250	bcde	0.9	ef	4.2	a	4.3	bcde	8 June	30 June
Spartan	HB	7,050	bcde	1.0	de	3.3	def	4.1	cde	8 June	23 June
NC-2927	SH	5,090	cde	0.7	f	4.0	ab	3.9	e	8 June	21 June
Echota	HB	4,620	cde	1.1	de	3.4	de	4.4	ab	8 June	8 July
NC-1871	HB	4,490	cde	0.7	f	3.8	bc	4.2	bcde	8 June	18 June
NC-3129	HB	4,460	cde	0.9	ef	4.0	ab	4.3	abcd	8 June	21 June
Misty	SH	4,420	cde	1.2	de	3.4	de	4.2	bcde	8 June	28 June
Aurora	HB	1,990	de	0.9	def	3.0	f	4.4	abc	30 June	19 July
Sampson	SH	1,940	e	1.1	de	3.1	ef	4.3	abcd	8 June	25 June

1 Type: HB = highbush; SH = southern highbush.
2 Numbers followed by the same letter are not significantly different (Waller-Duncan Multiple Range Test LSD P = 0.05).
3 Berry taste: 1 = poor; 5 = excellent.
4 Berry appearance: 1 = poor; 5 = excellent.
5 Date by which half of the total season's harvest was picked.

Materials and Methods

Plants were acquired from Fall Creek Nursery, Lowell, OR; Finch Nursery, Bailey, NC; DeGrandchamp's Farm, South Haven, MI; and from Dr. Jim Ballington at North Carolina State University, Raleigh, NC. They ranged in age from one-year rooted cuttings to two-year-old plants. They were planted at the 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/A of sulfur. Seventy pounds of phosphorus/A were incorporated into the field prior to bed shaping and planting. 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 ft apart in the row with 12 ft between rows. The rabbiteye blueberries were planted at the other end with 6 ft between plants and 12 ft. between rows. All plants were mulched with a three ft wide, six-inch layer of wood chips. Plots were drip irrigated using point source emitters (1 gal/hr/plant).

Plants showing iron chlorosis were fertilized with Peters Professional Acid fertilizer (24-12-12) and iron chelate the first year. Plants have been 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.

Insecticide applications included Danitol and Imidan. Fungicide applications included lime sulfur, Pristine, Captec and Abound. Roundup and Sinbar were applied for weed control. Netting was used over the planting for bird control.

Table 2. Rabbiteye blueberry yield, fruit size, taste, appearance ratings and harvest dates, Lexington, KY, 2010.

Variety	Yield (lbs/A)[1]		Berry Weight (oz/25 berries)		Berry Taste (1-5)[2]		Berry Appearance (1-5)[3]		First Harvest Date	Harvest Midpoint[4] Date
NC-1827	2,940	a	0.7	c	3.5	a	4.6	a	25 June	13 July
Columbus	990	b	1.4	ab	3.1	a	4.8	a	30 June	27 July
Climax	430	b	0.7	c	2.6	a	4.5	a	8 July	22 July
Onslow	310	b	1.3	ab	2.8	a	4.5	a	15 July	04 Aug
Ira	150	b	1.7	a	3.0	a	4.5	a	29 July	29 July
Tifblue	80	b	1.5	a	2.8	a	4.5	a	29 July	29 July
Powderblue	40	b	1.0	bc	3.5	a	5.0	a	29 July	29 July

1 Numbers followed by the same letter are not significantly different (Waller-Duncan Multiple Range Test LSD P = 0.05).
2 Berry taste: 1 = poor; 5 = excellent.
3 Berry appearance: 1 = poor; 5 = excellent.
4 Date by which half of the total season's harvest was picked.

Results

Harvest and fruit characteristic data for the highbush and southern highbush varieties are shown in Table 1. Among the southern highbush varieties, all of the Duplin and Legacy and all but one Arlen plant in the plot died. Four of five Echota highbush plants have died.

The 2010 season was frost free. Rainfall was normal in January, July and August; below normal in February, March, April, and June; and above normal in May. Temperatures from March to August were above normal. Fruit were harvested once a week. Twenty-five berries from each plant were weighed to determine average berry size at each harvest, and fruit were rated for taste and appearance several times during the season.

Neither highbush nor southern highbush types tended to have greater yields, berry weights, taste ratings or appearance ratings. Chandler (highbush) had the highest yield this year as well as in 2009 and 2008. This year it yielded significantly more than any other variety. Pamlico and Ozarkblue (southern highbush) and Bluecrop (highbush) have also been among the top five producers in 2008-2010. Chandler and Ozarkblue have had the largest berries for these three seasons. NC-2927, NC-1871 and Pamlico produced some of the smallest berries. Most of the varieties were first harvested on 8 June, 17 days earlier than in 2009, and 19 days earlier than in 2008. Aurora had the latest first harvest date for the third year in a row.

Yields for the rabbiteye blueberries (Table 2) were considerably lower than those of the highbush blueberries because these plants have generally not grown as fast as the highbush blueberries. Also, most rabbiteye plants suffered a foliar burn, possibly caused by a fungicide spray combination applied on 13 May. The highbush and southern highbush plants experienced little to no foliar burn. NC-1827 produced the highest rabbiteye yields. NC-1827 has been the highest yielding rabbiteye variety in each of the last three seasons. Berry tastes and appearances were not different among the rabbiteye varieties.

Table 3. Rate of flower bud development for blueberry varieties and types, in decreasing order of rate.

Variety	Type[1]	Floral Development Rate[2]
Sampson	SH	.031
Powderblue	R	.031
NC-3129	HB	.030
Lenore	SH	.030
Misty	SH	.027
Climax	R	.026
Ira	R	.024
Tifblue	R	.024
Ozarkblue	SH	.022
Onslow	R	.022
Star	SH	.022
Spartan	HB	.022
Echota	HB	.022
Pamlico	SH	.020
Columbus	R	.019
Aurora	HB	.019
NC-1827	R	.016
Chandler	HB	.016
Bluecrop	HB	.016
NC-2927	SH	.016
NC-1871	HB	.014
Arlen	SH	.014

1 Type: HB = highbush; SH = southern highbush; R = rabbiteye.
2 Measured in developmental units/day; regression slope for floral stage (1=dormant; 2=bud scales cracked; 3=buds swelling; 4= buds beginning to open; 5= flowers separating; 6= flowers extending). Based on floral development measurements taken on January 14, February 2, February 28, March 16, 2010.

They tend to have very attractive berries with a heavy, waxy bloom.

Rabbiteye blueberries are less sensitive to variations in soil pH and the fruit generally mature later than those of highbush and southern highbush varieties. Thus, rabbiteye blueberries could extend the Kentucky blueberry harvest period. NC-1827 was the first rabbiteye harvested, as it was in the previous two test years. Its first harvest date was later than those for all but one of the highbush varieties. Columbus, Ira and Tifblue had the latest first harvest date of 29 July.

This trial was initiated to evaluate rabbiteye and southern highbush blueberry plants for adaptation to central Kentucky growing conditions. These plants typically have shorter chilling requirements than highbush blueberries, and once these requirements are satisfied, buds begin to develop when exposed to warm weather. Consequently, these buds may begin developing earlier and have a more rapid development rate than the highbush varieties. In 2010 Sampson and Lenore (southern highbush), Powderblue (rabbiteye), and NC-3129 (highbush) had some of the fastest developmental rates (Table 3). Both Lenore and Powderblue were in this group in 2009. NC-1871 (highbush) and Arlen (southern highbush) had the slowest developmental rates and would theoretically be expected to sustain less flower loss from late spring frosts. However, in 2009 these two varieties tended to be in the fastest developmental grouping.

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Muskmelon and Specialty Melon Variety Evaluations

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Thirty-six melon varieties were evaluated in a replicated trial for their performance under Kentucky conditions. These included ananas, canary, Christmas, eastern muskmelons, galia, gourmet, honeydew, and a Charentais-ananas cross.

Materials and Methods

Varieties were seeded on 29 April into plastic plug trays (72 cells per tray) at the UK Horticulture Research Farm in Lexington. Trays were set on a greenhouse bench to germinate and seedlings were thinned to one per cell. Plants were set into black plastic-mulched, raised beds using a waterwheel setter on 27 May. Each plot was 21 ft long, with seven plants set three ft apart within the row and six ft between rows. Each treatment was replicated four times in a randomized complete block design. For the first two replicates, 50 lbs of nitrogen/A and 6.5 lbs each of phosphorus and potassium/A were applied as 5-20-20 and ammonium nitrate beneath the plastic mulch as the beds were formed. Replicates three and four received 50 lbs of nitrogen/A as ammonium nitrate applied beneath the plastic as the beds were formed. Drip irrigation provided water and fertilizer as needed. The plot was fertigated with a total of 30 lbs of nitrogen/A as ammonium nitrate divided into three applications over the season. The systemic insecticide Admire Pro was applied by hand sprayer as a drench to the base of each plant after transplanting, using the

Table 1. Specialty melon variety trial yield and fruit characteristics, Lexington, Ky., 2010.

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)
Crescent Moon	MM	RU	74	761 a	9,680	7.8	3	9.1	7.9	2.1	6.0	3.6
Orange Sherbet	MM	RU,SW	83	751 a	9,250	8.1	0	9.8	7.5	2.0	7.0	3.4
Athena	MM	RU, SW	80	734 ab	12,620	5.8	1	8.4	7.0	2.0	5.3	2.9
Rockstar	MM	HM	73	721 abc	9,420	8.6	5	8.3	7.0	2.1	5.4	2.6
Atlantis	MM	RU,SW	74	715 a-e	11,840	6.0	1	8.5	6.6	2.0	5.4	2.6
Strike	MM	SW	85	710 a-e	11,500	6.3	8	8.9	7.0	2.2	5.7	2.4
Star Fire	MM	HM	87	704 a-e	11,060	6.4	0	7.8	7.4	2.2	5.2	3.1
Maverick	MM	HM, HL	83	687 a-f	14,430	4.7	0	6.8	6.3	1.9	4.2	2.5
Ariel	MM	SW	82	653 a-h	9,330	7.0	0	7.7	7.1	2.0	5.0	3.1
Grand Slam	MM	SW,HL	85	652 a-h	10,460	6.4	2	9.0	6.9	2.2	5.7	2.4
Minerva	MM	RU	77	618 a-i	7,870	7.9	0	8.4	7.9	1.9	5.6	3.9
Aphrodite	MM	RU,SW	80	616 a-j	7,610	7.9	0	8.9	7.6	2.0	6.3	3.8
Harper Hybrid	MM	HM	86	556 a-j	14,260	4.0	0	6.4	6.3	1.8	3.8	2.5
Sugar Cube	MM	HM,ST,RU	69-81	489	17,200	2.9	1	6.1	5.4	1.6	3.8	2.3
Home Run	MM	HL	85	469 b-j	10,800	4.5	4	8.0	6.6	2.2	5.2	2.3
Goddess	MM	SW	70	414 fghij	6,740	6.1	6	8.1	7.1	2.3	5.2	2.6
Dutchess	MM	RU	75	398 ghij	10,370	3.6	10	7.3	6.2	1.8	4.8	2.6
Hanna's Choice	MM	ER	81	391 hij	8,180	4.8	1	7.4	5.7	2.7	4.3	2.0
Lil' Loupe	MM	HM	76	347 ij	15,380	2.3	0	5.1	4.9	1.5	3.1	1.7
Sweet Delight	HD	RU	90	750 a	7,690	9.6	0	9.2	8.6	1.9	5.8	4.8
Honey Brew	HD	RU	90	717 abcd	9,248	7.8	1	9.5	7.6	2.0	6.1	3.6
Angelina	HD	SW	85-90	669 a-g	9,420	7.0	0	7.9	7.8	2.1	4.5	3.5
Mini Musketeers	HD	RU	75-80	457 c-j	29,040	1.6	2	5.1	4.6	1.1	3.0	2.0
Green Flesh	HD	RU	110	456 c-j	6,310	7.4	0	8.7	8.4	1.8	5.7	4.6
Honey Ace	HD	SG	75	415 fghij	5,620	7.7	0	8.3	7.5	2.1	4.8	3.2
Gourmet Premium	AN	SW	73	733 abc	13,480	5.4	1	7.1	6.4	1.8	4.4	2.9
Robust	AN	HL	90-95	614 a-i	7,520	8.1	0	9.3	7.2	2.2	6.1	2.7
AM-04-16	AN	RU	65-75	367 ij	10,030	3.6	0	6.5	5.1	1.4	4.2	2.4
Camposol	CA	SW	80	615 a-i	8,120	7.6	1	9.4	7.4	2.0	6.2	3.5
Dorado	CA	ST	85	602 a-i	7,260	8.4	0	9.6	7.3	2.0	6.3	3.2
SMX 7057	CA	SG	82	350 ij	5,620	5.9	0	9.5	7.8	1.9	6.1	3.9
HSR 4402	GA	HL	80-85	440 efghij	12,710	3.5	0	6.4	6.0	1.9	3.8	2.2
Visa Premium	GA	SW	78	316 j	8,470	3.8	14	7.1	6.4	2.1	4.3	2.3
Sensation	GO	SW	80	441 d-j	8,640	5.2	4	7.1	6.7	1.9	3.9	3.1
Lambkin	CR	HM, ST	68-70	406 ghij	8,380	4.9	0	8.2	6.2	1.6	5.1	3.0
Tasty Bites	CH	RU	75-80	540 a-j	18,930	2.8	1	5.9	5.2	1.5	3.6	2.2

1 Melon type: AN = ananas, CA = canary, CH = charentais x ananas cross, CR = Christmas, GA = galia; GO = gourmet, HD = honeydew, 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.

maximum rate of 10.5 fl oz/A. Foliar insecticide and miticide applications included Pounce, Asana, Oberon, Mustang Max and Acramite. Weekly foliar fungicide applications included Manzate, Dithane, fixed copper, Bravo, Quadris, and Pristine. One fruit from each replication was measured and evaluated for flavor, soluble solids, interior color, rind color, and net type. Fruit were harvested twice a week.

Results and Discussion

Harvest and variety evaluation data are in Tables 1 and 2. The growing season was drier and hotter than normal. Flavor was exceptional due to the dryness, and most melon varieties evaluated previously performed well. Varieties are grouped by melon type and listed in order of declining yield within each type. Weed control was excellent. Bacterial wilt was the primary disease. More than 100 plants had to be replaced about two weeks after planting due to bacterial wilt or transplant scalding. No virus was observed, and less powdery mildew was observed than in previous years.

Eastern muskmelon. Of the 15 muskmelon varieties tested, the highest yielding 11 had statistically similar yields. Most of these also had good flavor ratings. Orange Sherbet, Athena, Atlantis, Rockstar, Star Fire, Maverick and Ariel all had comparable yields, good flavor ratings, and fruit weights in the 6-8 lb range. Harper Hybrid, Dutchess, and Hanna's Choice tended to be the best tasting muskmelons but with smaller fruit, in the 3-5 lb range. Orange Sherbet was one of the higher yielding, larger, and better tasting melons this season and in the 2008 trial. Rockstar was also notable for its high yields and large melon sizes. Lil' Loupe stood out for its very small size and good flavor. It has potential for a specialty niche market. Athena, the industry standard in flavor and sugar content, performed well.

Table 2. Specialty melon trial fruit characteristics, Lexington, Ky., 2010.

Variety	Flavor (1-5)[1]	Sugar (%)	Interior Color[2]	Rind Color[3]	Fruit Shape[4]	Net Type[5]	Comments
Crescent Moon	3.0	9.6	or.	str.	ob.	hv.-med.	Large melon; deep sutures; asymmetric shape; sl. firm-firm flesh; musky taste
Orange Sherbet	4.2	12.2	or.	str.	ob.	med.-co.	Attractive interior/exterior; nice sweet flavor; many split in field; firm, smooth, fine-granular flesh
Athena	4.2	12.3	or.	str.	ob.	med.-med.	Slight sutures or none; sl. firm flesh; nice flavor
Rockstar	4.2	12.2	or.	str.	ob.	med.-med.	Nice sweet flavor; sl. almond shape, some irreg. shaped; sl. sutures; sl. firm flesh
Atlantis	4.2	12.1	or.	str.	ob.	med.-med.	V. slight sutures; attractive, firm, smooth, fine-granular flesh
Strike	3.3	10.6	or.	str.	ob.	med.-co.	Some checking; sl. firm, smooth, thick flesh
Star Fire	4.2	12.2	or.	str.	ob.	hv.-co.	Slight sutures; harvest at slip; soft, smooth, melting flesh
Maverick	4.3	12.7	or.	str.	ob.	med.-med.	Exc. flavor if v. ripe; sl. sutures; many split; smooth, soft, melting flesh
Ariel	4.0	11.6	or.	str.	ob.	med.-med.	V. slight sutures; smooth, firm flesh; good flavor
Grand Slam	4.1	13.8	or.	str.	elong.	med. to hv.-med.	V. large; attractive; no sutures; firm, chewy flesh
Minerva	3.9	13.5	lt. or.	str.	sl. ob.	heavy	Sunken pock-marks on rind; slightly dry and chewy, firm-v. firm flesh
Aphrodite	4.0	11.6	or.	str.	ob.	hv-co.	Some cracking; soft, smooth, melting flesh
Harper Hybrid	4.5	12.9	or.	str.	rnd.	med.-med.	Splitting/cracking; soft, smooth, melting flesh; nice flavor
Sugar Cube	4.2	13.2	deep or.	str.	ob.	med.-co.	Harvest at slip; no sutures; smooth, firm, melting flesh; nice, variable flavor
Home Run	3.9	11.5	or.	str.	ob.	med.-med.	Attractive, thick, smooth, melting flesh
Goddess	4.3	11.7	lt. or.	str.	ob.	hv.-co.	Attractive interior/exterior; splits w/ rain; smooth, sl. firm-firm flesh
Dutchess	4.5	13.4	or.-lt. or.	str.	ob.	med.-med. to co.	Attractive interior/exterior; firm flesh; nice, intense flavor; long aftertaste
Hanna's Choice	4.4	12.8	or.	str.	ob.- alm.	med.-co.	Cracks at stem end; smooth, melting flesh: nice flavor
Lil' Loupe	4.2	13.3	or.	str.	rnd.	med.-med.	Slight sutures; smooth, firm flesh
Sweet Delight	4.5	13.2	lt. gr.	cr.	rnd., alm	fine-fine	Harvest when ext. cream colored & waxy, w/ good aroma; green blotches on rind; lt. netting at stem end; some ripe w/o being waxy; coarse-granular, crunchy, firm flesh
Honey Brew	4.4	14.3	lt. gr.-cr.	cr.	ob.	dif.-fine	Harvest when ext. cream colored & waxy, w/ good aroma; nice sweet flavor; soft flesh
Angelina	4.4	14.7	lt. gr.	cr.	ob.- rnd.	fine-fine	Harvest when ext. cream colored & waxy, w/ good aroma; some light netting; crunchy, firm flesh; nice flavor
Mini Musketeers	4.4	14.8	cr.	cr.	sl. ob.	fine to none -fine	Harvest when ext. cream colored & waxy w/ radial checking, & before slip; incomplete, light, diffuse net; many split; crisp flesh
Green Flesh	4.7	13.7	lt. gr.	cr. to gr.	rnd.	coarse	Harvest when ext. cream colored & waxy, w/ good aroma; netting not attractive; crunchy flesh
Honey Ace	4.7	15.4	lt. gr.-cr.	cr.	ob.- rnd.	dif.-fine	Harvest when ext. cream colored & waxy, w/ good aroma; cracks w/ rain; sl. crunchy, coarse-granular flesh; v. nice sweet flavor

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Table 2. Specialty melon trial fruit characteristics, Lexington, Ky., 2010.

