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UK UNIVERSITY OF KENTUCKY College of Agriculture

2011 Fruit and Vegetable Research Report

UKAg RESEARCH **University of Kentucky • Lexington, Kentucky 40546**

2011 Fruit and Vegetable Crops Research Report

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Acknowledgments

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

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

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Cover: Mixed vegetables in a high tunnel in Fall.

Contents

The 2011 Fruit and Vegetable Crops Research and Demonstration Program

Timothy Coolong, Department of Horticulture

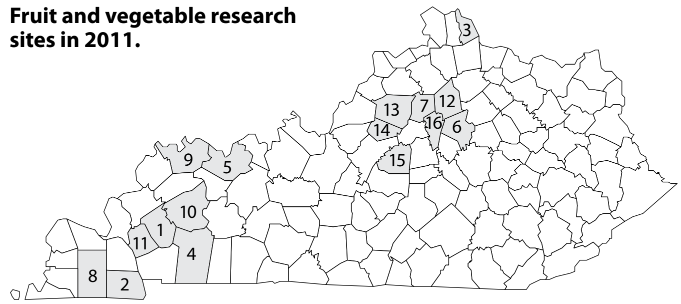
Fruit and vegetable production in Kentucky continues to grow. The 2011 Fruit and Vegetable crops research report includes results for more than 19 field research plots and several demonstration trials. This year's fruit and vegetable research and demonstration trials were conducted in more than counties 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, and Entomology This report also includes collaborative research projects conducted with faculty and staff at Kentucky State University and Murray State University. Many of these reports include data on varietal performance as well as different production methods in an effort to provide growers with better tools, which they can use to improve fruit and vegetable production in Kentucky.

Variety trials included in this year's publication include: fresh market peas, eggplant, seedless watermelons, bell peppers, hydroponic tomatoes, onions, blackberries, apples, peaches, and grapes. Additional research trials include strip tillage, organic management of cucumber beetles, insecticide and fungicide performance, and pesticide fate in plants. 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 also may collaborate with researchers in surrounding states to discuss results of variety trials they have conducted. In addition, we consider such things as seed availability, which is often of particular concern for organic growers. Only then, after much research and analysis, will we make variety recommendations for Kentucky. The results presented in this publication often reflect a single year of data at a limited number of locations. Although some varieties perform well across Kentucky year after year, others may not. Here are some helpful guidelines for interpreting the results of fruit and vegetable variety trials:

Our Yields vs. Your Yields

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

Fruit and vegetable research sites in 2011.



1. Caldwell
2. Calloway
3. Campbell
4. Christian
5. Daviess
6. Fayette
7. Franklin
8. Graves
9. Henderson
10. Hopkins
11. Lyon
12. Scott
13. Shelby
14. Spencer
15. Washington
16. Woodford

Statistics

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

Statistical significance is shown in tables by the letters that follow a given number. When two varieties have yields followed by completely different letters than 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 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 a 5-percent chance exists 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 percent of the time those varieties will be different. If the P value is 0.01, then 99 percent 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 Central Kentucky

Dave Spalding and Timothy Coolong, Department of Horticulture

Introduction

Five on-farm commercial demonstrations were conducted in Central and Northern Kentucky in 2011. Grower/cooperators were from Campbell, Fayette, Scott, Washington, and Woodford counties. The grower/cooperator in Campbell County grew two acres of mixed vegetables for distribution to local area feeding programs for the poor and elderly. The grower/cooperator in Fayette County grew one acre of mixed organic vegetables for local farmers markets and an on-farm market. The grower/cooperator in Scott County grew about a quarter of an acre of mixed organic vegetables for a local community-supported agriculture market. The grower/cooperator in Washington County grew one acre of broccoli for the wholesale market and the auction market. The Woodford County grower/cooperator grew about one acre of mixed vegetables for the local market.

Materials and Methods

Grower/cooperators were provided with black plastic mulch and drip irrigation for up to an 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 from each plot and scheduled, promoted, and coordinated field days at each site. An Extension associate made regular weekly visits to each plot to scout the crop and make appropriate recommendations.

Four of the five demonstration plots consisted of a mix of vegetables (tomatoes, peppers, squash, melons, green beans, and sweet corn) while the fifth plot consisted of broccoli only. The plots were planted in raised 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 broccoli-only plot was planted into raised beds with the broccoli planted 12 inches apart in the row. Except for the organic plots, the plots were sprayed with the appropriate fungicides and insecticides as needed, and cooperators were asked to follow the fertigation schedule provided.

Results and Discussion

Weather conditions in 2011 were challenging for vegetable production at times. Much of Central Kentucky experienced an abnormally warm and wet spring and a hot and wet summer. Because of the wet conditions most crops were planted later than is typical. Persistent, warm and wet weather in spring resulted in high weed pressure. The same conditions were ideal for the development of disease and insect problems.

Table 1. Costs and returns of grower/cooperators.

Inputs	Campbell (2.00 acre)	Fayette (1.00 acre)	Scott (0.25 acre)	Woodford (1.00 acre)
Plants and Seeds	$5,630.00	N/A	$ 254.15	$ 284.00
Fertilizer	264.00	-	---	106.00
Black Plastic	342.00	-	42.75	168.50
Drip Lines	324.00	-	40.50	162.00
Fertilizer Injector	120.00[1]	-	---	---
Herbicide	---	-	---	---
Insecticide	134.00	-	---	64.00
Fungicide	373.00	-	---	---
Water	285.00[2] (240,000 gal)	-	190.00 (40,000 gal)	140.00 (30,000 gal)
Labor	7,450.00[3] (1,400.0 hrs)	-	3,120.00[3] (950.0 hrs)	--- [4] (360.0 hrs)
Machine	140.00 (16.0 hrs)	-	70.00 (8.0 hrs)	86.00 (10.0 hrs)
Marketing	---	-	120.00	56.00
Total Expenses	15,062.00	-	3,837.40	1,066.50
Income	59,393 lbs	-	5,775.00	1,460.00
Net Income	N/A	-	1,937.60	393.50
Net Income/ Acre	N/A	-	7,750.40	393.50
Dollar Return/ Dollar Input	N/A		1.50	1.37

1 Costs amortized over three years.
2 Cost of electric usage and 5 year amortized cost of pump.
3 Includes unpaid volunteer or family labor.
4 All unpaid family labor.

The grower/cooperator in Washington County abandoned the broccoli plot because it bolted (flowered) prematurely due to unusually high temperatures at harvest time. The wet weather prevented growers from cultivating early in the growing season, and weeds became a serious problem, especially for the organic grower/cooperators. For the Scott County grower/cooperator, bacterial wilt of cucurbits was a significant issue limiting production. The Fayette County grower/cooperator did well given the tough growing season and was pleased with sweetpotato production with the plasticulture system. The grower/cooperators in Woodford County intend to use the production system again next year.

The Campbell County plot was unique in that the land was donated for use by a nonprofit organization who arranged for volunteers to plant, maintain and harvest the produce. The nonprofit then donated the produce that was harvested to area feeding programs for the poor and elderly. This arrangement worked well in that fresh produce was made available to an at-risk population. Production could have been higher, but a late planting of tomatoes was disappointing due to poor quality transplants. Plans are to expand the project to approximately five acres in 2012 and include fruit trees and brambles to be planted for future production.

On-Farm Commercial Vegetable Demonstrations in Western Kentucky

Vaden Fenton, Department of Horticulture

Introduction

Seven on-farm commercial vegetable demonstration plots were conducted in Western Kentucky in 2011. Grower/cooperators were located in Hopkins, Daviess, Webster, Caldwell, Lyon, and Graves counties. There were two growers each in Daviess and Graves counties. None of the growers previously had used the plasticulture system for commercial production.

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

Inputs	Webster 0.25 acre	Graves 1.5 acre	Lyon 0.75 acre	Daviess 0.25 acre	Daviess 0.06 acre	Graves 0.25 acre	Caldwell 0.25 acre	Hopkins 0.25 acre
Plants/seeds	$372.81	$71.25	$212.58	$40.00	$70.00	$120.00	$260.00	N/A
fertilizer	66	205	108.37	60	26	380	0	N/A
Plastic	50	0	0	0	0	0	0	N/A
Drip lines	25	165	160.65	100	0	400	134	N/A
Herbicides	10	55	15	10	0	0	10	N/A
insecticides	30	91.25	217.12	20	10	600	40	N/A
irrigation	0	25	0	200	50	25	0	N/A
Field labor[z]	60	400	92.5	300	0	1200	278	N/A
Machinery	50	100	0	100	0	0	40	N/A
Total expense	663.81	1197.50	806.22	870	156	2725	762	N/A
income	1350.50	3200	5500	3200	200	5720	755	N/A
Net income	686.69	2002.50	4693.78	2330	44	2995	-7	N/A
Net Income /Acre	2655.24	1335	6258.37	9320	264	11980		N/A
Dollar return/ Dollar input[y]	2.0	2.7	6.8	3.7	1.3	2.1	0.99	N/A

[z] When labor equals $0 it is considered unpaid family labor.
[y] Dollar return/Dollar input = income/total expenses.

Plots consisted of mixed vegetables on a quarter of an acre in Hopkins, Webster, Daviess and Caldwell counties. Two additional growers had one and a half acres of pumpkin in Graves County and three-quarters of an acre of pumpkin in Lyon County.

Material and Methods

Each grower was provided with 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 plastic mulch and drip layer, 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, when necessary, fungicide and insecticide recommendations were made in accordance with UK Vegetable Production Guide for Commercial Growers (ID-36). All of the mixed vegetable plots were planted on black plastic mulch whereas the two pumpkin growers planted their crop on white-on-black plastic. White-on-black plastic is used for late summer planting as opposed to using the black plastic mulch for early spring planting.

Results and Discussion

Another wet spring in April and May caused a late planting date for the spring crops. Drip irrigation effectively improved pumpkin production due to the low levels of rainfall in the summer.

The two growers in Daviess County made a profit. Both growers were pleased with the plasticulture system and plan on making it a part of their production system.

The grower in Webster County experienced some difficulties with the plastic-laying machine as wet conditions early in spring made it difficult to shape proper beds. One of the primary reasons for using plastic mulches is to extend the season in the spring. However, heavy spring rains and wet conditions often make early planting a challenge with plastic mulch. Plots in Caldwell and Graves counties were prepared later than usual because of the wet spring. Nonetheless, growers were satisfied with the system and saw an increase in yield over the past years of planting on bare ground.

The two pumpkin growers—one in Lyon County and the other in Graves County—were pleased with their results. Both growers decided to try the plastic mulch system as a way to better manage weeds. The grower in Lyon County planted rye the previous fall and killed it a few weeks before laying the plastic. This created some problems for the machine, and the grower had a few misshapen beds. Overall, the rye created a mat-like structure and kept the weed pressure relatively low. This grower had his highest yield and gross profit from the rye-mulch production system. The other grower in Graves County did not use a rye cover crop the previous fall. He, too, had a higher yield and higher gross profit from previous years.

Overall, it was a great year for all the participants. All of the growers have indicated an interest and are planning to continue the use of the plasticulture production system. A few of the growers have inquired about purchasing the equipment for themselves. In the words of one of the growers, he "would never grow vegetables any other way."

On-Farm Commercial Vegetable Demonstrations in West-Central Kentucky

Ty Cato and Timothy Coolong, Department of Horticulture

Introduction

Four on-farm commercial vegetable production demonstrations were conducted in the Central Kentucky counties surrounding Louisville/Jefferson County. These locations were chosen due to the proximity of Jefferson County and the recent surge in commercial vegetable production to supply the demands of the Louisville food economy. Three growers in Shelby County and one grower in Spencer County were chosen for this demonstration. One grower in Shelby County produced mixed vegetables on a quarter of an acre for local farmers' markets and direct restaurant sales. Another grower in Shelby County produced mixed vegetables on a quarter of an acre for local farmers' markets and direct restaurant sales. The final Shelby County grower produced pumpkins on three-quarters of an acre for sale at his on-farm store. The Spencer County grower produced mixed vegetables on two acres for sale at multiple local farmers' markets, auction sales, wholesale, and direct restaurant sales.

Table 1. Cost and Profits of Growers

Inputs	Shelby (All-natural 1)	Shelby (All-natural 2)	Shelby (Conv.)	Spencer (Conv.)
Plant and Seeds	$288.00	$18.00	$63.00	$1026.00
Fertilizer	$10.00	None Used	In-ground residual	$165.00
Plastic Mulch	$28.35	$21.60	$85.05	$360.00
Drip Lines	$18.00	$18.00	$54.00	$386.00
Fertilizer Injector	N/A	N/A	N/A	$175.00
Herbicide	N/A	N/A	$40.00	$900.00
Insecticide	$5.00	N/A	Not used	$550.00
Fungicide	N/A	N/A	$35.00	$200.00
Water	$100.00	$100.00	$210.00	$640.00
Manual Labor			$130.00	$4182.00
Machine Labor	$20.00 (Fuel)	$50.00	$10.00 (Fuel)	$1000.00 (Fuel)
Marketing	$120.00 (gas)	$0.00	~$0.00 (Sold in On-farm store)	$3000.00
Total Expenses	$523.00	$168.00	$478.00	$12584.00
Yield	*	*	162 Pumpkins	*
Revenue	$800.00	$200.00	$717.66	$19600.00
Profit	$277.00	$32.00	$239.66	$7016.00

Materials and Methods

The growers were provided with plastic mulch and drip tape for up to 1 acre of production. The University of Kentucky Horticulture Department also provided a bed-shaper/plastic layer, a waterwheel transplanter, and a plastic mulch lifter to remove the mulch at the end of the growing season. All other inputs including, but not limited to: fertilizer, pesticides, irrigation pumps, and labor (both manual and mechanical) were provided by the grower. The grower was given the task of recording basic information such as yield data, input costs, etc. An Extension Associate from the Department of Horticulture made weekly visits to provide assistance to the grower with pathology issues, harvesting practices, and any other commercial production issue that might have needed attention. The Extension Associate was also involved in setting up demonstration field days to display commercial vegetable production techniques to other growers that may be interested in getting involved.

The production method consisted of forming raised beds with plastic mulch sealed on top of the beds. The height of the beds ranged from six to eight inches and the plastic used was either black 1 mil for early season crops or white on black 1 mil for late season crops. The black plastic provides transplants with the heat they need early in the growing season, whereas the white on black plastic reflects the heat of the sun away from the bed for late-season crops that are planted in the heat of the summer.

Both conventional and all-natural growing practices were used in the demonstration plots. Two plots were strictly conventional, relying on synthetic fertilizer, herbicides, insecticides, and fungicides. The other two plots were grown using all-natural practices. One of these two was not sprayed at all and the other plot only had natural insecticides sprayed on it. The all-natural plots also relied on little to no fertility inputs.

Results and Discussion

The weather played a significant role in commercial vegetable production in the 2011 growing season. With 18 to 19 inches of rain recorded in parts of Shelby County in April alone; it was difficult to plant in a timely fashion, let alone, get ground prepared for planting. With the wet weather combining with warm temperatures, pest pressures were high. Most of the disease issues consisted of common problems such as bacterial wilt, early blight, septoria leaf spot and various others. Some viral diseases were noticed as well. Insect pests included cucumber beetles, aphids, squash bugs, and Colorado potato beetles. Squash Vine borer pressure was high as well, particularly with summer squash and zucchini plantings. Late season infestations of powdery mildew of cucurbits were common. However, the biggest problem encountered this season was weed pressure. Some plots became completely overrun with weeds.

Two growers in Shelby County used all-natural techniques and a third grower in the county grew conventionally managed pumpkins. The pumpkin grower did experience a large amount of cucurbit powdery mildew late in the season, but did not spray because of the close proximity of pumpkin harvest. The Spencer County grower experienced a heavy pest pressure, but did experience good yields despite this. This grower expanded from the previous year and plans on expanding even more for the 2012 growing season.

Overall, the plots did well in a season that was challenging for vegetable production. With the continuing education provided by Extension Associates and Specialists, commercial vegetable production in this region should increase in quantity and quality in the coming years. This increase will provide a much needed source of local, healthy, fresh produce for the large Louisville market.

Peach Variety Demonstration

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

Introduction

One of the initial and most important decisions every fruit grower makes is cultivar choice. Although cultivar performance and fruit quality information is 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 to perform 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 (1). This planting consisted of two trees per variety spaced 6 feet apart within rows 18 feet apart. The phenology (timing of flowering, etc.) of each cultivar was recorded in 2005 (1), in 2006 (2), and again in 2007 and 2008 (3). In spring 2009, one tree per variety was removed in order to allow adequate spacing for future growth. Yield, fruit size (average weight of 25 fruit), and

Table 1. Results of the 2008 thru 2011 harvest from the 2004 peach cultivar trial at Princeton, Ky.

	Date of Harvest				Cumulative Yield[1]	Yield (lbs/tree)				Fruit Wt (oz)				Brix (%)			
Cultivar	2008	2009	2010	2011	(lbs/tree)	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011
Allstar	Aug 4	Jul 27	Jul 22	Jul 25	358	111	30	90	71	5.1	6.8	4.0	4.2	12.3	9.9	11.9	11.0
Blushingstar	Aug 7	Jul 30	Jul 21	Jul 27	311	56	78	34	96	4.8	7.1	5.9	4.5	12.4	9.2	14.3	11.8
Contender	Aug 4	Jul 26	Jul 21	Jul 27	420	119	45	100	108	4.5	6.8	4.5	5.6	12.0	10.6	12.9	13.5
Coralstar	Aug 1	Jul 21	Jul 15	Jul 27	255	90	29	32	68	5.4	9.6	7.1	5.9	14.8	11.3	14.4	11.3
Cresthaven	Aug 18	Aug 7	Aug 9	Aug 23	186	49	40	61	2	7.1	7.6	5.9	1.6	12.0	11.9	12.8	9.4
Crimson Rocket	Jul 30	Jul 30	Jul 29	Aug1	29	8	7	7	4	3.7	.	3.1	2.8	14.8	12.3	.	12.6
Encore	Aug 26	Aug 17	Aug 16	Aug 23	237	80	26	41	39	6.9	7.1	6.8	8.5	12.7	13.0	15.0	13.1
Ernie's Choice	Jul 30	Jul 24	Jul 21	Jul 25	38	3	8	8	18	3.4	5.1	4.5	4.5	16.8	10.9	16.3	11.9
Flat Wonderful	Jul 14	Jun 20	Jul 15	Jul 5	69*	17	17	21	14	3.8	3.4	2.3	2.5	12.0	13.5	13.3	10.1
Galaxy	Aug 21	Jul27	Jul 15	Jul 5	260*	72	1	117	70	4.9	.	3.7	4.8	13.8	18.0	13.4	12.1
Glowingstar	Aug 7	Jul 30	Jul 21	Jul 27	389	112	75	25	108	5.6	6.2	5.1	4.8	10.9	11.6	13.7	11.4
John Boy	Jul 28	Jul 22	Jul 15	Jul 18	256	47	105	36	53	6.0	6.1	8.5	6.5	13.7	11.9	14.7	11.9
John Boy II	Aug 1	Jul 27	Jul 12	Jul 20	187	74	22	9	55	4.8	5.4	5.1	6.1	12.5	9.3	16.2	11.9
Klondike White	Jul 30	Jul 24	Jul 22	Jul 12	242	107	3	92	22	4.7	5.6	2.5	5.9	16.0	12.8	15.1	9.9
Laurol	Aug 28	Aug 28	Aug 16	Aug 23	315	87	46	47	78	6.2	7.9	5.1	5.4	12.7	12.9	14.8	13.3
PF 1	Jun 29	Jun 24	Jun 10	Jun 22	277	57	49	57	89	3.4	5.2	4.2	4.0	8.2	.	9.4	8.2
PF 15A	Jul 28	Jul 2	Jul 20	Jul 25	181	75	11	25	33	3.5	4.9	5.2	3.4	8.0	10.9	12.7	11.8
PF 17	Aug 4	Jul 28	Jul 21	Jul 27	350	76	75	69	87	5.4	5.9	4.5	4.8	10.7	10.7	12.5	11.9
PF 20-007	Aug 1	Jul 20	Jul 21	Jul 27	332	87	32	125	31	6.5	9.6	4.8	7.9	10.1	10.4	10.7	12.6
PF 24C	Aug 11	Aug 5	.	Aug 1	140	42	58	0	14	6.2	4.5	.	4.5	11.1	.	.	13.1
PF 25	Aug 21	Aug 7	Aug 16	Aug 23	227	80	29	72	27	4.9	8.0	3.7	5.4	13.2	12.6	13.1	11.3
PF 27 A	Aug 15	Aug 7	Aug16	Aug 23	257	58	2	106	78	4.5	.	4.0	6.3	12.3	.	13.7	13.3
PF 35-007	Aug 15	Aug 13	Jul 12	Aug 23	311	37	55	77	117	5.1	10.2	4.8	5.9	13.8	12.7	13.0	10.7
PF 5B	Jun 29	Jun 10	Jun 10	Jun 22	166	60	18	18	46	3.4	4.4	4.0	4.2	10.0	9.8	11.2	19.0
PF 7	Jul 11	Jun 30	Jun 30	Jul 9	146	51	33	5	47	3.8	5.6	.	4.7	10.2	8.3	10.1	9.2
PF Lucky 13	Jul 21	Jul 2	Jul 1	Jul 12	231	86	8	20	80	3.1	4.2	5.1	4.8	11.0	11.5	11.0	7.7
PF Lucky 21	Aug 4	Jul 4	Jul 29	Aug 1	279	84	58	69	38	6.5	5.6	3.4	5.1	11.8	10.3	.	12.2
Redhaven	Jul 22	Jul 15	Jul 12	Jul 15	202	81	8	21	51	3.7	4.9	13.9	6.3	11.5	11.7	13.9	10.4
RedStar	Jul 22	Jul 16	Jul 12	Jul 11	161	49	14	3	67	4.0	5.4	14.1	6.2	12.1	9.7	14.1	10.4
Reliance	Jul 14	Jul 14	Jul 15	Jul 10	165*	28	8	72	57	4.2	4.8	4.8	7.1	11.0	11.9	13.3	11.9
Snow Brite	Jul 14	no harvest		Jul 5	73	26	0	0	20	2.5	.	.	3.1	10.6	.	.	9.0
Snow Giant	Aug 25	Aug 25	Aug 16	Aug 23	237	82	55	35	48	7.9	7.9	6.5	4.5	13.3	10.5	16.8	11.7
Spring Snow	Jun 27	Jun 5	Jun 18	.	37*	5	8	24	0	3.1	3.8	5.2	5.1	9.6	13.1	11.7	13.2
Sugar Giant	Aug 15	Jul 27	Jul 29	Jul 27	58	17	1	22	17	5.4	.	4.5	4.2	11.3	10.9	.	10.2
Sugar May	Jul 8	Jun 5	Jun	Jun 27	63*	21	4	1	37	2.5	4.4	.	3.4	9.2	11.9	13.4	7.3
Summer Breeze	Jul 25	Jul 18	Jul 15	Jul 18	196	70	28	41	33	5.0	5.4	3.7	4.9	10.8	9.9	16.6	10.9
Sweet-N-Up	Aug 7	Jul 30	Aug 9	Aug 1	73	30	16	0.9	27	7.3	8.5	.	5.6	14.7	11.8	16.8	13.1
True Gold	Aug 11	Aug 10	Jul 21	Aug 1	188	66	48	4	11	7.2	6.5	5.9	5.7	11.7	10.0	13.3	.
White Lady	Aug 7	Jul 20	Jul 21	Jul 18	138	77	9	1	12	3.1	5.6	.	5.8	10.1	11.7	21.7	11.6

[1] 2006, 2008, 2009, 2010, and 2011. There was no harvest in 2007 due to the spring freeze.
*Indicates first harvested in 2008.

Brix readings of three fruit were recorded at harvest in 2006 and 2008 through 2011. No fruit was harvested in 2007 due to a series of freezes from April 5-10, 2007, that affected all fruit crops in Kentucky. Bacterial-spot ratings recorded in July 2009 were reported in previous reports (4, 5).

Results and Discussion

The date of harvest averaged about five days later in 2011 than it did in 2010 (Table 1). Contender, Allstar, and Glowingstar, have the highest cumulative yields to date. Allstar, Contender, and PF 35-007 were among the top three in yield per tree in 2011. 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.

Fifty-eight percent of the cultivars had higher yields in 2011 than in 2010. But some cultivars had little or no yield in 2011, due to poor winter flower bud survival and possibly due to poor pollination for those cultivars. Average fruit weight was 5.0 ounces per fruit in 2011, versus 4.6 ounces per fruit in 2010, 6.2 ounces per fruit in 2009, and 4.8 ounces in 2008. Brix readings averaged 11.5 in 2011, compared to 13.8 in 2010, 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.

All peach cultivars in this trial generally have good flavor. Flat Wonderful and Galaxy are peen-to (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

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

2002 Apple Rootstock Trial

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-feet-by-15-feet spacing.

