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UNIVERSITY OF KENTUCKY COLLEGE OF AGRICULTURE, FOOD AND ENVIRONMENT, LEXINGTON, KY, 40546

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Fruit and Vegetable

2013 RESEARCH REPORT

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2013 Fruit and Vegetable Crops Research Report

Edited by Shubin K. Saha, John Snyder and Chris Smigell

CONTRIBUTORS

Horticulture

Chair
Robert L. Houtz

Faculty
Doug Archbold
Shubin K. Saha
John Snyder
John Strang
Patsy Wilson

Area Extension Associates
Ty Cato, Shelbyville, Louisville metro area (vegetables)
Chris Smigell, Lexington, central Kentucky (small fruits)
Dave Spalding, Lexington, central Kentucky (vegetables)

Horticulture Farm Manager
Mark Williams (Interim)

Horticulture Organic Farming Research and Education Unit and CSA Manager
Tiffany Thompson

Horticulture Professional Staff assisting with projects included in this report
Dave Lowry
Sean Lynch
Joseph Tucker
Jeff Wheeler
Neal Wilson
Dwight Wolfe
Lucas Hanks

Entomology

Faculty
Ric Bessin

Graduate Students
Amanda Skidmore
Rachelyn Dobson

Plant Pathology

Faculty
Kenny Seebold
Nicole Ward

Professional Staff
Julie Beale
Brenda Kennedy
Sara Long

Nutrition and Food Science

Faculty
Pam Sigler

Food Systems Innovation Center

Angela Anandappa

Extension Agents

Agriculture and Natural Resources and Horticulture (county research sites)
Caldwell Co., Shane Bogle
Campbell Co., DJ Scully, David Koester,
Clark Co., David Davis
Fayette Co., Nick Carter, Jamie Dockery
Franklin Co., Keenan Bishop, Lora Bailey
Gallatin Co., David Hull
Garrard Co., Jay Hettmansperger
Jefferson Co., Wayne Long, Sarah Stolz
Madison Co., Brandon Sears, Amanda Sears
Oldham Co., Tracy M. Missun
Shelby Co., Corinne Kephart
Spencer Co., Bryce Roberts

Kentucky State University

College of Agriculture Food Science and Sustainable Systems
Dean
Dr. Teferi Tsegaye

Faculty
George F. Antonious
John D. Sedlacek
Maifan Silitonga
Kirk Pomper

Professional Staff
Jon Cambron
Karen Friley
Sherry Crabtree
Irina Howard
Jeremiah Lowe
Joni Nelson
Anthony Silvernail

Berea College

Agriculture and Natural Resources Program
Faculty
Sean Clark

Assistant Farm Manager
Janet Meyer

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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 experi-mental pesticide must first be labeled for the crop in question before it can be used by growers, regardless of how it might have been used in research trials. The most recent product label is the final authority concerning application rates, precautions, harvest intervals, and other relevant information. Contact your county's Cooperative Extension office if you need assistance in interpreting pesticide labels.

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

Cover: Trellised seedless cucumbers grown in a high tunnel.

Several of the research reports presented in this document were partially funded by the Kentucky Agricultural Development Board through a grant to the Kentucky Horticulture Council.

Contents

The 2013 Fruit and Vegetable Crops Research Program

Shubin K. Saha, Department of Horticulture

Fruit and vegetable production in Kentucky continues to grow. The 2013 Fruit and Vegetable crops research report includes results for more than 15 field research plots and multiple demonstration trials. This year fruit and vegetable research and demonstration trials were conducted in more than 12 counties in Kentucky (see map, right). 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 Berea College.

Variety trials included in this year's publication include: cabbage, asparagus, bell peppers, blueberries, blackberries, raspberries, apples, peaches, and grapes. Additional research trials include organic management of cucumber beetles, financial comparison of organic potato integrated pest management systems, and effect of organic fertilizer materials for production of kale. Variety trials provide us with much of the information necessary to update our recommendations in our Vegetable Production Guide for Commercial Growers (ID-36). However, when making decisions about what varieties to include in ID-36, we factor in performance of varieties at multiple locations in Kentucky over multiple years. We may also collaborate with researchers in surrounding states to discuss results of variety trials they have conducted. Only then after much research and analysis will we make variety recommendations for Kentucky. The results presented in this publication often reflect a single year of data at a limited number of locations. Although some varieties perform well across Kentucky year after year, others may not. Here are some helpful guidelines for interpreting the results of fruit and vegetable variety trials:

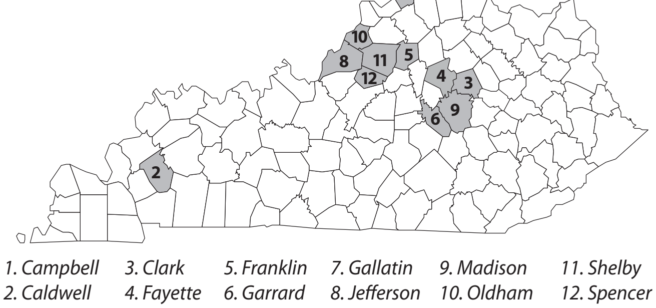
Our Yields vs. Your Yields

Yields reported in variety trial results are extrapolated from small plots. Depending on the crop, individual plots range from 8 to 200 plants. Our yields are calculated by multiplying the yields in these small plots by correction factors to estimate per-acre yield. For example, if you can plant 4,200 tomato plants per acre (assuming 18" within row spacing) and our trials only have 10 plants per plot, we must multiply our average plot yields by a factor of 420 to calculate per acre yields. Thus, small errors can be greatly amplified. Furthermore, because we do not include factors such as drive rows in our calculations, our per-acre yields are typically much higher than what is found on an average farm. Due to the availability of labor, research plots may be harvested more often than would be economically possible. Keep this in mind when reviewing the research papers in this publication.

Statistics

Often yield or quality data will be presented in tables followed by a series of letters (a, ab, bc, etc.). These letters indicate if the yields of the varieties are statistically different.

Fruit and vegetable research sites in 2013.



Two varieties may have average yields that appear to be quite different. For example if tomato variety 1 has an average yield of 2000 boxes per acre and variety 2 yields 2300 boxes per acre one would as-sume that variety 2 had a greater yield. However, just because the two varieties had different average yields, does not mean that they are *statistically or significantly* different. In the tomato example, variety 1 may have consisted of four plots with yields of 1800, 1900, 2200, and 2100 boxes per acre. The average yield would then be 2000 boxes per acre. Tomato variety 2 may have had four plots with yields of 1700, 2500, 2800, and 2200 boxes per acre. The four plots together would average 2300 boxes per acre. The tomato varieties have plots with yield averages that overlap, and therefore would not be considered statistically dif-ferent, even though the average per acre yields for the two varieties appear to be quite different. This example also demonstrates variability. Good varieties are those that not only yield well, but have little variation. Tomato variety 2 may have had similar yields as variety 1, but also had much greater variation. Therefore, all other things being equal, tomato variety 1 may be a better choice, due to less variation in the field.

Statistical significance is shown in tables by the letters that follow a given number. For example, when two varieties have yields followed by completely different letters 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 we have a 5% chance that our results are real and not simply due to chance or error. Put another way, if two varieties are said to be different at $P<0.05$, then at least 95% of the time those varieties will be different. If the *P* value is 0.01, then 99% of the time those varieties will be different. Different *P* values can be used, but typically $P < 0.05$ is considered standard practice.

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

On-Farm Commercial Vegetable Demonstrations

Ty Cato, Department of Horticulture

Introduction

Five on-farm commercial vegetable production demonstrations were conducted in the north central part of the state, in Oldham, Jefferson, and Spencer Counties. These locations were chosen due to the recent surge in commercial vegetable production to supply the Louisville area demand for locally grown food. Three growers in Jefferson County, one grower in Spencer County, and one grower in Oldham County were chosen for this demonstration. The Oldham County grower produced mixed vegetables on 0.62 acres for local farmers markets and a CSA (Community Supported Agriculture.) The growers in Jefferson County grew 1.53 acres, 1.54 acres, and 0.87 acres of mixed vegetables, respectively. The first grower operated a CSA and sold to farmers markets. The second grower provided his Louisville-based restaurant with produce from the plot. The third grower sold at an on-farm store and farmer's markets, as well as producing value added products for sale, such as salsas and sauces. The Spencer County grower grew 0.43 acres of mixed vegetables and sold at a farmers market.

Materials and Methods

The growers were provided with plastic mulch and drip tape for up to one acre of production. The University of Kentucky Horticulture Department also provided a bed-shaper/plastic layer, a water-wheel transplanter, and a plastic mulch lifter to remove the mulch at the end of the growing season. All other inputs including fertilizer, pesticides, irrigation pumps, and labor (both manual and mechanical) were provided by the grower. The grower recorded basic information such as yield data, input costs, etc. An extension associate from the Department of Horticulture made weekly visits to provide assistance with disease management, harvesting practices, and any other production issue needing attention. The extension associate was also involved in setting up demonstration field days to display commercial vegetable production techniques to other growers interested in producing vegetables.

Conventional, certified organic, and all natural growing practices were used in the demonstration plots. Three plots were conventional, relying on synthetic fertilizer, herbicides, insecticides, and fungicides. One plot was certified organic and the last plot was maintained using organic practices, without organic certification. The five demonstrations used 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 that they need early in the growing season, whereas the white on black plastic reflects the heat of the sun away from the bed, reducing heat stress on transplants set in the heat of the summer.

Results and Discussion

The 2013 growing season presented some problems for commercial producers in north central Kentucky. The first problem was very cool spring temperatures that delayed the transplanting date of early spring crops. While not a huge problem, it did delay yields on certain crops by one to two weeks.

Second, a period of heavy rain, lasting approximately five to seven days in early June promoted the development of Septoria leaf blight on tomatoes. The disease did not become

Table 1: Costs and profits for mixed vegetable plots, Jefferson, Oldham, Spencer Counties, 2013

	Jefferson Conventional 1	Oldham All Natural	Spencer Conventional	Jefferson Conventional 2	Jefferson Organic
Plot Acreage	0.9	0.6	0.4	1.5	1.5
Inputs					
Plants and Seeds	$1013.00	$280.00	$112.26	$2534.42	$700.00
Fertilizer	487.00	82.76	43.75	120.00	1100.00
Plastic Mulch	189.00	86.40	69.30	204.00	180.00
Drip Lines	126.00	57.60	46.20	136.00	119.00
Fertilizer Injector and Irrigation Fittings	728.00	N/A	841.14	175.00	N/A
Herbicide	N/A	N/A	N/A	100.00	N/A
Insecticide	110.00	8.00	N/A	100.00	110.00
Fungicide	N/A	20.00	N/A	N/A	N/A
Water	900.00	154.80	Pond	200.00	900.00
Manual Labor	1450.00	2024.29	1240.00	1218.10	8000.00
Machine Labor (Fuel cost)	125.00	38.25	74.25	1488.55	1400.00
Marketing	N/A	166.50	109.75	2086.39	N/A
Total Expenses	5128.00	2918.60	2536.65	8362.46	12509.00
Yield	*	*	*	*	*
Revenue	4744.00	10140.75	483.50	14540.00	8600.00
Profit	-$384.00	$7222.15	-$2053.15	$6177.54	-$3458.00

* Yields for mixed vegetable production varybased on crops

a significant problem until another soaking rain about a week later, in which the disease spread rapidly, as the Septoria fungus spreads by splashing rain. Combined with early blight, Septoria severely damaged tomato plants, thus limiting yields. Organic growers tried to prevent the spread by removing infected foliage from the field and applying preventative fixed copper sprays. Conventional growers tried to slow disease development and dispersal of inoculum using fungicides such as azoxystrobin, within a rotational schedule including chlorothalonil.

Powdery mildew became a problem later, affecting pumpkins, summer squash, and cucumbers primarily. This disease could be managed with a myclobutanil fungicide, in a rotation of other preventative sprays. Most heavily damaged summer squash plantings were removed and replanted, because of rapid plant growth and quick fruit set.

One of the biggest problems for the cooperating growers this season was deer feeding damage. One Jefferson County grower's entire tomato crop was devastated by deer. The Spencer County grower lost all of his sweet potatoes and most of his bush beans to deer damage. This onslaught of deer was limited by installing various types of fencing around the plots. Some of the fencing was far more effective than others. Eight foot tall mesh fencing seemed more effective than various heights of stranded fishing line spaced four to five feet apart. The organic grower installed a twelve foot tall barbed wire fence around his entire farm. While this was by far the most effective, it was also cost prohibitive for most growers.

Weed pressure was only a major problem with one grower, due to a miscommunication regarding what herbicides can be applied between the beds. This issue was rectified mid-summer and the weeds were no longer at an unacceptable level for the remainder of the season.

Other issues reduced the profitability of the demonstration plots. Whether it was not having access to a market soon enough, delayed and/or greatly diminished yields due to abiotic and biotic factors, or post-harvest loss due to bacterial soft rot, all of these contributed to low profits by some of the growers (Table 1). Labor issues affected growers as well. Not having enough help for harvest caused some crops to be lost with no profit seen. Initial start-up costs for conventional growers greatly reduced profitability as well. These initial costs were for one time investments (e.g. equipment) that could be amortized over the useable life of the product, thus leading to increased profits in the years to come.

On-Farm Commercial Vegetable Demonstrations

Dave Spalding, Department of Horticulture

Introduction

Four on-farm commercial demonstrations were conducted in central and northern Kentucky in 2013. Grower/cooperators were from Campbell, Clark, Gallatin, and Garrard counties. The grower/cooperator in Campbell County grew 0.50 acre of mixed cut flowers and fall vegetables (including squash, gourds and pumpkins) for local farmers markets. The grower/cooperator in Clark County grew approximately 1.0 acre of mixed vegetables for the local farmers market. The grower/cooperator in Gallatin County grew 3.0 acre of tomatoes, 1.0 acre of cantaloupe, 1.0 acre of watermelon, 1.0 acre of pumpkins and 3.0 acres of sweet corn for the local wholesale and retail markets. The Garrard County grower/cooperator grew about 0.50 acre of mixed vegetables for a local CSA market. Two demonstration plots, one in Clark and one in Madison County were abandoned in mid-summer due primarily to a lack of available labor.

Table 1. Costs and returns of grower/cooperators, Central Kentucky, 2013.

Inputs	Campbell (0.50 acre)	Clark (1.0 acre)	Gallatin (3.0 acre)	Garrard (0.50 acre)
Plants and Seeds	$210.00	$400.00	$3,300.00	$110.00
Fertilizer	300.00	431.00	1,800.00	240.00
Black Plastic	86.00	186.00	558.00	86.00
Drip Lines	81.00	162.00	486.00	81.00
Fertilizer Injector	0	60.00*	60.00*	0
Herbicide	0	31.98	120.00	0
Insecticide	0	56.22	475.00	0
Fungicide	0	179.08	581.00	85.00
Water	105.00 (80,00 gal)	419.11 (186,000 gal)	3,200.00** (550,000 gal)	125.00 (70,000 gal)
Labor	0 (300 hrs)****	0 (327 hrs)****	18,210.00 (29,450 hrs)***	0 (240 hrs)****
Machine	230.40 (24 hrs)	128.20 (13 hrs)	4,500.00 (420 hrs)	87.12 (9.50 hrs)
Marketing	250.00	977.10	3,350.00	25.00
Total Expenses	1,262.40	3,030.69	36,640.00	839.12
Income	1,950.00	11,942.00	72,279.45	900.00
Net Income	687.60	8,911.31	35,639.45	60.88
Net Income/Acre	1,375.20	8,911.31	11,879.82	121.76
Dollar Return /Dollar Input	1.54	3.94	1.97	1.07

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

Materials and Methods

Grower/cooperators were provided with black plastic mulch and drip lines for up to 1 acre and the use of the University of Kentucky horticulture department's equipment for raised–bed preparation and transplanting. The cooperators supplied all other inputs, including labor and management of the crop. In addition to identifying and working closely with cooperators, county extension agents took soil samples 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.

The plots were planted into raised beds covered with black plastic mulch and drip tape 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 bell pepper only plot was planted into raised beds with the bell peppers planted in double rows 18 inches apart in the row. Except for the organic plots, the others 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 2013 were less than ideal for vegetable production. An abnormally wet and cool spring gave way to a wet and mostly cool summer for much of Central Kentucky. Despite the wet conditions, most crops were planted at typical times. After most crops were planted and growing, the weather stayed relatively cool and wet for most of the summer. The cool and wet conditions that persisted for most of the growing season were conducive to increased disease and fertility problems. However the biggest problem for most growers, particularly the organic growers, was weeds.

The grower/cooperator in Gallatin County used a white plastic mulch for part of his production. White plastic use in early season production did not appear to perform as well as the traditional black plastic. This is likely a result of the black plastic warming the soil for good early season establishment of transplants. However, when used in later plantings the results were better with most of the improvement coming from a higher survival rate of transplants, as a result of maintaining cooler soil temperatures. These findings were essentially the same as observed the previous year.

Fruit and Vegetable Disease Observations from the Plant Disease Diagnostic Laboratory—2013

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

Introduction

Plant disease diagnosis and formulation of disease management recommendations are the result of U.K. 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 U.K. campus in Lexington, and one at the U.K. Research and Education Center in Princeton. Two full-time diagnosticians and a full-time diagnostic assistant are employed in the PDDL; extension specialists Drs. Kenny Seebold and Nicole Ward provide diagnostic and disease management expertise in vegetable and fruit crops, respectively.

Most plant samples are submitted to the PDDL by county extension agents on behalf of their local growers and home gardeners. Fruit and vegetable samples comprised roughly one-third of the approximately 3,500 plant specimens examined in 2013. One-half of fruit and vegetable samples were from commercial growers (1).

Materials and Methods

Fruit and vegetable disease diagnosis involves a great deal of investigation into the possible causes of disease symptoms. Most visual diagnoses include microscopy to determine plant parts that are affected and to identify the pathogen(s) involved. In addition, many specimens require specific tests such as moist chamber incubation, isolation onto culture media, enzyme-linked immunosorbent assay (ELISA), polymerase chain reaction (PCR) assay, nematode extraction, or soil pH and soluble salts tests. Fruits and vegetables are high value crops for which a high proportion of diagnostic samples require specialized testing and/or consultation with U.K. faculty plant pathologists and horticulturists. Computer-based laboratory records are maintained to provide information used in conducting plant disease surveys, identifying new disease outbreaks, and formulating educational programs. All diagnoses of plant diseases are reported to a national repository.

Results and Discussion

Abundant rain throughout much of the 2013 growing season and generally cool temperatures favored development of many plant diseases, particularly those caused by fungi and oomycetes. The following summary includes the predominant diseases submitted as diagnostic samples, as well as a description of several unusual or significant diseases of fruit and vegetable crops.

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

Phytophthora root rot on blueberry (*Phytophthora cinnamomi*) has been seen more and more frequently in Kentucky in recent years and was a serious problem for blueberry producers in 2013. Wet soils favor disease development and spread, and the pathogen can survive in soil for extended periods. Extension programs to educate growers on disease prevention and management were initiated in response to this increasing problem.

Strawberry viruses were a source of concern for some growers in Kentucky and elsewhere in the eastern U.S. this spring. Plants with dual infections of strawberry mottle virus (SMoV) and strawberry mild yellow edge virus (SMYEV) were released from a Nova Scotia nursery. Symptomatic plants from this source that had been planted on a Kentucky farm were sent to the USDA-ARS Horticulture Crops Research Unit in Corvallis, OR, for testing, and presence of the two viruses was confirmed. Infected plants exhibited symptoms of stunting, slight leaf distortion and mild yellowing, particularly at leaf margins. General recommendations for management were removal of infected plants in order to reduce the risk of spread to nearby healthy plants, implementation of an insect-control program to reduce the aphid vector and weed management to minimize risk of virus carryover in weed hosts.

Tomato spotted wilt virus (TSWV) was not observed as commonly as in 2012 but was still an important disease in tomato. Incidence was typically low in a given field, but when the virus was detected in tomatoes in greenhouse/high tunnel structures, incidence tended to be quite high. A range of symptoms was observed.

Late blight (*Phytophthora infestans*) was not widespread in Kentucky but was diagnosed in tomato in four counties and did cause significant plant loss where it occurred. Kentucky isolates of *P. infestans* were submitted for strain identification as part of a regional project at Cornell University and were determined to belong to clonal lineage US-23.

Cucurbit downy mildew (*Pseudoperonospora cubensis*) developed earlier than usual this year (first confirmation in Kentucky on July 25) and resulted in severe canopy loss in some areas.

Tree Fruit Diseases

Pome fruits. Cedar-apple rust (*Gymnosporangium juniperi-virginianae*) occurred at high levels on susceptible apple varieties; frequent rains in spring favored infection. Levels of scab (*Venturia inaequalis*) and frogeye leaf spot

(*Botryosphaeria obtusa*) were moderate. Although fire blight (*Erwinia amylovora*) was seen, cooler temperatures during bloom reduced incidence of infections. Fruit rots—especially bitter rot (*Glomerella cingulata*)—were common in late summer. Thread blight (*Corticium stevensii*) was diagnosed on pear. This disease is rarely seen except in wet years and in humid/shaded locations.

Stone fruits. Brown rot (*Monilinia fructicola*) was the most commonly observed stone fruit disease and affected peach, nectarine and cherry. Limited incidence and severity of bacterial leaf spot (*Xanthomonas campestris* pv. *pruni*) and scab (*Venturia carpophila*) were recorded on peach.

Small Fruit Diseases

Grapes. Anthracnose (*Elsinoe ampelina*) and black rot (*Guignardia bidwellii*) were common. Bitter rot (*Melanconium fuligineum*) was also diagnosed several times in western Kentucky on 'Cabernet Franc' from commercial vineyards and 'Concord' from home fruit plantings. Superficial symptoms of this fruit rot are similar to those of black rot or Phomopsis fruit rot. Downy mildew (*Plasmopara viticola*) was first diagnosed in July, which is fairly typical in our area, and was a full month later than in 2012. Several cases of leaf blight (*Isariopsis clavispora*) were diagnosed as a late-season foliar disease.