Variety	Flavor (1-5)[1]	Sugar (%)	Interior Color[2]	Rind Color[3]	Fruit Shape[4]	Net Type[5]	Comments
Gourmet Premium	3.8	12.6	lt. gr.-cr.	str.	ob.	med.-med.	Harvest at slip; severe field splitting; smooth, firm, melting flesh; v. nice flavor at full slip
Robust	4.1	11.3	cr.-sal.	or. to str.	ob.	fine-med.	Harvest at 1st slip; attractive ext.; v. large melon, ripens rapidly in field; soft, melting flesh
AM-04-16	4.4	13.5	lt. gr.-cr.	or. to str.	elong.	dif.-med.	Harvest at slip & full color; smooth, sl. firm, melting flesh; delicate sweet flavor, variable flavor
Camposol	4.5	13.9	lt. gr.-cr.	dk. yl.	alm.	none	Harvest when entire rind is yellow, w/ no green left; attractive exterior/interior; less cracking than Dorado; soft, smooth flesh
Dorado	4.7	13.7	lt. gr.-cr.	dk. yl.	alm.	none	Harvest when entire rind is yellow, w/ no green left; attractive ext./int.; no sutures, little checking; sl. firm, granular, melting flesh
SMX 7057	4.8	15.2	lt. gr.	dk. yl.	alm.	none	Harvest when entire rind is yellow, w/ no green left; attractive exterior; some checking; sl. crunchy, melting flesh; good after taste, nice sweet flavor
HSR 4402	4.6	15.4	lt. gr.	lt. gr. to yl.	rnd.	med-med	Harvest when rind yellow & before slip; tight netting, no sutures; sl. firm flesh
Visa Premium	3.4	10.5	lt. gr.-cr.	gr. yl.	ob.	med-fine	Harvest at full slip; small cavity; a lot of cracking & splitting; smooth, sl. firm, fine-granular flesh
Sensation	4.8	14.2	cr.	str.	rnd.	med-fine	Harvest at full slip & pale yellow base color beneath green; small cavity; attractive; smooth, melting flesh; excellent flavor
Lambkin	4.6	15.7	lt. gr.-cr.	dk. gr., yl. fleck	ob.	none	Harvest when yellowish flecks appear & cream ground color; doesn't slip; coarse-granular, firm & crunchy to soft flesh
Tasty Bites	4.6	13.7	lt. or.	str.	ob.	fine	Harvest when well colored & slips; tight uniform netting; crunchy, crisp flesh; nice flavor & after taste

1 Flavor: 1 = poor; 5 = excellent, sweet taste, pleasant texture.
2 Interior color: lt = light; or = orange; cr = cream; gr = green; sal = salmon.
3 Rind color: dk = dark; lt = light; or = orange; cr = cream; gr = green; yl = yellow; str = straw.
4 Fruit shape: alm = almond; ob = oblong; rnd = round; elong = elongate.
5 Net type: the dash separates two descriptions; the first is net density, or amount of fruit surface covered by net, the second describes how coarse the net feels; dif = diffuse (very little) amount of netting; fine = little amount of netting / not coarse; med = medium amount of netting / med. coarseness; hv = heavy amount of netting; co = coarse.

Honeydew. All of the honeydew varieties had high sugar contents and high flavor ratings. Sweet Delight was one of the higher yielding honeydews. Some of its fruit displayed small, dark green rind blotches. Honey Brew, our standard recommendation which has done well in previous trials in Lexington, also performed very well. Mini Musketeers is a tiny, whitish melon that is very similar in size, shape, and color to the Asian melon, Sprite. Unfortunately, fruit splitting in the field was a problem with Mini Musketeers.

Ananas. Robust was the best large ananas melon. AM-04-16 is a smaller ananas, that also performed well and had a high flavor rating and sugar content. Ananas melons should be harvested daily, because of their rapid ripening, short harvest window and short storage life.

Canary. Camposol and Dorado had similar yields, producing close to twice as much as SMX 7057. All three were excellent and had very high flavor ratings.

Galia. HSR 4402 was the best galia melon, with a very good flavor and a high sugar content.

Gourmet. Sensation is an outstanding melon in 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.

Christmas. Lambkin is a small, dark green Christmas melon with greenish yellow flecking. It had excellent flavor and exceptionally high sugar content. The flesh varied from firm and crunchy to soft and had coarse, granular texture.

Charentais X Ananas. Tasty Bites is an excellent, small, personal-sized melon. It had a very good taste and aftertaste, and firm, crunchy, light orange flesh. Splitting was not a problem, as it typically is with Charentais melons in Kentucky trials.

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Acorn and Butternut Squash Cultivar Trial

Dave Spalding and Timothy Coolong, Department of Horticulture

Introduction

The hard winter squashes have been grown in Kentucky for many years but not in large volumes. Typically, growers sell their hard squashes at harvest, usually before the first frost. As a result, growers are often selling their product during a time when supply is high and prices are low. Prices typically increase in the late winter and early spring months, which means an increase in profits for growers, Co-ops and others who can store these squashes. For these reasons a cultivar trial was initiated in 2010 to evaluate eleven butternut and five acorn cultivars for yield and marketability. Also, these cultivars will be informally evaluated for their storability through the winter months.

Table 1. Results of 2010 Butternut Squash Cultivar Trial.

Cultivar	Marketable Fruit No.		Marketable Weight		Average Weight		Cull No.		Cull Weight	
Matilda	8,711	bcde[1]	35,875	a	4.00	c	674	b	1,625	b
Atlas	7,674	cde	32,275	ab	4.25	bc	3,578	a	11,125	a
Maxim	8,089	cde	31,775	ab	4.00	c	1,037	b	3,000	b
Ultra HP	7,311	de	30,600	ab	4.25	bc	1,140	b	3,300	b
Casius	5,600	ed	28,000	ab	5.00	b	726	b	2,700	b
Argonaut	2,904	f	26,350	ab	8.75	a	881	b	4,400	b
Victory	11,822	b	25,825	ab	2.00	de	1,815	b	3,375	b
Bugle	19,133	a	25,350	ab	1.50	e	3,163	a	2,975	b
Avalon	9,022	bcd	22,500	b	2.50	d	1,400	b	2,175	b
Frisco	6,481	cd	21,550	b	3.50	c	1,400	b	3,175	b
Zenith	10,837	bc	21,550	b	2.00	de	1,695	b	2,350	b

[1] Numbers with the same letter values within the same column are not significantly different.

Materials and Methods

The trial was conducted at the UK Horticultural Research Farm. Seed of 11 butternut and 5 acorn squash cultivars were seeded in the greenhouse in 72-cell trays on 12 May 2010. Plants were transplanted to the field on 15 June 2010 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 10 plants planted in a single row with 3 ft between plants. The plot received a preplant application of 50 lb/A of N, 50 lb/A of P_2O_5 and 50 lb/A of K_2O, as indicated by soil samples. An additional 50 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 15 September. Fruit of each cultivar were graded as marketable or culls and the graded fruit were counted and weighed.

Results and Discussion

The processing cultivars of the butternut squash were the highest yielders but all had fruit that were too large for the commercial retail market. The cultivar Matilda had the highest marketable yield at 35,875 lb/A and the cultivar Argonaut had the highest average fruit size at 8.75 lb per fruit. Of the commercial retail cultivars, the cultivar Victory had the highest marketable yield per acre and along with the cultivar Avalon had very nice uniformed fruit. The cultivar Bugle had very small fruit and is probably not an acceptable retail cultivar.

Of the five acorn squash cultivars evaluated, Table Star had the highest marketable yield per acre and the cultivar Tay Belle PM had the highest average weight per fruit. However, none of the marketable yields were significantly different due to the high degree of variability and the very high level of cull fruit. Unfortunately, the acorn squash cultivars were planted among the butternut cultivars and matured 5 to 6 weeks before the butternut cultivars were ready to harvest. This delay in harvest accounted for much of the increased cull rate and some of the overall variability in the acorn cultivars.

Table 2. Results of 2010 Acorn Squash Cultivar Trial.

Cultivar	Marketable Fruit No.		Marketable Weight		Average Weight		Cull No.		Cull Weight	
Table Star	10,733	a[1]	13,175	a	1.00	c	4,926	ab	5,975	b
Autum Delight	8,452	a	12,575	a	1.50	b	2,904	b	4,375	b
Tay Belle PM	6,844	a	11,050	a	2.00	a	6,948	a	10,525	a
Messa Queen	7,207	a	10,050	a	1.25	bc	4,044	b	4,975	b
Table Ace	6,326	a	8,125	a	1.00	c	4,148	b	5,625	b

[1] Numbers with the same letter values within the same column are not significantly different.

Kentucky Red Onion Variety Trial 2010

Timothy Coolong, Lucas Hanks, and Janet Pfeiffer, Department of Horticulture

This paper reports on the evaluation of nine red onion varieties in central Kentucky.

Introduction

Fresh market onions represent a potentially lucrative crop for Kentucky growers. Although many growers currently are having success growing yellow sweet onions for sale at farmers markets or produce auctions, many of the same growers have reported mixed results when growing red onions, particularly using a plasticulture production system. Growers have indicated that red onions tend to be smaller and more pungent than the larger mild yellow onions that are commonly grown. Therefore a trial was conducted in spring of 2010 to determine varietal performance of nine commonly available intermediate and long-day red onion varieties using a plasticulture production system.

Materials and Methods

The trial was conducted at the UK Horticulture Research Farm in Lexington, Kentucky during the spring and summer of 2010. Nine onion varieties, Red Burgermaster, Red Bull, Red Wing, Red Beauty, Red Defender, Desert Sunrise, Mars, Grateful Red, and Red Zeppelin were seeded into greenhouse flats the second week of February 2010. Seedlings were greenhouse grown using standard production techniques. Seedlings were pulled from trays, and bare roots plants were transplanted into the field on 14 April 2010. Plants were set into raised beds covered with black plastic mulch with two lines of drip tape. Plant beds were spaced on 6.5-ft centers. Plants were arranged in four rows on each bed with six-inch spacing between rows and six-inch spacing between plants within a row. Plots consisted of 160 plants of each variety replicated four times in a completely randomized design. The field received approximately 70 lb of preplant nitrogen (19-19-19) per acre applied only under the plastic mulch. Onions were fertigated weekly with 15 lb of nitrogen from either ammonium or calcium nitrate (alternated weekly) for six weeks beginning four weeks after planting. Goal 2XL (oxyfluorfen) was applied within six days of transplant over the top of plants to provide within- row and between-row weed control. Additional fungicide and insecticide (mainly for thrips) applications were made using University of Kentucky standard procedures (ID-36, *Vegetable Production Guide for Commercial Growers*).

Plants began to go "tops down" during the first week of July. Foliage was allowed to begin to dry in the field, and plants were harvested on 23 July 2010. Onions were bagged and cured for one week prior to grading. Onions were graded for quality and size according to USDA standards for U.S. No. 1 fresh market bulb onions. Yield data were calculated based on a plant population of 53,612 plants/A (spacing used in this study). Statistics were performed using the GLM and Duncan's multiple comparisons procedures of SAS statistical software. Results were considered significantly different if $P< 0.05$.

Results and Discussion

The 2010 growing season was challenging for many onion growers in Kentucky. The incidence of two bacterial diseases, sour skin (*Burkholderia cepacia*) and center rot (*Pantoea ananatis*), normally of minor importance, increased significantly due to the unusually warm weather. Other fungal diseases such as purple blotch (*Alternaria porri*), were prevalent due to wet spring weather. Despite regularly scheduled sprays, this trial was heavily impacted by sour skin. As such, our total marketable yields were lower than expected (Table 1). Nonetheless, some varieties stood out. Red Wing, Red Beauty, and Red Burgermaster produced the highest marketable yields. Though no onions produced "jumbo" bulbs, Mars and Red Burgermaster produced primarily large bulbs with 5224 and 4296 lb of large bulbs per acre, respectively. Not surprisingly these two varieties also produced the largest average bulbs, averaging 7.0 oz. per bulb for Mars and 6.5 oz. per bulb for Red Burgermaster. Both Red Wing and Red Beauty were noteworthy for producing round

Table 1. Marketable yield, and yield of small, medium, large onions as well as % of culls and average bulb weight of marketable bulbs for nine red onion varieties grown in Lexington, KY in 2010. Varieties are ordered based on marketable yield (highest to lowest).[a]

Variety	Seed Source	Marketable Yield (lbs/A)		Small (lb/A)		Medium (lbs/A)		Large (lb/A)		Culls (%)[b]		Avg Bulb Weight (oz.)	
Red Wing	JS	11437	a	437	a	7873	a	3127	bc	41.3	b	5.3	b
Red Beauty	SW	11333	a	249	bc	7802	a	3282	bc	40.2	b	5.2	b
Red Burgermaster	RE	9659	ab	203	bc	5160	bc	4296	ab	48.0	ab	6.5	a
Mars	JS	9256	bc	111	c	3921	cd	5224	a	55.0	ab	7.0	a
Red Defender	HR	8796	bcd	269	abc	6227	ab	2300	cd	42.5	b	5.5	b
Red Zepplin	RE	8178	cd	311	ab	7383	ab	484	de	43.2	ab	5.1	b
Grateful Red	ST	7246	cd	290	abc	5413	bc	1543	cde	48.0	ab	5.4	b
Red Bull	JS	6969	d	212	bc	6495	ab	262	e	51.0	ab	4.9	b
Desert Sunrise	JS	3103	e	198	bc	2778	d	127	e	64.5	a	3.9	c

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

[a] Yield values based on a per acre population of 53,612 plants, grading based on USDA size and quality standards.

[b] % cull based on weight of nonmarketable bulbs/total weight of harvested bulbs.

bulbs, with Red Wing having a particularly hard outer skin likely making it suitable for storage. Red Bull, despite yielding lower than many varieties, was extremely uniform, with over 93% of bulbs graded medium according to USDA guidelines. Desert Sunrise had an attractive deep red color but had the lowest yields and matured earliest. Because of early maturation of Desert Sunrise, plants were small when bulbing was induced, resulting in smaller bulbs on average.

As mentioned previously, marketable yields were low in 2010 due to disease pressure. Consequently, the percentages of bulbs culled, almost all due to disease, were high. Percentages of culls ranged from 40 to 65%. This high cull rate would be unacceptable for commercial growers. Our results were not unusual, however. Due to disease pressure, onions across Central Kentucky performed poorly in 2010. Although culls were high, it is likely that this was due more to high disease pressure than from inadequacies of these selected varieties.

This was the first year trialing for several of these varieties in Kentucky, so further trials are warranted. 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 and among locations.

Cabbage and Broccoli Cultivar Trial at Princeton, KY

Vaden Fenton, Dwight Wolfe, June Johnston, Ginny Travis, and Timothy Coolong, Department of Horticulture

Introduction

Growers and researchers in agriculture crop production are always looking for ways to extend the growing season or production cycle. We have seen the introduction of high tunnel structures, improving temperature tolerance in certain varieties, both crops that can tolerate heat and crops that can tolerate a low temperature. Cole crops broccoli and cabbages can tolerate temperatures of 22-23° F and 17-18° F respectively according to Coolong et al (1).

Materials and Methods

The variety trial was conducted at the University of Kentucky Research and Educational Center in Princeton. The seeds of both broccoli and cabbages were planted at the UK Horticulture Research Farm greenhouses in Lexington and transplanted to the field in Princeton on August 10 and 11, 2010. The research plot was a randomized complete block design with four rows and four replications. Each replication had 24 plants planted at 12 inches between plants within a row with row spacing 6 ft, center to center. A plastic mulch layer with drip tape and a waterwheel setter were used to prepare the planting area. The plants were then planted August 11 by hand using a small hand shovel. The beds for the cabbages were saturated prior to planting because of the severe drought that we experienced this year. The broccoli beds were not saturated, which led to a high increase in plant loss. Because of the time of year the plot was established, a white-on-black plastic mulch was used as opposed to the traditional black plastic mulch in order to reduce the amount of heat directly above the plastic and in the root zone of the plants. The plot was scouted regularly for sign of insects and diseases, and insecticides were applied accordingly. The insecticide Pounce (permethrin) was sprayed four weeks after transplant and Warrior (lambda-cyhalothrin) was sprayed two weeks later. The crop was harvested 63, 77, and 91 days after transplanting on October 13 and 27, and on November 10, respectively. The number of plants, the number of heads harvested, and the plants' total weight per plot were recorded. A hard freeze did not occur in Princeton, KY until November 6, when the temperature dropped to 21.4° F.

Table 1. Results of cabbage and broccoli variety trials at UKREC, Princeton, KY.

Broccoli Varieties	Days to Maturity[1]	Yield (lb/A)[1]	No. Heads/ A[2]	Avg Wt/ Head (oz)
Packman	48	7,040	16,013	7.0
Everest	51	4,467	13,765	5.2
Premium Crop	56	2,843	15,708	2.9
Green Magic	60	2,695	12,381	3.4
Gypsy	63	2,522	12,282	3.3
Diplomat	67	2,125	10,800	3.1
Emerald	68	1,908	11,623	2.7
Arcardia	76	1,399	9,996	2.2
Marathon	82	790	4,169	3.0
Mean	--	2,865	11,860	3.6
LSD (0.05)		1,207	3,261	1.2
Cabbage Varieties	**Days to Maturity[1]**	**Yield (lb/A)[1]**	**No. Heads/ A[2]**	**Avg Wt/ Head (oz)**
Parel	65	10,178	7,995	19.8
Checkmate	65	8,659	6,257	21.7
Artost	68	6,089	4,991	19.6
Invento	65-70	5,264	4,417	16.7
Benelli	78	1,500	935	24.6
Mean	--	6,876	5,362	20.1
LSD (0.05)[3]		ns[4]	ns	ns

1 Days to maturity obtained from Seedway, except for the cabbage variety Invento.
2 Values are based on per acre population of 14,520 plants per acre and assumes 100% survival.
3 Least significant difference. This is the difference between two means within a column in which there is only 1 chance in 20 of exceeding.
4 ns = means are not statistically significant different at the 0.05 probability level.

Results and Discussion

Yield in the broccoli trial was greatest for Packman (Table 1). It also had the highest average weight per head. The nine varieties separate in to three groups when viewed from the perspective of average weight per head. Packman had significantly the highest average head weight, followed by Everest which was significantly greater in than all of the other varieties in this trial. Arcadia and Marathon were the latest broccoli varieties to mature. Marathon was only harvested once, (November 10) and was the poorest performer in the broccoli variety trial.

Although, yield and number of heads per acre were highest for Parel, there were no statistically significant differences in yield between cabbage varieties in this trial. Benelli was the latest maturing cabbage variety.

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Green Bean Variety Evaluation

John Strang[1], Chris Smigell[1], Patrick Kelley[1], Pam Sigler[2], Kenny Seebold[3], Sandra Bastin[4], Darrell Slone[1], and John Snyder[1], Departments of: Horticulture[1], Family and Consumer Sciences Extension[2], Plant Pathology[3], and Nutrition and Food Science[4]

Introduction

Green beans are popular at most retail markets across the state. In recent years a number of varieties of green beans with a darker green color have been developed. These newer, darker green varieties may be preferred by consumers. Twenty green bean varieties, including some older recommended varieties and many newer varieties, were evaluated in this trial.

Materials and Methods

Varieties were planted in the field on 24 June at the UK Horticulture Research Farm in Lexington. Approximately 120 seeds were planted in each 20-ft-long plot. Rows were 28 inches apart. Each treatment was replicated four times in a randomized complete block design. Thirty pounds of actual nitrogen as ammonium nitrate and 2 pt/A of Prowl 3.3 EC preemergence herbicide were applied and incorporated into the soil prior to planting. Quadris and fixed copper fungicides and Pounce, Capture, and Brigade insecticides were applied as needed. The plot was drip irrigated as needed. Plants were harvested by hand six times weekly on 12, 19, 24 August, and 2, 10, 18 September. Plant virus disease evaluations were made on 28 August.

Consumer Survey

Fresh green beans

Eighteen varieties of green beans were harvested on August 24. Approximately four ounces were placed in labeled, sealable plastic bags, unwashed, for a consumer survey. Four ounces of each variety were washed, weighed, and placed in a stainless steel pan with eight ounces of water. Beans were cooked covered until tender. The stove temperature was set at medium (4 on a setting ranging from 1 to 9). Cooking times ranged from 10 to 18 minutes. A panel of nine adults (two males and seven females) participated in the evaluation. All of the participants indicated that they liked green beans, with 78% eating green beans weekly or more often. The panel rated the beans for visual appeal (fresh and cooked), taste and texture of the cooked beans, and likelihood of purchasing that variety.

Canned green beans

Beans were fresh-packed in pint or quart (depending on sample amount) sterilized canning jars. One teaspoon of canning salt was added to each jar. Boiling water was added, leaving one inch of headspace in the jars. Air pockets and bubbles were removed from the jars. Two-piece canning lids were applied, hand tight. Jars were inserted into a pressure canner with two inches of water. After sealing the lid, the temperature of the canner was raised to 212° F and allowed to vent steam for 10 minutes. After 10 minutes, a weight was added to the canner to create 15 lb of pressure, and this was maintained for 20 minutes for pint and 25 minutes for quart jars.