2003 Apple Rootstock Trial

The 2003 apple rootstock trial compares 11 rootstocks with Golden Delicious as the scion. Two trees of each rootstock

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

Rootstock[1]	Percent Survival (number of trees planted)	Cumulative Yield (2004-2011) (lbs/tree)	Yield (lbs/tree)	Fruit Weight (oz)	Trunk Cross-Sectional Area (sq. in.)	Height (ft.)	Spread (ft.)	Number of Root Suckers	Cumulative Yield Efficiency (lbs/sq. in.)
P.14	43 (7)	1111	88	5.6	25.0	14.0	12.8	4.7	44.9
M.9 Burgmer 756	14 (7)	937	122	5.4	17.4	12.4	11.1	0.0	53.9
M.9 NAKB T337	43 (7)	719	83	6.7	14.6	12.4	11.0	1.0	50.0
M.26 NAKB	57 (7)	614	36	5.4	12.8	10.3	9.6	0.0	48.0
M.26 EMLA	29 (7)	315	20	6.1	9.4	9.3	8.0	0.0	33.5
M.9 Nic29	57 (7)	482	42	5.8	8.9	8.9	9.2	9.5	51.0
Supporter 4	43 (7)	442	53	6.4	8.4	10.5	8.1	4.0	51.2
B.9 Treco	71 (7)	216	9	5.6	4.3	7.3	7.0	2.2	50.8
B.9 Europe	71 (7)	108	2	—[2]	2.3	6.2	5.5	3.0	47.4
Mean	49	480	40	5.9	10.0	9.5	8.7	3.1	47.4
LSD (5%)	NS	308	42	NS	5.9	4.0	2.8	NS	NS

1 Arranged in descending order of cumulative yield.
2 Sample size was too small to determine fruit weight.

were planted in a randomized complete block design with four replications (blocks). Trees were planted on 8-feet-by-15-feet spacing.

2009 Peach Rootstock Trial

The 2009 peach rootstock trial compares 14 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-feet-by-20 feet spacing.

2010 Apple Rootstock Trial

A planting of Aztec Fuji apple on 31 different rootstocks with four blocks per rootstock and up to three trees per rootstock per block (256 trees for Princeton) 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 with a range of from 3 to 7 inches.

Orchard floor management consists of a 6½-foot bare ground herbicide-treated strip with mowed sod alleyways. Trees are fertilized and sprayed with pesticides according to local recommendations (1, 2). Yield and trunk circumference measurements are recorded for all of the rootstock trials, and trunk cross-sectional area is calculated from the trunk circumference measurements taken 10 inches above the graft union 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 (in ounces) of 50 fruit.

Results and Discussion

December and January temperatures across Kentucky were 8.8 degrees and 2.9 degrees below normal, respectively. Temperatures from February through June were consistently above normal, and April and July were both 4 degrees above normal. The NC-140 orchard at Princeton experienced 38 days above 90 degrees from May through September.

January precipitation averages across the state were almost two inches below normal, while February through June was 12.6

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

Rootstock[1]	Percent Survival (number of trees planted)	Cumulative Yield (2005-2011)[2] (lbs/tree)	Yield (lbs/tree)	Fruit Weight (oz)	Trunk Cross-Sectional Area (sq. in.)	Cumulative Yield Efficiency (lbs/sq. in.)
PiAu56-83	100 (8)	810	117	7.4	49.5	20.7
PiAu51-4	100 (7)	777	124	7.5	43.5	22.9
M.9 Pajam2	88 (8)	649	98	7.9	22.4	36.8
M.26	75 (8)	537	101	7.3	20.2	35.3
J-TE-H	100 (8)	631	89	7.9	18.8	42.9
G.16	50 (8)	554	103	7.4	17.8	39.5
M.9 NAKBT337	75 (8)	642	141	7.8	16.6	45.4
Bud.62-396	100 (8)	601	105	7.4	15.6	49.0
CG.3041	88 (8)	583	118	7.2	15.2	47.0
CG.5935	75 (8)	543	94	8.1	13.3	50.2
B.9	50 (8)	163	22	6.5	4.1	53.5
Mean	77	618	105	7.5	23.5	38.7
LSD (5%)	31	145	NS	0.6	5.8	9.9

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.

inches above normal. Roughly 7.7 inches of this precipitation came in April. July and August were 1.9 inches below normal and September rainfall was 7.4 inches above normal. Western Kentucky received far less rainfall during the summer than other areas of the state.

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). Significant differences were observed for cumulative yield, 2011 yield, height, spread, and trunk cross-sectional area (TCSA), but no differences were observed in tree mortality, fruit weight, cumulative yield efficiency, or number of root suckers (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.

2003 Apple Rootstock Trial

Mortality, cumulative yield, fruit weight, trunk cross-sectional area, and cumulative yield efficiency varied significantly among the rootstocks in the 2003 apple rootstock trial (Table 2). Trees on B.9, G.16 and CG.5935 rootstocks have the highest mortality (50 percent to 75 percent) in this trial. The highest cumulative yield and highest yield for 2011 were observed for scions on Pi Au 56-83, which also had the largest trunk cross-sectional area. Biennial bearing in this trial was evident in that yield in 2011 averaged about a third less than that of 2010.

2009 Peach Rootstock Trial

Mortality, Julian date of 90 percent bloom, TCSA, yield, and number of root suckers varied significantly among the 14 rootstocks in this trial, (Table 3). Trees on Bright's Hybrid and Viking have had the highest mortality rates, 50 percent and 25 percent, respectively. Trees on Krymsk 86 averaged the earliest 90 percent bloom date, March 23, while trees on Krymsk 1 averaged the latest date of 90 percent bloom, April 3. The number of root suckers for trees on *P. americana* averaged 15.1, significantly more than on any of the other rootstocks.

This was the first year to collect yield data from this trial. Only peaches 2.25 inches in size or greater were harvested, but sample sizes were inadequate (fewer than 20 fruit) to determine fruit size as measured by average fruit weight. Yield was highest for trees with Krymsk-86 and HOBK-10 rootstocks, and lowest for trees on

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

Rootstock[1]	Tree Mortality (% lost)	Julian Date of 90% Bloom	Yield (lbs/tree)	Number of Root Suckers	Trunk Cross-Sectional Area (sq. in.)
Microbac	0	89.0	2.9	4.4	8.4
Krymsk 86	0	87.0	4.2	0.0	8.1
Bright's Hybrid	50	90.0	0.9	0.3	7.9
Guardian	0	89.0	2.4	0.6	7.4
Viking	25	90.2	3.3	0.0	7.3
Atlas	0	89.8	2.9	0.1	7.1
Lovell	0	90.5	3.1	0.5	6.9
KV010-127	0	90.4	2.0	0.2	6.8
KV010-123	12.5	92.1	2.2	0.9	6.3
HBOK 32	12.5	91.7	4.0	0.0	5.5
HBOK 10	0	92.3	4.2	0.0	4.7
P. american	0	92.6	4.0	15.1	4.3
Controller	0	93.0	3.1	0.0	4.1
Krymsk 1	0	93.0	2.9	6.5	2.9
Mean	7.1	90.8	3.1	2.2	6.2
LSD (5%)	22.2	2.8	1.8	5.0	1.4

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

Table 4. 2010 NC-140 apple rootstock trial, Princeton, Ky.

Rootstock[1]	Number of trees planted	Tree mortality (% lost)	Number of flower clusters	Number of Root Suckers	Trunk Cross-Sectional Area (sq. in.)
PiAu 9-90	7	43	17	1.3	3.117
B.70-20-20	12	0	5	0.6	2.835
PiAu 51-11	12	0	11	0.0	2.613
G.202 N	8	0	16	1.0	2.496
G.935 N	11	9	16	0.4	2.204
G.5202	8	0	8	0.4	2.198
B.70-6-8	12	0	26	0.0	2.144
M.26 EMLA	12	0	31	0.0	2.117
M.9 Pajam2	12	10	43	2.2	2.097
B.7-3-150	12	0	27	0.0	2.083
B.67-5-32	12	0	24	0.2	2.051
G.4814	8	50	20	2.8	2.017
G.3001	3	0	31	0.3	1.975
G.11	9	11	48	0.0	1.916
G.935 TC	5	20	38	0.3	1.826
G.202 TC	12	0	12	0.9	1.824
G.4004	4	0	8	0.3	1.714
B.10	12	0	13	0.0	1.694
G.41 TC	1	0	33	0.0	1.690
M.9 NAKBT337	10	8	28	0.8	1.686
Supp.3	5	0	63	0.0	1.669
B.64-194	8	13	30	0.7	1.655
G.5087	2	0	15	0.0	1.482
G.4214	5	20	32	0.0	1.412
G.4003	7	0	26	0.1	1.147
G.4013	4	50	11	0.0	1.118
G.2034	3	33	34	0.5	1.035
B.9	12	0	34	0.2	1.001
G.41 N	6	50	8	0.0	0.972
B.7-20-21	12	0	17	0.6	0.575
B.71-7-22	10	0	23	0.5	0.477
Means	NA	9	23	0.4	1.823
LSD (0.05)	NA	32	22	NS	0.705

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

Bright's Hybrid. Due to poor weather conditions this past spring (hail damage, etc.), and the emergence of the cicada brood XIX, peaches harvested in this trial would not have been considered commercial quality even though they met the commercial size requirements for this trial.

2010 Apple Rootstock Trial

Mortality and TCSA varied significantly among the 31 rootstocks in this trial (Table 4). Only 50 percent of the trees on G.4013, G.41N, and G.4814 rootstocks have survived. Scions on PiAu 9-90, and B70-20-20 rootstocks are the largest, and scions on B.7-20-21 and B.71.7-22 are the smallest.

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Wine and Table Grape Cultivar Evaluation Trial in Kentucky

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Introduction

The climate in Kentucky is well-suited to produce a variety of wine and table grape cultivars. However, cold winter temperatures and long, warm, humid summers pose challenges to growing grapes in Kentucky. Successful production is determined by the use of proper cultural practices and matching cultivar 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, *V. vinifera* cultivars often produce more desirable wines and potentially have the highest economic gain for grape growers and wine makers. However, *V. vinifera* cultivars are more susceptible to winter injury and diseases, often resulting in a lower yield and increased labor inputs. A cultivar trial consisting of table, interspecific hybrid, and *V. vinifera* grape cultivars was conducted to assess and improve fruit and wine quality through cultural management, rootstock and clone selection. The following research update is intended to provide the 2011 season production and cultivar performance results.

Table 1. Yield components for the 2011 American/hybrid winegrape cultivar trial, UK Horticulture Research Farm.

Cultivar / Rootstock	Harvest Date	Yield per Acre[z] (tons)	Yield per Foot[y] (lb)	Shoots Per Foot of Cordon[x]	% Culled Clusters[w]	Cluster Weight (g)
White						
NY76.084	8/11	6.2	2.8	10.0	3.2	104
Cayuga	8/25	8.5	3.9	7.4	0.0	195
Seyval blanc	8/23	6.5	3.0	9.5	3.5	168
Vignoles	8/24	4.8	2.2	10.3	9.2	76
Chardonel/C-3309	9/2	8.5	3.9	8.3	3.7	230
Chardonel/OR	9/2	7.3	3.3	7.3	0.9	213
Vidal/5C	10/3	7.6	3.5	8.2	4.7	151
Vidal/OR	10/3	7.6	3.5	7.5	7.7	173
Villard	8/27	9.1	4.2	9.2	0.0	180
Traminette	8/30	7.6	3.5	8.2	3.3	148
Traminette/5C	8/30	7.5	3.4	8.1	5.3	155
Frontenac Gris	8/10	0.5	0.2	5.6	88.7	92
Red						
Marquette	8/10	0.0	0.0	7.1	100.0	na
Foch	8/26	0.8	0.4	8.4	86.5	67
Corot Noir	8/27	7.4	3.4	8.6	2.3	150
Frontenac	8/10	0.2	0.1	10.4	97.9	112
GR7	9/1	2.3	1.1	10.9	80.4	128
Chancellor	9/12	6.3	2.9	8.4	10.5	112
Noiret	9/3	5.6	2.6	8.8	13.1	131
Chamb/101-14	10/4	8.5	3.9	7.8	1.4	188
Chamb/OR	10/4	1.5	0.7	3.5	4.9	113
Norton	10/4	7.6	3.5	8.8	0.0	92
St. Vincent	10/1	10.6	4.9	10.9	0.4	146

[z] Yield per acre calculated using 8ft x 10ft vine/row spacing, with 545 vines per acre.
[y] Total yield divided by the total length of cordon = yield per linear foot of cordon.
[x] Total number of shoots divided by the total length of cordon = shoots per linear foot of cordon.
[w] Percentage of harvested clusters having ≥ 30% damage caused by cluster rot, insect damage and/or bird damage.

Table 2. Yield components for the 2011 table grape cultivar trial, UK Horticulture Research Farm.

Cultivar / Rootstock	Harvest Date	Yield per Acre[z] (tons)	Yield per Foot[y] (lb)	Shoots Per Foot of Cordon[x]	% Culled Clusters[w]	Cluster Weight (g)
Einset	7/29	3.0	1.4	6.7	25.8	98
Reliance	8/2	7.7	3.5	5.8	2.7	201
Jupiter	8/3	6.5	3.0	7.6	22.5	162
Marquis	8/22	7.1	3.3	7.5	0.5	204
Neptune	9/1	9.3	4.3	7.1	0.0	264

[z] Yield per acre calculated using 8ft x 10ft vine/row spacing, with 545 vines per acre.
[y] Total yield divided by the total length of cordon = yield per linear foot of cordon.
[x] Total number of shoots divided by the total length of cordon = shoots per linear foot of cordon.
[w] Percentage of harvested clusters having ≥ 30% damage caused by cluster rot, insect damage and/or bird damage.

Materials and Methods

Two research vineyards were planted in the spring of 2006 at the University of Kentucky Horticulture Research Farm in Lexington. Twelve varieties within these vineyards were planted in 2008 as part of the NE-1020 Multi-State Evaluation of Winegrape Cultivar 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 cultivars 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 per acre (8 feet between vines and 10 feet between rows) and trained to a 6-foot single high wire bilateral cordon. Vines were own-rooted with the exception of Chambourcin, Chardonel, Vidal Blanc and Traminette, which additionally were planted on the rootstocks 101-14, 3309 and 5C, respectively.

Vineyard Two consists of 15 European cultivars 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 per acre

(7 feet between vines and 10 feet between rows) and trained to vertically shoot positioned (VSP) bilateral cordons.

Standard commercial cultural management practices were implemented in both vineyards. In March of 2011 vines were spur pruned and dehilled. No herbicide or tillage was utilized to control winter annual weeds. 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 expressed normal to high vigor and no nitrogen fertilizer was applied during any part of the 2011 growing season. 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 four to six shoots per foot of cordon (*V. vinifera*) and five to seven shoots per foot of cordon (hybrid) in mid-May and cluster thinned to appropriate crop loads post fruit set (berries bb size). Vines on VSP trellising system were hedged manually 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 per 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 in hybrid cultivars during the months leading up to the 2011 season. However, significant winter injury has been observed on most *V. vinifera* cultivars. Malbec, Pinot Noir, and Syrah suffered more than 70 percent vine mortality and will no longer be assessed as potential cultivars for grape production in

Table 3. Yield components for the 2011 Vinifera winegrape cultivar trial, UK Horticulture Research Farm.

Cultivar / Clone	Harvest Date	Yield per Acre[z] (tons)	Yield per Foot[y] (lb)	Shoots Per Foot of Cordon[x]	% Culled Clusters[w]	Cluster Weight (g)
White						
Pinot Grigio #146	8/23	5.6	2.5	6.7	15.7	131
Pinot Grigio #152	8/23	5.5	2.5	6.7	27.1	125
Pinot Grigio #4	8/23	5.9	2.7	6.7	12.1	141
Chardonnay #15	9/1	4.2	1.9	5.4	0.9	91
Chardonnay #37	9/1	3.8	1.7	6.1	6.2	98
Chardonnay #4	9/1	5.5	2.5	5.3	3.8	162
Chardonnay #43	9/1	4.6	2.1	5.8	1.8	108
Chardonnay #76	9/1	4.1	1.9	6.1	4.5	107
Viognier	8/25	8.0	3.7	6.6	1.1	180
Rkatsiteli	9/16	5.2	2.4	5.2	0.0	208.4
Riesling #12	9/22	4.1	1.1	5.9	56.1	110
Riesling #17	9/22	4.1	1.0	5.5	62.3	109
Riesling #9	9/22	4.2	0.8	6.1	71.7	114.7
Red						
Limberger	9/2	8.1	3.4	5.3	3.6	168
Petite Verdot #2	9/24	4.3	2.0	5.1	6.5	108
Tinto Cao	9/24	2.8	1.3	5.2	19.9	120
Touriga	9/16	3.1	1.4	5.3	15.4	98
Sangiovese #12	10/1	7.3	3.4	5.2	2.9	241
Cabernet Franc #1	9/27	6.5	3.0	6.1	1.7	140
Cabernet Franc #214	9/27	7.4	3.4	7.5	14.7	129
Cabernet Franc #312	9/27	6.0	2.7	5.9	22.9	166
Cabernet Franc #4	9/27	5.5	2.5	6.5	24.2	148
Cabernet Franc #5	9/27	6.1	2.8	7.0	24.0	140
Cabernet Sauvignon #337	9/24	6.4	2.9	5.7	6.0	143
Cabernet Sauvignon #8	9/24	4.3	2.0	5.5	28.3	125

[z] Yield per acre calculated using 7ft x 10ft vine/row spacing, with 622 vines per acre.
[y] Total yield divided by the total length of cordon = yield per linear foot of cordon.
[x] Total number of shoots divided by the total length of cordon = shoots per linear foot of cordon.
[w] Percentage of harvested clusters having ≥ 30% damage caused by cluster rot, insect damage and/or bird damage.

Table 4. Fruit composition for the 2011 American/hybrid winegrape cultivar trial, UK Horticulture Research Farm.[z]

Cultivar / Rootstock	Berry Wt. (g)	TSS[y] (%)	Juice pH	TA[x] (g/L)
White				
NY76.084	179	15.5	3.09	8.0
Cayuga	385	19.0	3.36	6.3
Seyval blanc	159	20.0	3.25	7.0
Frontenac Gris	99	24.0	3.32	9.0
Vignoles	152	24.1	3.22	8.0
Chardonel/C-3309	240	22.5	3.52	6.3
Chardonel/OR	242	22.1	3.43	6.5
Vidal/5C	213	22.9	3.63	5.2
Vidal/OR	210	22.8	3.64	5.0
Villard	278	17.6	3.08	8.5
Traminette	188	20.8	3.58	4.8
Traminette/5C	180	20.1	3.66	4.8
Red				
Marquette	N/A	N/A	N/A	N/A
Foch	125	23.4	3.51	5.5
Corot Noir	234	19.1	3.53	5.8
Frontenac	114	23.0	3.59	10.4
GR7	158	22.5	3.62	6.5
Chancellor	195	21.1	3.61	6.6
Noiret	188	19.5	3.68	5.8
Chamb/101-14	255	22.7	3.45	6.2
Chamb/OR	248	23.7	3.46	5.3
Norton	123	23.1	3.5	9.1
St. Vincent	270	19.2	3.28	7.8

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

Kentucky. All hybrid cultivars showed less than 15 percent of culled (non-marketable) clusters with the exception of the early ripening cultivars Frontenac, Frontenac Gris, Foch, GR7 and Marquette that lost almost a full crop to high early season bird pressure (Table 1). Of the *V. vinifera* cultivars, Riesling (clone 9, 12, 17), Pinot Grigio (clone 152), Cabernet Franc (214, 312, 4, 5), and Cabernet Sauvignon (clone 8) had significant incidence of bunch rot (Table 3). Typically, Riesling and Pinot Grigio have increased incidence of bunch rot in warm climates; however frequent rains in September increased bunch rot incidence of Cabernet Franc and Cabernet Sauvignon during the 2011 harvest (Table 3). Cabernet Sauvignon clone 337 had significantly less incidence of rot than clone 8 due to higher vine vigor and less fruit exposure, resulting in delayed fruit maturation (Table 3). Cabernet Franc clone 1 had significantly less incidence of bunch rot than all other clones due to virus like symptoms resulting in fruit of substandard fruit maturity (Table 3). Cabernet Franc clone 1 and Cabernet Sauvignon clone 337 do not represent superior clone choices. All table grape cultivars with the exception of Marquis and Neptune had less than 15 percent bunch rot due to early season grape berry moth damage and June beetle damage (Table 2).

Yield, shoots per foot of cordon and cluster weight for all hybrid (Table 1), *V. vinifera* (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 2012 season, and harvest data will better represent commercial production in 2012.

Due to heavy rainfall in April, disease pressure was high and required increased early season disease control. Heavy rains later in the season resulted in early ripening cultivars having better fruit chemistry and less fruit rot than later ripening cultivars. However, all grape cultivars reached acceptable fruit chemistry profiles. TSS, juice pH and TA for hybrid (Table 4), *V. vinifera* (Table 6) and table grape (Table 5) cultivars were all within commercially acceptable ranges.

Results of the 2011 growing season represent an average year for the production of grapes in Kentucky. As previously mentioned, heavy spring rains made disease control difficult. Late-season rains affected harvest, and increased difficulty in controlling late season downy mildew infections, in some cases leading to earlier than normal leaf defoliation.

The vineyards at the University of Kentucky Horticulture Research Farm are planted in an ideal location 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 2011 table grape cultivar trial, UK Horticulture Research Farm.[z]

Cultivar / Rootstock	Berry Wt. (g)	TSS[y] (%)	Juice pH	TA[x] (g/L)
Einset	234	17.4	3.14	5.1
Reliance	240	19.8	3.29	5.0
Jupiter	392	17.1	3.43	5.0
Marquis	435	18.0	3.43	5.0
Neptune	315	21.8	3.44	4.8

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

Table 6. Fruit composition for the 2011 vinifera winegrape cultivar trial, UK Horticulture Research Farm.[z]

Cultivar / Clone #	Berry Wt. (g)	TSS[y] (%)	Juice pH	TA[x] (g/L)
White				
Pinot Grigio #146	161	20.4	3.48	6.1
Pinot Grigio #152	173	20.6	3.42	6.2
Pinot Grigio #4	165	20.6	3.49	6.2
Chardonnay #15	179	21.5	3.57	5.8
Chardonnay #37	165	21.3	3.63	4.9
Chardonnay #4	185	20.8	3.65	5.2
Chardonnay #43	170	20.9	3.61	5.8
Chardonnay #76	166	21.0	3.63	5.2
Viognier	187	20.8	3.45	6.0
Rkatsiteli	262	20.2	3.34	6.2
Riesling #12	182	18.3	3.32	5.9
Riesling #17	196	17.6	3.38	5.2
Riesling #9	185	17.7	3.34	5.8
Red				
Limberger	308	21.0	3.63	5.0
Petite Verdot #2	119	20.6	3.62	4.8
Tinto Cao	162	21.9	3.67	4.5
Touriga	200	21.9	3.67	4.5
Sangiovese #12	296	20.8	3.48	5.0
Cabernet Franc #1	197	18.2	3.49	5.8
Cabernet Franc #214	156	21.5	3.57	4.6
Cabernet Franc #312	181	19.5	3.54	4.6
Cabernet Franc #4	175	21.5	3.62	4.5
Cabernet Franc #5	205	20.9	3.60	4.6
Cabernet Sauvignon #337	159	19.4	3.46	7.1
Cabernet Sauvignon #8	165	21.2	3.45	4.9

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

The Prime-Jan® and Prime-Ark®45 Thorny Primocane-fruiting Blackberry Trial at Kentucky State University

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Introduction

Kentucky's climate is well-suited for blackberry production and small-scale commercial production for U-Pick, Community Supported Agriculture (CSAs), and farmers' markets. 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, which are usually vegetative, and floricanes, the same canes that flower and produce fruit the next growing season. Floricanes then die after fruiting and need to be removed. Primocane-fruiting blackberries have the potential to produce two crops per year, with a normal summer crop (floricane) and a later crop on the current season primocanes. Primocane-fruiting blackberries flower and fruit from mid-summer until frost, depending on temperatures, plant health, and the location in which they are grown. Growers can reduce pruning costs by mowing canes in late winter to obtain a primocane crop only; 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 in 2011 for the thorny primocane-fruiting blackberry cultivars 'Prime-Jan®' and 'Prime-Ark®45' from the University of Arkansas Blackberry Breeding Program that were established at the Kentucky State University Research Farm in June 2010.

	Yield (lb/A)[z]		Average Fruit Weight (g)		Harvest Dates (start to end)	
Selection	**Floricane**	**Primocane**	**Floricane**	**Primocane**	**Floricane**	**Primocane**
'Prime-Jan®'	586	921*	3.4	2.2**	6/17-7/14	8/11-10/29
'Prime-Ark®45'	552	3904	4.1	3.8	6/17-7/18	8/11-10/29

[z] Significantly different from the mean below with a P-value of either <0.05 (*) for <0.003(**).