Brambles. Cane and leaf rust (*Kuehneola uredinis*) was diagnosed on multiple blackberry samples, as well as a few cases of cane blight (*Leptosphaeria coniothyrium*) and spur blight (*Didymella applanata*). Raspberry ringspot virus (RpRSV) was confirmed via ELISA on both black raspberry and blackberry.

Blueberries. Root and collar rot (*Phytophthora cinnamomi*) was extremely common on blueberry. Various fungal stem canker/blight diseases were also seen (*Botyrosphaeria* sp., *Phoma* sp., *Phomopsis* sp.)

Strawberries. Leaf blight (*Phomopsis obscurans*) was seen frequently on strawberry. Strawberry mottle virus (SMoV) and strawberry mild yellow edge virus (SMYEV) were confirmed in Kentucky (see above).

Vegetable diseases

Beans and peas. Foliar/pod diseases, including angular leaf spot (*Phaeoisariopsis griseola*) and anthracnose (*Glomerella lindemuthiana*), were common due to frequent rains. Common bacterial blight (*Xanothomonas campestris* pv. *phaseoli*) on bean and bacterial blight (*Pseudomonas syringae* pv. *pisi*) on pea were both diagnosed on home garden samples.

Cole crops. Few diseases were observed on cole crops. White leaf spot (*Mycosphaerella capesllae*) was diagnosed on turnip and Chinese cabbage in autumn.

Cucurbits. Bacterial wilt (*Erwinia tracheiphila*) was a problem on cantaloupe early in the season in areas where striped cucumber beetle pressure was high. Angular leaf spot (*Pseudomonas syringae* pv. *lachrymans*) also developed on melon and squash in early summer. Downy mildew (*Pseudoperonospora cubensis*—see above) and powdery mildew (*Sphaerotheca fuliginea*) became a problem later in the season on cucumber and pumpkin. Gummy stem blight (*Didymella bryoniae*) was diagnosed frequently, particularly on watermelon. A few cases of Phytophthora blight (*Phytophthora capsici*) were diagnosed on pumpkin and winter squash.

Peppers. Bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) was common on pepper. Few other pepper diseases were observed.

Tomatoes. The foliar diseases early blight (*Alternaria solani*) and Septoria leaf spot (*Septoria lycopersici*) were common in field production and home gardens. These diseases plus leaf mold (*Fulvia fulva*) were prevalent in greenhouse/high tunnel systems. Timber rot (*Sclerotinia sclerotiorum*) and tobacco mosaic virus and tomato spotted wilt virus (see above) were also common in structures. Late blight (*Phytophthora infestans*) affected tomato plantings in certain areas (see above).

Other vegetables. Root-knot nematode (*Meloidogyne incognita*) was seen frequently on potato, and severe scurf (*Monilochaetes infuscans*) was diagnosed on sweet potato from several locations.

Fruits and vegetables are high value crops. Because many of them are new or expanding crops in Kentucky and involve production systems unfamiliar to Kentucky growers, disease diagnosis and management are even more critical. The PDDL is an important resource for extension agents and the growers they assist. The PDDL encourages county extension agents to include in their programming the importance of accurate disease diagnosis and timely sample submission. The information gained from diagnostic analyses will help improve production practices and reduce disease occurrences and epidemics.

The PDDL relies on funds from the National Plant Diagnostic Network and IPM grants to help defray some of the laboratory operating costs.

Literature Cited

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Rootstock Effects on Apple and Peach Tree Growth and Yield

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

Introduction

Although apple and peach are the principal tree fruits grown in Kentucky, the hot and humid summers and heavy clay soils make their production more difficult here than in some neighboring tree fruit producing regions. The hot, humid summers lead to high disease and insect pressure in Kentucky orchards. Despite these challenges, orchards can 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 orchards 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 on the West Coast and distributed to cooperators. Kentucky's NC-140 rootstock plantings are located at the UK Research and Education Center (UKREC) at Princeton. They are:

1. The 2009 peach rootstock trial compares fourteen rootstocks with 'Redhaven' as the scion cultivar. Eight trees of each rootstock were planted in a randomized complete block design with eight replications (blocks). Trees were planted in March 2009 on a 16 ft x 20 ft spacing.
2. The 2010 apple rootstock trial is a planting of 'Aztec Fuji' apple on thirty-one different rootstocks with four blocks per rootstock and up to three trees per rootstock per block. It was planted 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 dug up, reset, and allowed to resettle through the summer. The heights of the graft unions above the soil line now average five inches with a range of from three to seven inches.

Orchard floor management for these trials consists of 6.5 ft bare ground, herbicide-treated strips 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 both trials and trunk cross-sectional area (TCSA) is calculated from the trunk circumference measurements taken 12 inches above the graft union for apple, and six inches above for peach. Cumulative yield efficiency is the cumulative yield (total of all the annual yields) divided by the current year's trunk cross-sectional area of the tree. The TCSA 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 the final (usually the tenth) seasons of each trial. Fruit size is calculated as the average weight (oz) per fruit. All data is statistically analyzed using SAS v.9.3[3].

Results and Discussion

The 2013 growing season in Kentucky started late with below normal temperatures and above normal rainfall. Monthly temperature averages were 6ºF and 5°F above normal for December and January, respectively. Temperatures were 6°F below normal for March and 2°F below normal for July and August. Princeton had 16 days at or above 90°F compared to 54 in 2012. Monthly precipitation averages across the state for 2013 were above normal for all but February and May. June and July monthly averages were 1.6 and 1.8 inches above normal, respectively. In Princeton, temperatures dipped to 29ºF on the mornings of April 2, 3, and 5, and just below freezing on April 20 and 25. Peaches bloomed and matured about 25 days later than in 2012.

1. 2009 Peach Rootstock Trial

The first year yield data was collected from this trial was in 2011 (4). The yield in that year was poor due to weather conditions (hail damage, etc.) and the emergence of the cicada brood XIX. Most of the peaches harvested would not have been considered commercial quality even though they met the commercial size requirements for this trial. In 2012, a crop that was of commercial size and quality was harvested, in spite of the early season and season-long drought. In 2013, the third crop of peaches from this trial was harvested.

Mortality, Julian date of 90% bloom and 10% fruit maturity, cumulative yield (2011-2013), yield (2013), size, number of root suckers, trunk cross-sectional area (TCSA), and cumulative yield efficiency varied significantly among the fourteen rootstocks in this trial (Table 1). Trees on Bright's Hybrid and Viking have had the highest mortality rates, 50% and 25%, respectively. The date of 90% bloom averaged less than two days from first to last with scions on Bright's Hybrid and Krymsk 86 being the earliest and those on P. americana and Controller 5 being the latest to reach 90% bloom. Fruit maturity was the latest for scions on Lovell, and earliest by about six days for scions on Krymsk1 and P. americana. Scions on P. americana and Krymsk1 averaged the greatest number of root suckers, as

Table 1. 2013 results for the 2009 NC-140 peach rootstock planting, Princeton, KY.

Rootstock[1]	Tree Mortality (% lost)	Julian Date of 90% Bloom	Julian Date of 10% Maturity	Cumulative Yield (2011-2013) (lbs/tree)	2013 Yield (lbs/tree)	Fruit Weight (oz/fruit)	Number of Root Suckers	TCSA (sq. in)	Cumulative Yield Efficiency (2011-2013) (lbs/ sq in TCSA)
Microbac	0	99.6	192.6	113	55.7	6.7	9.6	17.9	6.39
Guardian	0	99.6	191.9	121	72.8	6.5	0.5	16.8	7.24
Krymsk 86	0	99.5	192.0	111	59.8	7.1	0.1	16.5	6.81
Viking	25	100.2	193.2	118	65.6	6.7	0.2	16.2	7.24
Bright's Hybrid	50	99.5	191.3	77	27.5	6.6	0.5	15.9	4.83
Lovell	0	99.9	196.1	131	76.1	6.9	0.3	15.7	8.37
KV010-127	0	99.9	194.5	118	68.0	6.5	1.0	14.9	7.95
Atlas	0	100.0	190.8	144	89.3	7.1	0.0	14.8	9.37
KV010-123	12.5	100.3	192.6	126	77.4	7.0	0.4	14.4	8.80
HBOK 32	12.5	100.1	194.7	103	62.0	6.5	0.0	12.6	8.23
HBOK 10	0	100.0	192.6	104	65.8	7.0	0.0	11.4	8.94
Controller 5	0	100.9	190.6	87	46.0	6.3	0.0	10.5	8.52
P. americana	12.5	100.9	190.2	71	32.8	6.1	14.0	9.2	7.66
Krymsk 1	12.5	100.3	190.1	38	13.0	6.4	12.7	5.8	6.81
Mean	8.9	100.0	192.4	105	58.1	6.7	2.8	13.7	7.66
LSD (5%)	26.5	0.8	1.66	33	26.0	NS	4.5	2.3	2.13

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

Table 2. 2013 results for the 2010 NC-140 apple rootstock trial, Princeton, KY.

Rootstock[1]	Initial Number of Trees	Tree Mortality (% lost)	Cumulative Yield (2012-2013) (lbs/tree)	2013 Yield (lbs/tree)	Fruit Weight (oz/fruit)	Number of Root Suckers	TCSA (sq. in.)	Cumulative Yield Efficiency (lbs/sq in TCSA)
PiAu 9-90	4	0	15.0	7.7	5.1	2.9	9.5	2.04
B.70-20-20	12	0	16.7	10.6	5.1	3.8	9.4	1.80
PiAu 51-11	11	0	22.9	11.0	5.4	0.6	7.2	3.18
B.70-6-8	12	0	22.4	9.0	5.4	0.0	6.8	3.21
B.7-3-150	12	0	26.4	14.7	5.1	0.2	6.6	4.07
B.67-5-32	12	0	20.0	13.2	4.7	1.3	6.5	2.87
G.202 N	8	0	37.4	20.2	6.0	1.0	6.0	6.32
B.64-194	7	0	18.0	9.0	5.1	1.0	5.4	3.29
M.26 EMLA	11	0	27.9	15.2	6.0	0.1	5.3	5.21
G.5222	8	0	39.5	19.8	5.2	3.0	5.3	7.76
G.935 N	10	0	39.6	20.5	6.0	0.3	5.1	7.81
G.4814	4	0	31.0	16.3	5.2	6.5	5.0	6.05
G.3001	3	0	24.2	11.2	5.9	0.1	4.6	4.73
G.4004	4	0	27.5	20.7	5.2	1.3	4.5	6.12
M.9 Pajam2	9	11	24.0	15.2	5.8	8.7	4.4	5.17
G.935 TC	4	0	20.9	12.1	6.0	0.9	4.3	4.93
G.11	8	13	31.7	17.4	6.7	0.4	4.2	7.57
G.202 TC	12	0	26.8	13.2	5.7	0.7	4.2	6.56
Supp.3	5	0	30.4	18.3	7.8	0.5	4.0	7.74
M.9 NAKBT337	12	17	27.1	13.0	6.1	1.6	4.0	6.56
B.10	1	0	16.9	8.4	5.8	0.0	3.6	4.85
G.4013	2	0	6.1	4.4	4.3	0.0	3.2	1.89
G.4214	2	0	13.0	8.6	5.4	0.6	3.1	4.66
G.5087	4	0	20.2	12.1	4.9	0.2	3.0	6.07
G.41 TC	12	0	12.8	12.8	6.0	0.3	2.8	4.44
G.4003	7	0	18.7	9.9	5.7	0.2	2.3	8.19
G.41 N	3	0	9.0	5.9	5.0	0.4	2.1	4.30
B.9	12	8	6.2	3.1	5.9	2.1	1.5	3.87
G.2034	2	0	10.6	7.0	6.1	0.1	1.5	5.32
B.7-20-21	12	0	1.8	1.1	4.9	0.2	1.3	1.28
B.71-7-22	10	20	0.7	0.2	5.2	0.7	0.8	0.33
Means	NA	3	20.7	11.7	5.6	1.3	4.4	4.78
LSD (0.05)	NS	NS	13.9	9.0	NS	3.3	1.7	2.77

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

they did in 2012. Microbac continues to be the most vigorous rootstock and Krymsk 1 the least vigorous in this trial. Yield per-tree was highest for scions on Atlas and lowest for scions on Krymsk 1. Cumulative yield was highest for Atlas, but was not significantly different from that of Lovell, KV010-123, Viking, Guardian, KV010-127, Microbac, or Krymsk86. Scions on Atlas also had the highest cumulative yield efficiency. Fruit size did not differ significantly among rootstocks.

2. 2010 Apple Rootstock Trial

In 2013, no significant differences were observed for mortality or average weight per fruit, but cumulative yield per tree (2012-2013), yield per tree (2013), number of root suckers, TCSA, and yield efficiency varied significantly among the 31 rootstocks (Table 2). Trees with PiAu 9-90 and B70-20-20 rootstocks are the largest, and trees with B.7-20-21 and B.71.7-22 are the smallest. This was the second year that these trees were harvested, and yield was greatest for scions on G.4004, G.935N, and G.202N and lowest for B.7-20-21 and B.71-7-22. Root sucker growth was highest for M.9 Pajam 2, followed by G.4814 and B.70-20-20. G.4003, followed by G935N, G.5222, Supp.3, and G.11 had the highest cumulative yield efficiency.

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Feasibility Study of Organic Apple Production in Kentucky

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

Introduction

Nationally, there is a growing market for organically grown apples. However, there are no research studies from the mid-South that extension specialists can refer to that have identified the challenges that organic apple growers in Kentucky might face, or that have assessed currently recommended techniques to address those challenges. Organic apple production techniques (Hinman and Ames, 2011) have never been assessed under Kentucky growing conditions. The challenges to organic apple production in Kentucky and the mid-South need to be clearly identified, so that solutions can be studied, developed, and recommended. Existing and especially newly emerging technologies may make organic apple production increasingly possible.

To determine the feasibility of, and identify the challenges to organic apple production in Kentucky, a high-density, certified organic apple orchard was established in 2007 on the University of Kentucky Horticultural Research Farm in Lexington. This orchard was managed using organically certified techniques and materials for disease and insect control since its inception. This report summarizes the performance of the maturing trees from 2011 through 2013.

Materials and Methods

Trees of the apple scab resistant cultivars 'Redfree,' 'Crimson Crisp' and 'Enterprise' on B9 rootstocks were planted in April 2007 in three rows. Each row contained four blocks of three trees of each cultivar per block with border trees at both ends of each row and a guard row of trees on both sides of the group of three research rows. Trees were set at a 6 ft by 18.5 ft spacing within and between rows, respectively. There are a total of 215 trees on about a half acre. Trickle irrigation was installed soon after planting. A grass groundcover was established between rows, and the ground beneath the rows was periodically tilled with a Weed Badger 4000-NST (Weed Badger Division, Marion, ND 58466).

Each tree was staked to a metal pole in year 1. Trees were pruned to a slender spindle until year 6 (2012). However, lower branches were often pulled downwards due to their fruit load, impeding weed tillage. Thus, in 2012 a low wire at 3 ft above the ground was attached to the poles, and the lower branches and trickle irrigation line were tied to it. In 2013, an upper wire was attached at 5.5 ft above the ground and upper branches were tied to it.

Trees were fertilized with Nature Safe fertilizer at 100 lb N/A each spring and were sprayed with organically-approved compounds which were reported and/or recommended for controlling the major apple diseases and insect pests (Table 1). Fruit were thinned by spraying a mixture of lime-sulfur plus Organocide (fish oil/sesame oil), each at 2.5% v/v, at petal fall across cultivars, followed by hand thinning.

Table 1. Organically approved compounds used for disease and insect control, 2011-2013.

Problems	
Diseases	**Compounds**
fireblight	fixed copper, streptomycin
apple scab, rusts, fruit rots, sooty blotch, flyspeck, leaf spots, powdery mildew	Microthiol sulfur, lime sulfur, fixed copper, Regalia, Kaligreen
Insects	**Compounds**
scale	dormant oil
plum curculio, codling moth, oriental fruit moth	Entrust, Surround, Carpovirusine, Neem oil, codling moth pheromone mating disruption lures
aphids, tarnished plant bugs, leafrollers, stink bug	pyrethrum
dogwood borers	nematodes (*Heterohabditis bacteriophora*)

Table 2. Yield per tree and fruit size (mean ± SE) of organically-grown apples at the Horticultural Research Farm, Lexington, Kentucky, 2011-2013.

Cultivar	Year	Yield (lbs/tree)			
		Total	Marketable (% of total)	All	Marketable
Redfree	2011	4.9 ± 1.1	3.6 ± 0.7 (73)	4.1 ± 0.1	4.3 ± 0.1
	2012	3.0 ± 0.5	2.0 ± 0.4 (67)	6.6 ± 0.3	7.0 ± 0.4
	2013	13.4 ± 1.5	9.9 ± 1.2 (74)	4.1 ± 0.1	4.2 ± 0.1
Crimson Crisp	2011	4.7 ± 0.9	1.9 ± 0.5 (40)	5.2 ± 0.2	5.7 ± 0.2
	2012	7.1 ± 1.0	3.3 ± 0.5 (46)	4.8 ± 0.2	5.4 ± 0.2
	2013	8.0 ± 0.7	4.4 ± 0.4 (55)	5.2 ± 0.1	5.4 ± 0.1
Enterprise	2011	9.1 ± 0.9	4.4 ± 0.7 (48)	6.8 ± 0.2	7.3 ± 0.2
	2012	8.1 ± 1.1	3.5 ± 0.6 (43)	9.0 ± 0.4	9.4 ± 0.4
	2013	18.4 ± 1.4	7.8 ± 0.8 (42)	7.7 ± 0.3	7.8 ± 0.2

The total and marketable yield and fruit count were recorded for each tree. Fruit were considered marketable if they had no significant disease or insect injury and were of acceptable size. A spring freeze during bloom in 2012 reduced the expected crop.

Results and Discussion

Total yield. The total yields included all fruit on the tree, whether marketable or not. The total 2013 yields were higher than those in 2011 and 2012. However, the lighter crop in 2012 due to the spring freeze likely contributed to a greater bloom intensity in 2013 and thus a higher yield than in the previous years. Enterprise had the greatest yield each year. Redfree yield increased appreciably in 2013, while that of Crimson Crisp did not.

Marketable yield. A portion of the crop was not marketable each year, due to both insect and disease damage. Redfree yielded the highest marketable percent of the total crop, around 70%. Crimson Crisp and Enterprise ranged from 40-55% and 42-48% over the three-year period, respectively. It is worth noting that Redfree was the first cultivar harvested each season, in early August, with the shortest time for exposure to diseases and insects, and had the highest marketable yield each year. The data suggest that disease resistant cultivars with earlier harvest dates like Redfree may be more appropriate for organic production. The marketable yields of Crimson Crisp and Enterprise must be appreciably increased to make organic production with them economically sustainable.

Fruit size. Fruit size was comparable within each cultivar in 2011 and 2013. However, the thinning effect of the spring freeze led to a light crop with larger fruit for Redfree and Enterprise in 2012. Generally, Enterprise was the largest, followed by Crimson Crisp, then Redfree.

It is clear that economically significant marketable organic apple yields will not be easy to achieve, but critical limiting factors have been identified. As expected, the major limitations are diseases and insects. Brown marmorated stink bug movement into the area is expected to present problems as currently there are no organically certified pesticides that effectively control this insect. Fruit thinning with lime sulfur/fish+sesame oil plus hand-thinning was successful. Weed management under the trees with periodic, shallow tillage was successful once the lower limbs were pulled up and away from the path of the equipment. However, vole damage has continued to be a problem despite cultivation to remove habitat. Fertility was sufficient. The project will continue for a few more years to determine if total and marketable yields can be increased as the trees age and with modified and/or new insect and disease control strategies.

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The 'Prime-Jan®' and 'Prime-Ark®45' Thorny Primocane-Fruiting Blackberry Trial

Kirk W. Pomper, Jeremiah D. Lowe, and Sheri B. Crabtree, College of Agriculture, Food Science, and Sustainable Systems, Kentucky State University; John R. Clark, Department of Horticulture, University of Arkansas; and John G. Strang, Department of Horticulture, University of Kentucky

Introduction

The climate of Kentucky is well-suited for blackberry production Blackberry plants are unusual among fruit crops in having perennial root systems but having biennial canes. There are two cane types: primocanes, or first year canes, which are usually vegetative, and floricanes, which are the same canes and flower and produce fruit the next growing season. Floricanes then die after fruiting and need to be removed. Primocane-fruiting blackberries can 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 location. 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.

The 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, 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°F can greatly reduce fruit set, size and quality on primocanes. This 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 objective of this study is to compare yields and fruit quality of 'Prime-Ark®45'and 'Prime-Jan® under Kentucky growing conditions. Here we report the results of the trial in its third year after establishment.

Materials and Methods

In April 2010, plants of the commercially available, thorny, primocane-fruiting cultivars 'Prime-Jan®' and 'Prime- Ark®45,' were planted at the KSU Research and Demonstration Farm, in Frankfort, Kentucky. Plants were arranged in a randomized complete block design, with four blocks, including five plants of each cultivar per block (total of 20 plants of each cultivar) in a 10 foot plot. Spacing was two feet between each plant, and five feet between groups of five plants, with each row 125 feet long. 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. Weeds were controlled by placing a six- to eight-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. In 2013, dormant canes were mowed in mid-March. Therefore, only primocane fruit were harvested in 2013. Primocanes began producing fruit in late July. They were harvested each Monday and Thursday until a killing frost of 26°F on October 25.

Results and Discussion

Primocane fruit were harvested from late July 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.' Growing conditions in 2013 were mild compared to 2012; there were 40 out of 122 days with a high temperature above 85°F from June through September. The average high in July was 81.9°F. In June 2012 there were three days that the temperature was over 100°F and only five days with high temperatures below 85°F. The lower temperatures in 2013 led to a higher yield for both varieties compared to 2012. The University of Arkansas Blackberry Breeding Program already recommends that 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 2013 data suggests that in Kentucky 'Prime-Ark®45' yields should be higher than 'Prime-Jan®' and similar to some floricane varieties. 'Prime-Ark®45' should be considered by commercial growers interested in producing primocane fruiting blackberries.

