Evaluation of Thornless Semi-Erect and Erect Blackberry Training Systems and Varieties for Kentucky—2001 and 2002

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Introduction

Blackberries continue to be a popular market item for Kentucky consumers, and most growers find that high-quality blackberries are readily marketable. This study is being conducted as part of the New Crop Opportunities Fruit Project at the Horticulture Research Farm in Lexington, Kentucky. The first part of the study has been designed to evaluate two training systems for three thornless, semi-erect blackberry varieties using a double-T four-wire trellis. The second part is to evaluate the use of a plastic bailing-twine trellis for cane stabilization versus no trellis for two thornless, erect blackberry varieties.

Materials and Methods

Semi-erect thornless blackberry plants were set the spring of 2000 into black plastic-mulched beds. Each plot consisted of three plants of either Hull Thornless, Triple Crown, or Chester spaced 8 feet apart in the row with 12 feet between rows. Each plot was replicated three times in a randomized block design. All plants were trained on a double-T four-wire trellis with the lower two wires 2 feet apart and the top two wires 4 feet apart. Two training systems were used—a conventional system and the Oregon system.

In the conventional system, primocanes were topped when they had extended 1 foot above the top of the trellis. Dead fruiting canes that had cropped were removed in the fall. During early spring dormant pruning, spindly canes and/or those that had red-necked cane borer swellings were removed. Lateral branches were pruned back to 18 inches in length, and those that were within 18 inches of the ground were removed completely.

Primocanes were not summer tipped for the Oregon system. In the spring, canes were not thinned, although those with red- necked cane borer swellings were removed. Low laterals, within 18 inches of the ground, were removed. Laterals above this were not cut back and were wound around, and sometimes loosely tied, to the closest trellis wire extending away from the plant.

Arapaho and Apache erect blackberry plants were set 3 feet apart in the guard rows on the north and south sides of the semi-erect blackberry plot. Trellising treatments (supported and unsupported) and varieties were each replicated three times in a completely randomized design. Plots consisted of three plants of the same blackberry variety. Metal fence posts were set at intervals of 9 feet and plastic bailer twine was run on both sides of the supported treatment at a height of 3.5 feet.

During the first (2000) growing season, canes were allowed to trail and grow as much as possible. In the spring of 2001, the erect blackberry canes were pruned severely to encourage the development of more vigorous shoots for the following season. During the summer of 2001 and 2002, primocanes were tipped at a height of about 3 feet. Spindly canes and those with red-necked cane borer swellings were removed in the spring of 2002. Laterals were cut back to a length of 16 to 18 inches.

The black plastic mulch was removed during the spring of 2001, and plants were watered by hand as needed. The summer of 2002 was dry, and a trickle irrigation system was installed. Plants were fertilized in February with calcium nitrate at the rate of 8 lb/100-foot row (43.5 lb N/A). Weeds were controlled by hand weeding, spot treatment with Roundup® and in 2002 with Princep 4L. A conventional fungicide spray program using Kocide, Captan, Nova, and Benlate was maintained. Japanese beetles and green June beetle pressure was severe in 2002, and both Sevin and malathion were used for control. Bird pressure was also severe early in 2002, and an avian alarm was set up. The plants were harvested in 2001 and 2002. Data were collected for yield, fruit size, and fruit soluble solids.

Analysis of the 2002 data suggested that there was a mix-up in labeling of the Arapaho and Apache plants at planting. A visual inspection of the plants during the dormant season indicated that this was so. Arapaho canes remain green during the winter, while Apache canes turn red. Plants and plots were subsequently relabeled, and the data analysis was corrected. This resulted in the loss of precision in the 2002 data.

Results and Discussion

Statistical analysis was not conducted on the 2001 yield data (Table 1), but trends for berry weight and soluble solids (% sugar) content were similar to those obtained in 2002. Triple Crown tended to be the highest yielding and Hull Thornless the lowest yielding in 2001, while this was reversed in 2002, although there was no significant difference in yield. The fruit load in 2001 could have been re-

Table 1. Thornless blackberry yield, berry weight, and soluble solids, 2001 harvest.

Variety	Average Yield (lb/A)	Average Berry Wt. (g)	Soluble Solids (%)
Triple Crown	6,471	7.6	10.0
Chester	5,908	5.2	7.6
Hull Thornless	1,897	5.5	6.5
Apache[1]	2,517	8.0	11.4
Arapaho[1]	353	4.3	11.7

1 The erect thornless blackberries were pruned severely the spring of 2001.

sponsible for the reversal in 2002. Arapaho and Apache had very low yields in 2001 due to severe spring pruning.

Results for the semi-erect blackberries for 2002 are presented in Tables 2, 3, and 6. There were no significant differences in yield between the three semi-erect blackberry varieties or between training systems. Triple Crown had a larger berry size than the other two varieties. Triple Crown berries also had 1.3% higher soluble solids (sugar) content than Chester, which in turn had 2% higher soluble solids content than Hull Thornless. The Triple Crown fruit were noticeably sweeter than the other berries. They also had a higher pH (Table 6) than Chester and Hull Thornless. Pickers felt that Triple Crown had the most attractive looking fruit. Average berry size was slightly larger for the conventional training system in contrast with the Oregon training system. There was no difference in berry pH between the conventional and Oregon training systems (data not shown).

Table 2. Thornless semi-erect blackberry variety yield, average berry weight, and soluble solids, 2002 harvest.

Variety	Yield[1] (lb/A)	Average Berry Wt.[1] (g)	Soluble Solids[1] (%)
Hull Thornless	13,459 a	5.4 b	8.6 c
Chester	10,865 a	5.2 b	10.6 b
Triple Crown	9,815 a	6.9 a	11.9 a

1 Numbers followed by the same letter are not significantly different (Duncan Waller LSD P = 0.05).

Results for the erect blackberries are indicated in Tables 4 and 5. There was no difference in yield, average berry weight, or soluble solids content between the Apache and Arapaho plants. Nor was there a difference in yield or berry weight between the no-trellis and string-trellis treatments. However, there was a trend for Apache to yield more than Arapaho and for the string-trellis plants to yield more than the no-trellis plants. These trends may become more apparent in future harvests as a mix-up in the Arapaho and Apache plants at planting, which resulted in a loss of two degrees of freedom in the 2002 analysis, is rectified. The string-trellised plants did have slightly lower soluble solids content. Berry pH did not differ between the Arapaho or Apache varieties, and this was not affected by trellising (data not shown). Bird losses were more severe on the erect blackberries because these were the first to ripen. Pickers indicated that of the two thornless erect blackberries, Apache had the more attractive fruit.

Table 3. Thornless semi-erect blackberry yield, average berry weight, and soluble solids based on training system, 2002 harvest.

Training System	Yield[1] (lb/A)	Average Berry Wt.[1] (g)	Soluble Solids[1] (%)
Conventional	10,722 a	6.0 a	10.3 a
Oregon System	12,037 a	5.7 b	10.4 a

1 Numbers followed by the same letter are not significantly different (Duncan Waller LSD P = 0.05).

Table 4. Thornless erect blackberry variety yield, average berry weight, and soluble solids, 2002 harvest.