Results and Discussion

The 2010 growing season was abnormally hot and dry, which led to poor pollination and blossom drop. This evaluation should be helpful in selecting varieties for midsummer planting. Harvest was initiated when the earliest maturing varieties were ready to harvest. Since several varieties were not mature on the first two harvest dates, this led to the large number of harvests for this trial. Harvest yields, plant and bean characteristics are reported in Table 1. Visual and cooked taste ratings for both fresh and canned green beans are shown in Table 2. Pony Express, Caprice and Brio were the top performers based on plant, pod, visual and cooked ratings. Jade, Pony Express, Tema, Caprice, Lewis and Prevail were some of the higher yielding varieties under these growing conditions (Table 1). Varieties with the darkest green fruit were Lewis, Crockett, Concesa, Prevail, Boone, Pony Express, Hickock, and Savannah (ranked from darkest to lightest). Crockett, Boone, Hickock, and Savannah, also had a glossy appearance. It is interesting to note that a number of the darker green varieties also had slightly higher plant virus infection ratings. Bush Blue Lake, an older variety, ranked midway in variety yields.

In Table 2, Brio, Pony Express, Caprice, Boone, Tema, Savannah and Cabot ranked toward the top of the combined fresh appearance and cooked ratings. The six varieties with the highest raw visual appeal included Pony Express, Savannah, Concesa and Crocket which were darker green colored beans, and of these, Savannah and Crockett also had a glossy appearance. After beans were cooked, visual appeal preferences changed, and only Boone and Pony Express remained in the top six ranking. Thus, it appears that the dark green pod color is a primary preference factor for fresh green beans as opposed to cooked beans. Pod glossiness did not seem to make much difference in the fresh bean visual appeal rating and was even less important in the cooked bean visual appeal rating. In considering just the taste of freshly cooked green beans, Caprice, Cabot, Savannah, Pony Express and Boone were ranked as some of the best. Magnum and Greencrop, the two flat pod varieties, ranked

Table 1. Green bean yield, plant and bean characteristics.

Variety	Seed Source	Days to Harvest	Total Yield 6 Harvests (bu/A)[1]	Plant Height (in)	Plant Width (in)	Plant Habit (1-5)[2]	Pod Position (1-5)[3]	Plant Stand (1-5)[4]	Virus Rating (1-5)[5]	Pod Color (1-5)[6]	Pod Straight-ness (1-5)[7]	Pod Length (in)	Pod Uniformity (1-5)[8]	Comments
Jade	SG	60	626 a	16.3	24.5	1.5	2.0	2.9	1.8 def	3.8	3.0	6.6	3.5	Round pod
Pony Express	SG, SW	53-55	575 ab	16.3	19.5	2.1	2.9	3.4	1.8 def	4.0	3.0	5.5	3.3	Round pod
Tema	SG	53	523 a-c	18.0	22.8	2.0	2.6	4.1	1.5 ef	2.0	3.4	6.0	3.4	Round pod
Caprice	SW, ST	58	501 a-d	18.0	21.5	2.4	2.4	4.5	2.0 c-f	3.0	2.8	5.6	3.0	Round pod
Lewis	SW,HM	53	490 a-e	19.5	24.8	4.5	4.0	4.4	3.3 ab	4.3	4.0	5.6	4.0	Round pod
Prevail	SW	55	483 a-e	14.8	17.3	2.0	2.1	2.9	2.0 c-f	4.1	4.0	5.3	4.0	Round pod, tender
Cabot	HM	55	470 a-f	18.8	2.1	2.4	2.8	3.8	2.0 c-f	3.4	3.8	6.0	3.8	Round pod
Brio	SG	54	455 a-g	16.8	21.3	3.0	3.1	3.0	1.5 ef	2.3	2.6	5.8	2.9	Attractive, round pod
Storm	ST	51	453 a-g	16.8	21.3	1.6	1.8	3.1	1.8 d-f	2.3	3.1	6.1	3.1	Round pod
Magnum	ST	51	451 a-g	18.5	21.0	1.6	1.6	2.8	1.3 f	1.9	2.6	7.5	2.5	Flat pod
Espada	HM	56	447 a-g	18.8	24.8	2.6	2.8	4.8	2.3 cde	3.1	2.9	5.4	2.9	Round pod, lodged badly
Bush Blue Lake	ST	55	394 b-h	19.8	25.5	2.0	2.4	4.1	1.3 f	2.8	2.3	5.8	2.4	Round pod
Dusky	SW	56	388 c-h	15.0	20.5	3.4	2.9	3.0	2.0 c-f	3.5	3.5	5.5	3.4	Round pod
Savannah	HM	55	358 c-h	20.5	20.5	4.3	4.3	4.1	1.8 def	3.9	4.0	4.8	4.1	Glossy, round pod, v. attractive, good raw
Hickock	HM,SW	54	322 d-h	18.5	21.0	3.6	3.6	3.3	2.8 abc	4.0	3.6	5.2	4.1	Glossy, round pod, varies from dark to med. green
Crockett	HM,SW	60	317 fgh	17.8	19.0	5.0	4.1	4.3	2.8 abc	4.3	3.3	5.3	3.6	Slender, glossy, round, dark, attractive, crunchy, good raw
Boone	HM,SW	60	292 fgh	20.5	23.3	4.6	4.5	4.5	3.5 a	4.1	3.6	5.1	3.6	Dark, glossy, attractive, round
Greencrop	SW	52	286 gh	17.3	22.5	1.6	2.1	4.1	1.3 f	1.9	2.9	7.8	2.8	Flat pod
Concesa	HM	55	284 gh	21.3	20.5	4.8	4.3	3.9	3.5 a	4.3	3.1	5.5	3.3	Plants break at base, attractive, round pod
Masai	SW	55	234 h	18.5	16.8	4.0	3.6	2.6	2.5 bcd	3.3	3.8	4.5	4.3	Small, slender, round pod, attractive

1 Means in the same column followed by the same letters are not significantly different (Waller-Duncan multiple range test LSD P = 0.05).
2 Plant habit: 1 = prone; 3 = moderate; 5 = erect.
3 Pod position: 1 = all pods on ground; 3 = just off ground; 5 = high.
4 Plant stand: 1 = poor; 3 = average; 5 = excellent.
5 Virus rating: 1 = no virus; 5 = all leaves with symptoms.
6 Pod color: 1 = light; 3 = medium; 5 = dark green.
7 Pod straightness: 1 = J curve; 5 = straight.
8 Pod uniformity; 1 = poor; 3 = average; 5 = excellent.

very low in fresh bean visual appeal and cooked taste and texture, but Magnum ranked at the top in cooked visual appeal. Evaluators were unable to differentiate taste differences in the canned product, since all varieties became soft and mushy (data not shown). This may be because the beans had been harvested in a less mature state for the fresh market.

Acknowledgments

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Table 2. Visual and taste ratings for fresh green beans.

Variety	Visual Appeal RAW (1-5)[1]	Visual Appeal COOKED (1-5)[1]	Taste COOKED (1-5)[1]	Texture COOKED (1-5)[1]	Visual + COOKED Ratings	Likely to purchase after seeing and tasting (% responding Yes)[2]
Brio	4.9	3.8	3.2	3.9	15.8	67%
Pony Express	4.1	3.4	3.6	3.7	14.8	67%
Caprice	4.0	3.4	3.7	3.4	14.5	56%
Boone	3.8	3.6	3.4	3.6	14.4	44%
Tema	3.9	3.6	3.3	3.6	14.4	78%
Savannah	4.0	2.8	3.7	3.6	14.1	67%
Cabot	3.8	3.2	3.7	3.4	14.1	44%
Bush Blue Lake	3.9	3.8	3.3	3.1	14.1	22%
Espada	3.8	3.4	3.1	3.3	13.6	67%
Lewis	3.7	3.2	3.3	3.2	13.4	56%
Dusky	3.6	3.3	2.7	3.1	12.7	11%
Concesa	4.0	2.6	2.9	3.1	12.6	33%
Masai[3]	3.4	3.0	2.6	2.8	11.8	26%
Prevail[3]	3.2	3.2	2.8	2.6	11.8	28%
Storm	3.6	3.2	2.7	2.3	11.8	44%
Jade	3.4	3.2	2.7	2.3	11.6	22%
Magnum	3.2	3.9	2.1	2.3	11.5	22%
Crockett	4.0	2.4	2.2	2.6	11.2	11%
Hickock	3.2	2.9	2.4	2.4	10.9	11%
Greencrop	2.7	2.8	2.1	2.3	9.9	11%

1 Rating 1 = poor; 5 = excellent
2 Participants = 9 (2 males, 7 females); All liked green beans; Frequency of eating green beans: 44% weekly; 33% more than once a week; 22% twice a month
3 Only 5 evaluators

Cultivar Evaluations and Fungicide Programs for Managing Powdery Mildew on Pumpkin

Kenneth Seebold, Department of Plant Pathology; Timothy Coolong and Lucas Hanks, Department of Horticulture

Introduction

Powdery mildew (PM), caused by the fungus *Podosphaera xanthii*, is a serious constraint to pumpkin production in Kentucky each year. Cultural practices, cultivar disease resistance, and fungicides are employed to manage PM. Pumpkin cultivars commonly planted in Kentucky have varying levels of resistance to PM, and planting them can allow the use of fungicides at reduced rates or on longer spray intervals. However, conditions often favor PM, so fungicides are usually needed to sufficiently suppress the disease. This report describes an experiment designed to evaluate three fungicide programs (no input, minimum input, and maximum input) on three cultivars of pumpkin (no resistance to PM, low-to-moderate resistance, and moderate-to-high resistance) to determine if fungicide requirements could be lowered or eliminated by employing host resistance while maintaining acceptable yields and quality.

Materials and Methods

The experiment was conducted at the Horticultural Crops Research Station in Lexington. The cultivars planted were Howden (no PM resistance), Aladdin (low-to-moderate resistance), and Camaro (moderate-to-high resistance). Resistance levels were determined in a previous trial (Coolong and Seebold,

Table 1. Effect of cultivar and fungicides on the severity of powdery mildew and yield of pumpkin, Lexington, KY 2010.

Treatment	PM Severity AUDPC[c]		Yield/A Cwt[e]		Yield/A Number		Yield/A Avg. Fruit Wt. (lb)	
Fungicide Effect								
Untreated check	1275	a[d]	126	b	1157	b	10.4	a
Initiate 2 pt/A[a]	912	b	164	ab	1432	ab	11.3	a
Rally 40WSP 5 oz/A alt. with Initiate 2 pt/A[b]	607	c	187	a	1707	a	10.6	a
Cultivar Effect								
Camaro	269	b	256	a	2104	a	12.1	a
Aladdin	1183	a	128	b	1237	b	10.8	ab
Howden	1480	a	72	c	811	b	8.8	b

a Initiate 720SC (chlorothalonil) applied on 16 Aug, 27 Aug, and 6 Sep (10-day schedule).
b Rally 40WSP alternated with Initiate 720SC, applied on 16 Aug, 27 Aug, and 6 Sep (10-day schedule).
c PM severity: overall (season-long) severity of PM as determined by the area under disease progress curves (AUDPC) calculated from severity ratings taken on 23 Jul, 17 Aug, 25 Aug, 2 Sep, and 10 Sep.
d Means in the same column followed by the same letter do not differ significantly as determined by Fisher's protected LSD test ($P \leq 0.05$). Statistics for foliar disease severity were calculated on arcsin-transformed means; non-transformed means are reported in the table.
e Cwt refers to 100 weight per acre, 1 cwt equals 100 lb.

2008). Pumpkins were seeded into 128 cell trays on 7 June and greenhouse-grown for four weeks until planting on 15 July. Plants were transplanted using a tobacco setter into bare-ground raised beds. Beds were spaced on eight-ft centers, and plants were spaced four ft apart within rows. Two plants were placed in each hole. Each plot consisted of ten plants (five hills) and plots were separated by 12 ft within rows. Plots were arranged in a strip-plot design with fungicide treatments comprising the main plots (strips), and the three varieties representing sub-plots within the main plot. Each cultivar was replicated four times within each fungicide treatment, with each replication containing ten plants of each cultivar. Drip irrigation tape was placed on the surface of each bed to provide supplemental water. Approximately 70 lb/A of nitrogen were incorporated pre-planting using 19-19-19. After seedling establishment plants were fertilized with a broadcast application of ammonium nitrate at a rate of 50 lb/A of nitrogen such that the total (preplant + fertigation) nitrogen application for the season was 120 lb/A.

Command (clomazone) herbicide was applied to areas between plots while within-row spaces were hand-cultivated as needed after vines began to run. No maintenance fungicides were used during this study. Admire (imidacloprid) was applied to the soil at transplanting for control of cucumber beetles. Capture (bifenthrin) was applied at approximately eight and ten weeks after seeding to control squash bugs and cucumber beetles.

Two fungicide programs were initiated when symptoms were first observed in the disease-susceptible border rows. The first was a low-cost program, spraying Initiate 720SC (chlorothalonil) at 2 pt/A on a 10-day schedule (16 Aug, 27 Aug, and 6 Sep). The second program, the UK standard (higher cost), consisted of Rally 40WSP at 5 oz/A, alternated with Initiate 720SC at 2 pt/A on a 10-day schedule (same dates as the first treatment). Unsprayed plots of each cultivar served as controls. Applications were made with a CO_2-powered backpack sprayer equipped with a three-nozzle hand boom fitted with TX-18 hollow-cone nozzles (20-in. spacing). Application volume was 40 GPA, and sprayer pressure was 7 psi.

Powdery mildew evaluations started on 23 July to gather baseline data, then resumed at the first sign of symptoms on 17 August and continued on an eight-day schedule until 10 September. The upper and lower canopies of plants were separately evaluated using a 0-5 scale where 0 = no symptoms, 1 = 1%, 2 = 10%, 3 = 30%, 4 = 60%, and 5 = 100% of the upper and lower canopies having 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*x2), where x = assigned rating.

Table 2. Severity of powdery mildew and yield of pumpkin as influenced by host resistance and fungicide programs, Lexington, KY, 2010.

Cultivar	Fungicide Program	PM Severity AUDPC[c]		Yield/A Cwt[e]		Yield/A Number		Yield/A Avg. Fruit Wt. (lb)	
Camaro	none	358	d[d]	222	abc	1769	ab	12.5	a
Camaro	Initiate[a]	268	de	262	ab	2178	a	11.9	ab
Camaro	Rally + Initiate[b]	179	e	285	a	2382	a	12.0	ab
Aladdin	none	1667	ab	77	ed	907	bc	10.1	abc
Aladdin	Initiate	1195	ab	129	cde	1157	bc	11.3	ab
Aladdin	Rally + Initiate	686	c	166	bcd	1565	ab	10.7	abc
Howden	none	1975	a	47	e	590	c	7.9	c
Howden	Initiate	1392	ab	89	ed	862	bc	10.2	abc
Howden	Rally + Initiate	1074	bc	85	ed	998	bc	8.7	bc

a Initiate 720SC (chlorothalonil) applied on 16 Aug, 27 Aug, and 6 Sep (10-day schedule).
b Rally 40WSP alternated with Initiate 720SC, applied on 16 Aug, 27 Aug, and 6 Sep (10-day schedule).
c PM severity: overall (season-long) severity of PM as determined by the area under disease progress curves (AUDPC) calculated from severity ratings taken on 23 Jul, 17 Aug, 25 Aug, 2 Sep, and 10 Sep.
d Means in the same column followed by the same letter do not differ significantly as determined by Fisher's protected LSD test ($P \leq 0.05$). Statistics for foliar disease severity were calculated on arcsin-transformed means; non-transformed means are reported in the table.
e cwt refers to 100 weight per acre, 1 cwt equals 100 lb.

Results and Discussion

Temperatures were significantly above normal and rainfall was well below normal during the trial, and conditions were moderately favorable for developing PM. Yields in 2010 were much lower for all treatments than in 2009 (data not shown). Much of this decrease seems to be due to a decrease in average pumpkin size, though numbers of pumpkins also decreased in 2010 compared to 2009. 'Camaro' was the highest yielding cultivar, followed by Aladdin and then 'Howden,' regardless of fungicide treatment (Table 1). 'Camaro' had the highest yields, resulting from large numbers of fruit per acre. Aladdin had statistically lower yields than 'Camaro,' with similarly sized fruits, but much fewer per acre. 'Howden' had yields that were significantly lower than both Camaro and Aladdin. The yields of all cultivars increased when plants were subjected to either fungicide program, but because of plot sizes and variations, the yield increases between the two fungicide programs were not significantly different. There were no fungicide-by-variety interactions for yield.

Cultivars differed significantly in their susceptibility to PM (Table 1), as was demonstrated in previous studies. As in the 2009 trial, 'Camaro' was affected the least while 'Howden' showed the highest disease severity, with severity values five times greater than those of Camaro. Overall, the alternation of Rally 40WSP and Initiate 720SC, averaged across cultivars, gave significantly greater suppression of PM than the untreated control or Initiate alone. The Initiate-only program also had significantly less disease compared to the control. No significant weight-per-acre differences were found between the two programs. Numerically, though, fungicide treatments gave somewhat greater weight-per-acre than the control, with the Initiate/Rally alternation having the highest weight.

Within individual cultivars, Initiate applied on a 10-day schedule did not differ significantly from the untreated control. However, the alternation of Rally and Initiate significantly suppressed disease on all three cultivars (Table 2), providing a 50-60% reduction in PM severity. More importantly, untreated 'Camaro' had significantly less PM severity than either 'Howden' or 'Aladdin' treated with the alternation of Rally and Initiate. No differences in disease were observed between any fungicide treatment on 'Camaro.' Yield was similar between fungicide treatments for each variety. A trend towards greater yield for the Rally and Initiate alternation was seen for all cultivars.

Data from the trial indicate that a variety such as 'Camaro,' with high resistance to PM, can eliminate the need for fungicides during moderate disease pressure. In years or locations that favor higher levels of PM, reduced fungicide inputs would likely suffice to acceptably control disease while maintaining acceptable yields. When varieties with little or no resistance to PM are planted, a PM-specific fungicide such as Rally 40WSP will be required plus a protectant fungicide such as chlorothalonil to provide adequate suppression of disease.

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Understanding Cucurbit Pest Phenology in Central Kentucky

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Production of cucurbit crops present growers with a number of challenges. Several insects are severe pests by themselves as foliage and fruit feeders or stem and root borers but are of even greater concern when they vector the plant diseases bacterial wilt and yellow vine decline. For any system to be considered a candidate for integrated pest management, basic understandings of the insects involved and their ecological activity are needed to make assessments and ultimately, management decisions. The goal of this study was to gain a better understanding of the seasonal activity of several key pests in Kentucky cucurbit crops, namely: the striped cucumber beetle (*Acalymma vittatum*), squash bug (*Anasa tristis*), and squash vine borer (*Melittia cucurbitae*).

Materials and Methods

To estimate the date of first spring emergence of striped cucumber beetles and squash bugs, trays of squash seedings (Blue Hubbard variety) were started in 72-cell trays a checker-board pattern (i.e., every other cell was planted). Seedlings were grown in a glass house for three weeks prior to field deployment under the following conditions: 25/21° C (day/night temperature), 16:8 hours (light:dark). Seedlings were watered as needed and provided with 20-20-20 fertilizer at 10 days post seeding.

Six trays were placed at dispersed locations across the UK's Horticulture Research Farm (South Farm) in Lexington, KY. Three of the locations at South Farm were located within the organically managed section, while the other three were placed near areas of the farm with a history of cucurbit production and managed conventionally. An additional four trays were placed in areas of the entomology section of the University of Kentucky's Spindletop Research farm near Georgetown, KY. Trays were marked with orange plot flags and placed upon 2 ft by 4 ft pieces of 3/8 in. plywood to facilitate visibility and weed control. Trays were replaced at regular seven-day intervals, beginning on 23 April 2010 and ending on 4 June 2010. At three, five, and seven days post deployment, trays were visually searched for striped cucumber beetles and squash bugs. All specimens were collected from the trays and stored in 95% ethanol.

To monitor activity of the key cucurbit pests throughout the season, a small plot of cucurbits grown on black plastic (six-ft-row centers) with drip irrigation was established in the entomology section of the Spindletop farm. Two parallel rows each of winter squash (Betternut 304 variety) and muskmelon (Strike variety) were planted at three or two ft in-row spacing, respectively. Seedlings were provided by the University of Kentucky, Department of Horticulture's organic research unit and were approximately three weeks old at the time of planting on 2 June 2010. Following planting, five plants within the first 50 ft of the each row were selected at random and visually inspected for the presence of adult striped cucumber beetles or any stage of the squash bug twice weekly from 4 June 2010 through 13 August 2010. Weed control was accomplished through the use of 4-ft-wide landscape fabric (weed mat) between the rows of plastic.