Table 1. Yields and berry weights for 'Prime-Jan®' and 'Prime-Ark®45' from the University of Arkansas Blackberry Breeding Program at the Kentucky State University Research Farm, 2013.

Selection	Fruit Weight (g)	Yield (lb/acre)	Harvest Dates
'Prime-Jan®'	3.50 b[z]	3305 b	7/18-10/22
'Prime-Ark®45'	4.69 a	8812 a	8/1-10/22

[z] Numbers followed by the same letter are not significantly different (Least Significant Difference P ≤ 0.05)

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Organic Grape Cultivar Evaluation Trial in Kentucky

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

Introduction

Little if any grape acreage is dedicated to organic production in Kentucky largely due to climatic conditions conducive to recurring pest problems during the growing season. Grape growers have expressed interest in organic production; however, there are limited resources and recommendations for this type of production system. Although organic grape production methods have been developed in other regions, they have not yet been tested under the climatic conditions of Kentucky. This project has been initiated to study the challenges and limitations to organic grape production in Kentucky and attempts to identify crop protection strategies to maximize vineyard outputs and vine health.

Materials and Methods

Two identical 0.5-acre experimental blocks were planted in a randomized complete block design in the spring of 2011. One block was treated with only OMRI-certified products (organic block), while the other block (conventional block) received a spray program consisting of non-OMRI-certified products currently used to control vineyard pests in most commercial Kentucky vineyards. Cultivars used in this experiment were chosen due to their reduced susceptibility to black rot and tolerance to sulfur-based fungicides traditionally used to control powdery mildew in organic production systems. Initial vineyard site preparation consisted of spading a 4-foot-wide area directly under each vine row, while allowing natural vegetation to serve as a ground cover in the row middles. Immediately following spading in the spring of 2011 vines were established at a vine-row spacing of 10 feet between rows and 8 feet within each row. Vines were trained to a 6-foot-high bilateral cordon training system during the 2011 and 2012 seasons. All but the strongest cane developed during the 2011 season was removed during dormant pruning in March 2012 with this cane serving as the newly established vine trunk. The two strongest shoots arising from this newly established trunk were trained to the fruiting wire in 2012.

Herbicides were used to control weeds in the conventional block; mechanical tillage was used to control weeds in the organic block using a Weed Badger. Two applications of glyphosate were applied as an in-row banded spray to the conventional block in both May and July to prevent the herbicide spray from contacting the vine foliage; grow tubes were applied around each vine immediately before spraying and were then removed the following day. Five tillage passes per year were required to adequately control weeds directly under each vine row of the organic block. Although more passes were required to control weeds in the organic block, this block did not require the application or removal of grow tubes used in the conventional block, thus resulting in a significant savings in both labor and materials required to control in-row weeds. Weed control through mechanical cultivation generally resulted in a more uniform and pleasing appearance; the herbicide application appeared scorched and less uniform. Fertilization was not necessary in either the conventional or organic grape planting.

In order to reduce vine stress during initial vineyard establishment, all flower clusters were removed as soon as they appeared in both 2011 and 2012. Cluster thinning was done shortly after fruit set in 2013. Vines showing sufficient vigor were allowed to carry one cluster per shoot on shoots derived from canes tied to fruiting wire.

Results and Discussion

Between treatment blocks there were few differences in vine vegetative vigor when considering either average shoot length or average number of nodes per shoot in 2011. After the first vintage, the average length of the newly established trunk measured 43 inches at dormant pruning in both the organic and conventional blocks. Differences in vine vigor were more apparent during the 2012 growing season with organically treated vines appearing to have significantly higher vigor than the vines in the conventional block. This increase in vine vigor allowed for nearly full establishment of the fruiting wire, while many vines in the conventional block failed to completely fill the same space. Differences in vine vigor during the 2012 season can likely be attributed to the effectiveness of the mechanical weed control as compared to the herbicide control used in the conventional block.

Improved vine vigor and vine size expressed by vines in the organic block during the 2012 season should have resulted in a larger yield in 2013, the third growing season. However, due to above average spring and summer rainfall, fruit yield was substantially limited by black rot infections that occurred on fruit in the organic block during the 2013 growing season (Tables 1 and 2). Although harvested fruit from the conventional block expressed marked reductions in cluster rot incidence and severity, vines were less vigorous than vines in the organic block and required higher level of cluster thinning which reduced the total number of clusters and total yield per vine (Tables 1 and 2).

Fungicides were applied prophylactically to the Conventional vines during the 2011-2013 seasons, according to the protocols established in the *Midwest Commercial Small Fruit and Spray Guide* (ID-94). No fungicides were applied to vines located in the organic block in 2011-2012; copper and sulfur-based fungicides were used to control powdery and downy mildew in 2013. There were no visual signs of fruit or foliar diseases on vines planted in the conventional block during the 2011-2013 seasons (Table 3). Likewise, there were no significant signs of foliar disease observed in the organic block during the relatively dry seasons of 2011 and 2012 (Table 3). During the 2013 season frequent early rains resulted in commercially unacceptable levels of black rot infections on fruit of several cultivars planted in the organic block including Traminette, Villard blanc, Mars, Noiret, Corot Noir, and Valvin Muscat (Table 2). Less black rot was observed on cultivars: Brianna, Cayuga White, Edelweiss, Vanessa, and Villard Noir; however, fruit damage caused by June beetles on these cultivars was substantial (Table 2).

This study has shown the potential advantages of using organic production practices during establishment of disease resistant cultivars adapted to the climate of Kentucky. Although there was a limited need for fungicide application to treat common foliar diseases during the relatively dry 2011-2012 seasons, control of foliar and fruit diseases was less than ideal on some vines receiving organic fungicide treatments in the wet 2013 vintage. Of the cultivars used during this experiment, Brianna, Cayuga White, Edelweiss, Vanessa, and Villard Noir appear to be the most promising cultivars for organic grape production in Kentucky. Further investigation will need to be done to monitor the long-term performance of such cultivars to determine the economic potential these may have for Kentucky vineyards.

Table 1. Yield components for the 2013 organic winegrape cultivar trial, UK Horticulture Research Farm.

Cultivar/ Rootstock	Harvest Date	Yield per Acre[1] (tons)	Yield per Foot[2] (lb)	Shoots Per Foot of Cordon[3]	% Culled Clusters[4]	Cluster Weight (lb)
Organic						
Brianna*	08/07	0.2	0.1	3.7	-	0.12
Cayuga*	08/26	2.8	1.3	3.4	69	0.32
Corot Noir	09/06	1.3	0.7	3.6	85	0.22
Edelweiss*	08/07	0.3	0.1	3.6	-	0.14
Mars	08/16	0.0	0.0	4.1	100	-
Noiret	08/19	0.0	0.0	3.7	100	-
Traminette/101-14	09/25	0.0	0.0	3.9	100	-
Valvin Muscat/5C*	09/25	0.0	0.0	4.3	100	-
Vanessa	08/16	0.0	0.0	3.3	100	-
Villard Blanc	09/25	0.0	0.0	4.2	100	-
Villard Noir*	09/07	0.7	0.5	3.7	73	0.28
Conventional						
Brianna*	08/07	0.5	0.3	3.7	-	0.17
Cayuga*	08/15	1.2	0.8	3.5	17	0.67
Corot Noir	09/06	1.4	0.8	3.7	5	0.62
Edelweiss*	08/06	0.7	0.5	3.9	-	0.38
Mars	08/13	1.0	0.9	4.1	45	0.48
Noiret	09/16	0.8	0.5	4.2	2	0.48
Traminette/101-14	09/06	0.4	0.5	5.0	38	0.40
Valvin Muscat/5C*	-	-	-	4.3	-	-
Vanessa	08/16	0.0	0.0	3.2	100	-
Villard Blanc	09/17	1.5	1.1	4.7	0	0.73
Villard Noir*	09/20	1.0	0.7	4.0	16	0.49

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

Table 2. Fruit damage rating August 21st, 2013, organic cultivar trial, UK Horticulture Research Farm.

Cultivar	Black Rot Instance[1]	Black Rot Severity[2]	June Beetle Instance[1]	June Beetle Severity[2]
Cayuga	10	20	18	58
Corot Noir	93	38	30	36
Traminette/101-14	100	98	2	8
Valvin Muscat/5C	98	98	0	0
Villard Blanc	100	88	2	9
Villard Noir	11	9	20	27

1 Instance: Percentage of all clusters with any amount of damage
2 Severity: Percentage of damage on individual clusters

Table 3. Foliar disease rating September 28th, 2013, organic cultivar trial, UK Horticulture Research Farm.

Cultivar	Severity[1]	Percentage[2]
Organic		
Corot Noir	1.8	2.0
Mars	2.4	3.9
Noiret	1.7	1.5
Traminette	1.1	1.4
Vanessa	2.4	3.7
Villard Blanc	1.0	1.0
Conventional		
Corot Noir	1.0	1.0
Mars	1.5	1.0
Noiret	1.0	1.0
Traminette	0.5	0.5
Vanessa	1.5	1.5
Villard Blanc	1.0	1.0

1 Severity: 0 to 5 (O = No Damage à 5 = Leaves Completely Damaged (chlorotic/ necrotic))
2 Percentage: 0 = 0%, 1 = 1-25%, 2 = 26-50%, 3 = 51-75%, 4 = 76-99%, 5= 100%

Leafhoppers Associated with Newly Established Primocane Blackberry and Raspberry Plantings in Central Kentucky

John D. Sedlacek, Jeannie M. Haak, Karen L. Friley, Kirk W. Pomper, Jeremiah D. Lowe and Sheri B. Crabtree, College of Agriculture, Food Science, and Sustainable Systems, Kentucky State University

Introduction

Growing blackberries and raspberries can be profitable in Kentucky due to the long summers, warm temperatures and the demand for locally produced fruit. One of the limiting factors for high yields is insect pest damage. Some insects and mites that damage foliage include leafhoppers, spider mites, raspberry aphids, leaf rollers, climbing cutworms, blackberry psyllid, western winter moth, raspberry sawfly, stink bugs, scale insects, white flies, and thrips (Pritts 1991).

Leafhoppers (Hemiptera: Cicadellidae) damage the plants by feeding on their leaves, causing shoot tip distortion, leaf margin curling, and yellowing leaves. Leafhoppers can also be vectors of plant pathogens, causing a variety of diseases. Rubus stunt is a leafhopper-transmitted disease found in wild and cultivated *Rubus* plants in Europe, the Middle East, and Russia (Converse 1991). It has not been found in North America, but the primary leafhopper vector *Macropsis fuscula* occurs in the western United States (Converse 1991).

Kentucky State University (KSU) horticulture personnel are examining the suitability of newly released primocane fruiting blackberries and raspberries in central Kentucky. This study quantifies leafhoppers during a five-week period in mid-summer 2012 in central Kentucky.

Materials and Methods

Bushes of six varieties of blackberry and raspberry were obtained from Indiana Berry and Plant Company (Plymouth, Indiana). The varieties were Black Magic™, Caroline, Fall Gold, Heritage, Nantahala, and Prime Ark 45®. These plants were given to growers in early June at five sites in three Kentucky counties: Fayette, Franklin, and Shelby. All varieties were also planted and sampled at the KSU Research Farm (Frankfort, KY). Each site had 15 plants of each variety except the Montessori school which had 10 total plants.

Insects for sampling were caught on sticky traps. Thirty-one 6 x 6 inch yellow sticky traps were stapled to tobacco stakes close to the main cane of the blackberry or raspberry plants. Traps were removed from stakes and placed into one gallon plastic storage bags and labeled with location name, sample number, date, and variety. They were then placed into a freezer for a minimum of 24 hours to kill live insects. Samples were taken weekly at each site and each variety at each location.

Traps were inspected with a Bausch & Lomb lighted magnifier and Nikon binocular dissecting microscope. Species and species groups (i.e., unidentifiable species within a genus) were assigned a reference number, counted, and recorded. Dr. Paul Freytag, Professor Emeritus, University of Kentucky Department of Entomology, was consulted concerning species identifications. *The leafhoppers of Illinois, (Eurymelinae-Balcluthinae)* and *The Nearctic leafhoppers (Homoptera: Cicadellidae)* were used as taxonomic keys (DeLong 1948; Oman 1949).

Results

Thirty-nine species and species groups were found over the five-week period (Table 1). A total of 20,818 leafhoppers were caught. Four leafhoppers comprised 90% of the total catch. *Agallia constricta* was most abundant (68%), *Cuerna costalis* represented 9% of the total, *Graphocephala* spp. (7%), and *Draeculacephala* spp. (6%) (Figure 1). KSU Farm had the most leafhoppers trapped. This may be because the bramble test plot was near other blackberry and raspberry plantings that were previously established, and these could have contributed to the larger number of leafhoppers trapped at this location.

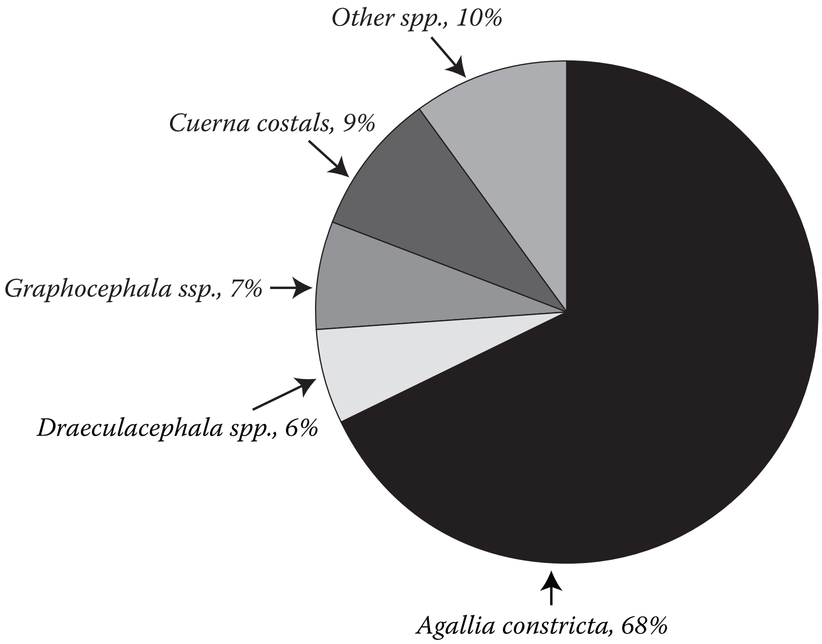
Agallia constricta is a light brown, straw to greenish-tinged leafhopper 3.4 – 3.8 mm in length (Amgueddfa Cymru 2010a). It can be distinguished by two spots on its vertex and two spots on its pronotum. It can be a vector for the potato yellow dwarf virus and is commonly found in the Southeastern United States (Amgueddfa Cymru 2010a).

Table 1. Leafhopper species/species groups caught in/near brambles in three central Kentucky counties.*

Cuerna costalis
Agallia constricta
Graphocephala spp.
Draeculacephala spp.
Endria/Flexamia spp.
Erythroneura spp.
Scaphoideus spp.
Paraulacizes irrorata
Novellina seminuda
Stirellus bicolor
Empoasca spp.
Deltocephalus spp.
Polyamia sp.
Balclutha sp.
Chlorotettix sp.
Scaphytopius frontalis
Paraphlepsius sp.
Aceratagallia sp.
Tylozygus bifidus
Collandonus sp.
Gyponana spp.
Japananus spp.
Flexamia spp.
Spangbergiella sp.

*15 additional species were unidentified.

Figure 1. Percentages of the four most abundant leafhopper species by overall trap count .



Cuerna costalis has a yellow or white stripe on the sides, red and black legs, and grows to about 8.4 mm in length (Amgueddfa Cymru 2010b). It has two generations per year and overwinters in Kentucky (Amgueddfa Cymru 2010b). This leafhopper feeds on the xylem fluid of plants and is a known vector for phony peach disease and Pierce's disease (grape) and has been found in the United States in the northern, southern, and mid-western states. It has also been found in Ontario, Canada (Amgueddfa Cymru 2010b).

Graphocephala spp. are 6.7 to 8.4 mm long, striped leafhoppers, commonly known as "sharpshooters." They may have stripes in varying shades of red, green, blue, and yellow, with no more than two colors present (Amgueddfa Cymru 2010c). Similar to *Draeculacephala* spp. in size and coloration, it has been found in southern and midwestern United States. Feeding by large numbers can cause leaf scorch (Amgueddfa Cymru 2010d).

Draeculacephala spp. are commonly called "dragon heads" because of their long, conical heads. They range from 5.5 – 9 mm in length and are green and bright to faded blue. *Draeculacephala* can live for about 100 days and are abundant throughout the United States and Canada (Amgueddfa Cymru 2010c).

Fortunately, *Macropsis fuscula* was not collected in this study. However, it is important to continue to survey leafhoppers in Kentucky to determine if this vector of rubus stunt has become established. We will continue sampling blackberry plantings for this insect.

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Wine and Seedless Table Grape Cultivar Evaluation Trial

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

Introduction

The climate in Kentucky is well suited to produce a variety of wine and table grape cultivars. However, spring frosts, winter temperature fluctuations and long, warm, humid summers pose challenges to growing grapes in Kentucky. Successful production requires 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). *V. vinifera* cultivars often produce more desirable wines than the interspecific hybrids and Norton 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, and rootstock and clone selection. The following research update provides the 2013 season production and cultivar performance results.

Materials and Methods

Two research vineyards were planted in the spring of 2006 at the University of Kentucky Horticulture Research Farm in Lexington, Kentucky. 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/acre (8 ft between vines and 10 ft between rows) and trained to a 6-foot single high wire bilateral cordon. Vines were planted as own-rooted vines with the exception of Chambourcin, Chardonel, Vidal bBlanc and Traminette that were additionally planted on the rootstocks 101-14, 3309 and 5C, respectively. In 2008 own-rooted Chambourcin, Frontenac Gris, and Marquette were added to this planting. Vineyard two was established in 2006 and consists of 15 European cultivars (*Vitis vinifera*) and 21 different clones. Each cultivar and clone 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/acre (7 ft between vines and 10 ft between rows) and trained to bilateral cordons located 36 inches from ground level. Shoots were trained to a modified ballerina system with downward-positioned shoots allowed to grow on the east side of the trellis. In 2008 the *V. vinifera* cultivars Cabernet Sauvignon #8, Malbec, Petite Verdot, Rkatsitelli, Touriga, Tinto Cao, and Pinot Noir were added to this planting.

Standard commercial cultural management practices were used in both vineyards. In March 2013 vines were spur pruned to retain approximately six count buds per linear foot of vineyard row. 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 a single spot spray where necessary. Vines expressed normal to high vigor and no fertilizer was applied during the 2013 growing season. Disease and pest control were in accordance with the *Midwest Commercial Small Fruit and Grape Spray Guide* (ID-94).

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). Bird netting was only applied to the hybrid block in the 2013 growing season due to reduced bird feeding. 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 0.100 N sodium hydroxide) until harvest. Each vine was harvested separately to determine the number of clusters and yield/vine. A final 100-berry sample was taken at harvest to determine fruit chemistry (TSS, pH and TA) and berry weight.

Results and Discussion

The 2013 vintage was largely defined by cooler temperatures and above average rainfall, especially during June, July, and August in which rainfall totals were nearly twice the historical average. Above average rainfall required diligent canopy management and timely fungicide applications to reduce damage caused by fungal pathogens. Downy mildew was especially difficult to control on late ripening cultivars carrying a larger than average crop. For most cultivars both cluster size and the number of clusters per shoot were larger than average resulting in large yields despite appropriate shoot and cluster thinning (Tables 1-3). Although the average yield for all white hybrid cultivars was nearly 7.5 tons per acre, fruit composition values were held within a commercially acceptable range (Tables 1 and 4). Larger than average yields, cool temperatures, and above average rainfall delayed harvest dates and led to lower than average sugar accumulation and higher than normal Titratable Acidity (Tables 4-6). Cool weather also delayed veraison, which seemed to reduce the severity of fruit damage caused by June beetles typically attracted to soft ripening fruit. Cooler, slower ripening conditions produced white wines with exceptional aroma and acid structure; however these conditions also led to less than ideal phenolic maturity of late ripening red grape cultivars, especially on cultivars suffering from over-cropping and intense downy mildew pressure. Despite larger than average rainfall, cluster rot severity was low for all cultivars except Riesling, which had nearly 30% culled clusters (Table 3). The only other yield loss to vineyard pests was bird damage to early ripening red cultivars Frontenac, Foch, GR7, and Marquette, where yields were reduced from 45% to 73% (Table 1).

The effects of rootstocks on vine performance are becoming more apparent as vines become older and are subjected to more stress. When compared to corresponding own rooted vines, Chardonel, Traminette, and Vidal blanc vines planted on rootstock have all maintained larger overall vine size resulting in larger berry size, cluster size and yield per acre (Tables 1 and 4). This increase in productivity has not been detrimental to fruit composition at harvest, suggesting that rootstocks may help maintain long-term vine productivity in Kentucky vineyards.

The vineyards at the University of Kentucky Horticulture Research Farm are planted in an excellent site where most varieties can reach full production potential. Not all sites in Kentucky will be able to consistently produce 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.

This project was funded by the Kentucky Agriculture Development Board through a grant to the Kentucky Vineyard Society.

Table 2. Yield components for the seedless table grape cultivar trial, UK Horticulture Research Farm, Lexington, KY, 2013.

Cultivar	Harvest Date	Yield per Acre[1] (tons)	Yield per Foot[2] (lb)	Shoots Per Foot of Cordon[3]	% Culled Clusters[4]	Cluster Weight (lb)
Einset	08/06	2.0	1.1	4.7	51	0.24
Reliance	08/13	3.3	1.9	5.7	61	0.56
Jupiter	08/13	2.3	1.2	5.8	80	0.30
Marquis	08/30	3.9	2.0	4.9	14	0.62
Neptune	09/11	6.1	3.2	5.1	0	0.75

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

Table 1. Yield components for the American/hybrid winegrape cultivar trial, UK Horticulture Research Farm, Lexington, KY, 2013.