Variety	Yield[1] (lb/A)	Average Berry Wt.[1] (g)	Soluble Solids[1] (%)
Apache	6,131 a	6.6 a	10.6 a
Arapaho	2,947 a	7.0 a	10.9 a

1 Numbers followed by the same letter are not significantly different (Duncan Waller LSD P = 0.05).

Table 5. Thornless erect blackberry yield, average berry weight, and soluble solids based on training system, 2002 harvest.

Training System	Yield[1] (lb/A)	Average Berry Wt.[1] (g)	Soluble Solids[1] (%)
No trellis	3,786 a	6.0 a	11.0 a
String trellis	5,291 a	7.6 a	10.4 b

1 Numbers followed by the same letter are not significantly different (Duncan Waller LSD P = 0.05).

Table 6. Thornless semi-erect blackberry pH, July 9, 2002, harvest.

Variety	Berry pH[1]
Triple Crown	3.2 a
Chester	2.9 b
Hull Thornless	2.9 b

1 Numbers followed by the same letter are not significantly different (Duncan Waller LSD P = 0.05).

2002 Blackberry Cultivar Trial Results at the University of Kentucky Research and Education Center, Princeton

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Introduction

In the spring of 2000, a blackberry cultivar trial was established at the University of Kentucky Research and Education Center, Princeton, Kentucky.

Materials and Methods

The trial consisted of five cultivars, Navaho, Arapaho, Apache, Kiowa, and Chickasaw, allocated to five replications or blocks in a randomized complete block design. Each cultivar-replication combination consisted of a 10-foot-long plot followed by a 5-foot-long grass area to serve as a buffer. Plots consisted of six plants spaced 2 feet apart within each plot and 14 feet between rows. Plants grew well and looked healthy throughout the season of 2000. However, in 2001, all Navaho plants developed symptoms of Tobacco Ring Spot Virus. Navaho plants were removed during the fall of 2001 after laboratory confirmation of virus infection. In 2002, plots were harvested between June 18 and Aug. 1, on a two- to six-day schedule as dictated by the ripening process. Yield and berry size (weight of 50 berries per plot) data were recorded at each harvest, and total yield and average berry size calculated.

Results and Discussion

Results are shown in Table 1. Arapaho ripened the earliest but also had the lowest yield. Conversely, Apache yielded the most fruit but was also the last to ripen. Kiowa and Chickasaw were intermediate between Apache and Arapaho in both yield and ripening date. Arapaho had the shortest harvest period of 25 days, followed closely by Chickasaw with 39 days. Kiowa had the longest harvest period of 44 days.

In 2002, Chickasaw plants showed symptoms of Impatiens Necrotic Spot Virus and were subsequently removed.

Table 1. 2002 blackberry yield and fruit size of the 2000 blackberry cultivar trial at the UK Research and Education Center, Princeton, Kentucky.

Cultivar	Yield (lb/A)	Berry Size (g/berry)	Percent Fruit Ripened By June 30	Percent Fruit Ripened By July 15	Harvest Period
Apache	9,801	7.6	3	64	6/27-8/1
Kiowa	7,499	8.7	19	71	6/18-8/1
Chickasaw	6,192	7.0	17	85	6/18-7/26
Arapaho	3,454	3.5	76	100	6/18-7/12
* LSD (5%)	2,987	0.9	NA	NA	NA

* LSD = Least significant difference at the 5% level.

Blackberry Cultivar Evaluation—Quicksand

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Introduction

Blackberry (*Rubus*), a native plant, grows well in Kentucky, and new improved blackberry cultivars offer a chance for crop diversification and a high income per acre crop for Kentucky agricultural producers. Blackberries have multiple uses, including fresh or processed consumption, wine production, and medicinal purposes. *Rubus* has lower establishment and labor costs than many horticultural enterprises. It is also important to note that blackberries have the potential to be grown on hilly land and strip mine sites and have a low erosion potential in conjunction with sod strips. With available mechanization, blackberries can be grown on a large scale and mechanically harvested, or they may be grown on small scale and hand-harvested for local fresh markets.

Methods

A thorny and thornless blackberry cultivar and advanced breeding selection trial was planted as a randomized complete block in May 2000 on raised beds. For the thorny cultivars, six plants/replication were planted 2 feet apart in the row. The thornless erect cultivars were planted with four plants/replication at a spacing of 3 feet in the row. Plants of a thornless semi-erect cultivar (Triple Crown) were planted 4 feet apart in the row with three plants per replication. All rows were spaced 8 feet apart. There were a total of five replications for all the cultivars and selections with a 3-foot space between replications. The blackberries received a single application of 50 lb actual N/A from ammonium nitrate in March of 2001, 2002, and 2003. The blackberries were observed for vigor, winter/spring hardiness, disease problems, as well as fruit yield, berry size, appearance, and firmness.

Results

Many thorny and thornless blackberry cultivars have a tendency to de-harden and break dormancy early in Quicksand where 60° to 70°F temperatures in January and February may be followed by 10° to 20°F temperatures in March and April. This weather pattern occurs at least once every four or five years and did so in 2002 and 2003. Thornless cultivars such as Hull and Triple Crown, while considered less hardy than thorny blackberries, do very well here under our growing conditions because they are slow to break bud and remain dormant later into the spring. Table 1 shows the bloom development and the presence of floricane injury for both years. Canes showing injury at that time tend to die during warm weather prior to harvest, reducing yield and berry quality. *Entries or selections preceded by an "A" and followed by a number are unreleased breeding selections, are not for sale, and are not available commercially at the time of this testing and reporting.*

The 12 cultivars being tested at Quicksand were evaluated three years after planting for survival (Table 3). A grower who invests $2,700 to $3,300 in order to establish an acre of blackberries needs at least two good fruiting years to break even and begin making a profit. Among the 12 cultivars being tested, eight still had plant stands of 80% or better, whereas four of the cultivars had stands of 60% or less. An unidentified *Phytophthora* species was isolated from the decaying roots of many of the blackberry cultivars with poor stands.

Yield and berry size of the three thorny blackberry cultivars tested are shown in Tables 4 and 6. Kiowa produced the highest average yield (5,675 lb/A) and had the least amount of visible cane injury. Unfortunately, Kiowa is very susceptible to a fungal disease called double blossom. In a

Table 1. Blackberry cultivar/selection bloom and floricane evaluation.

	Percent Full Bloom		Floricane Injury		Comments	
Cultivar/Selection*	**5/04/02**	**4/25/03**	**5/04/02**	**4/25/03**	**5/04/02**	**4/25/03**
A1963	0	0	injury	8%	3/5 reps visible injury	4/5 reps visible injury
A1539	80	30	none	10%	-	4/5 reps visible injury
A2049	48	50	injury	-	3/5 reps visible injury	plants died out
A1857	37	0	injury	40%	2/5 reps visible injury	4/5 reps injury
A1854	98	45	injury	10%	1/5 reps visible injury	plants dead 3/5 reps
A1960	15	0	injury	76%	4/5 reps visible injury	5/5 reps injury
A1689	1	0	slight injury	0	1/5 reps visible injury	0/5 reps injury
Ouachita (A1905)	6	0	none	5%		1/5 reps injury
Navaho	1	0	severe injury	65%	4/5 reps severe injury	5/5 reps injury plants dying
Kiowa	5	0	none	17%	-	5/5 reps injury
Shawnee	61	11	none	7%	-	5/5 reps injury
Triple Crown	0	0	none	0	-	0/5 reps injury healthy plants

* Entries or selections preceded by an "A" and followed by a number are unreleased breeding selections and are not available commercially at the time of this testing and reporting.