The first commercially available thorny primocane-fruiting blackberry varieties, Prime-Jim® and Prime-Jan®, were released by the University of Arkansas in 2004 (Clark et al., 2005; Clark, 2008). In Kentucky trials, Prime-Jan® has higher yields and larger fruit than Prime-Jim®. Prime-Ark®45 was recently released for commercial production by the University of Arkansas, but has not been tested in Kentucky (Clark and Perkins-Veazie, 2011). Fruit size and quality of primocane-fruiting blackberries can be affected by the environment. Summer temperatures above 85 degrees can greatly reduce fruit set, size and quality on primocanes, which results in substantial reductions in yield and fruit quality in areas with this temperature range in summer and fall (Clark et al., 2005; Stanton et al., 2007). The objectives of this study were to determine whether Prime-Ark®45 was superior to Prime-Jan® in terms of yield and fruit quality under Kentucky growing conditions.

Materials and Methods

In April 2010, a blackberry variety trial was established at Kentucky State University (KSU). Plants of the commercially available primocane-fruiting cultivars Prime-Jan® and Prime-Ark®45—both are thorny erect, primocane-fruiting selections—were planted at the KSU Research and Demonstration Farm in Frankfort. Plants were arranged in a randomized complete block design, with four blocks, including five plants of each cultivar per block (total of 20 plants of each cultivar) in a 10-foot plot. Spacing was 2 feet between each plant and 5 feet between groups of five plants, with each row being 125 feet in length. Rows were spaced 14 feet apart. This trial was planted on certified organic land and managed with organic practices following the National Organic Program standards. Weed control was achieved by placing a 6- to 8-inch deep layer of straw around plants, adding straw when necessary and hand weeding. Plants were irrigated weekly with t-tape laid in the rows.

There were few fruit on primocanes in the fall of 2010, so fruit were not harvested. Floricane fruit began ripening in June 2011. Primocanes began producing ripe fruit in late August 2011 that were harvested each Monday and Thursday until a killing frost on October 29, 2011.

Results and Discussion

Floricane fruit were harvested from mid-June to mid-July 2011 (Table 1). Prime-Jan® and Prime-Ark®45 had similar floricane yields (approximately 550 pounds per acre), which were about half of the floricane yields for mature plantings of Prime-Jan® in previous years. The lower yields in this trial likely reflect that the plants are establishing and could not support the development of many canes the previous year for floricane fruit production. Berry size from floricanes was similar for both cultivars.

Primocane fruit were harvested from early August until frost in late October (Table 1). Primocane production of Prime-Ark®45 out yielded Prime-Jan® by almost a threefold margin, and berry size was also larger for Prime-Ark®45. Temperatures were above normal during extended periods of the summer and fall; there were 64 out of 122 days with a daily high temperature above 85 degrees from June through September. The average high in July was 88.6 degrees and only three days in that month had high temperatures that were below 85 degrees. Visual inspections of the developing fruit on inflorescences of both cultivars indicated that high temperatures reduced drupelet set in Prime-Jan® to a greater extent than Prime-Ark®45, thereby reducing yields in Prime-Jan®. The University of Arkansas Blackberry Breeding Program recommends that commercial producers plant Prime-Ark®45 instead of Prime-Jan® due to the superior shipping quality of the firmer fruit of Prime-Ark®45. Year-to-year yield characteristics will need to be further evaluated, however the 2011 data suggests that Prime-Ark®45 yields well in Kentucky and that fruit set is less affected by hot summer temperatures than Prime-Jan®. Prime-Ark®45 should be considered by commercial growers interested in producing primocane fruiting blackberries.

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Stink Bug Incidence in Primocane-fruiting Blackberry Selections in Kentucky

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Introduction

Figure 1. Relative abundance of stink bug species.

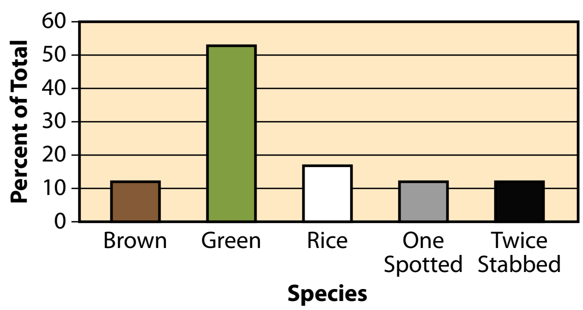
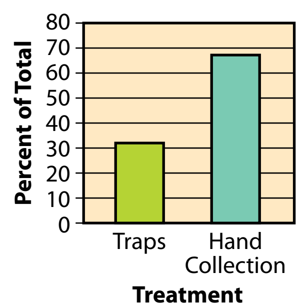


Figure 2. Relative abundance of all species combined by collection method.



Primocane-fruiting blackberries produce fruit on current-season canes. These blackberries flower and fruit from late-summer until frost, and have the potential to produce two crops per year: first the normal summer crop on floricanes and then a later crop on primocanes (Clark et al. 2005). These blackberries can be pruned by mowing canes in the late winter, providing anthracnose, cane blight and red-necked cane borer control without pesticides (Clark 2008). Organic primocane blackberry production has great potential for small-scale commercial growers, community-supported agriculture, and farmers' markets.

Brown and green stink bugs (Hemiptera: *Pentatomidae*) have become insect pests of organic blackberries in Kentucky (Gomez and Mizell 2008, Townsend and Bessin 2010). The insects cause damage by directly feeding on blackberry drupelets, discoloring fruit, and imparting foul odors (Johnson and Lewis 2005). Stink bug species have not been well studied in blackberries in Kentucky although damage has been noted by growers and researchers. The objective of this study was to identify the incidence of stink bug species in organically managed blackberries using two methods of collection.

Materials and Methods

An existing plot of primocane-fruiting blackberry cultivars Prime-Jim® and Prime-Jan® was selected as the study site at the Kentucky State University Research and Demonstration Farm in Frankfort. A completely randomized design of three plots with five plants of each cultivar per treatment was used. Each plot was 9 m and the rows were 4.3 m apart. The plots were managed in 2011 with organic growing practices following the National Organic Program standards. Weed control was achieved by hand weeding and using a weed eater. Three replicate plots of each variety were mowed on April 6 (control). Treatment One mowing occurred on June 24. Stink bugs were sampled weekly by hand collecting from blackberry bushes. We used visual inspection and hand collecting stink bugs in each plot and Florida stink bug traps to quantify stink bugs. Traps were placed in each cultivar treatment and were emptied weekly from July 11 to September 29. Stink bugs were identified, counted, and the results were tabulated.

Results and Discussion

Stink bugs were found across treatments during the 2011 sampling period which extended from July 11 until September 29. Five stink bug species were identified during the period of fruit ripening in the planting. The green stink bug was the most abundant, followed by rice stink bug and then brown, twice stabbed and one-spotted stink bugs at 53 percent, 16 percent, 11 percent, 11 percent and 11 percent, respectively (Figure 1).

Brown marmorated stinkbug is a new invasive pest in Kentucky; however, this species was not identified in the planting this year. Both visual inspection and hand collection of stink bugs as well as the use of the Florida stink bug traps resulted in the capture of stink bugs. Although hand collecting required more time, more than twice as many stink bugs were captured compared to the stink bug trap, at 68 percent and 32 percent, respectively (Figure 2). Populations of stink bug species might vary year to year and affect management decisions, therefore this study will be repeated next year.

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Pea Variety Evaluations

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Peas can help provide an early cash flow for early season markets. There are three types of green pod peas: English or shelling peas; snap peas, in which the peas are allowed to fill out and the entire pod is consumed; and snow peas, in which the pods are picked with minimal seed development and the entire pod is consumed. This trial was established to evaluate eleven English, five snap, and six snow pea varieties for performance in the Central Kentucky area.

Materials and Methods

This trial was conducted at the Horticultural Research Farm in Lexington. The soil was fertilized prior to planting with 300 pounds per acre of 19-19-19. Seeds were sown on April 4 on bare, Maury silt loam. Varieties were planted in 20-foot long double rows that were 9 inches apart on 3½-foot centers. Seeds were sown approximately 2 inches apart. Plots were replicated four times in a randomized block design. Dual II Magnum herbicide was applied prior to planting and incorporated at a rate of 1.7 pints per acre on April 4. No fungicides or insecticides were used.

Peas were harvested by hand twice weekly on June 2, 6, 10, 13, 17, 21, and 24. Plant height, pod length and width, number of peas per pod, and number of pods per plant node were recorded. Sweetness was evaluated by taste and rated on a 1-5 scale.

All pea varieties were evaluated by a consumer taste panel in the Family Consumer Sciences department as varieties matured. Varieties were evaluated fresh (washed and pod strings removed); steamed (1 inch of water in a pan with ½ cup peas or pods in a basket in pan; cooked on medium high heat on a stove for three minutes); microwaved (1 inch of water in a ceramic dish, ½ cup peas or pods, high power for 4 min.); and blanched in salt water (one inch water and ¼ teaspoon salt, ½ cup peas or pods; medium high heat on stove for 3 minutes). Groups of five pea varieties were sampled by six consumers. Not all consumers tasted each variety in all four preparation methods. Each variety/preparation was evaluated for color,

Table 1. Pea variety average yields and average characteristic measurements, sorted by pea type, Lexington, Ky., 2011.

Variety	Type[1]	Seed Source	Days to Harvest	Pod Yield (lb/A)[2]	Plant Height (in.)	Pod Length (in.)	Pod Width (in.)	No. Peas/ Pod	No. Pods/ Node	Sweet-ness (1-5)[3]	Comments
Oregon Trail	Eng	RU	61	44,290 a	22.5	3.3	0.6	8.3	2.0	4.0	Attractive pod
Sabre	Eng	ST	65	39,400 ab	22.8	3.5	0.5	8.0	1.8	-	
Legacy	Eng	RU	67	36,100 bc	24.5	3.0	0.6	8.5	2.5	4.0	Starchy later in season
Bolero	Eng	SW, ST	69	35,790 bc	21.5	2.9	0.6	7.0	2.5	3.0	Most pods starchy
Progress #9	Eng	SW	62	35,380 bc	23.0	3.2	0.6	8.0	1.6	3.2	Most pods starchy; large, pale, smooth pea
Knight	Eng	SW	62	35,210 bc	24.5	3.6	0.6	8.3	1.9	3.8	Matures rapidly
Green Arrow	Eng	SW	68	33,170 bc	27.5	4.1	0.6	9.5	1.6	3.2	
Utrillo	Eng	SW, ST	71	30,160 cd	30.3	4.6	0.8	8.3	1.0	4.0	
Destiny	Eng	RU	66	24,540 de	21.3	3.1	0.5	8.3	2.3	3.8	
Mr. Big	Eng	SW, ST	68	19,450 ef	29.3	4.7	0.7	7.5	1.0	-	
Feisty	Eng	JO	61	15,340 f	22.0	3.4	0.6	9.3	2.0	3.6	Attractive pod
Cascadia	Snap	SW, ST	65	47,880 a	29.0	2.8	0.6	5.8	1.9	3.6	Crunchy; has a string
Sugar Sprint	Snap	ST	62	36,890 b	21.8	2.8	0.6	5.8	1.8	2.8	Very tender, crunchy; no string
Sugar Ann	Snap	SI	52/60	31,500 c	27.5	2.6	0.5	6.8	1.1	4.2	Very sweet, crunchy; has a string
Sugar Daddy	Snap	RU	74	23,110 d	27.8	2.7	0.5	5.3	1.4	3.4	Tender pod, no string; didn't pollinate well
Sugar Star	Snap	RU	70	18,370 d	25.0	2.8	0.5	5.5	1.3	2.9	Not as sweet as Sugar Daddy; no string
Oregon Giant	Snow	ST	60	42,720 a	27.5	4.0	0.9	7.5	2.0	2.4	
Oregon Sugar Pod II	Snow	SW	68	41,330 a	29.0	3.8	0.9	7.8	2.0	2.6	
Little Sweetie	Snow	ST	60	36,420 a	28.8	3.6	0.8	7.5	1.9	2.3	Not sweet
Dwarf White Sugar	Snow	SW	50	22,260 b	34.0	3.1	0.6	7.3	1.5	2.5	Has two strings
Dwarf Grey Sugar	Snow	SW	65	16,100 b	48.0	2.8	0.6	6.5	2.0	2.3	Tough raw

1 Eng = English pea; Snap = Snap pea; Snow = Snow pea.
2 Numbers followed by the same letter are not significantly different (Waller-Duncan Multiple Range Test LSD P = 0.05).
3 Sweetness rating: 1 = starchy; 5 = very sweet

appearance (size and shape), taste, and texture. All of these attributes were rated on a 1-5 scale. An average was calculated of all the consumers' ratings for an attribute. The four average attribute ratings were summed and averaged to provide an overall rating for each preparation method. Overall ratings for each preparation method also were summed and averaged to give a final average overall eating quality rating for each variety.

Results

The spring was particularly rainy and wet soil caused the planting to be established later than recommended. As a result peas were harvested throughout June when temperatures were warmer than desired for peas. This enhanced the conversion of fruit sugars to starch, particularly for later maturing varieties. Thus these evaluations are an assessment of pea yield and quality under warmer than normal conditions. Pea variety characteristics and yields are presented in Table 1 and taste evaluation results are in Table 2. The Snow Sweet snow pea variety did not germinate sufficiently to be evaluated.

The Oregon Trail English pea had the highest, followed closely by Sabre. However neither was rated in the top five in the taste evaluations. Green Arrow was ranked at the top in the average of overall taste and appearance ratings followed by Bolero, Utrillo and Mr. Big. Legacy and Bolero were notable in that they averaged 2.5 pods per node, making hand harvest more efficient. Mr. Big, Utrillo, and Green Arrow produced exceptionally long pods. Green Arrow and Feisty were notable in that they averaged 9.5 and 9.3 peas per pod, respectively.

Cascadia was clearly the top performing snap pea variety in yield, taste (raw and cooked), and appearance. The second-best variety was judged to be Sugar Ann, based on a relatively high yield and excellent taste and appearance evaluations. Both of these varieties possess strings that need to be removed for consumption. Sugar Sprint, Sugar Daddy, and Sugar Star pods do not possess strings.

Oregon Giant, Oregon Sugar Pod II, and Little Sweetie were the top yielding snow peas. Oregon Giant and Oregon Sugar Pod II had large pods and averaged two per node. Dwarf White Sugar ranked the highest in overall consumer taste evaluations primarily due to higher ratings for the blanched-in-salt water and microwaved preparations. Oregon Giant and Oregon Sugar Pod II came in a close second in taste evaluations.

Taste evaluations generally showed that peas of all types, blanched in salt water, rated higher in flavor than the other cooking methods. It appears the addition of salt made the difference.

Table 2. Taste evaluations by consumer panel, peas prepared four ways.[1]

	Fresh					Steamed					Blanched in salt water					Microwaved					
Variety	Color	Appearance (size and shape)	Taste	Texture	Overall rating	Color	Appearance (size and shape)	Taste	Texture	Overall rating	Color	Appearance (size and shape)	Taste	Texture	Overall rating	Color	Appearance (size and shape)	Taste	Texture	Overall rating	Average of overall ratings
Oregon Trail	3.0	3.4	3.3	3.4	3.3	3.5	2.6	3.3	3.5	3.2	3.9	3.6	4.0	4.0	3.9	4.0	3.5	3.6	3.6	3.7	3.5
Sabre	2.9	3.8	2.6	2.6	3.0	3.6	3.1	3.0	3.0	3.2	4.0	3.9	3.6	3.6	3.8	3.8	3.6	3.3	3.5	3.5	3.4
Legacy	2.4	2.8	2.3	3.3	2.7	3.8	3.1	3.1	3.1	3.3	4.3	3.8	3.8	3.9	3.9	3.9	3.6	3.4	3.4	3.6	3.4
Bolero	3.5	3.3	2.9	3.9	3.4	4.3	3.4	3.6	3.8	3.8	4.6	4.1	4.3	3.9	4.2	4.5	4.5	4.1	4.1	4.3	3.9
Progress #9	2.5	3.3	1.5	2.8	2.5	2.6	1.9	2.4	2.6	2.4	3.3	3.0	2.6	3.0	3.0	3.1	2.9	2.6	2.9	2.8	2.7
Knight	3.0	2.9	3.0	3.1	3.0	3.1	2.9	3.3	3.1	3.1	3.6	3.4	3.0	3.6	3.4	3.4	3.4	2.9	3.1	3.2	3.2
Green Arrow	3.8	3.9	3.9	4.0	3.9	3.8	3.5	3.4	3.6	3.6	4.6	4.5	4.4	4.4	4.5	4.1	4.0	3.6	3.9	3.9	4.0
Utrillo	3.7	3.4	3.6	3.7	3.6	4.1	3.4	3.4	3.7	3.7	4.4	4.3	4.4	4.3	4.4	3.7	3.1	3.4	3.7	3.5	3.8
Destiny	3.8	3.8	2.6	3.4	3.4	3.8	3.2	3.4	3.6	3.5	4.2	4.0	4.2	4.0	4.1	4.0	3.8	3.6	3.6	3.0	3.5
Mr. Big	3.4	3.0	3.4	3.9	3.4	3.8	3.1	3.6	3.4	3.5	3.9	3.6	4.0	4.0	3.9	3.8	3.1	3.6	3.9	3.6	3.6
Feisty	3.5	3.6	3.4	3.3	3.4	4.0	3.5	3.4	3.1	3.5	4.1	3.9	3.9	3.1	3.8	4.1	3.9	3.8	3.4	3.8	3.6
Cascadia	4.5	4.3	5.0	5.0	4.7	4.5	4.5	4.8	4.8	4.6	4.8	4.5	4.8	4.7	4.7	4.5	4.5	4.5	4.5	4.5	4.6
Sugar Sprint	2.5	2.5	2.3	2.3	2.4	3.0	2.8	3.0	3.3	3.0	3.5	3.0	3.5	3.3	3.3	3.3	3.5	3.3	3.5	3.4	3.0
Sugar Ann	4.2	3.8	4.0	4.0	4.0	4.6	4.8	4.8	4.8	4.8	4.0	4.8	4.8	4.8	4.7	4.2	4.2	4.2	4.0	4.2	4.3
Sugar Daddy	3.2	2.8	3.4	3.0	3.1	3.2	3.0	3.4	3.0	3.2	3.2	3.6	3.4	3.4	3.4	3.0	3.6	2.6	2.8	3.0	3.2
Sugar Star	3.8	3.5	3.0	3.3	3.4	4.8	3.8	4.3	3.8	4.1	4.3	4.0	4.3	4.0	4.1	3.5	3.0	3.8	4.0	3.6	3.8
Oregon Giant	2.8	3.0	3.3	4.5	3.4	4.8	4.8	4.0	4.8	4.6	4.0	4.3	3.3	3.0	3.6	3.3	3.5	2.5	2.5	2.9	3.6
Oregon Sugar Pod II	3.6	3.6	3.3	4.3	3.7	4.2	4.2	3.0	3.8	3.8	4.0	4.4	4.3	4.0	4.3	3.5	3.6	3.0	3.0	3.3	3.6
Little Sweetie	2.0	1.8	2.8	2.6	2.3	2.6	2.6	2.4	2.2	2.5	2.8	2.8	2.4	2.4	2.6	2.4	2.2	1.8	2.0	2.1	2.4
Dwarf White Sugar	3.6	3.8	3.6	3.6	3.7	4.2	3.8	2.8	3.2	3.5	4.0	4.2	3.8	4.4	4.2	4.2	4.0	3.6	3.6	3.9	3.8
Dwarf Grey Sugar	4.0	3.4	2.2	2.2	3.0	3.8	4.0	2.4	2.4	3.2	3.0	3.4	3.0	2.6	3.1	3.8	3.8	1.4	1.6	2.7	3.0

[1] All rankings are based on a 1-5 scale with 1 = poor ; 5 = excellent

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Eggplant Variety Evaluations

Chris Smigell, John Strang, Janet Pfeiffer, John Snyder, and Darrell Slone, Department of Horticulture

Eggplant sales make up a minor portion of Kentucky-produced vegetable sales, but growers need to keep up with new variety introductions to address consumer purchasing trends. Eleven eggplant varieties were evaluated in this trial. These included several Italian types, two white varieties, one Japanese variety, and several specialty types.

Materials and Methods

Varieties were seeded on April 24 into plastic plug trays (72 cells per tray) at the UK Horticultural Research Farm in Lexington. Greenhouse-grown transplants were set into black plastic-covered, raised beds using a waterwheel setter on June 6. Each plot was 20 feet long and contained 13 plants set 1½ feet apart within the row and 6 feet between rows. Each treatment was replicated four times in a randomized complete block design. Sixty pounds of nitrogen per acre as urea was applied prior to plastic laying. Drip irrigation provided water and nitrogen as needed. A total of 40.5 pounds of nitrogen per acre as urea was split equally between three fertigation applications on August 3, 15, and 31. No herbicides were applied, and rows were mulched with straw between beds. Foliar insecticide sprays included Pounce, Actara, Brigade, Danitol and the miticide Acramite. Weekly foliar fungicide applications included Bravo, Cabrio, Copper, Maneb, and Quadris. Weekly harvests began July 12 and

Table 1. Eggplant variety trial marketable yield and fruit characteristics, 2011.

Variety	Seed Source	Days to Harv.	Total Yield (lb/A)[1]		Small 2.5-3 in. dia. (lb/A)	Med. 3-4 in. dia. (lb/A)	Large >4 in. dia. (lb/A)	Cull Fruit (%)[2]	Total Yield (No/A)	Small 2.5-3 in. dia. (No/A)	Med. 3-4 in. dia. (No/A)	Large >4 in. dia. (No/A)	Appearance (1-5)	Comments
Epic	SW	64	49,441	a	1,475	40,068	7,898	6.8	63,292	3,258	53,054	6,981	4.3	Italian, long tapered purple/black teardrop, few spines
Irene	SW	65	48,761	ab	307	19,232	29,222	8.6	56,125	652	27,830	27,644	3.9	Italian, broad oval purple/black teardrop, sharp spines
Santana	SW	65	46,627	a-c	1,136	25,899	19,593	2.4	55,195	2,699	35,648	16,847	4.8	Large Italian, few soft spines, purple/black
Night Shadow	SI	68	41,991	a-d	461	23,441	18,089	3.6	47,748	1,210	31,460	15,078	4.6	Italian, teardrop, few soft spines, purple/ black
Tango	JO	60	41,107	a-d	41,107	0	0	8.4	117,928	117,928	0	0	4.0	Cylindrical, small, few spines, white, firm fruit
Belen	SI	70	40,960	a-d	4,123	33,325	3,512	8.6	60,314	9,494	47,562	3,258	4.3	Oval, medium sized, purple/black, spineless
Nubia	SW	64	38,555	b-d	670	29,215	8,670	5.4	49,889	1,862	40,488	7,539	4.8	Broad teardrop, dark wine streaks over cream background, sharp spines, attractive
Nadia	SW	67	37,850	cd	4,659	29,436	3,756	4.0	53,985	10,332	40,209	3,444	4.5	Italian, black, medium teardrop shape, soft spines
Dairyu	SW	60	37,152	cd	37,152	0	0	16.2	103,315	103,315	0	0	4.1	Japanese, long slender, purple/black, few soft spines
Megal	SW	60	34,450	d	24,816	9,633	0	9.6	65,247	52,309	12,938	0	4.3	Long tapered, few soft spines, purple/black,
Imolese Berese	SW	66	31,274	d	13,752	17,522	0	7.0	60,407	32,856	27,551	0	3.3	Pearly white firm fruit, few sharp spines, often cracked at calyx

1 Numbers followed by the same letter are not significantly different (Waller-Duncan Multiple Range Test LSD P = 0.05).
2 Cull percentage by weight.

ended on September 9. Marketable fruit were graded as small (2.5—3 inches in diameter), medium (3-4 inches in diameter), and large (greater than 4 inches in diameter) and rated on appearance. Cull fruit were counted and weighed.

Results

This trial yielded well (Table 1), and plants were large. Epic was one of the top yielding varieties. It produced a long, tapered, Italian type fruit, many of which were in the medium size category. Irene, Santana, and Night Shadow were teardrop-shaped, Italian type varieties that produced larger portions of fruit in the large size category. Both were rated as some of the most attractive Italian types in the trial. Irene was the broadest eggplant and thus had the largest weight and number in the large category. Both Irene and Night Shadow were slightly more oval in shape than Santana. Belen, a medium-sized Italian variety, was notable in that the fruit were spineless. If the market demands a long, purple/black, almost cylindrical fruit, Megal is a good choice. Nubia was an attractive specialty eggplant with dark wine-colored streaks over a cream background. Tango was judged to be the most attractive and productive of the two white eggplant. All fruit graded out in the small category, and it was firm and had a short cylindrical shape. Dairyu, the one Japanese eggplant in the trial, produced a high number of eggplant per acre. However, it had a 16.2 percent cull rate, mostly due to scarring and sunburn. Irene, Nubia and Imolese Berese had some of the sharpest calyx spines of the varieties evaluated. Just about all the varieties were attractive. Some produced smaller eggplant that would not size up into the large size class. Growers should assess their market and select varieties that best meet market size preferences. Cull fruit were graded out mostly because of sunburn, scarring, and fruit malformation.