Cultivar /Rootstock	Harvest Date	Yield per Acre[1] (tons)	Yield per Foot[2] (lb)	Shoots Per Foot of Cordon[3]	% Culled Clusters[4]	Cluster Weight (lb)
White						
NY76.084	08/23	6.7	3.3	5.5	4	0.37
Cayuga	08/26	8.5	4.2	5.3	2	0.56
Seyval blanc	09/04	5.5	4.6	5.2	19	0.93
Vignoles	09/04	2.8	1.4	5.6	14	0.23
Chardonel/C-3309	09/09	11.4	5.7	5.1	2	1.00
Chardonel/OR	09/09	7.0	3.5	4.6	5	0.75
Vidal blanc/5C	09/30	10.3	5.3	4.5	6	0.87
Vidal blanc/OR	09/30	8.5	4.2	4.5	5	0.78
Villard	09/16	8.9	4.6	4.8	0	0.68
Traminette	09/11	6.0	3.0	5.6	0	0.34
Traminette/5C	09/11	7.1	3.6	5.4	3	0.41
Frontenac Gris	08/30	1.8	0.9	5.3	30	0.21
Red						
Marquette	08/30	1.9	1.0	5.6	47	0.15
Foch	09/04	1.0	0.5	5.7	73	0.10
Corot Noir	09/04	9.2	4.5	4.4	2	0.69
Frontenac	09/23	1.4	0.7	4.9	71	0.19
GR7	09/09	2.4	1.2	5.4	45	0.20
Chancellor	09/20	7.1	3.5	5.7	4	0.41
Noiret	09/16	4.0	2.0	4.1	3	0.36
Chambourcin/101-14	10/14	8.1	4.4	4.2	2	0.72
Chambourcin/OR	10/14	2.1	1.4	5.2	0	0.49
Norton	10/21	8.6	4.1	6.6	1	0.29
St. Vincent	10/14	11.3	5.6	5.2	0	0.73

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

Table 3. Yield components for the vinifera winegrape cultivar trial, UK Horticulture Research Farm, Lexington, KY, 2013.

Cultivar/Clone	Harvest Date	Yield per Acre[1] (tons)	Yield per Foot[2] (lb)	Shoots Per Foot of Cordon[3]	% Culled Clusters[4]	Cluster Weight (lb)
White						
Pinot Grigio #146	09/01	4.6	2.7	5.3	6	0.33
Pinot Grigio #152	09/01	4.9	5.6	9.4	7	0.34
Pinot Grigio #4	09/01	5.3	2.8	5.1	3	0.34
Chardonnay #15	09/18	5.8	3.3	4.8	0	0.37
Chardonnay #37	09/18	4.5	2.6	4.8	2	0.34
Chardonnay #4	09/18	7.0	3.9	4.7	1	0.52
Chardonnay #43	09/18	6.2	3.1	4.9	3	0.37
Chardonnay #76	09/18	4.6	2.6	5.1	6	0.35
Viognier	09/17	8.5	4.9	5.4	0	0.49
Rkatsiteli	09/23	5.0	3.8	5.2	0	0.59
Riesling #12	09/20	4.7	2.6	5.1	25	0.36
Riesling #17	09/20	4.1	2.3	4.9	31	0.39
Riesling #9	09/20	4.6	2.4	4.8	33	0.38
Red						
Limberger	09/30	9.1	5.0	4.5	0	0.62
Petite Verdot #2	09/30	4.3	3.0	4.9	1	0.28
Tinto Cao	10/15	6.6	4.5	4.6	0	0.46
Touriga	09/20	6.0	3.4	5.2	0	0.29
Cabernet Franc #214	10/15	8.9	4.6	5.5	2	0.49
Cabernet Franc #312	10/15	8.6	4.6	5.3	18	0.61
Cabernet Franc #4	10/15	6.6	3.7	5.7	21	0.51
Cabernet Franc #5	10/15	10.0	5.4	5.6	7	0.60
Cabernet Sauvignon #337	10/15	8.1	3.9	5.0	2	0.46
Cabernet Sauvignon #8	10/15	7.7	4.0	5.4	0	0.40

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

Table 4. Fruit composition for the American/hybrid winegrape cultivar trial, UK Horticulture Research Farm, Lexington, KY, 2013.[1]

Cultivar/Rootstock	100 Berry Wt. (lb)	TSS[2] (%)	Juice pH	TA[3] (%)
White				
NY76.084	0.44	16	3.0	0.90
Cayuga	0.75	18.3	3.2	0.82
Seyval blanc	0.49	20.3	3.4	0.67
Frontenac Gris	0.23	24	3.4	0.67
Vignoles	0.42	23.4	3.2	1.29
Chardonel/C-3309	0.58	19.5	3.2	1.18
Chardonel/OR	0.57	21.0	3.2	0.77
Vidal/5C	0.55	19.2	3.7	0.78
Vidal/OR	0.42	20.4	3.6	0.77
Villard	0.66	21.8	3.3	0.72
Traminette	0.46	20.8	3.4	0.67
Traminette/5C	0.45	20.7	3.5	0.83
Red				
Marquette	0.23	26.5	3.2	0.64
Foch	0.30	22.1	3.4	0.66
Corot Noir	0.59	16.4	3.6	0.58
Frontenac	0.26	24.5	3.6	1.47
GR7	0.41	21.1	3.5	0.67
Chancellor	0.47	21.8	3.5	0.75
Noiret	0.51	19.2	3.4	0.81
Chambourcin/101-14	0.62	22.7	3.7	0.76
Chambourcin/OR	0.57	22.5	3.7	0.86
Norton	0.32	22.0	3.8	1.28
St. Vincent	0.82	20.3	3.4	0.95

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

Table 5. Fruit Composition for the seedless table grape cultivar trial, UK Horticulture Research Farm, Lexington, KY, 2013.[1]

Cultivar/Rootstock	Berry Wt. (g)	TSS[2] (%)	Juice pH	TA[3] (%)
Einset	0.60	20.6	3.3	0.57
Reliance	0.57	17.7	3.1	0.85
Jupiter	0.97	19.3	3.5	0.67
Marquis	1.30	18.6	3.5	0.65
Neptune	1.10	20.7	3.4	0.80

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

Table 6. Fruit Composition for the vinifera winegrape cultivar trial, UK Horticulture Research Farm, Lexington, KY, 2013.[1]

Cultivar/Clone #	Berry Wt. (lb)	TSS[2] (%)	Juice pH	TA[3] (%)
White				
Pinot Grigio #146	0.26	18.3	3.4	0.59
Pinot Grigio #152	0.27	18.0	3.5	0.57
Pinot Grigio #4	0.28	18.2	3.3	0.56
Chardonnay #15	0.40	20.4	3.8	0.72
Chardonnay #37	0.41	20.5	3.8	0.68
Chardonnay #4	0.42	20.8	3.7	0.89
Chardonnay #43	0.41	20.5	3.9	0.69
Chardonnay #76	0.40	20.6	3.9	0.65
Viognier	0.28	19.9	3.9	0.65
Rkatsiteli	0.47	17.8	3.4	0.71
Riesling #12	0.42	19.7	3.5	0.57
Riesling #17	0.41	17.2	3.6	0.56
Riesling #9	0.44	17.0	3.3	0.56
Red				
Limberger	0.46	17.4	3.6	0.62
Petite Verdot #2	0.28	22.0	3.6	0.65
Tinto Cao	0.41	20.3	4.0	0.51
Touriga	0.48	19.8	3.6	0.51
Cabernet Franc #214	0.45	21.6	4.0	0.45
Cabernet Franc #312	0.46	21.4	4.1	0.47
Cabernet Franc #4	0.48	21.5	4.0	0.44
Cabernet Franc #5	0.50	20.7	4.0	0.42
Cabernet Sauvignon #337	0.41	19.8	4.0	0.51
Cabernet Sauvignon #8	0.41	20.7	3.9	0.53

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

Rabbiteye Blueberry Variety Evaluation, 2013

Chris Smigell, John Strang and John Snyder, Department of Horticulture

This trial was established to evaluate rabbiteye blueberry (*Vaccinium ashei* Reade) and southern highbush blueberry (*V. corymbosum* L.) variety adaptation to central Kentucky growing conditions. These blueberry types typically have shorter chilling requirements and may bloom earlier than highbush blueberries, making them more prone to spring frost injury. Rabbiteye blueberries are less winter hardy than highbush and most southern highbush blueberries. However they are less sensitive to higher soil pH and fruit later in the season allowing for fruit season extension.

Materials and Methods

The blueberries were planted at the Horticultural Research Farm in Lexington in the spring 2004. Plants were acquired from Fall Creek Nursery, Lowell, OR; Finch Nursery, Bailey, NC; DeGrandchamp's Farm, South Haven, MI; and Dr. Jim Ballington at North Carolina State University, Raleigh, NC. Most of the highbush and southern highbush varieties were removed from the trial in 2011.

Plants were set on raised beds of Maury silt loam soil into which peat and composted pine bark mulch had been incorporated and the soil pH had been adjusted from 5.6 to 4.6 by applying 653 lb of sulfur per acre. Seventy pounds of phosphorus, as triple super phosphate was applied per acre and incorporated into the field prior to bed shaping and planting. Five replications of individual plant plots were set in rows running east to west in a randomized block design. The southern highbush and highbush plants were randomized together at one end of the planting and spaced 4 ft apart in the row with 12 ft between rows. The rabbiteye blueberries were planted at the other end with 6 ft between plants and 12 ft. between rows. All plants were mulched with a three-foot-wide, six-inch-deep layer of wood chips. Plants have been fertilized yearly with Scott's Osmocote Plus 5-6 month controlled release (15-9-12) fertilizer that contains six trace elements and magnesium at the rate of 1 oz per plant in March, April, May, June, and July. Fungicide applications included lime sulfur, Rally, and Captan. Herbicides for weed control included Surflan, Roundup, and Rely. All chemicals were applied as per recommendations in the *Midwest Small Fruit and Grape Spray Guide* (ID-94).

Fruit were harvested on 23 June, 6 July, and 11 July. Twenty five berries from each plant were weighed to determine average berry size at each harvest, and fruit were rated for taste and appearance several times during the season.

Results

Rainfall was above normal in January, below normal in February and March, and above normal in April and May. Monthly temperature averages were 6 and 5°F above normal for December and January, respectively. The average temperature in March was 6 degrees below normal, and for the rest of the season temperatures generally ran below normal.

A freeze occurred on the morning of 2 April 2013. The Kentucky Mesonet weather station, located 100 feet from the planting, recorded a minimum temperature of 28.°F five feet above ground. The freeze eliminated the entire crop on all rabbiteye varieties except for the 'NC-1827' selection (Table 1). The highbush variety, 'Spartan' and the southern highbush variety, 'Lenore' both had crops, although not large ones. The smaller crops on the 'Spartan' and 'Lenore' were at least partially due to a delay in erecting bird nets on the planting. Other non-replicated highbush and southern highbush varieties in the planting had good crops, and commercial highbush blueberry growers had full crops across Kentucky in 2013. 'Spartan' and 'Lenore' had higher yields than the NC-1827, but the yield differences were not statistically significant. One of the reasons for establishing this trial was to compare the effect of frosts on rabbiteye varieties versus highbush and southern highbush varieties. This is the first year that the rabbiteye blueberries have mostly frosted out and the highbush and southern highbush have not.

Highbush and southern highbush varieties produce fruit earlier in the season than rabbiteye varieties as shown by the difference in first harvest dates (Table 1). Previous data shows that 'NC-1827' has consistently been one of the earliest producing and highest yielding rabbiteye varieties in this trial.

There were no significant differences in berry taste between varieties. 'Spartan' had a significantly higher individual berry weight than the 'Lenore' and 'NC-1827'. Berry weight or size was considerably larger in 2013 than 2012. The rabbiteye 'NC-1827' had a significantly higher appearance rating. Rabbiteye fruit were nearly spherical, had a very heavy, attractive bloom, and were very uniform in appearance, compared to 'Spartan' and 'Lenore'.

Acknowledgments

The authors would like to thank Grant Clouser, Paul Dengle, Dave Lowry and Joseph Tucker for their hard work and assistance in the successful completion of this trial.

Funding for this project was provided by a grant from the Agricultural Development Board through the Kentucky Horticulture Council.

Table 1. Highbush, southern highbush, and rabbiteye blueberry yield, fruit size, taste, appearance ratings and first harvest dates, Lexington, KY, 2013.

Variety	Type[1]	Yield (lbs/A)[2]	Berry wt (oz/25 berries)	Berry taste (1-5)[3]	Berry appearance (1-5)[4]	First harvest (date)
Spartan	HB	1529 a	1.7 a	4.2 a	4.1 b	28 June
Lenore	SH	1229 a	1.3 b	4.5 a	4.2 b	28 June
NC-1827	R	861 a	1.3 b	4.3 a	4.6 a	11 July
Climax	R	-	-	-	-	-
Columbus	R	-	-	-	-	-
Ira	R	-	-	-	-	-
Powderblue	R	-	-	-	-	-
Tifblue	R	-	-	-	-	-

1 Type: HB = highbush; SH = southern highbush; R = rabbiteye
2 Means followed by the same letter are not significantly different (Walter-Duncan Multiple Range Test LSD P = 0.05)
3 Berry taste: 1 = poor; 5 = excellent
4 Berry appearance 1=poor, 5=excellent

Advanced Thorny and Thornless Primocane-fruiting Blackberry Selection Trial

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

Introduction

Blackberry plants are unusual among fruit crops in that they have perennial root systems, but have biennial canes. There are two cane types, primocanes, or first year canes, which are usually vegetative, and floricanes, which are the same canes and 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 location. Growers can reduce pruning costs by mowing canes in late winter to obtain a primocane crop only. Mowing 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.

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

Materials and Methods

In June 2011, plants of the commercially available primocane-fruiting cultivar 'Prime-Ark 45®' (thorny erect, primocane-fruiting) and the Arkansas Primocane-fruiting (APF) selections of thorny or thornless (T) advanced selections (APF-153 T, APF-156 T, APF-158, APF-172, APF-185 T, APF-190 T, and APF-205 T) from the UARK blackberry breeding program, were planted at the Kentucky State University (KSU) Research and Demonstration Farm in Frankfort, Kentucky. Plants were arranged in a randomized complete block design, with four blocks, including five plants of each cultivar per block (total of 20 plants of each cultivar) in a 10 foot plot. Spacing was two feet between each plant, and five feet between groups of five plants; with each row being 70 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. Weeds werecontrolled by placing a 6-8 in. deep layer of straw around plants, adding straw when necessary and hand weeding. Plants were irrigated weekly with t-tape laid in the rows. Floricanes of most selections began producing fruit in June 2013, and fruit were harvested each Monday and Thursday until a killing frost (26°F) on 25 October.

Results and Discussion

This year floricanes began producing fruit in June. Primocane fruit production began in late June for all selections. Fruit production continued until frost (Table 1). APF-158 had the highest yield at 7146 lb/acre. . Yields of other selections in this trial were much lower, ranging from 5636-760 lb/A. Prime-Ark 45® had a yield of 3795 lb/acre. APF-153 T had the largest average berry weight at 6.26 g. APF-172, APF-185T, and APF-190T had the smallest berry weights, which were below 4.5 g. Growing conditions in 2013 were mild compared to 2012. The average high in July was 81.9°F. There were 40 out of 122 days with a daily high temperature above 85°F from June through September. In June, 2012 there were three days that the temperature was over 100°F and only five days in that month had high temperatures that were below 85°F. The lower temperatures in 2013 and increased age and size of plants led to a higher yield for all varieties compared to 2012. Berry weights were larger in 2013 than in 2012. Overall, APF-158, and APF-190T had a superior yield to Prime-Ark 45® and APF-153T and APF-205T had greater average berry weights. Year to year yield and fruit quality characteristics will need to be further evaluated. APF-153T has been released as Prime-Ark Freedom®.

Table 1. Yields and berry weights for seven advanced primocane-fruiting selections and 'Prime-Jan®', from the University of Arkansas Blackberry Breeding Program, at the Kentucky State University Research Farm, 2013.

Selection	Fruit Weight (oz)	Yield (lb/acre)	Harvest Date
Prime-Ark 45	0.17 cd[Z]	3795 c	6/24-10/22
APF-153 T	0.22 a	760 d	6/27-10/22
APF-156 T	0.17 cd	1976 d	6/27-10/22
APF-158	0.18 bc	7147 a	6/24-10/22
APF-172	0.15 e	3507 c	6/24-10/22
APF-185 T	0.15 e	868 d	6/24-10/22
APF-190 T	0.16 de	5636 b	6/24-10/18
APF-205 T	0.19 b	1329 d	6/27-10/22

Z Numbers followed by the same letter are not significantly different (Least Significant Difference P ≤ 0.05)

Literature Cited

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Bell Pepper Bacterial Spot Variety Trial, Central Kentucky

John Strang, Chris Smigell, Lucas Hanks, and John Snyder, Department of Horticulture; and Kenny Seebold, Department of Plant Pathology

Introduction

Bell peppers currently account for roughly 500 acres of Kentucky fresh market vegetable production according to the 2012 Kentucky Produce Planting and Marketing Intentions Grower Survey and Outlook (www.uky.edu/Ag/CCD/plantingsurvey2012.pdf). Seventeen bell pepper *Capsicum annuum* varieties with resistance to a number of races of *Xanthomonas campestris* pv. *vesicatoria* (Xcv), the causal agent of bacterial spot, were evaluated for yield and bacterial spot resistance in a replicated trial. A number of the varieties were selected based on fruit quality and yield performance in a 2012 non-replicated screening trial. The intent of this study was to evaluate variety performance following inoculation with the races of Xcv currently found in Kentucky.

Materials and Methods

Varieties were seeded on 20 March 2013 into 72-cell plastic plug trays (Landmark Plastics Corp., Akron, OH) filled with ProMix BX general growing medium at the UK Horticultural Research Farm in Lexington. Greenhouse-grown transplants were set into black plastic-covered, raised beds using a water wheel setter on 30 May. All transplants were watered in with approximately a pint of starter solution (6 lb of 10-30-20 in 100 gallons of water). Each plot was 15 ft long and contained 30 plants set 12 inches apart in double rows spaced 15 inches apart in the bed. Beds were 6 ft apart. Plots were replicated four times in a randomized block design.

Sixty pounds of nitrogen per acre as 19-19-19 was applied and tilled in prior to plastic laying. Beginning 14 June a rotation of urea, 20-20-20, and calcium nitrate was applied weekly via fertigation at a rate of 6 lb 4 oz nitrogen per acre for a total of 13 applications totaling 81 lb of nitrogen per acre. Following this, four weekly nitrogen maintenance applications of 2 lb nitrogen per acre as urea were made for a total of 8 additional lb of nitrogen per acre. Dual II Magnum herbicide was applied on 9 June between beds at a rate of 1.0 pt per acre. No fungicide or bactericide applications were made to the planting. Coragen was applied through the drip lines on 16 July at a rate of 5 fl oz per acre for insect control. Five Mustang Max sprays were applied at two week intervals beginning 6 August for corn borer control. Stakes were driven along the outer row of the double row of plants on each bed and two levels of tomato twine were used to support the plants and reduce fruit sunscald.

Two pepper plants in each plot were inoculated on 30 July with Xcv isolated from peppers from the Somerset, KY, area. One leaf on each plant was infiltrated with a suspension of Xcv at 10^8 colony-forming units per ml. Severity of bacterial spot was assessed four times (9 August, 16 August, 27 August, and 5 September) by estimating the percentage of diseased leaf area (% DLA). Values for % DLA were used to calculate the area under the disease progress curve (AUDPC), an indicator of cumulative disease severity for the season.

The plot was harvested four times during the season (2 August, 27 August, 13 September and 8 October). Marketable fruit were graded and weighed into the categories of jumbo, extra large and large (all fruit >3 inches diameter), total marketable yield (all fruit >2.5 inches diameter) plus misshapen but sound fruit, which could be sold as "choppers" to food service buyers, and cull fruit.

Results

Lexington received eight more inches of rainfall than normal from June through September; temperatures were 1 and 1.6°F warmer than normal in June and September and 1.7 and 0.4°F cooler than normal in July and August. Drip irrigation was applied shortly after transplanting and all varieties showed good survival rates. The cool season was not conducive to the development of bacterial spot, and overall severity was low throughout the trial.

Varieties are ranked in Table 1 based on the percentage of jumbo, large and extra large fruit (by weight) since growers make most of their income from these size classes. 'Excursion II,' 'Alliance,' 'Lafayette,' 'Currier,' 'Revolution' and 'Declaration' were the best performing varieties in this trial based on percentage and tonnage of at least 30.4 tons per acre of jumbo, extra large and large fruit, low amounts of silvering and cull fruit. 'Excursion II,' 'Lafayette' and 'Alliance' produced at least 40 tons per acre of marketable fruit. 'Excursion II' fruit had a very low percentage of silvering, and was rated high for fruit shape uniformity and overall fruit appearance, however fruit size was not maintained at the last harvest. 'Lafayette,' 'Declaration,' and 'Revolution' also rated high for fruit shape uniformity. 'Declaration,' 'Revolution,' 'Islamorada,' and 'Lafayette' rated highest for overall fruit appearance. 'PS09941819 X5R' had the highest total marketable yield, at 46 tons per acre, but a very large percentage of fruit displayed silvering. 'Red Knight' and 'HMX 2641' had some of the lowest yields in the trial but had the highest percentage of four-lobed fruit. 'Aristotle,' one of the primary bacterial spot resistant varieties planted over the last 10 years, showed lower yields of jumbo, extra large and large fruit and high levels of fruit silvering. Fruit cullage was primarily due to corn borer injury and a slight amount of sunscald. Table 2 provides information on the seed sources, days to harvest, fruit color and reported bacterial spot race resistance.

Symptoms of bacterial spot were observed on 'Red Knight' before plants were inoculated, and likely resulted from infection by Xcv present in seeds. Severity of bacterial spot was greatest on 'Red Knight' and 'Excursion II,' which had 10.25% and 9.25% DLA, respectively, at the last evaluation made on 5 September (Table 3). Disease severity did not exceed 2% DLA in any of the other varieties. Cumulative severity of bacterial spot (AUDPC) was highest for 'Red Knight,' followed by 'Vanguard' (Table 3). The AUDPC values for 'Excursion II' and 'Aristrocrat' were not significantly different from 'Vanguard.'