Table 2. 2003 blackberry cultivar survival evaluation.

		Plant[1] No./Year							
Cultivar*	**Date**	**2000**	**2001**	**2003**	**Avg. No. Floricanes[2]**	**Avg. % Floricane Injury[3]**	**Avg. No. Primocanes[4]**	**Disease Rating[5]**	**Comments**
A1963 T[6]	7/28	6	5.8	5.6	18	78	16.8	0	good regrowth
A1539 T	7/28	6	5.2	5.2	9.8	74	15.8	0	good regrowth
A2049 T	7/28	6	5.8	1.6	0.4	-	0.4	-	dead/dying plants
A1857 T	7/28	6	6	5.0	10.6	90	8.8	-	3/5 reps dying
A1854	7/28	6	5	3.2	-	-	-	-	5/5 reps dying
A1960 T	7/28	6	6	3.6	6.4	92	5.8	-	5/5 reps dying
A1689 T	7/28	4	2.4	4	5.2	74	12	-	2/5 reps dying plants
Ouachita (A1905 T)	7/28	6	5.2	4.8	14.2	88	11.6	-	4/5 reps good regrowth
Navaho	7/28	4	4	2.4	5.2	57	4.6	-	5/5 reps dying out
Kiowa	7/28	6	4.6	5	10	90	7.6	DB	3/5 reps dying out
Shawnee	7/28	6	5.6	5.8	11.4	92	13	DB	good regrowth
Triple Crown	7/28	3	3	3.6	7.2	1	9.4	0	5/5 reps healthy

* Entries or selections preceded by an "A" and followed by a number are unreleased breeding selections and are not available commercially at the time of this testing and reporting.
1 Number of live plants/rep.
2 Number of floricanes present.
3 Percentage of injury or death to the floricanes: 0 = no injury,1 = 10-20% death while 5 = 80-100% death.
4 New primocane present actual count/rep.
5 Presence of disease: DB = Double Blossom, OR = Orange Rust, PH = Phytophthora Root Rot; 0 = no disease, 5 = 100% diseased.
6 "T" means the cultivar is thornless.

warm, humid climate, it would be hard to raise Kiowa without having a good fungicide spray program. Kiowa canes also have a tendency to lie down, thus making picking and mowing difficult. The selection A1854 had a tremendous fruit set in 2002, but the injured floricanes in all five reps slowly went down hill, resulting in a smaller berry size. The plants did not recover and have died out (Table 2). Shawnee had an average yield of 5,566.5 lb/A and has an attractive berry but is also subject to cold temperature floricane injury. In past trials at Quicksand, Shawnee has had problems with hardiness and double blossom and was included in this trial as a check for those problems.

The highest yielding thornless blackberry (Tables 5 and 6) was Triple Crown (8,102 lb/A) followed by A1689 with

Table 3. Survival of blackberry cultivars after two years.

Cultivar*	Percent Plant Survival[1]
A1963 T	93
A1539 T	87
A2049 T	27
A1857 T	84
A1854	53
A1960 T	60
A1689 T	100
Ouachita (A1905 T)	80
Navaho	60
Kiowa	83
Shawnee	97
Triple Crown	100

* Entries or selections preceded by an "A" and followed by a number are unreleased breeding selections and are not available commercially at the time of this testing and reporting.
1 Blackberry survival after two full years. Plant survival is based on live plants in five replications.

a two-year average of 5,173 lb/A and Ouachita (A1905) with 4,919 lb/A average. The three cultivars A1857, Navaho, and A2049 all suffered severe floricane injury and plant death. In 2003, the fruit from Navaho were so small and dried they were not marketable. The plants died out in 2003. The numbered cultivars A1689 and Ouachita (A1905) appeared to suffer less cane injury and produced attractive fruit. The fruit quality of these two selections made them the "pickers' choice" among all the blackberries harvested the past two years. Additional tests are needed to determine the long-term suitability of any blackberry cultivar to our climatic conditions, and further tests are planned for 2004 on these and additional blackberry cultivars and selections planted in 2002.

Table 4. 2002 thorny blackberry cultivar/selection evaluation, Quicksand.

Cultivar/Selection*	Harvest Start[1]	Harvest Days[2]	Pounds Fruit/A	Fruit Size (oz)	Taste[3]	Appearance[4]	% SS[5]	Disease Rating[6]	Remarks
Kiowa	6/27	40	7185 A	0.322	T	A+	8.0	2.4	Double Blossom
A1854	6/18	35	4052 A	0.123	S,T	A	9.0	0.6	
Shawnee	6/20	36	4010 A	0.382	S	A	8.4	2.5	Double Blossom
LSD			3805	0.478					

* Entries or selections preceded by an "A" and followed by a number are unreleased breeding selections and are not available commercially at the time of this testing and reporting.
LSD 5% Least significant difference at the 5% level.
1 The first day of harvest for that cultivar.
2 The number of days between first and last harvest for each cultivar.
3 Taste of fresh fruit: T = tart, S = sweet, B = bland.
4 Appearance: A- = below average, A = average, A+ = above average.
5 % SS is the percent soluble solids of fresh berries.
6 Disease ratings are on a 0 to 5 scale: 0 = no disease seen, 5 = 100% of plants have disease present.

Table 5. 2002 thornless blackberry cultivar evaluation.

Cultivar/Selection*	Harvest Start[1]	Harvest Days[2]	Pounds Fruit/A	Fruit Size (oz)	Taste[3]	Appearance[4]	% SS[5]	Disease Rating[6]	Remarks
Triple Crown	7/06	28	7623 A	0.193 A	S	A	10.0	0	
A1689	6/30	37	4793 B	0.188 B	S	A	9.3	0	
Ouachita (A1905)	6/24	41	3472 BC	0.183 C	S	A+	10.2	0	
A1963	6/26	33	2165 CD	0.178 D	S	A+	8.3	0	
A1960	6/23	40	2103 CD	0.166 E	S	A+	9.9	0	
A1539	6/19	43	1873 DE	0.164 E	T	A+	9.2	0	
A1857	6/20	26	801 DEF	0.134 F	ST	A	10.9	0	uneven drupelets
Navaho	6/26	23	537 EF	0.010 H	ST	A-	8.8	0	uneven drupelets
A2049	6/21	28	452 F	0.119 G	ST	A-	10.5	0	
LSD 5%			1369	0.004					

* Entries or selections preceded by an "A" and followed by a number are unreleased breeding selections and are not available commercially at the time of this testing and reporting.
LSD 5% Least significant difference at the 5% level.
1 The first day of harvest for that cultivar.
2 The number of days between first and last harvest for each cultivar.
3 Taste of fresh fruit: T = tart, S = sweet, B = bland.
4 Appearance: A- = below average, A = average, A+ = above average.
5 % SS is the percent soluble solids of fresh berries.
6 Disease ratings are on a 0 to 5 scale: 0 = no disease seen, 5 = 100% of plants have disease present.

Table 6. 2003 blackberry cultivar evaluation.