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The authors would like to thank the following persons for their hard work and assistance in the successful completion of this trial: Travis Cole, Charles Daugherty, Dave Palmquist, Dave Lowry, Kirk Ranta, Joseph Tucker, and Andrea Watts.

Seedless Watermelon Variety Evaluation

Timothy Coolong, Lucas Hanks, and Jessica Cole, Department of Horticulture

Introduction

Thirty varieties of seedless watermelons were evaluated at the University of Kentucky in the 2011 growing season. The goal of this trial was to identify suitable seedless watermelons for commercial production in Kentucky, with an emphasis on medium and large weight classes as well as watermelons with an oblong shape.

Materials and Methods

Varieties were seeded on April 15 into plastic plug trays (98 cells per tray) at the Horticulture Research Farm in Lexington. Seedlings were greenhouse grown until June 1 and then placed outside to harden off. Plants were set into white-on-black plastic-mulched, raised beds using a waterwheel setter on June 6. Each plot contained eight plants set 3 feet apart in the row with 7 feet between rows. Each variety was replicated four times in a randomized complete block design for a total of 32 plants of each variety. A pollenizer variety, Ace, was planted between every third and fourth seedless watermelon plant. Pollenizers were planted approximately 3-4 inches from edge of the mulched bed. Preplant fertility (19-19-19, N-P_2O_5-K_2O) was applied directly under the plastic mulch at a rate of 75 pounds per acre nitrogen. Supplemental fertility was applied through the irrigation system at a rate of 15 pounds per acre per week of nitrogen, beginning two weeks after transplanting and continuing until 90 pounds per acre nitrogen had been applied in addition to preplant fertility. The herbicides clomazone (Command 3ME, 1 pint per acre) and ethalfluralin (Curbit, 4 pints per acre) were applied between rows prior to planting. Approximately three weeks after transplant, the herbicide halosulfuron (Sandea, 1 ounce per acre) was applied between rows. Weed control was complete through fruit maturation. The systemic insecticide, imidacloprid (Admire Pro, 10.5 ounces per acre) was applied using a backpack sprayer immediately after transplanting. Weekly foliar fungicide applications were made according to University of Kentucky recommendations for commercial watermelon production (Coolong et al., 2009). Insecticide applications were made as needed for cucumber beetles, aphids, and spider mites. Fruit were harvested twice beginning August 15 and concluding September 2. Five watermelons were used from each replication to determine average fruit length and width. Flesh samples from three fruit from three replications were subjected to soluble solids analysis. Yield data were calculated based on a plant population of 2074 plants per acre (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 growing season of 2011 was warm with regular rainfall and yields were good. There were statistically significant differences between varieties for total yield in pounds and number of fruit per acre, pounds per fruit, and percentage of culls. Crunchy Red had the highest yield in pounds per acre, though was closely followed by Matrix, Crisp N Sweet, Majestic and Harmony (Table 1). Ten varieties had yields exceeding 90,000 pounds per acre. The highest yielding variety in number of fruit per acre was Fenway, which averaged 6610 fruit per acre. Several other varieties including Crunchy Red, Majestic, and Nomad all averaged more than 6000 fruit per acre. The largest fruit were recorded for the variety Matrix, which averaged 20.2 pounds per fruit. Other varieties with average fruit weights of 18 pounds or more included Revolution, HSR 4618, HSR 4620, Harmony, Majestic, Olympia, and Fascination. The majority of the melons trialed weighed from 15 to 18 pounds. Fruit quality was generally high in this trial with the average percentage of cull fruit in each variety ranging from 0.9 percent to 1.8 percent of total harvested weight. There were no significant differences in sugar content between varieties. Average fruit length and width were recorded as well. This data is presented in Table 1 as a length-width ratio in order to represent the shape of a melon. The greater the length-to-width ratio the more elongated the melon. Varieties displaying elongated characteristics included: HSR 4620, HSR 4618, Revolution, and Matrix. Varieties that were nearly round in appearance included: Fenway, Nomad, Gypsy, 4502 Seedless, and SWT 7138. Although this trial only reflects one year of data, the results were promising and suggest that several new varieties would be worth growing in Kentucky.

Table 1. Total yield, average fruit weight, percent culls, soluble sugars and the length to width ratio are presented for 30 varieties of seedless watermelon grown in Lexington, KY in the summer of 2011. Varieties are ordered based on total yield in pounds/acre.

Variety	Total Yield[z] (Pounds/Acre)		Total Yield[z] (Fruit/Acre)		Average Fruit Weight (Pounds/Fruit)		Cull[y] (%)	Soluble Sugars (%)	Length/ Width[x] (Ratio)	Seed Source[w]
Crunchy Red	106,280	a[v]	6050	ab	17.8	bcdef	1.0	11.8	1.3	SW
Matrix	104,750	ab	5206	abcd	20.2	a	0.9	11.5	1.6	SW
Crisp N Sweet	102,270	abc	5440	abc	18.9	abcd	1.1	11.7	1.4	SW
Majestic	100,900	abcd	6090	ab	16.7	defgh	1.0	12.1	1.2	S
Harmony	100,580	abcde	5470	abc	18.3	abcde	1.2	11.6	1.2	SW
Nomad	99,930	abcde	6090	ab	16.7	defgh	1.1	11.7	1.1	HM
HSR 4618	99,290	abcdef	5190	abcd	19.2	ab	1.0	11.5	1.5	HOL
Olympia	96,240	abcdefg	5100	bcd	18.9	abcd	1.1	11.9	1.2	RU
HSR 4620	96,150	abcdefg	5060	bcd	19.0	abc	1.1	11.0	2.1	HOL
Fenway	92,000	bcdefgh	6610	a	13.8	ij	1.2	12.0	1.0	S
7197 HQ	84,700	bcdefghi	4860	bcd	17.4	bcdefgh	1.3	11.3	1.4	AC
Vagabond	83,680	cdefghij	5440	abc	15.4	hi	1.3	11.5	1.2	HM
Liberty	83,320	cdefghij	5250	abcd	15.9	fghi	1.3	11.7	1.2	NU
Fascination	83,250	cdefghij	4490	cd	18.5	abcde	1.3	11.0	1.2	RU
Cooperstown	81,530	defghij	4930	bcd	16.6	defgh	1.3	12.0	1.2	RU
Revolution	80,980	defghij	4470	cd	18.3	abcde	1.3	11.6	1.6	NU
Melody	80,530	efghij	5060	bcd	16.0	fghi	1.3	11.7	1.3	SW
HSR 4624	79,320	fghij	5100	bcd	15.6	fghi	1.4	11.3	1.4	HOL
Declaration	78,050	ghij	4540	cd	17.3	bcdefgh	1.4	10.9	1.2	NU
Summer King	77,180	ghij	4930	bcd	15.9	fghi	1.4	11.5	1.2	RU
Troubadour	76,320	ghij	5530	abc	13.9	ij	1.5	11.1	1.1	HM
7167	74,390	hij	4540	cd	16.5	efgh	1.5	11.7	1.2	AC
Gypsy	72,800	hij	4490	cd	16.3	efgh	1.5	11.9	1.0	HM
Sweet Delight	71,023	ij	4150	cd	17.2	bcdefgh	1.5	11.3	1.2	RU
Bold Ruler	69,600	ij	4540	cd	15.4	ghi	1.6	11.9	1.1	SK
Sweet Treasure	68,440	ij	3850	d	17.8	bcdefg	1.6	10.5	1.2	SK
SWT 7138	67,570	ij	5250	abcd	12.9	j	1.6	10.7	1.0	SK
4502 Seedless	67,220	ij	3850	d	17.7	bcdefg	1.7	11.3	1.1	SW
Tri X 313	66,990	ij	3890	d	17.3	bcdefgh	1.6	10.9	1.2	SW
Nun 1000	64,380	j	3850	d	16.8	cdefgh	1.8	11.2	1.2	NU

z Yields based on a plant population of 2074 plants per acre
y Percentage of cull calculated by dividing weight of cull fruit by the total harvested weight of fruit (marketable + cull)
x The ratio of length to width will increase as melons become more oblong and approach 1.0 for a spherical melon
w Seed sources listed in Appendix A. Many varieties are available through several seed distributors.
v Means in the same column followed by different letters were significantly different at P > 0.05 as determined by Duncan's multiple range test.

Literature Cited

Coolong, T., K. Seebold, R. Bessin, J. Strang, and T. Jones. 2009. *Vegetable Production Guide for Commercial Growers, 2010-2011*. University of Kentucky Cooperative Extension Service Bulletin. ID-36. 132 pp.

Bell Pepper Variety Evaluation 2011

Vaden Fenton and Timothy Coolong, Department of Horticulture, University of Kentucky, and Pat Williams, Department of Agriculture Science, Murray State University.

Introduction

Bell peppers grown for the fresh market are an important vegetable commodity in Kentucky. As new varieties continue to be released trials are necessary to ensure that appropriate recommendations are made to growers. This report presents the results of a bell pepper variety trial conducted as a joint collaboration between the University of Kentucky Department of Horticulture and Murray State University (MSU) Department of Agriculture. This trial was conducted at the MSU farm in Murray, Ky.

Materials and Methods

Nine pepper varieties were seeded into 98 cell trays on May 5, 2011, and greenhouse grown using standard practices. Transplants were planted July 12, 2011, using a waterwheel setter. This experiment was conducted using plastic culture mulch production system. The bed shaper and mulch layer along with the plastic mulch and drip tape was provided by the University of Kentucky Department of Horticulture. The varieties planted were Patriot, Karisma, Revolution, Declaration, Alliance, Allegiance, Heritage, Mysterio and Vanguard. With a plant population of 11,616 plants per acre planted double rows with 15 inches in-row spacing with 6 foot between-row spacing in a randomized complete block design with four replications. Each variety had 10 plants per replication. The plot received no preplant soil fertility, but was fertilized through the drip-irrigation system after planting with Peter's 20-20-20 soluble fertilizer. The peppers were evaluated for average fruit weight, number of fruits per acre and total yield per acre.

Results and Discussion

Two varieties, Heritage and Patriot, had significant plant mortality and were not included in the statistical analysis presented in Table 1. Yields were lower than would be expected for plasticuture-grown bell peppers in Kentucky. This was likely due to the high temperatures experienced in July and early August when fruit was being set. High temperatures will cause peppers to drop flower blooms, reducing yields. There were no significant differences in average fruit weight or yield in pounds of fruit per acre. The number of fruit per acre were significantly different however (P =0.08) between varieties. This data should not be considered conclusive, but may serve as a guide for growers wishing to conduct trials of newer varieties on their own farms.

Table 1. Yield and average fruit weight of seven varieties of bell pepper trialed in Murray, Ky., in 2011.

Variety	Yield[z] (no./acre)		Yield[z] (lbs/acre)		Average fruit weight (oz/fruit)	
Declaration	89314	a[y]	21473	a	3.9	a
Karisma	87618	a	20548	a	3.7	a
Alliance	74423	ab	19924	a	4.3	a
Allegiance	68502	ab	17305	a	4.1	a
Revolution	66770	ab	17038	a	3.8	a
Vanguard	60339	ab	16452	a	4.2	a
Mysterio	48207	b	11987	a	3.9	a

z Yield calculated based on a plant population of 11,616 plants/acre.
y Numbers in the same column followed by the same letters are not significantly different according to Duncan's mean separation test.

Acknowledgements

We would like to gratefully acknowledge Harris Moran Seed Company for providing seed of the varieties used in this trial.

An Evaluation of Onion Varieties and Set Size

Timothy Coolong, Department of Horticulture

This paper reports on the evaluation of three onion varieties distributed among three set sizes in Central Kentucky.

Introduction

Fresh market onions represent a potentially lucrative crop for Kentucky farmers. Although many growers are having success growing yellow sweet onions for sale at farmers' markets or produce auctions, many have reported mixed results when attempting to grow transplants or when purchasing transplants from out-of-state sources. Cool winter temperatures and poor light levels have made it difficult to produce quality transplants in late winter. Onion sets could potentially provide an alternative to growing transplants for Kentucky farmers. Onions sets are more compact than transplants and can be stored for a longer period of time. Growing onions from sets is not common in Kentucky, and little information is available regarding performance of available varieties as well as the impact of onion set size on yield. Therefore a trial was conducted in 2010 to determine the impact of set size and variety on yield of spring onions. A plasticulture production system was chosen as many onion growers utilize plastic mulches.

Materials and Methods

The trial was conducted at the University of Kentucky Horticulture Research Farm in Lexington during the spring and summer of 2010. Three varieties of onion sets—Forum, Talon, and Sherman—were selected. Sets from each variety were planted according to size (diameter): 10-14, 14-17, 17-21, and 21-24 millimeters. Sets were planted April 12, 2010, into raised beds covered with black plastic mulch with two lines of drip tape. Plant beds were spaced on 6½-foot centers. Sets 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 100 plants of each variety replicated three times in a completely randomized design. The field received approximately 70 pounds of preplant nitrogen (19-19-19, N-P_2O_5-K_2O) per acre applied only under the plastic mulch. Onions were fertigated weekly with 15 pounds of nitrogen from either ammonium or calcium nitrate (alternated weekly) for six weeks beginning four weeks after planting. Oxyflourfen (Goal 2XL, 2 ounces per acre) was applied within two weeks of planting, once sprouts began to emerge from the sets to provide within-row and between-row weed control. Additional fungicide and insecticide applications (for thrips) were made using University of Kentucky standard procedures (Coolong et al, 2009).

Plants began to go "tops down" during the last week of June and the first week of July. Foliage was allowed to begin to dry in the field and plants were harvested July 14, 2010.

Onions were bagged and cured for two weeks 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 per acre (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 $P< 0.05$.

Table 1. Marketable yield, and yield of small, medium, large onions as well as % of loss due to disease and average bulb weight of marketable bulbs for main effects means of three varieties and four sizes of onion sets grown in Lexington, Ky., in 2010.

Variety	Marketable Yield[a] (lbs/A)	Small (lbs/A)	Medium (lbs/A)	Large (lbs/A)	Jumbo (lbs/A)	Loss (%)[b]	Average Bulb Weight (oz.)
Talon	12282	156	7241	4884	0	43	6.1
Forum	8976	61	4690	4189	36	59	6.5
Sherman	7253	288	5317	1648	0	58	5.1
Sig.[c]	*P=0.09*	*	*	*P=0.08*	NS	NS	*
Size (mm)							
10-14	8242	138	6114	1989	0	59	6.0
14-17	9815	156	4993	4666	0	54	6.0
17-21	9937	124	5353	4461	0	55	6.2
21-24	10244	253	6399	3552	40	45	5.3
Sig.[c]	NS	NS	NS	NS	NS	NS	NS

[a] Yield values based on a per acre population of 53,612 plants, grading based on USDA size and quality standards.
[b] % loss based on numbers of planted bulbs/total numbers of harvested bulbs
[c] * Significance at P<0.05, NS: not significant

Table 2. Marketable yield, and yield of small, medium, large onions as well as % of loss due to disease and average bulb weight of marketable bulbs for three varieties and four sizes of onion sets grown in Lexington, Ky., in 2010.

Variety	Size (mm)	Marketable Yield[a] (lbs/A)	Small (lbs/A)	Medium (lbs/A)	Large (lbs/A)	Jumbo (lbs/A)	Loss (%)[b]	Average Bulb Weight (oz.)
Talon	10-14	10090	88	7874	2129	0	51	5.9
	14-17	13644	161	6270	7213	0	43	6.8
	17-21	16108	57	8371	7680	0	33	6.7
	21-24	10560	284	6826	3449	0	43	5.1
Forum	10-14	8083	0	4928	3154	0	63	6.6
	14-17	8155	268	3747	4388	0	65	6.6
	17-21	10184	0	3994	6189	0	60	7.3
	21-24	9613	191	5544	3758	120	50	5.8
Sherman	10-14	6552	327	5540	684	0	63	5.6
	14-17	5734	287	4324	1124	0	61	4.4
	17-21	5660	252	4246	1162	0	67	5.2
	21-24	10560	2501	6826	3449	0	43	5.1
Sig.[c]	NS	NS	NS	NS	NS	NS	NS	NS

[a] Yield values based on a per acre population of 53,612 plants, grading based on USDA size and quality standards.
[b] % loss based on numbers of planted bulbs/total numbers of harvested bulbs
[c] * Significance at P<0.05, NS: not significant

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 disease. The high disease pressure resulted in significant loss in the field. The high percentage of loss observed (bulbs not harvested) was almost exclusively due to disease. The percentage of loss was not significantly affected by either cultivar or set size (Table 1), and there was no interaction between the two variables and bulbs not harvested due to disease (Table 2). As such, total marketable yields were lower than expected. Typical yields for Kentucky onion growers using a similar plasticulture production system generally range from 25,000-30,000 pounds per acre, in this study our yields were roughly one-half to one-third of that. There were no significant interactions between variety and set size for any of the variables measured (Table 2). However when main effects means were present, variety had a significant effect on several yield parameters, including yield of small and medium bulbs as well as bulb size (Table 1). Though not significant using $P<0.05$ as a threshold, total marketable yield and yield of large bulbs was significant if using $P<0.10$, with P values of 0.09 and 0.08, respectively (Table 1). Talon was the highest yielding variety, with much of the yield coming from a relatively large number of medium-size bulbs. Although not significant, the percentage of loss of Talon due to disease was less than the other varieties. It is likely this lack of loss due to disease led to the significantly higher yields for this variety. Average bulb size was greatest for Forum and lowest for Sherman. Sherman produced large numbers of small bulbs and few large bulbs resulting in the smaller average size.

Though not significant in this study a trend seems to be emerging between set size and average bulb size (Tables 1 and 2). Though not true in every treatment combination, the largest set size (21-24 millimeters) frequently had the smallest average bulb weight (Table 2). This appears to correspond to a large increase in the amount of small bulbs produced relative to the other set sizes (Table 1). This trend is apparent in for the Talon and Forum varieties, though not for Sherman (Table 2). Generally it seems that the sets in the 14-17 and 17-21 millimeter range produce the largest bulbs and highest yields of large bulbs in this production system (Table 1). Although only a single season of data is presented and high levels of disease were present some trends seem to be emerging. Overall Talon seemed to be the best performing variety in a season that featured high levels of disease pressure.

Though not significant in this trial, set size may have an effect on yield and average bulb weight. Further study is warranted. With more replication and larger plot sizes, it is likely that some variation present in the results would be reduced and trends that are apparent but not quite significant may become so.

This was the first year for trialing 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.

Literature Cited

Coolong, T., K. Seebold, R. Bessin, J. Strang, and T. Jones. 2009. *Vegetable Production Guide for Commercial Growers, 2010-2011.* University of Kentucky Cooperative Extension Service Bulletin. ID-36. 132 pp.

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Hydroponic Tomato Demonstration

Stephen Berberich and Timothy Coolong, Department of Horticulture

There has been a recent surge of interest in hydroponic tomato production in Kentucky. Some growers consider hydroponic tomato production a means of diversification as well as potential use of idle tobacco greenhouses, while others view it as an alternative crop to improve cash flow. Hydroponic tomato production can be profitable, but new growers must be aware of the practices necessary for success. Compared to field production, hydroponic production requires some specific cultural practices and a high level of management.

The purpose of this greenhouse demonstration plot was to show simple qualitative comparisons between proven hydroponic production practices and some questionable practices often attempted. This demonstration compared yields of four popular greenhouse varieties in various root substrates, but it was not replicated. The intent was to illustrate standard hydroponic production techniques where extension agents, existing growers, and prospective growers could see the necessary equipment and materials in conjunction with the effect of fertilizer and media choice.

To illustrate the importance of a proper fertilizer program, two fertilizer treatments were utilized for this demonstration. A typical hydroponic fertilizer, Peter's 5-11-26 plus calcium nitrate (Modified Steiner Solution), with an analysis proven suitable for hydroponic tomatoes, was used for one treatment. The other treatment was an alternative fertilizer often used by new growers, 20-10-20 Peter's peat-lite water soluble fertilizer. Although the 20-10-20 does not meet the nutritional needs of hydroponic tomato, it frequently is used because it is readily available at local farm stores and greenhouse supply outlets.

Materials and Methods

Prior to transplanting, the greenhouse was set up with a high-wire trellis system that was connected to the frame of the greenhouse. Support strings were utilized to support tomato plants. Plants were fastened to the strings with vine clips. The greenhouse floor was covered with white woven polypropylene ground cover (DeWitt Company, Sikeston, Mo.) and drip-irrigation lines with pressure compensating emitters and two drip stakes (Netafim USA, Fresno, Calif.) per container were installed for 18-inch center-to-center pot spacing to allow approximately 4 feet2 of greenhouse floor space per plant. All necessary filters, regulators, and valves were installed. Irrigation water was tested and determined to contained 28 mg·L-1 Ca, 14 mg·L-1 Mg, with pH 7.6 and alkalinity 47 ppm total carbonates. Incoming water was treated with sulfuric acid to reduce alkalinity and adjust pH from 7.6 to 5.9. The acid was pumped into the irrigation lines with a water-operated 1 to 100 ratio proportional injector (Chemilizer HN55, Hydro Systems Company, Cincinnati, Ohio). Two additional water-operated proportional injectors were installed for each fertilizer treatment.

The greenhouse was set up to accommodate four types of containers: Perlite in Bato buckets, SunGro Metro-Mix 560 Coir (SunGro Horticulture Distribution Inc., Bellevue, Wash.) in C1200 (11-inch top diameter, 9.5-inch height) nursery container (Nursery Supplies, Inc., Chambersburg, Penn.), Perlite in five-gallon white polyethylene grow bags, Rockwool slabs (Grodan Rockwool Vital Slab, 20 by 7.5 by 100 centimeters).

Four tomato cultivars—Trust, Big Beef, Geronimo, and Cobra—were seeded into pre-moistened 1½-inch Rockwool cube sheets (Grodan, 1938 Road 3 East N9Y2E5, Kingsville, Ontario) in standard 10-inch by 20-inch propagation trays on December 11, 2010. All of the cultivars used are indeterminate and all but Big Beef were for greenhouse production. Greenhouse temperature was set at 76 degrees during the day and 68 degrees at night for germination. At first true leaf stage , plants were fertigated one time with 20-10-20 Peat-Lite Special (Everris NA, Inc., Marysville, Ohio) water soluble fertilizer at 150 ppm N and then as needed with 15-5-15 Cal-Mag (Everris NA, Inc) at 150 ppm N. Greenhouse temperature was set at negative DIF 64/68 degrees day/night to control internode elongation and maintain compact plants. On Jan 7, 2011, plants were transferred to pre-moistened 3-inch Rockwool cubes.

The seedlings were transplanted into the permanent growing medium on February 1, 2011. Two plants were placed in each container for the Bato buckets, nursery containers, and grow bags. Six plants were placed in each Rockwool slab. Greenhouse temperature was set at 75/65 degrees day/night and relative humidity at less than 80 percent. A class C bumblebee hive (Biobest Mini-Hive, Biobest Canada LTD, Leamington, ON) was kept in the greenhouse at all times during flowering.

Fertigation of the containers filled with perlite was controlled with a solar irradiation based irrigation controller (Solar-Gro 12i, Davis Engineering, Winnetka, Calif.). Fertigation of the containers filled with Metro-Mix 560 and the Rockwool slabs was controlled by a programmable duration sequence timer (ESP modular, Rain Bird Corporation, Tucson, Ariz.). Half of the plants of each cultivar in each row were fertigated with the Modified Steiner Nutrient Solution. The other half of the plants were fertigated with the alternative solution. The Modified Steiner Solution was derived from the following fertilizers: 5-11-26 (Peters Professional Hydroponic Special, Everris NA, Inc, Marysville, Ohio), greenhouse grade Ca(NO3)2 (Yara North America, Inc., Tampa, Fla.), and CaCl2 (Cor-Clear, Tetra Chemicals, Woodlands, Texas). The concentration of each element follows: 170 mg·L-1 N, 40 mg·L-1 P, 304 mg·L-1 K, 180 mg·L-1 Ca, 48 mg·L-1 Mg, 3 mg·L-1 Fe, 1 mg·L-1 Mn, 1 mg·L-1 B, 0.4 mg·L-1 Zn, 0.2 mg·L-1 Cu, and 0.1 mg·L-1 Mo. The alternative fertilizer solutions was derived from the following fertilizers: 20-10-20 Peat-lite (Peters Professional, Everris NA, Inc.), CaCl2 (Cor-Clear, Tetra Chemicals, Woodlands, Texas), and MgSO4 (K&S North America, Kali Division, N.Y.). The concentration of each element follows: 170 mg·L-1 N, 37 mg·L-1 P, 141 mg·L-1 K, 180 mg·L-1 Ca, 49 mg·L-1 Mg, 0.85 mg·L-1 Fe, 0.48 mg·L-1 Mn, 0.17 mg·L-1 B, 0.14 mg·L-1 Zn, 0.08 mg·L-1 Cu, and 0.09 mg·L-1 Mo.

