PR-739

University of Kentucky
College of Agriculture, Food and Environment
Agricultural Experiment Station

Fruit and Vegetable

2017 ANNUAL RESEARCH REPORT

Agricultural Experiment Station | Kentucky Tobacco Research and Development Center | Veterinary Diagnostic Laboratory | Division of Regulatory Services | Research and Education Center | Robinson Forest | Robinson Center for Appalachian Resource Sustainability | University of Kentucky Superfund Research Center | Equine Programs

2017 Fruit and Vegetable Crops Research Report

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Acknowledgments

Grants from the Agricultural Development Board through the Kentucky Horticulture Council have allowed an expansion of the field research and demonstration program to meet the informational and educational needs of our growing vegetable and fruit industries. The editors would also like to thank the Kentucky Vegetable Growers Association and the Kentucky State Horticulture Society for providing funds to cover the costs of printing in 2017.

Important Note to Readers

The majority of research reports in this volume do not include treatments with experimental pesticides. It should be understood that any experimental pesticide must first be labeled for the crop in question before it can be used by growers, regardless of how it might have been used in research trials. The most recent product label is the final authority concerning application rates, pre-cautions, 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: Pumpkin from a fungicide and cultivar evaluation at the U.K. Horticultural Research Farm in Lexington, 2017.
Photographer: Callie Hicks

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 2017 Fruit and Vegetable Crops Research Program

John Strang, Horticulture

Fruit and vegetable production continues to show sustained growth in Kentucky. As the industry grows around a diverse collection of marketing tactics (wholesale, farmers markets, CSAs, and direct to restaurants) as well as various production systems, there continues to be a need for applied practical information to support the industry. The 2017 Fruit and Vegetable Crops research report includes results for 16 projects. This year fruit and vegetable research, demonstration plots were conducted in 13 counties in Kentucky: Bath, Boone, Boyle, Breckinridge, Jessamine, Kenton, Laurel, Lewis, Lincoln, Marshal, McCracken, Metcalfe and Shelby. Research was conducted by faculty and staff from the Horticulture and Plant Pathology Departments in the University of Kentucky College of Agriculture, Food and Environment. Faculty and staff of Kentucky State University also contributed to this report.

Variety trials included in this year's publication include bell peppers, blackberries, broccoli, Brussels sprouts, cauliflower, green beans, and haskap berries. Additional research trials include rootstock effects on apple and peach tree growth and yield, small scale equipment to optimize tomato disease management, sustainable production of living organic container-grown kitchen herbs, timing of bark inlay grafting of pawpaw as it affects success rate, parasitoid wasps associated with blackberries bordered by native perennial plants versus pasture borders, an investigation of the impact of Soil-Set®, Grain-Set®, and Liqui-Plex® formulations on hot pepper yield, and evaluation of soil amended with organic manure as it affected antioxidant content of arugula and mustard greens. Evaluation of varieties is a continuing necessity and allows us to provide the most up to date information in communications with vegetable growers. The vegetable variety trial results are the basis for updating the recommendations in our Vegetable Production Guide for Commercial Growers (ID-36). These updates are not based solely on one season's data or location. It is necessary to trial varieties in multiple seasons and if at all possible, multiple locations. We may also collaborate with researchers in surrounding states such as Ohio, Indiana, and Tennessee to discuss results of variety trials they have conducted. 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. Following 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 1 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. 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 whether the yields of the varieties are statistically different. Two varieties may have average yields that are numerically different, but statistically are the same. For example, if tomato variety 1 has an average yield of 2,000 boxes per acre, and variety 2 yields 2,300 boxes per acre, one would assume that variety 2 had a greater yield. However, just because the two varieties had different average yields does not mean that they are statistically or significantly different. In the tomato example, variety 1 may have consisted of four plots with yields of 1,800; 1,900; 2,200; and 2,100 boxes per acre. The average yield would then be 2,000 boxes per acre. Tomato variety 2 may have had four plots with yields of 1,700; 2,500; 2,800; and 2,200 boxes per acre. The four plots together would average 2,300 boxes per acre. The tomato varieties have plots with yield averages that overlap, and therefore would not be considered statistically different, even though the average per acre yields for the two varieties appear to be quite different. This example also demonstrates variability. Good varieties are those that not only yield well but have little variation. Tomato variety 2 may have had yields similar to variety 1 but also 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, they are significantly different; however, if they share even one letter, 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 followed by the letters "abc" would be different from yield data followed by "efg."

When determining statistical significance we typically use a P value of 0.05. In this case, P stands for probability. If two varieties are said to be different at $P < 0.05$, then at least 95 percent of the time those varieties will be different. If the P value is 0.01, then 99 percent of the time those varieties will be different. Different P values can be used, but typically $P < 0.05$ is considered standard practice for agricultural research.

This approach 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 Fruit and Vegetable Demonstrations

Ty Cato, Horticulture

Introduction

In 2017, three on-farm commercial vegetable production demonstrations were conducted in the north-central part of the state in Breckinridge, Kenton, and Shelby Counties. These locations were chosen due to their proximity to both Jefferson County and the Cincinnati/Northern Kentucky areas, where the demand for locally produced vegetable crops has increased in the past years. One grower in each of the three counties was chosen to participate in the demonstration program. The Breckinridge County grower produced 1.24 acres of certified organic squash, tomatoes, peppers, and eggplant for wholesale and farmers markets. The Kenton County grower produced 0.31 acres of certified organic mixed vegetables for farmers markets. The Shelby County grower produced 0.92 acres of strawberries for wholesale, U-pick, and farmers markets.

Table 1. Profitability of the three demonstrations

	Breckinridge Organic (mixed production)	Kenton Organic (mixed production)	Shelby (strawberry)
Plot Acreage	1.24	0.31	0.92
Inputs			
Plants and Seeds	$2300.00	$823.00	$3456.00
Fertilizer	1000.00	N/A	100.00
Plastic Mulch	270.00	42.00	150.00
Drip Tape	180.00	28.00	100.00
Irrigation Fittings and Fertilizer Injector	200.00	N/A	
Herbicide	N/A	N/A	60.00
Insecticide	N/A	N/A	N/A
Fungicide	N/A	N/A	N/A
Water	3000.00	N/A	300.00
Manual Labor	5500.00	2366.00	500.00
Machine Labor (Fuel cost)	600.00	1134.00	180.00
Marketing	N/A	N/A	N/A
Miscellaneous	N/A	200.00	400.00
Total Expenses	13050.00	4593.00	5546.00
Yield	*	*	
Revenue	26000.00	6022.00	3800.00
Profit	$12950.00	$1429.00	-$1746.00

*Yields vary for mixed production systems

Materials and Methods

The growers were provided with plastic mulch and drip tape for up to 1 acre of production. The University of Kentucky horticulture department also provided a bed-shaper/plastic layer, a 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, 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 issues needing attention. The extension associate was also involved in planning and preparing field days to display commercial vegetable production techniques to other growers interested in producing vegetables.

Two of the three plots were USDA certified organic and the other was managed conventionally. Conventional management included the use of synthetic fertilizers and pesticides. The three demonstrations used raised beds covered with black plastic mulch with drip tape buried beneath the plastic. The height of the beds ranged from 3 to 6 inches and the black plastic mulch was 4 feet wide and 1 mil in thickness. The black plastic provides transplants with the heat that they need early in the growing season. The drip tape was 8 mil with emitters spaced every 12 inches, with a flow rate of 0.45 gallons per minute, per 100 feet.

Results and Discussion

The 2017 growing season presented some problems for commercial producers in north-central Kentucky. The Breckinridge County plot had minor weed pressure that was mitigated with mechanical cultivation. The Kenton County plot, which was located on a flood plain, was established unusually late due to soil that was too saturated to work until early to mid-May. Weeds were also an issue but were dealt with by means of mechanical cultivation. Periods of heavy rain in July promoted the development of Septoria leaf blight on tomatoes in the Kenton and Breckinridge County plots. The disease spread rapidly in the warm, wet weather, as it spreads by splashing rain. Combined with early blight, Septoria severely damaged tomato foliage, thus limiting yields.

Powdery mildew became a problem later, affecting summer squash and cucumbers primarily at both the Breckinridge and Kenton County plots. Most heavily damaged summer squash plantings were removed and replanted because of rapid plant growth and quick fruit set. As powdery mildew is expected in cucurbits most years in Kentucky, a preventative fungicide program should have been implemented shortly after transplanting, but the organic growers chose not to use OMRI approved fungicides. An example of such a fungicide program can be found in the cucurbit chapter of the *Commercial Vegetable Production Guide* (ID-36). Bacterial wilt of cucurbits was also present in both the Breckinridge and Kenton County plots. The diseased plants were removed from the field to prevent any additional spread of the disease. Bacterial wilt is vectored by cucumber beetles; therefore preventative management of these insects is essential for cucurbit production in Kentucky. Certified organic growers have had success using floating row covers to exclude the insects from the crops.

The strawberry plot in Shelby County experienced heavy weed pressure both between the beds and in the planting holes. This weed pressure plus spring rains and frost substantially reduced the strawberry yield, resulting in negative profits for the grower. Plasticulture strawberry production success requires a high level of grower management skill and decent weather in early spring and during harvest because of the high input costs. Most experienced plasticulture strawberry growers did not do well this season because of frost losses and rain during harvest that resulted in fruit decay despite good spray programs.

Profitability of the three demonstrations varied greatly. Diminished yields due to biotic factors contributed to negative profits for the Shelby County strawberry grower (Table 1). Initial start-up costs for the conventional strawberry grower greatly reduced profitability as well. These initial costs were for one-time investments (e.g. equipment) that could be amortized over the life of the product, thus leading to increased profits in the years to come. The most profitable plots, based on size and return, were the Breckinridge and Kenton County certified organic operations.

Fruiting Characteristics of Three Primocane-fruiting Blackberry Selections at Kentucky State University

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Introduction

In Kentucky, over 670 farms grow berry crops, including blackberries, valued at over $2,600,000 annually (Census of Agriculture, 2012). Kentucky's climate is well suited for blackberry production.

Two cane types exist within brambles: primocanes (or first-year canes), which are usually vegetative, and floricanes, which are the same canes, flowering and producing fruit the next growing season. 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. These flower and fruit from mid-summer until frost, depending on temperature, plant health, and the location in which they are grown. Growers can reduce pruning costs by mowing canes in late winter to obtain a primocane crop only; this also provides anthracnose, cane blight, and red-necked cane borer control without pesticides. Relying only on a primocane crop also avoids potential winter injury of floricanes. However, later ripening blackberries are more prone to spotted wing drosophila infestations and growers that are marketing the berries will need to maintain a spray program.

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). 'Black MagicTM' is a thorny, primocane-fruiting selection suited for home growers and on-farm sales (Clark et al., 2014). 'Prime-Ark®45,' released in 2009 for commercial use, has improved heat tolerance and shipping traits compared to previous selections (Clark and Perkins-Veazie, 2011). 'Prime-Ark® Freedom' was the first thornless primocane-fruiting blackberry and produces large fruit but displays inferior shipping traits compared to 'Prime-Ark® 45' (Clark, 2014). 'Prime-Ark® Traveler,' also a thornless primocane-fruiting selection, has improved storage and shipping characteristics compared to 'Prime-Ark® Freedom' and is also recommended for commercial production (Clark and Salgado, 2016). In fall 2017, APF-205T was released as 'Stark® Black Gem®.'

Summer temperatures above 85°F can greatly reduce fruit set, size, and quality on primocanes, which results in substantial reductions in yield and fruit quality (Clark et al., 2005; Stanton et al., 2007). The objective of this study was to determine if 'Prime-Ark® Traveler' is superior to 'Stark® Black Gem®' (APF-205T) and the advanced selection APF-268 in terms of yield and fruit quality under Kentucky growing conditions. Here we report results from the trial in its first year of fruit production.

Materials and Methods

In May 2016, a primocane-bearing blackberry trial was planted at the KSU Research and Demonstration Farm on certified organic land. The planting contained the selections 'Prime-Ark® Traveler,' 'Stark® Black Gem®,' and APF-268, which are all primocane-fruiting selections from the University of Arkansas. Plants were arranged in a completely randomized design, with four replicate plots each containing five plants of 'Prime-Ark® Traveler,' 'Stark® Black Gem®,' or APF-268 (total of 20 plants of each selection) in 10-foot plots with a plant spacing of 2 feet. This trial was managed with organic practices following the National Organic Program standards. A combination of cultivation, hand weeding, and straw mulch was used for weed control. Drip irrigation was used as needed. Plots were fertilized with NatureSafe 10-2-8 fertilizer (Griffin Industries LLC, Cold Spring, KY) at 100 lb of N per acre. Primocanes were tipped on all selections at one meter beginning in early June to promote lateral branching and flowering. Ripe fruit were harvested twice a week, from late June through mid-October. Analysis of variance and least significant difference means separation were performed using CoStat Statistical Software (CoHort Software, Monterey, CA).

Results and Discussion

Fruit were harvested from late June until mid-October (Table 1). Floricane harvest concluded at the end of July, at which point primocane harvest began. Growing conditions in 2017 were hot; 49 out of 122 days from June through September had a daily high temperature above 85°F. The average high for July was 84.9°F. The high temperatures may have reduced fruit set, size, and quality on primocanes.

In 2017, no significant differences were found among the three selections in berry size for the floricane crop. At 474 lb/acre, APF-268 had a significantly greater yield than the other two selections; 'Prime-Ark® Traveler' showed a trend to have a higher yield than 'Stark® Black Gem®'. Primocane fruit size varied significantly; 'Stark® Black Gem®' and APF-268 had a larger fruit size than 'Prime-Ark® Traveler' (4.8 g vs 3.4 g). APF-268 had significantly higher primocane yield (2420 lb/acre)

Table 1. 2017 yields and berry weights for 'Prime-Ark® Traveler', 'Stark® Black Gem®', and APF-268 at the Kentucky State University Harold R. Benson Research and Demonstration Farm, Frankfort, Kentucky.

	Floricane				Primocane			
Selection	Fruit Weight (g)		Yield (lb/acre)		Fruit Weight (g)		Yield (lb/acre)	
'Stark® Black Gem®'	3.29	a[1]	29	b	4.82	a	1745	b
'Prime-Ark® Traveler'	2.83	a	176	b	3.42	b	1274	c
APF-268	2.78	a	474	a	4.83	a	2420	a

[1] Numbers followed by the same letter are not significantly different (least significant difference $P = 0.05$)

whereas 'Prime-Ark® Traveler' had the lowest yield (1274 lb/acre) and 'Stark® Black Gem®' was between the two.

The University of Arkansas Blackberry Breeding Program recommends that commercial producers plant 'Prime-Ark® Traveler' due to its superior shipping and storage qualities. Due to softer fruit, 'Stark® Black Gem®' is recommended for pick-your-own (also called U-pick) and on-farm sales as well as for home gardens. Year-to-year yield characteristics will need to be evaluated further; however, the first-year data suggest that 'Stark® Black Gem®' has large fruit and yields well in Kentucky and should be considered by growers interested in producing primocane fruiting blackberries for markets with little shipping.

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Erect Thornless Blackberry Cultivar Trial

Dwight Wolfe, June Johnston, and Ginny Travis, Horticulture

Introduction

Blackberries are an important small fruit crop in Kentucky. Demand for this fruit at farmers' markets is strong and generally exceeds supply. Producers are looking for better cultivars that are thornless, productive and have berries with good size and flavor. Resistance to orange rust and rosette are also a consideration among growers. Three thornless erect cultivars (Natchez, Osage, and Ouachita) and two selections (A-2434T and A-2491T), all from John Clark's breeding program at the University of Arkansas, are being evaluated at the UKREC, Princeton, Kentucky.

Materials and Methods

Twenty plants each of five cultivars, Natchez, Osage, Ouachita, and two numbered selections, A-2491T and A-2434T were planted in the spring of 2013. One cultivar was allocated to each plot and each of the four rows in this trial contained five plots per row. Plants were spaced 2.5 feet apart within 12.5-foot long plots in rows spaced 18 feet between rows. Cultivars were randomized in a randomized block design with each row being one block. Trickle irrigation was installed, and plants were maintained according to local recommendations (1, 2). Fruit in 2017 were harvested from one to three times per week as needed from June 16 through July 17. Yield and number of fruit picked were recorded. Fruit size was calculated as the average weight (yield divided by the number of berries picked) for each plot.

Results and Discussion

Yields averaged from just over 8 lbs. per 5-plant plot for A-2491 to over 22 lbs. per plot for Osage (Table 1). Yields varied significantly among cultivars in 2017 (Table 1), with Osage being significantly more productive than Natchez and A-2491-T. But yields were much lower than last year for all cultivars. Some plants might have been over cropped or stressed last year due to injury at the base of the floricanes and depleted most plant reserves to produce the fruit. Primocane growth in 2017 was vigorous and leaf size was good.

A-2434-T, and Natchez (Table 1) had significantly larger berries than all other cultivars/selections in 2017. However, berry size (as measured by weight per berry) was similar to that in

Table 1. Summary of 2017 results from the blackberry cultivar trial at UKREC, Princeton, KY.

			Percent Yield				
Cultivar	Yield (lbs./plot)[1]	Weight (g/berry)[2]	1st week of harvest	2nd week of harvest	3rd week of harvest	4th week of harvest	5rd week of harvest
Osage	22.7 (47.6)	3.4	42.7	32.3	14.3	5.8	4.9
A-2434-T	15.8 (30.4)	4.8	42.0	23.0	20.2	10.1	4.7
Ouachita	14.8 (22.3)	3.8	21.3	30.9	18.6	15.6	13.7
Natchez	9.0 (12.3)	4.6	49.6	26.6	18.3	3.9	1.7
A-2491-T	8.5 (9.1)	3.9	24.5	24.9	24.7	14.7	11.3
LSD(0.05)[3]	7.0 (9.4)	0.7	13.5	4.8	NS[4]	6.2	5.8

1 2016 yields in parentheses.

2 Fruit weight was calculated as the average weight (yield divided by the number of berries picked) for each plot. Fruit size was similar to that in 2016 but small than in 2015 for all cultivars.

3 Least significant difference at 0.05 probability level. Differences between two numbers within a column that are less than the least significant difference are not significantly different from one another at the 0.05 probability level.

4 NS denotes that values within a column were not significantly different from one another at 0.05 probability level.

2016 but averaged about 2 grams smaller for all cultivars compared to that obtained in 2015 (3). Berry size remained fairly constant throughout the season for Osage, but was more variable for the other cultivars (Figure 2).

This year, all berries in this trial ripened over about a four-week period from about June 16 through about July 17. The percent of fruit ripening for each cultivar varied significantly for each week except for the third one (Table 1). Ouachita and A-2491-T significantly lagged the other cultivars in ripening during the first and last picking (Table 1). All cultivars rated good to excellent in taste, with no significant differences between cultivars being detected this season.

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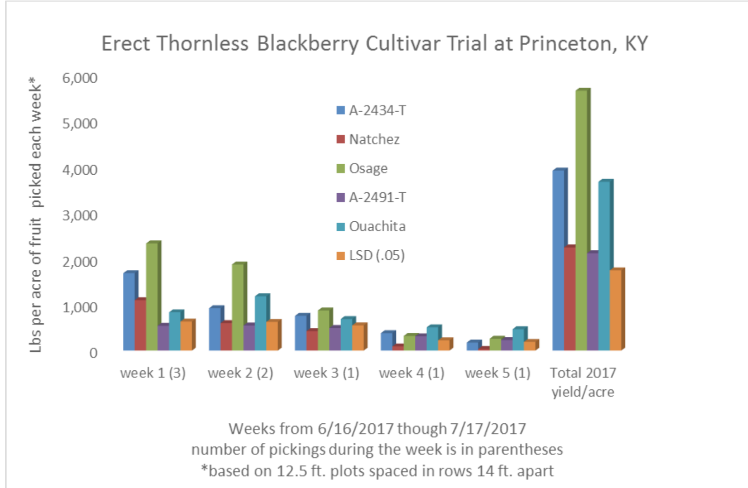

Figure 1. Weekly and total yield per acre in 2017 of erect thornless blackberry cultivars.

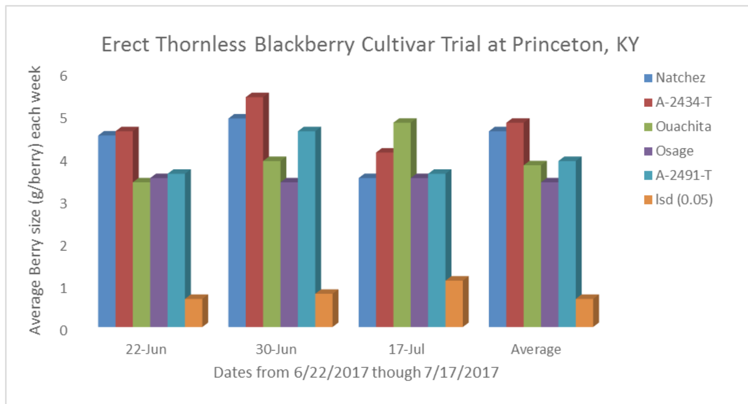

Figure 2. Berry size (as measured by average weight per berry) in 2017 for erect thornless blackberry cultivars.