Cultivar/Selection*	Pounds Fruit/A	Fruit Size (oz)	Taste[1]	Appearance[2]
A1963	2843.7	0.175	S	A
A1539	6178.3	0.189	S	A
A2049	703.3	0.19	ST	A-
A1857	4945.9	0.159	ST	A
A1854	3908.6	0.122	ST	A
A1960	2242	0.151	ST	A
A1689	5552.1	0.212	S	A
Ouachita (A1905)	6366.1	0.173	ST	A
Navaho	1577.2	0.087	ST	A
Kiowa	4165.4	0.312	ST	A+
Shawnee	7123	0.118	ST	A+
Triple Crown	8581.8	0.122	S	A+
LSD 5%				

* Entries or selections preceded by an "A" and followed by a number are unreleased breeding selections and are not available commercially at the time of this testing and reporting.
LSD 5% Least significant difference at the 5% level.

1 Taste of fresh fruit: T = tart, S = sweet, B = bland.

2 Appearance: A- = below average, A = average, A+ = above average.

Extending Blackberry Fruit Shelf Life: Container Type and Modified Atmosphere Storage

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Introduction

Blackberry fruits have a short shelf life, and some quality loss can occur under recommended refrigerated storage conditions. Blackberry growers in Kentucky have indicated some preference for fiber baskets over plastic clamshell containers for marketing the berries, although the latter type of container is most common in the major retail chains. Shelf life of blackberries in the fiber baskets has not been directly compared to that in the clamshell containers, although more water loss from berries in the open basket may be expected, which could affect their quality and appearance. Modified atmosphere (MA) storage, raising CO_2 and/or lowering O_2 from ambient levels, has become common postharvest practice for extending shelf life of many perishable crops such as blackberries, and simple, cost-effective techniques for MA use are commercially available regardless of the scale of production. Although blackberries grown on the West Coast are commonly stored and shipped under MA conditions, the response of eastern thornless blackberries to MA storage has not been reported. The objectives of this work were to study 1) the influence of storage container type on blackberry fresh weight during postharvest storage and 2) the response of Chester thornless blackberry to MA conditions in refrigerated storage.

Materials and Methods

Chester thornless blackberries were harvested once a week for four weeks from the thornless blackberry planting at the University of Kentucky Horticulture Farm. Six fiber baskets and six plastic clamshells, each with 150 to 200 g of fruit, were prepared and weighed on each harvest date. The containers were placed in 2°C storage, and after a week were removed, weighed again, and set at room temperature. They were reweighed again after three days.

For MA studies, quality of a sub-sample of 12 to 15 berries was measured as described below on each harvest date, and 150 to 200 g of fruit were placed into plastic bags and weighed. The open bags were set into 1-liter Mason jars. To incorporate a modified atmosphere into each jar, the lids were loosely placed on each jar, and a needle was inserted through a septum in the lid to inject the MA. Then, 20% CO_2 or 5% O_2, with the other gases at ambient levels, was flushed through each bottle for approximately 30 seconds. After this application, the needle was removed and the lid was sealed. Control jars of ambient air were sealed shut without flushing. The containers were stored at 2°C. After seven days, the jars were removed from cold storage, and the quality of the fruit in half the jars of each treatment was measured. The bags of fruit were removed from the remaining jars and were set open in clamshell containers at ambient temperature for three days, at which time fruit quality parameters were measured. There were at least three containers per MA treatment per harvest date analyzed at seven and 10 days after harvest.

Quality traits of individual fruit measured included color using a Minolta Chroma Meter Model CR-200 and firmness using a Chatillon Force Gauge. A harvest date mean and a jar/container mean for color and firmness values were derived from the data. Data were analyzed by analysis of variance (ANOVA).

Results and Discussion

In cold storage, the fruit in the fiber baskets lost significantly more fresh weight than those in the clamshell containers (8.5% versus 6.3%). During the post-cold storage three-day period at room temperature, berries in the fiber baskets also lost significantly more fresh weight (15.1% versus 10.6% in the clamshell containers). Thus, fiber baskets may work well for immediate marketing of blackberries, but they are inferior to clamshells if a period of cold storage precedes marketing.

Neither modified atmosphere treatment affected the postharvest quality of Chester blackberries during or after cold storage. Fruit firmness increased slightly, less than 10%, during cold storage and decreased about 25% during the subsequent three days at room temperature. Fruit color somewhat intensified during postharvest storage. The blackberries tolerated the MA conditions with no obvious adverse effects even though they were in the upper range of conditions that are commercially used, but there was no obvious benefit to the use of MA. It remains to be determined if other eastern thornless blackberry cultivars will respond comparably.

Distribution of Blackberry Orange Rust and Rosette Diseases in Kentucky

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Introduction

Blackberries in Kentucky are subject to several serious diseases. Some of these diseases are present in native blackberries growing in the wild and represent a threat to domestic blackberries growing nearby. In addition, some diseases may be endemic to certain regions of Kentucky due to unique weather or topography.

Orange rust. This disease affects both blackberry and black raspberry and can often be seen in native or naturalized wild plantings. In Kentucky, orange rust is caused by the fungus *Gymnoconia nitens*, but the fungus *Arthuriomyces peckianus*, causing identical symptoms, may also be involved. Orange rust is the most important of several rusts of blackberry. Infected plants can be easily identified shortly after growth appears in spring when newly formed shoots appear weak and spindly. The new expanding leaves on such canes are stunted or misshapen and pale green to yellowish. The leaf edges may have a bronze color. The lower leaf surfaces of these infected shoots bear tiny orange pustules, visible with a hand lens. In a few weeks, the lower surface of infected fully expanded leaves are covered with highly visible waxy, bright orange blister-like pustules. Spores from these pustules, when blown to nearby healthy plants, will initiate new infections. Diseased blackberries become infected systemically, even below ground, and will bear little or no fruit.

Rosette. Also called "double blossom," rosette disease, caused by the fungus *Cercosporella rubi*, mainly affects blackberries, and only rarely raspberries or black raspberries. First symptoms are flowers with distorted petals, giving the appearance of a double flower (hence double blossom). The mycelium of the fungus grows over the flower pistils and stamens, producing a whitish spore mass. Unopened flowers are usually elongated and larger, coarser, and redder than normal. Sepals on infected flowers enlarge and occasionally become leaf-like. On some varieties, shoots may appear abnormal with leafy proliferation (rosette) or witches'-broom. Berries do not develop from infected branches, and other parts of the cane may produce only small, poor quality fruit.

For both of these diseases, blackberries can become infected from fungal spores produced on wild blackberries nearby. Therefore, it is important to remove and destroy infected blackberry plants as they occur in the field and also wild blackberries and other brambles near the planting.

The objective of this study was to begin a survey of blackberry plantings and native blackberry patches in Kentucky for presence of orange rust and rosette diseases.

Materials and Methods

Selected and representative commercial blackberry plantings and wild brambles statewide were surveyed as opportunities occurred on field visits by Extension personnel during the 2003 growing season. Blackberries were examined for symptoms and signs of orange rust disease and for symptoms of rosette disease. Samples of plants showing symptoms of either disease were collected and disease identifications were verified microscopically as needed in the University of Kentucky Plant Pathology Department Plant Disease Diagnostic Laboratory.

Archived UK Plant Disease Diagnostic Laboratory databases were searched for county records of blackberry orange rust and rosette diseases. Data from 1983-1992 and 1993-2002 were searched and recorded.