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The authors would like to thank Grant Clouser, Paul Dengle, Dave Lowry and Joseph Tucker for their hard work and assistance in the successful completion of this trial.

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Table 1. Yield data and fruit characteristic ratings, 2013.

Variety	Jumbo + XL + Large (%)[1]	Total Marketable Yield (tons/A)[2]	Cull (%)	Silvering (%)[3]	Fruit Shape Uniformity[4]	Fruit Appearance[5]	4-lobed Fruit (%)	Fruit Size Maintained[6]	Fruit Comments
Excursion II	85 a[7]	40.9 ab[7]	2.7	0.4	4.1	4.3	45	3.1	Attractive; large, but few XL in early harvests; one fruit with bacterial spot
Islamorada	83 ab	33.0 cd	4.1	8.9	3.8	4.1	58	3.5	Attractive, good size, last harvest; one fruit with bacterial spot, some pointy fruit
Lafayette	81 abc	40.5 ab	2.5	8.7	3.9	4.1	53	3.4	Attractive; fair no. of XL fruit in first harvest; size held up throughout season
Alliance	81 abc	40.6 ab	3.0	2.9	3.8	4.0	47	3.8	Attractive; very little silvering; a lot of XL at first harvest; size held up through season
Currier	79 a-d	38.6 bc	2.4	12.5	3.8	3.9	55	3.1	Attractive; a lot of XL at second harvest; fair amount of small & medium fruit the last harvest; one fruit with bacterial spot
Revolution	78 bcd	39.0 bc	3.1	7.1	3.9	4.4	37	4.4	Attractive; very large firm blocky fruit; lots of XL fruit the last harvest
Karisma	76 cd	38.4 bc	2.8	11.8	3.7	3.8	55	3.0	Size held up through second harvest; mostly medium size at last harvest
Clifton No. 1	76 cd	36.9 bcd	5.2	14.7	3.3	3.6	58	2.9	Very firm, thick wall; many with silvering
Declaration	76 cd	40.0 b	3.0	3.6	4.3	4.5	50	3.1	Lighter green than other varieties; size held up well through second harvest; had more small short fruit
PS09941819 X5R	73 de	46.3 a	3.0	28.2	3.6	3.5	55	4.8	Attractive; a lot of XL, at first harvest and size very large at last harvest; extreme silvering first two harvests
Vanguard	72 de	36.2 bcd	3.6	13.6	3.5	4.0	65	4.4	Attractive; a lot of XL throughout the season
Archimedes	72 de	39.4 b	2.0	11.0	3.4	3.8	63	3.6	Fair no. of XL; some fruit elongated; very little fruit silvering; many small misshapen fruit at last harvest
Aristotle	68 ef	40.5 ab	2.1	29.5	3.9	3.6	43	3	Fair no. of XL at first two harvests, extreme silvering; medium size fruit at last harvest
Tomcat	66 ef	34.3 bcd	2.4	42.4	3.5	3.1	55	3	Medium sized very firm fruit; not many XL fruit; excessive silvering
Aristocrat	64 f	35.8 bcd	1.9	45.4	3.1	3.1	53	2.6	Large blocky fruit first two harvests and size dropped off for last harvest; excessive silvering
HMX 2641	63 f	31.6 d	2.4	47.1	2.9	2.7	75	2.3	Medium sized fruit; mostly small fruit at last harvest; excessive silvering
Red Knight	54 g	31.4 d	1.9	37.7	3.3	3.0	70	2.6	XL very firm fruit at first harvest; small size at last harvest; excessive silvering

1 Percent of total marketable yield weight that was graded as jumbo, extra large and large (all fruit >3 inches diameter)
2 Total marketable yield included jumbo, extra large, large and medium fruit (all fruit >2.5 inches diameter) plus misshapen but sound fruit which could be sold as 'choppers' to food service buyers.
3 Percent of total marketable yield weight that showed silvering or very fine, light colored streaking in harvests 1, 2 and 4.
4 Fruit shape uniformity at first harvest: 1=poor, 5=excellent
5 Fruit appearance at first harvest: 1=poor, 5=excellent
6 Fruit size maintenance at last harvest: 1=poor, 5=excellent
7 Means in column followed by the same letter are not significantly different (Waller-Duncan Multiple Range Test LSD P≤0.05).

Table 2. Bell pepper days to harvest, seed source and fruit color.

Variety	Seed Source	Days to Harvest[1]	Fruit Color Green[2]	Ripe
Excursion II	RU	75	med	red
Islamorada	SW	72	med	red
Lafayette	CL	70	lt-med	yellow
Alliance	HM	74	lt-med	red
Currier	SW	73	lt-dk	red
Revolution	SW	72	lt-med	red
Karisma	CL	71-75	med	red
Clifton No. 1	CL	75	med-dk	red
Declaration	HM	70-75	lt-med	red
PS0994-1819 X5R	RU	73-75	med	red
Vanguard	ST	75	med	red
Archimedes X3R	SW	76	med	red
Aristotle X3R	ST	70-75	med-dk	red
Tomcat	CL	75	med	red
Aristocrat	CL	75	med	red
HMX 2641	CL	65	med	red
Red Knight X3R	RU	64	med	red

1 Days to harvest from seed catalogues and websites.
2 Green fruit color: med=medium, lt=light, dk=dark

Table 3. Bacterial spot severity on 17 varieties of bell pepper and Xcv race resistance

Variety	Seed Source	Bacterial spot severity: % disease (5 September)[1]	AUDPC[2]	Bacterial Spot Race Resistance[3]
Red Knight X3R	RU	10.3 a[4]	384.5 a[4]	1,2,3
Vanguard	ST	2.0 b	126.4 b	1-5
Excursion II	RU	9.3 a	103.3 bc	1,2,3
Aristocrat	CL	1.0 b	63.3 bcd	unknown
Tomcat	CL	1.0 b	38.3 cd	1-5,7-9
Currier	SW	1.3 b	36.0 cd	1,2,3
Lafayette	CL	0.8 b	17.5 d	1,2,3
Alliance	HM	0.3 b	15.5 d	1,2,3,5
Aristotle X3R	ST	0.8 b	14.6 d	1,2,3
Karisma	CL	0.5 b	13.5 d	1,2,3
Clifton No. 1	CL	0.3 b	12.4 d	unknown
Archimedes X3R	SW	0.5 b	8.5 d	1,2,3
Islamorada	SW	0 b	7.9 d	1-5
Revolution	SW	0.3 b	4.3 d	1,2,3,5
HMX 2641	CL	0 b	3.1 d	1-4
Declaration	HM	0 b	2.3 d	1,2,3,5
PS0994-1819 X5R	RU	0 b	2.3 d	1-5

1 Percentage of diseased leaf area with symptoms of bacterial spot on the last evaluation of the trial (5 September).
2 Total severity of disease calculated from ratings taken on 9, 16, and 27 August, and 5 September as the area under the disease progress curve (AUDPC, showing cumulative disease severity for the season.
3 Bacterial spot race resistance from seed catalogues and websites.
4 Means in column followed by the same letter are not significantly different (Fisher's Least Significant Difference, LSD P≤0.05).

Spring Red and Savoy Cabbage Variety Evaluation

Chris Smigell, John Strang, Lucas Hanks, and John Snyder, Department of Horticulture; Pam Sigler, Program and Staff Development; and Elizabeth Buckner, Family and Consumer Sciences

Thirteen red and eight savoy cabbage varieties were evaluated in a replicated trial to evaluate their performance under central Kentucky conditions. Culinary evaluations were conducted to assess consumer varietal preferences.

Materials and Methods

Varieties were seeded on 12 February 2013 into 72 cell plastic plug trays filled with ProMix BX general growing medium (Premier Horticulture, Inc.) at the UK Horticulture Research Farm in Lexington. Greenhouse-grown transplants were set into the field on 16 April 12 inches apart in single rows with 36 inches between rows. Each plot row was 10 feet long and contained 11 plants. Varieties were replicated four times in a randomized complete block design. Dacthal (14 lb/A) and Devrinol (4 lb/A) herbicides were mixed into the soil, and Goal (2 pt/A) was applied to the soil surface prior to planting. Select Max (16 fl oz/A) was applied for post-emergence grass control on 3 June.

Sixty pounds per acre of nitrogen, phosphorus and potassium were applied as 19-19-19, prior to planting, and tilled in. Approximately one cup of starter solution (6 lb of 10-30-20 in 100 gallons of water) was applied at transplanting. The plot was drip-irrigated and fertigated weekly with 10 lb of nitrogen per acre beginning on 31 May for a total of 7 fertigations and 70 lb of nitrogen per acre. These fertigations used a rotation of calcium nitrate, urea and 20-20-20. Coragen insecticide (5 fl oz/A) was applied 3 June through the drip lines, and Danitol (1pt/A), Brigade (5 oz/A) and Mustang Max (4 oz/A) were sprayed for insect control.

All marketable heads were harvested when firm and were evaluated for total marketable yield, number of heads per acre, head weight and size. Harvesting began on 2 July and continued on a roughly weekly basis through 21 August. One head from each replication was evaluated for core length, head firmness, internal and external appearance, color, and raw product taste.

Culinary evaluations were conducted on two heads of each variety by two Family Consumer Science panels. The first panel rated the red varieties for visual appeal, and flavor and texture when prepared raw, steamed or roasted. The second panel rated the savoy varieties for visual appeal, and flavor and texture in the raw form only. Both panels commented on the attractive appearance of all cabbage varieties, regarding cut cabbage color, leaf texture, internal design and core appearance.

Steamed cabbage was chopped into bite-sized pieces. Two cups of chopped cabbage were placed in a steamer basket that was placed into a covered stainless steel pan holding one cup of water. Cabbage was cooked over medium heat (7-9) for 10 minutes. Cabbage to be roasted was cut into 1-inch-thick rounds. These were placed in a single layer on a baking sheet covered with parchment paper that had been coated with one tablespoon of extra-virgin olive oil. The cabbage was then brushed with olive oil and was roasted in a preheated 400°F oven for 42 minutes until the cabbage was tender and the edges had turned golden.

Results and Discussion

The growing season was cool, wet and ideal for cabbage production. Harvest and head evaluation data for red and savoy cabbage are shown in Tables 1 and 2. One head from each of four replications was measured (length, width and core length), tasted, and rated for color and appearance by two horticulture department personnel. Varieties are ranked based on total marketable yield in Tables 1 and 2. Family Consumer Science taste panel evaluations are ranked based on cut head visual appearance and are shown in Table 3. In Kentucky total marketable yield is not the primary grower consideration used for selecting a variety. Since specialty cabbage types are generally sold directly to consumers, appearance and quality are primary concerns for obtaining repeat sales.

The top red varieties based on Horticultural Research Farm and Family Consumer Science evaluations were Scarlet King, Rondale and Rio Grande Red. The top savoy varieties were Savoy King, Savoy Ace Improved and Savoy Blue.

Horticultural Research Farm Evaluations

Scarlet King, Super Red 80, Red Dynasty, Rondale, Kosaro and Rio Grande Red were the best performing red varieties (Tables 1 and 2). Rondale and Rio Grande Red were rated lower than most other varieties for internal appearance because several heads showed some core browning. Growers should select varieties that produce heads in their most marketable size range. Rio Grande Red had larger heads averaging 4.0 lb. while Kosaro heads averaged 2.9 lb. Kosaro had a relatively small core length. All red varieties were very firm.

The top savoy varieties were Savoy King, Savoy Ace Improved, Clarissa, Savoy Blue and Miletta. Head firmness was lower for Savoy King because in retrospect this variety was harvested too early, although the heads looked very good at the time of harvest. Heads left longer in the field became very large without splitting. Savoy Blue and Taler were rated lower for internal appearance because several heads displayed internal tip burn, which is associated with calcium deficiency. Raw savoy cabbage tended to be not as sweet as the red cabbage and a little dry. Savoy cabbage heads are less dense as compared with conventional cabbage.

Family Consumer Science Evaluations

All of the cabbage consumer panel participants ate cabbage regularly with 50% of red cabbage panelists, and 76% of the savoy cabbage panelists eating it monthly or more frequently. Participants most frequently ate cabbage raw in salads or slaw. The majority of both red cabbage panelists and savoy cabbage panelists purchased cabbage from grocery stores (88% and 82%, respectively), and farmer's markets (50% and 41%, respectively).

Participants rated the red cabbage for appearance, flavor and texture in a variety of preparation styles (raw, steamed and roasted) on a Likert Scale of 1 to 5 (1 = not at all appealing and 5 = very appealing). All varieties of raw red cabbage received an average or appealing rating (mean $\geq$ 3.0) for appearance and texture with the exception of Primero (visual appeal mean = 2.75). Flavor of the raw cabbage varied from not appealing (mean = 2.86 for Super Red 80 and Super Red 90) to very appealing (mean > 4 for Scarlet King, Rondale, and Rio Grande Red).

Steamed and roasted cabbage ranked as average or less appealing visually. Scarlet King and Rondale were the only varieties receiving an appealing (mean = 4) rating for flavor when steamed. Rondale received the highest rating for texture when steamed (mean = 4.5). Scarlet King, Rio Grande Red and Rondale received appealing ratings (mean > 4) for flavor and texture when roasted. None of the participants had eaten roasted cabbage prior to the panel but all indicated that they would roast cabbage in the future.

Participants rated the visual appeal, flavor and texture of raw savoy cabbage. All varieties received a mean score greater than 3.0 on a 5 point Likert Scale with 5 being very appealing. Savoy King (mean = 4.06) and Savoy Blue (mean = 4.53) received the highest rating for visual appeal. Savory Blue received the highest mean score (4.06) for flavor with Taler, Miletta, and Primavoy receiving less than appealing ratings (mean < 3.0). Taler is the only variety that received less than appealing (mean < 3.0) for texture.

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Table 1. Variety yield data, head dimensions, split head number, firmness and taste ratings, and comments.

Variety	Seed Source	Days to Harvest[1]	Total Marketable Yield (lb/A)	Heads (No/A)	Avg. Head Wt (lb)	Head Length X Width (in)	Core Length (in)	Head Firmness (1-5)[2]	Split Heads (No/A)	Taste Raw (1-5)[2]	Comments
(Red)											
Rio Grande Red	SI	73	62,944 a[3]	15,609	4.0	6.8X6.6	3.8	4.8	0	3.9	Crunchy, slightly to not sweet, a little core browning
Scarlet King	SI	70	62,109 a	15,972	3.9	6.7X7.2	3.6	4.5	0	4.5	Mild, crunchy, slightly sweet
Super Red 80	JO	82	54,740 ab	16,698	3.3	6.2X6.1	3.0	4.9	0	4.7	Mild, crunchy, sweet
Rondale	ST	75	50,711 abc	15,246	3.3	6.9X6.1	2.9	4.8	0	4.4	Mild, crunchy, slightly to not sweet, some with core browning
Red Dynasty	SI,S	72	47,843 bcd	14,157	3.4	6.9X5.9	3.8	4.9	0	4.7	Mild, crunchy, sweet
Kosaro	SW	74	43,669 bcd	15,246	2.9	6.0X5.9	2.7	5.0	0	4.4	Mild, crunchy slightly sweet
Azurro	SW	78	43,306 bcd	13,794	3.1	6.5X6.7	3.1	4.5	0	3.1	Some sulfur notes, nice iridescent wrapper leaves
Integro	JO	85	41,201 bcd	14,520	2.8	6.6X5.4	3.3	5.0	0	4.6	Mild, very crunchy, slightly sweet, a few with core browning
Cairo	SW	85	39,785 cde	14,157	2.8	5.6X6.0	2.5	4.6	0	4.0	Crunchy, dry, slightly bitter and sweet
Primero	SW	72	36,590 cde	15,972	2.3	5.2X5.8	3.0	4.9	363	4.1	Mild, crunchy, slightly sweet, some core browning, nice waxy bloom
Super Red 90	CL	Mid late	35,102 de	12,705	2.8	6.6X5.4	4.0	4.8	0	4.6	Mild, crunchy, slightly sweet
Red Jewel	CL,SK	75	34,360 de	14,157	3.1	5.4X5.4	2.8	4.7	0	3.4	Crunchy, sulfur notes, slightly bitter and sweet
Ruby Perfection	JO	86	26,463 e	11,253	2.4	6.5X4.7	3.7	5.0	0	4.5	Mild, very crunchy, slightly sweet, large core for size
(Savoy)											
Savoy King	CL	80	70,458 a	15,609	4.5	5.9X9.3	3.9	3.6	0	3.9	Mild, slightly dry, not sweet; heads get very large and flat if left in field
Savoy Ace Improved	RU	73	58,842 ab	13,794	4.3	7.7X7.7	4.0	4.1	0	3.9	Mild, crunchy, not sweet
Savoy Blue	ST	80	56,810 ab	12,705	4.5	6.3X7.9	3.1	3.7	0	4.4	Mild, slightly sweet, tip burn
Clarissa	SW	78	51,183 ab	18,150	2.8	6.4X6.5	3.1	4.0	0	4.3	Crunchy, slight sulfur note, slightly sweet
Alcosa	SW,JO	62	46,500 ab	14,520	3.2	6.7X6.8	3.3	3.5	6,534	3.1	Dry, some sulfur notes, not sweet
Primavoy	ST	98	45,266 ab	13,431	3.4	7.1X7.2	5.0	3.8	0	3.3	Mild, dry, not sweet, slightly tough, large core, heads did not fill well
Miletta	ST	88	45,121 ab	15,246	3.0	6.3X7.4	3.3	3.9	0	4.5	Mild, crunchy, slightly sweet
Taler	ST	85	38,587 b	13,794	2.8	6.6X6.9	5.1	3.7	0	3.0	Dry, not sweet, some tip burn, large core, did not mature

1 Days to harvest from seed catalogues
2 Head Firmness and Raw Taste: 1= poor; 5= excellent
3 Means in column followed by the same letter are not significantly different (Waller-Duncan Multiple Range Test LSD $P \leq 0.05$)

Table 2. Red and savoy cabbage head appearance and color, 2013.

Variety	External Appearance (1-5)[1]	Internal Appearance (1-5)[2]	Color Intensity (1-5)[3]	Internal Color
(Red)				
Rio Grande Red	4.6	3.6	3.8	Rose purple
Scarlet King	4.5	4.3	4.0	Rose purple
Super Red 80	4.6	4.5	4.2	Reddish purple
Rondale	4.4	3.7	4.5	Dark purple
Red Dynasty	4.4	4.5	4.4	Rose purple
Kosaro	4.5	4.5	4.8	Dark purple
Azurro	4.7	4.3	4.2	Reddish purple
Integro	4.7	4.1	4.8	Dark purple
Cairo	4.3	4.5	4.5	Dark purple
Primero	4.0	4.0	4.3	Purple
Super Red 90	4.5	3.8	4.2	Rose purple
Red Jewel	4.4	4.2	4.1	Rose purple
Ruby Perfection	4.6	4.0	5.0	Dark purple
(Savoy)				
Savoy King	4.6	4.4		Cream to green
Savoy Ace Improved	4.8	4.6		Cream
Savoy Blue	4.8	2.7		Cream to yellow
Clarissa	4.6	4.6		Yellowish green
Alcosa	4.1	4.2		Cream to green
Primavoy	4.7	3.0		Cream to green
Miletta	4.7	4.7		Cream to green
Taler	4.0	2.5		Cream to light green

1 External appearance: 1=poor; 5=excellent
2 Internal appearance: 1=poor; 5=excellent
3 Color intensity: 1=light; 5=dark purple

Table 3. Family Consumer Science red and savoy cabbage visual appearance, flavor and texture evaluations, 2013.

Variety	Visual Appeal Raw (1-5)[1]	Flavor Raw (1-5)[1]	Texture Raw (1-5)[1]	Visual Appeal Steamed (1-5)[1]	Flavor Steamed (1-5)[1]	Texture Steamed (1-5)[1]	Visual Appeal Roasted (1-5)[1]	Flavor Roasted (1-5)[1]	Texture Roasted (1-5)[1]
(Red)									
Super Red 80	4.4	2.9	4.4	3.3	3.3	3.7	2.8	3.0	3.5
Cairo	4.3	3.5	4.6	3.3	3.7	3.5	2.3	3.2	3.3
Rio Grande Red	4.1	4.1	4.3	3.0	3.8	3.8	3.2	4.5	4.7
Scarlet King	4.1	4.1	4.1	3.3	4.0	4.0	3.3	4.2	4.0
Red Jewel	4.1	3.6	4.1	2.2	3.5	4.0	3.0	3.2	3.8
Kosaro	4.0	3.6	4.0	2.2	2.8	3.5	3.2	3.3	3.8
Integro	4.0	3.1	3.7	2.5	3.2	3.8	2.5	3.0	3.8
Rondale	4.0	4.1	4.3	3.0	4.0	4.5	3.3	4.3	4.3
Azurro	3.9	3.9	3.8	2.2	2.8	3.0	3.3	2.8	3.7
Red Dynasty	3.8	3.4	3.6	2.3	2.5	3.3	3.0	2.5	3.3
Super Red 90	3.8	2.9	4.0	2.3	2.7	3.5	2.8	3.0	3.8
Ruby Perfection	3.1	3.6	3.7	2.8	3.7	4.2	2.3	2.5	3.8
Primero	2.8	3.3	3.4	2.2	2.5	3.3	3.5	3.3	3.7
(Savoy)									
Savoy Blue	4.5	4.1	3.8						
Savoy King	4.1	3.7	3.7						
Clarissa	4.0	3.2	3.5						
Miletta	3.8	2.7	3.6						
Alcosa	3.5	3.5	3.8						
Taler	3.5	2.3	2.9						
Primavoy	3.4	2.9	3.6						
Savoy Ace Improved	3.1	3.8	3.9						

1 Appearance, flavor and texture mean ratings: 1 = poor; 5 = excellent. Red cabbage was rated by six and the savoy cabbage by 17 evaluators.