Parasitoid Wasps Associated with Blackberries Bordered by Native Perennial Plants versus Pasture Borders in Franklin County, Kentucky

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Introduction

Spotted Wing Drosophila (SWD), *Drosophila suzukii*, is a relatively new invasive pest of small fruit and fruit tree crops in Kentucky. Farmers typically respond to this pest by using broad spectrum insecticides, which pose risks to the environment and human health and can also reduce populations of non-target species such as parasitic wasps. Thus, there exists a need for alternative means of SWD management that are effective and environmentally friendly. Conservation biological control is one method used to manage crop pests. This method enhances the survival, longevity, and fertility of natural enemies (e.g., lady beetles and parasitic wasps). Managing a crop's surroundings can be part of this strategy. (Landis et.al, 2000, Lu et.al, 2014). This study examined blackberry plots bordered by either 19 species of native perennial plants or by periodically mowed pasture to determine if either border habitat affected the population density and/or diversity of beneficial parasitic wasps. The objective of this research was to determine if the presence of native perennial plants increased the abundance and diversity of parasitic hymenoptera in blackberries.

Materials and Methods

STUDY AREA

This study was conducted at the Kentucky State University Harold R. Benson Research and Demonstration Farm in Franklin County, Kentucky. 'Prime ARK Traveler' blackberries were hand-planted with 60 cm plant spacing and 4 m row spacing in late June 2016. The four sampling areas were native perennial borders (NP), blackberry plots bordered by native perennials (BBNP), pasture borders (P), and blackberries bordered by pasture border rows (BBP). Blackberry plots were 25 m long x 12 m wide and the lengths were bordered by either 19 species of native perennial plants or left as pasture that were 25 m in length x 2 m wide. Thimbleweed, *Anemone virginiana*; smooth blue aster, *Aster laevis*; New England aster, *Aster novae-anglica*; purple coneflower, *Echinacea purpurea*; rattlesnake master, *Erygium yuccifolium*; Joe Pye weed, *Eupatorium fistulosum*; common boneset, *Eupatorium perfoliatum*; blue lobelia, *Lobelia siphilitica*; bee balm, *Monarda fistulosa*; foxglove beardtongue, *Penstemon digitalis*; hairy beardtongue, *Penstemon hirsutus*; slender mountain mint, *Pycantheum tennuifolium*; grey-headed coneflower, *Ratibida pinnata*; stiff goldenrod, *Solidago rigida*; big bluestem, *Andropogon gerardii*; side-oats grama, *Bouteloua curtipendula*; prairie switchgrass, *Panicum virgatum*; little bluestem, *Schizacharium scoparium*; and prairie dropseed, *Sporobolus heterolepis*. Native perennial border rows were planted in 2011.

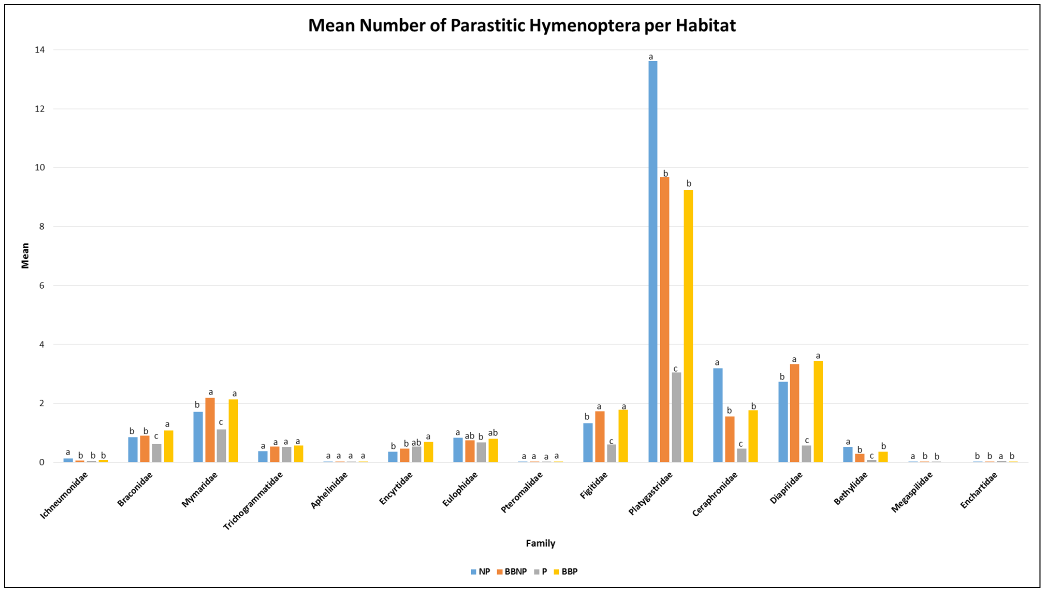

Figure 1. Mean number of Hymenoptera insects by habitat over the sampling period. NP = native perennial plots; BBNP = blackberry plots next to native perennial plots; P = pasture plots; BBP = blackberry plots next to pasture plots.

SAMPLING AND IDENTIFICATION PROCEDURES

Five yellow 355 ml pan traps were placed equidistant from each other and from the ends of each border row. A single trap was placed in the center of each of 10 (2 parallel rows of 5 lengths), 4 m lengths of blackberries. Each trap was filled with 100 ml of 20 percent propylene glycol and two drops of Dawn dish soap. Trapping began on June 22, 2017, and traps were collected and reset through September 8, 2017. Traps were deployed each week for four days, contents collected, and transferred into either 70 percent ethanol or 5 percent acetic acid in the laboratory. Parasitoids were identified and enumerated using a binocular dissecting microscope. Data were analyzed using ANOVA and Fisher's Protected LSD procedures in CoStat Statistical Software (CoHort Software 2006).

Results and Discussion

The five most abundant hymenoptera families identified in the study were *Platygastridae*, *Ceraphronidae*, *Diapriidae, Figitidae*, and *Mymaridae*. Interestingly, *Diapriidae* and *Figitidae* have been known to parasitize *Drosophila suzukii* (Cini, et. al, 2012). Significantly more I*chneumonidae, Playtgastridae, Ceraphronidae, Bethylidae*, and *Megaspilidae* were found in the native perennial border rows than in any of the other habitats. *Mymaridae, Figitidae,* and *Diapriidae* were significantly more abundant in both native perennial blackberry rows and pasture blackberry rows than in the border rows (Figure 1). *Braconidae* were significantly more abundant in pasture blackberry rows. *Enchartidae* were significantly more abundant in pasture border rows than in any other habitat. *Encyrtidae* were significantly more abundant in the pasture row and pasture blackberry rows than in the native perennial habitats.

Access to floral resources and potential prey is the likely explanation for the higher abundance of parasitic hymenoptera in the native perennial border rows. These rows provide floral resources and microhabitat in the form of 14 species of native flowering and 5 species of native grasses. The pasture blackberry rows and native perennial blackberry rows also provide floral resources in the form of blackberry flowers. A more abundant or more attractive selection of insect hosts is also a likely explanation for more abundant parasitic hymenoptera populations in the blackberry rows. The pasture border rows appeared to be the least attractive of the four habitats, which is likely due to the lack of floral resources and less complex microhabitats. The results indicate that native perennial plants can provide food and other resources for parasitic hymenoptera populations, which could impact spotted wing drosophila populations.

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Acknowledgment

This research was supported by the USDA NIFA, Cooperative Research Evans Allen, Award No. 2105-33100-08907, Project Number KYX-10-10-45P.

Haskap Selection and Variety Evaluation

John Strang, Chris Smigell, and John Snyder, Horticulture

Haskap (*Lonicera caerulea* subspecies *emphyllocalyx*) is a blue honeysuckle subspecies. Dr. Maxine Thompson, retired professor at Oregon State University, has designated the name of this subspecies as Haskap to differentiate it from Honeyberries. She has been making Haskap crosses and working to increase its adaptation to more moderate climates. Haskaps are native to Canada and the northern islands of Japan where it is popular both fresh and in baked goods, juices, ice cream, candies and wine. Honeyberries and haskaps have been commercialized in Canada largely due to the work of Dr. Bob Bors at the University of Saskatchewan.

Haskaps differ from the Honeyberries (*Lonicera kamchatika* subspecies *kamtshatica*, *edulis*, *boczkarnikovae* and altaica - native to Russia, North Korea and the Czech Republic) in that haskaps are adapted to more moderate climates and bloom later. Even so, they bloom during April in Kentucky when frosts are prevalent. Flowers have been reported to be hardy to 17°F.

Furthermore, they are not well adapted to high summer temperatures and a long growing season. Plants cease growth shortly after fruiting and then leaf bronzing occurs. It has been suggested that sunburn and/or high temperature exposure causes this, as no diseases have been associated with the problem (Bors et al. 2016). Varieties vary in the amount and timing of leaf bronzing and American varieties have some resistance to this.

We are evaluating haskaps as a potential crop for Kentucky growers since they have very high antioxidant levels and ripen early with strawberries, and thus do not need insecticide sprays to

Table 1. Haskap yields and fruit characteristics

Selection/ variety	Yield/ plant[1] (oz)		Wt 20 berries[1,2] (oz)		Attractiveness[3] (1-5)	Firmness (1-5)[4]	Sweetness (1-5)[5]	Flavor (1-5)[6]	Adhering flower petals (1-5)[7]
85-19	50.8	a	0.55	e	4.0	3.4	3.0	3.3	1.4
85-35	38.9	ab	0.83	b	4.2	3.3	2.9	3.3	1.3
44-19	26.4	bc	0.58	de	3.0	3.4	2.6	3.1	1.9
84-105	19.3	bc	0.69	cd	3.0	2.4	2.8	3.0	2.4
51-02	16.4	bc	0.67	cde	3.9	2.6	3.2	3.5	1.4
46-55	16.2	bc	1.05	a	3.6	3.1	3.7	4.1	2.0
21-20	15.9	bc	0.56	e	3.0	2.3	2.7	2.6	2.4
85-28	13.4	bc	0.71	c	2.5	2.6	3.1	3.1	3.6
Borealis	12.6	c	0.65	cde	2.6	2.7	3.2	3.6	2.3
56-51	11.9	c	0.93	b	2.7	3.1	2.9	2.6	2.2
29-55	5.4	c	0.64	cde	4.0	2.8	3.9	4.6	1.5

1 Numbers followed by the same letter are not significantly different (Duncan Multiple Range Test LSD $P \leq 0.05$).
2 Average weight based on 20 berries at first 3 harvests.
3 Attractiveness: 1 = poor, 5 = excellent.
4 Firmness: 1 = soft, 5 = very firm.
5 Sweetness based on two evaluations: 1 = tart, 5 = sweet.
6 Flavor: 1 = poor; 5 = excellent.
7 Flower petals adhering to fruit: 1 = none; 5 = many.

Table 2. Haskap plant survival, size, percent bloom, foliar frost injury and leaf bronzing

Selection/ variety	Plant mortality[1] (% dead)	Plant Volume[2] (cu ft)	Bloom 2017[3,4] (%)		Foliar frost injury 2017[4,5] (%)		Leaf bronzing 2016[4] (AUDPC)[6]		Leaf bronzing 2017[4] (AUDPC)[6]	
85-19	17	21.9	96	a	14	bc	944	d	1459	c
85-35	33	11.5	93	a	20	ab	2081	cd	1657	c
44-19	17	9.4	92	a	21	ab	2650	a-d	3101	a
84-105	100	6.6			3	d	4550	a	931	c
51-02	0	11.5	93	a	23	ab	2473	bcd	2166	bc
46-55	50	10.6	71	b	25	a	3278	abc	3009	a
21-20	50	16.5	90	a	27	a	3366	abc	2853	bc
85-28	33	15.7	85	ab	8	cd	3432	abc	1952	c
Borealis	50	2.7	97	a	28	a	3897	ab	3654	a
56-51	33	11.0	32	c	19	ab	1877	cd	3557	a
29-55	17	6.0	87	ab	20	ab	1479	cd	1586	c

1 Assessed on 4 November 2017.
2 Calculated as volume of a cylinder based on plant height and width.
3 Visual estimate of percent bloom on 25 March 2017. Bloom was delayed on 84-105 and it was too early to rate this selection.
4 Means within same column followed by the same letter are not significantly different (Duncan's Multiple Range Test LSD $P \leq 0.05$).
5 Visual estimate on 4 April 2017 of percent leaf injury following a freeze down to16.8 °F on 15 March 2017.
6 The area under the disease progress curve (AUDPC) is a quantitative summary of disease intensity over time, calculated from leaf bronzing and drop ratings taken on 18 July, 11 August, 2 and 15 September, and 11 October 2016 and 23 August, 11 and 22 September, and 7 October 2017. Higher numbers in the columns indicate greater cumulative leaf bronzing and leaf drop.

control spotted wing drosophila. The crop has been reported to have few insect and disease pests other than powdery mildew and thus has potential for organic production.

Haskap plants provided by Gardens Alive! Inc. (Lawrenceburg, IN) were planted at the University of Kentucky Horticultural Research Farm in Lexington to evaluate their adaptation and production potential. Very few fruit were produced in 2015, the second growing season, and no yield data were collected. Yields and data for the 2016 growing season were reported in the 2016 Fruit and Vegetable Research Report (Strang et. al, 2016). This report contains plant development and leaf bronzing evaluations as well as yield and fruit quality results for the 2017 season.

Materials and Methods

Ten potted, leafed-out Haskap selections and the variety 'Borealis' were moved from a greenhouse and transplanted on 2 June 2014. Plants were set 6 feet apart in rows with 12 feet between rows. Individual plant plots were replicated six times in a randomized block design. Six-foot wide DeWitt Sunbelt Weed Barrier was cut to fit around the plants and stapled to the ground with SSS8 8-inch long, 8 gauge heavy duty staples for weed control down the row. Hard plastic, ¾-inch drip irrigation tubing was installed on top of the landscape fabric down each replication row and a one-gallon per hour emitter was inserted 6 inches from the base of each plant. Irrigation was provided as needed.

No insecticides, fungicides or herbicides were used on the planting. Plants were only fertilized in April 2016, with one cup of Nature Safe 10-2-8. Bird netting was erected over each row prior to berry ripening, resting on wires attached to T-shaped supports and anchored to the ground with wire staples in 2016 and 2017.

Frost injury, plant bloom density and floral development data were collected in spring, 2017. Fruit were harvested and weighed on four dates. Twenty berries were weighed at the first three harvests to determine average berry weight. Berry appearance, firmness, sweetness, flavor, and flower petal adherence to the fruit were also assessed three times for each plant. On the second harvest berry °brix was measured with an Atago Pal-1 pocket refractometer (Atago, USA Inc., Bellevue, WA) and titratable acidity was measured by end-point titration to pH 8.2 with 0.1N NaOH. Berry pH was measured using a Hannah 222 pH meter (Hanna Instruments, Ann Arbor, MI). Percentage of leaf bronzing over the whole plant was estimated and calculated as the area under the disease progress curve (AUDPC) four times in 2017 and plant height and width were measured on 12 October 2017. Plant mortality was assessed on 4 November 2017.

Results and Discussion

The 2017 season was very warm early in the season and cooler later, with more rainfall than normal. Fruit were harvested on 8, 15, 27, and 30 May. Harvest began 5 days earlier than it did in 2016. Fruit yield and berry characteristics are shown in Table 1. Selections are ranked based on yield-per-plant.

Table 3. Haskap selection/variety fruit observations

Selection/ variety	Fruit Observations
85-19	Very attractive, medium-sized, uniform shape, color and size; nice taste, not as tart; firm skin; shook from bush easily when ripe
85-35	Very attractive, large, uniform shape, thicker firm skin that holds up well; few with adhering stems, no conjoined berries[1], shook from the bush easily when ripe
44-19	Variable size and shape, round- to elongate-shaped; skin holds up well; only a few conjoined berries; a few adhering leaves; no adhering flower parts; little more difficult to pull off plant
84-105	Variable size and shape; very soft, tender fruit that damage easily; no conjoined fruit; few to many with persistent flower parts; fruit easy to pull off plant
51-02	Attractive, elongated, variable size and shape; skin soft but holds up; early ripening; very few conjoined fruit or adhering stems; fruit easy to pull off plant
46-55	Very large, elongated, variable size and shape; sweet taste and good flavor; some fruit leakage; tender skin; some adhering leaves and stems; number of conjoined fruit; little more difficult to pull off plant
21-20	Variable size, shape and color, softer fruit; few conjoined fruit; few adhering leaves and flowers; more difficult pull off plant
85-28	Very variable size and shape; some eggplant-shaped; large fruit, not that attractive; skin soft to firm; wet-looking, mushy; lots of adhering flower parts, some adhering leaves and some conjoined fruit; fruit easy to pull off plant
Borealis	Variable shape and size, fair number of adhering leaves and conjoined fruit
56-51	Large, round to oval-shape, many conjoined fruit; tart; persistent flower parts; fruit easy to pull off plant
29-55	Attractive, medium- to large fruit, uniform shape; excellent mild sweet flavor, very few conjoined fruit

1 Conjoined berries are open on one side exposing the two fruitlets, as opposed to most berries where the two fruitlets are completely enclosed in a blue sack forming a single berry.

Table 4. Haskap selection/variety juice characteristics[1]

Selection/variety	°Brix	Juice pH	T.A. (g/L)[2]
85-19	10.7	2.81	27.09
85-35	10.7	2.97	28.83
44-19	11.5	2.79	38.11
84-105	10.8	2.95	30.57
51-02	10.9	2.99	27.47
46-55	12.7	3.00	20.70
21-20	10.3	2.68	37.34
85-28	10.8	3.09	21.09
Borealis	9.6	3.08	22.44
56-51	10.1	2.76	39.86
29-55	13.3	3.24	18.30

1 Based on one composite sample from the second harvest, 15 May.
2 TA = Titratable acidity measured as grams of tartaric acid per liter of juice.

Overall, selections **85-19** and **85-35** were superior in this trial as in 2016. Selection 85-19 had a higher yield than 85-35 in 2017, but both were the highest yielding selections in both seasons. Selection 85-19 produced an attractive, medium sized fruit that was relatively firm and had fairly good flavor and sweetness ratings. It also has few flower petals that adhere to the fruit after harvest. Its brix level, 10.7, was similar to many of the other selections. Its plants are large in comparison with other selections and 'Borealis,' they have survived well, and have had some of the lowest levels of leaf bronzing in 2016 and 2017.

Fruit of selection 85-35 was also very attractive, and larger than those of 85-19. It had similar sweetness and flavor ratings to 85-19 and few flower parts remaining on the fruit after harvest. Plant size was somewhat smaller, plant mortality was slightly higher, and leaf bronzing was statistically identical to that of 85-19. Both selections dropped ripe berries easily when the bushes were jostled, and neither had conjoined berries. For both selections, berry skins were firm and fruits had a uniform shape. Floral development for both selections in 2017 (Figure 1) was slightly slower than for several selections and 'Borealis,' which indicates that the blooms of these two selections might be a little less susceptible to spring frost injury.

'Borealis,' the standard variety in the trial, in general has not performed as well as 85-19 and 85-35. Their yields and fruit sizes were significantly greater than those of 'Borealis,' which was one of the better-yielding, larger-fruited haskap varieties in Canada. 'Borealis' fruit were rated slightly better for sweetness and flavor than were 85-19 and 85-35, and this is reflected in the brix, pH and titratable acidity ratings in Table 4. 'Borealis' has had significantly smaller plants and a statistically higher leaf bronzing rating, although this variety has been reported to have little leaf sunburn or bronzing (Bors et. al. 2016). Three 'Borealis' plants (50 percent) have died in the trial.

Selections that show potential are:

- 44-19, which had a higher yield and firm, medium-sized fruit, but had smaller plants and a lower sweetness rating
- 51-02, which has a higher yield, very sweet, good-flavored, but softer fruit, good plant size, and still has 100 percent plant survival
- 46-55, which had the largest berry size, high sweetness and flavor ratings, highest brix reading, high berry attractiveness, but moderate yield, a few more flower parts adhering to the fruit, and a loss of fifty percent of the plants
- 29-55, which was very attractive, had the highest sweetness and flavor ratings, low leaf bronzing levels, but lowest yield, softer fruit and some of the smallest plants.

The haskap selections' brix, pH and titratable acidity readings are in Table 4. Fruit sweetness is a function of the sugar and acid contents. The high sweetness ratings for 29-55 and 46-55 (Table 1) correlated well with the high brix and pH levels in Table 4. Titratable acidity levels are very high for haskaps in comparison with other small fruits.