Results and Discussion

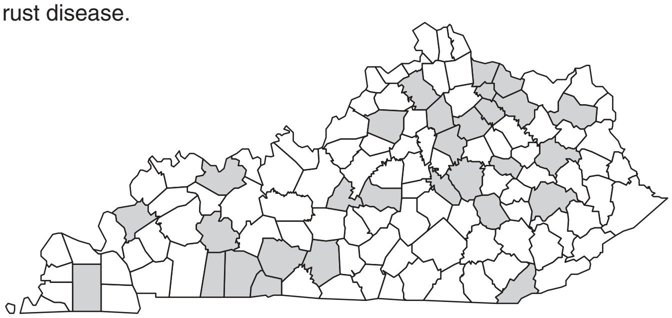
During the past 20 years, blackberry orange rust has been observed in 30 Kentucky counties (Table 1, Figure 1). The disease appears to be distributed throughout the state wherever blackberries are grown. Western, central, and eastern regions of Kentucky are equally represented

Table 1. Kentucky counties with records of blackberry orange rust disease.

1983-1992 Laboratory Data	1993-2002 Laboratory Data	2003 Survey
Bourbon	Daviess	Barren
Crittenden	Fayette	Bell
Logan	Graves	Bracken
Madison	Jackson	Bourbon*
Morgan	Marion	Breathitt
Todd	Muhlenberg	Carter
Warren	Shelby	Daviess*
	Woodford	Fayette*
		Fleming
		Garrard
		LaRue
		Mason
		Nicholas
		Jackson*
		Owen
		Powell
		Robertson
		Scott
		Simpson
		Woodford*

* Previously reported.

Figure 1. Kentucky counties with records of blackberry orange rust disease.



in the survey. The survey this year doubled the number of counties reporting orange rust compared to grower and county agent sampling during the previous 20 years. This suggests that the true extent of orange rust in Kentucky will only be found with a dedicated survey for the disease or that orange rust disease has not been noticed by or caused much concern for growers in the past.

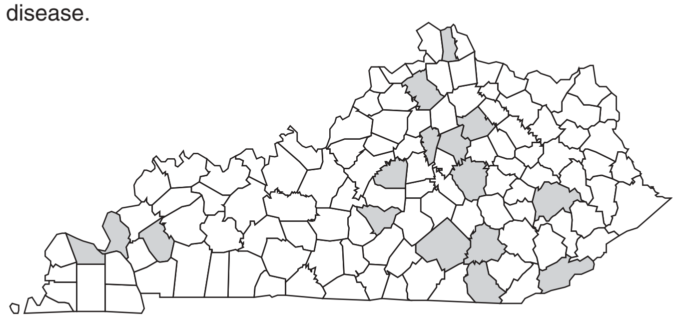
Blackberry rosette is found in 16 counties, and it also appears to be distributed within each region of the state (Table 2, Figure 2). However, it appears that 11 to 20 years ago the disease was more commonly noticed or caused concern in Western Kentucky, one to 10 years ago in Central Kentucky, and now is being more commonly noticed in Eastern Kentucky. Again, the survey in one year added significantly to the total number of counties recording rosette disease.

Table 2. Kentucky counties with records of blackberry rosette disease.

1983-1992 Laboratory Data	1993-2002 Laboratory Data	2003 Survey
Caldwell	Bourbon	Breathitt
Harlan	Fayette	Laurel
Livingston	Kenton	Whitley
McCracken	Madison	Woodford*
Washington	Owen	
	Pulaski	
	Taylor	
	Woodford	

* Previously reported.

Figure 2. Kentucky counties with records of blackberry rosette disease.



Records of the two diseases in this survey are likely biased toward counties where commercial blackberries are grown; this is where Extension personnel would make most of their investigations. Based on disease distribution revealed in this survey, it should be assumed that blackberry orange rust and rosette diseases can occur statewide. Kentucky blackberry growers will want to know where these diseases are a threat so that they can be alert to the need for eradication of wild plantings nearby and for the need to apply appropriate and timely controls on their blackberry crops.

Related Literature

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Fluctuating Controlled Water Table Irrigation on Geraniums

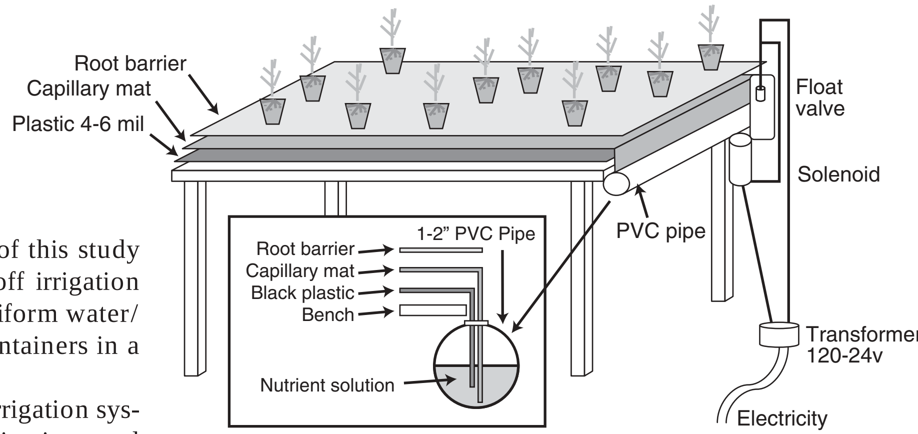
J.W. Buxton and J.A. Pfeiffer, Department of Horticulture

Introduction

Improper irrigation significantly limits the growth, quality, and profit of commercial container-grown crops. Generally crops are either irrigated too frequently or more likely insufficiently irrigated, especially under bright, warm conditions. Also, most crops are not irrigated uniformly. The objective of this study was to develop an automatic, no-runoff irrigation system that controls and maintains a uniform water/air ratio in the growing media of all containers in a growing area.

The Controlled Water Table (CWT) irrigation system is a modification of capillary mat irrigation used extensively in commercial greenhouses (Figure 1). The vertical placement of the water surface in the trough below the bench determines the air/water ratio in the container growing medium. With the water surface at bench level (0 CWT), the medium holds the maximum amount of water. Lowering the water surface in the trough below the bench decreases the water content and increases the air content in the growing medium. CWT has been used to grow many commercial greenhouse crops in various container sizes (2,3,4,5). Geranium studies are discussed in this report.

Figure 1. Construction of CWT.



Materials and Methods

Rooted geranium cuttings were planted in a 15-cm plastic container containing a peat-based growing medium. Peter's Peatlite fertilizer (15N-7P-14K) at the rate of 100 mg N per liter with proportional amounts of other elements as indicated by the fertilizer analysis was used as the fertilizer source. The six plants of each treatment were spaced on 30.5 cm centers in a randomized complete block design with three replications. At the conclusion of the research, geranium tops were cut off at the medium surface, and leaf area and plant dry weight were determined. Data for leaf area are presented here.

Results

At constant CWT, the medium air exchange occurs very slowly; therefore, CO_2, ethylene, and other gasses accumulate and may become toxic, and O_2 concentration is lowered (1,6). In fluctuating CWT studies, the level of the water surface goes up and down between the two distances below the bench surface. When the water in the trough moves from the high to the low level, the amount of moisture in the growing medium decreases and the amount of air increases. Also, the possible toxic gases in the medium will be flushed out when the water rises, and fresh air is moved into the medium when the water goes down.