Monitoring for squash vine borer was conducted through the use of two Texas cone traps set on opposite ends of the phenology plot at the Spindletop Farm and an additional trap at the South Farm. All traps were set on 4 June 2010 and baited with pheromone lures (Great Lakes IPM), which were changed every two weeks until the end of the study (13 August 2010). Traps were serviced twice weekly during this period.

Results and Discussion

Through our observations of the seedling trays, striped cucumber beetle was first observed on the Blue Hubbard squash trays early May. While they were observed in great numbers, these trays did represent the only available cucurbits in the field on this farm in early May. (Figure 1). Squash bugs were also found to be attracted to the trays by late May.

Very similar seasonal patterns were observed for striped cucumber beetle in the squash and melon plots, with the largest peak in observations being in early to mid-July, which coincided with peak flowering in this plot (Figure 2). Because the squash bug undergoes gradual metamorphosis and nymphs feed similar to the adults, it can cause damage due to feeding throughout its development that continues as a winged adult. Although we initially observed a few of these insects on the seedling trays, they were not detected in the phenology plots until two weeks later. Once there, however, masses of eggs were found immediately. By observing the nymphs as they developed, we were able to estimate the dates when important transitions between life stages were occurred in the field (Figure 3). Specifically, within a week of observing adults, hatchling nymphs were present, which are the optimal target stage for foliar chemical control and by mid July, very late stage nymphs were observed, indicating that the 2nd generation of adults would subsequently follow.

Squash vive borer observations were somewhat sporadic, and though further investigation is warranted, they were generally highest in mid-June and again in mid-to-late July (Figure 4). Also of note is that on the same date of first trap capture, adult moths were observed at both UK farms as well as on a private farm in Boyle county, KY, which indicates a reasonable level of sensitivity for this trapping method. The squash vine borer trapping data appear to indicate that there may be two generations that occurred during the summer separated by about one month.

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Figure 1. Early observations of striped cucumber beetle on trays of seedlings.

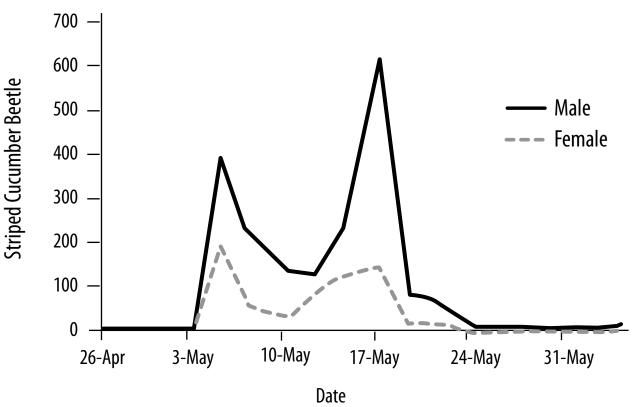


Figure 2. Seasonal observations of striped cucumber beetle in winter squash and muskmelon plots.

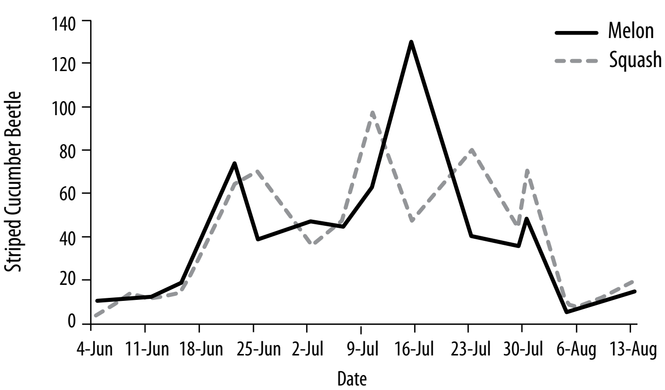


Figure 3. Total adult squash bugs observed in winter squash plots.

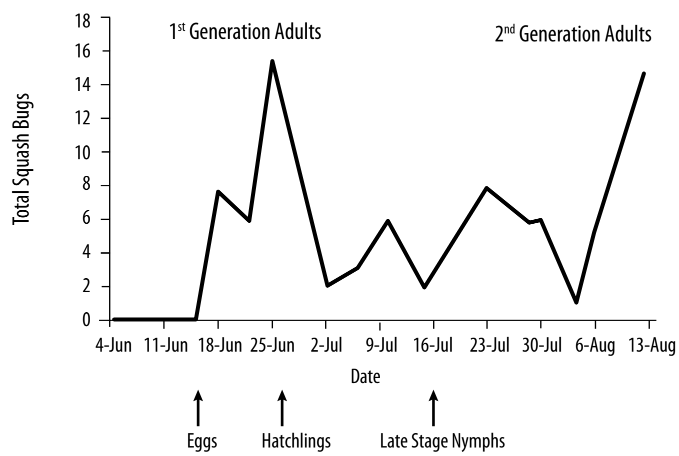
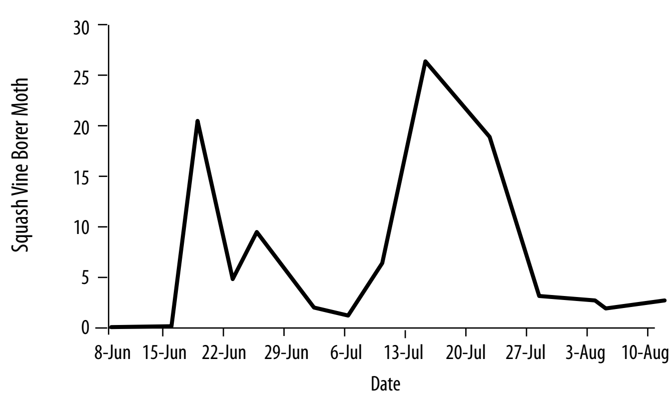


Figure 4. Total trap captures of squash vine borer.



Development of Organic Melon Production Methods to Control Bacterial Wilt

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Introduction

The warm, humid Kentucky summer climate produces many challenges for organic vegetable growers. Organic cropping systems have been researched, developed and promulgated by the University of Kentucky for many vegetable crops; however, growing many types of cucurbits is considered a challenge due to the presence of bacterial wilt of cucurbits. This disease, which is vectored by cucumber beetles, can lead to 100% cucurbit crop failure depending upon beetle populations and infection rates.

Bacterial wilt is vectored by striped and spotted cucumber beetles *(Acalymma vittatum (Fabricius) and Diabrotica undecimpunctata, respectively).* The beetles vector bacterial wilt to cucurbits by either depositing bacterially infected frass on plants where bacteria later enter plant wounds and proliferate or by transferring bacteria from chewing mouthparts directly into the plant during insect feeding. Bacterial wilt progresses as xylem-inhabiting bacteria that lead to wilting and subsequent death of the cucurbit plant. Vegetables harvested from infected plants typically develop internal rot after harvest and are unmarketable. Field identification of bacterial wilt entails observation of the visible plant symptoms and the characteristic vascular bacterial streaming between separated plant parts.

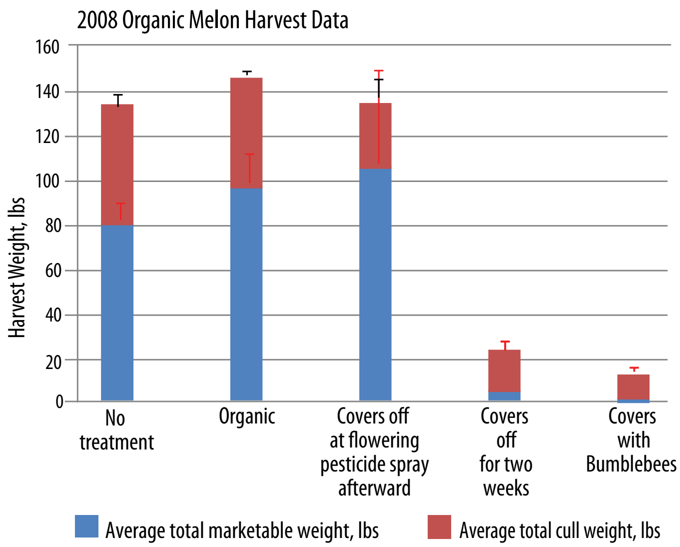
Farmers typically try to exclude beetles from cucurbit crops as a way to lessen disease; however, specific reliable organic crop production methods have not been developed for this region. Current regional organic production methods are included as a treatment in this project. To further develop successful production of organic cucurbits, this project was organized to develop an organic production system to control cucumber beetles on melons. This paper discusses three summers' field effort to implement a row-cover system of cucurbit production using row covers.

Materials and Methods

The project location is the UK Horticulture Research Farm of the University of Kentucky in Lexington, Kentucky. This project was conducted on an approximately 110-by-210-ft plot within the organic research area on the farm. The soil is a silt-loam Maury series. A cover crop of hairy vetch and rye was grown on the site prior to preparation of the site for vegetable production. Treatment sites consisted of three parallel rows of 30-ft length, with a 10-ft buffer between the adjacent treatment beds. Plants were grown using a plasticulture production system. Muskmelons variety 'Athena' were used for this project. The greenhouse-germinated seedlings were transplanted using a waterwheel setter. The site was maintained during the season by mechanical and hand weeding.

The main treatments for the three field seasons consisted of a (1) control with no treatment, (2) organic standard production method, which consisted of laying row cover fabric over the crop to exclude beetles until flowering and then uncovering the crop until the end of the season with organic pesticides applied as needed, and (3) the preferred method, which included row-cover fabric until flowering, uncovering for two weeks with organic pesticides applied as needed and then recovering with the row-cover fabric until harvest. Additional treatments were included in the project, testing different approaches including bumblebee pollination, opened ends of row covers, and shorter duration uncovering for pollination.

Figure 1. 2008 Season average harvest weights by treatment.



Results and Discussion

The first-year results were impacted by an aphid infestation, which significantly reduced the treatment options under covers. Application of lady beetles or similar aphid parasites at appropriate times while the crops are covered will keep the aphids in check.

The 2008 season results are displayed in Figure 1 with the reporting data as the combination of the treatment average cull harvest weight and the treatment average marketable weight as an indicator of pollination success. Ultimately the success of pollination is the objective of the preferred method, since the treatment reduces the amount of time the plants are open to pollination.

In season 2009, temperatures were cool for the month of July, delaying the harvest for several weeks (Figure 2). However, the cooler temperatures did not cause significant crop yield reduction beyond bacterial wilt infection.

For the 2010 season, temperatures hovered in the 90s for about two weeks during the ripening stage of the crop (Figure 3). This duration of high temperature is unusual for this region. The harvest yield was somewhat less than in previous years.

Figure 2. 2009 Season average harvest weights by treatment.

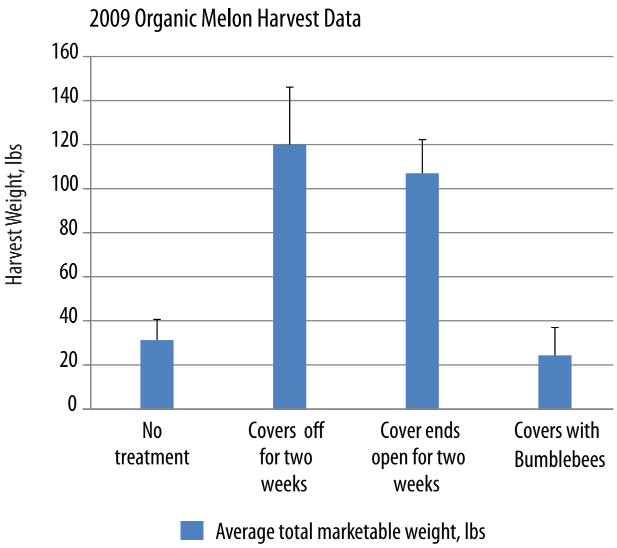
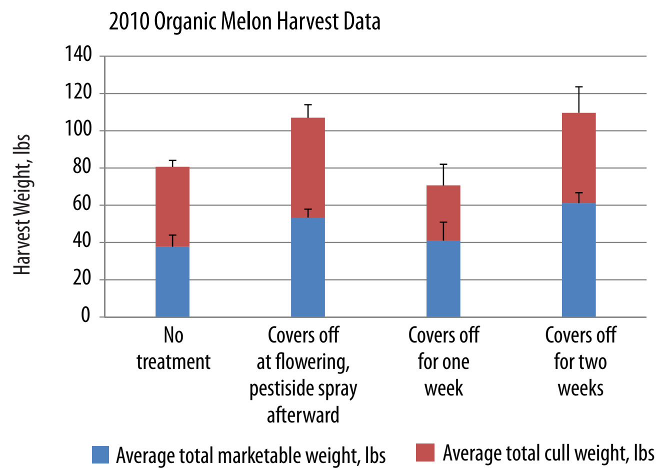


Figure 3. 2010 Season average harvest weights by treatment.



Conclusions

The preferred treatment method detailed in this research (continuous row covers until flowering, removal for two weeks and replacing covers until harvest, organic pesticide sprays while crop uncovered) has advantages over the standard organic treatment method for this region in that it increases the crop protection from Bacterial Wilt while at the same time reducing the amount of pesticides required to protect the crop from flowering to the end of the season.

The preferred method allows for pollination similar to that of the standard organic production, suggesting that we do not lose yield by excluding pollinators for the remainder of the season. The standard organic method and the preferred method were not significantly different in pollination/yield.

The additional treatment refinement in 2010, investigating whether one or two weeks of natural pollination would have a significant effect, found that two weeks uncovered provided a statistically significant increase in pollination/yield over one week of uncovered pollination. The preferred method provided essentially the same results as the standard organic production method while providing additional crop protection and reduced costs.

Weed Control Effectiveness of Hay and Straw Mulches Between Plastic-covered Beds

John Wilhoit, Department of Biosystems and Agricultural Engineering, and Timothy Coolong, Department of Horticulture

Introduction

Black plastic mulch, used extensively in vegetable production systems, has great weed control benefits, but weed control between the rows can still be a significant challenge. Weeds can hinder access for crop maintenance and harvesting activities, and the crop growth can be adversely affected from shading if the weeds get large enough (Law et al., 2006). Weed control is especially challenging for organic or sustainable growers who do not use chemical herbicides.

Using hay and straw mulches between plastic-covered beds is a non-herbicide weed control option that many growers like because they can get the mulch up over the edge of the plastic, helping to smother out weeds where they are hard to control by other methods, and the decomposed mulch incorporates readily at the end of the season, helping to add organic matter to the soil (Waterpenny Farm, 2009; Roxberry Farm, 2009). Mulch can also help keep soil from splashing onto beds when it rains (Stall, 2008). Weed control effectiveness can depend on the quantity of mulch used. Schonbeck (1996) considered 7 to 10 tons of hay or straw per acre sufficient for substantial weed control, while four to five tons per acre was not. Introducing weed seed is a concern with the hay mulch, however, and straw from harvested grain can introduce grain seed that can also be a weed problem (Stall, 2008; Relf and McDaniel, 2004). Other disadvantages of hay and straw mulch include the high cost of purchasing enough material to get sufficient weed suppression and the difficulty of applying the materials in such quantities, especially for larger-scale operations (Schonbeck, 2009).

In 2006 a study was conducted at the UK Horticulture Research Farm designed to specifically assess the weed control efficacy of organic mulches used between rows of plastic mulch

(Law et al., 2006). Wheat straw and other organic mulches were used in organically managed bell pepper production. In the first year of the study, when the mulches were applied early in the season without any prior mechanical cultivation, weed control was very poor in all of the treatments, resulting in a near crop failure. However, in the second season when treatment application was delayed until the plots had been shallow cultivated several times to control early weeds, the organic mulches provided good weed control throughout the harvesting season. According to Schonbeck (1996), many growers cultivate for the first several weeks after planting and then apply mulch for effective weed control for the remaining part of the season.

An alternative to the use of new hay or straw for mulching that can cut costs substantially is to use old or spoiled hay that is no longer good for animal feed (Stout, 1998). It is not known what effect old or spoiled hay might have on the viability of weed seed. Using hay from an early first cutting is a practice that one farm indicated could decrease the amount of weed seed present (Roxberry Farm, 2009). Using round hay or straw bales that can be rolled out between beds is a way to cut down on the effort required to put out the mulch, but considerable effort is still required for larger operations (Delate, 2003, Waterpenny Farm, 2009).

A three-point hitch-mounted round bale unroller modified to offset the bale allows a tractor to straddle a row of plastic and unroll round bales of hay or straw between the rows. This implement was used in both the 2009 and 2010 seasons to apply different hay and straw mulch treatments to watermelon plots at the UK Horticulture Research Farm. The study investigated the effects of different factors on weed control, including the type, quantity, and age of the mulching material used. The age of the hay and straw was of interest in case it had any effect on the viability of seed introduced with the hay or straw bales.

Materials and Methods

In 2009, hay and straw mulches were applied between the plastic-covered beds used to grow watermelon. Watermelon seedlings were planted on 6 July in beds on 8-ft centers covered with black plastic (48 inches wide). The bare ground between beds was cultivated 16 July to remove weeds. Round bales of hay and straw mulch treatments were applied 20 July using the offset round bale unroller. Three different hay/straw mulches were used, including: 1) new wheat straw, 2) new mixed grass hay, and 3) old (1 year) mixed grass hay. The new and old hay bales came from the same field, and both were first cuttings. The mulches were applied in two thicknesses, one rolling the bales out once (approximately 4 in. thickness), and the other rolling the bales out twice (approximately 8 in. thickness). The experimental design used was a randomized block with 2 thicknesses x 3 mulch treatments + control, with four replications of each of the seven treatments. Treatment plots were 35 ft long.

Mulch biomass was measured the day after application by collecting all of the mulch between two boards spaced 3 ft apart laid between the edges of the plastic and weighing the mulch in the field. The mulch was then returned and spread on the area. Weed biomass was determined at the end of the season, after most of the watermelons had been harvested, by collecting all aboveground weed material from within two different 4 ft x 2 ft rectangular frames placed within the 35 ft long plot. The weeds were oven-dried for 24 hours and then weighed. Weeds were collected on 30 September.

In 2010, hay and straw mulches were again applied between the beds used to grow watermelon. This time the watermelon rows were on planted on 7-ft centers, because the wider spacing used in 2009 left a bare gap that required a lot of manual work to cover with mulch. The watermelon seedlings were planted on 21 June, and they were cultivated to remove weeds on 9 July. The hay and straw mulches were applied on 12 and 14 July. The same hay and straw mulches were used, but with the addition of one-year old straw, and they were again applied in two thicknesses. A randomized block design was used with 2 thicknesses x 4 mulch treatments plus control, with four replications of each of the nine treatments. Treatment plots were 32-ft long. Mulch biomass was collected and weighed two days after the mulch was applied, using the same methods as in 2009. Weeds were collected on 7 October and their mass was determined using the same methods as before.

Results and Discussion

Mulch biomass amounts were determined as a check on the thickness of the mulch applied. The results in tons/acre are shown in Table 1. In 2009, because of the wider row spacing, there was a gap that had to be filled in by hand between the layers of mulch rolled out from the bales and the edges of the plastic. Also, the freshly-baled wheat straw did not roll out in layers, but instead, the bale essentially fell apart when the net wrap was taken off, so the straw mulch treatment plots had to be spread mostly by hand. Despite the extent of manual spreading required, the biomass amounts applied were fairly consistent, although the amount in the double-thickness treatment plots tended to be somewhat less than twice that in the single thickness plots. Also, the straw mulch was a bit lighter than the hay mulch. In 2010, there was a heavy rain in the afternoon after the mulch treatments were applied, and many of the bales rolled out in much thicker layers than they had the previous year. Both of these factors contributed to the mulch biomass being much heavier than in 2009. The double mulch thickness was especially high for all of the mulches except the new straw. As in 2009, the new straw was lighter than the other mulches. Also as in 2009, the bales of new straw would not roll out in layers, but interestingly the bales of old straw would.