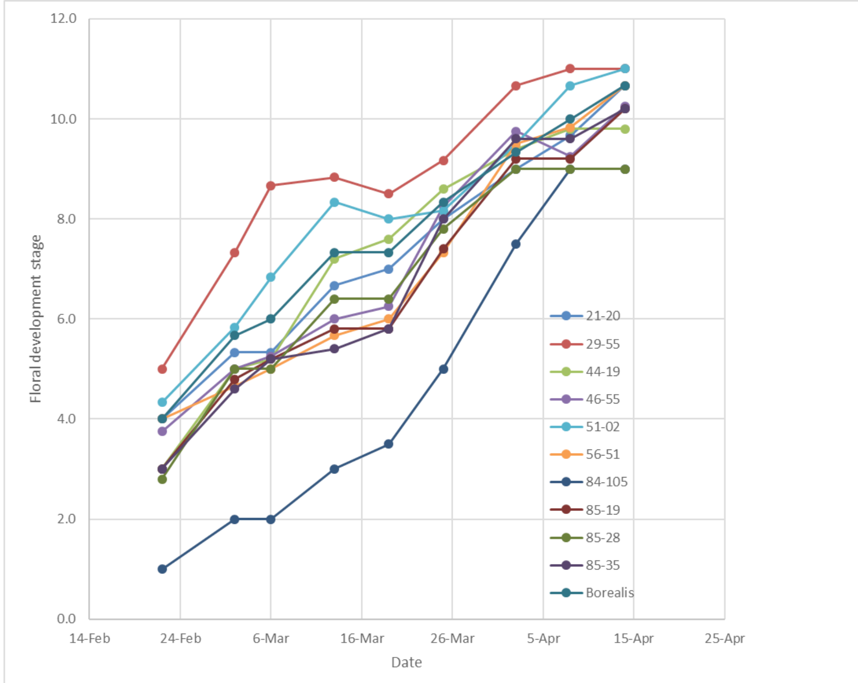

Figure 1. Selection/variety floral development stage by date.
Floral developmental stages: 1 = buds dormant; 2 = buds showing green; 3 = ¼ inch green; 4 = flower buds visible; 5 = first bloom; 6 = 25% bloom; 7 = 50% bloom; 8 = 75% bloom; 9 = 100% bloom; 10 = petal fall; 11 = small fruit

Evaluation of harvest dates (data not shown) shows that all selections produced fruit from 8 May through 22 May, 2017. 'Borealis,' 51-02 and 29-55 produced most of their fruit on 8 May. Selections 44-19, 56-51, 85-19 and 85-28 were next in the order of ripening. The 21-20, 46-55 and 85-35 selections were next, and 84-105 produced the bulk of its fruit late, on 30 May. It is interesting that these data correspond well with Figure 1 in that 29-55, Borealis and 51-02 floral development tended to be the earliest of all the selections and 84-105 was the slowest to develop in the spring and produced most of its fruit late.

Selections 21-20, 84-105, 56-51, and 85-28 have performed less desirably. The selections 85-28, 21-20, and 84-105 all had relatively high numbers of dried flower petals that adhered to the fruit. These would not be attractive if sold fresh, and may not be useable in processed whole fruit products.

Japanese beetles caused some minor leaf feeding damage in 2017. Several dead plants were taken to the University of Kentucky Plant Diagnostic Lab and were diagnosed with Phytophthora root rot. No powdery mildew has been detected in the planting.

Acknowledgments

The authors would like to thank Steve Diver, Dave Lowry, Joseph Tucker, Nancy Elmore, Somjintana Sutthithanakool and Kanokwan Khanthawong for their help and assistance in the successful completion of this trial.
Funding for this project was provided by Gardens Alive!, Inc. and through a grant from the Kentucky Horticulture Council through the Agricultural Development Fund.

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Timing of Bark Inlay Grafting of Pawpaw Affects Success Rate

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Introduction

Pawpaw, a tree fruit native to the eastern U.S., is in small-scale commercial production, although its popularity is on the rise. Many small-scale farmers have seedling pawpaw trees or wild trees that produce low yields and poor quality fruit (Peterson, 2003). New commercial pawpaw varieties are available that will increase yield and fruit quality, and improve consumer opinion and demand for fruit. Currently, the most common techniques for propagating varieties of pawpaw are clonal propagation by chip budding, whip and tongue grafts, and cleft grafts (Pomper and Layne, 2005). Bark inlay grafting is a technique that allows the union of a rootstock limb or trunk much larger in size than the scion. This technique has not been well-developed for pawpaw and is a potential method for growers to change wild and/or seedling pawpaw trees to higher yielding, higher quality cultivars. The objective of this study was to determine the optimum timing for bark inlay grafting of pawpaw in Kentucky.

Materials and Methods

Three commercially available pawpaw cultivars with large, high quality fruit and high yields were selected: 'KSU-Atwood,' 'Sunflower,' and 'Susquehanna.' The bark inlay grafting method was performed on 12- to 15-year-old mature trees. Scion wood was collected in March and stored under refrigeration until grafting. Trees approximately 2 to 3 inches in diameter were selected, and the trunk was cut at a height of approximately 1 foot. Three trees of each cultivar were grafted on two dates (early and late May 2016 and 2017) at the Kentucky State University H.R. Benson Research and Demonstration Farm in Frankfort.

Using a sharp grafting knife, two parallel incisions the width of the scion were made in the trunk where the trunk was cut off, down to the cambial layer. A slanted cut was made at the base of the scion using a razor blade and then a second cut was made on the opposite side that was slightly shorter, producing a chisel-shaped scion base (Figure 1). This scion base was inserted under the bark flap with the longer cut facing inward toward the trunk. The scion and trunk were wrapped in Parafilm grafting tape (Bemis Co., Oshkosh, WI) to prevent desiccation. The trunk and graft site were subsequently

Table 1. Bark inlay grafting take and growth by grafting date

	Success rate		Scion growth	
Date grafted	2016 (%)	2017 (%)	2016 (m)	2017 (m)
Early May	91	78	0.78	0.56
Late May	67	44	0.76	0.48
	*	NS	NS	NS

Table 2. Bark inlay grafting take and growth by cultivar

	Success rate		Scion growth	
Cultivar	2016 (%)	2017 (%)	2016 (m)	2017 (m)
Atwood	67	67	1.10	0.57
Sunflower	100	50	0.69	0.55
Susquehanna	71	67	0.63	0.48
	NS	NS	NS	NS

Figure 1. Scion cuts in preparation for the bark inlay graft on pawpaw.

wrapped in freezer tape to ensure good contact between cambial layers and to help support the graft union. Grafts were evaluated for survival and growth. Data were analyzed using CoStat Statistical software (CoHort Software, Monterey, CA) and subjected to analysis of variance and least significant difference (LSD) means separation. Treatment means were separated based on a significance level of $P < 0.05$.

Results and Discussion

Trees grafted using the bark inlay method in early May 2016 (May 3) had a success rate of 91 percent, whereas trees grafted in late May (May 23) had a success rate of 67 percent (Table 1). These differences were significant. Growth was similar between the two dates, with scions grafted in early May growing an average of 0.78 m, whereas scions grafted in late May grew an average of 0.76 m. Neither graft success rate nor growth were significantly different among cultivars. Atwood grafts grew an average of 1.1 m, Sunflower 0.69 m, and Susquehanna 0.63 m. 100 percent of Sunflower grafts were successful, compared to 71 percent of Susquehanna and 67 percent of Atwood (Table 2).

In 2017, pawpaw trees grafted using bark inlay in early May (May 2) had a success rate of 78 percent, compared to trees grafted in late May (May 26), which had a success rate of 44 percent. However, these differences were not statistically significant. Again, growth was similar between the two dates but was slightly lower than in 2016. Trees grafted in early May grew an average of 0.56 m, while scions grafted in late May grew an average of 0.48 m. As in 2016, neither graft success rate nor growth was significantly different among cultivars. Both Atwood and Susquehanna had success rates of 67 percent, and 50 percent of Sunflower grafts were successful in 2017. Atwood grafts grew an average of 0.57 m, Sunflower 0.55 m, and Susquehanna grafts grew 0.48 m during the 2017 season.

Grafting success and growth may have been lower in 2017 compared to 2016 due to less desirable trees being available for grafting in 2017. Healthy, optimally sized trees were selected in 2016, therefore fewer were available in 2017, which led to some less vigorous or larger diameter rootstock trees being used. Due to a higher success rate, the recommended time for performing bark inlay grafting of pawpaw trees is early May rather than late May. Scions will continue to be evaluated for survival, growth, and precocity of fruit bearing.

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Rootstock Effects on Apple and Peach Tree Growth and Yield

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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 and can 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 researchers from 29 other states in the United States, three Canadian provinces, Mexico, and Chile 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.

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:

- The **2009 peach rootstock trial**, which compares fourteen rootstocks with ‘Redhaven’ as the scion cultivar (Table 1). 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 x 20 feet spacing.
- The **2010 apple rootstock trial**, which compares thirty-one different rootstocks with ‘Aztec Fuji’ as the scion cultivar (Table 2). The experimental design was a randomized complete block design with four blocks with from one to three trees per rootstock per block. The trees were planted in March 2010 and trained to the tall spindle system. 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 of 2010. The heights of the graft unions above the soil line average 5 inches with a range of 3 to 7 inches.

Orchard floor management for these trials consists of 6.5 feet bare ground, herbicide-treated strips with mowed sod alleyways. Trees are fertilized and sprayed with pesticides according to local recommendations (1, 2). For the 2017 growing season, mortality, yield (both number of fruit and total

Table 1. Rootstocks in the 2009 NC-140 peach rootstock trial

Rootstock	Tree Vigor (Percent of Lovell)	Genetic origin	Breeding program
Atlas	120	*Prunus sp. x almond hybrid*	Zaiger Genetics
BH-5 (Bright's Hybrid #5)	110	*Prunus sp. x almond hybrid*	Bill Bright
Controller™ 5	60	*P. salicina x P. persica*	USDA-UC Davis
Guardian	110	Southeastern US standard	
HBOK 10 (ControllerTM 8)	90	Harrow Blood, Siberian C parentage	UC Davis
HBOK 32 (ControllerTM 7)	80	Harrow Blood, Siberian C parentage	UC Davis
Krymsk 1	50	*P. tomentosa x P. cerasifera*	a Russian rootstock
Krymsk 86	110	*P. cerasifera x P. persica*	a Russian rootstock
KV010-123	100	Red leaf peach x Bailey	Ralph Scorza –USDA
KV010-127	100	Red leaf peach x Bailey	Ralph-Scorza –USDA
Lovell	100	A commercial standard	
Mirobac cv. PAC 941(Replantpac™)	110	*P. cerasifera x P.dulcis*	Agromillora Iberia, Barcelona
Prunus americana	60	Seedling selection	Bailey's Nursery
Viking	110	*Prunus sp. x almond hybrid*	Zaiger Genetics

weight per tree), number of root suckers, tree height, and trunk circumference measurements were recorded for both trials. Trunk cross-sectional area (TCSA) is calculated from the trunk circumference measurements taken 12 inches above the graft union for apple and 6 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. The cumulative yield efficiency is an indicator of the proportion of nutrient resources a tree is putting into fruit production relative to vegetative growth. Fruit size is calculated as the average weight (oz) per fruit. All data is statistically analyzed using SAS v.9.4 (SAS Institute Inc., Cary, NC, USA).

Results and Discussion

The mild winter and spring of 2016 resulted in "bumper crops" of both rootstock trials.

2009 PEACH ROOTSTOCK TRIAL

Mortality, Julian date of 90 percent bloom, cumulative yield from 2011 through 2017, 2017 yield, number of root suckers, trunk cross-sectional area (TCSA), cumulative yield efficiency, and tree height varied significantly among the fourteen rootstocks in this trial (Table 3). Krymsk1 and Bright's Hybrid have had the highest mortality rates, 75 percent and 50 percent, respectively. Krymsk 1 was the earliest to bloom. Time of bloom did not differ significantly among the other thirteen rootstocks. Time of fruit ripening (or 10% fruit maturity) also did not differ significantly among the fourteen rootstocks. Microbac and Guardian have produced the largest trees (TCSA) to date, but they are not statistically different in size from Viking, Lovell, KV010-127, or Krymsk 86. Scions on Krymsk 1 are the smallest trees in terms of both TCSA and tree height. Yield per tree was greatest for Atlas and Lovell, but this was not significantly different from Guardian, Bright's Hybrid, Viking, or KV010-127. Cumulative yield from 2011 through 2017 was greatest for Atlas, but this was not significantly different from that of Lovell, Guardian, KV010-123, Viking, or KV010-127. Atlas had the highest cumulative yield efficiency, but this was not significantly different from Lovell or KV010-127. P. *americana* and Microbac had significantly more root suckers than the other rootstocks. Average fruit size was largest from scions on Krymsk 86, but this was not significantly larger than any of the fruit from the other scions, except for HBOK 32, and Viking. To date, none of the rootstocks in this trial have surpassed the industry standards of Lovell or Guardian with regards to overall performance.

Table 2. Rootstocks in the 2010 apple rootstock trial with 'Aztec Fuji' as the scion cultivar

Rootstock	Clone status	Breeding Program—Location
B.9	named	Budagovsky—Michurinsk State Agrarian University, Michurinsk, Tambov Region, Russia
B.10		
B.7-3-150	not released	
B.7-20-21		
B.64-194		
B.67-5-32		
B.70-6-8		
B.70-20-20		
B.71-7-22		
G.11	named	Cornell-Geneva— New York State Agricultural Experiment Station
G.41 N[1]		
G.41 TC[2]		
G.202 N[1]		
G.202 TC[2]		
G.935 N[1]		
G.935 TC[2]		
CG.2034	not released	
CG.3001		
CG.4003		
CG4004		
CG.4013		
CG.4214		
CG.4814		
CG.5087		
CG.5222		
Supp.3	named	Pillnitz— Institut fur Obstforschaung, Dresden-Pillnitz, Germany
PiAu.9-90	not released	
PiAu.51-11		
M.9 NAKBT337	named	NAKB clone of M.9— NAKB, Netherlands
M.9 Pajam2	named	CTIFL clone of M.9— CTIFL, France
M.26 EMLA	named	E. Malling clone of M.26— East Malling Res. Station, Kent, England

2010 APPLE ROOTSTOCK TRIAL

In 2012, a tree with G.11 as the rootstock was lost due to deer damage, a tree on B.9 broke at the graft union, and two trees with M.9 NAKBT337 were lost, possibly from winter injury. Three trees (one M.9 Pajam2 and two B.71-7-22) succumbed to fire blight infections in 2013, and seventeen trees succumbed in 2014 to fire blight (including two B.64-194, five M.26 EMLA, two Supporter 3, one PiAu51-11, four M.9 NAKBT337, and three M.9 Pajam2). In 2015, a tree on G.935 N broke at the graft union, and three trees succumbed to winter injury (two B.70-20-20 and one M.9 Pajam2). In 2016, one tree on B.10, one on CG.2034, and one on M.26 EMLA, broke at their graft unions. One tree on B.71-7-22 was lost to fire blight. In 2017, five more trees were lost, one on G.935 TC (winter injury), two on M.9 NAKBT337 (fire blight), one on B.67-5-32 (broke at graft union), and one on Supporter 3 (fire blight). As reported previously (4), NC-140 cooperators agreed to discontinue the evaluation of B.70-20-20 as it has proven to produce trees too large for high density plantings. Consequently, this rootstock was removed from this trial in January 2016.

Mortality, cumulative yield from 2012 through 2017, yield per tree for 2017, average weight per fruit, TCSA, cumulative yield efficiency, and tree height varied significantly among the 31 rootstocks (Table 4). M.9 NAKBT337 had the highest tree mortality (67%), but this was not significantly different from Supp. 3, M.9 Pajam2, M.26 EMLA, CG.2034, B.71-7-22, or B.64-194.

PiAu.9-90 rootstocks produced the largest trees in terms of TCSA, but they were not significantly larger than trees on B.70-6-8 or B.7-3-150. Similarly, B.71-7-22 produced the smallest trees, but they were not significantly smaller than trees on B.9, B.7-20-21, CG.2034, CG.4003, or G.41N. Yield in 2017 was greatest for G.935N, but this not significantly different from G.41 TC, CG.4013, Supp.3, CG.4004, or CG.5087. CG.4004 trees have produced the most fruit in this trial (total of all harvests from 2012 through 2017, or cumulative yield), but not significantly more so than for trees on G.935N, CG.4814, CG.5222, CG.5087, B.7-3-150, G.202N, G.202TC, G.41N. Fruit size (as measured by average fruit weight) ranged from 6.8 ounces for M.26 EMLA down to 4.4 ounces for B.7-20-21. The number of root suckers ranged from over 10 suckers for PiAu.9-90 to none for B.70-6-8, G.11, and M.26EMLA. B.9 had the highest cumulative yield efficiency, but it was not significantly different from G.41N, CG.4004, B.71-7-22, CG.4003, G.935N, CG.5087, M.9 NAKBT337, CG.4013, G.41TC, B.10, or G.202TC.

The three Malling rootstocks in this trial are typically considered to be industry standards throughout many apple producing regions but have had survival rates of less than 50 percent due to their susceptibility to fire blight. Further, a number of other rootstocks in this trial are proving to be too vigorous for the tall spindle system, and some not vigorous enough. To date, any recommendations based on this data with regards to apple rootstock choices would at best be tentative.

NC-140 rootstock trials are typically carried out over ten growing seasons. Consequently, results in this report should be considered preliminary until final results are made available at the completion of each trial.

Table 3. 2017 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 (2011-2017) (lbs./tree)	2017 Yield (lbs./tree)	Fruit Weight (oz./fruit)	Number of Root Suckers per tree	TCSA (sq.in.)	Cumulative Yield Efficiency (2011-2017) (lbs. / sq. in. TCSA)	Tree Height (ft.)
Microbac	0.0	83.3	174.6	386.3	85.6	7.6	9.6	32.8	11.8	13.5
Guardian	0.0	83.4	175.4	516.6	123.4	7.4	0.1	32.5	15.9	12.8
Viking	25.0	83.2	175.2	478.1	110.7	6.9	0.0	29.8	16.1	13.0
Lovell	0.0	83.3	176.5	562.8	148.9	7.5	0.0	29.1	19.3	12.8
KV010-127	0.0	83.4	175.5	467.3	103.6	7.6	0.0	28.7	16.3	13.1
Krymsk 86	0.0	83.3	175.0	394.0	87.3	8.2	0.3	28.6	13.8	13.1
Atlas	0.0	83.4	176.5	585.0	150.9	7.4	0.0	27.6	21.2	12.0
KV010-123	12.5	83.4	175.7	492.8	94.6	7.5	0.4	26.7	18.5	12.4
Bright's Hybrid	50.0	83.5	176.7	379.1	110.9	6.2	1.5	25.6	14.8	12.4
HBOK 32	12.5	83.6	176.3	427.0	98.1	7.1	0.0	23.3	18.4	11.8
HBOK 10	0.0	82.6	175.4	418.2	98.3	7.7	0.0	23.1	18.1	11.3
Controller 5	0.0	82.6	173.8	329.1	63.8	7.7	0.0	19.3	17.1	11.1
P. americana	25.0	82.8	175.6	254.1	61.2	7.7	12.0	16.2	15.7	10.1
Krymsk 1	75.0	79.0	.	110.7	0.0	.	1.0	10.6	10.4	7.2
Mean	14.3	82.9	175.6	414.4	95.5	7.4	0.7	25.3	16.4	12.2
LSD (5%)[2]	28.3	0.7	NS[3]	110.4	49.9	1.0	1.8	4.9	2.8	1.2

[1] Arranged in descending order of trunk cross-sectional area (TCSA) for each rootstock.
[2] Least significant difference (LSD) at the 5% probability level. Differences between two numbers within a column that are less than the LSD value are not significantly different.
[3] "NS" indicates that difference among the means within the column were not statistically different in the analysis of variance.

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Table 4. 2017 results for the 2010 NC-140 apple rootstock trial, Princeton, KY

Rootstock[1]	Initial Number of Trees	Tree Mortality (% lost)	Cum. Yield (2012-2017) (lbs./tree)	2017 Yield (lbs./tree)	Fruit Weight (oz./fruit)	Number of Root Suckers per Tree	TCSA (sq.in.)	Cum. Yield Efficiency (2012-2017) (lbs./sq. in TCSA)	Tree Height (ft.)
PiAu 9-90	4	0	141.5	36.5	5.7	10.8	21.8	8.1	12.7
B.7-3-150	12	0	176.0	40.5	6.0	0.8	18.3	10.2	14.0
B.70-6-8	11	0	145.9	24.6	6.4	0.0	17.8	8.6	13.8
B.64-194	7	29	137.7	27.9	5.9	4.0	16.6	8.4	13.4
PiAu 51-11	11	9	158.6	36.7	6.1	2.0	16.6	10.4	13.1
B.67-5-32	12	8	150.5	30.4	6.6	2.6	15.1	10.8	12.6
M.26 EMLA	11	55	156.6	32.3	6.8	0.0	14.0	11.7	13.4
G.935 TC	4	25	155.5	27.3	6.1	7.7	13.5	12.0	13.3
G.202 N	8	0	174.0	12.5	6.7	3.3	12.5	15.3	13.5
CG.5222	8	0	179.5	10.1	6.6	8.4	11.4	16.2	13.5
CG.3001	3	0	122.3	16.9	6.5	1.7	10.9	11.4	13.2
CG.4814	4	0	198.0	39.8	5.7	8.3	10.1	19.9	11.1
M.9 Pajam2	9	56	166.5	25.1	5.8	7.0	10.0	18.5	12.0
G.935 N	10	10	227.9	82.3	5.8	6.4	9.8	24.0	12.6
CG.4004	4	0	233.0	45.8	6.6	7.0	8.9	26.4	12.7
G.11	8	13	150.3	15.8	6.4	0.0	8.8	18.0	12.1
M.9 NAKBT337	12	67	161.3	21.8	5.8	2.3	8.5	23.0	11.7
CG.4214	4	0	148.5	27.3	6.2	2.5	8.4	17.9	13.0
G.202 TC	12	0	171.8	28.4	5.9	9.7	8.4	21.3	11.9
CG.5087	2	0	176.2	43.6	6.3	2.0	8.3	23.1	13.6
Supp.3	5	60	149.8	51.5	5.2	1.5	7.6	19.9	10.4
CG.4013	2	0	161.0	64.5	5.2	4.5	7.4	22.0	11.3
B.10	12	8	158.4	40.7	5.6	0.1	7.4	21.7	10.5
G.41 TC	1	0	158.6	71.9	5.2	2.0	7.3	21.8	12.1
G.41 N	3	0	168.5	17.8	6.5	0.7	5.9	28.6	10.3
CG.4003	7	0	125.6	13.4	5.9	2.6	5.2	25.1	9.7
CG.2034	2	50	91.7	3.7	6.0	3.0	4.6	20.0	8.8
B.7-20-21	12	0	31.2	10.3	4.4	0.3	2.6	12.1	6.8
B.9	12	8	74.4	12.5	5.4	1.3	2.5	30.2	7.5
B.71-7-22	10	30	44.0	10.8	5.9	2.3	1.8	25.3	6.8
Means	NA	15.8	146.1	28.8	6.0	3.2	10.4	17.3	11.6
LSD (5%)[2]	NA	40.4	64.9	40.7	1.6	5.9	5.0	9.9	1.9

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

2 Least significant difference (LSD) at the 5% probability level. Differences between two numbers within a column that are less than the LSD value are not significantly different.