Constant CWT. Geraniums in 15-cm containers were grown with the CWT set at 0, 2, 4, and 6 cm (Figure 2). Plant growth at CWT 0 and 2 cm was significantly larger than that of those grown at CWT 4 and 6 cm. Roots of plants grown at CWT 0 cm grew mostly in the middle of the container and few reached the bottom, indicating that the water content was too great and the air content too low near the bottom. However, roots of plants at CWT 2 cm were distributed uniformly from the center to the bottom of the container.

Fluctuating CWT and Day/Night Regulation. A day/night regulation of a fluctuating CWT was compared with the constant CWT. The treatments were CWT 2 cm day (D) and night (N), CWT 2 cm D, 2-4 cm D and N, and 2-4 cm D. In the CWT 2-4 cm treatments, the nutrient solution fluctuated between 2 cm and 4 cm. The CWT table was turned off at 7 p.m. and came on at 7 a.m. The control for the fluctuating system is shown in Figure 3. The CWT treat-

Figure 2. The leaf area of geraniums grown at CWT of 0, 2, 4, and 6 cm.

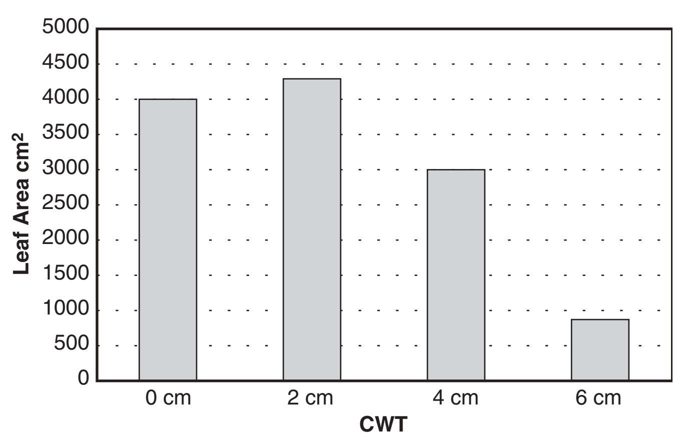
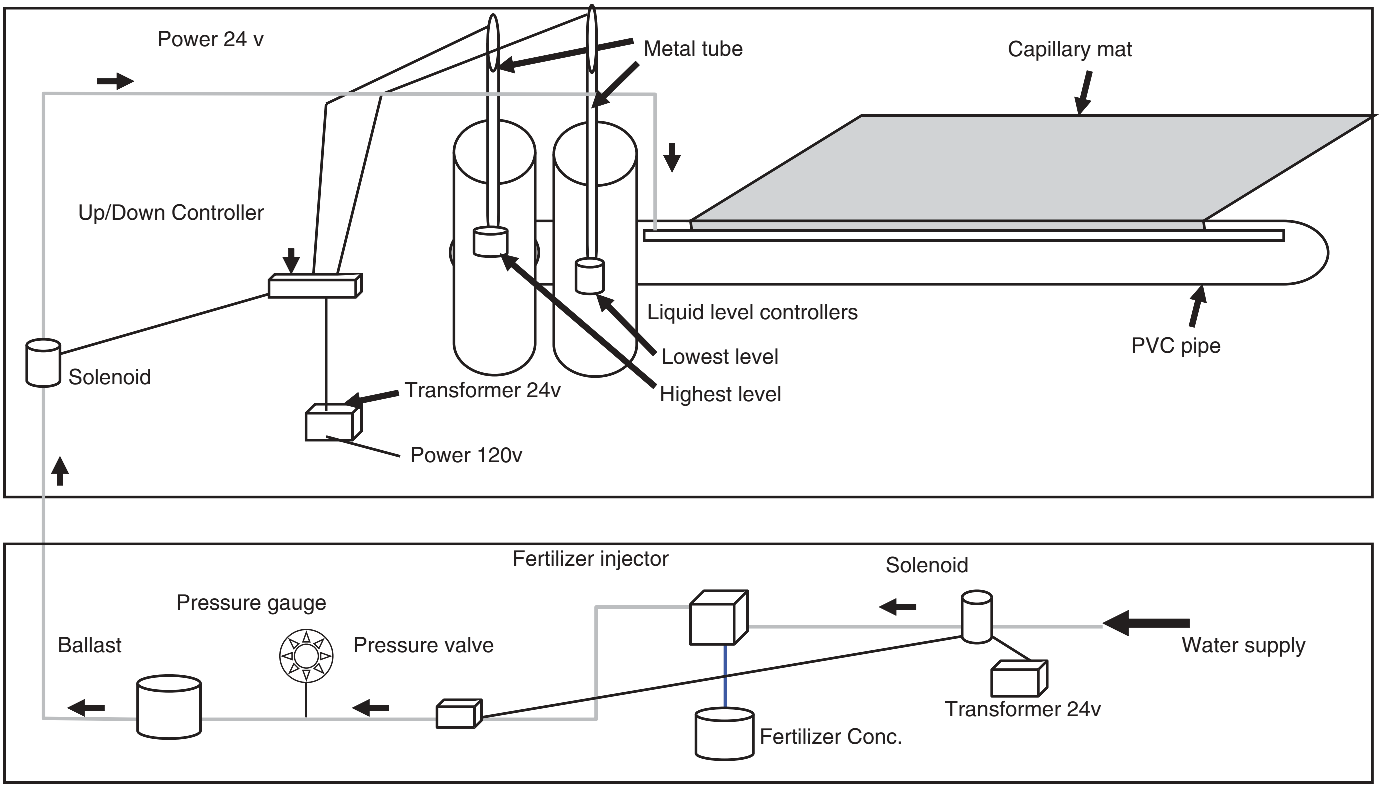


Figure 3. Control system for the fluctuating CWT.



ments did not significantly affect geranium leaf area or dry weight (Figure 4). Alternating the CWT between 2 and 4 cm appears to have some benefit, and turning the system off at night seems to reduce growth in both the constant and fluctuating CWT compared to being on continuously. However, the variability within the study was large, and additional studies are needed to confirm results.

Fluctuating CWT. In this study the treatments were CWT 2 cm, CWT 2-3 cm, CWT 2-4 cm, and CWT 1-4 cm. The leaf area of plants grown at a constant CWT of 2 cm, 2-3 cm, and 2-4 cm treatments had the same leaf area. However, plants grown at 1-4 cm were significantly smaller than the plants in the other treatments (Figure 5). Apparently, dropping the water table to 4 cm below the bench, even for a short time, reduces growth. Plants grown in constant CWT 4 cm in the previous discussion above also grew poorly (Figure 2).

Plant placement from trough. The first plant in each treatment is 15 cm from the trough, whereas the sixth pot is 165 cm from the trough. While young plants grow at the same rate, as plants became larger, the first pot was larger than the sixth pot (Figure 6). At the end of the experiment,

Figure 4. Effect of various CWT treatments on geranium leaf area.