Fertigation solution concentration was verified by analysis of samples sent to the University of Kentucky Regulatory Services lab or Waters Agricultural Lab every time a new batch was mixed. Plant tissue was sent to Waters Agricultural Lab for analysis three times during the growing season.

Plants were pruned and de-leafed per standard practices. Fruit was harvest one time per week at the pink to red stage and graded according to USDA standards for greenhouse tomatoes. This trial was designed so that each variety/substrate/fertil-

Table 1. Yields of four tomato varieties grown hydroponically with two primary fertilizer solutions in four substrates in Lexington, Ky., in the Spring and Summer of 2011. Statistical comparisons between treatments have not been conducted for the data presented below.

Variety	Base Fertilizer[z]	Substrate[y]	Cull Fruit W/BER[x]	Cull Fruit Total	Cull Fruit Weight W/ BER	Cull Fruit Weight Total	Medium Fruit	Large Fruit	Extra Large	Total Fruit Yield[w]
			No/plant		Pounds/Plant					
Geronimo	5-11-26	Bag	0.3	9.6	0.0	1.9	0.8	1.2	10.2	12.2
		Bato	0.1	5.1	0.1	1.4	0.2	0.8	9.9	10.9
		Pine	0.1	10.0	0.0	2.2	0.2	1.9	7.5	9.6
		Slab	0.2	7.3	0.0	1.7	0.2	1.3	11.3	12.8
	20-10-20	Bag	21.0	28.3	2.5	3.4	0.2	1.7	2.0	4.0
		Bato	33.0	38.9	3.8	4.3	0.1	0.7	1.5	2.3
		Pine	9.5	15.5	1.6	2.8	0.3	1.4	4.7	6.5
		Slab	46.8	51.7	3.6	4.2	0.3	0.9	1.5	2.8
Big Beef	5-11-26	Bag	0.8	7.4	0.2	1.4	0.2	2.0	8.7	10.9
		Bato	0.0	5.1	0.0	1.1	0.2	1.6	11.3	13.0
		Pine	0.1	5.4	0.1	1.2	0.2	2.1	9.2	11.5
		Slab	1.0	5.5	0.2	1.3	0.2	1.5	9.4	11.1
	20-10-20	Bag	13.8	15.8	2.0	2.3	0.4	2.7	2.9	6.1
		Bato	13.1	16.8	1.9	2.2	0.5	1.9	2.7	5.2
		Pine	1.6	5.3	0.4	1.1	0.2	1.5	5.2	6.9
		Slab	56.8	60.5	4.7	5.3	0.4	1.1	1.5	3.0
Trust	5-11-26	Bag	0.0	13.5	0.0	3.3	0.3	2.6	7.4	10.3
		Bato	0.6	6.5	0.0	1.5	0.3	2.3	8.2	11.0
		Pine	0.6	12.6	0.2	3.1	0.1	1.8	7.8	9.8
		Slab	0.2	9.3	0.0	2.6	0.2	1.8	8.7	10.7
	20-10-20	Bag	6.6	13.9	1.0	2.2	1.0	3.1	0.8	4.9
		Bato	7.9	15.8	1.1	2.4	0.6	2.4	1.2	4.2
		Pine	2.5	13.1	0.4	2.4	0.4	2.6	3.3	6.3
		Slab	22.3	27.7	2.8	3.8	0.4	2.7	2.7	5.8
Cobra	5-11-26	Bag	0.0	5.5	0.0	0.9	1.1	5.3	4.6	11.0
		Bato	0.0	6.4	0.0	1.3	0.6	4.3	5.5	10.5
		Pine	0.0	3.6	0.0	0.8	1.4	4.4	3.5	9.4
		Slab	0.0	5.7	0.0	1.1	0.7	4.3	5.5	10.5
	20-10-20	Bag	11.6	14.6	1.3	1.7	0.9	2.8	1.8	5.5
		Bato	19.4	24.3	1.9	2.6	0.6	4.2	1.2	6.0
		Pine	10.3	15.8	1.1	2.0	1.1	3.1	3.3	7.5
		Slab	39.0	46.0	2.3	3.1	0.4	1.1	0.9	2.5

[w] Total yield includes the yield of fruit graded into the "small" category, which are not presented as an individual table column
[x] BER: Blossom end rot; fruit were graded according to USDA standards for greenhouse tomato
[y] Bato: perlite in Bato buckets; Pine: SunGro Metro-Mix 560 Coir C1200 (11-inch top diameter, 9.5-inch height) Bag: perlite in five-gallon white polyethylene grow bags; Slab: Rockwool slabs (20 x 7.5 x 100cm)
[z] 5-11-26: Peter's Hydroponic Special; 20-10-20: Peter's Peat-Lite Special. Base fertilizers required the addition of calcium nitrate, magnesium sulfate and calcium chloride

izer regime combination consisted of eight plants, except for those treatments utilizing the Rockwool slab substrate, which consisted of six plants. All data is the average of these eight or six plants per treatment combination.

Results and Discussion

Yields are presented as pounds of fruit per plant in Table 1. Yields were lower than would be expected for hydroponic tomatoes; however, this demonstration was conducted for only a short period (harvest period April 26—August 9, 2011) compared to typical hydroponic tomatoes production (harvest period late March-November) in Kentucky. Nonetheless, the results were as expected and should prove informative to growers in Kentucky. All of the varieties performed similarly with regard to yield during the trial period. However, at the end of the trial plants of the variety Geromino appeared the healthiest and most vigorous. Cobra and Big Beef, a field variety sometimes utilized in the greenhouse, were visibly weaker. During the latter portion of the trial, the variety Trust experience a high degree of fruit splitting that was concomitant with increases in day temperature and sunlight. Based on yield data and observations of plant growth, Geronimo was the best performing variety. Big Beef performed well over a short harvest period, but plant growth at the end of the trial suggested that this would not be a good choice for a grower who wanted to grow hydroponically for an eleven-month growing cycle.

The difference between the two fertilizer regimes was most notable. Plants grown with the Peter's 5-11-26 hydroponic fertilizer in the Modified Steiner Solution performed better than those grown in the 20-10-20-based solution. In general the plants grown in the 20-10-20-based solution experienced a large amount of blossom end rot (BER), a calcium deficiency, compared to plants grown in the recommended solution. Interestingly, both solutions had similar levels of Ca (180 mg· L-1), but the 20-10-20 fertilizer contains a significant amount of N as ammonium. Ammonium can compete with Ca for uptake by plants likely inducing a Ca deficiency, resulting in large numbers of culls due to BER (Table 1).

Interestingly, the varieties that are traditionally used for greenhouse production, Geronimo, Trust, and Cobra, performed better in the perlite and Rockwool-based media than in the pine bark-based media, while a variety typically used for field production, Big Beef, did not appear to be negatively affected by the pine-bark growing media. A pine bark-based substrate has at times been used in combination with a 20-10-20 based fertility program with the belief that the additional buffering capacity of the pine bark media compared to perlite or Rockwool, would offset any negative attributes of the fertilizer mix. Our results suggest that within the 20-10-20-based fertility program, the plants grown in the pine bark-based media did perform better than others, but that the yields were substantially less than those plants grown with the recommended fertilizer solution.

These results suggest that fertilizer solution can have substantial impact on the productivity of hydroponic tomatoes. With minimal buffering capacity compared to field production, interactions between nutrients and even minor deficiencies are magnified.

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IR-4 Evaluation of Conventional and Potentially Organic Insecticides for Management of Flea Beetles on Eggplant

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Although not planted on a large acreage, eggplant is an important vegetable for market growers in Kentucky, providing good yields and harvest opportunities over a long portion of the growing season. While disease susceptibility is relatively low compared to some other vegetables, eggplant is subject to numerous insect pests, including Colorado potato beetle, aphids, flea beetles, stink bugs, whiteflies, and beet armyworm. Among these pests, flea beetles generally occur more frequently than others and their damage can severely reduce the vigor of young plants in the field.

Three species of flea beetles are common on eggplant—the eggplant flea beetle, tobacco flea beetle and the potato flea beetle. They attack on the upper and lower sides of the leaves chewing shot holes. Leaves can become completely riddled with these holes and may even be killed. Small plants with fewer leaves are more susceptible to damage, particularly from the overwintering generation.

In 2010, commercial growers from several Southern states reported difficulties managing flea beetles on eggplant with the recommended insecticides. Because of these reports to IR-4 state liaisons, the IR-4 project (the Minor Use Pesticide

Table 1. Insected evaluated for flea beetle control on eggplant.

Trt No.	Insecticide	Rate	Type of insecticide
1	Control	---	---
2	Brigade 2 EC (bifenthrin)	189 ml/A	Synthetic
3	cyantraniliprole	607 ml/A	Synthetic
4	Assail 30 SG(acetamiprid)	113 gm/A	Synthetic
5	Beleaf 50 SG (flonicamid)	81 gm/A	Synthetic
6	Agri-Mek 0.15 EC (abamectin)	473 ml/A	Synthetic
7	Entrust 80 WP (spinosad)	71 gm/A	Organic
8	*Chromobacterium substagae*	7570 ml/A	Bacterial
9	Azera (azadirachtin and pyrethrum)	946 ml/A	Botanical

Table 2. Mean flea beetle counts (total per 5 plants) following June 24 applications.

Trt No.	27-Jun 3 DAT[z]	1-Jul 7 DAT	7-Jul 13 DAT
1	2.00 a[y]	5.25 a	9.75 a
2	0.00 b	0.75 c	5.25 a
3	0.75 ab	1.75 bc	5.75 a
4	0.50 ab	2.50 bc	8.50 a
5	1.25 ab	3.00 b	7.00 a
6	0.75 ab	1.50 bc	8.75 a
7	0.50ab	2.25 bc	7.75 a
8	1.25 ab	3.50 ab	9.25 a
9	1.50ab	3.50 ab	7.75 a

z DAT = Days after treatment.
y Means followed by the same letter within a column are not significantly different.

Table 3. Mean flea beetle counts (total per 5 plants) following July 7 applications.

Trt No.	9-Jul 2 DAT[z]	12-Jul 5 DAT	18-Jul 11 DAT
1	10.75 a[y]	7.75 ab	16.25 a
2	0.25 c	0.75 b	0.75 b
3	1.50 bc	2.00 b	5.50 ab
4	1.00 bc	1.00 b	7.00 ab
5	10.50 a	4.25 b	17.25 a
6	2.25 bc	3.25 b	13.25 ab
7	4.25 b	10.50 ab	13.25 ab
8	8.00 a	6.50 ab	9.25 ab
9	11.25 a	16.50 a	14.75 ab

z DAT = Days after treatment.
y Means followed by the same letter within a column are not significantly different.

Table 4. Mean flea beetle counts (total per 5 plants) following July 18 applications.

Trt No.	19-Jul 1 DAT[z]	22-Jul 4 DAT	25-Jul 7 DAT
1	22.25 a[y]	13.00 a	13.50 a
2	1.75 d	0.50 c	3.00 b
3	3.75 cd	0.75 c	3.75 b
4	4.25 cd	2.75 bc	5.50 b
5	14.50 abc	7.75 abc	14.00 a
6	8.25 cd	10.75 ab	10.25 ab
7	7.25 cd	6.50 abc	16.75 a
8	11.00 bcd	9.50 abc	4.75 b
9	21.50 ab	14.50 a	18.00 a

z DAT = Days after treatment.
y Means followed by the same letter within a column are not significantly different.

Clearance program), initiated several studies to look at alternative insecticides for control of flea beetles on eggplant. The results presented below are from an IR-4 sponsored project conducted in Kentucky in 2011.

Material and Methods

This trial was conducted on the University of Kentucky Horticulture Farm in Lexington. Transplants of the variety Santana were started from pelleted seed in the greenhouse on 1 April 2011 in 72 cell flats and transplanted to the field on June 7, 2011. Plots were established on 5- inch raised beds using a plasticulture production system. Individual plots consisted of a single row of eggplant with 18-inch spacing between plants and six feet between rows. Plots were arranged as a randomized block design with four replications of blocks. Plots were maintained according to conventional irrigation and fertility recommendations.

Initially, flea beetles were recorded biweekly until numbers increased to the point where the first insecticide treatments needed to be applied. The flea beetle species observed were the tobacco and potato flea beetles. On June 27 and July 1, 7, 9, 12, 18, 19, 22, and 25, the total numbers of flea beetles per five random plants (above and below surface of leaves and on stems) per plot were recorded. It was intended to be one, four, and seven days post treatment for the three applications but weather conditions impacted when counts could be made. Generally all counts were made in the morning when plants were dry and beetles were more sluggish. All data were subjected to ANOVA and means separated by LSD (0.05).

The insecticides tested and the rates used are listed in Table 1. Bifenthrin (Brigade) was selected as the commercial standard against which the other insecticides could be compared. Insecticide treatments for flea beetles were applied on June 24 and July 7 and 18. Treatments were applied with a CO2 sprayer at 40 psi with three TXVS-12 nozzles (one over the center of the row and one on each side of the row). Each plot received 500 milliliters of finished spray and 1.25 milliliters of Scanner surfactant. After insecticide treatments, flea beetle counts were made periodically to estimate the duration of control.

Eggplant was harvested from the plots on six different dates as fruit matured. All marketable fruit were harvested with the 40-foot plots, counted and weighed. Harvests were discontinued month after the final insecticide application date. Data were subject to ANOVA and means separated by LSD (0.05).

Table 5. Mean cumulative harvest weight (lbs.) of marketable fruit (entire 40 ft plot).

Trt No.	22-Jul	27-Jul	1-Aug	6-Aug	13-Aug	19-Aug
1	3.10 abc[z]	5.88 b	15.20 ab	44.20 cd	80.55 b	104.98 bcd
2	2.65 c	7.68 ab	18.18 ab	51.90 bc	89.10 ab	122.85 ab
3	2.50 c	5.50 b	12.08 b	39.73 cd	67.33 b	85.00 d
4	5.98 a	11.08 a	22.43 a	75.28 a	110.35 a	143.33 a
5	1.38 c	4.08 b	13.15 b	43.98 cd	82.90 b	120.30 abc
6	2.38 c	6.43 b	12.10 b	38.30 cd	82.60 b	113.85 abcd
7	2.20 c	5.23 b	15.45 ab	59.90 b	89.25 ab	108.35 bcd
8	2.75 bc	4.35 b	10.23 b	34.38 d	63.98 b	85.83 cd
9	5.75 ab	6.90 ab	16.03 ab	51.43 bc	86.20 ab	107.05 bcd

z Means followed by the same letter within a column are not significantly different.

Table 6. Mean cumulative numbers of marketable fruit (entire 40 ft. plot).

Trt No.	22-Jul	27-Jul	1-Aug	6-Aug	13-Aug	19-Aug
1	3.50 ab[z]	6.00 ab	15.50 ab	44.75 bcd	82.00 ab	111.75 abc
2	2.50 ab	6.75 ab	17.00 ab	51.00 bc	93.75 ab	138.00 a
3	3.00 ab	5.50 b	11.00 b	36.75 cd	64.50 b	86.50 c
4	5.50 a	9.75 a	19.75 a	69.00 a	104.50 a	145.75 a
5	1.75 b	4.00 b	12.50 ab	42.75 bcd	85.00 ab	131.00 ab
6	2.75 ab	6.25 ab	11.50 b	37.50 cd	83.00 ab	121.50 abc
7	2.00 b	4.50 b	14.50 ab	55.75 ab	88.00 ab	112.25 abc
8	3.00 ab	4.25 b	10.25 b	34.50 d	63.00 b	88.50 bc
9	5.50 a	6.50 ab	14.00 ab	49.25 bcd	83.50 ab	108.50 abc

z Means followed by the same letter within a column are not significantly different.

Results and Discussion

Following the first application on June 24, only Brigade significantly reduced flea beetles at three days after treatment, while all insecticides except the *Chromobacterium substagae* and Azera reduced numbers at seven days after treatment when compared to the no insecticide control (Table 2). None of the insecticide treatments were different form the untreated control 13 days after application.

With the second set of applications on July 7, all treatments except Beleaf, *Chromobacterium substagae,* and Azera reduced flea beetle numbers two days after treatment, statistically none of the treatments were different with control at five days after treatment, and only Brigade was different from the untreated control at 11 days post application (Table 3).

With the third round of treatments that were applied on July 18, all insecticides except Azera significantly reduced flea beetle numbers one day post application, while only Brigade, cyantraniliprole, and Assail reduced flea beetle numbers at four days after application (Table 4). With the final flea beetle count with this round of applications, Brigade, cyantraniliprole, Assail, and *Chromobacterium substagae* reduced flea beetle numbers at seven days post application.

The harvest data in Tables 5 and 6 represent cumulative yield to date at those sampling periods. Based on the weight of marketable fruit harvested presented in Table 5, Assail produced significantly more cumulative yield than the untreated control plots on July 27 and August 6, 13, and 19. Entrust plots had significantly more cumulative yield on August 6 than the no insecticide control plots. In terms of the number of fruit harvest, few treatments were different form the untreated control plots at any of the dates which would indicate that the treatments and control of flea beetles had little effect on the quantity of fruit the plants were setting.

This study indicated that all of the insecticides tested except Azera could reduce the numbers of flea beetles, however Briagade, Assail, Entrust appeared to provide more consistent control of flea beetles on eggplant.

Evaluation of a Biopesticide and Conventional Fungicides for Management of Phytophthora Blight of Yellow Squash

Kenneth Seebold, Department of Plant Pathology

Introduction

Phytophthora blight, caused by *Phytophthora capsici,* has become a serious disease of cucurbits grown in many parts of the United States. Isolated, but serious, outbreaks of this disease have occurred on watermelon and pumpkin in Kentucky; however, overall incidence of this disease has been relatively low to date. All cucurbits are affected by this disease, as are solanaceous vegetables such as eggplant, pepper, and tomato (Koike et al., 2007). Roots, stems, foliage, and fruit are susceptible to infection by *P. capsici;* however, symptoms tend to be limited to specific plant parts, depending upon the host. Within the Cucurbitaceae, *P. capsici* tends to infect only fruit on cucumber, cantaloupe, and watermelon, but will attack all structures of pumpkins, winter squash, and yellow squash (Hausbeck and Lamour, 2004).

Cultural practices, host resistance, and fungicides are employed in the management of Phytophthora blight (Seebold, 2011). The cultural practices most commonly recommended include crop rotation, sanitation, and water management. Phytophthora blight is more likely to be severe where soils remain saturated for long periods, and disease risk can be reduced by controlling irrigation and improving soil drainage. While a number of pepper varieties with resistance to Phytophthora blight are commercially available, no blight-resistant cucurbits have been released to date. Fungicides can be useful against Phytophthora blight if used in conjunction with sound cultural practices, and if they are applied in a timely manner. Generally, fungicides with the best efficacy against Phytophthora blight tend to be relatively expensive and are prone to development of resistance in pathogen populations. Thus, there is a need for alternative approaches to managing Phytophthora blight with fungicides.

Preliminary experiments conducted in 2009 and 2010 with a biological control agent, Bioten (a formulation of the fungi *Trichoderma viride* and *Trichoderma gamsii*), demonstrated moderate suppression of disease. The current study was conducted to evaluate the potential of the biocontrol agent, Bioten WP, to augment the performance of commercially available fungicides against Phytophthora blight.

Materials and Methods

The experiment was conducted at the University of Kentucky Spindletop Farm in north Lexington. Yellow squash (cv. Sunray) were seeded into 128 cell trays during the week of May 26 and greenhouse grown for three weeks until planting on June 16. Plants were transplanted using a waterwheel setter into raised, plastic-mulched beds. Beds were spaced on 6-foot centers, and plants were transplanted 15 inches apart; each plot was 20 feet long. Each plot was separated by a 5-foot planted buffer. Fertility, insect, and weed management followed recommended practices. The experimental design was a split-plot, randomized complete block (five replications). Whole-plot factors were Tenet WP (pre-transplant) or a water control. Subplots consisted of six fungicide programs: Ridomil Gold SL (at-transplant); Ridomil Gold (at transplant) followed by Ridomil Gold Copper (foliar); Presidio plus Kentan, alternated with Ridomil Gold Copper (foliar); Revus plus Kentan, alternated with Ridomil Gold Copper (foliar); Ridomil Gold (at transplant) followed by Presidio plus Kentan, alternated with Ridomil Gold Copper (foliar); and Ridomil Gold (at transplant) followed by Revus plus Kentan, alternated with Ridomil Gold Copper (foliar).

Bioten WP was applied through drip-irrigation to whole beds immediately prior to transplanting and six days after transplanting, and beds not treated with Tenet received water only. Ridomil Gold SL was applied once, after transplanting, as a drench; each plant in a Ridomil Gold-treated plot was treated with 4 fluid ounces of fungicide solution. Application of foliar fungicides began two weeks after transplanting and continued on a 10-day interval for a total of three sprays. Foliar fungicides were applied with a CO2-powered backpack sprayer fitted with three hollow-cone (TSX-18) nozzles (one over the bed center and two directed at the sides of plants). Operating pressure was 60 psi and application volume was 40 gallons per acre. Plots were inoculated on July 2 with *Phytophthora capsici* by placing a 1-inch thick slice of pathogen-infested squash fruit at the base of plants in the buffers between plots. Overhead irrigation was applied as needed to maintain disease-favorable conditions.

Incidence of Phythophthora blight was assessed by counting the number of plants with symptoms of disease on July 8, 13, 23, and 31. Season-long severity of disease was determined as the area under the disease progress curve (AUDPC), calculated from weekly disease severity data. Plots were harvested on July 16 and 23; marketable yield was determined as the weight of healthy fruit.

Table 1. Effect of Bioten and conventional fungicides on the incidence & severity of Phytophthora blight on summer squash (cv. Sunray) – 2011, Lexington, Ky.

Treatment		Application		Phytophthora blight (AUDPC)[y]		Marketable fruit (lb/plot)	
		Rate/A	Timing[z]				
1	Ridomil Gold SL	1 pt	B	8.3	ab[x]	15.6	bc
2	Bioten 4WP	2.2 lb	AB				
	Ridomil Gold SL	1 pt	B	4.4	bcd	26.7	ab
3	Ridomil Gold SL	1 pt	B				
	Ridomil Gold Copper	2 lb	CDE	7.2	bcd	16.0	bc
4	Bioten 4WP	2.2 lb	AB				
	Ridomil Gold SL	1 pt	B				
	Ridomil Gold Copper	2 lb	CDE	6.9	bcd	27.3	ab
5	Presidio SC + Kentan DF	4 fl oz + 2 lb	CE				
	Ridomil Gold Copper	2 lb	D	5.8	bcd	25.8	ab
6	Bioten 4WP	2.2 lb	AB				
	Presidio SC + Kentan DF	4 fl oz + 2 lb	CE				
	Ridomil Gold Copper	2 lb	D	3.4	de	31.5	a
7	Revus + Kentan DF	8 fl oz + 2 lb	CE				
	Ridomil Gold Copper	2 lb	D	5.3	b-d	23.3	abc
8	Bioten 4WP	2.2 lb	AB				
	Revus + Kentan DF	8 fl oz + 2 lb	CE				
	Ridomil Gold Copper	2 lb	D	4.8	b-d	24.3	abc
9	Ridomil Gold SL	1 pt	B				
	Presidio SC + Kentan DF	4 fl oz + 2 lb	CE				
	Ridomil Gold Copper	2 lb	D	3.1	de	29.0	a
10	Bioten 4WP	2.2 lb	AB				
	Ridomil Gold SL	1 pt	B				
	Presidio SC + Kentan DF	4 fl oz + 2 lb	CE				
	Ridomil Gold Copper	2 lb	D	1.9	e	31.1	a
11	Ridomil Gold SL	1 pt	B				
	Revus + Kentan DF	8 fl oz + 2 lb	CE				
	Ridomil Gold Copper	2 lb	D	3.6	cde	24.8	abc
12	Bioten 4WP	2.2 lb	AB				
	Ridomil Gold SL	1 pt	B				
	Revus + Kentan DF	8 fl oz + 2 lb	CE				
	Ridomil Gold Copper	2 lb	D	2.6	e	20.5	abc
13	Untreated check	--		11.9	a	12.9	c
14	Bioten 4WP	2.2 lb	AB	7.7	bc	20.7	abc

z Application dates: A=6/16, B=6/23, C=7/04, D=7/14, E=7/27.
y AUDPC=area under disease progress curve, calculated from ratings of disease incidence taken on 7/08, 7/15, 7/23, and 8/01.
x Means followed by the same letter do not differ significantly as determined by Fisher's protected least significant difference test ($P \leq 0.1$).