Green Bean Variety Evaluation

John Strang, Chris Smigell, and John Snyder, Horticulture

Introduction

Green beans are popular at most retail markets across the state. In recent years a number of darker green bean varieties have been developed. These are often preferred by consumers. Nineteen newer, disease resistant green bean, and a few older standard varieties, as well as one purple variety were evaluated in this trial.

Materials and Methods

Varieties were planted in a field of Maury silt loam soil on 31 May at the University of Kentucky Horticultural Research Farm in Lexington. Approximately 120 seeds per variety were planted in 20-foot-long plots in rows that were 28 inches apart. Each treatment (variety) was replicated four times in a randomized complete block design. Fifty pounds of actual nitrogen as urea was incorporated prior to planting. Dual II Magnum at 1.5 pt. per acre pre-emergence herbicide was applied one day after planting. No fungicides or insecticides were applied to the plot. The plot was drip-irrigated as needed. Plants were harvested by hand six times over a two–and-a-half-week period on 21, 25, 28, and 31 July, and 3 and 7 August.

Small quantities of all varieties were harvested the afternoon of 6 August for taste evaluations. That evening approximately four ounces of each variety were cooked uncovered at a medium temperature setting in 2 cups of water for 10 to 15 minutes until tender. Beans were allowed to cool to room temperature, and then placed in sealable plastic bags, and refrigerated. On the morning of 7 August, the beans were placed on paper plates and five individuals (two males and three females) that liked green beans evaluated the samples for visual appeal, taste and texture.

Results and Discussion

The 2017 growing season was abnormally wet and cool. Most plants showed some injury from the preemergence herbicide but grew out of this. Only a few seeds of the Inspiration variety came up. It is suspected that this variety may have been more susceptible to Dual II Magnum herbicide injury than other varieties as a germination test conducted with seeds wrapped in a wet paper towel showed 60 percent germination.

Harvest began when the earliest maturing varieties were ready to harvest. Yields and plant and bean characteristics are in Tables 1 and 2. Visual and cooked taste ratings are in Table 3. It was difficult in this study to select one or two top varieties that performed the best for all the characteristics evaluated. Varieties were selected because of their disease resistance and most have resistance to bean common mosaic virus. Some have extensive disease resistance packages and growers should consider these varieties if there is a history of a particular disease or diseases on their farm.

Jade II and **Achiever** were two very dark green, glossy beans that had higher total yields and fairly high yields on one harvest date. Jade II had straight, six-inch long beans rated highly for cooked taste and texture, but had a lower cooked visual appeal rating. Achiever was a very uniform bean and had a medium rating for cooked taste and texture. **BA 0958** is another attractive, slightly glossy, dark green, round bean with a lower yield, but rated very highly for pod straightness, uniformity and both raw- and cooked visual appeal, taste and texture.

Colter, **Opportune** and **Momentum** green beans were lighter green and yielded well. Colter beans were slim, uniform and highly rated for raw visual appeal and cooked taste, visual appeal and texture. The Opportune variety held its beans up off the ground well, beans retained their stems well

Table 1. Days to harvest, yields, and disease resistances

Variety	Seed Source	Days to Harvest[1]	Total Yield 6 Harvests (bu/A)[2]		Highest Yield 1 Harvest (bu/A)[2,3]		Highest Yield Harvest (Date)	Disease Resistance (1-5)[4]
Furano	ST	54	785	a	284	abc	7/25	HR: BCMV
Amethyst	JS	56	711	ab	239	bc	8/11	R: BCMV
Greencrop	SW	52	697	abc	284	abc	7/29	R: BCMV
Momentum	SY	56	691	abc	354	a	7/28	HR: BCMV
Caprice	SW	56	654	bcd	198	cd	7/29	HR: BCMV, HB, Xap; IR: BBS
Achiever	SW	53	632	bcde	337	ab	7/25	IR: whiteflies
Jade II	BL	60	610	bcde	249	bc	7/25	HR: BCMV; IR: Rust
Colter	CF	53	582	cdef	218	cd	7/26	HR: BCMV, BCTV, Rust
Opportune	SY	56	557	def	207	cd	7/28	HR: BCMV
Cosmos	JS	56	551	defg	202	cd	7/31	HR: BCMV, BCTV; IR: BBS
Bowie	SW	54	543	efgh	282	abc	7/28	HR: BCMV, BCTV, HB, BBS; IR: Xap
Bronco	HO	53	543	efgh	206	cd	7/28	IR: BCMV
Sybaris	ST	56	530	efgh	187	cd	7/28	HR: BCMV; IR: Rust 90
Ambition	CF	54	519	efgh	217	cd	7/29	R: BCMV; IR: whiteflies
BA 0958	ST	53	510	efgh	241	bc	7/29	R: BCMV; IR: BBS, root rot
Annihilator	CF	54	462	fgh	197	cd	7/27	R: BCMV, BCTV
Orient	JS	55	427	gh	229	c	7/30	HR: BCMV, HB; IR: BBS, BCTV
Serengeti	SY	55	418	h	201	cd	7/31	HR: BCMV
Slenderette	HO	53	233	i	114	d	8/4	BCMV, BCTV, BPMV

1 Days to harvest as reported by seed companies.
2 Means in the same column followed by the same letters are not significantly different (Waller-Duncan multiple range test LSD $P \leq 0.05$).
3 Highest yield obtained on one harvest date.
4 Disease resistance from seed company catalogues: HR = high resistance; R = resistance; IR = intermediate resistance; BPMV = pod mottle virus; BCMV = common mosaic virus; BCTV = beet curly top virus; HB = halo blight; Xap = common bacterial blight; BBS = bacterial brown spot; Rust = common rust.

during picking, and it had one of the highest cooked taste ratings. Momentum was one of the highest yielding green beans and was also one of the highest yielding on one harvest date. Its beans were attractive, slightly glossy, but rated fairly low for taste when cooked.

Furano, a light green colored, flat bean was one of the highest yielding in the trial. It performed slightly better than the other flat green bean, Greencrop. Beans were very straight, retained their stems well at harvest and were rated highly for raw visual appeal and rated midway with respect to the other varieties for cooked visual appeal, taste and texture.

Amethyst, the only purple bean in the trial, had a very high total yield and one-time harvest yield. Beans were very straight and rated very highly for raw visual appeal as well as cooked visual appeal, taste and texture. This purple bean turns olive green when cooked and the cooking water turns lime green. The purple coloring on the fresh beans is not uniform over the entire bean and there are grayish green areas, mostly on the side of the bean with less sunlight exposure.

The **Orient** green bean is notable in that it was one of the highest rated varieties for visual appeal, taste and texture when cooked. It has attractive, slim, short, very straight, uniform, light green beans, but lower yields. It has an extensive disease resistance package and is a specialty market item that may be attractive to restaurants because the beans can be served whole.

Acknowledgments

The authors would like to thank the following individuals for their hard work and assistance in the successful completion of this trial: Joseph Tucker, John Walsh, Dave Lowry, Grant Clouser, Steve Diver, Somjintana Sutthithanakool and Kanokwan Khanthawong.

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

Table 2. Plant and bean characteristics

Variety	Plant Height (in.)	Plant Width (in.)	Plant Habit (1-5)[1]	Pod Position (1-5)[2]	Pod Color (1-5)[3]	Straightness (1-5)[4]	Pod Length (in.)	Pod Uniformity (1-5)[5]	Beans with stems (%)[6]	Comments
Furano	21	29	2.3	2.0	2.0	4.0	5.1	3.7	93	Attractive, flat bean
Amethyst	19	24	4.5	1.5	-[7]	4.2	5.3	3.9	73	Pod color not uniform, purple with gray areas
Greencrop	22	30	2.4	1.8	2.0	3.3	7.3	3.6	88	Attractive, flat, lt green pod
Momentum	19	25	3.4	2.4	3.4	3.7	5.6	3.9	75	Attractive, uniform, slim, slightly glossy
Caprice	20	24	3.5	3.0	3.0	3.5	5.8	3.9	80	Attractive, slightly glossy
Achiever	16	21	4.0	2.0	4.0	4.2	5.5	4.1	78	Attractive, slightly glossy
Jade II	17	24	3.9	2.1	4.0	3.6	6.0	3.7	73	Attractive, slim, glossy
Colter	17	22	4.1	2.5	3.1	3.9	5.5	3.9	88	Slim bean
Opportune	18	22	2.8	2.6	3.1	3.6	5.6	3.6	98	Attractive, slim, glossy
Cosmos	18	25	3.3	1.9	2.9	3.0	5.5	3.2	60	Light colored, beans curled
Bowie	20	23	3.8	2.9	3.7	3.9	5.0	4.0	70	Attractive, uniform, slightly glossy, breaks easily during harvest
Bronco	18	24	3.5	2.1	3.0	3.7	5.0	4.0	97	Attractive, slim, picks easily
Sybaris	18	21	4.1	1.8	4.0	3.5	5.5	3.6	85	Slim, slightly glossy
Ambition	17	20	4.0	2.6	4.0	4.1	5.5	4.0	88	Very attractive, uniform, slim, slightly glossy
BA 0958	19	24	3.8	2.9	4.0	4.0	5.7	4.3	85	Attractive, slightly glossy
Annihilator	16	21	4.3	2.0	3.4	3.5	5.5	3.4	63	Not glossy
Orient	17	20	3.9	2.3	2.9	4.3	4.0	4.3	85	Attractive, short bean, harvests easily, specialty market
Serengeti	18	24	3.0	2.6	3.0	4.3	6.0	4.1	65	Attractive, straight, slim
Slenderette	17	22	3.5	2.1	2.9	3.9	4.6	3.7	95	Attractive, light green

1 Plant habit: 1 = prone; 3 = moderate; 5 = erect.
2 Pod position: 1 = all pods on ground; 3 = just off ground; 5 = high.
3 Pod color: 1 = light; 3 = medium; 5 = dark green.
4 Pod straightness: 1 = J curve; 5 = straight.
5 Pod uniformity; 1 = poor; 3 = average; 5 = excellent.
6 Percent of beans with stems still attached after picking, determined from a random sample of 10 beans.
7 Purple pods.

Table 3. Visual and taste ratings for fresh green beans

Variety	Visual Appeal RAW (1-5)[1,2]	Visual Appeal COOKED (1-5)[1,2]	Taste COOKED (1-5)[1,2]	Texture COOKED (1-5)[1,2]	Sum of All Ratings	Cooked Color
Orient	3.8	4.1	3.6	4.2	15.7	Uniform dk green
BA 0958	4	4.0	3.6	4.0	15.6	Dk green
Bowie	3.9	3.9	3.5	4.0	15.3	Uniform dk green
Opportune	4.2	3.6	4.1	3.4	15.3	Lt-dk green, variable
Amethyst	3.6	3.7	3.7	4.2	15.2	Olive green
Colter	3.8	4.3	3.6	3.4	15.1	Dk green
Cosmos	3.7	3.9	3.3	4.0	14.9	Lt-dk green, variable
Ambition	3.9	3.5	3.6	3.8	14.8	Dk green
Slenderette	3.9	3.4	3.6	3.8	14.7	Lt green
Annihilator	3.3	4.3	3.6	3.4	14.6	Dk green
Achiever	4	4.1	3.1	3.4	14.6	Dk green
Sybaris	3.6	3.6	3.1	3.6	13.9	Dk green
Furano	3.8	3.3	3.3	3.4	13.8	Lt green
Jade II	3.2	2.9	3.8	3.8	13.7	Very dk green
Serengeti	3	3.7	3.1	3.6	13.4	Lt-dk green variable
Momentum	3.4	3.5	2.8	3.7	13.4	Variable color
Caprice	4	3.3	2.5	2.8	12.6	Lt green
Bronco	3.3	3.0	2.3	3.8	12.4	Lt green, firm
Greencrop	2.9	3.0	2.9	2.4	11.2	Lt green, variable

[1] Rating 1 = poor; 5 = excellent.
[2] Participants = 5 (2 males, 3 females); All liked green beans.

Broccoli Cultivar Trial in Western Kentucky, Fall 2016 and Spring 2017

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Introduction

Broccoli is a popular crop when grown in home gardens and has strong local demand, but commercial production is limited. Newer cultivars, some with greater reported heat tolerance and climactic adaptability have become available since a trial in 2012 and 2013 (Wright et al, 2013). Improving fall productivity and expanding spring harvests with advanced cultivars has the potential to create more interest in commercial production. Twenty cultivars were evaluated for their performance and adaptability under local conditions.

Materials and Methods

The fall 2016 trial was conducted at the UK Research and Education Center in Princeton, KY, on a plot comprised of Crider Silt Loam soil. Fifty-cell plastic plug trays were filled with BM2 Germinating Mix medium (Berger, Inc.) and seeded on 27 June. A water-soluble fertilizer was applied every 10 days after emergence using 0.8 ounces (4 tsp)/gallon of 12-48-8 Sol-U-Grow (Miller Chemical & Fertilizer Corp.) for the first two waterings, and the same rate of 20-20-20 thereafter. Three 0.33 fluid oz. (2 tsp.)/gallon sprays of Sevin XLR Plus (Bayer CropScience LP) were applied during this period for insect control. The same methods were used for the spring 2017 trial seeded on 7 February.

Transplanting of seedlings occurred on 12 August (fall trial) and 10 April (spring trial), using black plastic mulch covered raised beds and 12-inch emitter, 0.45 gpm/100 ft. irrigation tape. Rows from the fall trial were reused for spring planting. Low greenhouse light intensity created noticeably leggy plants in spring 2017, requiring a secondary planting on 14 April to fill bare spaces. Recommendations from a soil test report and the *Vegetable Production Guide for Commercial Growers* (ID-36) directed the application rate of pre-plant and post-plant fertilizers (Saha et al, 2016). Insecticides were sprayed biweekly from 28 August to 10 October for the fall season and from 23 May to June 21 for the spring season.

A 5 feet center-to-center bed distance with 12-inch plant spacing generated an 8,712 per acre population was used to calculate yield data. Cultivars were replicated four times in a randomized complete block design with 10 plants per plot and 12-foot plot length. SAS software (SAS Institute, Cary, NC) was used to analyze harvest data, subjecting it to analysis of variance (ANOVA) and separating means using Duncan's Multiple Range Test. Results were considered significantly different if $P \leq 0.05$.

Results and Discussion

Temperatures were slightly above average from September to November 2016, with a 7.1-inch rainfall deficit during this same period (Kentucky Climate Center, 2017; Kentucky Mesonet, 2017). The dry conditions noticeably reduced disease and insect pressure and permitted an extended harvest season with 12 passes total, from 6 October to 21 November. Heads harvested at maturity were larger than 4 inches in diameter with a 6-inch cut stem length. A 12-inch ruler placed along the center of each head and stem aided in measuring the diameter. Heads were inspected for quality characteristics and defects

Table 1. Maturity, marketability, and culls of broccoli cultivars, Fall 2016

Cultivar	Marketable[3]									Cull		
	Seed Source[1]	Days to Maturity[2]	Yield (lb./A)[4,5]		Heads (No/A)[6]		Mean wt. (oz.)			(%)[7]		Reasons for Culling
Emerald Star	SK	63-85	7,115	a	8,422	a	13.5	bc		4.3	de	Small size
Millennium	SK	60-85	7,008	a	7,430	abc	14.9	ab		5.8	de	Small size
Eastern Crown	SK	55-81	6,838	ab	7,841	ab	14.0	bc		4.5	de	Poor compactness
Emerald Crown	SK	55-81	6,711	ab	7,841	ab	13.7	bc		8.5	de	Poor compactness
Greenpak 28	SY	57-88	6,512	abc	7,260	abc	16.3	a		7.7	de	Small size, poor shape
Monaco	SY	68-91	6,501	abc	7,550	abc	14.3	abc		13.0	de	Poor compactness
Asteroid	HM	55-85	6,282	abcd	7,260	abc	13.9	bc		3.9	e	Small size, poor shape
Imperial	SK	55-78	5,954	bcde	6,790	bcd	12.2	cd		10.7	de	Poor color/shape
Green Magic	SK	55-81	5,222	bcdef	6,970	bcd	12.0	cd		10.5	de	Poor compactness
HMX 5136	HM	63-85	5,077	cdef	6,389	bcd	12.7	bcd		12.4	cde	Poor color/shape
Delano	BZ	74-101	4,946	cdef	5,808	cde	13.6	bc		11.4	de	Small size, poor shape
Corvina	BZ	68-95	4,794	def	6,389	bcd	12.0	cd		9.0	de	Small size, poor shape
Luna	HM	60-78	4,794	def	6,098	bcde	12.6	bcd		26.1	cd	Poor color/shapes
Lieutenant	S	55-81	4,490	ef	6,679	abc	10.8	de		7.0	de	Poor compactness
Parasol	NO	74-101	4,250	f	4,646	e	14.6	ab		18.8	cde	Small size, poor shape
Emerald Jewel	SK	68-95	4,091	f	6,098	bcde	10.7	de		18.2	cde	Small size, poor color
NBL 8334	S	63-91	3,993	f	4,937	de	13.0	bcd		33.1	c	Small size, poor shape
Gypsy	SK	60-78	2,137	g	2,614	f	13.1	bc		65.8	b	Poor color/shape
Patron	SK	68-85	2,097	g	2,614	f	12.8	bcd		80.0	ab	Poor color/shape
Everest	SY	55-74	478	h	871	g	8.8	e		90.1	a	Leaf penetration
Sig.[8]			***		***		***			***		

1 See Appendix A for seed companies and addresses.
2 Number of days recorded from transplant to first and last harvests
3 Consists of well-shaped, compact heads, larger than four inches in diameter with characteristic color and without damage or defects such as leaf penetration or hollow stem.
4 Marketable yields calculated using: $\Sigma_{i\rightarrow j}$ (head weight * 8,712 per acre plant population, assuming 100% survival) / 10 plants per plot.
5 Means within columns separated using Duncan's Multiple Range Test LSD ($P \leq 0.05$). Two means having one or more of the same letters are NS.
6 Number of marketable heads per acre calculated using: # of marketable heads per plot * 871.2
7 Cull percent by weight calculated using: cull yield / (total yield of cull + yield of marketable heads).
8 *** Significant at $P \leq 0.001$ based upon general linear model analysis of variance test.

after harvesting. Though evaluated for hollow stem, none of the heads collected had this undesirable trait.

Spring and early summer 2017 were wetter than normal, with 2.2 inches above average rainfall in May and June. Excess soil moisture from rainfall, as well as runoff from an adjacent overhead irrigated wheat disease trial delayed planting, stunted field growth and limited productivity, resulting in only five harvest passes between 30 May and 24 June. Despite monthly average temperatures being near normal, a total of 20 days with highs above 80°F occurred during harvest. Uniform cool conditions are best for growth and quality of broccoli. The elevated temperatures likely contributed to the poor production, severe deficiencies in head quality, and high cull rates observed at harvest, causing early trial abandonment with no statistical analysis.

Yield and cultivar characteristics are shown in Tables 1 and 2. Seven leading cultivars had similar yields-per-acre in excess of 6,000 pounds and ranged between 7,200 and 8,400 marketable

Table 2. Diameter and quality characteristics of broccoli cultivars, fall 2016

Cultivar	Diameter (in)		Head Quality Characteristics (1-5)				
	Head	Stem	Color[1]	Shape[2]	Compactness[3]	Leaf Penetration[4]	Bead Size[5]
Emerald Star	5.7	1.4	4.7	4.5	4.5	5.0	3.9
Millennium	5.9	1.4	4.2	4.6	4.4	5.0	3.9
Eastern Crown	5.7	1.3	4.8	4.5	4.5	5.0	3.9
Emerald Crown	5.7	1.3	4.5	4.5	4.5	4.9	3.7
Greenpak 28	5.9	1.5	4.6	4.5	4.5	5.0	3.8
Monaco	6.2	1.6	4.4	3.9	4.0	5.0	4.0
Asteroid	6.0	1.5	4.7	4.1	4.0	5.0	3.4
Imperial	5.7	1.4	4.8	4.3	4.4	4.8	3.9
Green Magic	5.7	1.4	4.3	3.8	3.9	4.8	3.6
HMX 5136	5.8	1.3	4.5	4.3	4.5	5.0	3.4
Delano	5.8	1.4	4.6	4.1	4.4	5.0	3.5
Corvina	5.6	1.4	4.1	3.9	4.3	5.0	4.0
Luna	5.7	1.3	3.8	3.7	3.9	5.0	4.0
Lieutenant	5.2	1.4	4.8	3.6	3.9	5.0	3.6
Parasol	5.3	1.5	4.0	3.9	4.0	5.0	3.8
Emerald Jewel	5.6	1.3	4.3	3.4	3.8	5.0	4.7
NBL 8334	6.0	1.5	4.0	3.2	3.2	5.0	3.8
Gypsy	6.0	1.5	3.2	2.6	3.1	5.0	4.0
Patron	5.5	1.4	3.2	2.5	3.2	4.5	4.8
Everest	5.5	1.3	3.8	2.4	2.6	2.8	3.4
Significance[6]	**	***	***	***	***	***	***

1 Color rating scale: 1 = off-colored, 2 = yellow, 3 = light green, 4 = green, 5 = dark green or blue/purple-green.
2 Shape rating scale: 1 = sunken, 2 = flat, 3 = low dome, 4 = moderate dome, 5 = high dome.
3 Compactness rating scale: 1 = very loose, 2 = loose, 3 = moderate, 4 = compact, 5 = very compact.
4 Leaf penetration rating scale: 1 = very heavy, 2 = heavy, 3 = moderate, 4 = light, 5 = none.
5 Bead size rating scale: 1 = very large or coarse, 2 = large, 3 = moderate, 4 = small, 5 = very small or fine.
6 ** or *** Significant at $P \leq 0.01$ or 0.001, respectively, based upon general linear model analysis of variance test.

heads (Table 1). Among the top group, Emerald Star and Millennium were notable for extrapolated yields above 7,000 pounds per acre. Greenpak 28 produced the largest heads, while all of the top cultivars had mean weights above 13.5 ounces. Culling due to deficiencies in quality characteristics was a relatively minor occurrence for most cultivars. Only Luna, NBL 8334, Gypsy, Patron, and Everest had cull rates higher than 25 percent due to poor head size, shape, coloration, or compactness. Leaf penetration also occurred infrequently, except for Everest, where nine out of ten heads exhibited this negative quality.