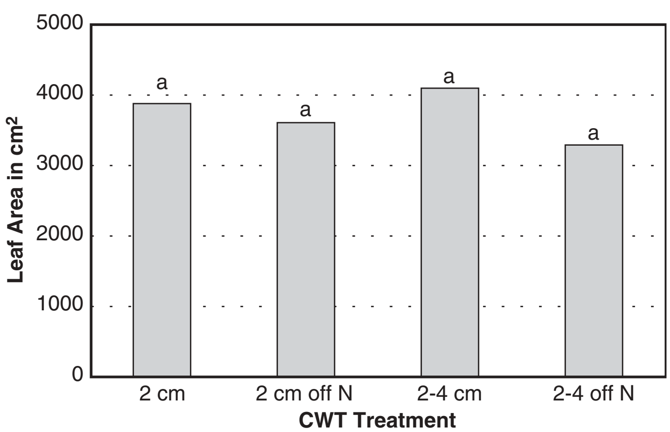


Figure 5. The effect of fluctuating CWT at 2 cm, 2-3 cm, 2-4 cm, and 1-4 cm on geranium leaf area.

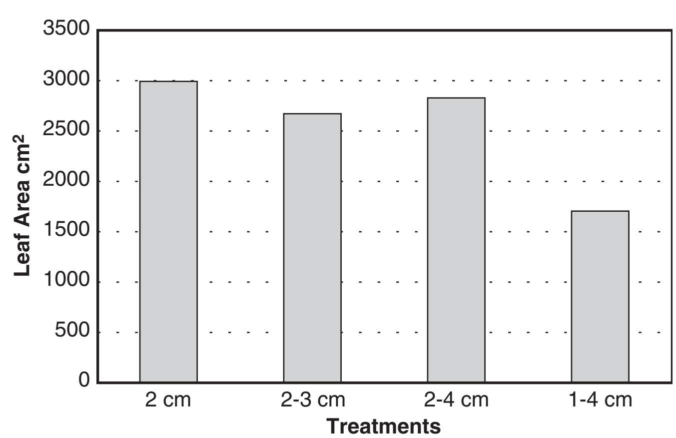


Figure 6. The effect of position of container from the trough on the leaf area of geranium.

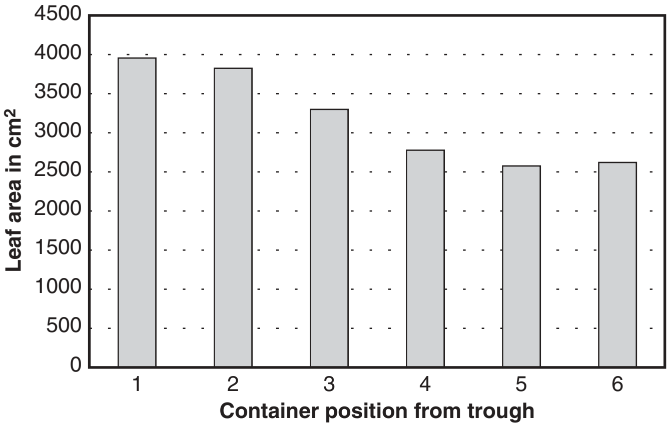
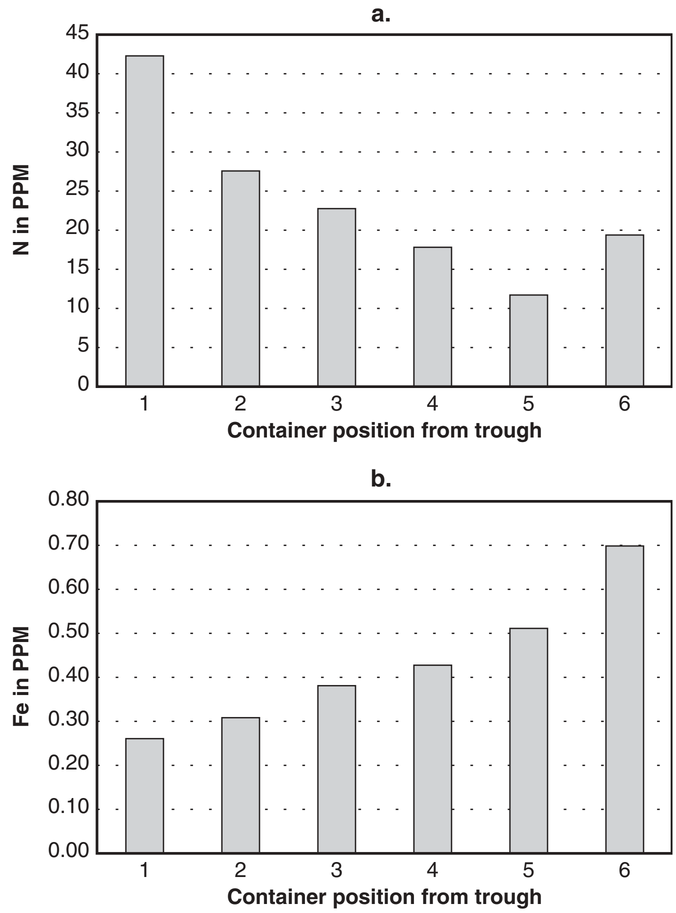


Figure 7. The effect of container position from the trough on the concentration of (a) nitrogen and (b) iron in the capillary mat at the end of the experiment.



samples of water from the mat were analyzed for N, P, K, Ca, Mg, Zn, Cu, Fe, and Mn. Only the data for N and Fe are shown (Figures 7a and 7b). The amount of N, K, P, Ca, Mg, and Mn in the mat decreased from position 1 to 5, whereas the amount of Fe increased the greater the distance from the trough. Zn and Cu remained nearly constant. In general, the amount of each nutrient at position 6 was greater than at position 5. The evaporation of water from the mat edge at position 6 probably concentrated the nutrients. The data suggest the first pot removes more nutrients, such as N, relative to the water uptake, and the next pots in the row receive decreased concentration of some nutrients the greater the distance from the trough. Future work will identify the nutrient concentration needed at different stages in development.

Conclusion

A CWT irrigation system is adaptable for the production of many container-grown plants and provides several advantages over other irrigation systems.

1. Unlike any other irrigation system, CWT maintains the same water/air ratio in all containers on a bench regardless of any differences in evapotranspiration. Thus, the effect of the micro-environment on water use, in different areas of the greenhouse, is not a factor in water management. With other irrigation systems, the water/air content changes between irrigation cycles, and the containers in different areas of a bench will lose water at different rates.
2. CWT-irrigated plants are rarely under water stress conditions; the stomates remain open for CO_2 entry, so photosynthesis is not inhibited. Crop uniformity should improve, and labor and space will be used efficiently.
3. The water or nutrient solution does not run off the bench or drip from pots onto the floor as with overhead irrigation or some types of subirrigation systems. The nutrient solution is held within the capillary mat under a constant negative water potential.

Other advantages include:

4. No pump or large tank is required for recirculation as with ebb and flood irrigation;
5. Existing greenhouse benches are easily retrofitted;
6. Components are readily available and relatively inexpensive; and
7. Disease potential is reduced as the solution is not recirculated, and therefore little chance exists to spread disease.