Results and Discussion

Temperatures were above normal and precipitation was normal during the trial period, resulting in conditions that were favorable for an epidemic of Phytophthora blight. Highest severity of disease was observed untreated plots, where incidence of Phytophthora blight approached 90 percent by the end of the trial (Table 1). Bioten, the biological control agent tested in this trial, significantly reduced the severity of Phytophthora blight in the study by 35 percent compared to the untreated control. Performance of Bioten alone against the disease was similar to Ridomil Gold SL applied once prior to planting (a standard recommendation) and all but one of the fungicide-only programs. The combination of Ridomil Gold at transplanting followed by Presidio plus Kentan, alternated with Ridomil Gold Copper, reduced the severity of Phytophthora blight by 60 percent relative to Bioten applied alone. Overall, severity of disease was 33 percent lower where Bioten was applied in conjunction with conventional fungicides, averaged across fungicide programs, than in the same fungicide programs without Bioten (Table 2). Squash yields followed a similar trend, with Bioten providing a 21 percent increase in yield, averaged across all Bioten and Bioten plus fungicide programs, over the mean for treatments that did not receive the biocontrol product (Table 2).

Table 2. Effect of Bioten vs. no Bioten on the incidence & severity of Phytophthora blight on summer squash (cv. Sunray), averaged across all fungicide treatments – 2011, Lexington, Ky.

Treatment		Application		Phytophthora blight[y] (AUDPC)		Yield / plot Marketable fruit Weight (lb)	
		Rate/A	Timing[z]				
1	No Bioten	--		6.7	a[x]	26.4	a
2	Bioten 4WP	2.2 lb	AB	4.5	b	20.8	b

z Application dates: A=6/16, B=6/23
y AUDPC=area under disease progress curve, calculated from ratings of disease incidence taken on 7/08, 7/15, 7/23, and 8/01.
x Means followed by the same letter do not differ significantly as determined by Fisher's protected least significant difference test ($P \leq 0.1$).

The results of this study demonstrate the potential of Bioten as tool for managing Phytophthora blight of yellow squash. Bioten does not appear to perform adequately enough to function as a stand-alone solution for the disease; however, these data suggest that this product can be used in conjunction with conventional fungicides to improve overall control of Phytophthora blight and enhance yield. Further work is needed to determine if Bioten can perform consistently from year to year and on vegetables other than summer squash.

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Preliminary Results of Utilizing Squash Bees for Cucurbit Pollination Under Row Covers

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Many growers utilize row covers for frost protection and as a physical barrier to insect pests in several crop systems (Perring et al. 1989). However, when utilized in crops where insect pollination is required, additional considerations must be taken into account.

Beyond ongoing concerns regarding the future of managed honeybee colonies, it is unlikely the Italian variety managed in the United States would be practical under row covers. This is due to their behavior in enclosed spaces and when exposed to higher temperatures. While some studies have indicated that bumblebees might show promise in small-scale settings (Jesse et al. 2007, Owens et al. 2008, Caudle 2010), their foraging under row covers might be limited to short distances. Bumblebees also increase costs to growers through purchase of the colonies and their care.

The framework of this study was designed to exploit the behavior of male squash bees, which use closed squash and pumpkin flowers as nighttime resting sites. Early in the season, female squash bees also rest in closed flowers before nests are constructed in the soil (Hurd et al. 1974). This pattern allows them to be easily captured and released under row covers, or to be captured by trapping them under row covers while they are resting in the flowers. Squash bees are presumed to have evolved and dispersed from central Mexico and are active during or before dawn, so they may be able to better tolerate the temperatures under the row covers than bumblebees by avoiding activity during the heat of the day. Approximately one squash bee per 20 squash or pumpkin flowers is required for adequate pollination (Tepedino et al. 1981, Delaplane and Mayer 2000).

In this study, we investigated two methods to utilize squash bees and other wild pollinators in a cucurbit production system using extended-season row covers. Providing these assumptions are true and that enough squash bees are trapped under the covers to fulfill continued pollination requirements, this would allow for extended use of row covers during the pollination period for cucurbits. By utilizing the row covers for a longer period of time, we hope to reduce the need for insecticide applications.

Materials and Methods

This experiment was conducted at the University of Kentucky's Spindletop Research Farm, near Lexington, Ky., in the summer of 2011. The field plot consisted of eight 120-foot-long rows of Table Ace acorn squash grown on raised beds with black plastic and trickle irrigation, and set at 2-foot spacing between plants. The rows were placed 6-feet on center.

Each subplot containing four rows that were 12 feet long (approximately 16 plants) was assigned to one of four treatments:

- **Open.** Row covers used from transplanting to anthesis (flowering), then removed and followed by spraying with Pyganic EC 5.0 as warranted.
- **Closed.** Row covers employed for the entire season.
- **Natural.** Row covers employed to anthesis and until squash bees observed elsewhere on the farm, then covers removed in the evening and re-covered the following afternoon).
- **Under.** Row covers employed for the entire season, but with five female and seven male squash bees released under the covers. The bees for the under treatment were collected from squash plants elsewhere on the Spindletop farm. This release rate corresponded to approximately one squash bee per five plants.

The effectiveness was assessed through total yield by grading harvested fruit as either marketable or cull due to insect damage. As pollination affects both quantity and quality of fruit, fruit number and fruit weight were compared across treatments.

Results and Discussion

All experimental treatments (except closed) yielded fruit quantities that seemed adequate for the size of the plots. Virtually no developed fruits were collected from the closed treatment, indicating the squash bees likely were responsible for proving adequate fruit set for pollination in the other covered treatments. Generally, more fruit were collected from the open treatment (Figure 1), however many of these were culled due to insect damage, primarily attributed to squash bugs. Therefore, based on marketable number, these three treatments provided statistically indistinguishable results (Figure 2). Nonetheless, a small dip in fruit quality was indicated by lower marketable weight for the treatment plots naturally infested by squash bees, but not for the treatment plots where the bees were released under the covers (Figure 3).

Conclusions

In general, this study demonstrates the potential for the biology squash bees to be exploited by growers of cucurbit crops, which could allow them to achieve adequate pollination under extended-season row covers without exposing their crops to cucumber beetle, squash bug, and squash bug pressure and/or applying chemical insecticides. While the natural treatment showed some promise, it is unclear how reliable it might be due to the uncertainty associated with trapping the bees that fly into the plot on their own. However, the possibility for a grower to collect their own bees from an exposed planting of squash and then release them under the covers protecting a crop might prove to be beneficial. The potential benefit is due to the effectiveness of the row cover to exclude pests and the reduction or elimination of costly insecticide applications associated with keeping the covers in use until harvest.

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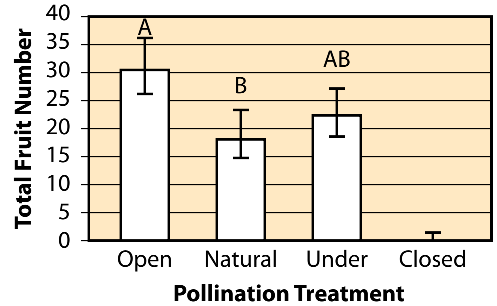
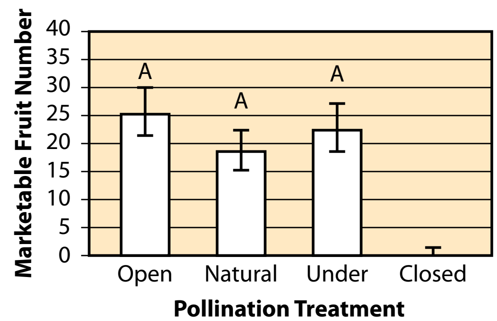
Figure 1. Total yield of developed squash by fruit number.



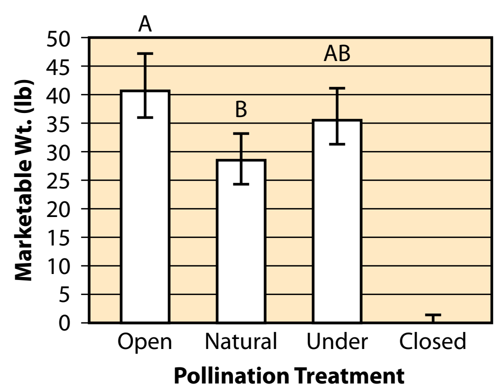
Mean numbers followed by the same letter are statistically indistinguishable.

Figure 2. Total marketable yield of squash by fruit number.



Mean numbers followed by the same letter are statistically indistinguishable.

Figure 3. Marketable yield of squash by weight.



Mean numbers followed by the same letter are statistically indistinguishable.

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The Impact of Row-Cover Placement for the Organic Production of Muskmelon and Butternut Squash in Kentucky

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Introduction

Kentucky's warm and humid summer climate generates many challenges for organic vegetable growers. Organic cropping systems have been researched and developed by the University of Kentucky for many vegetable crops; however, growing cucurbits including squash, muskmelons, watermelon, cucumbers, and pumpkins can be challenging due to bacterial wilt. The causal bacterium, *Erwinia tracheiphila,* is vectored by striped and spotted cucumber beetles (*Acalymma vittatum* and *Diabrotica undecimpunctata howardi,* respectively) and can lead to catastrophic crop failures depending upon beetle populations and infection rates.

Bacterial wilt is transmitted by cucumber beetles either depositing infected frass on plants, where the bacteria can enter plant wounds and proliferate, or by the transfer of bacteria directly into the plant from chewing mouthparts during feeding. Bacterial wilt progresses as xylem-inhabiting bacteria and ultimately leads to wilting and subsequent death of the plant. Vegetables harvested from infected plants typically develop internal rot after harvest and are unmarketable.

Exclusion of the beetles from plants circumvents the disease; however, specific reliable organic crop production methods have not been developed for this region. To further develop successful production of organic cucurbits, this project was organized to develop an organic production system to control cucumber beetles on melons, with the implementation of a row-cover system.

Materials and Methods

In March 2010, two research plots measuring 50 feet by 300 feet were set aside for this experiment at the University of Kentucky Horticulture Research Farm, located in Lexington. The plots were on the farm's Organic Farming Unit, the 25-acre USDA organically certified portion of the farm.

There were four replications; the plot plan was a randomized complete block with a split-split design. Each treatment was 20 feet long; each subplot consisted of a 60-foot row (three treatments), plus 15 feet (5 feet between each treatment), for a total of 75 feet per subplot. There were four treatments per replication, for a total of twelve randomized treatments per 300-foot-long row. Ten plants (either melon or squash) were in each treatment. Melons and squash were transplanted in separate identical fields located adjacent to each other.

Four treatments were used in this experiment:

- Treatment 1 (T1)—control, with reemay removed immediately after transplanting and no organic pesticides applied;
- Treatment 2 (T2)—standard organic, with reemay removed completely at anthesis and organic pesticides applied afterwards;
- Treatment 3 (T3)—on/off/on, with the reemay removed at anthesis and replaced two weeks later, and with organic pesticides applied while the reemay was removed; and
- Treatment 4 (T4)—10 days post-anthesis, with the reemay ends opened 10 days post anthesis to allow pollinators access, then removed completely and organic pesticides applied afterward.

Plots were spaded on April 30 and May 25 using an Imants rotary spading machine (Italy). Three different fertility treatments were applied on May 27, including Fertrell Earth-Friendly All Purpose 5-3-3 (5N-3P-3K) granular fertilizer (FreshStart Grower's Supply, Louisville, Ky.) applied at a rate of 34.4 pounds per treatment, composted manure applied at 212.5 pounds per treatment for a 30 percent mineralization rate, and 584 pounds per treatment for a 10 percent mineralization rate. A total of 75

Table 1. Muskmelon 'Strike' Organic Practice 2010 – Treatment Effects

	Plant #	Fruit Yield	Mrktbl Yield (# fruit)	Mrktbl Wt (lbs.)	Cull (# fruit)	Cull Wt (lbs.)	Sugar 7/29 (%)	Sugar 8/3 (%)	#Dead 7/5	#Dead 9/7
Treatment 1	4.8±0.4	7.6±0.8	2.9±0.4	13.0±1.9	4.5±0.5	16.9±1.6	6.3±0.9	6.5±1.0	2.1±0.3	5.9±0.4
Treatment 2	10.0±0.1	25.4±1.0	16.3±0.9	70.1±3.7	9.2±0.9	41.6±4.4	9.4±0.7	9.9±0.2	0	0.2±0.1
Treatment 3	10.1±0.1	25.5±1.0	9.3±1.0	36.4±4.2	15.5±1.5	65.6±6.4	8.5±0.5	5.4±1.0	0	0
Treatment 4	10.0±0.1	22.5±1.5	12.5±1.3	59.4±5.7	9.1±0.9	35.2±3.1	9.4±0.5	8.5±0.7	0	0.3±0.1
Treatment	*	*	*	*	*	*	*	*	*	*

* Significant at P<0.05
Treatment 1: Control, no pest management.
Treatment 2: Standard organic pest management (remay removed at anthesis + insecticides).
Treatment 3: On/ All data is averaged for the 4 reps.
Treatment Off/On; remay removed for 14 days at anthesis, then replaced.
Treatment 4: 10 days post anthesis; remay ends opened for10 days at anthesis, then removed and insecticides applied.
Plant #: Total number of live plants remaining at first harvest (out of 10 planted).
Fruit yield: number of fruit.
Mrktbl Yield: Total number of marketable fruit
Sugar: measured by refractometer
#Dead: total plant mortality at indicated dates (~half way and end of season).

Table 2. Muskmelon 'Strike' Organic Practice 2010 – Fertilizer Effects

	Plant #	Fruit Yield	Mrktbl Yield (# fruit)	Mrktbl Wt (lbs.)	Cull (# fruit)	Cull Wt (lbs.)	Sugar 7/29 (%)	Sugar 8/3 (%)	#Dead 7/5	#Dead 9/7
Fertrell	9.2±0.4	22.9±1.5	11.8±1.2	52.8±5.3	11.1±1.2	43.8±5.3	9.9±0.3	7.9±0.7	0.4±0.2	1.4±0.4
30% min. rate	8.7±0.4	19.3±1.5	9.2±1.1	40.4±4.6	9.2±0.9	37.1±3.5	8.5±0.6	7.4±0.8	0.6±0.2	1.4±0.4
10% min. rate	8.3±0.5	18.5±1.8	9.7±1.3	41.0±5.7	8.4±1.2	38.5±5.3	6.8±0.8	7.5±0.8	0.6±0.2	1.9±0.6
Fertilizer	NS	*	NS	NS	NS	NS	*	NS	NS	NS

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

Fertrell: Fertrell fertilizer treatment
30% min. rate: Compost applied based on 30% mineralization rate.
10% min. rate: Compost applied based on 10% mineralization rate.
Plant #: Total number of live plants remaining at first harvest (out of 10 planted).
Fruit yield: number of fruit.
Mrktbl Yield: Total number of marketable fruit
Sugar: measured by refractometer
#Dead: total plant mortality at indicated dates (~half way and end of season).

pounds of preplant nitrogen was applied per 20-foot-by-50-foot plot by one of the fertility treatments.

Melon Strike and winter squash Betternut seeds were sown in the certified organic UK Organic Farming Unit greenhouse on May 3 and 4. Ten flats of untreated Strike seeds and ten flats of Strike seeds treated with the biological fungicide seed/soil treatment Kodiak®, *Bacillus subtilis* strain GB03, (Chemtura Corp., Middlebury, Conn.) at a rate of 0.5 ounces per 100 pounds of seed were sown into McEnroe Premium Organic Potting Soil (Seven Springs Farm, Check, Va.), as were ten flats of untreated Betternut seeds and ten flats of Kodiak® treated Betternut seeds. A total of 20 flats of melon Strike were sown, as were a total of 20 flats of squash Betternut.

Eight 300-foot-long rows of black plastic (Deerfield Supplies, Elkton, Ky.) were laid in each plot on May 27, 29, and 31. Drip irrigation (Deerfield Supplies) was laid at the same time as the black plastic. Both melon and squash plants were transplanted on May 31 and immediately covered with hoops and reemay. On June 4, reemay was removed from T1—the control treatment—in both the melon and squash plots, and hand and mechanical weeding was conducted using Glaser oscillating hoes (Peaceful Valley Farm and Garden Supply, Grass Valley, Calif.). On June 22, at plant anthesis, reemay was removed completely from T2. Reemay also was removed temporarily from T3, to be replaced in 2 weeks. The ends of the reemay on T4 were opened to allow pollinators access. On July 2, reemay on T4 was removed completely after the 10-day period. Reemay on T3 was replaced on July 6, after the two-week period.

Treatments 2, 3, and 4 in both melon and squash plots were sprayed with Pyganic EC 1.4 (Peaceful Valley Farm and Garden Supply, Grass Valley, CA), an OMRI-listed pyrethrum-based insecticide used to control cucumber beetles, squash bugs, and squash vine borer on June 29. Additional sprays of Pyganic EC 1.4 were made to T2 and T4 on July 8, 14, and 21 at a rate of 3 ounces per 7.5 gallons. An additional Pyganic EC 1.4 spray was applied only to the squash plot on July 28. Melon harvests occurred on July 29, and August 3 and 9. Squash harvests occurred on August 13 and 23.

Results and Discussion

Muskmelon Strike. There were significant differences for treatment effects, with the control (Treatment 1) consistently lower in total and marketable yield, weights, and culls (Table 1). It appears that the marketable yield and weight of fruit in Treatment 3 was lower than the other treatments except for the control. This potentially was due to increased incidence of vole damage under the row covers.

There were also significant differences among the three fertilizer treatments, with fruit yield and sugar from the Fertrell fertilizer treatment being significantly higher than the two

Table 3. Muskmelon 'Strike' Organic Practice 2010 – Kodiak Effects

	Plant #	Fruit Yield	Mrktbl Yield (# fruit)	Mrktbl Wt (lbs.)	Cull (# fruit)	Cull Wt (lbs.)	Sugar 7/29 (%)	Sugar 8/3 (%)	#Dead 7/5	#Dead 9/7
Kodiak+	8.8±0.4	21.1±1.3	10.9±0.9	46.6±4.2	9.8±1.0	40.1±4.0	8.3±0.5	8.4±0.5	0.6±0.2	1.7±0.4
Kodiak-	8.7±0.4	19.4±1.3	9.6±1.0	42.7±4.4	9.4±0.8	39.5±3.8	8.5±0.5	6.8±0.7	0.5±0.2	1.5±0.4
Kodiak	NS	*	NS	NS	NS	NS	NS	*	NS	NS

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

Plant #: Total number of live plants remaining at first harvest (out of 10 planted).
Fruit yield: number of fruit.
Mrktbl Yield: Total number of marketable fruit
Sugar: measured by refractometer
#Dead: total plant mortality at indicated dates (~half way and end of season).

Table 4. Squash 'Betternut' Organic Practice 2010 – Treatment Effects

	Plant #	Fruit Yield	Mrktbl Yield (# fruit)	Mrktbl Wt (lbs.)	Cull (# fruit)	Cull Wt (lbs.)	#Dead 7/5	#Dead 9/7
Treatment 1	2.5±0.3	17.1±1.3	11.2±1.1	18.3±1.6	5.9±0.5	7.3±0.7	1.2±0.3	2.3±0.3
Treatment 2	5.1±0.4	27.1±2.2	20.1±1.7	37.7±3.0	7.0±1.1	11.0±2.0	0.4±0.1	0.8±0.2
Treatment 3	5.2±0.3	28.5±2.2	20.3±1.7	36.0±3.0	8.3±1.2	13.4±1.8	0.2±0.1	1.0±0.2
Treatment 4	4.9±0.4	27.6±2.4	20.5±2.9	32.1±3.5	9.3±1.0	14.0±2.0	0.4±0.2	1.0±0.3
Treatment	*	*	*	*	NS	*	*	*

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

Treatment 1: Control, no pest management.
Treatment 2: Standard organic pest management (remay removed at anthesis + insecticides).
Treatment 3: On/ All data is averaged for the 4 reps.
Treatment Off/On; remay removed for 14 days at anthesis, then replaced.
Treatment 4: 10 days post anthesis; remay ends opened for10 days at anthesis, then removed and insecticides applied.
Plant #: Total number of live plants remaining at first harvest (out of 10 planted).
Fruit yield: number of fruit.
Mrktbl Yield: Total number of marketable fruit
Sugar: measured by refractometer
#Dead: total plant mortality at indicated dates (~half way and end of season).

compost treatments (Table 2). It appears that the amount of compost used was either not sufficient or was not mineralized at a rate needed by the plants during fruit production.

Significant effects from the Kodiak seed treatment were seen in fruit yield, with the +Kodiak treatment yield significantly higher than the—Kodiak treatment. The sugar reading from the August 3 harvest date was also higher with the +Kodiak treatment (Table 3). Based on this data, it appears that Kodiak seed treatments might impart some level of resistance to bacterial wilt in this melon.

Squash Betternut. There were significant differences among the four treatments, with the control (Treatment 1) consistently lower in total and marketable yield, as well as marketable and cull weight (Table 4). In terms of treatment differences, there did not seem to be a significant advantage of using extended duration row covers (Treatment 4) over the standard organic practice (Treatment 2). Additionally, it was found that reapplying row covers after the two-week pollination period was impossible due to the rapid vining nature of the plants. In the future wider sections of row cover will be investigated that will allow the simultaneous coverage of multiple rows instead of the single row approach that was used in this study. This will allow the plants to spread out and vine while maintaining the row-cover protection.

Evaluation of Conservation Tillage and Plasticulture Production Systems for Organically and Conventionally Grown Bell Peppers in Well-Watered and Drought Conditions

Zheng Wang and Timothy Coolong, Department of Horticulture

Introduction

No- or minimum-tillage production systems utilized by agronomic farmers have led to improvements in soil conservation. Benefits of conservative tillage include minimizing soil structural disturbance, retaining soil moisture, and enhancing soil microbial activity. In general, conservation tillage systems are not used for vegetable production; however, many growers have expressed an interest in such systems in recent years.

Strip tillage is considered a conservation tillage where narrow rows of the field are tilled, but areas between rows are undisturbed and covered with the residues from previous cover crops. Strip-tillage systems represent a good compromise for vegetable growers combining positive aspects of conservation and traditional tillage systems. Typically herbicides are used heavily in strip tillage systems to control weeds due to an inability to cultivate the non-disturbed areas of fields. However, organic farmers have expressed an interest in strip tillage-systems as well. Typically, in an organic minimal-tillage production system, residues from previous cover crops are rolled and crimped to serve as mulch.

Because strip tillage for vegetable production has not been as thoroughly researched as conventional tillage-management practices, many questions remain. One question regards efficient water use in vegetable crops grown in strip-tillage systems. This report presents results from one year of research comparing organic and conventionally managed plasticulture and strip-tillage systems exposed to two different moisture regimes (well-watered and dry). Bell peppers were used as a model for this trial as they have a relatively shallow root system, making them ideal candidates for water-management research. Four main plots—conventional plasticulture, conventional strip tillage, organic plasticulture, and organic strip tillage—each with two subplots represented well-watered and dry conditions.

Materials and Methods

The experiment was conducted at the University of Kentucky Horticultural Research Farm in Lexington using certified organic and conventionally managed land. For the organic strip tillage plots, a rye-vetch cover crop was roller-crimped on May 7, 2011, and again on May 21. For conventionally managed strip-tillage plots, glyphosate (Roundup WeatherMax) was applied to a wheat cover crop on May 5, 2011. For organic and conventionally managed plasticulture plots, the cover crops were mowed using a flail mower, and the ground was prepared using a spader (organic) or moldboard plow (conventional) prior to laying plastic. Soil samples were taken in mid-April. Thus, the fertilizer was applied according to nutrient contributions of the rye-vetch cover crop in organically managed plots or based on current recommendations for conventionally produced peppers (Coolong et al, 2009). Plot dimensions were 50 feet wide by 85 feet long with a total eight rows, two of which were border rows and with the center six rows being the experimental unit. White-on-black plastic mulches were laid for both organic and conventional plots with a row spacing of 6-feet. The strip tillage plots were prepared using a two-row strip tillage implement with rows spaced 3½-feet apart. Organic plots were fertilized with at a rate of 80 pounds per acre of nitrogen [10-2-8 N-P_2O_5-K_2O (cover crops contributed approximately 70 per acre of nitrogen)]. Preplant fertility (19-19-19, N-P_2O_5-K_2O) was applied in conventional plots directly under the plastic mulch or in the prepared strips at a rate of 75 pounds per acre of nitrogen. Supplemental fertility for conventional plots was applied through the irrigation system at a rate of 15 pounds per acre per week of nitrogen, beginning 2 weeks after transplanting and continuing until 75 pounds per acre of nitrogen had been applied in addition to preplant fertility.

Seed preparation and transplanting. Hybrid pepper cultivar Aristotle was seeded into organic and conventional growing media on April 15, and irrigation was applied to prevent the seedlings from drying. Transplanting was performed eight weeks after seeding. Seedlings were transplanted in a double row in plasticulture plots with 15 inches between two plants and in a single row for strip tillage with 12 inches between two plants, respectively.