Managing Brown Marmorated Stink Bug using Selective Exclusion Screening Materials

Rachelyn Dobson, Chelsea Berrish, and Ric Bessin, Department of Entomology

Brown marmorated stink bug (BMSB), ***Halyomorpha halys*** (Stål) is a new invasive pest in Kentucky. It was first confirmed in Boyd, Jefferson, and Fayette counties in the fall of 2010. BMSB is increasing in Kentucky rapidly and is likely to be a key pest of most field crops, most fruit crops, and many vegetable crops including tomatoes, peppers, beans, eggplant, sweet corn, and okra. In states that have had BMSB for a longer time, BMSB has become the primary pest of many crops and has been particularly problematic with organic production. While conventional producers have several insecticides that provide satisfactory BMSB control, organic producers have had very limited results with OMRI-approved materials. Coordinated research studies in a dozen states are investigating management of BMSB on certified organic farms. Tactics being evaluated include the use of OMRI-approved insecticides, trap crops, and selective exclusionary netting.

While the finest screening materials should exclude all stages of BMSB, they are also likely to exclude natural enemies of the BMSB and other pests, and other beneficial insects. This pepper trial was conducted in a transitional organic plot to evaluate the impact of three types of exclusionary screening materials on BMSB damage to the peppers, productivity of the plants, and natural enemies of insect pests.

Materials & Methods

Untreated bell pepper (*Capsicum annuum* L.) seeds ('Aristotle,' Seedway, Hall, NY) were grown in 72-cell trays using Organic Grow Mix in an organic greenhouse. Seedlings were planted in the field on May 14, on the University of Kentucky Horticultural Research Farm in Lexington. Prior to bed preparation, 100 units of organic nitrogen (Fertrell 4-2-4) were cultivated into the soil and incorporated to a depth of 6 inches with a rotary tiller. Four pairs of plant beds 120 feet in length were established. Each pair of beds had an 18 inch furrow between the beds and there were 48 inches between pairs of beds. Pepper plants were set as double rows on black plastic with 18 inches between staggered rows and 15 inches between plants in a row. Landscape fabric was laid to suppress weeds in alleyways between replicates and secured with landscape staples. A dome like cage was created using a two ½ inch diameter, 15-foot reinforcing construction rods (Lowes, Lexington, KY). The rods were driven eight inches into the soil on a bed and extended from one corner of one plastic bed to the opposite corner of the other bed to create the frame to support the netting materials. The two rods were secured in the center where they crossed with wire for stability. Each frame enclosed a 6.5 ft section of the paired beds and was approximately 4.5 ft in height. Cage fabric was draped over the frames and secured around the base of the cages with a total of 16 paving stones. Treatments were: 1) unscreened control plots; 2) ⅙-inch mesh (Industrial Netting, Minneapolis, MN); 3) ⅛-inch mesh (Industrial Netting, Minneapolis, MN) and 4) a fine mesh 30% woven shade cloth (Shade Cloth Store, Libertyville, IL). Treatments were randomized and exclusionary netting materials were placed over pepper rows prior to fruit initiation stage; a total of 24 pepper plants were covered by each cage. Yellow sticky cards were attached to 18-inch wooden stakes, placed in the center of each cage and collected every week for a total of six weeks. Cards were put out on June 6, 13, 20, and 27; July 3, 11, 18, and 25; and August 1, 8, 15, and 22. Sticky cards were placed inside clear plastic bags, labeled at collection, and refrigerated for later insect identification. Insect categories identified were lady beetles, hover flies, lacewings, big-eyed bugs, and damsel bugs. Peppers were harvested in the mature green stage and graded according to USDA size categories of "Fancy," "No. 1" and "No. 2" (USDA 2005). Stink bug damage and sunscald were recorded along with the number of other culls. Harvest dates were 15 July, 30 July, and 12 September. Brown marmorated stink bug was counted in each cage at time of harvest.

Results

Barrier fabrics influenced yield and marketability of bell peppers ($p < 0.05$). There were more marketable fruit per cage and increased fruit weight per cage in the uncovered, ⅙-inch and ⅛-inch netting treatments than the fine mesh shade cloth (Table 1). The ⅛-inch and ⅙-inch treatments did not increase or decrease marketable fruit yield as compared to the uncovered control. The uncovered control had more fruit that graded USDA Fancy than did the ⅙-inch screen or the fine mesh netting (Table 2). Barrier fabrics influenced fruit damage to bell peppers (Table 3). All screens reduced damage by piercing sucking insects, green stink bug and BMSB, with the fine mesh providing more protection than the ⅛-inch netting. The ⅛-inch and fine mesh also significantly reduced the number of sunscald fruit. The fine mesh had significantly fewer cull fruit than the other treatments. All of the barrier fabrics reduced the percentage of piercing-sucking damaged fruit compared to the uncovered control, and the fine mesh had proportionally less piercing-sucking damage than other netted treatments (Table 4).

Physical barriers are used to prevent plant damage by excluding insect pests from accessing plants, although beneficial insects may also be excluded. Barrier fabrics reduce the numbers of lady beetles and hover flies captured on sticky cards compared to the uncovered control (Table 5). Fewer hover flies were collected on yellow sticky cards in the fine mesh than the more course barrier fabrics. No stink bugs were found in the cages at the end of the study.

Conclusions

The number of BMSB and native (green and brown) stink bugs were low in this study. The barrier nettings were able to reduce damage by piercing-sucking pests, with the fine mesh fabrics providing a higher level of protection. The barrier fabrics also provided protection from sunscald. However, barrier fabrics also reduced fruit yield, likely due to plant shading. The finer barrier mesh provided the least number of marketable fruit despite having less fruit damage from insects. The barrier mesh fabrics also reduced the number of beneficial insects as compared to the no-barrier control treatment, but the trend was for the more open mesh treatments to have more beneficial insects than those with a tighter weave. There may be a yield cost with using barrier fabrics to exclude BMSB that may not be recovered with low densities of BMSB.

References

USDA. 2005. United States Standards for Grades of Sweet Peppers. http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRDC5050318.

Table 1. Total Yield and fruit weight (lb) and number of marketable bell peppers 'Aristotle' grown in cages with barrier fabrics at the UK Horticultural Farm, 2013

Treatment	Total fruit per cage[1,2]	Total fruit wt (lb) per cage	Marketable fruit per cage
Fine mesh	108.0 c	43.7 b	89.2 b
1/8″	138.2 b	54.8 a	110.2 a
1/6″	144.6 ab	56.3 a	113.2 a
No screen	153.6 a	55.2 a	123.2 a
P; d.f.	*P* = .0001; 3, 16	*P* = .0059; 3, 16	*P* = .0019; 3, 16

[1] Means within the same column followed by the same letter are not significantly different (ANOVA, LSD P ≤ 0.05).
[2] Fruit were harvested from all of the 24 plants in each cage.

Table 2. USDA Grade distribution of marketable bell peppers 'Aristotle' grown in cages with barrier fabrics at the UK Horticultural Farm, 2013

Treatment	USDA Grades of Marketable Fruit		
	No. Fancy[1]	No. 1	No. 2
Fine mesh	49.2 b	34.2	5.8 c
1/8″	58.4 ab	37.6	14.8 ab
1/6″	50.2 b	42.2	20.8 a
No screen	66.8 a	43.3	13.0 b
P; d.f.	*P* =0.01; 3,16	*P* =0.15; 3,16	*P* =0.0012; 3,16

[1] Means within the same column followed by the same letter are not significantly different (ANOVA, LSD P ≤ 0.05).

Table 3. Number of culled fruit within damage type categories of bell peppers 'Aristotle' grown in cages with barrier fabrics at the UK Horticultural Farm, 2013

Treatment	Fruit Damage Category			
	Sunscald[1]	Piercing-sucking	Other damage	Total
Fine mesh	0.0 c	2.4 c	16.4 a	18.8 b
1/8″	1.4 bc	12.6 b	13.2 ab	27.2 a
1/6″	2.6 ab	8.8 bc	20.0 a	31.4 a
No screen	3.4 a	24.6 a	2.4 b	30.4 a
P; d.f.	*P* = 0.0048; 3,16	*P* = 0.0001; 3,16	*P* = 0.03; 3,16	*P* = .018; 3,16

[1] Means within the same column followed by the same letter are not significantly different (ANOVA, LSD P ≤ 0.05).

Table 4. Percent piercing-sucking damage on bell peppers 'Aristotle' grown in cages with barrier fabrics from 30-July to 10-Sept. at the UK Horticulture Research Farm, 2013

Treatment	Percentage Piercing-sucking Damage[1]
Fine mesh	2.2 c
1/8″	9.2 b
1/6″	6.0 b
No screen	16.2 a
P; d.f.	*P* = 0.0002; 3,16

[1] Means in the same column followed by the same letter are not significantly different (ANOVA, LSD P ≤ 0.05).

Table 5. Number of beneficial insects identified on yellow sticky cards placed in cages with barrier fabrics enclosing bell peppers 'Aristotle' from 6-Jun to 27-Aug. at the UK Horticultural Research Station, 2013

Treatment	Lady Beetles[1]	Hover Flies	Green Lacewings	Damsel bugs
Fine mesh	0.4 b	0.2 c	0.2 b	0.0
1/8″	2.4 b	2.0 bc	0.0 b	0.0
1/6″	3.0 b	3.2 b	0.0 b	0.4
No screen	8.8 a	13.4 a	0.8 b	0.0
P; d.f.	*P* = 0.0001; 3,16	*P* = 0.0001; 3,16	*P* = 0.027; 3,16	*P* = 0.09; 3,16

[1] Means in the same column followed by the same letter are not significantly different (ANOVA, LSD P ≤ 0.05).

Developing More Resilient Cantaloupe Production Systems

Amanda Skidmore, Tim Coolong, Mark Williams, Department of Horticulture; and Ric Bessin, Department of Entomology

The key to successful cantaloupe production in Kentucky has relied upon effective management of insect pests and the pathogens they may vector. Cucumber beetles, striped and spotted, are key pests of all cucurbit crops and they also vector *Erwinia tracheiphila* (Smith), the pathogen that causes bacterial wilt of cucurbits. Management of this disease relies on preventing the beetles from feeding on cucurbit plants, particularly prior to fruit set when the plants are small. Many producers have been using systemic neonicotinoid insecticides as a transplant drench to provide the first three weeks of control of cucumber beetles when the plants are first set in the field. After three weeks they monitor for cucumber beetles and use one of several pyrethroids to reduce beetle numbers as needed (Bessin 2004).

However, use of some insecticides with cucurbit production has the potential to interfere with insect pollinators upon which cucurbit crops are entirely dependent. Without pollinators there will be no fruit set. There has been national concern over the loss of honey bee colonies since Colony Collapse Disorder (CCD) was first recognized in 2006. While insecticides were not directly implicated in a recent USDA/EPA report on CCD (USDA 2013), the report did indicate that neonicotinoid insecticides may play a role in terms of colony health.

Another factor we are addressing in this study is soil health. Vegetable production systems employing raised plastic beds require intense soil manipulation. Excessive tillage can have negative effects on soil structure through reduction of organic matter and breaking the structure of soil (USDA NRCS 2013). With this study we begin evaluating strip tillage as an alternative to the traditional raised plastic bed system.

Materials and Methods

This study was conducted at the UK Horticultural Research Farm in Lexington, KY. In the fall of 2012, a cover crop consisting of winter rye, field pea, and radish was established for all plots. Fungicide-treated cantaloupe (*Cucumis melo* L.) seeds ('Athena,' Seedway, Hall, NY) and grown in 72-cell plastic trays until four weeks of age. In the spring of 2013, half of the plots had the soil completely prepared with a rotary tiller and raised beds with black plastic and trickle irrigation established. In the other plots, the cover crop was flail mowed as the rye began to produce a seed head. A strip eight inches wide was then tilled in each plot for the plant bed. This study used a split plot design with tillage practice treatments arranged in the main plots as a randomized block design and with or without row cover treatments in the split plot. Transplants were set in the field on May 21, 2013, in conventionally managed plots on the UK Horticultural Research Farm. Each main plot was forty feet in length and consisted of two outer border rows and two center rows for data collection (on six foot centers), one with a row cover over wire hoops and one without a row cover. The 6-foot-wide spunbond polypropylene row covers (Agribon AG- 30) were held down with lose soil in plots with raised beds and paving stones every 2 to 3 feet in the strip till plots. In-row plant spacing of 2 feet resulted in 21 plants per row. Row covers were removed with the initiation of female flower formation on June 18, 2013. The plants in the rows without a row cover received ⅙ fl oz of a water-diluted drench of imidacloprid (Macho 2F) at a rate of 16 fl oz/A. Prior to transplanting and bed formation, 100 units of nitrogen/A in the form of calcium nitrate was incorporated in the soil and was tilled to a depth of 6 inches with a rotary tiller. Drip tape was laid on top of the row in the strip till plots and held in place with landscape fabric staples approximately every ten feet.

On a weekly basis, insect pests and natural enemies of pests were recorded from three 3.28 by 3.28-foot samples in each uncovered sub plot. While female flowers were present, weekly pollinator survey was conducted in each plot with three one-minute observations. A single yellow sticky card attached to a 12-inch stake was placed in each subplot and changed weekly to monitor for natural enemies (data yet to be processed). A single pitfall trap was also placed in each subplot row and changed weekly to monitor ground associated arthropods (data yet to be processed). Plots were harvested and graded according to USDA standards (USDA 2008) and causes for culling were identified. Soil core samples were collected from each plot before planting, post-planting, mid-season, and at the end of the season (data yet to be processed).

Data were subjected to analysis or variance using a split-plot randomized block design. Prior to analysis of the percentile data, these data transformed by arcsine of the square root to account for non-homogeneity of the variance amongt the means (SAS 2012). Means presented in the table are of the raw data.

Results and Discussion

The 2013 growing season at the UK Horticultural Research Farm can be characterized as excessively wet and cool. Weekly counts of striped cucumber beetles averaged over the season indicated significantly higher numbers in the subplots without the early season row cover treatment than in those plots with early season row covers without insecticide (Table 1). This difference was more pronounced in the plasticulture system. No significant differences were observed with average numbers of spotted cucumber beetles. Significantly more lady beetles were observed in the strip-till plots compared to the plasticulture plots and this effect was similar with and without row covers. This difference may be due to the increased shelter and structural complexity of the strip till plots or may be in response to alternative food items.

Weekly counts of pollinators found no significant differences in visitation rates of honey bees, bumble bees or other bees with respect to tillage practices, early season row covers, or the interaction between these factors (Table 2). However, there was a significant effect of the row cover on the mean number of female cantaloupe flowers, with the plants that were under the row covers early season having more female flowers. Plants grown under the early season row covers appeared larger and more vigorous and the number of female flowers reflected these differences.

Tillage practices significantly influenced the total number and total weight of cantaloupes produced (Table 3) and this effect was more pronounced without the row cover. On average, the raised bed with black plastic produced about 40% more cantaloupes than did the strip tillage plots. There were significantly more marketable cantaloupes produced with the plasticulture system than with the strip tillage.

All treatments exhibited a large number of culled fruit; the majority were culled due to effects of the very wet weather, which resulted in fruit splitting. The mean number of culled fruit due to insect feeding was significantly higher in the plasticulture plots than the strip tillage plots while the row cover had no detectable effect on insect damage (Table 4). The numbers of poorly pollinated fruit resulting in culling were not significantly different among treatments. The percentage of insect damaged fruit relative to the total number of fruit produced was significantly higher in the plasticulture plots.

In terms of fruit production, the plasticulture system outperformed the strip tillage system in this study. Some of this may be due to the raised bed providing more drainage in this excessively wet year or the combination of black plastic and raised bed heating the soil more rapidly with the prolonged cool conditions during the growing season. Early-season row covers reduced the average number of striped cucumber beetles throughout the season compared to a systemic insecticide treatment. Strip tillage, with greater structural complexity due to cover crop residue on the soil surface, had a beneficial effect on the numbers of lady beetles. Visitation rates of pollinators did not differ much among our treatments, although it may be difficult to see differences among treatments in plots of this size. There was an effect of tillage on the number insect damaged fruits with strip tillage plots having much less insect damage. This difference may be the result of increased levels of natural enemies in the strip till plots or possibly temperature or moisture differences affecting the cucumber beetles. Some of these answers may become available as the remainders of the samples collected during the summer are processed.

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Table 1. Mean number (SE) of spotted and striped cucumber beetles and lady beetles during weekly square meter observation of cantaloupe, 'Athena,' grown in strip tillage or plasticulture plots with and without row covers at the UK Horticultural Farm, 2013

Treatment	Striped cucumber beetle	Spotted cucumber beetle	Lady beetles
Plasticulture No row cover	8.33 (1.5)	0.83 (0.2)	7.83 (0.4)
Plasticulture With row Cover	3.67 (1.3)	0.92 (1.6)	14.17 (2.7)
Strip tillage No row cover	4.25 (1.6)	0.92 (1.6)	4.75 (0.9)
Strip tillage With row cover	4.17 (1.4)	0.75 (1.6)	5.00 (0.9)
Row cover effect	$p = 0.03$; 1,6	$p = 0.54$; 1,6	$p = 0.09$; 1,6
Tillage effect	$p = 0.37$; 1,3	$p = 0.89$; 1,3	$p = 0.04$; 1,3
Interaction	$p = 0.03$; 1,6	$p = 0.10$; 1,6	$p = 0.11$; 1,6

Table 2. Mean number pollinators (SE) and female flowers observed during one minute observations of 1 m of row of cantaloupes, 'Athena,' grown in strip tillage or plasticulture plots with and without row covers at the UK Horticultural Farm, 2013

Treatment	Honey bees	Bumble bees	Other bees	Female flowers
Plasticulture No row cover	5.25 (1.0)	0.30 (0.2)	0.25 (3.0)	1.67 (0.4)
Plasticulture With row Cover	5.7 (1.4)	0.67 (0.5)	0.33 (3.7)	3.83 (0.4)
Strip tillage No row cover	10.8 (0.7)	0.42 (0.2)	0.42 (4.6)	1.67 (0.1)
Strip tillage With row cover	8.3 (0.4)	0.50 (0.3)	0.91 (2.1)	2.25 (0.9)
Row cover effect	$p = 0.18$; 1,6	$p = 0.39$; 1,6	$p = 0.29$; 1,6	$p = 0.04$; 1,6
Tillage effect	$p = 0.06$; 1,3	$p = 1.0$; 1,3	$p = 0.17$; 1,3	$p = 0.26$; 1,3
Interaction	$p = 0.08$; 1,6	$p = 0.56$; 1,6	$p = 0.44$; 1,6	$p = 0.19$; 1,6

Table 3. Mean number and weight of fruit (SE) and number of marketable cantaloupes, 'Athena,' grown in strip tillage or plasticulture plots with and without row covers at the UK Horticultural Farm, 2013

Treatment	Number of Fruit	Weight of Fruit (lb)	Number of Marketable Fruit
Plasticulture No row cover	80.8 (4.1)	375.4 (15.1)	32.3 (3.0)
Plasticulture With row Cover	69.0 (3.2)	290.9 (20.3)	24.3 (3.7)
Strip tillage No row cover	44.0 (2.5)	176.9 (8.7)	7.5 (4.6)
Strip tillage With row cover	49.8 (9.3)	182.2 (23.4)	4.5 (2.1)
Row cover effect	$p = 0.47$; 1,6	$p = 0.07$; 1,6	$p = 0.09$; 1,6
Tillage effect	$p = 0.03$; 1,3	$p = 0.01$; 1,3	$p = 0.02$; 1,3
Interaction	$p = 0.06$; 1,6	$p = 0.05$; 1,6	$p = 0.40$; 1,6

Table 4. Mean number harvested cantaloupe, 'Athena,' fruit (SE) in various cull classes grown in strip tillage or plasticulture plots with and without row covers at the UK Horticultural Farm, 2013

Treatment	Number of Insect Damaged Fruit	Number of Poorly Pollinated Fruit	Percent Insect Damaged Fruit
Plasticulture No row cover	7.5 (3.0)	1.25 (0.5)	8.9 (3.3)
Plasticulture With row Cover	8.8 (2.7)	0.5 (0.5)	12.3 (3.4)
Strip tillage No row cover	1.3 (0.6)	0.0 (0.0)	2.7 (1.3)
Strip tillage With row cover	0.5 (0.5)	1.0 (0.7)	0.8 (0.8)
Row cover effect	$p = 0.90$; d.f.= 1,6	$p = 0.84$; d.f.= 1,6	$p = 0.70$; d.f.= 1,6
Tillage effect	$p = 0.05$; d.f.= 1,3	$p = 0.32$; d.f.= 1,3	$p = 0.06$; d.f.= 1,3
Interaction	$p = 0.64$; d.f.= 1,6	$p = 0.19$; d.f.= 1,6	$p = 0.12$; d.f.= 1,6

Financial Comparison of Organic Potato Production Using Different Integrated Pest Management Systems

Sean Clark and Janet Meyer, Berea College Agriculture and Natural Resources Program

Introduction

Potatoes are one of the least expensive fresh vegetables to buy, though organic price premiums can be relatively high, as much as 80% or more than conventional retail prices (Lin et al. 2008). Producing organic potatoes therefore can be profitable for market gardeners and small farmers selling direct to customers, even when yields are low and input costs high, as is often reported (e.g. Mäder et al 2002, Maggio et al. 2008, Varis et al. 1996).

Scaling up small-scale, organic potato production can be risky, in large part due to weeds, insects, and diseases, and the limited management options and/or high costs. An organic grower seeking to sell potatoes to wholesale distributors or institutional consumers, like schools or hospitals, cannot afford to depend exclusively on labor-intensive, market-gardening pest control practices, such as hand-cultivating weeds or hand-picking Colorado potato beetles (*Leptinotarsa decemlineata*). Less labor-intensive production practices, through mechanization and other technologies, are necessary for economic viability. Here we report the results of field trials comparing the cost-effectiveness and practicality of four pest management systems for growing organic potatoes to sell through regional wholesale markets.

Materials and Methods

In 2010 a 0.8-acre, transitional organic field with silty loam soil was planted with two potato cultivars under four different organic pest management systems (0.10 acre for each cultivar X system combination). The four systems were: 1) clean-cultivated with hilling; 2) clean-cultivated with hilling followed by straw mulch; 3) raised beds with white plastic mulch; and 4) raised beds with white plastic mulch and floating row covers (Agribon 15). Approved fertilizer (NatureSafe, 13-0-0) was applied at planting to provide 125 lbs of N per acre.