Head coloration is an important characteristic for marketability. When uniformly green heads are desired, Millennium, Emerald Crown, and Monaco are superior cultivars. Emerald Star, Eastern Crown, Greenpak 28, and Asteroid will develop a slight blue-green coloration on some heads when exposed to cool temperatures nearing harvest.

The spring 2017 trial shows the high-risk nature of early season broccoli production in Kentucky; however, market potential exists for locally sourced produce. Any growers wishing to cultivate broccoli for spring markets should temper the size of their planting to minimize the risk of monetary loss.

Acknowledgments

The authors wish to express their appreciation to the UKREC farm crew, Dr. Winston Dunwell, and the seed suppliers that submitted cultivars for their assistance in the successful completion of this project. Funding was provided by a grant from the Kentucky Horticulture Council through the Agriculture Development Fund.

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Fall Brussels Sprouts and Cauliflower Cultivar Trial in Western Kentucky, 2015

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Introduction

Brussels sprouts and cauliflower have climactic and management requirements similar to cabbage or broccoli. They grow easily alongside these more popular crops. However, planting is limited by lack of information on production practices. There is also potential to expand the range of suitable cultivars for growth in Kentucky. The objective of this trial is to present appropriate production practices and to evaluate 16 Brussels sprouts and 20 cauliflower cultivars for their performance under local conditions.

Materials and Methods

The trial was conducted at the UK Research and Education Center in Princeton, Kentucky, on a plot comprised of Crider Silt Loam soil. Fifty-cell plastic plug trays were filled with BM2 Germinating Mix medium (Berger, Inc.) and seeded on 15 June. Seedlings remained in the trays for 6 weeks under partial shade with automated watering twice daily. A water soluble fertilizer was applied every 10 days after emergence using 0.8 ounces (4 tsp)/gallon of 12-48-8 Sol-U-Grow (Miller Chemical & Fertilizer Corp.) and sprayed with 0.33 fluid oz. (2 tsp.)/gallon of Sevin XLR Plus (Bayer CropScience LP) for insect control.

Transplants were planted on 5 August into black plastic mulch covered raised beds with 12-inch emitter, 0.45 gpm/100 ft. drip irrigation tape. Application of a pre-plant incorporated fertilizer was based on recommendations from a soil test report. Weekly fertigation ran from 31 August until 21 October, totaling 6 cycles. Each cycle applied 10 lb. of actual N-P-K per acre using a 20-20-20 water soluble formulation. Disease and insect scouting occurred weekly with pesticides applied from 25 August until 23 October as directed in *Vegetable Production Guide for Commercial Growers* (ID-36).

A 5-foot center-to-center bed with 18-inch plant spacing produced a 5,808 per acre plant population used to calculate yield data. Cultivars were replicated three times for Brussels sprouts and four times for cauliflower in a randomized, complete block design with 10 plants per plot and a 15-foot plot length. Data collected at harvest were subjected to analysis of variance (ANOVA) using SAS software (SAS Institute, Cary, NC) with means separated using Duncan's Multiple Range Test. Results were considered significantly different if $P \leq 0.05$.

Brussels sprouts

Topping and harvest were scheduled using seed supplier–provided maturity periods, counted from transplanting following the Julian calendar. Topping consisted of removing the top inch of each plant using hand shears in order to promote uniform growth of sprouts along the stem length. Plant leaves were retained (not stripped) for the duration of the season to promote sprout growth. Harvest occurred weekly starting 13 November and ending 23 December, totaling 6 passes. A long-handled lopper was used for whole stem harvest to cut plants at their bases. Leaves were removed from stems post-harvest by hand stripping outside of the trial field.

Cauliflower

Cultivars were inspected for head development starting a week prior to maturity from transplant, and every 3 to 4 days thereafter. For most cultivars, the spreading of crown leaves revealed the head. Self-blanching cultivars, which produce shielding wrapper leaves to provide cover, required confirmation by touch. At approximately 2 inches in diameter, each head was loosely wrapped using 8 to 12 leaves and secured with colored rubber bands. Harvest of 5- to 6-inch diameter heads occurred 7 to 10 days after tying, between 16 October and 23 November. Leaves surrounding the heads (8-12) were trimmed to market acceptability outside of the trial field.

Table 1. Stem yield of Brussels sprouts cultivars, 2015.

Variety	Seed Source[1]	Days to Maturity[2]	Total Marketable Yield (lb/A)[3]		Stems (No/A)		Mean Weight (lb./stem)	
Jade Cross E	ST	95	8,821	a[4]	5,001	ab	1.8	a
Dimitri	SW	105	8,181	ab	5,324	ab	1.5	ab
Cobus	ST	130	6,153	abc	5,808	a	1.1	bc
Franklin	SW	100	5,904	abc	5,001	ab	1.2	bc
Dagan	SW	100	5,797	bcd	4,840	ab	1.2	bc
Churchill	JS	90	5,655	bcd	5,163	ab	1.1	bc
Hestia	SW	100	5,442	bcd	5,001	ab	1.1	bc
Divino	SW	100	4,908	cd	4,517	ab	1.1	bc
Aurelius	ST	140	4,837	cd	5,163	ab	0.9	cd
Gustus	ST	120	4,659	cd	4,679	ab	1.0	bcd
Diablo	JS	110	4,019	cd	5,324	ab	0.8	cd
Nelson	RU	90	3,984	cd	4,840	ab	0.8	cd
Nautic	JS	105	3,735	cd	4,003	b	0.9	cd
Long Island Improved	RU	100	2,881	de	1,613	c	1.8	a
Red Ball (red)	SW	120	391	e	807	d	0.5	d
Catskill Improved	SW	95	.[5]		.		.	

1 See Appendix A for seed companies and addresses.
2 Days to maturity obtained from seed catalogues and online sources.
3 Total marketable stem yield calculated using: average marketable stem weight * marketable stems (No/A).
4 Means within columns followed by one or more of the same letter are not significantly different (Duncan's Multiple Range Test LSD P ≤ 0.05).
5 Catskill Improved failed to produce stems/sprouts.

Table 2. Stem lengths (in) of Brussels sprouts cultivars, including percentage marketable, 2015.

Variety	Marketable Length[1]		% Marketable (of Total)[2]		Unmarketable[3]		Total (mean)	
Jade Cross E	10.1	ab[4]	76.6	a	3.8	f	12.9	def
Dimitri	10.7	a	56.0	cde	8.9	bcd	18.8	ab
Cobus	9.9	ab	51.8	def	9.2	abc	19.2	a
Franklin	9.1	abc	64.6	bc	5.6	def	13.9	de
Dagan	9.9	ab	64.5	bc	6.2	cdef	15.0	cde
Churchill	9.3	abc	65.6	abc	5.9	cdef	14.2	de
Hestia	7.4	bc	49.2	ef	8.1	cde	14.7	cde
Divino	7.7	abc	61.2	bcd	5.2	ef	11.7	ef
Aurelius	7.8	abc	48.6	ef	8.5	cde	15.9	abcd
Gustus	7.8	abc	46.3	ef	8.8	bcd	15.3	bcd
Diablo	6.4	cd	43.7	f	8.4	cde	14.4	de
Nelson	7.7	abc	52.7	def	7.3	cde	14.3	de
Nautic	8.2	abc	44.8	ef	12.4	a	18.3	abc
Long Island Improved	8.4	abc	70.9	ab	7.4	cde	9.8	fg
Red Ball (red)	3.5	d	27.7	g	11.9	ab	13.2	def
Catskill Improved	.[5]		.		6.2	cdef	6.2	g

1 Marketable stems consist of sprouts between 1 and 1 ½ inch in diameter.
2 Percentage of marketable stem calculated by dividing the length of marketable stem by the total stem length (marketable and unmarketable).
3 Unmarketable stems consist of sprouts less than 1 inch or more than 1 ½ inch in diameter, or ones that are otherwise too loose or affected by disease.
4 Means within columns followed by one or more of the same letter are not significantly different (Duncan's Multiple Range Test LSD *P* ≤ 0.05).
5 Catskill Improved failed to produce stems/sprouts.

Results and Discussion

The fall growing season was exceptionally mild and ideal for extended harvests of later maturing cultivars. Average monthly temperatures for November and December were 3 and 10°F above normal, respectively. A 21.8°F freeze on 22 November (Kentucky Mesonet, 2016) injured a few remaining cauliflower heads, but as harvest was mostly completed, it did not appreciably affect final yields. Brussels sprouts were unaffected, allowing harvesting into late December. Rainfall during November and December was 3.5 inches above normal (Kentucky Climate Center, 2016). The increased moisture promoted later season development of bacterial leaf spot (*Pseudomonas syringae*), causing considerable losses of sprouts at the stem bases of susceptible cultivars. Some later maturing cauliflower heads developed spots associated with downy mildew (*Peronospora parasitica*), but infections generally were not severe or widespread enough to seriously affect marketable yields.

Brussels sprouts

Cultivar evaluation for stem and sprout yield, stem length, as well as sprout number and characteristics are shown in Tables 1 through 3. Four leading cultivars had statistically similar marketable stem yields, but Jade Cross E and Dimitri were exceptional for yields above 8,000 pounds (Table 1). Long Island Improved, Red Ball, and Catskill Improved had plant populations similar to other cultivars, but they developed fewer marketable stems. In the greenhouse, these three had noticeably smaller seed size and weak seedling growth in trays, which likely directly affected field growth. However, Long Island Improved did produce some stems similar to Jade Cross E in weight and visual characteristics. Dimitri, Jade Cross E, and Cobus formed long marketable stem sections, but Dimitri and Cobus, similar to Nautic, had large unmarketable portions, which reduced the remaining marketable percentage (Table 2). Jade Cross E produced shorter stems but had less unmarketable waste.

As with total stem yields, Jade Cross E and Dimitri had the greatest yields of shelled sprouts (Table 3). Long Island Improved developed a number of sprouts similar to Jade Cross E but had far fewer marketable stems, reducing its total yield. Dagan, Hestia, Nelson, and many of the earliest maturing (90-100 day) cultivars responded poorly to warm temperatures during growth, developing numerous large and loose sprouts at the plants' bases. Jade Cross E, with its densely packed stems of compact sprouts, was an exception. Later maturing cultivars (≥105 days) had more uniform growth but produced lengthy, unmarketable upper stem portions with numerous small-sized sprouts. The tasting panel was unable to detect a consistent difference in bitterness among cultivars evaluated.

Cauliflower

Tables 4 and 5 show the harvest maturity, yield, and head characteristics of the cultivars evaluated. Twelve leading cultivars were similar in total yield and mean head weights (Table 4). Steady and Flamenco were notable for having marketable yields over 19,000 pounds per acre and heads greater than 7 inches in diameter. Higher total yields generally corresponded with heavier mean weights and larger diameters, as opposed to greater number of heads. Observed maturities differed from those stated by seed sources, sometimes greatly, with the trend always later than described. However, harvests of Steady, Flamenco, Terzolo, Fargo, and Skywalker were all within 5 days of advertised maturity. Differences in growing conditions between the trial location and those of plant breeders and seed suppliers, including year-to-year differences in weather patterns, are likely the primary source of this disparity.

Casper was highly rated for self-blanching, whiteness of curd color, and absence of defects due to riciness or fuzziness (Table 5). The plants developed many long, shading exterior leaves with a tight covering of wrapper leaves surrounding each head. Terzolo and Panther rated highly for head compactness and shape, respectively, but the differences between cultivars were minor and did not influence marketability.

Cauliflower deserves to be more widely grown alongside other cole crops as several new cultivars in this trial showed promise in their suitability for growth in Kentucky. Steady, Flamenco, Aquarius, and Synergy are favorable for their yields and desirable characteristics. Interested growers should try Argos and Casper as self-blanching cultivars.

Table 3. Sprout yield, number, characteristics and notes of Brussels sprouts cultivars, 2015

Variety	Total Marketable Yield (lb/A)[1]		Number/ Stem[2]		Mean Weight (oz)		Compactness (1-5)[3]		Bitterness Cooked (1-5)[4]	Notes
Jade Cross E	4,741	ab[5]	42.0	ab	0.35	bc	4.8	ab	4.3	Stems with closely spaced sprouts, very low bacterial leaf spot incidence
Dimitri	5,177	a	35.7	bc	0.40	ab	4.7	ab	4.3	Long stems with widely spaced sprouts, very low bacterial spot incidence
Cobus	3,153	cd	27.0	d	0.32	bc	4.7	ab	4.2	Long stems with widely spaced sprouts
Franklin	3,785	bcd	29.7	cd	0.40	ab	4.0	bcd	4.0	Moderate bacterial spot incidence
Dagan	3,283	cd	28.4	d	0.39	ab	3.5	d	4.5	Uneven (loose) sprout development
Churchill	3,680	bcd	27.7	d	0.38	ab	4.0	bcd	4.7	Plants tend to produce suckers
Hestia	3,990	abc	25.6	de	0.48	a	3.6	cd	4.3	Uneven (loose) sprout development, moderate bacterial leaf spot incidence
Divino	3,177	cd	26.2	d	0.39	ab	4.2	abcd	3.7	Moderate bacterial leaf spot incidence
Aurelius	3,294	bcd	25.2	de	0.39	ab	4.8	ab	4.0	Plants tend to lean
Gustus	3,106	cd	24.8	de	0.40	ab	4.4	abcd	4.0	High bacterial leaf spot incidence
Diablo	2,643	cde	19.0	e	0.38	abc	4.0	bcd	3.7	High bacterial leaf spot incidence
Nelson	2,338	de	23.8	de	0.33	bc	3.7	cd	3.8	High bacterial leaf spot incidence, uneven (loose) sprout development
Nautic	2,409	de	23.5	de	0.38	abc	4.5	abc	4.3	Plants tend to lean
Long Island Improved	1,334	ef	42.9	a	0.28	bc	5.0	a	4.0	Uneven stem formation
Red Ball (red)	116	f	9.1	f	0.26	c	4.0	bcd	4.0	Poor stem/sprout development
Catskill Improved	.[6]		.		.		.		.	Plants did not form stems/sprouts

[1] Total marketable sprout yield calculated using: number of sprouts per marketable stem * average sprout weight * marketable stems (No/A).
[2] Composed of a subset of 9 randomly selected marketable stems, 3 per plot.
[3] Compactness rating: 1 = very loose; 2 = loose; 3 = moderate; 4 = compact; 5 = very compact. Sprout compactness evaluated by lightly squeezing sprouts between the thumb and forefinger and observing elasticity and ability to resist compression.
[4] Bitterness cooked rating: 1 = very high; 2 = high; 3 = moderate; 4 = slight; 5 = none. Sprouts were drizzled with olive oil and cooked covered in aluminum foil at 400°F for 40 minutes. When cooled a trained 6 member panel evaluated samples' tastes.
[5] Means within columns separated by Duncan's Multiple Range Test LSD ($P \leq 0.05$). Means followed by one or more of the same letter are not significantly different.
[6] Catskill Improved failed to produce stems/sprouts.

Table 4. Days to maturity, yield, and head diameter of cauliflower cultivars, 2015.

Variety	Seed Source[1]	Advertised Days to Maturity[2]	Observed Days to Maturity	Total Marketable Yield (lb/A)[3, 4]		Heads (No/A)	Mean Weight (lb)		Diameter (in)	
Steady	SW	67	72-95	19,846	a[5]	5,663	3.4	a	7.6	a
Flamenco	SW	71	72-95	19,094	ab	5,518	3.3	ab	7.4	ab
Aquarius	ST	70	84-106	18,868	abc	5,663	3.2	abc	6.7	abc
Synergy	RU	79	95-106	17,926	abcd	4,791	3.1	abcd	6.9	abc
Argos	SW	80	95-106	17,678	abcd	5,227	3.0	abcd	6.9	abc
Artica	ST	75	95-106	17,115	abcde	5,372	2.9	abcde	6.6	abc
Apex	ST	71	95-106	16,801	abcde	5,663	2.9	abcde	6.8	abc
Absolute	SW	75	95-106	16,801	abcde	5,663	2.9	abcde	6.7	abc
Terzolo	SW	62	67-92	16,426	abcdef	5,518	2.8	abcdef	6.9	abc
Casper	ST	76	95-106	16,141	abcdef	5,518	2.8	abcdef	6.3	cd
Freedom	RU	67	72-95	16,006	abcdef	4,792	2.8	abcdef	6.9	abc
Incline	RU	76	95-106	15,646	abcdef	5,663	2.7	abcdef	6.7	abc
Cumberland	ST	76	95-106	14,954	bcdef	5,227	2.6	bcdef	6.2	cd
Denali	JS	73	92-101	14,870	bcdef	5,518	2.6	bcdef	6.3	cd
Basan	SW	75	95-106	14,128	cdefg	5,227	2.5	cdefg	6.3	cd
Altamira	SW	86	95-106	13,796	defgh	5,227	2.4	defgh	6.1	cde
Amazing	SW	75	84-101	12,524	efgh	5,518	2.3	efgh	6.5	bcd
Fargo	SW	90	95-106	11,921	fgh	5,518	2.2	fgh	5.6	de
Skywalker	JS	80	84-106	9,443	gh	4,646	1.7	gh	5.2	e
Panther (green)	SW	76	95-101	9,300	h	5,518	1.6	h	6.0	cde

1 See Appendix A for seed companies and addresses.
2 Advertized days to maturity post-transplant obtained from seed catalogues or online sources.
3 Yields based on per acre population of 5808 plants, assuming 100% survival.
4 Marketablility consists of clean, compact, unblemished heads larger than 4 inches in diameter and are free from damage or physiological disorder.
5 Means within columns separated by Duncan's Multiple Range Test LSD ($P \leq 0.05$). Means followed by one or more of the same letter are not significantly different.

Table 5. Self-Blanching and curd characteristics of cauliflower cultivars, 2015.

Variety	Self-Blanching (1-5)[1]		Color (1-5)[2]		Compactness (1-5)[3]		Shape (1-5)[4]		Riciness, Fuzziness (1-5)[5]	
Steady	2.6	fgh[6]	4.7	ab	4.6	abc	4.9	ab	4.4	abc
Flamenco	2.4	gh	4.4	ab	4.5	abc	4.8	ab	4.3	abc
Aquarius	3.8	abcde	4.5	ab	4.5	abc	4.9	ab	4.4	abc
Synergy	3.8	abcde	4.5	ab	4.6	abc	4.8	ab	4.5	abc
Argos	4.1	abc	4.7	ab	4.6	abc	4.9	ab	4.2	bcd
Artica	3.8	abcde	4.7	ab	4.5	abc	4.8	ab	3.7	de
Apex	3.7	bcde	4.5	ab	4.4	bc	4.8	ab	4.5	abc
Absolute	3.1	efg	4.5	ab	4.2	c	4.8	ab	4.1	cd
Terzolo	2.1	hi	4.3	ab	4.9	a	4.9	ab	4.6	abc
Casper	4.5	a	4.8	a	4.8	ab	4.9	ab	4.8	a
Freedom	2.8	fg	4.6	ab	4.8	ab	4.9	ab	4.4	abc
Incline	3.2	defg	4.5	ab	4.6	abc	4.8	ab	3.5	e
Cumberland	3.9	abcd	4.4	ab	4.6	abc	4.8	ab	4.6	abc
Denali	3.9	abcd	4.7	ab	4.6	abc	4.9	ab	4.5	abc
Basan	3.9	abcd	4.6	ab	4.6	abc	4.9	ab	4.4	abc
Altamira	3.4	cdef	4.7	ab	4.4	abc	4.8	ab	4.5	abc
Amazing	1.5	i	4.2	b	4.7	ab	4.9	ab	4.2	bcd
Fargo	4.2	ab	4.2	b	4.7	ab	4.8	ab	4.1	cd
Skywalker	4.1	abc	4.3	ab	4.5	abc	4.6	b	4.2	bcd
Panther (green)	.[7]		.		4.4	abc	5.0	a	4.7	ab

1 Evaluation of self-blanching conducted prior to harvest by removing the colored bands from exterior leaves and pushing them away from the head to observe the extent of head cover by interior leaves. Self-blanching rating: 1 = none; 2= slightly; 3 = partially; 4 = mostly; 5 = fully.
2 Color rating: 1 = yellow-green; 2 = yellow; 3 = light yellow; 4 = creamy white; 5 = white.
3 Compactness rating: 1 = very loose; 2 = loose; 3 = moderate; 4 = compact 5 = very compact.
4 Shape rating: 1 = sunken; 2 = flat; 3 = low dome; 4 = moderate dome; 5 = high dome.
5 Riciness is the elongation and separation of flower buds while fuzziness is the elongation of flower stamens (male pollen bearing portion) on heads. Multiple conditions can contribute to their formation, including exposure to high temperatures and direct sunlight, rapid growth and high nitrogen, and high humidity during head development. Heads that exhibit these defects are also often loose and discolored. Riciness, fuzziness rating: 1 =very heavy; 2 = heavy; 3 = moderate; 4 = light; 5 = none.
6 Means within columns separated by Duncan's Multiple Range Test LSD ($P \leq 0.05$). Means followed by one or more of the same letter are not significantly different.
7 Panther is a colored variety and does not require blanching.