The weed biomass results for all of the mulch treatments are shown in Table 2, and the combined results comparing types of mulches and mulch thickness are shown in Table 3. The 2009 growing season was very wet, and the weed pressures were very heavy. Under these conditions, all of the mulch treatments were very effective in controlling weeds compared to the control of no mulch. Both the new and the old hay were somewhat more effective than the straw, although the straw was still quite effective in suppressing weeds. There was a considerable amount of wheatgrass in the straw mulch treatments, and this accounted for the higher amount of weed biomass. Although not a problem in these plots, such wheatgrass has been observed to be detrimental when wheat straw mulch was applied earlier in

Table 1. Hay and straw mulch biomass applied between plastic-covered beds, 2009 and 2010.

Mulch Treatment	Mulch Biomass (tons/acre)	
	2009	2010
New Hay 1x	9.80	16.1
New Hay 2x	16.2	39.6
Old Hay 1x	9.35	10.8
Old Hay 2x	16.8	33.5
New Straw 1x	8.31	9.00
New Straw 2x	12.7	12.2
Old Straw 1x		14.8
Old Straw 2x		34.2

Table 2. Oven-dried weed biomass for different hay and straw mulch treatments, 2009 and 2010.

	Weed Biomass (lb)	
Mulch Treatment	2009	2010
New Hay 1x	0.04	0.02
New Hay 2x	0.01	0.00002
Old Hay 1x	0.13	0.06
Old Hay 2x	0.10	0.0002
New Straw 1x	0.14	0.08
New Straw 2x	0.04	0.03
Old Straw 1x		0.01
Old Straw 2x		0.002
Control (no mulch)	1.17	0.17

Table 3. Oven-dried weed biomass for different types of mulch and mulch thicknesses, 2009 and 2010.

	Weed Biomass (lb)			
Mulch Types	2009		2010	
New Hay	0.03	b	0.01	c
Old Hay	0.01	b	0.03	bc
New Straw	0.09	c	0.05	b
Old Straw			0.003	c
Control (no mulch)	1.17	a	0.17	a
Mulch Thickness				
1X	0.04	a	0.05	a
2X	0.01	b	0.01	b

the season. The double mulch thickness was more effective in controlling weeds, but both thicknesses were very effective. The old hay appeared to be slightly more effective than the new hay in controlling weeds, but the difference was not statistically significant.

In contrast to the 2009 season, the weed pressures during the 2010 season were low in these particular plots due to a combination of very heavy rains initially that actually seemed to drown out weeds early on, followed by a prolonged very dry period. Accordingly, the weed biomass amounts in 2010 were much lower than in the previous season, and even the amounts of weeds in the control plots with no mulch were not detrimental. Nevertheless, all of the mulch treatments were significantly more effective in controlling weeds than the control. As in 2009, the double-mulch thickness was significantly more effective, but both were very effective. The new straw plots again had a fair amount of wheatgrass. Interestingly, there was considerably less wheatgrass in the old straw plots, possibly indicating that germination of wheat seed in the bales was suppressed from the bale sitting outside for a year. This seed germination suppression effect from the bales sitting for a year was not evident in the mixed grass hay bales either year. However, considering how effective all the hay mulch treatments were at controlling weeds both years, the extent of germination of any seed present in the hay bales themselves must have been quite low.

Conclusions

The results of these trials suggest that mixed grass hay can be an effective mulch for suppressing weeds between beds, at least for later season production, provided that early weeds are cultivated prior to mulch application. The hay was effective, even at lower application rates of 8-10 tons/A used in these trials. Seed brought in with the bales of hay did not seem to contribute to weed pressures in this study, but it is not known to what extent they might be a problem with hay that was not a first cutting or that was particularly weedy. Year-old hay, which could be a considerably cheaper mulching material, was as effective as new hay or straw. Wheat straw was an effective mulch, but these trials confirm that wheat seed brought in with the bales can germinate and become a weed concern. Sitting outside for a year did seem to diminish germination of wheat seed in the bales of straw but did not necessarily affect any seed in the hay bales. The round bale unroller was effective at rolling out round bales between plastic-covered beds, but inconsistency in the thickness of layers in the bale made it difficult to roll out round bales uniformly. Freshly-baled wheat straw used in these trials did not roll in layers as round bales of hay had. The bales sitting for a year seemed to cause the wheat straw to mat together better, allowing it to roll out in layers.

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Sumagic Foliar Spray Effect on Fruit Quality of Greenhouse Grown Tomato

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Introduction

Excess stem elongation is a major issue for greenhouse-grown tomato seedlings. Excessive height makes transplants more susceptible to mechanical damage and drought stress though shipping, marketing, and transplant to the field or home garden. A supplemental label for Uniconazole (Sumagic formulation, Valent Biosciences, Libertyville, IL) has been released allowing its use on select vegetable crops. It is currently only allowed to be applied as a foliar spray on a limited range of vegetable transplants (tomato, pepper, eggplant, tomatillo, ground cherry, and pepino). Uniconazole acts in plants by inhibiting the biosynthesis of gibberellins, causing plant height suppression by reducing internode elongation. Non-chemical methods to control transplant height include negative DIF (night temperatures higher than daytime temperatures), mechanical brushing, and light quality manipulation (Duman and Duzyaman, 2003; Garner and Bjorkman, 1997; Li, et al., 2000; Rideout and Overstreet, 2003). However, each of these methods requires a larger amount of time, energy, labor, and/or materials to effectively control height and may cause negative side effects. Mechanical brushing can be a viable control, but long-term brushing has shown to cause reduction in total number and weight of fruits in certain cultivars of tomato (Johjima et al., 1992). Research into Uniconazole use has shown that it is a viable alternative to these methods (Schnelle, 2009). The risk of delayed fruit set, reduced fruit size, and yield are still concerns in respect to the use of plant growth regulators (PGRs) in vegetables. Other PGRs such as chlormequat chloride, daminozide and ethephon have been applied to the foliage of tomato transplants in the greenhouse and were found to control the height of transplants without effect on fruit yield following planting in the field (Pisarczyk and Splittstoesser, 1979). In addition to fruit set and yield concerns there is also the possibility that PGRs could impact the accumulation of carbohydrates in the fruit-impacting fruit flavor qualities (Kataoka, et al., 2003; Zandastra, et al., 2006). Total soluble solids (Brix) is indicative of perceived fruit sweetness, and titratable acidity is indicative of perceived flavor intensity and sourness in tomato fruits (Auerswald, et al., 1999; Dirinck et al., 1989). This study was designed to determine whether or not application of Uniconazole to tomato transplants impact plant height at transplant, first flower and fruit set date, and the flavor qualities of the ripe fruits (soluble solids, titratable acidity, and juice pH).

Materials and Methods

Seeds of tomatoes 'Early Girl' and 'Old Time Tasty' were sown on 19 Feb. 2010 in 36-cell trays containing a growing substrate consisting of 6.5 sphagnum peat : 2 perlite : 1.5 vermiculite (v/v) (Sunshine LA4; Sun Gro Horticulture, Vancouver, BC, Canada). Beginning at the 2 true leaf stage all plants were fertilized at each irrigation with 15N-2.2P-8K at 150 mg·L^{-1} N (Peters 15-5-15; The Scotts Company, LLC., Marysville, OH). 'Early Girl' is a hybrid, and 'Old Time Tasty' is an open pollinated 'heirloom' variety. Both varieties are indeterminate types generally produced for retail sale as transplants to home gardeners. Uniconazole foliar sprays were applied with a hand sprayer at the 4 true-leaf stage at concentrations of 0, 5 or 10 mg·L^{-1}. When the plants reached the market ready stage for retail sale as transplants (50% of the plants showing 7-8 expanded true leaves) the plant height was measured and each plant transplanted into a 25-cm container filled with a growing substrate consisting of 6.5 sphagnum peat : 2 perlite : 1.5 vermiculite (v/v) (Sunshine LA4; Sun Gro Horticulture, Vancouver, BC, Canada). Twenty fruits were harvested at the table ripe stage (Workman et al., 1957). The procedure for processing the tomatoes is as follows: Each fruit, when collected, was weighed and graded by size and then taken to the lab. Once there, each fruit was quartered and the fanicula, placenta, and seeds were removed. The remainder was then blended in a homogenizer for thirty seconds and allowed to settle for ten minutes. Afterwards the juice was placed in a centrifuge for 15 minutes at temperature of 4 °C at 10,000 rpm. Once out of the centrifuge clear internatant was removed with a pipette and tested for total soluble solids, titratable acidity and pH. Total soluble solids (Brix) measurements were taken using a handheld refractometer. Juice pH was measured using a Corning pH meter. Titratable acidity data was determined by titrating to the endpoint pH of 8.2 with .1 M NaOH using 5mL of juice.

Results and Discussion

Flowering and fruiting time as well as fruit quality characteristics of greenhouse grown tomatoes 'Early Girl' and 'Old Time Tasty' were not adversely affected by treatment with Uniconazole applied at concentrations that effectively controlled excess stem elongation prior to transplant. All data are shown in Table 1. Uniconazole treated plants were between 22% and 34% shorter than the untreated control plants at the market-ready stage. 'Early Girl' plants were 27% and 22% shorter than the control plants following applications of Uniconazole, respectively. Lack of additional height suppression with increased Uniconazole concentration is consistent with data reported by Schnelle (2009). 'Old Time Tasty' showed a similar response pattern. Plants treated with Uniconazole at 5 and 10 mg·L^{-1} were 34% to 30% shorter than the untreated control plants, respectively. The facts that maximum height control is achieved at such a low concentration, only a single application is necessary, and Uniconazole is a relatively inexpensive chemical, making this a very low-cost option for tomato seedling height control in terms of materials and labor.

Uniconazole application had no effect on the dates of the first open flower or the first visible fruit. The first open flower date was 18 Apr. (±1 day) for 'Early Girl' plants and 16 Apr. (±1 day) for 'Old Time Tasty' plants in all treatments. Every plant's first flower successfully self-pollinated and produced a mature fruit. First visible fruit date was recorded when a pea-size fruit was visible. Both 'Early Girl' and 'Old Time Tasty' showed first fruit on 28 Apr. (±1 day) on all plants in all treatments.

While the weight of ripe fruits was variable, there were no significant differences in average fruit weight between fruit harvested from control plants and Uniconazole treated plants in each variety. 'Old Time Tasty' produced larger fruits that were more variable in weight compared to 'Early Girl' (Table 1). The first set of mature fruits showed no variation in flavor characteristics. As shown in Table 1, the total soluble solids in all fruits tested were 5.0 ±0.3 Brix, and the titratable acidity was 4.4 ±0.2 $g{\cdot}L^{-1}$ citric acid.

Previous studies have reported variable results following PGR application to tomato seedlings. In some studies Uniconazole and/or Paclobutrazol-treated seedlings actually flowered and fruited earlier and produced higher yields in field production conditions than untreated control plants (Souza, et al, 1999; Zandastra, et al. 2006). The hypothesis is that the more compact, PGR-treated seedlings experienced less drought stress, thus less transplant shock, following planting in the field. More research is needed to test this hypothesis. Other studies, however, reported reduced fruit yield from PGR-treated plants (Adler and Wilcox, 1987; Wang and Greg, 1990). These varied results highlight the need for additional studies to determine the proper chemicals, concentration, and application time to effectively control seedling height without impacting fruiting performance.

Table 1. The average plant height at the market ready transplant stage and the weight, total soluble solids content, titratable acidity, and juice pH of ripe fruits harvested from 'Early Girl' (section A) or 'Old Time Tasty' (section B) tomato plants treated with 0, 5, or 10 $mg{\cdot}L^{-1}$ Uniconazole foliar sprays at the 4 true-leaf stage.

Uniconazole Conc. ($mg{\cdot}L^{-1}$)	Plant Height (cm)	Average Fruit Wt. (g)	Soluble Solids (Brix)	Titratable Acidity ($g{\cdot}L^{-1}$)	Juice pH
Section A: 'Early Girl'					
0	21.0a[z]	107a	4.8a	4.4a	4.3a
5	15.4b	115a	5.1a	4.5a	4.2a
10	16.3b	113a	4.9a	4.4a	4.3a
Section B: 'Old Time Tasty'					
0	23.0a	177a	5.0a	4.3a	4.3a
5	15.2b	188a	5.0a	4.5a	4.3a
10	16.0b	108a	4.8a	4.3a	4.3a

[z] Means followed by a different lower case letter within section and column are significantly different by the Waller-Duncan K-ratio t test at $P \leq 0.05$.

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Soil Amendments Reduced Half-Life of Dimethazone in Agricultural Fields

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Introduction

Clomazone is a commonly used to control broadleaf weeds [1]. The high water solubility of clomazone (1.1 g L^{-1}) and vapor pressure (1.44×10^{-4} mm Hg) [2] are good indicators of its potential for water contamination and off-site movement from agricultural fields into runoff water, streams, and rivers, impacting aquatic organisms. Agriculture is a major industry in Kentucky. About 80% of the farmers are small, limited resource farmers. These farmers are seeking alternatives to synthetic fertilizers to temper the escalating production costs associated with the increasing costs of energy and fertilizers and the problems of soil deterioration and erosion associated with intensive farming systems. Many farmers in Kentucky currently use municipal sewage sludge (MSS) on their farms as alternatives to synthetic fertilizers. Biosolids is a term used by the water treatment industry that refers to treated MSS. Biosolids are the byproducts of domestic and commercial wastewater treatment plants after treatment using either high temperature (Louisville Wastewater Treatment Plant, Louisville, KY) or lime (Nicholasville Wastewater Treatment Plant, Nicholasville, KY) to reduce pathogens.

Recycling wastes such as MSS for use as a low-cost fertilizer has resulted in a positive effect on the growth and yield of a wide variety of crops and promoted the restoration of ecologic and economic functions of land. Agricultural uses of MSS have shown promise for a variety of field crops (e.g., maize, sorghum, forage grasses) and for production of vegetables for human consumption (e.g., lettuce, cabbage, beans, potatoes, cucumbers) [3]. The organic matter content of composted MSS is high, and its addition to agricultural soils often improves soil physical and chemical properties and enhances biological activities [4]. Most agricultural benefits from MSS compost application are derived from improved physical properties related to the increased soil organic matter content in addition to its value as a fertilizer. Composts provide a stabilized form of organic matter that improves the physical properties of soils by increasing nutrient and water holding capacity, total pore space, aggregate stability, erosion resistance, temperature insulation, and decrease of apparent soil density [5]. The U.S. Environmental Protection Agency (USEPA) approved the use of municipal solids for land farming because it decreases dependence on synthetic fertilizers and provides significant economic advantages. MSS contains organic matter and macro- and micronutrients important for plant growth. Sixteen elements out of the ninety found in plants, known to be essential for plant growth, are present in biosolids [6]. Biosolids also enhanced soil microbial activity and bioremediation [4].

The objectives of this investigation were to: i) quantify dimethazone residues in soil under three management practices (MSS, MSS mixed with yard waste compost (MSS + YW), and no mulch soil (NM); ii) monitor the mobility of dimethazone residues from soil into runoff and infiltration water under three management practices; and iii) study the impact of mixing soil with MSS and MSS+YW on the concentration of NO_3–N, NH_4–N, and phosphorus ions in runoff and infiltration (seepage) water following natural rainfall events.

Materials and Methods

A field study was conducted in summer 2008 on a Lowell silty-loam soil (2.6% organic matter, pH 7). The soil has an average of 12% clay, 75% silt, and 13% sand. Eighteen (18) standard plots of 22 × 3.7 m each were established on a soil of 10% slope. Plots were separated using stainless steel metal borders 20 cm aboveground level to prevent cross contamination between adjacent treatments. The soil in six plots was mixed with municipal sewage sludge (MSS) obtained from Metropolitan Sewer District, Louisville, KY at 15 t $acre^{-1}$ (on dry-weight basis). The soil in six plots was mixed with MSS and yard waste (YW) compost (1:1) at a total of 15 t $acre^{-1}$ (on dry-weight basis). Yard waste (obtained from Con Robinson Co., Lexington, KY) was made from yard and lawn trimmings and vegetable remains. The native soil in six plots was used as a no-mulch (NM) control treatment (rototilled bare soil) for comparison purposes. The commercial formulation of dimethazone, also known as clomazone or "Command 3ME" was purchased from Woodford Feed Co., 498 Lexington Road, Versailles, KY. Plots were sprayed with Command 3ME formulation on 12 June 2008 at the rate of 1.5 pt (1 pt = 0.5 liter) $acre^{-1}$ using a CO_2-pressurized sprayer equipped with a 2-m boom and nozzles set at 60 cm above the soil surface. Plots were planted on 13 June 2008 with 9-week old sweet potato *Ipomoea batatas* cv. Beauregard seedlings obtained from Bonnie Plants (Union Springs, AL) through Anderson County Farm Services (Lawrenceburg, KY 40342) at 10 rows $plot^{-1}$ against the contour of the land slope. Irrigation was provided by a drip system.

During the growing season, runoff water from irrigation and rain was collected and quantified at the lower end of each plot using a tipping-bucket runoff metering apparatus. A gutter was installed across the lower end of each plot with 5% slope to direct runoff to the collection bottles for measurement and sampling. Each of the 18 tipping buckets was calibrated (one tip represents 3L of runoff) and maintained to provide precise measure of amount of runoff per tip. Number of tips was counted using mechanical runoff counters (ENM Company, 5617 Northwest Highway, Chicago, IL 60646). Collection of samples in 3.79-L, borosilicate glass bottles was carried out through a flow restricted composite collection system (approximately 40 mL per tip were collected). Total runoff water lost per runoff event, per each 0.02-acre plot was used to monitor dimethazone residues, NH_4-N, NO_3-N, and phosphate mobility into runoff water. Ammonia (NH_4-N), nitrate (NO_3-N), and phosphate ions were determined by the selective ion electrode [7].

Eighteen (18) pan lysimeters were used to monitor water seepage in each of the three soil treatments and presence or absence of dimethazone residues in the vadose zone (the unsaturated water layer below the plant root). Lysimeters (4 square ft each) were tunnel installed 1.5 m underground at the end of each of the 18 runoff plots, leaving the soil column above it intact. Volumes of water collected were recorded following each rainfall or irrigation event. Soil samples were taken to a depth of 15 cm from the rhizosphere of growing plants within the treatments prior to and after Command 3 ME application during the course of the study. Soil samples (6 replicates per treatment) were air dried in dim light at room temperature for 48 h to a constant weight and sieved to size of 2 mm. Twenty g soil were refluxed with 250 mL of 0.25 N HCl for 3h in a Soxhlet apparatus to extract dimethazone (the active ingredient in Command 3 ME). Dimethazone residues were extracted from the aqueous acid solution by liquid-liquid partition with n-hexane. The hexane portion was then washed with 25 mL of a saturated sodium bicarbonate ($NaHCO_3$) solution, and the $NaHCO_3$ wash was then discarded as described by Antonious [8]. The hexane extracts were dried over anhydrous Na_2SO_4 and concentrated by rotary vacuum (Buchi Rotavapor Model 461, Switzerland) and N_2 gas stream evaporation to 1 mL final volume for quantification. Each concentrated extract was subsequently passed through a 0.45 µm GD/X disposable syringe filter (Fisher Scientific, Pittsburg, PA).

Aliquots of runoff water and infiltration water samples (300 mL) collected from the field plots were filtered through filter paper No. 1 to remove sediments, then transferred quantitatively to a Buchner funnel and passed through a Whatman 934-AH glass microfiber filter (Fisher Scientific, Pittsburgh, PA, USA) using vacuum filtration. Dimethazone was extracted by liquid-liquid partition with 100 mL of n-hexane. One µL (n=3) of the concentrated hexane extract containing dimethazone was injected into a gas chromatograph (HP 5890, Hewlett Packard, Palo Alto, CA) equipped with a NP detector. Quality control (QC) samples included three field blanks to detect possible contamination during sampling, processing, and analysis. Residues of dimethazone in soil and water samples were related to soil management technique, and statistically analyzed using ANOVA and Duncan's multiple range test for mean comparisons [9]. Dimethazone residues detected in soil were used to calculate half-lives ($T_{1/2}$) in each of the three soil treatments. Half-lives were calculated by regression using the methods described by Anderson [10] using the equation $T_{1/2} = \ln 2/K$, where K = -2.303 × slope of the line.

Results and Discussion

Initial concentrations of dimethazone residues is soil immediately after spraying averaged 3.2, 11.8, and 1.3 µg g^{-1} dry soil in MSS, MSS+YW mix, and NM (bare soil), respectively. This variation in initial deposits among the three treatments could be a result of variation in soil surface area per unit weight of sample and/or variation in soil bulk density (weight of the soil per unit volume) after addition of soil amendments. Previous results suggested that addition of YW compost to native soil reduced soil bulk density and increased soil interspaces in MSS+YW treatments.