Potatoes were planted on April 29. Due to an extreme rain and severe flooding of the site several days after planting, all "clean-cultivated" plots were deemed a total loss. The field received over eight inches of rain in 48 hours (May 1-3, 2010) and was washed out by substantial surface runoff from higher elevations. The plots on raised beds with plastic mulch survived relatively intact.

'The raised beds covered in white plastic mulch were on 6-ft centers with two rows per bed spaced 2 ft apart. They were hand planted through holes in the plastic, made with a water wheel, to a depth of about 4 to 6 inches at 1-ft spacings within the row. Beds were prepared with a tractor-mounted bed shaper and plastic-mulch layer with drip irrigation installed as a single line down the center of each bed. The cultivars were 'Désirée' and 'Peanut.' All variable production costs (labor and material), yields, and returns were recorded throughout the production, marketing and sales period. Fixed costs per-acre were estimated based on equipment, land and storage.

In addition to weeds, Colorado potato beetle was anticipated to be the most important pest to manage and was therefore monitored with weekly scouting. Economic thresholds of two larvae per plant or 0.5 adult per plant (Dwyer et al. 2001) were used to justify a spinosad treatment (Entrust® SC). The scouting data indicated that the floating row covers did protect the plants to some degree early in the season, but the peak densities of adult beetles per plant were nearly identical with and without floating row covers. An unanticipated pest, diagnosed by the University of Kentucky Plant Disease Diagnostic Laboratory as black dot disease caused by the fungus *Colletotrichum coccodes*, resulted in extremely poor stands of 'Peanut'.

In 2011, a few changes were made to the trial. In an effort to avoid pathogen contamination from the first-year site, the trial was moved to another transitional organic field on the farm nearly a half mile from the previous site–one also with silty loam soil. The floating-row-cover production system was dropped from the trial due to the high costs (material and labor) and lack of clear benefits. Thus, the trial included three potato production systems: 1) clean-cultivated and hilled; 2) clean-cultivated and hilled followed by straw mulch; and 3) raised beds with plastic mulch. A single cultivar, 'Red Pontiac,' was grown in three 0.10-acre plots. Potatoes in the two clean-cultivated systems were grown in single rows and planted into non-bedded furrows for ease in cultivation and hilling. Because the site had been in grass/legume pasture, we assumed some N credit and only applied 75 lb of N (NatureSafe, 13-0-0). All systems were on drip irrigation.

Seed potatoes were planted in the plastic-mulched raised beds on March 25, but in the other two systems planting could not occur until May 11 due to wet soil. As in in the previous year, heavy rains and poor drainage were a problem early in the season. Standing water was common and the plants were severely affected by charcoal rot, a disease caused by the pathogen *Macrophomina phaseolina* (diagnosed by the University of Kentucky Plant Disease Diagnostic Laboratory). The disease was more severe in the clean-cultivated plots than in the one with plastic-mulched, raised beds.

Based on weekly scouting for Colorado potato beetle and using the thresholds in Dwyer et al. (2001), a single spinosad application was made to the plastic-mulch system, while two were applied to the straw-mulch system, and three to the bare-ground system (Table 1). The additional applications in the latter two treatments were deemed necessary as the number of larvae per plant reached the threshold while plants in the plastic-mulch system, which were planted earlier, were senescing.

Weeds in the plastic-mulch system were managed by cultivating between the plastic beds twice with a rototiller (BCS walk-behind tractor, 12-hp). The other two systems each received two cultivations–once with a tine weeder (Lely USA, Pella, IA) and once using a Williams tool system (Market Farm Implement, Friedens, PA)–and a single hilling. After the second cultivation and hilling, straw was manually applied to the clean-cultivated, straw-mulch system sufficient to cover the soil.

Results and Discussion

Yields

Potato yields were poor to marginal in both years of the trial. We expected weeds and Colorado potato beetle to be the most important pests to manage. However, plant pathogens and excessive wetness were by far the most important factors limiting yield in both years. The only production system demonstrating even minimally acceptable yields was that using raised beds and plastic mulch (Table 1). The plastic mulch, however, was not without some drawbacks. The inability to hill the potatoes resulted in many green tubers that were unmarketable. The plastic mulch also provided an appealing habitat for rodents, which damaged some of the tubers. Finally, although the plastic mulch is financially justifiable because it reduces hand weeding and/or machine cultivation costs, it does generate a significant amount of non-recyclable plastic waste. The floating row cover provided no benefits. In fact, it added material and labor costs and may have reduced yield due the fabric limiting the amount of light reaching the plants.

Costs

We expected higher production costs in this trial compared to the large farms of the western U.S. since we lacked the economy of scale and mechanized field operations. Furthermore, costs of organic insect pest and weed control are generally higher than for conventional pesticide-based methods. Indeed, the costs of production in this trial were considerably higher than those for large-scale production in the western U.S., which are reported to be about $2,000 per acre (Bohl and Johnson 2010; Painter et al. 2010). Our total costs averaged nearly $6,000 per acre (range: $3,807-$7,226) due in large part to high manual labor costs (Table 2).

Though most ground preparation and weed management activities, as well as lifting the tubers at harvest, were accomplished with tractor-driven implements, other activities relied heavily on human labor. Harvesting, cleaning, sorting, storing, and selling the potatoes contributed significantly to manual labor costs–and the greater the yield, the higher the cost. Manual labor costs ranged from 42% to 65% of total costs (Table 3), while in large-scale operations they are less than 10% of total costs (Bohl and Johnson. 2010, Painter et al. 2010).

Using straw mulch in 2011 contributed significantly both to material and labor costs in that system (Table 2). The intended purposes of the straw were to suppress weeds, prevent greening of growing tubers at the soil surface, provide habitat for predators of Colorado potato beetle, minimize soil splashing onto the leaves during rain and conserve moisture during any droughts. A longer-term function of the straw mulch is the addition of organic matter to the soil. Depending on how plastic and straw mulch costs are allocated (pest management vs. soil conservation), total pest management costs (for weeds and Colorado potato beetle) accounted for 10 to 20% of total production costs per acre. The straw mulch added nearly 40% more in costs over simple clean-cultivation-plus-hilling and generated no increase in yield, and at most only a slight reduction in scouting and spraying costs (Table 2). Seed potatoes accounted for 20 to 50% of material input costs and 10 to 15% of total production costs across the systems. Sources for certified organic seed, largely produced in Colorado and Maine, are limited, making acquisition a challenge both logistically and financially.

Based on the costs and yields measured in this trial, the raised bed/plastic mulch system has potential as long as diseases can be managed by: 1) crop rotation; 2) use of well-drained sites; 3) planting later in the season when conditions are dryer and warmer; and 4) readily available pathogen-free, certified-organic seed. The costs and yields recorded for this system can be used to determine a break-even point and assess the feasibility of producing organic potatoes under a range of market conditions. Dividing the yields by the costs of production gives us a break-even point of about $0.75-0.90 per pound (Figure 1). Since these were transitional organic fields and not yet certified, the potatoes were sold through wholesale markets at $0.50-0.75 per pound, which does not quite meet the break-even price. Retail prices for fresh potatoes at the local farmers market during the same period (late summer and fall) were $1.50-2.00 per pound, which would theoretically allow for a reasonable profit, assuming sufficient market demand. Thus, this production system could be sustained by selling retail but not likely via wholesale.

Conclusions

Securing a price of at least $1.20-1.40 would likely be necessary to justify the risk of growing potatoes organically instead of some more profitable and less risky crop. Production costs per pound could be reduced by improving yields and/or investing in equipment to substitute mechanization for manual labor. It's important to note that the pest management systems in this study did not adequately address potato diseases. Clearly, finding reliable means to minimize losses to disease and extreme weather is critical. In summary, this trial demonstrates some of the risks of producing potatoes organically in central Kentucky and provides some estimates of production costs.

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Table 1. Potato yields in organic production trials on the Berea College Farm, 2010-2011.

Cultivar	Production system	Year	Marketable tubers (lbs per acre)
Désirée	Plastic mulch	2010	9,825
Désirée	Plastic mulch + floating row cover	2010	6,534
Peanut	Plastic mulch	2010	2,952
Peanut	Plastic mulch + floating row cover	2010	2,130
Red Pontiac	Clean-cultivated + hilled	2011	1,887
Red Pontiac	Clean-cultivated, hilled + straw mulch	2011	1,694
Red Pontiac	Plastic mulch	2011	6,098

Table 2. Costs of production for potatoes produced organically in transitional organic fields, 2010 and 2011.

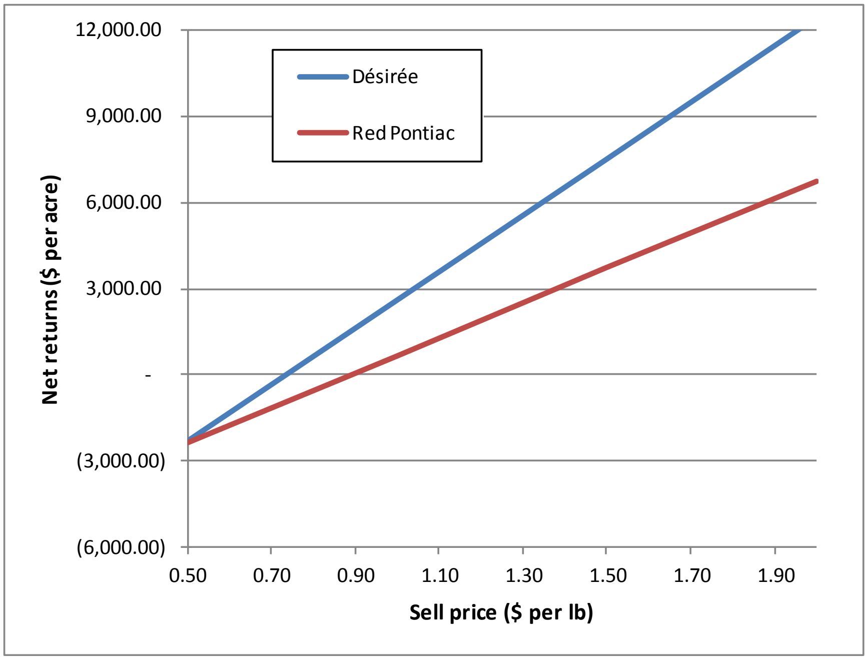
Cultivar	Désirée		Peanut		Red Pontiac		
Production system, year	Plastic mulch, 2010	Plastic mulch + row cover, 2010	Plastic mulch, 2010	Plastic mulch + row cover, 2010	Clean-cultivated + hilled, 2011	clean-cultivated, hilled + straw mulch, 2011	Plastic mulch, 2011
Variable costs ($/acre)							
Manual labor [Z]							
Ground prep and plastic laying	80.00	$80.00	$80.00	$80.00	0.00	0.00	0.00
Cutting seed potatoes	0.00	0.00	0.00	0.00	400.00	400.00	400.00
Planting	280.00	280.00	280.00	280.00	300.00	300.00	300.00
Fertilizing	200.00	200.00	200.00	200.00	0.00	0.00	0.00
Row cover installation	0.00	280.00	0.00	280.00	0.00	0.00	0.00
Straw mulch application	0.00	0.00	0.00	0.00	0.00	850.00	0.00
Hand cultivating/weeding	200.00	200.00	200.00	200.00	0.00	0.00	0.00
Scouting and spraying	160.00	200.00	160.00	200.00	550.00	400.00	130.00
Harvesting	1600.00	1065.04	481.18	347.19	307.58	276.12	993.97
Cleaning, sorting, storing, and selling	1970.00	1306.80	590.40	426.00	377.40	338.80	1219.60
Plastic removal and disposal	240.00	240.00	240.00	240.00	0.00	0.00	240.00
Manual labor subtotal	4730.00	3851.84	2231.58	2253.19	1934.98	2564.92	3283.57
Machine operation [Y]							
Ground preparation and plastic laying	160.00	160.00	160.00	160.00	30.00	30.00	130.00
Fertilizing	0.00	0.00	0.00	0.00	30.00	30.00	30.00
Cultivation and hilling	100.00	100.00	100.00	100.00	20.00	20.00	50.00
Harvest	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Plastic removal and disposal	160.00	160.00	160.00	160.00	0.00	0.00	160.00
Machine operation subtotal	470.00	470.00	470.00	470.00	130.00	130.00	420.00
Material costs							
Seed potato [X]	730.00	730.00	938.00	938.00	600.00	600.00	600.00
Fertilizer [W]	450.00	450.00	450.00	450.00	274.00	274.00	274.00
Insecticide [U]	62.00	62.00	62.00	62.00	234.00	156.00	78.00
Irrigation	300.00	300.00	300.00	300.00	300.00	300.00	300.00
Plastic mulch	150.00	150.00	150.00	150.00	0.00	0.00	150.00
Straw mulch	0.00	0.00	0.00	0.00	0.00	1800.00	0.00
Row cover [V]	0.00	390.00	0.00	390.00	0.00	0.00	0.00
Materials subtotal	1692.00	2082.00	1900.00	2290.00	1408.00	3130.00	1402.00
Total variable costs	6892.00	6403.84	4601.58	5013.19	3472.98	5824.92	5105.57
Fixed costs	334.00	334.00	334.00	334.00	334.00	334.00	334.00
Total costs	7226.00	6737.84	4935.58	5347.19	3806.98	6158.92	5439.57

[Z] manual labor costs at $10 per hour
[Y] machine operation at $20 per hour to account for labor, fuel, and maintenance
[X] certified organic with shipping in 2010 and conventional, untreated in 2011
[W] NatureSafe, 13-0-0, 125 lbs N in 2010, 75 lbs N in 2011
[V] floating row cover amortized over two years
[U] Spinosad (Entrust® SC)

Table 3. Percentage of total production costs attributed to manual labor, machine operation and purchased materials, 2010-11.

Production Costs ($/acre)	% of Total Production Costs						
	Plastic mulch, 2010, 'Désirée'	Plastic mulch+row cover, 2010, 'Désirée'	Plastic mulch, 2010, 'Peanut'	Plastic mulch+row cover, 2010, 'Peanut'	Clean-cultivated + hilled, 2011, 'Red Pontiac'	clean-cultivated, hilled + straw mulch, 2011, 'Red Pontiac'	Plastic mulch, 2011, 'Red Pontiac'
Manual Labor	65	57	45	42	51	42	60
Machine Operation	7	7	10	9	3	2	8
Materials	23	31	38	43	37	51	26

Figure 1. Net returns for potatoes produced organically on raised beds with plastic mulch at sell prices from $0.50 to $2.00 per pound. Break-even prices were within the range of $0.75 and $0.90 per pound.



Effect of Municipal Refuse Compost and Chicken Manure Applications on Kale and Collard Green Yields and Quality

George Antonius, Eric Turley, Regina Hill, Division of Environmental Studies, Kentucky State University; and John Snyder, Department of Horticulture, University of Kentucky

Introduction

In the United States, about 317 million tons of animal manure is produced annually from about 238,000 animal feeding operations [1] and nearly 90% of about 11 million tons of poultry litter produced annually is applied as fertilizer. [2, 3] The rapid growth in the poultry industry has resulted in significant manure generation. [4] Chicken manure (CM) contains all essential plant nutrients and has been documented as an excellent fertilizer. [5] In addition, the United States produces nearly 15 million dry tons of municipal sewage sludge (SS) each year. [6] The use of CM and SS as farm soil amendments provides a constructive means of waste disposal and a viable method for improving soil fertility and physical properties. [7] Using SS has shown promise for some field crops (e.g., maize, sorghum, and forage grasses) and vegetables (e.g., lettuce, cabbage, beans, potatoes, and cucumbers). [8]

The effects of organic soil amendments on the antioxidant contents of plants have received very little attention by scientists. Most studies have focused only on crop yield and soil properties after the addition of organic amendments, with little attention to crop nutritional composition. Vegetables contain numerous bioactive compounds known as "phytochemicals." Phenolic compounds are the largest category of phytochemicals and the most widely distributed in the plant kingdom. Many of these compounds are antioxidants. [9] Ascorbic acid (vitamin C), also an antioxidant, is the most important vitamin in fruits and vegetables for human nutrition. More than 90% of the vitamin C in human diets is supplied by fruits and vegetables.

The main objective of this study was to assess the impact of soil amendment with SS and CM on kale and collard green marketable yields, total phenols and ascorbic acid contents.

Materials and Methods

The study was conducted during the summer of 2012 on a Lowell silty-loam soil (2.5% organic matter, pH 6.7) on the Kentucky State University Research Farm, Franklin County, Kentucky. The experimental design consisted of a randomized complete block design replicated three times and included three soil treatments, amendment with SS CM, or unamended soil (no mulch-NM), and two crops, kale and collard greens. The soil in six plots was mixed with SS obtained from the Metropolitan Sewer District, Louisville, KY, and at 15 tons/A on a dry weight basis. Six plots were mixed with CM obtained from the Department of Animal and Food Sciences of the University of Kentucky in Lexington at 15 tons/A on a dry weight basis. The SS and CM were tilled into the topsoil to a depth of six inches. The native soils in six plots were used as a no-mulch control treatment (roto-tilled bare soil) for comparison purposes.

The plots were hand transplanted on 24 May 2012 with 45-day old kale (*Brassica oleracea* cv. Winterbor) and collard greens (*Brassica oleracea* cv. Top Bunch) seedlings. Plants were spaced 16 inches apart in rows two feet apart. At harvest, five representative plants from each plot were collected at random from each of the 18 field plots (six replicates for each soil treatment) and categorized as U.S. No.1, U.S. Commercial, or unclassified grades (plants that did not meet the other two grades) according to the USDA Standards grades for kale [10] and collard greens [11].

Representative kale and collard leaf samples (20 g) were ground and treated chemically to extract phenolic compounds and vitamin C. The concentrations of these compounds were measured. Soil pH, organic matter percent, and nitrogen, phosphorus, potassium, calcium, magnesium and zinc levels were also determined. Yield, quality, total phenols, ascorbic acid, and soil parameters tested under the three soil management practices were statistically analyzed using the ANOVA procedure. Means were compared using Duncan's multiple range test.

Results and discussion

The number of U.S. No. 1 collard plants was significantly greater in CM and SS mixed soil compared to NM soil, whereas the number of unclassified plants was greater in NM soil compared to the other two soil treatments (Figure 1, upper graph). The total yield of U.S. No. 1 collard greens from the CM-mixed soil was not significantly different from that obtained from SS-mixed soil but had a greater yield than that of the NM soil (Figure 1, lower graph). The numbers of U.S. No. 1 kale plants obtained from SS- and CM-amended soil were also greater compared to the NM soil (Figure 2, upper graph). The total yield of kale from the CM-amended soil was significantly greater than the total yield from the SS-treated soil. The total yield of kale classified as commercial grade was greater in the NM treatment compared to the CM and SS treatments (Figure 2, lower graph). Overall, collard greens and kale yields obtained from CM- and SS-amended soils were greater than the yields obtained from NM soil (Figure 3). These increases in U.S. No. 1 and total collard green and kale yields from CM and SS treatments might be due to improved soil fertility, nutrient retention, soil porosity, and water-holding capacity associated with the addition of soil amendments. Increased crop yields are often attributed to increased organic matter content and improvements in the physical properties of the soil such as increased aggregate stability, increased moisture holding capacity and reduced soil bulk density. The effects on yield of amending native soils with compost are also derived from availability of nutrients in the compost. [12]

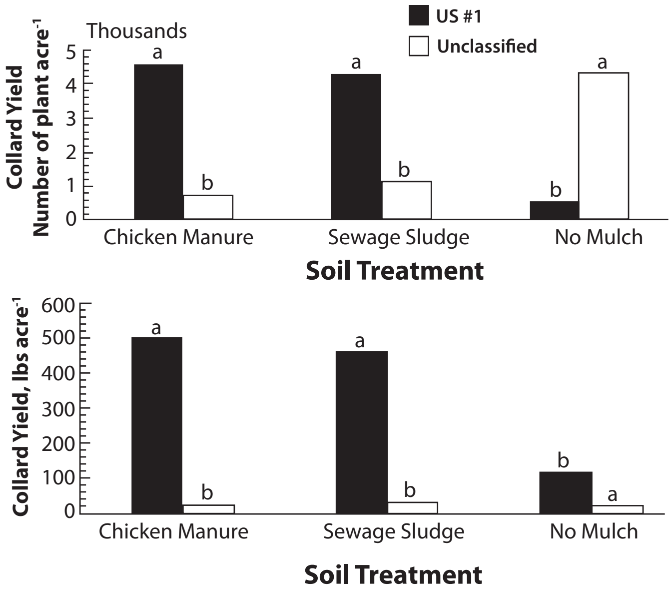


Figure 1. Yield of collard expressed as number of plants (upper graph) and lbs acre^{-1} (lower graph) grown under three soil management practices. Bars accompanied by different letter(s) in each class are significantly different ($P \leq 0.05$) using Duncan's multiple range test.

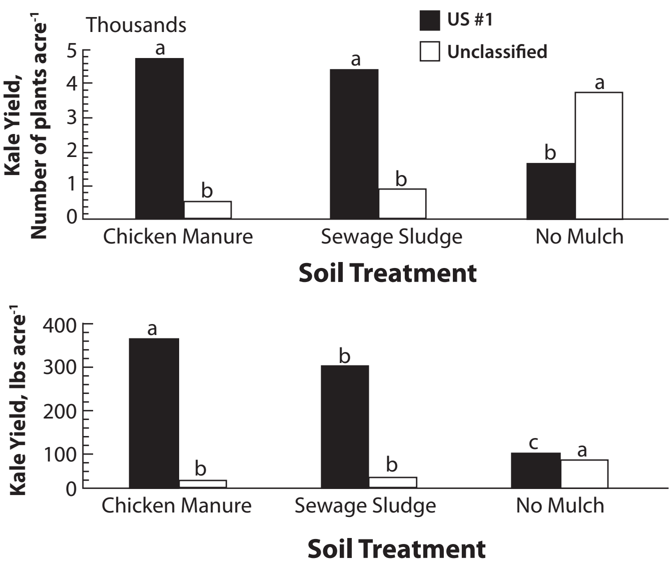


Figure 2. Yield of kale expressed as number of plants (upper graph) and lbs acre^{-1} (lower graph) grown under three soil management practices. Bars accompanied by different letter(s) in each class are significantly different ($P \leq 0.05$) using Duncan's multiple range test.