Irrigation system installation. Eight irrigation controllers were programmed to check the soil moisture every two hours from 7 a.m. to 9 p.m. Once the moisture was checked as "dry," irrigation would be turned on to water the plants for an hour. If the soil moisture was determined to be wetter than the set point, irrigation would not turn on. Forty-eight watermark moisture sensors were buried at a depth of 6 inches below soil surface to measure soil moisture levels and control irrigation. In addition, for purposes of logging soil volumetric water content for each treatment, five moisture probes were buried at different locations within each treatment. The soil moisture content was tested for every hour every day and the data would be stored in the dataloggers. In addition, eight soil temperature sensors were installed to a depth of 6 inches below soil surface for each treatment.

Leaf water potential. Four fully-expanded leaves picked from each individual row were used to measure leaf water potential using the pressure chamber method. Leaf samples were taken from 5:30 to 6 a.m. (pre-dawn) and 2 p.m. (mid-day). Samples were first taken on July 18 and then every 10 days until September 3.

Harvest. Three harvests were conducted on August 10, August 23 and September 13. Fifty-foot sections of each row were harvested. Fruit were then weighed, counted, and graded

Table 1. Average ranges of volumetric soil water content measured at depths of 6 and 10 inches and total water usage for irrigation among eight treatments

Treatment	Soil water content (%) 6 inches	10 inches	Total water usage for irrigation (gallons)
OPW[z]	22-25	23-30	1334
OPD	17-20	23-30	547
OSW	22-25	23-30	1682
OSD	17-20	23-30	595
CPW	23-27	28-33	2290
CPD	20-22	28-33	894
CSW	23-27	28-33	1881
CSD	20-22	28-33	680

[z] OPW: organic plasticulture well watered
OPD: organic plasticulture dry
OSW: organic strip tillage well watered
OSD: organic strip tillage dry
CPW: conventional plasticulture well watered
CPD: conventional plasticulture dry
CSW: conventional strip tillage well watered
CSD: conventional strip tillage dry

Table 2. Average leaf water potential (bar) among eight treatments measured at predawn and afternoon

Date		Treatments OPW[z]	OPD	OSW	OSD	CPW	CPD	CSW	CSD
18-Jul	Predawn	2.4	2.1	2.4	2.4	2.3	2.3	2.6	2.8
	Midday	7.0	10.5	10.9	10.8	8.7	9.6	10.9	9.4
22-Jul	Predawn	4.0	4.0	3.6	4.3	3.8	4.0	3.8	4.3
	Midday	7.3	9.3	8.4	9.1	7.6	9.4	7.2	8.3
29-Jul	Predawn	3.0	3.3	2.4	3.5	3.2	3.6	2.8	3.4
	Midday	8.4	10.3	7.5	10.0	7.8	8.9	8.5	9.5
6-Aug	Predawn	2.3	2.1	1.8	2.1	2.0	2.0	1.9	2.7
	Midday	6.1	7.1	6.1	8.0	5.5	7.3	6.5	6.7
19-Aug	Predawn	2.1	2.2	1.8	2.1	2.2	2.2	2.2	2.5
	Midday	7.3	7.9	7.3	8.6	6.7	8.2	7.3	7.9
3-Sep	Predawn	3.1	3.9	2.7	3.4	3.0	3.6	2.9	3.3
	Midday	13.1	14.4	13.5	14.5	13.4	14.0	13.2	14.0

[z] OPW: organic plasticulture well watered
OPD: organic plasticulture dry
OSW: organic strip tillage well watered
OSD: organic strip tillage dry
CPW: conventional plasticulture well watered
CPD: conventional plasticulture dry
CSW: conventional strip tillage well watered
CSD: conventional strip tillage dry

based on the United States Standards for Grades of Sweet Peppers. Grades were categorized into U.S. Fancy, U.S. No. 1, and U.S. No. 2 based upon their shape, size, and color. Ten representative fruits were selected to measure average length and width. Weights of the three grades of fruits were summed into a total yield and then transferred into a pound-per-acre basis. Also, cull fruits were counted and weighed. After weighing, five representative fruits were selected to measure the fruit water content. The selected fruits were oven-dried at 80 degrees Celsius for 24 hours and then dry weights were subtracted from the total fresh weights before drying to obtain the fruit water content.

Table 3. Yield data for bell pepper grown in different organic and conventional production systems under two tillage regimes and two irrigation strategies in 2011.

Treatment	Total Yield[z] lb/acre		Total Yield[z] no./acre		Fancy lbs/acre		No. 1 lbs/acre		No. 2 lbs/acre		Fancy avg. wt./fruit oz/fruit		Cull fruit %	
CPW[x]	32890	a[y]	78490	ab	28923	a	2630	b	1340	ab	7.1	a	8.1	b
OSW	28130	b	87990	a	20660	b	6070	a	1410	ab	6.1	cd	5.9	bcd
OPD	24040	bc	57726	c	19970	bc	2320	b	1760	a	7.0	a	7.5	b
OSD	23870	bc	74650	b	16950	bc	5160	a	1760	a	6.9	a	6.3	bc
CSW	22380	c	61380	c	18980	bc	2860	b	550	b	6.2	c	3.3	d
OPW	20709	c	53791	c	16960	bc	2580	b	1170	ab	6.9	a	5.9	bcd
CPD	20350	c	55660	c	17075	bc	2510	b	770	b	6.6	b	17.0	a
CSD	20060	c	57670	c	16350	c	3250	b	470	b	6.2	c	3.7	cd

[z] All the data were the average values among the three replications across three harvests.
[y] Duncan Multiple Range Test was applied to compare means and different letter indicated significance at $P<0.05$ level.
[x] OPW: organic plasticulture well-watered
OPD: organic plasticulture dry
OSW: organic strip tillage well-watered
OSD: organic strip tillage dry
CPW: conventional plasticulture well-watered
CPD: conventional plasticulture dry
CSW: conventional strip tillage well-watered
CSD: conventional strip tillage dry

Results and Discussion

The average volumetric soil water contents at 6 inches below soil surface for organic plasticulture and strip till were maintained around 22 percent to 25 percent for well-watered treatments and 17 percent to 20 percent for drought stress treatments. For water content at 10 inches below the soil surface, well-watered and drought treatments maintained approximately 23 percent to 30 percent. However, average soil water content was greater in conventional plots (22 percent to 25 percent and 17 percent to 20 percent versus 23 percent to 27 percent and 20 percent to 22 percent for 6-inch depths and 23 percent to 30 percent versus 28 percent to 33 percent for 10-inch depths) than in organic plots at all depths for both wet and dry treatments. The water content difference between organic and conventional plots also reflected different total water usage (TWU) for irrigation. Table 1 demonstrated the soil water content and total water usage for irrigation. The TWU for all wet treatments were two to three times greater than the dry treatments. Both wet and dry treatments for conventional strip and plastic mulch used more water than organic plots, especially the conventional plasticulture well-watered (CPW) treatment versus the organic plasticulture well-watered (OPW) treatment. The conventional strip-tillage well-watered (CSW) treatment versus the organic strip-tillage well-watered (OSW) treatment and the conventional strip-tillage dry (CSD) treatment vs. the organic strip-tillage dry (OSD) treatment had relatively smaller differences in TWU.

Leaf water potential was measured on July 18, 22, and 29, August 6 and 19, and September 3. Leaf water potentials among the eight treatments at morning (pre-dawn) and afternoon are shown in Table 2. Across all the treatments at different days, leaf water potential at afternoon was greater than data taken at the predawn. Leaf water potential for predawn was not significantly higher for wet treatments than dry ones, such as 2.44 versus 2.13 and 2.4 versus 2.41 on July 18, and 2.26 versus 2.11 and 1.99 versus 1.98 on August 6. However, leaf water potential obtained in the afternoon was generally greater for dry treatments than wetter ones.

Yield was significantly affected by treatment (Table 3). Yields were highest for the first harvest then declining in subsequent harvests for all treatments except OSW and OSD, for which yields during the second harvest period were greatest. For treatments of CPW and CPD, yields dropped significantly (data not shown from the second to third harvest). The CPW treatment had the greatest yield among the eight treatments. The OSW treatment had the second greatest yield, performing better than several plasticulture and conventional treatments. For yields of No. 1 and No. 2 peppers, OSW and OSD were greater than all the other treatments, and OSD and OPD were greater than treatments CPD, CSW, and CSD. The OSW had the greatest number of fruit per acre. Due to fall armyworm damage, CPD had the greatest percentage of cull fruits weight.

When comparing only the well-watered treatments, fruit yields were as follows: CPW > OSW > CSW > OPW. Water usage was similar and was as follows: CPW > CSW > OSW > OPW. Clearly water availability is essential for optimal yields, regardless of tillage system. When comparing water-use efficiency [WUE (yield per gallon used)] the CPW treatment had a lower WUE despite have the greatest yields. The WUE of the four well watered treatments were: OPW, OSW, CPW, and CSW; water efficiencies (pounds per gallon) were OPW 15.5 pounds per gallon, OSW16.7 pounds per gallon, CPW 14.4 pounds per gallon, CSW 11.9 pounds per gallon. For dry treatments, water became limited factor for determining yield.

Conclusions

The results of the first year of this trial suggest strip tillage of vegetables is viable. Although the conventional well-watered plasticulture treatment had the greatest yield, the organic well-watered strip-tillage system had the second greatest yield of the treatments. More work will be conducted to improve the strip-tillage systems. In addition, further research will be conducted to determine if any improvements in WUE may be obtained from reduced tillage production systems.

Literature Citied

Coolong, T., K. Seebold, R. Bessin, J. Strang, and T. Jones. 2009. *Vegetable Production Guide for Commercial Growers, 2010-2011.* University of Kentucky Cooperative Extension Service Bulletin. ID-36. 132 pp.

Concentration of Heavy Metals in Soil and Mobility to Plants

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Introduction

The benefits of organic amendments to growth and yield of vegetables have been clearly demonstrated. [1-3] Municipal sewage sludge (MSS), sometimes referred to as biosolids, contains organic matter, macronutrients, 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. [4] In addition, the simultaneous use of soil conditioners to enhance soil physical, chemical, and microbial conditions could also enhance soil bioremediation. [5, 6] Agricultural uses of MSS have shown promise for a variety of field crops (e.g., maize, sorghum, forage grasses) and production of vegetables (e.g., lettuce, cabbage, beans, potatoes, cucumbers [7] and sweetpotato [8]) and enhanced soil biological activities. [2] Composts provide a stabilized form of organic matter that improve the physical properties of soils by increasing nutrient and water-holding capacity, total pore space, aggregate stability, erosion resistance, temperature insulation, and decreasing apparent soil density. [9]

The United States produces nearly 15 million dry tons of municipal sewage sludge each year. [10] In addition, the rapid growth in the poultry industry has resulted in significant manure generation. More than 11.4 million tons of poultry litter was generated in the United States and approximately 90 percent was applied to land as fertilizer.[11] Poultry litter, that must be disposed contains all essential plant nutrients (N, P, K, S, Ca, Mg, B, Cu, Fe, Mn, Mo, and Zn) and has been documented as an excellent fertilizer. [12] The use of chicken manure and sewage sludge as soil amendments in land farming provide not only a constructive means of waste disposal, but also can improve soil fertility and physical properties. On the other hand, accumulation of heavy metals by plants grown in MSS and chicken manure (CM) amended soil can be a serious problem that requires a continuous monitoring.

There is limited information on heavy-metal absorption by edible plants grown in biosolids- and chicken manure-treated soil. The environmentally safe use of any soil amendment requires complete knowledge of the accumulation of their heavy metals in soil and edible portions of plants. The present study is a continuation of our previous work on recycling waste and use of soil amendments for land farming. The objectives of this investigation were to: quantify the concentration of seven heavy metals (Cd, Cr, Mo, Cu, Zn, Pb, and Ni) in soil amended with SS or CM and to determine bioavailability of heavy metals to cabbage leaves and broccoli heads at harvest.

Materials and Methods

A field study was conducted in summer 2010 on a Lowell silty-loam soil (2.6 percent organic matter, pH 7) located at Kentucky State University Research Farm in Franklin County, Ky. The soil has an average of 12 percent clay, 75 percent silt, and 13 percent sand. Eighteen standard plots of 22 by 3.7 m each were established. The soils in six plots were mixed with municipal sewage sludge (SS) obtained from the Metropolitan Sewer District, Louisville, Ky., and used at 15 t acre-1 (on dry weight basis). Six plots were mixed with chicken manure (CM) obtained from the Department of Animal and Food Sciences at the University of Kentucky in Lexington and mixed with native soil at 15 t acre-1 (on dry weight basis). Amendments were incorporated into the topsoil with a plowing depth of 15 centimeters. The native soils in six plots were used as a no-mulch (NM) control treatment (roto-tilled bare soil) for comparison purposes. Plots were planted on April 19, 2010, with six week-old cabbage (*Brassica oleracea* cv. Blue Vantage) intercropped with broccoli (*Brassica oleracea* cv. Packman) seedlings, planted at 10 rows plot-1 and irrigated by a uniform drip system.

At harvest (July 6, 2010), three plants were collected at random from each of the 18 field plots (six replicates for each soil treatment). Cabbage leaves and broccoli heads were washed with tap and deionized water and oven dried at 65 degrees Celsius for 48 hours. [13] The dried samples were ground manually with a ceramic mortar and pestle to pass through a 1 millimeter nonmetal sieve. Samples were re-dried to constant weight at 65 degrees Celsius using an oven. To 1 gram of each dry sample, 10 milliliters of concentrated nitric acid (HNO_3), trace metal grade was added and the mixture was allowed to stand overnight, heated for 4 hours at 125 degrees Celsius on a hot plate. The mixture was then diluted to 50 milliliters with double- distilled water and filtered through filter paper No.1.

Native and amended soils were collected to a depth of 15 centimeters from field plots using a 2.5 centimeter i.d. soil core sampler equipped with a plastic liner (Clements Associates, Newton, Iowa). Soil samples were oven-dried at 105 degrees Celsius to a constant weight and sieved through a nonmetal sieve to a size of 2 millimeters. Total metal concentrations in soil were determined using nitric acid as described above. Since the total metal concentration in soils is not a very useful predictor of bioavailability of soluble concentrations of metal uptake by plants, the calcium chloride ($CaCl_2$)—extracted metal fraction was used to determine the readily soluble and extractable metals. Ten-g dried soil samples were suspended in 25 milliliters of 0.01 $CaCl_2$ and heated at 90 degrees Celsius on a hot plate for 30 minutes. The resulting supernatants were filtered hot through Whatman filter paper #42, and 2 drops of 1 M HNO_3 trace metal grade were added to prevent metal precipitation and to inhibit microbial growth in samples. [14] Concentrations of Cd, Cr, Ni, Pb, Zn, Cu, and Mo were determined using inductively coupled plasma-mass spectrometer (ICP-MS) following the U.S. EPA method 6020a [15] and using an octopole collision cell ICP-MS (7500cx, Agilent, Santa Clara, Calif.). Elemental concentrations of soil and plants grown under three soil management practices were statistically analyzed using SAS ANOVA procedure. Means were compared using Duncan's multiple-range test. [16]

Results and Discussion

Analysis of the soil amendments used in this investigation indicated that Cr, Ni, Cu, Zn, Mo, Cd, Pb, and organic matter content were significantly greater ($P< 0.05$) in premixed sewage sludge than premixed chicken manure (Table 1). Total cabbage- and broccoli-head yields obtained from MSS and CM treatments were greater than yields obtained from the no-mulch treatment (Figure 1). This increase might be due to improved soil fertility, nutrient retention, soil porosity and water-holding capacity due to addition of soil amendments. Increased crop yields often are attributed to increased organic matter content and improvements in the physical properties of the soil, such as increased aggregate stability, [17] increased moisture-holding capacity, and reduced bulk density. [18] The effects of compost application on crop yield also are derived from availability of nutrients in compost. [19]

Data for all heavy metals in cabbage and broccoli analyzed in this investigation are expressed in dry weight. Water content of the cabbage leaves and broccoli heads were 93 percent and 91 percent, respectively. As previously described, [8, 13] plants can transfer and concentrate metals from soil. Regarding heavy metal bioavailability, Pb, Cd, and Ni are the heavy metals of greatest concern to human health since plants can accumulate these three toxic metals and introduce them into the food chain. Total Ni concentration in soil amended with MSS (1.4 µg g-1 dry soil) was significantly greater than CM and no-mulch treatments, while Ni available to plants was greatest in CM and lowest in SS mixed with soil compared to no-mulch treatment (Figure 2). These findings revealed that total Ni in MSS mixed with soil could be in a complex form that is not soluble in the mild CaCl2 solution used to extract metal ions from soil indicat-

Figure 1. Total yield of cabbage and total yield of broccoli grown under three soil management practices. Bars accompanied by different letter in each crop are significantly different (P< 0.05) from each other using Duncan's multiple range test (SAS Institute 2003). [16]

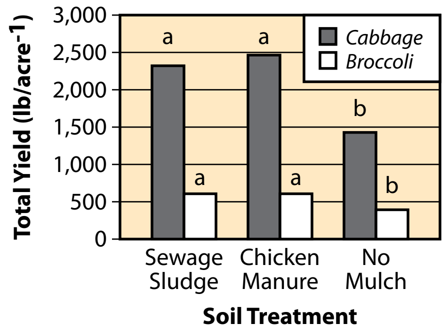
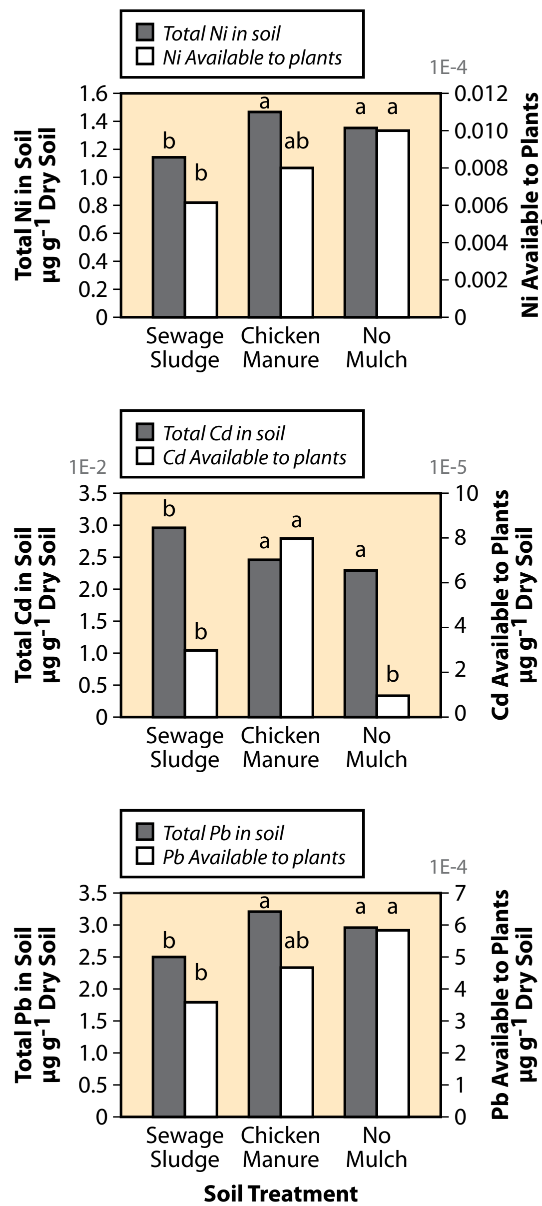


Figure 2. Concentrations of total Ni, Cd, and Pb (extracted using HNO3) and quantities of Ni, Cd, and Pb available to plants (extracted using CaCl2) in soil collected from the rhizosphere of plants grown under three soil management practices. Statistical comparisons were carried out among three soil treatments for each element. Bars for each total metal or metal available to plants accompanied by the same letter are not significantly different (P> 0.05) from each other using Duncan's multiple range test (SAS Institute 2003). [16]



ing that total concentration of Ni in soil do not necessary reflect Ni ions available to plants. Total Cd concentrations among the three soil treatments were not significantly different (Figure 2, middle graph). However, concentrations of Cd available to plants were greatest in CM treatments compared to other treatments. Total Pb concentration was lower in MSS amended soil than CM and no-mulch treatments while Pb available to plants was not significantly different in both MSS and CM treatments (Figure 2, lower graph). These findings indicated that either the CM compost used in this investigation or the native soil that was incorporated with CM was the source of this high concentration of Pb. Analyses of samples collected from premixed MSS and premixed CM amendments revealed that Pb concentrations were 1.47 and 0.16 μg g-1 dry weight, respectively, suggesting that no-mulch native soil could be the source of this Pb.

Bioavailability is defined as the proportion of the total metals in the soil that are available for the incorporation into biota. The bioaccumulation factor (BAF) is characterized by the ratio of the metal content in plant and total metal content in the soil. [20] Table 2 shows the BAF of seven heavy metals in cabbage leaves and broccoli heads of plants grown under three soil management practices. BAF values below 1 are desirable and present levels that do not pose human health hazards. On average, cabbage and broccoli were poor accumulators of Cr, Ni, Cu, Cd, and Pb (BAF < 1), while BAF values were > 1 for Zn and Mo. An elevated BAF for Cu and Zn is not surprising since they are essential plant nutrients. An elevated Ni and Mo BAF values of cabbage grown in chicken manure mixed soil is a characteristic that would be less favorable when cabbage grown on sites having high concentrations of Ni and Mo.

Acknowledgments

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Table 1. Concentration of heavy metals in premixed municipal sewage sludge (MSS) and premixed chicken manure (CM) extracted using nitric acid.

Content	Premixed Sewage Sludge	Premixed Chicken Manure
	mg g-1 dry weight	
Cr	4.62 a	0.26 b
Ni	4.76 a	0.50 b
Cu	30.25 a	4.08 b
Zn	58.51 a	28.03 b
Mo	1.771 a	0.199 b
Cd	0.129 a	0.031 b
Pb	1.468 a	0.156 b
% Organic Matter	63.75 a	57.54 b
pH	5.54 b	6.08 a

Each value in the table is an average obtained from analysis of six samples.
Organic matter was calculated as dry weight minus ash content.
pH was determined using a glass electrode in a soil: distilled water slurry
(1:5 W:V). Statistical comparisons were carried out between MSS and CM
using Duncan's multiple range test (SAS Institute 2003). [16]

Table 2. Bioaccumulation factor (BAF) of seven heavy metals by cabbage and broccoli grown in sewage sludge (SS) mixed soil, chicken manure (CM) mixed soil, and native soil. Statistical comparisons were carried out between SS, CM, and no-mulch treatments for each metal using Duncan's multiple range test (SAS Institute 2003). [16]

Metal	Overall Bioaccumulation Factor		
	Cabbage Leaves	Broccoli Heads	
Cr	0.06 a	0.03 a	
Ni	0.30 a	0.77 a	
Cu	0.81 a	0.99 a	
Zn	1.14 b	2.55 a	
Mo	4.39 b	7.14 a	
Cd	0.63 a	0.47 a	
Pb	0.03 a	0.03 a	
	Cabbage Bioaccumulation Factor		
Metal	Sewage Sludge	Chicken Manure	No Mulch
Cr	0.35 a	0.26 a	0.13 a
Ni	0.19 b	1.68 a	0.62 b
Cu	0.82 b	1.14 a	1.12 a
Zn	49.03 a	48.54 a	34.40 a
Mo	0.27 b	2.07 a	0.41 b
Cd	0.02 a	0.05 a	0.05 a
Pb	0.02 a	0.04 a	0.03 a
	Broccoli Bioaccumulation Factor		
Metal	Sewage Sludge	Chicken Manure	No Mulch
Cr	0.39 b	0.15 b	3.04 a
Ni	0.43 b	1.60 a	1.28 ab
Cu	2.24 b	2.61 ab	3.15 a
Zn	87.62 a	66.93 b	66.40 b
Mo	0.36 a	0.33 a	0.50 a
Cd	0.02 a	0.02 a	0.03 a
Pb	0.03 a	0.02 a	0.02 a

BAF is the ratio of the metal content in plant and total metal content in the soil. Each value in the table is an average obtained from analysis of six samples.

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A Simplified Biofilter for Remediation of Herbicides in Runoff and Seepage Water

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Introduction

Pesticides are used on most major crops in the United States and worldwide. The world market for pesticides is estimated at $33.59 billion, of which the United States represents the largest part in terms of dollars (33 percent) and pounds (22 percent) of active ingredients. [1] According to the USEPA, over 441 million kg of conventional pesticides were used in the U.S. [2] Of that total, 77 percent were used in agricultural applications and 11 percent were used for home and garden purposes. Approximately 1,200 water body impairments across the United States are attributed to pesticides. [3] In its most simple form, bioremediation of pesticides uses naturally occurring bacteria and fungi or plants. [4]

Soil microorganisms constitute a large dynamic source and sink of nutrients in all ecosystems and play a major role in N, C, and P cycling. [5]

Protecting the integrity of soil and water resources is one of the most essential environmental issues of the 21st century. Agricultural activities frequently are conducted in close proximity to lakes, reservoirs, and streams. Contaminated runoff from farmland contributes a significant proportion of the pesticide load released to surface waters. There is a concern over the risks of contamination of food and drinking water by residues of synthetic agrochemicals and the negative impact of agrochemicals on the countryside. A central hope in these concerns is the safe use of agrochemicals, development of new soil management practices, and use of mitigation techniques. Mitigation techniques must be simple, inexpensive, energy conserving, safe, and effective for pesticide removal, nutrient recycling, and erosion control.