Acknowledgments

The authors wish to express their appreciation to the UKREC farm crew, Dr. Winston Dunwell, and the seed suppliers that submitted cultivars for evaluation in their assistance in the successful completion of this project. Funding was provided by a grant from the Kentucky Horticulture Council through the Agriculture Development Fund.

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Bell Pepper Cultivar Evaluation, Central Kentucky

Chris Smigell, John Strang, and John Snyder, Horticulture

Introduction

Bell peppers can be profitable for Kentucky farmers. This replicated trial evaluated 12 bacterial spot–resistant bell pepper varieties in comparison to the industry standard, Aristotle. Some of the newer varieties have resistance to ten races of bacterial spot, while Aristotle has resistance to three. Resistance to a greater number of races makes production easier and can reduce the number of bactericide sprays, but the varieties still have to yield well and have the quality that buyers require.

Table 1. Total yields and yields by USDA grades, 2017

Variety	Total Marketable Yield (lb/A) [1,2]		U.S. Fancy (lb/A) [3]		U.S. No. 1 (lb/A) [4]		U.S. No. 2 (lb/A) [5]		Culled Fruit (lb/A) [6]		Fancy + No. 1 as % of Total Mkt. Yield
Turnpike	54,000	a	34,100	ab	6700	bc	13,200	bcd	3700	ab	76
Aristotle	53,800	a	29,600	abc	7000	abc	17,300	ab	1700	abc	68
Green Flash	53,000	a	35,200	a	6500	bc	11,400	cde	1400	bc	79
Boca	51,400	ab	33,400	ab	7600	abc	10,400	de	1600	bc	80
Alliance	50,000	abc	33,100	ab	1600	f	15,400	abc	3400	abc	69
Currier	48,700	abcd	33,000	ab	4800	cde	10,900	de	2500	abc	78
Bastille	45,500	abcd	25,800	bcd	6300	bcd	13,400	bcd	3800	ab	71
Karisma	44,500	bcd	22,800	cd	3100	ef	18,600	a	2500	abc	58
Dazzle	44,000	bcd	22,300	cd	9700	a	12,100	cd	1200	c	73
SDY 48	42,300	cd	27,300	abc	6100	bcd	8900	de	3900	a	79
Lafayette	42,100	cd	27,600	abc	3600	def	10,900	de	3900	a	74
Galleon	41,100	de	25,400	bcd	8200	ab	7500	e	1300	c	82
Mariner	33,700	e	18,400	d	2700	ef	12,600	cd	1700	abc	63

1 Includes yields of U.S. Fancy, No. 1, and No. 2 fruits.
2 Means in the same column followed by the same letters are not significantly different (Waller-Duncan multiple range test LSD P ≤ .05).
3 U.S. Fancy=undamaged, unblemished fruit >3 in. dia.
4 No. 1= undamaged, unblemished fruit >2.5 but <3 in. dia.
5 No 2=undamaged, unblemished fruit <2.5 in. dia., plus larger, but misshapen yet sound fruit which could be sold as 'choppers' to food service buyers.
6 Fruit of any size with surface scarring, sunscald, insect and disease damage.

Table 2. Fruit characteristic ratings

Variety	Cull (%)[1]	Silvering (%)[2]	Uniform Fruit Shape[3]	Fruit Appearance[4]	4-lobed fruit (%)	Blocki-ness[5]	Green Color[6]
Turnpike	6	1	4	3.7	30	2.8	3.7
Aristotle	3	6	3.7	3.8	23	3.2	3.6
Green Flash	3	1	3.7	4.0	55	3.5	4.2
Boca	3	3	4.3	4.2	35	4.0	4.2
Alliance	6	1	3.8	4.0	55	3.8	4.1
Currier	5	3	4.3	4.2	58	4.3	3.8
Bastille	8	5	3.7	3.8	65	4.1	4.2
Karisma	5	4	3.1	2.8	30	3	2.4
Dazzle	3	14	3.1	3.1	60	3.5	3
SDY 48	8	1	3.9	4.0	55	4.1	4.2
Lafayette	9	0	3.9	3.9	53	4.1	3.2
Galleon	3	7	3.5	3.8	63	3.6	4.4
Mariner	5	3	4	4.0	70	3.8	4.1

1 Percent of all harvested fruit culled due to surface scarring, sunscald, insect and disease damage.
2 Percent of total marketable yield in the 1st harvest that showed slivering or very fine, light colored streaking
3 Uniformity of fruit shape: 1=poor, 5=excellent.
4 Fruit appearance: 1=poor, 5=excellent.
5 1=long, slender fruit or very squat, flattened fruit, 5=fruit with equal height and width.
6 1=pale green, 5=dark green.

Materials and Methods

Varieties were seeded on 21 March into plastic plug trays (72 cells per tray) filled with Jiffy Seed Starting Mix 17 (Jiffy Products of America, Lorain, OH) 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 17 May. Each plot was 15 feet long and contained 30 plants set 12 inches apart in double rows spaced 15 inches apart in the bed. Beds were 5 feet apart. Fifty pounds of nitrogen/A as urea was applied prior to plastic laying. At planting each transplant was watered in with a pint of starter solution (6 lb of 10-30-20 in 100 gallons of water). Calcium nitrate was applied via fertigation weekly at a rate of 8.2 lb nitrogen/A from 12 June through 23 August. Dual II Magnum herbicide was applied between beds following transplanting. Four early-season bactericide/fungicide applications of Badge SC (fixed copper) plus Manzate Pro-Stick were made between 23 May and 27 June. Danitol was sprayed for brown marmorated stink bug control on 10 August.

The plot was harvested three times: 11 July, 1 August, and 27 August. Marketable fruit were weighed and graded according to the size classes U.S. Fancy (>3 in. diameter), U.S. No. 1 (>2.5 inches but <3 in. diameter), and U.S. No. 2 (<2.5 in. diameter plus misshapen but sound fruit which could be sold as 'choppers' to food service buyers) and cull fruit.

Results and Discussion

Average daily temperatures and rainfall for June and July were near normal. Average daily temperatures were two degrees below normal for August, with near normal precipitation.

Table 3. Variety attributes

Variety	Seed Source	Days to Harvest[1]	Ripe Fruit Color	Disease Resistances[2,3]	Fruit Comments
Turnpike	ST	75	red	HR: BS (1-5, 7-9), TMV, Phyt	Attractive; culls due to sunscald
Aristotle	ST	70-75	red	IR: BS (1-3), PVY, TMV	Attractive; blocky to long; a lot of pointy fruit
Green Flash	CF	mid	red	IR: BLS 1-10	Attractive; uniform color; tall/blocky; very productive; more scarring than other varieties
Boca	SW	73	red	HR: BLS 1-10	Many 3-lobed; 1 w/ ringspot; Many squat fruit second harvest
Alliance	HM	74	red	HR: BS (1-5), PVY, PYMV, TMV, PMV, IR: CMV	Blocky- to long-blocky; some extremely lg fruit; good size at third harvest
Currier	SW	73	red	HR: BS (1-3), PMV, PVY (0, 1,1-2), TMV; IR: CMV, Phyt	Attractive, variable shape; variable color; good size at 3rd harvest; has very thick walls
Bastille	SY	75	red	HR: BS (1-5,7-9), PMV, TMV	Variable shape; many culls from ripe rot
Karisma	CL	71-75	red	HR: BS (1,2,3), PVY (0,1), TMV PMV; IR:CMV	Very pale green color
Dazzle	SW	-	yellow	HR: BS (1-5); IR: TSWV	Glossy; many squat fruit
SDY 48	SW	73	red	IR: BS (1-10)	Uniform color; culls from sunscald and ripe rot
Lafayette	CL	70	yellow	HR: BS (1-3)	Very pale green; many squat/flat fruit; culls from sunscald; many squat/ flat; 5% stinkbug
Galleon	CF	mid-late	yellow	HR: BS (1-10)	Color varies on some fruit; some virus
Mariner	CF	early	red	IR: BS (1-10)	No squat fruit; few puckered fruit

1 Days to harvest as listed by seed companies.
2 HR=disease resistant (restricted disease development & symptoms); IR=intermediate resistance (may show more disease symptoms than 'resistant' varieties grown in same environment).
3 BS=bacterial spot (strains 1-10); Phyt=phytophthora root rot; TMV=tobacco mosaic virus; PVY=potato virus Y (strains 0, 1, and 1-2); PMV=pepper mottle virus; PYMV=pepper yellow mottle virus; CMV=cucumber mosaic virus; TSWV=tomato spotted wilt virus.

Table 4. Yields of first harvest, 11 July

Variety	Total Marketable Yield (lbs)[1]	Percent of Total Mkt. Yield		
		Fancy (%)	No. 1 (%)	No.2 (%)
Alliance	10900	67	5	28
Boca	10200	53	30	17
Aristotle	9900	51	20	29
Karisma	9600	50	11	39
Turnpike	7000	55	28	17
Green Flash	6800	42	34	24
SDY 48	5900	47	37	16
Bastille	5800	50	26	24
Currier	5600	58	12	30
Mariner	5500	40	20	40
Lafayette	5200	63	15	22
Galleon	4500	42	45	13
Dazzle	3500	51	33	16

1 Combined weights of Fancy, No. 1 and No. 2 fruit.

Table 5. Yields of middle harvest, 1 August

Variety	Total Marketable Yield (lbs)[1]	Percent of Total Mkt. Yield		
		Fancy (%)	No. 1 (%)	No.2 (%)
Green Flash	35700	66	1	33
Turnpike	33400	60	4	35
Boca	31600	62	3	35
Aristotle	29900	73	5	23
Karisma	28800	74	4	23
Alliance	27700	60	15	24
SDY 48	27300	71	11	18
Galleon	26800	74	6	20
Dazzle	26500	55	3	42
Currier	25700	74	5	21
Mariner	20900	61	4	34
Bastille	20800	73	8	19
Lafayette	20600	68	7	25

1 Combined weights of Fancy, No. 1 and No. 2 fruit.

The best performing bell pepper varieties in this trial were Turnpike, Aristotle, Green Flash, Boca, Alliance and Currier. Varieties are ranked in Table 1 by the total marketable yield for the entire trial. Yields of the seven highest-yielding varieties were not significantly different. Six of these also had the greatest yields of U.S. Fancy fruit, and these yields, too, were statistically similar.

Aristotle, which has been the primary bacterial spot–resistant pepper Kentucky for a number of years, was second in total yield at just under 27 tons/A. Turnpike had 27 tons/A. Both varieties had similar ratings for appearance and other characteristics, although both had lower four-lobed fruit percentages and blockiness ratings (Table 2) than nearly all the other varieties. Green Flash had the third-highest total marketable yield and decent ratings for overall appearance, percent of four-lobed fruit, and dark green color. Boca had the fourth-highest total yield and had some of the highest ratings for appearance, fruit shape uniformity, blockiness, and deep green color. Currier was the sixth-highest in total marketable yield but had the highest blockiness rating and was tied with Boca for the highest overall appearance and shape uniformity ratings. Currier and Boca had some of the highest percentages of U.S. Fancy fruit as well (Table1).

Nearly all of the top overall-yielding varieties also were the top yielders in the first harvest on 11 July (Table 4). Thus, these varieties are good choices for growers looking for larger, early-season yields when the prices are higher. At the middle harvest, nearly all varieties increased their yields of Fancy and

No. 2 fruit at the expense of the No. 1 grade (Table 5). The top overall-yielders Aristotle, Bastille, and Currier, were top-yielders in the last harvest, while Karisma, Boca, and Green Flash dropped off in yields (Table 6). Aristotle was the only variety to remain among the top four yielders in all three harvests, attesting to its track record as a top pepper variety (Tables 4, 5, and 6), although Turnpike, Green Flash, and Alliance also maintained yields. In addition, Aristotle, Green Flash, Alliance, Currier, and Bastille all maintained about 70 to 80 percent Fancy plus No. 1 fruit across all three harvests Table 7. Among these, Green Flash and Alliance ranked well for color and fruit appearance, Currier ranked well for shape uniformity, appearance, and blockiness, and Bastille ranked well for number of four-lobed fruit, blockiness, and color. Growers interested in consistent production throughout the season for farmers market or CSA sales should consider these varieties.

Note that Turnpike, Green Flash, Boca and Alliance have substantially better resistance (Table 3) to a greater number of races of bacterial spot than Aristotle. This trial was conducted using a good early spray program for bacterial spot, so varietal resistance was not tested in this evaluation.

Acknowledgments

The authors would like to thank the following persons for their hard work and assistance in the successful completion of this trial: Joseph Tucker, John Walsh, Dave Lowry, Grant Clouser, Steve Diver, Jackson Fallon, Mohmmad Dawood, Ammar Al Bayati, Somjintana Sutthithanakool, and Kanokwan Khanthawong.

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

Table 6. Yields of last harvest, 27 August

Variety	Total Marketable Yield (lbs)[1]	Percent of Total Mkt. Yield		
		Fancy (%)	No. 1 (%)	No.2 (%)
Bastille	18900	66	6	29
Currier	17400	46	26	27
Lafayette	16300	52	22	25
Aristotle	14000	52	32	16
Dazzle	13900	63	18	19
Turnpike	13500	32	32	36
Alliance	11500	44	33	23
Green Flash	10600	55	18	26
Galleon	9800	34	20	46
Boca	9600	56	12	33
SDY 48	9100	47	9	44
Mariner	7300	49	20	31
Karisma	6100	56	17	27

[1] Combined weights of Fancy, No. 1 and No. 2 fruit.

Table 7. Combined percentages of U.S. Fancy and No.1 fruit at each harvest.

	Percent of U.S. Fancy + No. 1 Fruit		
	1st Harvest	2nd Harvest	3rd Harvest
Turnpike[1]	83	64	64
Aristotle	71	78	84
Green Flash	76	67	73
Boca	83	65	68
Alliance	72	75	77
Currier	70	79	72
Bastille	76	81	72
Karisma	61	78	73
Dazzle	84	58	81
SDY 48	84	82	56
Lafayette	76	75	74
Galleon	87	80	54
Mariner	60	65	69

[1] Ranked by total-season yield.

Pumpkin Fungicide and Cultivar Evaluation

John Strang, John Walsh, Chris Smigell, and John Snyder, Horticulture; Emily Pfeufer and Will Barlow, Plant Pathology

Pumpkin has been a profitable crop for many Kentucky growers over the years. However, powdery and downy mildews have been serious production problems. These diseases can destroy foliage prematurely, resulting in pumpkins with thin walls, poor quality stems, and poor storage characteristics. Seed companies have developed a number of pumpkin varieties that have powdery mildew resistance or tolerance to improve marketable yields and storability. In this study nine pumpkin varieties, most with powdery mildew resistance, were evaluated in a replicated trial to determine their performance in Central Kentucky under a high-input fungicide program, a low-input fungicide program, and a minimal program that did not include any powdery mildew–specific fungicides.

Materials and Methods

Varieties were seeded on 6 June 2017 into a field of Maury Silt Loam manually with Stand and Plant seeders at the University of Kentucky Horticulture Research Farm in Lexington. This study was laid out in a split-plot design with powdery mildew fungicide spray treatments as main plots and varieties as sub plots. Four fields were used as replications with each field (replication) containing randomly assigned spray treatments: no treatment for powdery mildew, a low-input powdery mildew fungicide program, and a high-input fungicide program for powdery mildew. All plots were sprayed identically for downy mildew and insect management. Spray treatments are shown in Table 1. Individual plots were 21 feet long and consisted of two rows, each containing eight seeds set 3 feet apart in the row with 6 feet between rows. Individual plots were separated from the next plot by 6 feet. Guard rows were planted on both sides of each field or replication. Drip irrigation provided water and fertilizer as needed.

Fifty pounds of N/A as urea were incorporated into the field prior to planting. Plots were drip irrigated as needed and fertigated with a total of 16 lb N/A as calcium nitrate divided into five applications over the season beginning on 19 July and ending on 23 August.

A tank mix of 1.33 pt of Dual II Magnum plus 0.66 oz Sandea herbicides /A was applied on 7 June for weed control. Bindweed and morning glory seedlings that emerged were hand pulled and spot sprayed with glyphosate once pumpkin plants emerged. Greenhouse grown pumpkin transplants were set in the field where seeds did not emerge. Following plant emergence the systemic insecticide Macho 2.0 FL (Imidacloprid) at the rate of 20 fl oz/A (1.38 fl oz/1,000 linear foot of row) was applied as a drench to each plant with a backpack sprayer at 1.0 fl oz of solution per plant for squash bug control on 21 June.

Disease ratings were completed on August 11. The upper and lower side of 20 leaves per plot were evaluated for disease severity using the Horsfall-Barratt scale. Individual data points were transformed to the midpoint of the rating range prior to means calculation. Analysis of variance was conducted using PROC Mixed in SAS 9.4, followed by LSMEANS comparison using the Tukey post-hoc test (P = 0.05).

Table 1. Pumpkin fungicide and insecticide main plot spray treatments

Spray Number and Date	High Input Spray[1]	Low Input Spray[2]	Minimal program[3]	Insecticides for All Plots
1 June 29	PM- Aprovia Top + mancozeb	mancozeb	Mancozeb	Permethrin
2 July 10	PM- Fontelis + mancozeb	Topsin		Permethrin
3 July 19	PM- Quintec + mancozeb	mancozeb	Mancozeb	Permethrin
4 July 26	PM- Aprovia Top + chlorothalonil	Topsin		Assail
5 Aug. 2	PM- Fontelis + chlorothalonil	Chlorothalonil	Chlorothalonil	Assail
6 Aug. 9	PM- Quintec + mancozeb DM- Ranman	Topsin + Ranman	Ranman	
7 Aug. 16	PM- Aprovia Top + chlorothalonil DM-Previcur Flex	Chlorothalonil + Previcur Flex	Chlorothalonil Previcur Flex	Permethrin
8 Aug. 23	PM- Fontelis + chlorothalonil DM- Ranman	Topsin + Ranman	Ranman	No insecticide
9 Aug. 30	PM- Quintec + chlorothalonil DM-Previcur Flex	Chlorothalonil + Previcur Flex	Previcur Flex	Assail
10 Sept. 6	PM- Aprovia Top + chlorothalonil DM- Ranman	Topsin + Ranman	Ranman	No insecticide
Approximate season-long PM fungicide cost[4]	$517.20	$226.05	$101.72	

1 High Input program, PM = fungicides applied for powdery mildew; DM = fungicides applied for downy mildew
2 Low Input program lists fungicides applied for powdery and downy mildew
3 Minimal program lists fungicides applied for downy mildew and Plectosporium blight. Mancozeb and chlorothalonil have protectant activity against powdery mildew.
4 Total cost per acre, based on a Kentucky fungicide supplier's 2017 price list. This approximate cost does not include downy mildew fungicides or insecticides.

Harvest began on 18 September and continued through 3 October. Pumpkins were cut and piled in the field for each treatment and rated for fruit shape, smoothness, ribbing, color, and stem quality. The number of cull and green pumpkins were counted, and all pumpkins were weighed. All pumpkins were lifted by their stems during loading and a separate stem rating was made for number of rotten stems and those that broke upon lifting.

Results and Discussion

The spring season was cool and wet. Powdery mildew fungicide spray treatment results are shown in Table 2, and variety results are shown in Tables 3 and 4. Yields in lb/A were significantly higher (8.3%) for the high input spray treatment than the other treatments, Table 2. However, there was no difference in the number of pumpkins harvested between treatments. Thus the high input spray treatment increased pumpkin weight across all varieties, but not the number of pumpkins harvested. There was no significant difference in the number of culls between spray treatments. There was no significant interaction between fungicide treatments and variety for any of the yield parameters. All varieties responded similarly to each of the fungicide treatments.