The concentrations of total phenols were significantly greater (400 and 350 µg g-1 fresh weight) in collard leaves of plants grown in the CM and SS treatments, respectively, compared to plants grown in the NM soil (270 µg g-1 fresh weight) (Figure 4). Similarly, concentrations of total phenols in kale leaves of plants grown in NM (410 µg g-1 fresh weight) were significantly lower than in plants grown in CM and SS amended soils (580 and 520 µg g-1 fresh fruit, respectively).

Ascorbic acid concentrations in the leaves of collard and kale plants grown in NM soil were lower compared to those

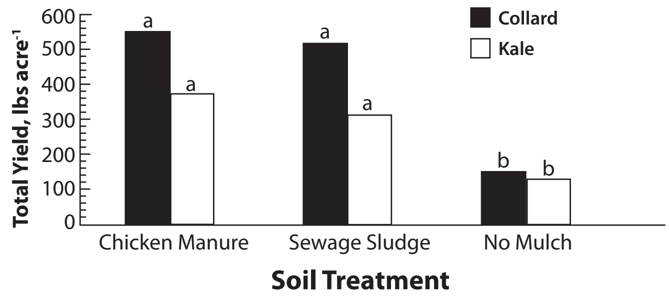


Figure 3. Yield of collard and yield of kale grown under three soil management practices. Bars accompanied by different letter in each crop are significantly different ($P \leq 0.05$) from each other using Duncan's multiple range test.

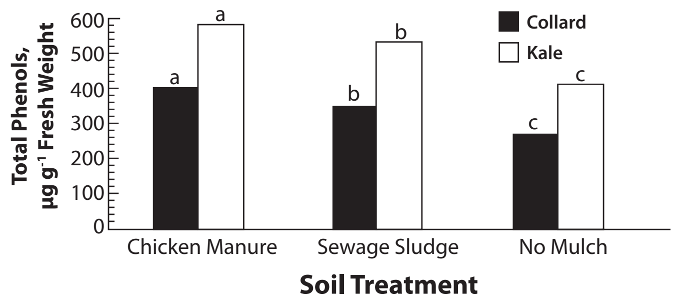


Figure 4. Concentrations of total phenols in collard and kale plants grown under three soil management practices. Bars for each crop accompanied by the same letter are not significantly different ($P \leq 0.05$) using Duncan's multiple range test.

in the plants grown in CM- and SS-amended soils. Ascorbic acid concentrations in collards grown in soil amended with CM and SS were not significantly different, though they were greater than that found in plants grown in NM soil (Figure 5). In contrast, ascorbic acid concentrations differed between the CM and SS treatments for kale. Regardless of soil treatments, total phenols and ascorbic acid concentrations were significantly ($P<$ 0.05) greater in kale than in collard (Figure 6).

Considerable emphasis has been placed on the effect of nitrogenous fertilizers on crop nutritional value. We investigated the chemical and physical properties of the three soil treatments used in this study that might explain variability among treatments and the impact on yield, phenols and ascorbic acid con-

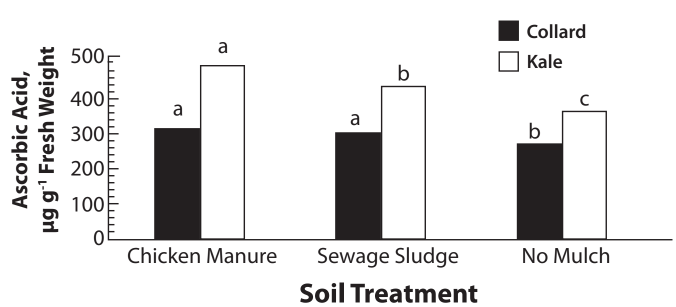


Figure 5. Concentrations of ascorbic acid in collard and kale plants grown under three soil management practices. Bars for each crop accompanied by the same letter are not significantly different ($P \leq 0.05$) using Duncan's multiple range test.

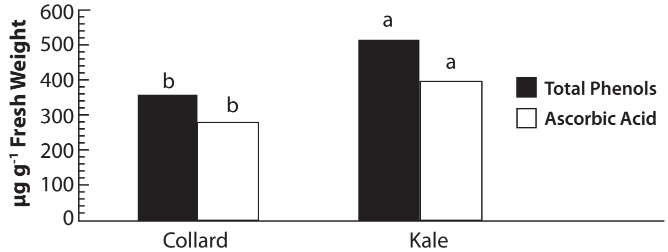


Figure 6. Overall concentrations of total phenols and ascorbic acid (in collard greens and kale grown under three soil management practices. Bars for each crop accompanied by the same letter are not significantly different ($P \leq 0.05$) using Duncan's multiple range test.

tents of kale and collard green grown with CM and SS. The CM treatment contained 6.4% organic matter (OM), whereas, the SS treatment contained 4.1% OM compared to 2.6% in the NM soil (Table 1). Concentrations of total nitrogen in soil amended with CM and SS were greater (0.32 and 0.26%, respectively) compared to 0.20% nitrogen content in the NM soil. Guertal and Edwards [16] found that collard yield was increased with increasing rates of soil nitrogen application. This might explain the increased yield of collard greens and kale grown in CM- and SS-amended soils compared to NM soil as indicated in Figure 3. Additional research on the impact of CM and SS on crop yield and crop nutritional composition of plants grown under these practices is under investigation by our research team.

Conclusion

SS and CM were mixed with native soil to study their impact on kale and collard green yields and quality. Plants grown in CM and SS amended soil produced the greatest number of U.S. No. 1 grade collard and kale greens compared to NM soil. Across all treatments, concentrations of ascorbic acid and phenols were generally greater in kale than in collards. CM and SS enhanced total phenols and ascorbic acid contents of kale and collard compared to NM soil.

Acknowledgments

We thank Dr. Tim Coolong for his assistance in providing kale and collards seedlings, and Mr. Hank Schweickart for preparing the field plots. This investigation was supported by a grant from USDA/NIFA to Kentucky State University under agreement No. KYX 10-13-48P.

Table1. Chemical characterization of chicken manure and sewage sludge amended soils, and no-mulch soil used for growing collard and kale at Kentucky State University Research Farm, Franklin County, Kentucky, 2013.

Soil treatment	Soil pH	P (lbs/A)	K (lbs/A)	Ca (lbs/A)	Mg (lbs/A)	Zn (lbs/A)	Total N (%)	OM (%)
CM	7.01 b	1210 a	480 a	11525 b	598 a	62 b	0.32 a	6.37 a
SS	7.14 a	1164 b	152 c	17105 a	531 b	65 a	0.26 b	4.13 b
NM	6.55 c	919 c	270 b	10535 c	622 a	45 c	0.20 c	2.55 c

Each value in the table is an average of six samples. Values within a column for each parameter followed by the same letter(s) are not significantly different ($P \leq 0.05$).

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Asparagus Variety Evaluation

Lucas Hanks, Shawn Wright, Tim Coolong, and John Snyder, Department of Horticulture

There are currently about 65 acres of asparagus being grown in Kentucky. Since asparagus plantings are typically harvested for 20 or more years it is important to evaluate newer varieties to enable informed planting decisions. Eight varieties of asparagus are being grown in a long-term replicated trial to assess their yields under Central Kentucky growing conditions.

Materials and Methods

One-year old crowns were purchased from Walker Brothers Plant Company and transplanted on 31 May 2011 at the UK Horticulture Research Farm in Lexington. Six-inch-deep furrows were dug in planting rows and crowns were planted at a 14 inch in-row spacing, with five feet between rows. This spacing is equivalent to a planting density of 5,808 plants per acre. Varieties are replicated four times in a randomized complete block design. Plot rows consist of 10 plants of a particular variety, for a total of 40 plants of each variety.

Four hundred pounds of 19-19-19 fertilizer per acre were applied in-furrow prior to transplanting. Drip irrigation was installed to aid plot establishment for the first growing season. Prior to spear emergence, Sandea herbicide was applied to the field at a rate of 1 oz/A. No asparagus spears were harvested during the 2011 growing season.

In early spring 2012, prior to spear emergence, plant residues were mowed off. Two hundred pounds per acre of 19-19-19 fertilizer were broadcast on the plot. Chateau herbicide was applied at a rate of 6 oz/A. After spear emergence in late spring, Sandea herbicide was applied at a rate of 1 oz/A, and again in mid-summer at the same rate. Again, no asparagus was harvested.

Table 1. Asparagus yield results, 2013.

Variety	Yield per plant[1] (lb.)	Yield per acre[2] (lb.)	Weight per spear[3] (oz.)	No. Spears per plant[4]	Spear width[3] (in.)
Jersey Supreme	0.54 a[5]	3136	0.39	22.2	0.39
Grande	0.53 a	3078	0.42	20.1	0.39
Atlas	0.50 ab	2904	0.43	18.6	0.41
Jersey Giant	0.43 abc	2497	0.36	20.3	0.36
Apollo	0.38 bcd	2207	0.38	15.9	0.38
UC-157	0.34 cd	1975	0.35	15.7	0.36
Jersey Knight	0.32 cd	1859	0.36	14.2	0.36
Purple Passion	0.24 d	1394	0.43	8.9	0.37

1 Average yield per plant for the entire season
2 Season-long average yield per plant x 5808 plants per acre
3 Average wt. per spear for the entire season
4 Average season-long wt. per plant divided by average season-long weight per spear
5 Means in column followed by same letter are not significantly different (Waller-Duncan Multiple-Range Test ($P \leq 0.05$)

On 28 March 2013, plant residues were mowed and an herbicide mixture of Gramoxone at 4 pt/A and Chateau at 6 oz/A were applied to the plot. At this time 19-19-19 granular fertilizer was broadcast at a rate of 100 pounds of nitrogen per acre. Spears initially emerged on 10 April. Harvest began on 13 April and continued until 5 June. Spears were harvested two or three times per week. Marketable spears, those 5 to 12 inches in length, were harvested and measured for weight and diameter. During this time weeds were controlled by hand cultivation as needed. On 15 June, Select Max herbicide was applied at a rate of 16 oz/A to control perennial grasses. Carbaryl 4L was applied on 5 May at a rate of 1 oz/A to control asparagus beetles. This single application suppressed insect pests and no other pesticides were applied

Results and Discussion

Harvest data for the eight asparagus varieties can be found in Table 1. There were no significant differences in spear width among varieties. Jersey Supreme, Grande and Atlas were the top performers for the first harvest year. Purple Passion yielded the least amount of marketable spears, nevertheless its unique coloration may allow for increased marketability. Overall, yields for all varieties were lower than expected, but crown productivity should increase over the next few growing seasons.

Acknowledgements

The authors would like to thank Paul Dengel and Joseph Tucker for their hard work and assistance in this evaluation. Funding for this project was provided by a grant from the Agricultural Development Board through the Kentucky Horticulture Council.

Appendix A: Sources of Vegetable Seeds

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

AAS .... All America Selection Trials, 1311 Butterfield Road, Suite 310, Downers Grove, IL 60515
AS/ASG .... Formerly Asgrow Seed Co., now Seminis (see "S" below)
AC.................. Abbott and Cobb Inc., Box 307, Feasterville, PA 19047
AG.................. Agway Inc., P.O. Box 1333, Syracuse, NY 13201
AM................. American Sunmelon, P.O. Box 153, Hinton, OK 73047
AR.................. Aristogenes Inc., 23723 Fargo Road, Parma, ID 83660
AT................... American Takii Inc., 301 Natividad Road, Salinas, CA 93906
B..................... BHN Seed, Division of Gargiulo Inc., 16750 Bonita Beach Rd., Bonita Springs, FL 34135
BBS................ Baer's Best Seed, 154 Green St., Reading, MA 01867
BC.................. Baker Creek Heirloom Seeds, 2278 Baker Creek Rd., Mansfield, OH 65704
BK.................. Bakker Brothers of Idaho Inc., P.O. Box 1964, Twin Falls, ID 83303
BR.................. Bruinsma Seeds B.V., P.O. Box 1463, High River, Alberta, Canada, TOL 1B0
BS................... Bodger Seed Ltd., 1800 North Tyler Ave., South El Monte, CA 91733
BU.................. W. Atlee Burpee & Co., P.O. Box 6929, Philadelphia, PA 19132
BZ.................. Bejo Zaden B.V., 1722 ZG Noordscharwoude, P.O. Box 9, The Netherlands
CA.................. Castle Inc., 190 Mast St., Morgan Hill, CA 95037
CF.................. Cliftons Seed Co., 2586 NC 43 West, Faison, NC 28341
CG.................. Cooks Garden Seed, PO Box C5030 Warminster, PA 18974
CH.................. Alf Christianson, P.O. Box 98, Mt. Vernon, WA 98273
CIRT............... Campbell Inst. for Res. and Tech., P-152 R5 Rd 12, Napoleon, OH 43545
CL.................. Clause Semences Professionnelles, 100 Breen Road, San Juan Bautista, CA 95045
CN.................. Canners Seed Corp., (Nunhems) Lewisville, ID 83431
CR.................. Crookham Co., P.O. Box 520, Caldwell, ID 83605
CS.................. Chesmore Seed Co., P.O. Box 8368, St. Joseph, MO 64508
D.................... Daehnfeldt Inc., P.O. Box 947, Albany, OR 97321
DN................. Denholm Seeds, P.O. Box 1150, Lompoc, CA 93438-1150
DR.................. DeRuiter Seeds Inc., P.O. Box 20228, Columbus, OH 43320
EB................... Ernest Benery, P.O. Box 1127, Muenden, Germany
EV.................. Evergreen Seeds, Evergreen YH Enterprises, P.O. Box 17538, Anaheim, CA 92817
EX.................. Express Seed, 300 Artino Drive, Oberlin, OH 44074
EW................ East/West Seed International Limited, P.O. Box 3, Bang Bua Thong, Nonthaburi 1110, Thailand
EZ................... ENZA Zaden, P.O. Box 7, 1600 AA, Enkhuisen, The Netherlands 02280-15844
FED................ Fedco Seed Co., P.P. Box 520 Waterville, ME, 04903
FM................. Ferry-Morse Seed Co., P.O. Box 4938, Modesto, CA 95352
G.................... German Seeds Inc., Box 398, Smithport, PA 16749-9990
GB.................. Green Barn Seed, 18855 Park Ave., Deephaven, MN 55391
GL.................. Gloeckner, 15 East 26th St., New York, NY 10010
GO................. Goldsmith Seeds Inc., 2280 Hecker Pass Highway, P.O. Box 1349, Gilroy, CA 95020
GU................. Gurney's Seed and Nursery Co., P.O. Box 4178, Greendale, IN 47025-4178
HL/HOL......... Hollar & Co. Inc., P.O. Box 106, Rocky Ford, CO 81067
H/HM............ Harris Moran Seed Co., 3670 Buffalo Rd., Rochester, NY 14624, 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.B. 1565, Haifa, Israel
JU................... J. W. Jung Seed Co., 335 High St., Randolf, WI 53957
JS/JSS........... Johnny's Selected Seeds, Foss Hill Road, Albion, MA 04910-9731
KS................... Krummrey & Sons Inc., P.O. 158, Stockbridge, MI 49285
KU.................. Known-you Seed Co., 26 Chung Cheng 2nd Road, Kaushiung Taiwan, 80271
KY.................. Known-You Seed Co., Ltd. 26 Chung Cheng Second Rd., Kaohsiung, Taiwan, R.O.C. 07-2919106
KZ.................. Kitazawa Seed Co., PO Box 13220 Oakland, CA 94661-3220
LI.................... Liberty Seed, P.O. Box 806, New Philadelphia, OH 44663
LSL................. LSL Plant Science, 1200 North El Dorado Place, Suite D-440, Tucson, AZ 85715
MB................. Malmborg's Inc., 5120 N. Lilac Dr., Brooklyn Center, MN 55429
MK................. Mikado Seed Growers Co. Ltd., 1208 Hoshikuki, Chiba City 280, Japan 0472 65-4847
ML................ J. Mollema & Sons Inc., Grand Rapids, MI 49507
MM................ MarketMore Inc., 4305 32nd St. W., Bradenton, FL 34205
MN................ Dr. Dave Davis, U of MN Hort Dept., 305 Alderman Hall, St. Paul, MN 55108
MR................. Martin Rispins & Son Inc., 3332 Ridge Rd., P.O. Box 5, Lansing, IL 60438
MS................. Musser Seed Co. Inc., Twin Falls, ID 83301
MWS............. Midwestern Seed Growers, 10559 Lackman Road, Lenexa, Kansas 66219
NE.................. Neuman Seed Co., 202 E. Main St., P.O. Box 1530, El Centro, CA 92244
NI................... Clark Nicklow, Box 457, Ashland, MA 01721
NU................. Nunhems (see Canners Seed Corp.)
NS.................. New England Seed Co., 3580 Main St., Hartford, CT 06120
NZ.................. Nickerson-Zwaan, P.O. Box 19, 2990 AA Barendrecht, The Netherlands
OE.................. Ohlsens-Enke, NY Munkegard, DK-2630, Taastrup, Denmark
ON................. Osbourne Seed Co., 2428 Old Hwy 99 South Road Mount Vernon, WA 98273
OS.................. Outstanding Seed Co., 354 Center Grange Road, Monaca PA 15061
OLS................ L.L. Olds Seed Co., P.O. Box 7790, Madison, WI 53707-7790

OT .... Orsetti Seed Co., P.O. Box 2350, Hollister, CA 95024-2350
P .... Pacific Seed Production Co., P.O. Box 947, Albany, OR 97321
PA/PK............. Park Seed Co., 1 Parkton Ave., Greenwood, SC 29647-0002
PARA.............. Paragon Seed Inc., P.O. Box 1906, Salinas CA, 93091
PE.................... Peter-Edward Seed Co. Inc., 302 South Center St., Eustis, FL 32726
PF.................... Pace Foods, P.O. Box 9200, Paris, TX 75460
PG................... The Pepper Gal, P.O. Box 23006, Ft. Lauderdale, FL 33307-3006
PL.................... Pure Line Seeds Inc., Box 8866, Moscow, ID
PM.................. Pan American Seed Company, P.O. Box 438, West Chicago, IL 60185
PR .... Pepper Research Inc., 980 SE 4 St., Belle Glade, FL 33430
PT.................... Pinetree Garden Seeds, P.O. Box 300, New Gloucester, ME 04260
R...................... Reed's Seeds, R.D. #2, Virgil Road, S. Cortland, NY 13045
RB/ROB .... Robson Seed Farms, P.O. Box 270, Hall, NY 14463
RC .... Rio Colorado Seeds Inc., 47801 Gila Ridge Rd., Yuma, AZ 85365
RE.................... Reimer Seed Co., PO Box 236, Mt. Holly, NC 28120
RG................... Rogers Seed Co., P.O. Box 4727, Boise, ID 83711-4727
RI/RIS............. Rispens Seeds Inc., 3332 Ridge Rd., P.O. Box 5, Lansing, IL 60438
RS.................... Royal Sluis, 1293 Harkins Road, Salinas, CA 93901
RU/RP/RUP .. Rupp Seeds Inc., 17919 Co. Rd. B, Wauseon, OH 43567
S .... Seminis Inc. (may include former Asgrow and Peto cultivars), 2700 Camino del Sol, Oxnard, CA 93030-7967
SE.................... Southern Exposure Seed Exchange, P.O. Box 460Mineral, VA 23117
SHUM............ Shumway Seed Co., 334 W. Stroud St. Randolph, WI 53956
SI/SG.............. Siegers Seed Co., 8265 Felch St., Zeeland, MI 49464-9503
SIT................... Seeds From Italy, P.O. Box 149, Winchester, MA 01890
SK.................... Sakata Seed America Inc., P.O. Box 880, Morgan Hill, CA 95038
SN................... Snow Seed Co., 21855 Rosehart Way, Salinas, CA 93980
SO .... Southwestern Seeds, 5023 Hammock Trail, Lake Park, GA 31636
SOC................ Seeds of Change, Sante Fe, NM
SST .... Southern States, 6606 W. Broad St., Richmond, VA 23230
ST.................... Stokes Seeds Inc., 737 Main St., Box 548, Buffalo, NY 14240
SU/SS............. Sunseeds, 18640 Sutter Blvd., P.O. Box 2078, Morgan Hill, CA 95038
SV .... Seed Savers Exchange, 3094 North Winn Rd., Decorah, IA 52101
SW.................. Seedway Inc., 1225 Zeager Rd., Elizabethtown, PA 17022
SY.................... Syngenta/Rogers, 600 North Armstrong Place (83704), P.O. Box 4188, Boise, ID 83711-4188
T/TR .... Territorial Seed Company, P.O. Box 158, Cottage Grove, OR 97424
TGS................. Tomato Growers Supply Co., P.O. Box 2237, Ft. Myers, FL 33902
TS.................... Tokita Seed Company, Ltd., Nakagawa, Omiya-shi, Saitama-ken 300, Japan
TT.................... Totally Tomatoes, P.O. Box 1626, Augusta, GA 30903
TW.................. Twilley Seeds Co. Inc., P.O. Box 65, Trevose, PA 19047
UA................... US Agriseeds, San Luis Obispo, CA 93401.
UG .... United Genetics, 8000 Fairview Road, Hollister, CA 95023
US .... US Seedless, 12812 Westbrook Dr., Fairfax, VA 22030
V...................... Vesey's Seed Limited, York, Prince Edward Island, Canada
VL.................... Vilmorin Inc., 6104 Yorkshire Ter., Bethesda, MD 20814
VS .... Vaughans Seed Co., 5300 Katrine Ave., Downers Grove, IL 60515-4095
VTR................. VTR Seeds, P.O. Box 2392, Hollister, CA 95024
WI .... Willhite Seed Co., P.O. Box 23, Poolville, TX 76076
WP .... Woodpraire Farms, 49 Kinney Road, Bridgewater, ME 04735
ZR .... Zeraim Seed Growers Company Ltd., P.O. Box 103, Gedera 70 700, Israel

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