Decline of dimethazone residues in soil as a function of time is presented in Figure 1. One day following Command 3ME application, dimethazone (the active ingredient in Command 3ME

Table 1. Average initial residues extracted one hour following spraying, dissipation constants, and half-life ($T_{1/2}$) values of dimethazone in native soil and soil incorporated with amendments in the rhizosphere of sweet potato plants grown at Kentucky State University Research Farm, Franklin County, Kentucky, USA.

Dependent Variable	Sewage Sludge Incorporated with Native Soil†	Sewage Sludge-Yard Waste Compost Incorporated with Native Soil	Native Soil
Initial Residues (µg g^{-1} dry soil)	3.2	11.8	1.3
Dissipation Constant (K)	0.028	0.037	0.016
$T_{1/2}$ Values (days)	25.1 b	18.8 b	43.0 a

† Each value in the table is an average of 3 replicates. $T_{1/2}$ values in a row accompanied by different letter are significantly different (P < 0.05) using ANOVA procedure.

Table 2. Dimethazone residues extracted from no-mulch soil and soil mixed with municipal sewage sludge (MSS) or MSS mixed with yard waste compost (MSS+YW) in relation to runoff and infiltration water volume collected under three management practices. Statistical comparisons were carried out among three soil management practices for each parameter.

Soil Treatment	Dimethazone (µg g^{-1} dry soil)	Runoff Water (Liter $acre^{-1}$)	Infiltration Water (Liter $acre^{-1}$)
YW + MSS	2.67 a	258.7 c	790 a
MSS	0.96 b	569.7 b	720 ab
No-Mulch	0.49 c	711.6 a	600 c

Values within a column accompanied by the same letter(s) are not significantly different (P< 0.05) using Duncan's Multiple Range test.

Table 3. Concentrations of dimethazone residues in runoff and infiltration water collected down the land slope from no-mulch soil and soil mixed with municipal sewage sludge (MSS) and MSS mixed with yard waste compost (MSS+YW). Statistical comparisons were carried out among three soil management practices for each parameter.

Soil Treatment	Dimethazone in Runoff Water (mg $acre^{-1}$)	Dimethazone in Infiltration Water (mg $acre^{-1}$)
YW + MSS	1810.9 c	190 a
MSS	6266.7 b	108 b
No-Mulch	14232 a	30 c

Values within a column accompanied by the same letter are not significantly different (P< 0.05) using Duncan's Multiple Range test.

Table 4. Concentrations of NO_3–N, NH_4–N, and phosphate ions in runoff water collected down the land slope of sweet potato field under three soil management practices. Statistical comparisons were carried out among three soil management practices for each parameter.

Soil Treatment	NO_3-N (mg $Liter^{-1}$)	NH_4-N (mg $Liter^{-1}$)	Phosphate (mg $Liter^{-1}$)
YW + MSS	14.9 a	17.0 a	2.5 b
MSS	12.9 a	16.4 a	6.0 a
No-Mulch	7.3 b	7.6 b	4.9 a

Values accompanied by the same letter are not significantly different (P < 0.05) using Duncan's Multiple Range test.

formulation) in the top 15 cm soil averaged 1.0, 2.1, and 4.45 μg g^{-1} dry soil in no-mulch (NM), MSS, and MSS+YW treatments, respectively. Figure 1 also indicates that in spite of the variability in dimethazone initial deposits among the three soil treatments, residues of dimethazone were detectable in soil and soil amended with compost for ninety days following Command 3ME spraying. Variation in the dissipation pattern among the three soil treatments could be attributed to dimethazone adsorption to soil organic matter. The two most important characteristics determining soil adsorption of a pesticide are the organic matter content of the soil and the water solubility of the pesticide. Soil organic matter has increased from 2.8% in native soil to 4.9 and 8.2% in MSS and MSS+YW amended soils, respectively (data not shown). Half-life ($T_{1/2}$) values of dimethazone in soil and soil mixed with amendments are presented in Table 1. Adsorption of nonionic pesticides on soil particles depends directly on the organic carbon content (K_{OC}) of the compound and the adsorbing phase. K_{OC} coefficient represents the sorption on a unit-carbon basis and can be used for comparison of sorption extent on soils with different organic matter contents. The greater the K_{OC} value of a pesticide, the stronger the binding to the soil [11, 12]. Dimethazone is highly soluble in water (1100 mg L^{-1}) and has a K_{OC} of 150-562 mL g^{-1}.[13] These properties indicate its potential for mobility and environmental pollution.

Addition of MSS+YW mix and MSS alone in native soil increased water infiltration, lowering surface runoff water volume compared to NM soil (Table 2). Surface runoff water volume from NM soil and MSS amended soil (712 and 570 L $acre^{-1}$, respectively) was significantly greater than runoff volume from soil amended with MSS-YW mix (259 L $acre^{-1}$). This may be due to reduced bulk density and increased soil interspaces in MSS+YW treatments that increased water infiltration into the soil column towards the vadose zone (the unsaturated water layer below the plant root), reducing surface water runoff down the land slope. Volume of infiltration water ranged from 600 L $acre^{-1}$ in NM soil to 790 L $acre^{-1}$ (32 % increase) in MSS+YW amended soil.

Results in Table 3 indicated that dimethazone was detected at 190 mg $acre^{-1}$ in infiltration water collected from MSS+YW mix, while dimethazone in infiltration water collected from no-mulch treatment averaged 30 mg $acre^{-1}$. On the contrary, runoff water collected from MSS+YW and NM treatments averaged 1,810 and 14,232 mg $acre^{-1}$, respectively. The concentrations of nitrogen as nitrate (NO_3 -N) and ammonia (NH_4-N) in runoff and infiltration water from three soil management practices varied among treatments (Table 4) and were all much higher than the limit of 10 mg L^{-1} allowed in drinking water. MSS contains great amounts of nutrients, especially N, P, and Ca. Phosphorus concentrations in sewage sludge reached levels comparable with super-phosphate fertilizer [14]. It should be emphasized that the concentrations of dimethazone, nitrate (NO_3 -N), ammonia (NH_4-N), and P detected down the land slope are for runoff and not receiving water. Portions of the pesticides and/or the runoff may be intercepted and the reminders would often be diluted by cleaner waters on reaching streams, ponds, and lakes. On the other hand, addition of amendments to native soil increased microbial activity as indicated by the increased activity of soil enzymes [4]. Soil microorganisms (bacteria, fungi, protozoa, algae) excrete a variety of enzymes that have been recognized as a primary means of degrading xenobiotics in soil. Degradation also included cleavage of the isoxazolidone N-C bond and complete removal of the isoxazolidone ring [15] from the dimethazone molecule, thereby decreasing dimethazone persistence in soil amended with MSS and YW compost. Considering that soil amendments increased soil water holding capacity, therefore, the decrease of dimethazone half-lives in soil mixed with MSS and MSS+YW treatments may have resulted from both greater microbial activity and increased soil moisture content. Soil management practices that reduce pesticide persistence and pesticide residue in soil and runoff water are vital to sustainable crop production.

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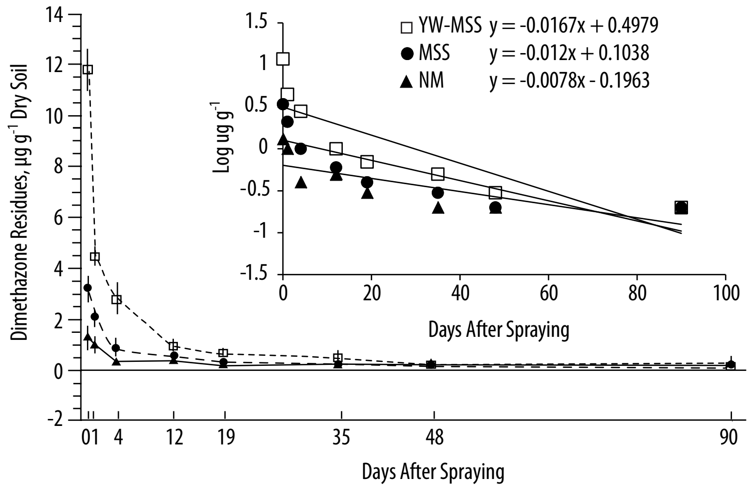
Figure 1. Dissipation of dimethazone residues in no-mulch soil and soil mixed with sewage sludge (MSS) or MSS mixed with yard waste compost (MSS+YW) following spraying under field conditions. Vertical lines indicate ± SD, where no line is shown, it is less than the size of the symbol.



Dissipation of Endosulfan on Field-Grown Pepper and Melon

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Introduction

The demonstration of the effectiveness of a pesticide is not in itself sufficient to recommend it for commercial usage. A pesticide and/or its metabolites must be safe for those who apply its formulations and it must leave no injurious residues on the edible portions of plants.[1-3] Endosulfan, a mixture of α- and β-isomers, is a broad-spectrum insecticide and is one of the organochlorine insecticides registered in the USA for control of insect pests on fruits and vegetables.[4,5] Endosulfan is one of the commonly used insecticides on vegetables in Kentucky.[5] Upon reaching the surface of plants, endosulfan is capable of penetrating the epidermis.[6] It is, therefore, not a systemic insecticide but a residual insecticide[7] that acts as a contact poison on chewing and sucking arthropods.

A number of re-entry studies indicated that dermal exposure is usually the most important pathway by which pesticides enter a field worker's body.[8, 9] The use of pesticides has been associated with many documented incidences of poisoning of agricultural workers who contact the plants or inhale dislodged residues during picking, stripping, thinning, pruning, and pinching crops.[10, 11] Establishing a re-entry period as a means of preventing exposure to pesticides allows toxic foliar residues to dissipate with time before workers come into contact with treated foliage.[3] The present work was designed to determine the magnitude and dissipation rate of endosulfan isomers and their major metabolite, the sulfate, on two leaf and fruit surfaces (bell pepper and melon) under field conditions.

Materials and Methods

In a complete randomized block design, pepper (*Capsicum annuum*) and melon (*Cucumis melo*) seedlings were planted at KSU Research Farm. After 45 d, plants were sprayed with endosulfan 3EC formulation at a height of 15-20 cm above the plant canopy at the rate of 0.44 kg A.I. in a total volume of 150 litre of water acre^{-1} using a 4-gallon portable backpack sprayer equipped with one conical nozzle operated at 40 psi (275 kPa). Pepper and melon fruits and leaves were collected from treated plants and untreated controls from the mid-canopy of plants at 1 h, 1, 3, 5, 7, 10, 14, and 30 days following spraying. Samples of pepper and melon fruits, 1-2 kg each, were collected at random for analysis of endosulfan residues. Unwashed fruits were quartered. Subsamples from the opposite quarters were collected, weighed, and kept frozen at -18° C until extracted. The frozen samples (0.5 - 1 kg of fruits) were macerated in a cutter-mixer, and a 100-g subsample was blended for 2 min with methylene chloride [CH_2Cl_2] + acetone (6+1) by volume; 150 mL). After homogenization, the mixture was vacuum filtered through a Buchner funnel containing a glass microfiber filter, Whatman 934-AH, of 55 mm diameter (Fisher Scientific, Pittsburgh, PA). The resultant liquid was quantitatively transferred to a separatory funnel containing methylene chloride (50 mL) and sodium chloride solution (40 g litre^{-1}; 50 mL), followed by liquid-liquid partition for 1 min. The CH_2Cl_2 extract was passed through anhydrous sodium sulfate and concentrated by rotary vacuum evaporator (Buchi Rotavapor Model 461, Switzerland) to a known volume.

Clean-up of plant extracts was carried out on an open glass chromatographic column (20 × 1.5 cm) packed with 6 g silica gel + magnesium oxide (2+1 by mass). The column was topped with a layer of anhydrous sodium sulfate (2 cm) and the adsorbent was first conditioned with hexane (50 mL), which was discarded. An aliquot of the concentrated extract was transferred to the column. The column was then eluted with acetone: hexane (20:80 by volume; 100 mL) which was collected in a 250-ml flask and concentrated by rotary evaporator at 35° C.

Alpha- and beta-endosulfan (6,7,8,9,10,10-hexachloro-1,5, 5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin-3-oxide) of 90% purity, and endosulfan sulfate (6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3- benzodioxathiepin-3,3- dioxide) of 98% purity were purchased from Drexel Chemical Company (Memphis, TN). Residues were detected and quantified on a Hewlett Packard (HP) model 5890A gas chromatograph (GC) equipped with a HP 5971 MSD operated in selective ion monitoring (SIM) and a HP 7673 automatic injector. Standards ranging from 10-50 ng mL^{-1} were prepared in hexane for GC-mass selective detection (MSD), and the unit areas were obtained using 1-µl injections. Linearity over the range of concentrations was determined using regression analysis. Recoveries from the leaf surfaces were evaluated by applying to the leaf surface a mixture containing 25 µg of each isomer or the sulfate metabolite. One mL of the same mixture was added to the fruit homogenate in the blender to achieve a concentration of 25 µg of each isomer or the sulfate metabolite g^{-1} fruit.

Recoveries of endosulfan isomers and endosulfan sulfate from fortified fruit samples ranged from 94 to 96% for α-endosulfan, 90 to 98% for β-endosulfan, and 92 to 96% for the sulfate metabolite. Recovery values from fortified leaf samples were 92 to 95%, 90 to 92% and 93 to 98% for α-, β-, and the sulfate metabolite, respectively. Quantification was based on average peak areas from two consecutive injections obtained from external standards prepared from each of the two isomers and the sulfate metabolite in hexane. Retention times of the α- and β-isomers and the sulfate metabolite were 23.5, 26.4, and 29.3 min, respectively. Residue data on plant tissues were used to calculate regression slopes and half-lives.[12] Half-lives were calculated from regression lines using the equation $T_{1/2} = \ln 2/K$, where K = -2.303 × slope of the line.

Results and Discussion

Commercial formulations of endosulfan contain two isomers and usually the α-isomer is more abundant than β-isomer.[4] The α-isomer is more volatile and less water soluble than the β-isomer. Following a single application of Endosulfan 3EC at 0.44 kg A.I. $acre^{-1}$, residue levels of the α-endosulfan on bell pepper and melon fruits declined over the 30-d study period (Table 1).

Endosulfan initial residues on the leaves (Table 2) were higher than on fruits (Table 1). This is because of the difference in surface area between fruits and leaves for the same unit weight of sample and could be also due to the position of the lamina. Endosulfan initial residues were somewhat greater on pepper leaves than on melon leaves. The dissipation of endosulfan residues following spraying indicated the relatively higher persistence of the β-isomer ($T_{1/2}$ = 2.5 days) on pepper fruits as compared to the α-isomer ($T_{1/2}$ = 0.95 days) during the experimental period (Table 3). Endosulfan sulfate, which is slowly degraded, both chemically and biologically,[13] was detected on the leaves and fruits as an oxidation product of the two isomers of endosulfan. The concentration of this transformation product fluctuated on the plant surface (Tables 1 and 2) and was not correlated with days after application of endosulfan. As a result, the formation and dissipation pattern of endosulfan sulfate on plant tissues during the experimental period could not be described by first order kinetics. Endosulfan sulfate is formed from the transformation of α- and β-isomers, which have different and irregular behaviors for conversion to the sulfate.[14] In addition to weather conditions that affect pesticide persistence on plants, the rate at which a crop grows greatly influences the apparent persistence of pesticide residues on the leaves and other parts because residues become diluted by a greater surface area as the plant grows.

The half-lives for each of the two isomers (Table 3) indicated that the β-isomer of endosulfan was generally more persistent than the α-isomer. Initial residues were higher on pepper than melon. These differences may be explained by the different cuticular wax composition, different thickness of wax deposition or more cracks in the cuticle of pepper fruits compared to melon fruits.

On pepper fruits, the α-isomer, which is the more toxic to mammals, dissipated faster ($T_{1/2}$ = 0.9 d) than the less toxic β-isomer ($T_{1/2}$ = 2.5 d). The persistence and degradation studies of endosulfan isomers in carnation plant (*Dianthus caryophyllus* L.) grown under greenhouse conditions revealed that the half-life ($T_{1/2}$) of the β-isomer was greater than that of the

Table 1. Residues of α-endosulfan, β-endosulfan, and endosulfan sulfate expressed as µg g^{-1} fresh fruit of melon and pepper collected at different time intervals following spraying with Endosulfan 3EC at 0.44 kg AI $acre^{-1}$ under field conditions.

	α-Endosulfan		β-Endosulfan		Endosulfan sulfate	
Time	Melon	Pepper	Melon	Pepper	Melon	Pepper
0	0.800	1.500	0.900	2.100	ND	ND
1	0.500	0.900	0.650	1.800	ND	ND
3	0.300	0.400	0.300	0.900	ND	0.100
7	0.050	0.100	0.100	0.500	0.050	0.150
10	0.010	0.060	0.060	0.200	0.130	0.200
14	0.010	0.030	ND	0.060	0.150	0.210
25	ND	0.010	ND	ND	0.180	0.230

ND not detectable.

Table 2. Residues of α-endosulfan, β-endosulfan, and endosulfan sulfate expressed as µg g^{-1} fresh leaves of melon and pepper collected at different time intervals following spraying with Endosulfan 3EC at 0.44 kg AI $acre^{-1}$ under field conditions.

	Endosulfan- I		Endosulfan- II		Endosulfan sulfate	
Time	Melon	Pepper	Melon	Pepper	Melon	Pepper
0	1.922	15.537	1.363	15.010	ND	ND
1	1.062	10.077	1.347	14.646	ND	ND
3	0.230	5.250	0.703	13.933	ND	35.551
7	0.012	0.297	0.041	2.522	12.662	52.270
10	ND	ND	0.015	1.813	14.329	59.435
14	ND	ND	0.011	0.859	17.599	ND
25	ND	ND	ND	ND	46.935	ND
31	ND	ND	ND	ND	ND	ND

ND not detectable.

α-isomer.[14] Studies on the dissipation of endosulfan isomers on chickpea under field conditions[15] indicated that the α-isomer was converted to the β-isomer in minor quantities, while it was converted into endosulfan sulfate on chickpea leaves in significant amounts. Although endosulfan sulfate was present in the same amount as the β-isomer in harvest pod covers, no α-isomer was detected in harvested grains or pod covers. Our study on bell pepper and melon also revealed that the β-isomer is more persistent than the α-isomer. The use of endosulfan on pepper under a wide range of production systems and multiple sprays should be kept to a minimum due to the long persistence of its β-isomer.

Table 3. Half-life ($T_{1/2}$) values of α-endosulfan and β-endosulfan on melon and pepper leaves and fruits of plants sprayed with Endosulfan 3EC at 0.44 kg AI acre^{-1} under field conditions.

	Fruits $T_{1/2}$ Values (days)		Leaves $T_{1/2}$ Values (days)	
	Melon	Bell Pepper	Melon	Bell Pepper
α-endosulfan	1.25	0.95	0.95	1.22
β-endosulfan	3.04	2.53	1.93	3.1

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Effect of Soil Amendment and Irrigation Regime on Bell Pepper Yield

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Many growers in Kentucky have expressed an interest in utilizing soil amendments. Soil amendments such as yard waste or composted municipal biosolids have been reported to improve soil physical characteristics such as bulk density and water-holding capacity (Shiralipour et al., 1992). Soil amendments also provide a source of supplemental fertility for crops. Typically composts of varying types will tend to release nutrients slowly over the course of a season compared to mineral fertilizers, which are immediately available to plants for uptake. The impact of soil amendments may also be influenced by irrigation regime or rainfall. Excessive applications of irrigation water may lead to leaching of nutrients or alter the decomposition of soil amendments. To investigate the potential interaction between irrigation regimes and soil amendments, the following study was conducted using bell pepper (*Capsicum annuum*).

Materials and Methods

On 16 July 2009, eight-week-old bell pepper 'Aristotle' plants were transplanted into plots amended with municipal sewage sludge (MSS), yard waste mixed with MSS, and no-mulch native soil (control). The MSS was obtained from Metropolitan Sewer District, Louisville, KY and added to the soil at a rate of 15 t acre^{-1} (on dry weight basis). Plots also contained MSS and yard waste (YW) mix (1:1) put out at a total of 15 t acre^{-1} (on dry weight basis). Yard waste (obtained from Con Robinson Co., Lexington, KY) was made from yard and lawn trimmings, and vegetable remains. Native soil (Lowell silty-loam soil (2.6% organic matter, pH 7, 12% clay, 75% silt, and 13% sand) was used as a control treatment (roto-tilled bare soil) for comparison purposes. Rows of peppers were spaced 1.08 meters apart with plants spaced approximately 0.3 meters apart within each row. Each soil treatment was replicated six times with each plot containing approximately 45-50 plants. Each row was supplied

Table 1. Yields in fruit per hectare and kg per hectare for 'Aristotle' pepper (*Capsicum annuum*) grown with municipal sewage sludge (MSS), yard waste (YW) and MSS mix (MSS+YW), and no mulch under daily and weekly irrigation regimes in Frankfort, Kentucky in 2009.