Biobeds (a cavity filled with composted materials) have been used in northern Europe for minimizing point-source contamination of water resources by pesticides. [6] Biobeds were tested for their ability to retain and degrade chlorpyrifos (an insecticide), metalaxyl (a fungicide), and imazamox (an herbicide) using farm available materials (vine-branch, citrus peel, urban waste, and green compost). The filling materials (a mixture of modified straw, peat moss, and native soil) of biobeds have increased sorption capacity and microbial activity for degradation of pesticides. [7] Degradation of the pesticides in biobeds was found to be faster than published values for degradation in soil. The half-life of pesticides tested was less than 14 days, compared to literature values of 60-70 days in soil. [7] Biobeds also reduced the concentration of sediment, so they might reduce the concentration of pesticides that are strongly sorbed to sediment. Little is known regarding biobed use in the United States. To the best of the author's knowledge, the present investigation is the first application of biobed systems for reducing runoff water loss and mitigation of off-site mobility of pesticides in runoff (non-point source contamination) in Kentucky agriculture, where most of the arable lands are highly erodible. The main objective of the present investigation was to assess the performance of biobed systems in treating residues of two herbicides—dimethazone and trifluralin—in runoff and seepage water arising from agricultural production under three soil management practices (municipal sewage sludge, sewage sludge mixed with yard waste and no-mulch native soil).

Materials and Methods

The field trial area was established on a Lowell silty loam soil (pH 6.7, 2 percent organic matter) of 10 percent slope located at the Kentucky State University (KSU) Research Farm in Franklin County, Ky. Eighteen field plots of 3.7 m wide and 22 m long each were installed with stanless steel borders along each side to prevent cross contamination among treatments. A gutter was installed across the lower end of each plot with 5 percent slope to direct runoff to the tipping buckets and collection bottles for runoff water measurement and sampling. Each of the 18 tipping-buckets was calibrated and was maintained to provide precise measure of amount of runoff per tip. Number of tips was counted using meachanical runoff counters (ENM Company, Chicago, Ill.). At the bottom of each plot, a pan lysimeter (n=18) of 1.6 m deep was installed for collecting infiltration water following natural rainfall events.

A composted mixture was prepared by mixing 50 percent chopped wheat straw (Anderson County Farm Services, Lawrenceburg, Ky.), 25 percent peat moss (Lowes) and 25 percent top soil (12 percent clay, 75 percent silt, 13 percent sand) obtained from the native soil at KSU Research Farm. The mixture was composted outside in open air, for 2 months prior to use. The mixture in the heap was covered with plastic sheets (Lowe's) and turned twice during this period. The microbial biomass of the mixture in the heap was monitored using the methods described by Antonious [5] to give an indication of microbial proliferation and activity in the composted materials. At the lower end of each of nine experimental plots, biobeds were installed while the other nine plots—having no biobed systems—were used for comparison purposes. Each biobed system was a cavity (3.7 by 3 by 1.5 m3) in the ground down the field slope filled with a 10-centimeter layer of limestone gravel at the bottom, then filled with the composted mixture as described above. Each biobed was covered with a tall fescue (*Festuca* sp., Kentucky 31) grass layer to help maintain a suitable level of temperature for microbial activity.

In addition to biofilters, three soil management practices were used in field plots: municipal sewage sludge (obtained from Metropolitan Sewer District, Louisville, Ky.) was mixed with yard waste compost (obtained from Con Robinson Company, Lexington, Ky.) and incorporated into native soil at 15 t acre-1 (on dry weight basis) with a plowing depth of 15 centimeters; municipal sewage sludge was mixed with native soil at 15 t acre-1 (on dry weight basis) with a plowing depth of 15 centimeters; and a no-mulch (NM) control treatment (roto-tilled bare soil) was used for comparison purposes. The soil in the experimental area was sprayed with a mixture of two pre-emergent herbicides, dimethazone and trifluralin formulations. One hundred-twenty five milliliters of Command 3ME formulation obtained from Platte Cemical Company and 300 milliliters of Treflan formulation were used at the recommended rates of application in Kentucky. [9] The two herbicides were mixed in a total volume of 15 gallons of water and sprayed uniformally on the field plots on July 14, 2009, using a portable backpack sprayer equipped with one conical nozzle operated at 40 psi (275 kPa). Seedlings of muskmelon (*Cucumis melo* cv. Athena) and bell pepper (*Capsicum annuum* cv. Artistotle) were grown in the greenhouse for five and eight weeks, respectively, prior to transplant. Seedlings were transplanted in the field plots. Peppers and melons were planted with 25 and 60 centimeters of in-row spacing, respectively. Rows were spaced 1.1 m apart. Plants were watered by a uniform drip-irrigation system and grown using standard production practices for Kentucky growers. [9] Runoff water under three natural rainfall events (July 17, July 27, and October 7, 2009) was collected and quantified at the lower end of each plot throughout the growing season using tipping-bucket runoff metering apparatus established by the Department of Agricultural Engineering, University of Kentucky, Lexington, Ky.

Eighteen pan lysimeters were used to monitor the presence or absence of pesticide residues in the vadose zone (the unsaturated water layer below the plant root). Water percolated through the vadose zone from each of the 18 plots was collected. The pan lysimeters (4 square feet each) were tunnel installed, leaving the soil column above it intact. This system allowed collection of infiltration water under normal field conditions (zero tension). Fifty grams of representative soil samples were taken prior to and after herbicides application during the course of the study. Soil samples were dried, sieved to a size of 2 millimeters, and extracted by shaking using 100 milliliters of acetonitrile: hexane: methanol mixture (45:45:10 v/v). The extracts were dried over anhydrous Na2SO4 and concentrated by rotary vacuum (Buchi Rotavapor, Switzerland) and N2 stream evaporation.

Trifluralin and dimethazone were extracted from 250 milliliters of representative runoff water and 500 milliliters of infiltration water samples with 150 milliliters of a mixture of methylene chloride [CH2Cl2] + acetone (6:1, v/v) and sodium chloride solution (40 g litre-1; 50 mL) by liquid-liquid partition for 1 minute. The solvent was filtered through a Buchner funnel containing Whatman 934-AH, of 55-millimeter-diameter glass microfiber filter, passed through anhydrous sodium sulfate (Na2SO4), and concentrated by rotary vacuum evaporator to a known volume. Concentrated extracts were injected into a gas chromatograph (GC) equipped with flame ionization detector (FID). Residues of dimethazone and trifluralin in soil and water samples were related to soil management technique, and statistically analyzed using ANOVA procedure (SAS Institute 2003) and Duncan's multiple-range test for mean comparisons. [10]

Results and Discussion

The increased organic matter content of soil due to the addition of soil amendments increased the concentration of dimethazone and trifluralin retained in soil (data not shown). Dimethazone residues extracted from sewage sludge (SS) and SS mixed with yard waste compost (SS+YW) increased by 14 percent and 50 percent, respectively compared to NM soil. Similarly, trifluralin residues increased by 17 percent and 75 percent in SS and SS+YW, respectively, comapred to NM native soil. This could be explained by the adsorption properties of dimethazone on soil particles [11] that varied with increasing percentages of organic matter following the addition of amendments as well as the partial degradation of dimethazone by soil microbes. [12, 13] Adsorption or binding might inhibit the mobility of xenobiotics via leaching and runoff, thus preventing the contamination of aquatic environments. This is particulary important because of the extensive use of herbicides such as trifluralin and its relatively high toxicity to fish. Some pesticides are highly soluble in water, but because of their ionic properties they bind tightly to the soil particles and pose minimal risk for groundwater contamination.

The present investigation is the first use of biobeds for retarding runoff water arising from agricultural fields. Under field conditions and depending on the rainfall events, biobeds reduced runoff water volume in no-mulch treatments by 44 percent to 88 percent compared to treatment with no biobeds (data not shown). Sewage sludge (SS) and SS+YW treatments reduced runoff water by 60 percent and 79 percent, respectively in plots with biofilters compared to plots with no biofilters (data not shown). Biobeds also were successful in reducing the concentrations of the two herbicides dimethazone and trifluralin in runoff water. Dimethazone residues in runoff water collected down the field slope from plots with biobeds were much lower than those in runoff from plots with no biobeds (Figure 1). Similarly, trifluralin residues in ruoff water from plots with biobeds were lower than trifluralin residues in runoff from plots with no biobeds (Figure 2). These findings indicated that biobeds are effective low-cost alternatives for treating dimethazone and trifluralin residues in runoff water, providing a matrix to facilitate

Figure 1. Dimethazone residues in runoff water collected down the land slope under three soil management practices. Each plot is 3.7 m wide by 22 m long (0.02 acre). Statistical comparisons were done between plots with biofilters and plots with no biofilter among three soil treatments. Bars accompanied by different letter are significantly different (P< 0.05) using Duncan's multiple range test (SAS Institute 2003). [10]

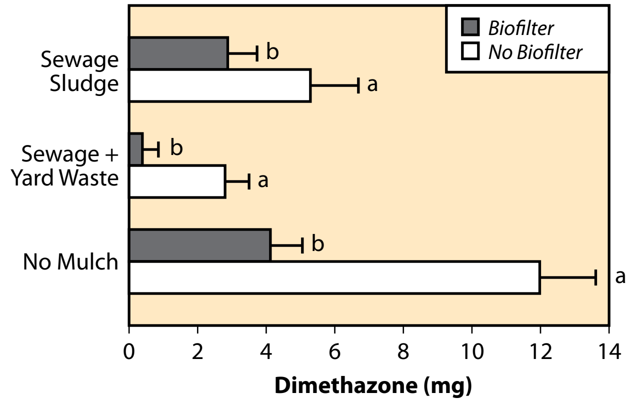


Figure 2. Trifluralin residues in runoff water collected down the land slope under three soil management practices. Each plot is 3.7 m by 22 m long (0.02 acre). Statistical comparisons were done between plots with biofilters and plots with no biofilter among three soil-management practices. Bars accompanied by different letter are significantly different (P< 0.05) using Duncan's multiple range test (SAS Institute 2003). [10]

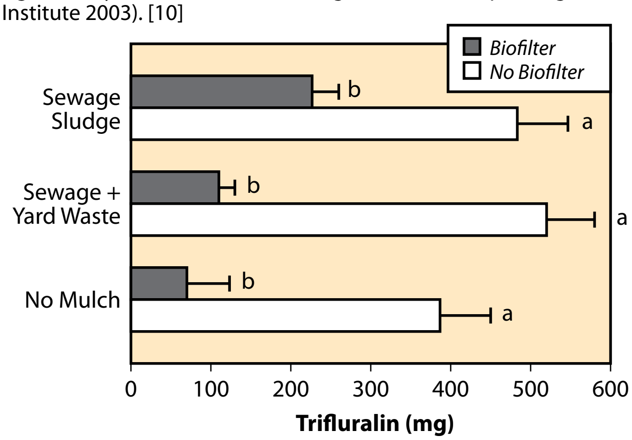
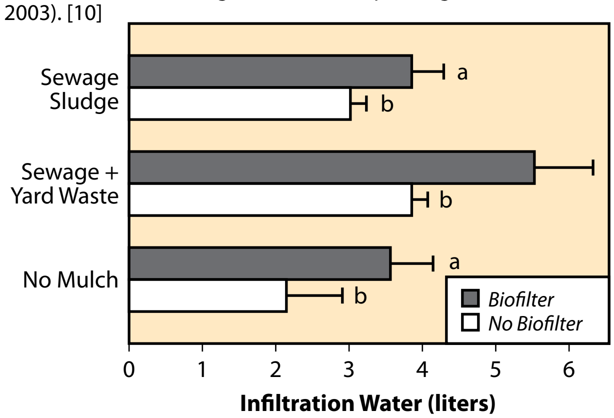


Figure 3. Infiltration water volume collected under three soil-management practices. Statistical comparisons were done between plots with biofilters and plots with no biofilter among three soil treatments. Bars accompanied by different letter are significantly different (P< 0.05) using Duncan's multiple range test (SAS Institute 2003). [10]



adsorption and/or biodegradation. Plots amended with SS+YW mix increased volume of water percolated into the vadose zone by 55 percent compared to no-mulch treatments. Plots with biofilters also increased the volume of water percolated into the vadose zone (Figure 3). This increase was greatest (44 percent) in SS+YW treatments. This increase could be attributed to the reduced bulk density and increased soil particle interspaces after addition of yard waste compost.

Water solubility, vapor pressure, and KOC value of a pesticide have a great impact on its mobility and distribution in the environment. Dimethazone residues in infiltration water were reduced from 0.5 to 0.31 milligram plot-1 (38 percent reduction), while trifluralin residues were reduced from 17.7 to 7.3 milligram plot-1 (60 percent reduction). This is attributed to the presence of biofilters as well as the physical and chemical characteristics of each of the two herbicides that vary from the high water solubility and low KOC values of dimethazone to the low water solubility and high KOC values of trifluralin.

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Fruit and Vegetable Disease Observations from the Plant Disease Diagnostic Laboratory—2011

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

Introduction

Diagnosing plant diseases and providing recommendations for their control are the result of University of Kentucky College of Agriculture research (Agricultural Experiment Station) and Cooperative Extension Service activities through the Department of Plant Pathology. We maintain two branches of the Plant Disease Diagnostic Laboratory (PDDL), one on the UK campus in Lexington, and one at the UK Research and Education Center in Princeton. Two full-time diagnosticians and a full-time diagnostic assistant are employed in the PDDL, and two of the four Extension faculty plant pathologists provide diagnostic and disease-management expertise in fruit and vegetable crops. Dr. Kenny Seebold continues his work on diseases of vegetable crops. In June, Dr. John Hartman retired from the UK Department of Plant Pathology after 40 years of service, during which his expertise in fruit diseases benefited commercial and home fruit growers throughout the Commonwealth. Dr. Nicole Ward joined the department in August as an Extension Plant Pathologist focusing on diseases of fruit and ornamental crops.

Of the more than 3,250 plant specimens examined to date in 2011, approximately 30 percent were fruits and vegetables and nearly half of those were from commercial growers (Bachi et al., 2011). 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 the past year, we have relied on funds from the National Plant Diagnostic Network to help defray some of the laboratory operating costs. However, a 25-percent cut in these funds is a challenge for the current fiscal year. In addition to receiving physical diagnostic samples, we also provide a Web-based digital consulting system where Extension agents can submit images for consultation on plant disease problems. In 2011, 31 percent 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 in 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.

Weather during the 2011 growing season in Kentucky was variable, favoring certain diseases and reducing the incidence of others. Early season rains and fairly cool temperatures were favorable for the development of a number of foliar diseases of both fruits and vegetables, and wet soil conditions made it difficult to plant new fruit and vegetable crops. February 2011 was the first month to have above normal precipitation since November 2010, and by the first half of March, abundant rainfall effectively ended all drought conditions across the Commonwealth. April was the wettest April ever recorded, and above average precipitation was recorded in May and June as well. Wet weather into later spring was favorable for vegetable diseases. Temperatures were above average from July through early September, with July 2011 being tied for the 5th warmest July on record. Overall during this period, soils became dry in much of the state, but pockets of abundant rainfall occurred.

Results and Discussion

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

Anthracnose crown rot (*Colletotrichum fragariae*) was diagnosed on strawberry in multiple locations during the fall planting season. Large losses soon after planting were reported on the Camarosa variety with more limited disease incidence on Chandler. Many plants were removed immediately, but because the pathogen can overwinter in infected plants and debris, growers must be prepared to manage all phases of anthracnose next spring.

Bacterial fruit blotch (*Acidovorax avenae* subsp. *citrulli*) was diagnosed in watermelon as an isolated occurrence (one farm affected).

Pythium blight (*Pythium* spp.) of aerial plant parts was enhanced by frequent rains throughout the early part of the summer. Stem blights of bean and potato as well as cottony leak fruit rot on watermelon were observed.

Cercospora leaf spots (*Cercospora* sp.), favored by high humidity, were seen on many specialty vegetable crops produced for the fresh market in Kentucky, including asparagus, celery, horseradish, lettuce, and potato.

Tree Fruit Diseases

Pome fruits. While levels of apple scab (*Venturia inaequalis*) and cedar-apple rust (*Gymnosporangium juniperi-virginianae*) were low to moderate, frogeye leaf spot (*Botryosphaeria obtusa*) was observed at higher levels in apple and was seen slightly earlier in the season than usual, beginning in early May. Fire blight (*Erwinia amylovora*) also occurred at low levels on both apple and pear. Fruit rots—including white rot (*Botryosphaeria dothidea*) and bitter rot (*Glomerella cingulata*)—occurred late in the season. The physiological condition bitter pit was seen on apple as well. A single but severe case of thread blight (*Corticium stevensii*) was diagnosed on apple, indicating a humid, shaded orchard setting.

Stone fruits. Leaf spot diseases of cherry caused by the fungus *Coccomyces hiemalis* and the bacterium *Xanthomonas campestris* pv. *pruni* were seen frequently, with occasional bacterial spot also occurring on other *Prunus* species, including peach and plum. Brown rot (*Monilinia fructicola*) was diagnosed on cherry, nectarine, peach and plum. Spring rains favored the development of peach leaf curl (*Taphrina deformans*) in some areas, but this disease was not as widespread as in the previous several years.

Small Fruit Diseases

Grapes. Anthracnose (*Elsinoe ampelina*) was more common than usual for the second year in a row, 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 from 2010, Isariopsis leaf blight (*Pseudocercospora vitis* [syn. *Isariopsis clavispora*]), was seen again this year in multiple locations.

Brambles. Cane blight (*Leptosphaeria coniothyrium*), double blossom disease (*Cercosporella rubi*), and root and collar rot (*Phytophthora* spp.) were diagnosed on brambles (blackberry and/or raspberry) samples. High temperatures promoted the physiological disorder known as "white drupelet" in which scattered drupelets within an aggregate expand to a normal size but fail to ripen.

Blueberries. Root and collar rot caused by *Phytophthora* spp. and stem dieback from species of the *Botryosphaeria* fungus were diagnosed occasionally on blueberry.

Strawberries. The most significant problem on strawberry was the crown rot phase of anthracnose (*Colletotrichum fragariae*), as noted above. Leather rot (*Phytophthora cactorum*) and leaf blight (*Phomopsis obscurans*) also were diagnosed.

Vegetable diseases

Beans. Foliar diseases including angular leaf spot (*Phaeoisariopsis griseola*) and common bacterial blight (*Xanthomonas campestris* pv. *phaseoli*) were common due to early wet weather and high humidity throughout the summer. 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. Bottom rot (*Rhizoctonia solani*) and stem rot (*Sclerotinia sclerotiorum*) were diagnosed in cabbage, and black rot (*Xanothomonas campestris* pv. *campestris*) was diagnosed in kale from several home-garden plantings.

Cucurbits. High humidity promoted foliar and vine diseases in cucurbits, in particular anthracnose (*Colletotrichum orbiculare*), Alternaria leaf blight (*Alternaria cucumerina*) and gummy stem blight (*Didymella bryoniae*). Downy mildew (*Pseudoperonospora cubensis*) developed only very late in the season in scattered areas. A single case of yellow vine decline was confirmed on zucchini via PCR assay. In addition to the bacterial fruit blotch (see above), fruit rots caused by oomycetes also were observed on watermelon, including Pythium cottony leak (*Pythium* sp.) and Phytophthora rot (*Phytophthora capsici*).

Peppers. Occasional cases of southern blight (*Sclerotium rolfsii*) and bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) were diagnosed on pepper.

Potatoes. Pythium rot (*Pythium* sp.) was seen on aboveground stems of potato (see above), while pink rot (*Phytophthora nicotianae*) and southern blight (*Sclerotium rolfsii*) were observed on tubers. Hot weather conditions favor both of the latter tuber diseases. Cases of common scab (*Streptomyces* sp.) and Fusarium dry rot (*Fusarium* sp.) also were seen.

Tomatoes. Foliar diseases such as early blight (*Alternaria solani*) and Septoria leaf spot (*Septoria lycopersici*) were common, while leaf mold (*Fulvia fulva*) and target spot (*Corynespora cassiicola*) were observed in a few cases where humidity was extremely high. Timber rot (*Sclerotinia sclerotiorum*) was fairly common in the early part of the season; also common were stem/vascular problems such as southern blight (*Sclerotium rolfsii*), bacterial canker (*Clavibacter michiganensis* subsp. *michiganensis*), and Fusarium wilt (*Fusarium oxysporum*). Physiological disorders included many cases of yellow shoulders and a diagnosis of fruit pox and gold fleck from the same farm; all are related to environmental conditions during fruit development and maturation.

Other vegetables. Cercospora leaf spots were seen in a number of vegetable crops (see above). Other vegetable diseases included Pythium root rot (*Pythium* sp.) on onion and an unusual find of white rot (*Sclerotium cepivorum*) on garlic.

Because fruits and vegetables are high-value crops, and many of them are new or expanding crops in Kentucky, the Plant Disease Diagnostic Laboratory is 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

Bachi, P., J. Beale, J. Hartman, D. Hershman, S. Long, K. Seebold, P. Vincelli and N. Ward. 2012. *Plant Diseases in Kentucky—Plant Disease Diagnostic Laboratory Summary, 2011.* UK Department of Plant Pathology (in press).

Appendix A: Sources of Vegetable Seeds

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

AAS .... All America Selection Trials, 1311 Butterfield Road, Suite 310, Downers Grove, IL 60515
AS/ASG .... Formerly Asgrow Seed Co., now Seminis (see "S" below)
AC.................. Abbott and Cobb Inc., Box 307, Feasterville, PA 19047
AG.................. Agway Inc., P.O. Box 1333, Syracuse, NY 13201
AM................. American Sunmelon, P.O. Box 153, Hinton, OK 73047
AR.................. Aristogenes Inc., 23723 Fargo Road, Parma, ID 83660
AT.................. American Takii Inc., 301 Natividad Road, Salinas, CA 93906
B..................... BHN Seed, Division of Gargiulo Inc., 16750 Bonita Beach Rd., Bonita Springs, FL 34135
BBS................ Baer's Best Seed, 154 Green St., Reading, MA 01867
BC.................. Baker Creek Heirloom Seeds, 2278 Baker Creek Rd., Mansfield, OH 65704
BK.................. Bakker Brothers of Idaho Inc., P.O. Box 1964, Twin Falls, ID 83303
BR.................. Bruinsma Seeds B.V., P.O. Box 1463, High River, Alberta, Canada, TOL 1B0
BS.................. Bodger Seed Ltd., 1800 North Tyler Ave., South El Monte, CA 91733
BU.................. W. Atlee Burpee & Co., P.O. Box 6929, Philadelphia, PA 19132
BZ.................. Bejo Zaden B.V., 1722 ZG Noordscharwoude, P.O. Box 9, The Netherlands
CA.................. Castle Inc., 190 Mast St., Morgan Hill, CA 95037
CF.................. Cliftons Seed Co., 2586 NC 43 West, Faison, NC 28341
CG.................. .Cooks Garden Seed, 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.O. Box 520, Waterville, ME, 04903
FM................. Ferry-Morse Seed Co., P.O. Box 4938, Modesto, CA 95352
G.................... German Seeds Inc., Box 398, Smithport, PA 16749-9990
GB.................. Green Barn Seed, 18855 Park Ave., Deephaven, MN 55391
GL.................. Gloeckner, 15 East 26th St., New York, NY 10010
GO................. Goldsmith Seeds Inc., 2280 Hecker Pass Highway, P.O. Box 1349, Gilroy, CA 95020
GU................. Gurney's Seed and Nursery Co., P.O. Box 4178, Greendale, IN 47025-4178
HL/HOL......... Hollar & Co. Inc., P.O. Box 106, Rocky Ford, CO 81067
H/HM............ Harris Moran Seed Co., 3670 Buffalo Rd., Rochester, NY 14624, Ph: (716) 442-0424
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.Box 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., P.O. Box 13220, Oakland, CA 94661-3220
LI.................... Liberty Seed, P.O. Box 806, New Philadelphia, OH 44663
LSL................. LSL Plant Science, 1200 North El Dorado Place, Suite D-440, Tucson, AZ 85715
MB................. Malmborg's Inc., 5120 N. Lilac Dr., Brooklyn Center, MN 55429
MK................. Mikado Seed Growers Co. Ltd., 1208 Hoshikuki, Chiba City 280, Japan 0472 65-4847
ML................. J. Mollema & Sons Inc., 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., P.O. Box 1406, Twin Falls, ID 83301-1406
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., P.O. Box 236, Mount 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, P.O. Box 4908, Rancho Dominguez, CA 90224
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