Overall, Kratos, Aladdin, and Apollo were the best yielding varieties in this trial. Camaro had the lowest powdery mildew severity, followed by Kratos and El Toro. Camaro yielded

Table 2. Powdery mildew fungicide pumpkin yield, fruit size, percent culls, and powdery mildew severity on the upper and lower leaf surfaces on August 11

Treatment[1]	Yield (lb/A)[2,3]		Yield (No./A)[2,3]		Fruit Size (lb)[3]		Culls (%)[3]		PM severity on upper leaf surface (%)[4]		PM severity on lower leaf surface (%)[4]	
High input	57,567	a	2,849	a	20.9	a	15	a	5.26	a	9.81	a
Low input	48,538	b	2,727	a	18.6	b	20	a	20.23	ab	29.05	b
Minimal	47,787	b	2,643	a	18.8	b	21	a	25.79	b	36.86	b

1 Spray program details in Table 1.
2 Yield averaged across all varieties.
3 Means in the same column followed by the same letters are not significantly different (Waller-Duncan multiple range test LSD *P* = 0.05).
4 Powdery mildew severity was rated on the upper and lower sides of 20 leaves per replicate on 11 August, using the Horsfall-Barratt scale. Data were transformed to the midpoint prior to conducting analysis of variance on the split-plot design. Means in the same column followed by the same letters are not significantly different (Tukey test *P* = 0.05).

well, but its light color reduces its value in many Kentucky markets. Notable were Early King, which was a very tall, elongated pumpkin with very nice stems and Cronus, a low yielding variety, with some of the largest, most attractive fruit with outstanding stems. All varieties but Howden had intermediate resistance to powdery mildew.

Kratos, Camaro, Aladdin, Apollo, and Early King were the highest yielding pumpkins based on pounds of marketable pumpkins per acre, Table 3. Kratos, Camaro, Aladdin, and Apollo produced some of the highest numbers of marketable pumpkins per acre. Early Giant and Cronus produced the largest pumpkins in the trial, while Apollo and Howden had on average the smallest pumpkins. Apollo, Kratos, and Cronus had the fewest cull fruits, while Early Giant had the most cull fruits, primarily due to stem decay, and also the highest powdery mildew pressure (Table 3). One cause of stem decay is excessive powdery mildew.

All varieties had dark orange skins except for Camaro, which was light orange, Table 4. This reduced its price at the Lincoln County Auction in Kentucky. Most of the varieties had a blocky shape, but Camaro, Kratos, El Toro, and Howden shapes varied more from blocky to round. Early Giant and Early King produced mostly tall, elongated pumpkins. Cronus and Early King had rougher skin, which was not objectionable, and Camaro had a very smooth skin. Kratos and Cronus had deeper, very apparent ribbing; Camaro had little ribbing. The Kratos and Cronus varieties had very large, attractive, green stems, many of which were indented into the fruit and buttressed.

Acknowledgments

The authors would like to thank Joseph Tucker, Dave Lowry, Jackson Fallon, Steve Diver, Grant Clouser, Somjintana Sutthithanakool and Kanokwan Khanthawong for their help and assistance in the successful completion of this trial.

Funding for this project was provided by a Kentucky Horticulture Council grant through the Agricultural Development Fund and general support from the University of Kentucky College of Agriculture, Food, and Environment.

Table 3. Pumpkin variety yield, size and percent culls

Variety	Seed Source	Days to Harvest[1]	Yield (lb/A)[2]	Yield (No/A)[2]	Size (lb)[2]	Culls (%)[2]	PM severity, upper leaf surface (%)[3]	PM severity, lower leaf surface (%)[3]	Disease Resistance[4]
Kratos	SW	115	66,435 a	3,718 a	17.9 cd	12 cd	14.8 ab	18.8 ab	IR: pm
Camaro	BL	110	61,117 ab	3,441 a	17.8 cd	18 bc	6.8 a	6.0 a	IR: pm
Aladdin	SW	110	59,731 abc	3,290 ab	18.3 cd	22 b	15.8 ab	24.5 bc	IR: pm
Apollo	SW	110	57,728 abc	3,769 a	15.3 e	9 d	21.5 ab	25.8 bc	IR: pm
Early King	SI	90	54,161 abc	2,798 bc	19.3 c	20 bc	22.7 b	28.1 bc	IR: pm
Early Giant	SI	95	49,386 bc	1,739 d	28.0 a	33 a	27.3 b	37.7 c	IR: pm
El Toro	SI	95	47,171 c	2,483 c	18.8 cd	20 bc	12.9 ab	18.8 ab	IR: pm
Cronus	SW	115	34,213 d	1,550 d	22.1 b	16 bcd	15.8 ab	33.2 bc	IR: pm
Howden	BL	115	31,732 d	1,865 d	17.1 de	29 bc	12.7 ab	34.1 bc	IR: br

1 Days to harvest as listed by seed companies.
2 Means in same column followed by same letters are not significantly different (Waller-Duncan multiple range test LSD $P = 0.05$).
3 Powdery mildew severity was rated on upper and lower sides of 20 leaves per replicate on August 11, 2017 using the Horsfall-Barratt scale. Data were transformed to the midpoint prior to conducting analysis of variance on the split-plot design. Means in the same column followed by the same letters are not significantly different (Tukey test $P = 0.05$).
4 Disease resistance as published by seed companies: IR = Intermediate resistance; pm = powdery mildew; br= black rot

Table 4. Pumpkin fruit characteristics

Variety	Color[1]	Shape (1-5)[2]	Smoothness (1-5)[3]	Ribbing (1-5)[4]	Stem (1-5)[5]	Comments
Kratos	do	2.4	3.8	4.0	4.5	Very attractive fruit, very nice stems
Camaro	lo	2.6	4.3	2.4	3.9	Thinner stems
Aladdin	do	2.0	3.8	2.9	3.3	Thinner stems
Apollo	do	2.2	3.1	3.3	3.9	Very attractive fruit, good stems
Early King	do	2.1	2.7	3.5	4.0	Variable fruit size and shape, good stems
Early Giant	do	2.0	3.5	3.6	3.1	Attractive tall pumpkins, more decayed stems
El Toro	do	2.4	3.5	3.6	4.2	Attractive fruit, very nice stems
Cronus	do	2.3	2.3	4.0	4.7	Very attractive fruit; very large, embedded, buttressed stems
Howden	do	2.4	3.1	3.7	3.3	Variable fruit size and shape

1 Pumpkin skin color: do = dark orange; lo = light orange.
2 Shape: 1 = oblate; 2 = blocky; 3 = round; 4= flat; 5= highly variable.
3 Smoothness; 1= rough warty; 5 = very smooth.
4 Ribbing; 1 = no ribbing; 5 = heavy ribbing.
5 Stem quality; 1= poor; 5 = excellent.

Soil Amended with Organic Manure Elevated Antioxidants Content of Arugula and Mustard Greens

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Introduction

Animal manure applied as organic fertilizer has important properties that cannot be obtained from synthetic inorganic fertilizers. Manures increase soil organic matter, improve soil physical structure, enhance soil fungal and bacterial activity, reduce eutrophication (excess N and P in natural water resources), provide low-cost adsorbents that bind with agricultural contaminants and prevent natural water contamination by pesticides (Antonious 2015). Over the past 50 years, N and P entering our nation's waters have increased dramatically (Keehner et al. 2011). Municipal sewage sludge (SS), a by-product of sewage treatment plants, is currently applied to some agricultural soils as an alternative to conventional inorganic fertilizers. Microorganisms in SS and other animal manures facilitate the slow release of the three main plant nutrients, N, P, and K, from soil organic matter.

Use of animal manure may reduce dependence on inorganic fertilizers and may provide alternative fertilizers for improving soil structure and nutrient status (Antonious et al. 2013). Use of organic amendments has been reviewed (Antonious 2009; Ozores-Hampton and Peach 2002). The use of chicken manure (CM) has overtaken use of other animal manure (e.g. pig manure, horse manure, and cow manure). Poultry litter contains all essential plant nutrients (N, P, K, S, Ca, Mg, B, Cu, Fe, Mn, Mo, and Zn), and has been documented as an excellent fertilizer (Subramanian and Gupta 2006). CM is one of the most commonly used soil amendments in the U.S. Because of the rapid growth of the poultry industry, CM has become increasingly available in recent years. Regarding the use of horse manure (HM) as organic fertilizer, typically, a ton of horse manure contains 11 pounds of N, 2 pounds of P and 8 pounds of K (Westendorf and Krogmann 2013). HM contains about 60 percent solids and 40 percent urine (Wheeler 2009).

A review of the literature revealed a lack of information regarding the impact of organic amendments on resulting plant nutritional and antioxidant properties. Investigators have focused on the plant yield and soil physical and chemical properties following the incorporation of animal manures as soil amendments with very little focus on the plant nutritional and antioxidant contents. Accordingly, the objectives of this study were to assess the impact of animal manure on arugula and mustard sugar and antioxidant content (ascorbic acid and total phenols).

Materials and Methods

The trial was conducted within an arugula (*Eruca sativa*) and mustard (*Brassica juncea*) field. Plants were grown on April 17, 2015 in 30 feet × 144 feet beds of freshly tilled soil at the University of Kentucky Horticultural Research Farm (Lexington, KY). Each bed, 12 feet × 30 feet, was divided into three replicates in a randomized complete block design (RCBD) with four soil treatments. The entire study area contained 24 experimental plots (2 crops × 3 replicates × 4 treatments). The treatments were native soil amended with: 1) sewage sludge (SS), 2) chicken manure (CM), 3) horse manure (HM). Animal manures were applied to soil to achieve a concentration of 5 percent N in each plot, except for the no-mulch bare soil (control treatment). SS used in this study was purchased from the Metropolitan Sewer District, Louisville, Kentucky. CM was obtained from the Department of Animal and Food Sciences, University of Kentucky, Lexington, Kentucky. HM was obtained from the Kentucky Horse Park (Lexington, Kentucky).

Arugula and mustard were grown according to Kentucky agricultural guidelines (Hessin et al. 2015), and no inorganic fertilizers were applied. At harvest (July 20, 2015), representative plant leaves (20 g) were blended with 150 mL of ethanol to extract phenols. The homogenates were filtered through Whatman No. 1 filter paper and one mL aliquots of filtrate were used for determination of total phenols using the Folin-Ciocalteu method (McGrath et al. 1982) against a standard calibration curve (1 to16 µg mL-1) using chlorogenic acid (Fisher Scientific Company, Pittsburg, PA, USA). Ascorbic acid was extracted by blending 20 g of leaves with 100 mL of 0.4 percent (w/v) oxalic acid (Antonious and Kasperbauer 2002) and was quantified using the potassium ferricyanide method (Hashmi 1973). Soluble sugars in 25 g leaves were extracted with 80% ethanol and quantified by the method described by VanEtten et al. 1974). Concentrations of ascorbic acid, total phenols, and sugar contents were compared using analysis of variance and Duncan's multiple range test for mean comparisons (SAS Institute 2016).

Results and Discussion

Overall, regardless of crop type, SS, CM, and HM significantly ($P< 0.05$) increased ascorbic acid in plants by 82, 90, and 31 percent, respectively. Whereas, SS, CM, and HM significantly increased total phenols by 77, 70, and 36%, respectively compared to the no mulch bare soil (data not shown).

Ascorbic acid and phenols concentrations in arugula (Figure 1, upper graph) were greatest in plants grown in SS and CM amended soils compared to HM and NM soils. Concentrations of free sugars did not differ among the three animal manures tested, but were significantly greater than that for the NM soil. Similarly, mustard plants grown in SS and CM amended soils contained the greatest concentrations of ascorbic acid and phenols (Fig. 1, lower graph) compared to HM and NM treatments. When the responses of the two crops were averaged, no significant differences were found among the three soil amendments in soluble sugars concentrations

(Fig. 2), whereas, ascorbic acid and phenols concentrations were greatest in SS and CM amended soils.

In summary, pronounced differences in ascorbic acid and phenols concentrations were found among arugula and mustard greens grown under the different soil amendments tested. Overall, regardless of plant type, plants grown in SS and CM amended soil contained the greatest concentration of ascorbic acid (855 and 892 µg g-1 fresh tissue, respectively) and total phenols (609 and 587 µg g-1 fresh tissue, respectively), whereas, the concentration of soluble sugars were not significantly different among animal manures tested. These results revealed great variability among the organic amendments tested for their influence on ascorbic acid and total phenols, two important phytochemicals in plants. This was a research study and the manures used in this study were not composted and the 130 day interval recommended between application and harvest was not adhered to. Growers using manure that is not properly composted should adhere to the 130 day recommendation.

Acknowledgments

The author thanks Steven Diver and his farm crew for maintaining the field plots, and Alexander Antonious and Thomas Trivette for collecting the leaf samples. This study was funded by a grant from the United States Department of Agriculture, National Institute of Food and Agriculture (USDA/NIFA) No. KYX-10-13-48P to Kentucky State University.

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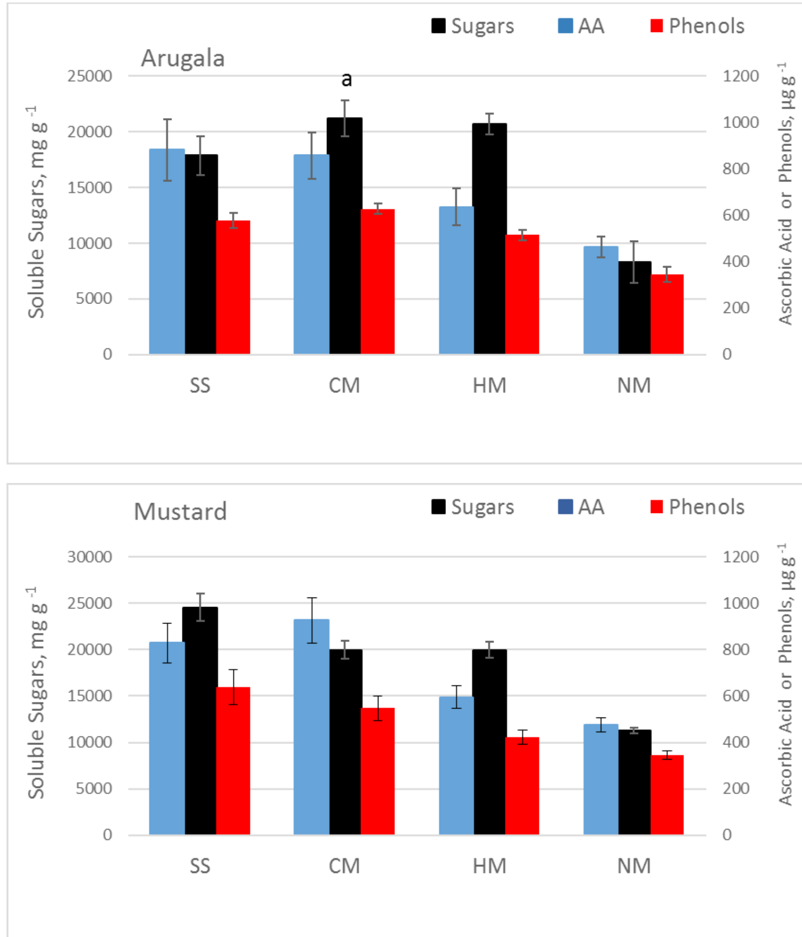

Figure 1. Concentrations of ascorbic acid (AA), total phenols and soluble sugars ± std error in arugula (upper graph) and mustard (lower graph) grown under four soil management practices. Statistical comparisons were carried out among four soil management practices for each parameter. Bars accompanied by the same letter are not significantly different (*P*> 0.05) using Duncan's multiple range test.

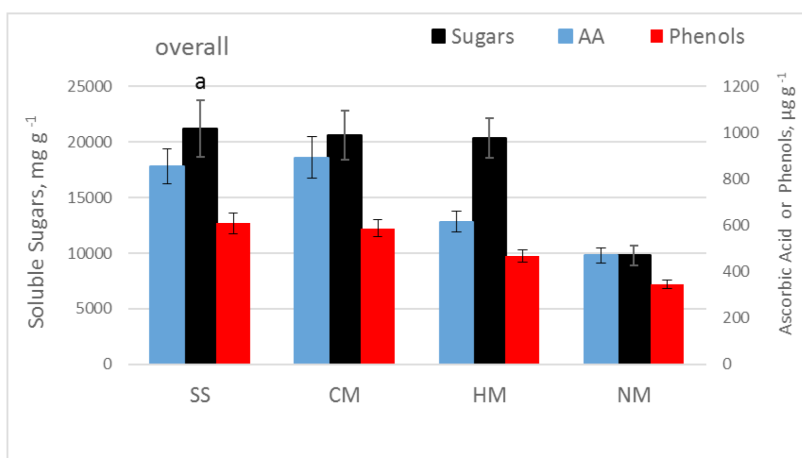

Figure 2. Overall concentrations of ascorbic acid (AA), total phenols and soluble sugars ± std. error under four soil management practices. Statistical comparisons were carried out among four soil management practices for each parameter. Bars accompanied by the same letter are not significantly different (*P*> 0.05) using Duncan's multiple range test.

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Small Scale Equipment to Optimize Tomato Disease Management

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Introduction

Tomatoes are arguably the most popular crop for the farmers' market, and numerous part-time and small scale producers grow them as part of their vegetable portfolio. Early blight, caused by the fungal pathogen *Alternaria tomatephila*, and Septoria leaf spot are together the most common diseases of tomato in Kentucky. Early blight may be managed well using a preventative fungicide program, however, the ability to control disease can be as reliant on the choice of delivery method as the types of fungicides used. At the same time, small scale producers may be less likely to invest in top-grade equipment for disease management, since the scale of their operations may dictate more conservative economic investment compared to larger scale commercial vegetable producers.

In this trial, identical fungicide programs were used to manage early blight of tomato, but the tested variable was the delivery equipment used to apply the fungicides. Different types of equipment included a hand-pump backpack sprayer, a mister-blower backpack sprayer, and a CO_2 backpack sprayer.

Materials and Methods

Tomato seeds were sown in 72-cell flats filled with pre-wetted ProMix BX on 27 Mar 2017. The variety 'Sunstart' was used because it is very susceptible to early blight. The field was located at the University of Kentucky Spindletop Farm in Lexington, KY and was prepared with 50 lb/A urea, broadcast and disked. Transplants were set into 18 ft-plots on raised beds prepared with black plastic mulch and a single line of drip irrigation on 18 May. Plant spacing was 18-in. and arranged as a randomized complete block design with four replications. Untreated border rows were established between treated rows to reduce the chance of spray drift among treatments. Potassium Nitrate was used as a starter fertilizer in the water wheel setter water. On 19 May, Platinum (11.0 fl. oz / A) was applied as a targeted 30 ml/plant drench at the base of each plant for insect management. Plants were of slightly reduced quality due to the need to hold them for optimal field conditions. Plants were fertigated with the equivalent of 10 lb calcium nitrate per week.

The fungicide program used was a relaxed schedule of the program defined in the Vegetable Production Guide for Commercial Growers, 2016-17 (ID-36), pg. 97. Actual fungicides and rates applied are listed by application date in Table 1. Six fungicide applications were made on 9, 16, and 27 June, and 5, 17, and 26 July. Volumes used were the equivalents of 30 gal/A for June applications and 50 gal/A in July applications. Equipment used were a Solo Deluxe 4-Gal Backpack Sprayer with diaphragm pump (retail cost \$90), a Stihl SR450 mister-blower (retail cost \$710), and an R&D CO_2 sprayer (retail cost \$1300). At the outset of the experiment, a Solo 5-Gal Rechargeable, Two-Speed backpack sprayer (retail cost approx. \$200) was also ordered and intended to be used, but it never successfully functioned, even after servicing by the supplier. Thus, those data are unavailable for this report. The hand-pumped backpack sprayer was outfitted with an adjustable brass spray nozzle to achieve a hollow-cone spray pattern, while the CO_2 sprayer was outfitted with a TX-18 hollow cone nozzle.

Plants were inoculated with a suspension of 2.5 x 103 *A. tomatephila* conidia / mL on the evening of 21 June. Plants were rated for disease on 3, 14, and 26 July using the Horsfall-Barratt scale. Disease ratings were transformed to the midpoint of each rating range prior to statistical analysis. Harvests occurred on 13 and 25 July, and 11 August. Plots were harvested individually by hand, with marketable yield weighed separately from unmarketable yield. At the 11 August harvest, plants were picked clean, regardless of whether fruit were adequately ripened. Analyses of variance with fungicide delivery equipment as the independent factor and disease or yield as the dependent variables were completed using PROC GLM in SAS 9.4. The Tukey test was used for a post-hoc means comparison.

Results and Discussion

At all disease ratings, untreated plants averaged higher early blight disease severity than the treated plots. No statistically significant differences were apparent among the fungicide delivery methods at each rating date, however, the CO_2 backpack severity ratings were numerically the lowest on 26 July (Table 2).

At the final yield estimate, taken on 11 August (Table 3), all fungicide treatments were significantly different from the untreated control. While none of the treatments were statistically different from each other, the mister-blower backpack treatment had numerically the highest marketable yields among the group. On 13 July, this same treatment had significantly less total yield compared to the untreated plot, but the marketable yields were not statistically different. One reason for this difference may be that the fungicide-treated plants had been treated with Actigard, which is known to occasionally drag down yields if applied when plants are in a stressed condition.

Acknowledgments

The authors would like to thank Lauren Spencer, Tim Hoey, Ruiyang Liu, Fan Xia, Xinyu Yuan, Xueqiong Xiao, Shine Baby, Jiaqi You, John Walsh, Jack Zeleznik, Grace Ragain, Dr. Bob Pearce, and Nolan Stephenson for their assistance with harvests. We would also like to thank the farm crew at Spindletop Farm and Dr. Ric Bessin for their assistance in setting up the field plots.

Funding for this project was provided by a grant from the Kentucky Vegetable Growers Association and general support from the University of Kentucky College of Agriculture, Food, and Environment.