	Average Fruit/Hectare[a]			Average kg/Hectare[b]				
Treatment	Medium	Large	X-large	Medium	Large	X-large	Total Marketable	Cull[c]
MSS/daily irrigation	7150	26390	11030	790	4190	2360	7340	14
MSS+YW/daily irrigation	7560	24930	17780	860	4590	4290	9740	16
No mulch/daily irrigation	9210	35650	17380	1010	5910	3910	10830	13
MSS/weekly irrigation	16050	36690	8420	1710	5840	1830	9380	17
MSS+YW/weekly irrigation	5970	17340	16330	690	3100	3970	7760	13
No mulch/weekly irrigation	16650	33040	13350	1680	5350	2890	9920	16
Significant[d]	NS	NS	NS	NS	NS	NS	NS	NS

[a,b] Average fruit number and weight in kg per hectare calculated using a plant population of 31115 plants per hectare.
[c] Percentage of culls calculated by dividing weight of cull fruit by the weight of total harvested fruit.
[d] Significance calculated using Proc GLM, P values > 0.05 were not considered significant.

with drip irrigation tape (Toro Aqua-Traxx, 0.45 gpm/100 ft, 12 inch emitter spacing)

Two irrigation treatments were also applied. One treatment consisted of irrigating for 25 minutes twice daily (5.8 hours/week). The other treatment consisted of watering once a week for 6 hours. The two treatments were arranged in a randomized design such that there were three replicates of each irrigation/soil amendment treatment. Plants received no preplant or supplemental fertility during the growing season except for that supplied by the soil amendments. A mixture of Command 3ME (clomazone) and Treflan 4E (trifluralin) were applied to manage weeds, while endosulfan was utilized for insect control. Pepper plants were harvested September 2009 and graded according to USDA standards.

Results and Discussion

There were no significant interactions between irrigation regime and amendment treatments for pepper yields (Table 1). In addtion, main effects for amendment or irrigation treatments were not significant. Although large numerical differences between treatments existed, particularly for medium fruit yields when comparing the two irrigation regimes, variabilty was large enough to prevent significant differences from being detected with $P<0.05$. Total marketable yields of peppers ranged from 7340-10,830 kg/ha, which equates to 3.2-4.8 tons/A. These yields are lower than typical for bell peppers grown with irrigation without plastic mulch in Kentucky. Typical yields would range from 8-12 tons/A for irrigated bell peppers grown without plastic mulch. No differences were observed between weekly and daily irrigation treatments. However, the summer of 2009 had rainfall patterns that may have masked the effects of the irrigation treatments. Multiple years of study should be conducted before any conclusions are drawn regarding the effects of irrigation and soil amendments on yields of bell pepper.

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Applying Calcium Chloride to Improve Firmness and Postharvest Quality in Fresh Market Tomatoes

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Calcium is an essential plant macro-nutrient. Adequate tissue levels of calcium in cultivated plants typically range from 0.5 to 1.5% (Mills and Jones, 1996). However it is not uncommon for shoot concentrations of calcium to reach 5% in many plants, provided sufficient soil calcium is present (Marschner, 1995). The wide range of calcium concentrations found in plants illustrates that there are large differences in the absolute calcium requirements of different crops and that plants will continue accumulating additional calcium as long as it is made available for uptake for the plant.

Recently, Ritenour et al., (2006) reported that dipping mature green tomato fruit into a calcium chloride solution (0.5 and 1.0% calcium chloride) resulted in improved storage life and less decay when compared to non-treated controls. This suggests that adding calcium chloride to wash tanks after harvest may improve shelf life of tomatoes. Interestingly, while substantial research has been conducted on the effects of applying calcium to tomatoes during growth as a means to reduce blossom end rot (Saure, 2001), little is known regarding on the effects of calcium applications in the field on tomato storage longevity and firmness. The results of Ritenour et al., (2006) suggest that tomato may be a good candidate for supplemental calcium applications during growth. Firmness in diced tomatoes has been shown to be positively affected by calcium applications (Anthon, et al., 2005), however in these studies the products were treated post-harvest. Therefore it is the intent of this proposal to determine the effects of supplemental calcium applications during growth on tomato firmness and storage longevity.

The purpose of this study was to determine if supplemental calcium chloride applied during the growth and development of tomato fruit will improve storage life of fresh market tomatoes. The study was conducted using a hydroponic production system in order to remove environmental factors normally present in a field trial.

Materials and Methods

Growing Conditions. Tomato variety 'Florida 47' were seeded into 72 cell trays using a peat based germinating media (Pro Mix) and grown for 8 weeks. Plants were fertilized twice-weekly with a Peters' 20-10-20 general purpose fertilizer beginning at the first true-leaf stage of plant growth. Seedlings were transplanted into three gallon white plastic grow bags containing perlite on 2 and 3 September 2009. Two plants were placed in each bag. Plants were strung and pruned according to standard growing practices for hydroponic tomatoes. All plants were fertilized with Peters Hydrosol 5-11-26 with ammonium nitrate and received the following: 80 $mg{\cdot}L^{-1}$ N, 61 $mg{\cdot}L^{-1}$ P, 281 $mg{\cdot}L^{-1}$ K, 40 $mg{\cdot}L^{-1}$ Mg 52 $mg{\cdot}L^{-1}$ S, 0.7 $mg{\cdot}L^{-1}$ B, 0.2 $mg{\cdot}L^{-1}$ Cu, 3.9 $mg{\cdot}L^{-1}$ Fe, 0.7 $mg{\cdot}L^{-1}$ Mn, 0.2 $mg{\cdot}L^{-1}$ Mo, and 0.2 $mg{\cdot}L^{-1}$ Zn. Irrigation water contained 41 $mg{\cdot}L^{-1}$ Ca with an alkalinity of 78 $mg{\cdot}L^{-1}$. Three calcium treatments were imposed utilizing $CaCl_2$ such that plants received 60, 180 and 360 $mg{\cdot}L^{-1}$ Ca in the fertilizer solution. Nutrient concentrations in the fertilizer solution were determined and confirmed every two weeks through water testing at the University of Kentucky Department of Regulatory Services. In addition, two $CaCl_2$ sprays containing 1 and 2% $CaCl_2$, respectively, and one control (water) spray were applied weekly to plants when fruit in the second cluster reached approximately 1.5 cm in diameter. A total of three sprays were applied to the plants. Three solution and three spray treatments were combined in a completely randomized factorial design with four replications of eight plants (four bags) each (Figure 1). This resulted in 36 randomized plots in the greenhouse. Nutrient solutions were delivered to the plants using a solar radiation-based Davis Greenhouse Irrigation controller. Greenhouse set points were 78/65° F day/night with 75% rh. A class C bumblebee hive (Koppert) was placed in the greenhouse when the first cluster of flowers was observed to open. Plants growth was terminated after the fifth cluster of fruit was harvested.

Mature fruits at the breaker stage were harvested beginning on 3 November 2009 and continuing until 12 January 2010. Fruit were graded according to USDA guidelines for fresh market tomatoes, with culls being sorted and the incidence of blossom end rot recorded. Fruit and leaf tissue from clusters one, two and three were collected for nutrient analysis. Fruit from cluster two was collected for texture and storage analyses.

Nutrient Analysis. Eight representative leaves and mature fruit were collected from clusters one through three from each plot, triple rinsed in deionized water and dried for five days in a forced air oven at 75° C. Dried samples were ground using a coffee grinder. Nutrient analysis was conducted using an inductively coupled spectrometer (ICP) at the University of Tennessee.

Texture Analysis. Texture analysis was conducted on a sample of three ripe fruit harvested two days prior from the second cluster of each treatment/replication using a TA XT Plus texture analyzer (Texture Technologies, Scarsdale, New York). Each of the three fruit from each plot were analyzed in duplicate for skin strength (g), skin elasticity (mm), and penetration force (kg) using a 2.0 mm TA 52 probe. Each fruit was tested on opposite sides of the equatorial plane. Fruit was analyzed using a 5.0 $mm{\cdot}s^{-1}$ pretest speed and 1.0 $mm{\cdot}s^{-1}$ test speed with a trigger of 0.00490 N. Distance of the probe test was 6.0 mm.

Storage. Eight mature fruit from the second cluster from each treatment/replication were placed into storage at 55° F (± 3° F), 80% (± 5%) relative humidity. Eight fruit were placed into a single aluminum baking dish 10.38 x 12.75 x 2.4 inches and weighed immediately prior to placing in storage. Stored fruit was then weighed and evaluated weekly for the presence of disease symptoms (bacterial soft rot, rhizopus rot, and anthraconose) for six weeks.

Results/Discussion

Plant Growth. Plants responded to increasing $CaCl_2$ levels in solution with a general increase in growth and vigor at the 180 and 360 $mg{\cdot}L^{-1}$ Ca concentrations when compared to plants grown at 60 $mg{\cdot}L^{-1}$ Ca. Plants exposed to $CaCl_2$ sprays did not appear visibly different with the exception of some burning and spotting of leaves and some fruit when exposed to the 2% $CaCl_2$ solution. This suggests that sprays of 2% $CaCl_2$ may lead to symptoms of phytotoxicity in tomato.

Nutrient Levels. Nutrient concentration in fruit and foliage were affected by cluster position and calcium treatments. There were no significant cluster by calcium solution, cluster by foliar spray, or foliar spray by calcium solution interactions. Fruit concentrations of boron (B), magnesium (Mg), phosphorous (P), sulfur (S), potassium (K), calcium (Ca) manganese (Mn), iron (Fe), copper (Cu) and zinc (Zn) were affected by cluster position for fruit tissue (Table 1). In general the concentrations of nutrients declined in fruit as cluster position increased. Some nutrients such as sulfur exhibited a large decrease in concentration with a high concentration of 6550 $mg{\cdot}L^{-1}$ in cluster one and a low concentration of 1177 $mg{\cdot}L^{-1}$ in cluster three. Calcium concentrations also declined as cluster number increased, though the change was relatively small compared to other nutrients such as S.

Calcium concentration in solution affected fruit concentrations of B, Mg, Ca, and Mo. Generally increasing Ca solution concentrations resulted in an increase in B, Ca, and Mo concentrations in fruit and a decrease in Mg concentrations. This suggests that the increasing calcium concentrations in the nutrient solution are an effective way to deliver calcium to tomato fruit. There were no significant effects of the foliar Ca spray on fruit nutrient concentration.

Table 1. Nutrient Concentration Fruit (ppm).

Treatment	B	Mg	P	S	K	Ca	Mn	Fe	Cu	Zn	Mo
Soln. Ca					*Cluster 1*						
60 ppm	1.8	2489.1	6550.2	6199.2	45879.6	1154.2	22.6	81.81	62.8	26.5	2.9
180 ppm	1.9	1865.6	5976.4	5416.3	43604.0	2019.7	18.9	121.5	97.7	33.5	1.8
360 ppm	2.0	1911.5	6098.5	5481.7	47178.5	1755.4	19.1	77.5	68.2	31.8	1.7
Ca Spray											
0	1.9	1916.9	6180.8	5453.3	44556.2	1707.9	18.9	114.9	81.7	29.1	1.8
1%	1.9	2403.6	6412.5	6157.7	46900.9	1681.0	24.3	101.4	90.7	37.2	2.8
2%	1.9	1948.7	6025.7	5486.7	45025.6	1520.7	17.2	63.6	57.0	24.9	1.9
Soln. Ca					*Cluster 2*						
60 ppm	1.7	1820.6	4853.3	5184.0	36085.9	1211.6	14.7	47.7	72.9	23.8	2.2
180 ppm	1.8	1602.5	4525.6	5029.6	36454.1	1561.8	14.5	47.4	82.3	23.2	1.8
360 ppm	1.7	1504.8	4415.6	4876.1	35758.3	1736.8	16.5	58.7	60.6	21.3	1.7
Ca Spray											
0	1.7	1575.1	4514.3	4970.4	35071.4	1673.4	15.6	54.1	68.2	21.3	1.8
1%	1.7	1628.9	4573.7	5086.9	36093.2	1469.0	14.8	51.7	86.7	24.6	1.8
2%	1.8	1713.8	4691.3	5032.2	37737.1	1384.0	15.3	47.9	62.7	22.4	1.9
Soln. Ca					*Cluster 3*						
60 ppm	1.6	1681.2	4950	1283.2	35832.5	893.9	14.3	31.0	8.8	14.3	2.5
180 ppm	1.9	1595.8	4879.3	1399.9	35580.7	1431.9	15.4	33.8	10.4	14.8	2.2
360 ppm	1.9	1452.5	4651.9	1134.9	36082.4	1555.6	15.9	41.5	10.7	15.0	2.0
Ca Spray											
0	1.7	1534.4	4834.1	1388.2	36216.0	1145.1	14.5	34.1	9.5	14.5	2.1
1%	1.8	1619.0	4846.1	1176.6	35067.3	1259.0	15.4	37.7	10.7	14.4	2.3
2%	1.9	1589.9	4817.3	1256.7	36127.7	1452.7	15.7	34.3	9.8	15.2	2.3
Cluster	*	*	*	*	*	*	*	*	*	*	NS
Ca Soln.	*	*	NS	NS	NS	*	NS	NS	NS	NS	*
Fol. Ca	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fol. x Soln.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS: Non significant at P<0.05. *: Significant at P<0.05

Nutrient concentrations in the leaves were affected by cluster position, Ca in solution and Ca foliar sprays. There was a significant Ca solution by foliar spray interaction for S, K and Ca concentrations in leaves (Table 2). Cluster position significantly affected B, Mg, P, Mn, Cu, Zn, and Mo concentrations in the foliage. Concentrations of nutrients generally decreased as cluster position increased, with the notable exception of Ca, which had a significant cluster by Ca solution interaction. Foliar Ca concentrations increased, with increasing cluster position for the lower Ca solution levels, but decreased slightly at the highest (360 $mg{\cdot}L^{-1}$) solution level.

Solution Ca levels significantly affected foliar concentrations of B, Mg, P, S, K, Ca, Mg, Zn, and Mo. Increasing levels of Ca in the fertilizer solution led to a decrease in the concentration of the all significantly affected nutrients except for Ca, which increased linearly with increasing solution Ca levels. Foliar applications of $CaCl_2$ significantly affected leaf B, P, S, K, Ca, and Mo concentrations. Generally the foliar application of $CaCl_2$ affected leaf nutrient concentrations in a similar manner as the Ca in solution, with affected nutrients declining in concentration as foliar $CaCl_2$ levels increased, with the exception of leaf Ca levels, which increased when foliar calcium was applied.

Interestingly, the foliar application of $CaCl_2$ only affected nutrient concentrations in leaves and not fruit, while the application of Ca in solution affected nutrient concentrations in both fruit and foliage. Additionally, Ca, which is the nutrient of primary interest in this study, was detected at levels nearly tenfold higher in the foliage than in the fruit. This suggests that Ca applications as a foliar spray may not be effective in a crop such as tomato where a small portion of the total accumulated calcium is found in the fruit relative to the foliage. Our results indicate that the most effective way to manipulate fruit calcium levels will be through the nutrient solution.

Of additional interest is the antagonism displayed between Ca and other nutrients. This suggests that applications of $CaCl_2$ may be utilized to manipulate the levels of other nutrients in plants. The use of $CaCl_2$ to reduce S accumulation in onion, resulting in decreased pungency, has previously been documented.

Yield. Tomato fruit yield was significantly affected by Ca levels in solution, but not by foliar applications of calcium (Table 3). In addition, there were no significant solution-by-foliar-spray-application interactions. As would be expected solution Ca concentration in solution affected the incidence of blossom end rot (BER), a calcium deficiency disorder, with the occurrence of BER decreasing as Ca concentrations increased. Interestingly, the amount of cull tomatoes due to factors other than BER increased slightly with increasing Ca concentrations. Increasing Ca concentrations in solution resulted in a significant increase in large and extra large fruit yields on plants. However, there was no difference in yield of plants exposed to Ca concentrations of 180 and 360 $mg{\cdot}L^{-1}$ Ca. Typically, 180 $mg{\cdot}L^{-1}$ is considered

Table 2. Nutrient Concentration Leaves (ppm).

Treatment	B	Mg	P	S	K	Ca	Mn	Fe	Cu	Zn	Mo
Soln. Ca						*Cluster 1*					
60 ppm	13	17062.2	12640.7	14166.5	47858.6	15660.8	259.6	113.9	21.0	28.0	14.2
180 ppm	12.8	10864.7	11418.0	8593.7	38857.6	30684.1	228.6	149.5	29.9	25.6	11.3
360 ppm	12.5	7905.8	10919.4	6894.6	35205.6	42161.3	228	209.3	29.4	25.6	9.0
Ca Spray											
0	13.1	11896.3	12385.8	11221.2	44882.0	27172.2	236.9	149.3	34.9	28.7	11.9
1%	12.5	10944.7	11315.2	8856.8	39119.4	31401.1	238.0	172.8	28.0	27.0	10.9
2%	12.7	12481.8	11166.7	9134.3	37192.1	31244.7	239.5	155.5	18.0	23.4	11.3
Soln. Ca						*Cluster 2*					
60 ppm	12.9	13209.8	11289.8	12517.7	44843.4	20043.8	263.4	132.1	65.2	35.8	11.7
180 ppm	12.1	8419.5	9971.2	8502.8	40332.8	29754.4	240.3	166.3	66.8	31.9	9.3
360 ppm	11.0	6036.7	9052.1	7397.9	35647.8	37586.1	228.1	210.6	61.8	29.9	7.4
Ca Spray											
0	12.6	9290.8	10572.8	11320.4	44425.3	24657.9	250.7	156.1	64.9	34.6	10.1
1%	11.7	8962.7	9998.3	8807.8	38755.2	31076.9	240.7	184.5	69.5	32.0	9.3
2%	11.8	9412.7	9742.3	8290.2	37643.5	31649.4	240.3	168.4	59.4	31.0	9.0
Soln. Ca						*Cluster 3*					
60 ppm	11.7	11135.9	9797.2	12234.8	42283.8	24341.9	327.0	233.8	126.8	51.8	12.0
180 ppm	10.9	8583.1	8865.2	10122.3	38874.7	30313.8	304.4	155	55.2	37.6	10.7
360 ppm	9.8	5481.8	7809.3	8229.3	33927.9	38063.1	284.2	166.9	90.1	37.8	8.0
Ca Spray											
0	11.4	8600.0	9471.8	11632.3	43373.17	26289.9	303.2	238.9	95.8	47.2	10.7
1%	10.4	8185.6	8329.0	9627.3	36513.6	31707.8	295.4	160.8	97.4	40.4	10.0
2%	10.6	8415.3	8670.9	9326.8	35199.6	34721.1	317.0	155.9	78.8	39.6	10.0
Cluster	*	*	*	NS	NS	NS	*	NS	*	*	*
Ca Soln.	*	*	*	*	*	*	*	NS	NS	*	*
Fol. Ca	*	NS	*	*	*	*	NS	NS	NS	NS	*
Fol. x Soln.	*	NS	NS	*	*	*	NS	NS	NS	NS	*

NS: Non significant at P<0.05. *: Significant at P<0.05

sufficient for hydroponic tomato production. Therefore, in this study, application of luxuriant levels of Ca did not result in an increase in yields.

Textural Attributes. Fruit soluble solids content (SSC) and percent dry matter content (DW) were significantly affected by foliar applications of $CaCl_2$. Both SSC and DW increased with the application of a 1% $CaCl_2$ solution when compared to the water control and the 2% $CaCl_2$ solution. This suggests that if foliar applications of $CaCl_2$ are to be applied, a 1% solution may be more effective for tomato than a 2% solution. Other textural attributes were measured, and while skin strength and penetration force were not affected by calcium treatment, skin elasticity was affected by calcium levels in solution. As calcium in solution increased, skin elasticity increased as well, rising from 67.8 mm in the low (60 $mg \cdot L^{-1}$) calcium solution to 72.5 mm in the high (360 $mg \cdot L^{-1}$) calcium solution. This suggests that applications of calcium in a fertilizer solution can affect some textural attributes of tomato fruit.

Table 3. Tomato Yield.

Treatment	Blossom end rot	Cull w/o BER	Small	Medium	Large	Extra large	Blossom end rot	Cull w/o BER	Small	Medium	Large	Extra large
Soln. Ca	*fruit weight grams per plant*						*fruit number per plant*					
60 ppm	359 a[1]	393 b	549 a	1189 a	317 b	165 b	2.7 a	3.4 a	5.5 a	6.5 a	1.3 b	0.5 b
180 ppm	113 b	508 a	473 a	1310 a	461 a	334 a	0.7 b	4.1 a	4.7 a	7.0 a	1.8 a	1.0 a
360 ppm	147 b	461 ab	488 a	1210 a	492 a	330 a	0.9 b	3.3 a	4.8 a	6.4 a	1.9 a	1.0 a
Ca Spray	*fruit weight grams per plant*						*fruit number per plant*					
0	197 a	439 a	483 a	1161 a	454 a	263 a	1.5 a	3.8 a	4.8 a	6.3 a	1.8 a	0.8 a
1%	227 a	461 a	507 a	1261 a	413 a	287 a	1.5 a	3.7 a	5.0 a	6.8 a	1.6 a	0.9 a
2%	195 a	463 a	519 a	1287 a	403 a	278 a	1.4 a	3.4 a	5.1 a	6.9 a	1.5 a	0.9 a
Soln. x Fol	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Ca Soln.	*	*	NS	NS	*	*	*	NS	NS	NS	*	*
Fol. Ca	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[1] Means within the same treatment class (soln. vs. spray) followed by different letters are significantly different at P<0.05.
NS: Non significant at P<0.5, *: Significant at P<0.05

Storage. As would be expected, weight loss and disease incidence increased significantly during storage (Figure 1a-d). Weight loss increased linearly with storage duration while disease incidence responded in a logistic manner with a sigmoidal curve, typical for disease growth. Disease was relatively low until week three of storage, where it grew exponentially (Figure 1c-d). Weight loss was unaffected by Ca concentration in solution. Disease incidence was not significantly affected by either calcium treatment. Foliar applications of $CaCl_2$ resulted in a significant increase in weight loss compared to the 0% (water) control treatment (Figure 1b). This suggests that the foliar application of $CaCl_2$ could potentially damage the fruit, resulting in an increase in water loss. Water loss is responsible for the majority of weight loss in storage. Interestingly, fruit exposed to the $CaCl_2$ sprays also had a higher DW and SSC at harvest. Perhaps, this increase in DW and SSC is the result of a slight increase in fruit damage and subsequent water loss as the fruit matures on the plant.

Table 4. Tomato Texture.

Treatment	SSC %	DW %	Skin strength (g)	Skin elasticity (mm)	Penetration force (kg)
Soln. Ca					
60 ppm	4.3 a[1]	3.8 a	4.06 a	67.8 b	1.25 a
180 ppm	4.2 a	3.8 a	3.72 a	70.5 ab	1.20 a
360 ppm	4.4 a	4.0 a	4.29 a	72.5 a	1.27 a
Ca Spray					
0	4.1 b	3.7 b	4.33 a	68.4 a	1.23 a
1%	4.4 a	4.0 a	4.07 a	71.7 a	1.27 a
2%	4.3 ab	3.8 ab	3.61 a	70.7 a	1.21 a
Soln. x Fol	NS	NS	NS	NS	NS
Ca Soln.	NS	NS	NS	*	NS
Fol. Ca	*	*	NS	NS	NS

[1] Means within the same treatment class (soln. vs. spray) followed by different letters are significantly different at P<0.05.
NS: Non significant at P<0.05, *: Significant at P<0.05

Conclusions. Results from this experiment indicated that quality of tomato fruit can be positively affected by increasing calcium supplied to plants in solution. Increasing Ca in solution resulted in an increase in Ca levels in the plant and the fruit and an improved in yield and skin elasticity. Although the foliar application of $CaCl_2$ resulted in an increase in Ca in the foliage, it did not affect fruit Ca levels. Applications of foliar $CaCl_2$ resulted in an increase in SSC and DW in mature

Figure 1a-d. Impact of three different concentrations of calcium chloride in solution (60, 180, and 360 ppm calcium) and in foliar sprays (0%, 1%, and 2% calcium chloride) on weight loss (a,b) and disease pressure (c,d) during six weeks for storage for hydroponically grown Florida 47 tomato *(Solanum lycopersicum)*.

Figure 1a.

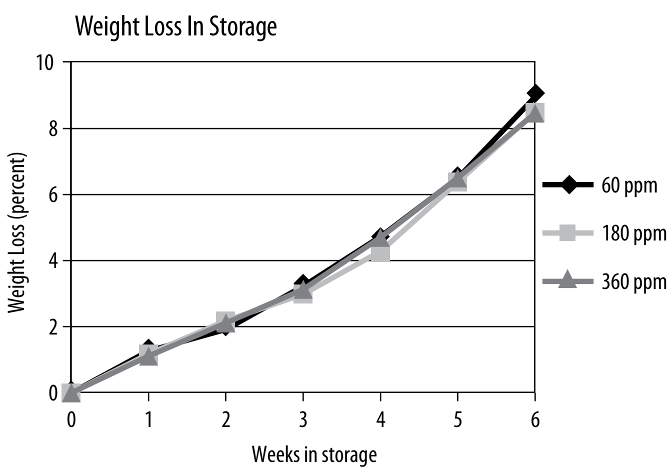


Figure 1b.

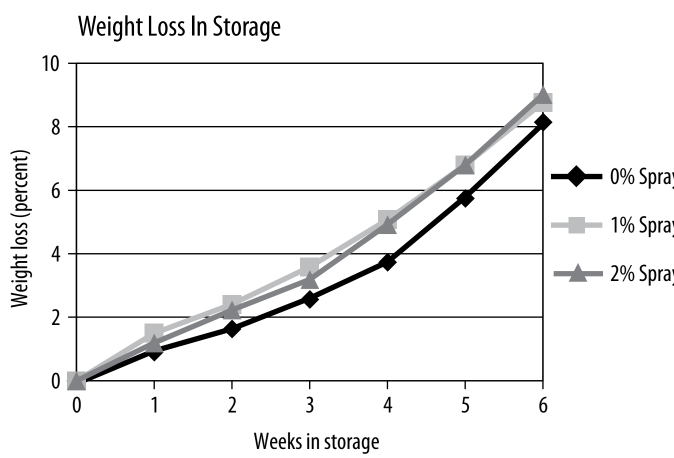


Figure 1c.

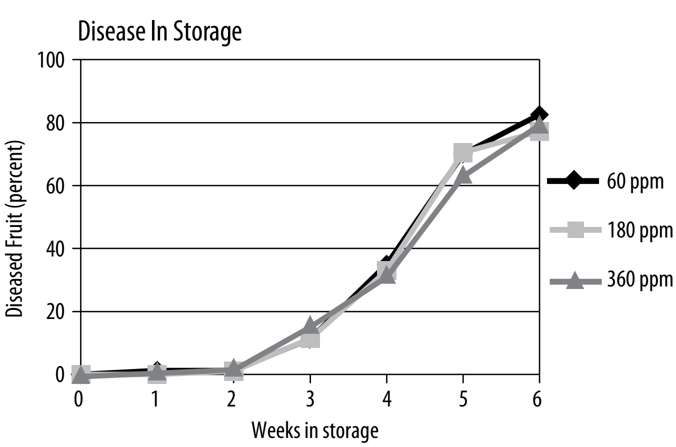
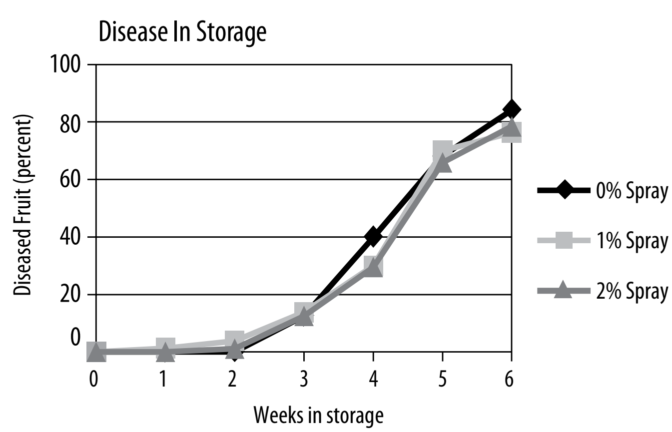


Figure 1d.



fruit. This suggests that foliar $CaCl_2$ could be used in situations where SSC and DW are of high importance, such as a tomato processor. However, foliar applications of $CaCl_2$ also resulted in an increase in weight loss in storage, which suggests that the $CaCl_2$ solution may have damaged the cuticle of the tomato, resulting in increased weight (water) loss in storage. In addition, leaf and fruit nutrient analysis suggest that leafy vegetables may be superior candidates for modification through the addition of $CaCl_2$ as the foliage of the tomato plant accumulated calcium at a much greater concentration than fruit. In addition, our results indicate that $CaCl_2$ when delivered through the fertilizer solution may have an antagonistic relationship with several other nutrients. Therefore, growers could use $CaCl_2$ applications to indirectly affect the accumulation of other nutrients in tomato. Our results suggest that calcium delivered with the fertilizer solution can positively affect tomato texture and yield and that the preferred method of application for tomato is through the fertilizer solution.

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Fruit and Vegetable Disease Observations from the Plant Disease Diagnostic Laboratory—2010

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Introduction

Diagnosing plant diseases and providing recommendations for their control are the result of UK College of Agriculture research (Kentucky Agricultural Experiment Station) and Cooperative Extension Service activities through the Department of Plant Pathology. We maintain two branches of the Plant Disease Diagnostic Laboratory (PDDL), one on the UK campus in Lexington, and one at the UK Research and Education Center in Princeton. Of the more than 3,100 plant specimens examined to date in 2010, approximately 30% were fruits and vegetables, and 40% of those were from commercial growers (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 exceeds $25,000, excluding UK physical plant overhead costs. During recent years we have acquired funds from Kentucky Integrated Pest Management and the Southern Plant Diagnostic Network to help defray some of the laboratory operating costs. In addition to receiving physical diagnostic samples, we also provide a web-based digital consulting system, to which Extension agents can submit images for consultation on plant disease problems. In 2010, approximately 33% 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 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, nematode extraction, or soil pH and soluble salts tests. In particular, many commercial fruit and vegetable diagnoses require consultation with UK faculty plant pathologists and horticulturists and/or need specialized testing. The Extension plant pathology group has tested protocols 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. Homeland Security rules require reporting of all diagnoses of plant diseases to USDA-APHIS on a real-time basis.

The 2010 growing season in Kentucky was a fairly good one for most fruit crops; disease pressure was higher in most vegetable crops than for fruits, although drier weather in 2010 made for a less disease-conducive season in general than in 2009. Harvest dates ran as much as two weeks earlier than normal due to warmer temperatures.

January precipitation was slightly below normal, while February through April was 4.3 inches below normal. Heavy rainfall in May was 3 inches above normal, and rainfall through September was normal or slightly below normal. Western Kentucky received far less rainfall during the summer than other portions of the state and was 6-9 inches below normal in September, while central and northern Kentucky were 3 to 6 inches below normal.

January and February temperatures were 3° and 6.9° F below normal, respectively. Temperatures for April through August ran consistently 3° to 4.8° F above normal. Louisville had 82 days, Bowling Green 75 days, Paducah 74 days, Lexington 44 days, Cincinnati 34 days, and Jackson 22 days above 90° F this summer. This was the second warmest year for Kentucky on record.

Results and Discussion

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

Diseases caused by Oomycete pathogens—Phytophthora and Pythium diseases of roots/crown, foliar Phytophthora blights and downy mildews can be problematic in most years in locations with wet soils, heavy irrigation, or susceptible crops grown in shade. Persistent cool, wet weather throughout much of the 2009 growing season allowed buildup of inoculum, particularly of soilborne oomycetes, giving rise to continued oomycete problems in 2010. Heavy rains in May 2010 promoted infections of many crops. Notable examples included:

Late blight (*Phytophthora infestans*) was officially diagnosed (in the PDDL) on tomato samples from 6 Kentucky counties (as opposed to 25 counties in 2009). Its presence in tomato seedlings from several large retail centers might have proven disastrous, but dry weather prevented widespread disease development in home gardens which can serve as inoculum for commercial plantings. Late blight was found in one commercial potato field that had had late blight the previous year.

Phytophthora root and collar rot (*Phytophthora* spp.) was extremely common in bramble and blueberry plantings and in some apple orchards. Of bramble samples submitted to the PDDL, more than one-quarter were confirmed to have Phytophthora root/collar rot; approximately one-half of blueberry samples submitted were infected with Phytophthora root/collar rot.

Pythium blight (*Pythium* spp.) of aerial plant parts included fruit rots of pepper, tomato and zucchini and stem blight of bean.

Tree Fruit Diseases

Pome Fruits—Moderate levels of cedar-apple rust (*Gymnosporangium juniperi-virginianae*) and frogeye leaf spot (*Botryosphaeria obtusa*) were observed in apple. Fire blight (*Erwinia amylovora*) also occurred at moderate levels on both apple and pear; some locations had more severe fire blight outbreaks. Fruit rots—including black rot (*Botryosphaeria obtusa*), white rot (*Botryosphaeria dothidea*) and bitter rot (*Glomerella cingulata*)—were common late in the season. A few samples of Phytophthora collar rot were submitted for laboratory confirmation. Although some orchards may have experienced scab infections, no samples of apple scab (*Venturia inaequalis*) from fruit trees were submitted to either PDDL location.

Stone Fruits—Leaf spot diseases of cherry caused by the fungus *Coccomyces hiemalis* and the bacterium *Xanthomonas campestris* pv. *pruni* were seen frequently. Scab (*Cladosporium carpophilum*) was diagnosed on apricot and peach, and brown rot (*Monilinia fructicola*) was diagnosed on apricot, cherry, peach and plum. Spring rains favored the development of peach leaf curl (*Taphrina deformans*), and the related disease plum pockets (*Taphrina communis*) was again diagnosed this year, as it was in 2008 and 2009.

Small Fruit Diseases

Grapes—Anthracnose (*Elsinoe ampelina*) was more common than usual this year, while black rot (*Guignardia bidwellii*) and Phomopsis cane and leaf spot (*Phomopsis viticola*) were seen at normal levels. Downy mildew (*Plasmopara viticola*) and powdery mildew (*Uncinula necator*) developed later in the season. An unusual find was Isariopsis leaf blight (*Pseudocercospora vitis* [syn. *Isariopsis clavispora*]) in a single location.

Brambles—More samples than usual were confirmed as infected with root and collar rot caused by *Phytophthora* spp.; both blackberry and raspberry were affected (see above). Cane blight (*Leptosphaeria coniothyrium*) was diagnosed on both blackberry and raspberry canes. Orange rust (*Gynnoconia nitens*) and cane and leaf rust (*Kuehneola uredinis*), as well as double blossom disease (*Cercosporella rubi*), were diagnosed on blackberry samples. Other fungal leaf spot diseases were minimal on brambles this year.

Blueberries—Root and collar rot caused by *Phytophthora* spp. was diagnosed frequently on blueberry; in fact, one half of the blueberry samples submitted to the Lexington PDDL had Phytophthora root/collar rot (see above). Leaf spot (*Phyllosticta* spp.) was also diagnosed several times.

Strawberries—Phytophthora diseases were common, including red stele (*Phytophthora fragariae*), leather rot (*Phytophthora cactorum*) and root/crown rot (*Phytophthora* spp.). Leaf blight (*Phomopsis obscurans*), anthracnose (*Colletotrichum acutatum*), and gray mold (*Botrytis cinerea*) fruit infections were diagnosed. Petiole rot, another phase of Botrytis blight, was seen in April; this phase of disease is more common in states further south and is atypical in Kentucky.

Vegetable diseases

Beans—Foliar diseases including angular leaf spot (*Phaeoisariopsis griseola*) and Cercospora leaf spot (*Cercospora* sp.), and pod infections of anthracnose (*Glomerella lindemuthianum*) were common due to early wet weather and high humidity. Root rot (*Rhizoctonia solani.*) occurred in many early plantings in home gardens, but later high temperatures favored southern blight (*Sclerotium rolfsii*), which was particularly common. One case each of ashy stem blight (*Macrophomina phaseolina*) and Pythium stem blight (*Pythium* sp.) was diagnosed (see above).

Cole crops—Diseases were fairly infrequent with wirestem (*Rhizoctonia solani*) and Phytophthora root/stem rot (*Phytophthora* sp.) being the most common.

Cucurbits—Bacterial wilt (*Erwinia tracheiphila*), which is vectored primarily by the striped cucumber beetle (*Acalymma vittatum*), occurred in many melon fields, causing widespread plant loss in some locations. A wide variety of fungal foliar/vine diseases were common in all cucurbit crops: anthracnose (*Colletotrichum orbiculare*), Alternaria leaf blight (*Alternaria cucumerina*), powdery mildew (*Podosphaera xanthii* and *Erysiphe cichoracerarum*), downy mildew (*Pseudoperonospora cubensis*), gummy stem blight (*Didymella bryoniae*) and Plectosporium blight (*Plectosporium tabacinum*). Oomycete fruit rots—Pythium rot (*Pythium* sp.) on zucchini and Phytophthora rot (*Phytophthora capsici*) on pumpkin—were diagnosed, but only on a few occasions.

Peppers—Southern blight (*Sclerotium rolfsii*) was the most commonly diagnosed disease of pepper during this growing season. Although the disease was not widespread in general, significant outbreaks of bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) occurred in a few locations on commercial peppers; follow-up testing with molecular diagnostic techniques (PCR and sequencing) allowed confirmation of the bacterial species and pathovar.

Tomatoes—Late blight in tomato (*Phytophthora infestans*) reappeared at alarming frequency early in the season; most cases were seedlings for sale in retail settings, but the disease was also found in commercial fields that had experienced outbreaks of late blight last year. Drier, hotter weather beginning in midsummer prevented a repeat of the late blight epidemic of 2009 (see above). Foliar diseases such as early blight (*Alternaria solani*), Septoria leaf spot (*Septoria lycopersici*), leaf mold (*Fulvia fulva*), bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) and bacterial speck (*Pseudomonas syringae* pv. *tomato*) were common; also common were stem/vascular problems such as southern blight (*Sclerotium rolfsii*), bacterial canker (*Clavibacter michiganensis* subsp. *michiganensis*) and Fusarium wilt (*Fusarium oxysporum*).

Other vegetables—Increased commercial production of onion resulted in more onion samples than usual; of note were diagnoses of purple blotch (*Alternaria porri*), pink root (*Phoma terrestris*) and sour skin (*Burkholderia cepacia*). Crazy top (*Sclerophthora macrospora*) occurred in sweet corn in a few locations in which flooding occurred soon after planting/plant emergence. Late blight (*Phytophthora infestans*) was diagnosed on potato in at least one commercial field.

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 Extension agents and the growers they assist. The information gained from diagnostic analyses will help to improve production practices and reduce disease in the future. We urge county Extension agents to stress in their programming the importance of accurate disease diagnosis and timely sample submission to provide Kentucky fruit and vegetable producers with the best possible disease management information.

Literature Cited

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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, PO 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.P. 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., Wlacott, 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., Randolf, 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
KU.................. Known-You Seed Co., 26 Chung Cheng 2nd Road, Kaushiung Taiwan, 80271
KY.................. Known-You Seed Co., Ltd. 26 Chung Cheng Second Rd., Kaohsiung, Taiwan, R.O.C. 07-2919106
KZ.................. Kitazawa Seed Co., PO 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., Grand Rapids, MI 49507
MM................ MarketMore Inc., 4305 32nd St. W., Bradenton, FL 34205
MN .... Dr. Dave Davis, U of MN Hort Dept., 305 Alderman Hall, St. Paul, MN 55108
MR................. Martin Rispins & Son Inc., 3332 Ridge Rd., P.O. Box 5, Lansing, IL 60438
MS................. Musser Seed Co. Inc., Twin Falls, ID 83301
MWS............. Midwestern Seed Growers, 10559 Lackman Road, Lenexa, Kansas 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., PO 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, Sante Fe, NM
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................... US Agriseeds, San Luis Obispo, CA 93401.
UG .... United Genetics, 8000 Fairview Road, Hollister, CA 95023
US .... US 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 .... Vaughans 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

12-2010