Table 1. Fungicide application dates and rates

Application date	Fungicides applied (rate / A)		
9 Jun	Dithane F45 1.2 qt/A	Nordox 2 lb/A	Actigard 0.33 oz /A
16 Jun	Dithane F45 1.2 qt/A	Nordox 2 lb/A	Actigard 0.33 oz / A
27 Jun	Quadris 6.0 fl oz/A	Dithane 1.2 qt/A	
5 Jul	Initiate 720 1.5 pt/A	Nordox 2 lb/A	
17 Jul	Fontelis 20 fl oz/A		
26 Jul	Initiate 720 1.5 pt/A	Nordox 2 lb/A	

Table 2. Disease severity on three rating dates after inoculation with the early blight pathogen and repeated fungicide applications

Treatment	Early blight July 3 (%)[z, y]		Early blight July 14 (%)[z, y]		Early blight July 26 (%)[z, y]	
Untreated	9.7	b	39.2	d	68.0	f
Hand-pump backpack	1.1	a	2.6	c	11.7	e
Mister-blower backpack	0.9	a	1.2	c	11.8	e
CO_2 backpack	0.9	a	1.7	c	7.1	e

z Ratings were assigned using the Horsfall-Barratt scale, but were transformed to the midpoint of the range prior to means calculations and subsequent statistical analysis.

Y Means in the same column followed by the same letters are not significantly different (Tukey test $P = 0.05$).

Table 3. Marketable and total yields from three harvests of 'Sunstart' tomato with three different types of fungicide application used.

Treatment	13 Jul yields (lb/plot)		25 Jul yields (lb/plot)		11 Aug yields (lb/plot)	
	Marketable	Total[z]	Marketable	Total	Marketable[z]	Total[z]
Untreated	4.9	10.4 a	23.7	53.2	2.7 d	30.8 f
Hand-pump backpack	4.2	7.3 ab	19.8	35.7	26.6 c	87.6 e
Mister-blower backpack	1.7	3.7 b	19.2	44.2	37.8 c	86.0 e
CO_2 backpack	2.7	6.2 ab	20.1	45.0	29.1 c	85.1 e

z Means in the same column followed by the same letters are not significantly different (Tukey test $P = 0.05$).

Investigating the Impact of Soil-Set®, Grain-Set®, and Liqui-Plex® Formulations on Hot Pepper, Capsicum annuum Yield

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Introduction

Hot pepper, *Capsicum* spp. is a source of antioxidants (Antonious 2017; Antonious et al. 2017). The consumption of hot pepper has increased during the last decade due to the increased consumption by ethnic populations and a greater interest in ethnic foods in the U.S. The impact of Soil-Set® (a soil amendment that contains natural enzymatic compounds and balanced nutrients), Grain-Set® (a foliar fertilizer that supplies Mn, S, and Zn to the growing plant), and Liqui-Plex® Bonder WP (a foliar fertilizer that contains minerals complexed with amino acids) on pepper yield and fruit quality characteristics (fruit length, width, and wall thickness) were investigated.

Soil-Set is one of the Organic Material Review Institute (OMRI)–listed products, approved for use in organic farms (https://www.omri.org/omri-lists). The product is applied directly to soil before crop emergence to promote decomposition of crop residues and other organic matter and improve soil structure, ultimately contributing to improved root development. It contains essential elements for plant growth (Cu, Fe, S, Mn, and Zn), bacterial metabolites, and natural enzymes. Kunito et al. (2001) and Antonious (2016) studied the impact of metals on soil microbial activity and reported that Cu and Zn may impact soil microorganisms and total enzymes secreted in soil.

Crop-Set contains a similar mix of essential elements (S, Cu, Fe, and Mn) and plant extracts but is applied as a foliar fertilizer after crop emergence to provide plant essential nutrients. Liqui-Plex is another foliar spray that contains micronutrients complexed with amino acids needed for plant growth. Foliar application of fertilizers bypasses chemical reactions in the soil that can make nutrients unavailable to plants. The effect of these formulations on yield and quality of treated crops require further investigation to evaluate the potential outcomes of wide application of such materials in order to stimulate the use of these organic products in agricultural production systems.

Materials and Methods

A field study was designed at Kentucky State University Harold R. Benson Research and Demonstration Farm on a silty-loam soil. Sixteen field plots 4 foot wide and 30 foot long (120 $foot^2$ each) were used in a randomized complete block design (RCBD) with four soil treatments (Soil-Set, Grain-Set, Liqui-Plex, and control plots) replicated four times with two border plots (one at each side of the field study). Each block was divided into the following four treatments: 1) control (untreated soil and untreated plants); 2) Soil-Set, applied at 32 oz per acre at planting; 3) Grain-Set, applied at 8 oz per acre at vegetative stage; and 4) Liqui-Plex Bonder WP, applied at 16 oz. per acre at vegetative stage. The soil was planted with 72 day old seedlings of hot pepper, *Capsicum annuum* var. Georgia Flam on June 2, 2017 and drip-irrigated as needed. Soil-Set®, Grain-Set®, and Liqui-Plex® Formulations were obtained from Alltech Crop Science (Nicholasville, KY). Soil-Set was sprayed on June 2 and Grain-Set and Liqui-Plex were sprayed twice, on July 7 and 11, 2017. At harvest, pepper fruit yield, number of ripe fruits, and fruit characteristics (fruit length, width, and fruit wall thickness) were recorded and statistically analyzed using ANOVA procedure (SAS 2016).

Table 1. Impact of Liqui-Plex, Soil-Set, and Grain-Set on hot pepper, Capsicum annuum var. Georgia Flame yield, number of fruits, and fruit quality characteristics of plants grown at KSU Research Farm (Franklin County, KY)

Treatment	Fruit/plot (No.)		Wt. of Fruits (g/plot)		Fruit Length (cm)		Fruit Width (cm)		Fruit Wall Thickness (mm)	
Harvest 1										
Liqui-Plex	192.8	a	5744	a	11.65	b	3.54	a	0.31	a
Control	186	b	5130	c	11.84	ab	3.44	a	0.31	a
Soil-Set	173	c	5245	b	12.19	a	3.49	a	0.3	a
Grain-Set	154.8	d	4230	d	12.22	a	3.42	a	0.3	a
Harvest 2										
Liqui-Plex	551.38	a	11213.1	a	12.24	a	3.48	a	0.277	a
Control	489	b	9280.2	b	11.61	a	3.34	ab	0.288	a
Soil-Set	546.51	a	10642.6	a	11.81	a	3.23	b	0.271	a
Grain-Set	536.25	a	10650.7	a	11.58	a	3.14	b	0.272	a
Average Total Harvest										
Liqui-Plex	369.79	a	8444.2	a	11.94	a	3.51	a	0.29	a
Control	337.5	c	7205.3	c	11.72	a	3.39	ab	0.30	a
Soil-Set	359.87	ab	7943.7	b	11.99	a	3.36	ab	0.29	a
Grain-Set	345.50	bc	7440.4	c	11.89	a	3.28	b	0.28	a

Note that each value in the table is an average of 12 replicates of each soil treatment. Statistical analysis was carried out among soil treatments. Values accompanied by the same letter(s) are not significantly different ($P > 0.05$) using SAS procedure.

Results and Discussion

In harvest 1, results revealed that pepper plants treated with the three formulations during the growing season did not change any of the fruit characteristics (fruit weight, length, width, and fruit wall thickness) tested. Whereas, plants treated with Liqui-Plex formulation produced the greatest yield and greatest number of ripe fruits compared to the other treatments. These results could promote the use of this formulation in growing pepper and other vegetables in Kentucky and other states. In harvest 2, weight and number of fruits obtained from all the treated plots were significantly greater ($P< 0.05$) compared to the control plots.

Results also revealed that pepper fruits obtained from this study are consistent in color and free of noticeable defects. Alltech Soil-Set formulated product used in this investigation is organic and OMRI (https://www.omri.org/omri-lists) approved. The development of the market for organically produced food has been largely consumer led. As a result, organic farming is one of the fastest growing segments of U.S. agriculture, and producers, exporters, and retailers are still struggling to meet consumer demand for a wide range of organic products. Table 1 shows that the average harvest of plants grown in soil treated with Liqui-Plex produced the larger yield in comparison with the control treatment.

Acknowledgments

This investigation was supported by an Evans-Allen grant from the USDA/NIFA to Kentucky State University under agreement # KYX 10-13-48P.

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Sustainable Production of Living Organic Container-Grown Kitchen Herbs

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Introduction

There is an established and growing market for 4-inch container-grown organic kitchen herbs. More and more, consumers are interested in organically grown produce, and the convenience of having a living plant to cut herbs from is clearly desirable since these plants stay fresher for many weeks as opposed to cut herbs in plastic packs that only last a few days. Most production of kitchen herbs in Europe and the U.S. employ sub-irrigation methods that supply water to the plants via the base of the container to avoid "staining" the foliage with the salts from the water used for overhead irrigation. While consumer demand and the potential for an expanded market are present, significant barriers exist for this form of production. Often cited is a lack of production information as well the fact that growers tend to be inexperienced in this area of production (Treadwell et al., 2007). While organic living kitchen herbs are readily available in the U.S., production methods utilizing an organic fertilization regime and alternative bio-containers (i.e. not plastic)

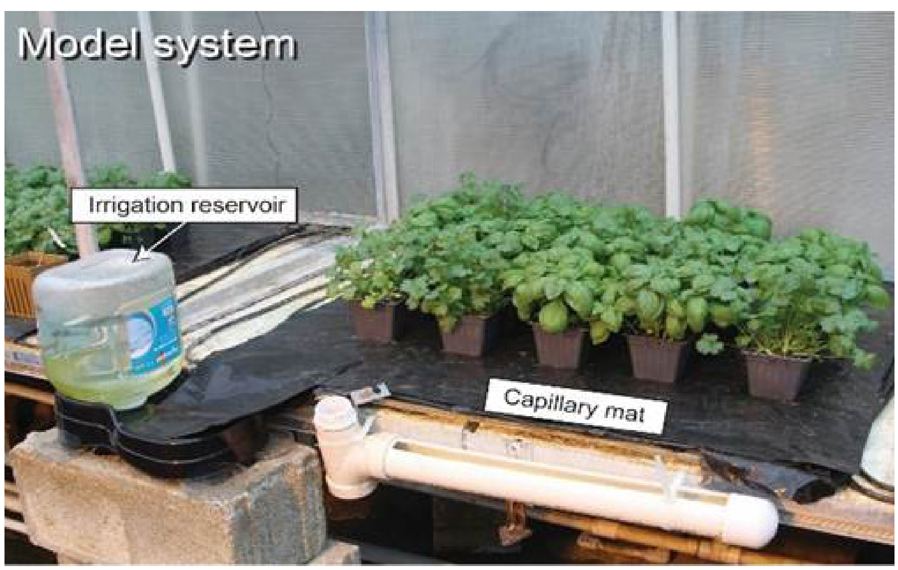

Figure 1. Model capillary mat system used to evaluate organic fertilizers

have not been extensively studied. The objective of this project was to develop a sustainable, organic production system for living herbs that minimizes water use through capillary mat sub-irrigation that utilizes an organic fertilizer program.

Methods and Materials

Organic basil and cilantro seeds purchased from Johnny's Selected Seeds were sown at a rate of 10 or 15 seeds per 4-inch plastic container. Each container was filled with an organic certified substrate (Black Gold Organic). Plants were grown using a capillary mat sub-irrigation system placed on a level greenhouse bench with one end of the mat submerged in a reservoir fitted to a carboy filled with either water or fertilizer. This system establishes a perched water table that provides a constant supply of water and nutrients to each container (Figure 1).

Plants were sub-irrigated with either water alone, a liquid inorganic (Peters 20-10-20) or organic (Daniels 3-1-1) fertilizer at 100 ppm. An additional set of plants had composted feather meal (12% N) incorporated into the substrate at a rate of 7 g L-1. Plants were evaluated after 5 weeks for plant height, biomass and leaf canopy. Leaf canopy areas for the Genovese basil were collected as a means of quantifying visual quality of the plants that a typical consumer may use to choose a plant in a retail setting. Aerial digital images were taken and then evaluated using the Sigma Scan Pro program in order to obtain a total canopy area.

Results and Discussion

Plants seeded at 15 seeds per container produced greater biomass and overall leaf cover compared to the lower seeding rate. Basil and cilantro plants irrigated with water alone produced inferior plants for all measured parameters while the highest quality plants were observed in the inorganic control (Figures 2 and 3). Genovese basil produced using the organic liquid fertilizer or incorporated feather meal showed comparable quality and growth (Fig. 2), but lime basil and cilantro plants showed increased growth with the incorporated fertilizer compared to liquid organic fertilizer (Figure 3).

The inorganic control plants produced the largest canopies, while the liquid organic and organic incorporation treatments produced slightly smaller canopies. While plant sizes between the two organic treatments and the inorganic control did not always visually appear to be significantly different (Figure 4), canopy sizes for the inorganically treated plants were significantly larger (Figure 2). However, differences in canopy areas between the two organic treatments were shown to not be statistically significant, suggesting that both fertilizing regimes produce comparable plants.

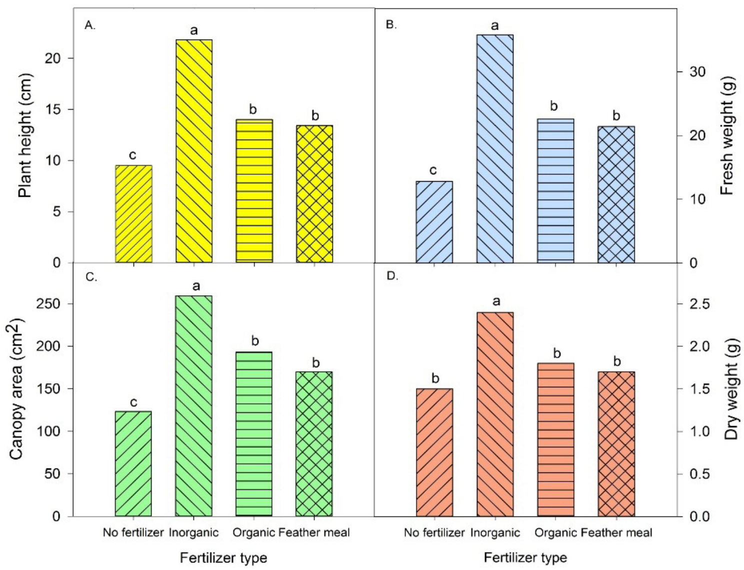

Figure 2. Plant height, leaf area, and biomass for Genovese basil grown on capillary mats and fertilized with conventional and organic fertilizers

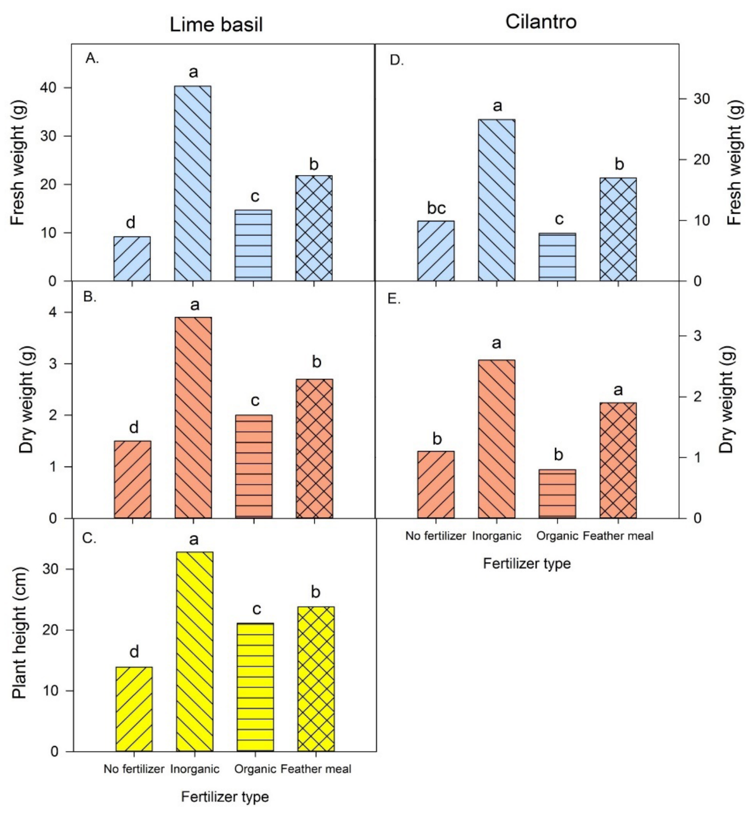

Figure 3. Plant heights and biomass measurements for cilantro and lime basil grown on capillary mats and fertilized with conventional and organic fertilizers

Organic herb production can present significant challenges (Williams et al. 2016) and specifically, there are few or no studies concerning organic, container-grown herbs. The current study showed that under the conditions of this study, organic fertilization could provide plant growth and quality similar to plants that were fertilized with a commercial liquid fertilizer (Figure 4). Container herbs require 4 to 5 weeks to a saleable product. In these short growing systems, only a small portion of the nitrogen important for growth is available from organic fertilizer sources. Organic vegetable transplant production is also a 4- to 5-week crop, and results have been similar to those reported here. For example, pepper transplants grown with inorganic fertilization showed superior development compared to organic options, but addition of the organic fertilizer considerably improved plant development compared to water alone (Gravel et al., 2012).

It does appear that there is potential for an organic production system using capillary mats to produce commercial quality organic basil and cilantro. Capillary mats are available in scalable systems to fit conventional greenhouse or high tunnel production. In general, for the current study, composted feather meal performed as well or better than the liquid organic fertilizer. However, the liquid fertilizer required more maintenance to prevent algal growth and to clean the system as the fertilizer aged. In contrast, the incorporated feather meal fertilizer proved to be much easier to handle in a sub-irrigation system than an organic liquid fertilizer.

Acknowledgments

The research was partially supported by the University of Kentucky Food Connection @UK student opportunity grant 2016.

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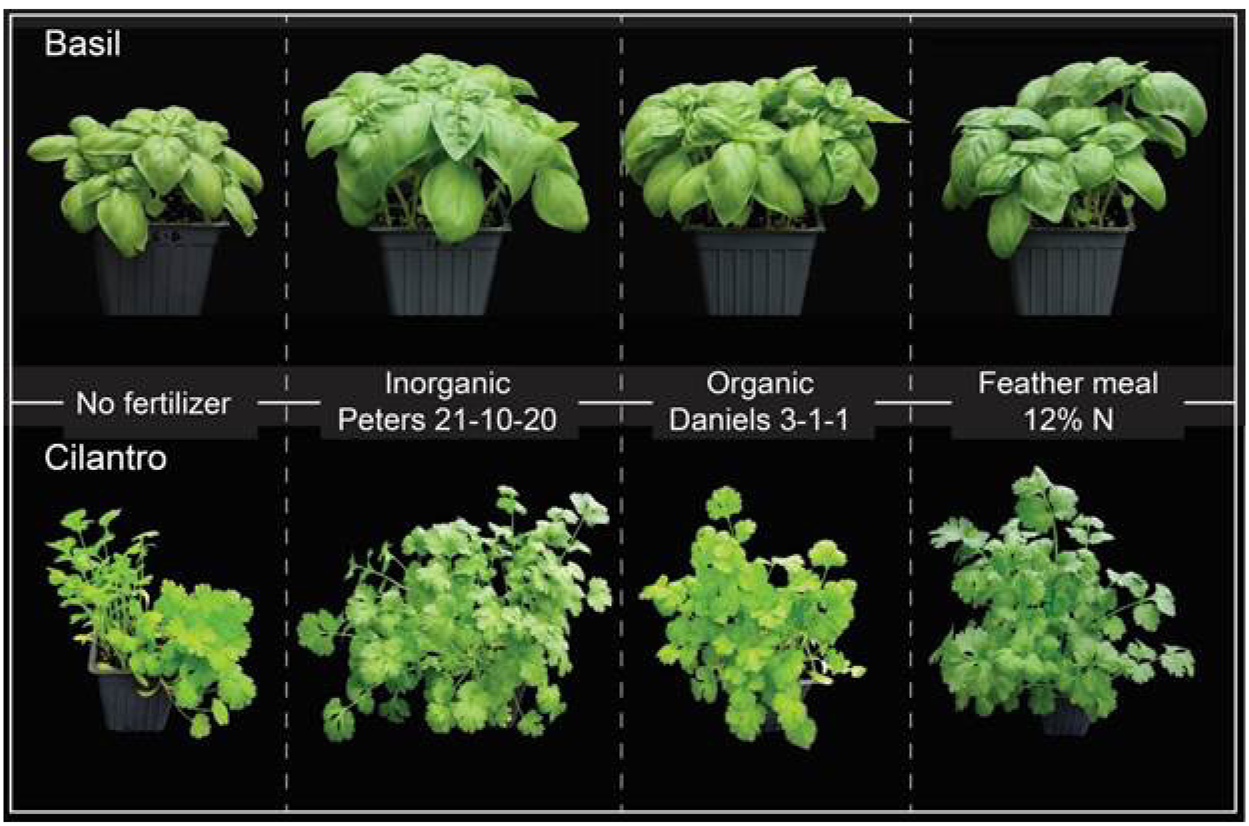

Figure 4. Comparison of overall plant quality across fertilizer treatments for Genovese basil and cilantro

Appendix A
Sources of Vegetable Seeds

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
BL................... Burrell Seed Growers, P.O. Box 150, Rocky Ford, CO 81067
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
HI................... High Mark Seeds, 5313 Woodrow Ln, Hahira, GA 31632
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
KB.................. K&B Development, LLC., 10030 New Avenue, Gilroy, CA 95020
KS................... Krummrey & Sons Inc., P.O. 158, Stockbridge, MI 49285
KY/KU........... 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
OR................... Origene Seeds, P.O. Box 699, Rehovet, Israel
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

12-2017