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Cut Roses for Christmas and Valentine's Day from Cuttings

Robert G. Anderson, Department of Horticulture

The cut flower market in the United States remains strong. Rose sales are up; more than 1.22 billion rose stems were sold in the United States in 1998, and per capita consumption has doubled in the last 20 years (6). Unfortunately, U.S. production has not only lost a significant portion of domestic share but has failed to expand with the global market. For roses, the percentage of domestic sales from imports in 1975, 1981, 1988, and 1992 ranged from 1%, 15%, 34%, and 52% respectively, and was 78% in 1998 (6). U.S. production has decreased only 40% in the last 10 years, but the market continues to expand with product from overseas.

The primary market periods are three major U.S. holidays—Valentine's Day, Mother's Day, and Christmas. In order to have flowers for these peak market periods, the plants must be maintained year-round in controlled environment greenhouses. Hybrid tea roses are unusual, because they flower continuously throughout the year. Thus, each rose plant must be visited by a worker once or twice a day, every day of the year, for flower harvest. Consequently, production costs are quite high, because labor must be used to harvest flowers every day of the year and thus to try to sell the flowers throughout the year, even when market demand is low. Of course, all other overhead and energy costs must be maintained for the calendar year as well. The primary market periods are certainly an important target, however. Valentine's Day prices of \$1.10 to \$2.25 per rose stem in the Chicago market compare favorably with the year-round average of \$0.33 (1).

Cheap labor overseas has been a main factor in the loss of U.S. rose production. Traditional methods of rose production (15,8) practiced in the United States, and now overseas, are labor intensive and monotonous, thus utilizing large numbers of unskilled, low-wage employees. While low production costs overseas were the main factor in the loss of this industry, current environmental laws and the nation's need for sustainable agricultural production systems that reduce the energy input per product and that increase the wages for individual employees are also important.

Greenhouses in Kentucky and the United States did not disappear with the change in the rose market; these businesses simply adapted to other markets and crops. The bedding plant industry that produces flowers for home and commercial landscapes has increased dramatically in the last 20 years. As the greenhouse industry changed, plant production technology changed as well. Ebb-flood irrigation, palletized benches, plug technology, and robotic transplanters have changed greenhouses (10). Greenhouse operators that have invested in new labor-efficient equipment are looking for new crops to pay for their investments.

An alternative to conventional rose production is to grow roses for only six months of the year. This production schedule would allow roses to be grown as part of the currently successful bedding plant business. Roses could be grown from cuttings started in August just as poinsettias are potted. Roses would compete with garden mums and poinsettias for greenhouse space in the summer and fall, but both crops have saturated their markets and prices have not increased in a number of years. After cut stems are harvested for Christmas and Valentine's Day, the plants can be discarded. This six-month alternative is well supported by an economic evaluation of single stem roses (5). An unusually high internal rate of return (175%) was estimated for Valentine's Day rose production integrated into a typical greenhouse system that produced bedding plants, garden mums, and poinsettias.

Roses can be grown from cuttings quite easily. Rose growers have used cuttings for the last 100 years as part of their production system, and all miniature roses for pots are propagated from cuttings (14). Cuttings have been used to produce roses for many university experiments (7,12,11,16). Evaluation of single node cuttings for cut rose production was begun in the late 1980s (2,17,13). In general, typical propagation systems, intermittent mist, bottom heat at 70° to 75°F, and application of rooting hormone work well. Anderson (3,4) proposed the use of single node rose cuttings as the source of plants for a mechanized cut flower production system.

Methods and Results *(July 2002—February 2003)*

1. Develop a production model to produce roses from cuttings for Christmas and Valentine's Day.

Roses are relatively easy to grow from cuttings. Flowering stems were harvested for cuttings on Aug. 16 and 29 and on Sept. 9 and 12, 2002. Cut rose stems were cut into 4- to 5-cm segments, each segment having a single leaf and bud. The lower 1 cm of each cutting received a 5-sec. dip in a solution of 750 ppm IBA in 50% ethanol. Cuttings were placed into a 6-cm pot containing a commercial growing medium. The cuttings were placed under intermittent mist, and the rooting media temperature maintained at 75°F.

Approximately 750 rooted cuttings from 14 red rose cultivars were transplanted into MetroMix 560 growing medium in 6-inch pots on Sept. 28 and on Oct. 22 and 27. Plants were placed pot to pot in a greenhouse that received ambient light levels. Greenhouse temperatures were maintained at an average daily temperature of 60°F during the fall and winter. Plants were irrigated by hand with a fertilizer solution, Peter's 20-10-20, with an EC of 1.0 to 1.2 dS and pH of 5.5 to 6.5 each day.

Pruning practices were compared during the winter of 2002-2003. Plants were pruned to 5 inches or 12 inches on Dec. 2 and compared with unpruned plants that were tied together in groups of four plants. The tying technique allowed light to reach the lower parts of the plant where new shoots could emerge.

2. Prepare economic simulations of the model that focus on production costs for alternative plant densities, containers, and pruning systems.

It is relatively simple to compare the yield of cut rose stems with sample production costs. Commercial greenhouses have an operating cost of approximately $0.25 per square foot per week (Will Southerland, 2002, personal communication). Rose plants transplanted in mid-October will use greenhouse space for 16 weeks if roses are harvested for Valentine's Day. Cut rose production, in this system, costs $4.00 per square foot of space used. The plants were planted into 6-inch pots, so there are four plants per square foot of space. Thus, the returns need to be at least $1.00 per plant. At prices of $1.00 or more per cut stem, this system needs to produce at least one high-quality stem per plant.

3. Validate the optimal economic model by growing the roses in the greenhouse in replicated studies.

Rose growth is directly related to the amount of light the plants receive. The winter of 2002-2003 had unusually low light levels, so overall rose performance was poor. All cultivars of roses pruned to a 5-inch height in early December had a yield of less than one stem per plant. 'Olympiad' and 'Cesar Chavez' roses produced 1.5 and 1.2 stems per plant in the 12-inch and tied treatments.

4. Evaluate cultivars of red roses for their performance in a short-term production system.

Modern red greenhouse rose varieties, 'Black Magic' and 'Fahrenheit'; traditional red greenhouse rose varieties, 'Samantha' and 'Taboo'; modern garden roses, 'Cesar Chavez', 'Burning Desire', 'Opening Night', 'Veteran's Honor', 'Crimson Bouquet', and 'Cardinal's Song'; and traditional red garden roses, 'Olympiad' and 'Ingrid Bergman', were evaluated in this study. 'Black Magic', 'Olympiad', 'Cesar Chavez', and 'Kardinal' will be used in 2003-2004 studies.

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2002 Garden Flower Trials: Results of Annual Flower Evaluations by Kentucky Master Gardeners

Robert G. Anderson, Department of Horticulture, and Master Gardeners from McCracken, Warren, Hardin, Pulaski, Jefferson, Fayette, Boone and Campbell Counties

Annual and perennial garden flowers have been evaluated for many years at the University of Kentucky. Trials have occurred at the University of Kentucky Arboretum since 1993. These trials were expanded at the Horticulture Research Farm in 1999 and 2000 with grants from the Kentucky Department of Agriculture, the Kentuckiana Greenhouse Association, and the New Crop Opportunities Center.

Demonstration gardens have been established at eight locations across the state. We wish to thank the Extension agents and Master Gardeners at these garden locations for planting, maintaining, and evaluating the annual flowers in these trials.

- Purchase Area Master Gardener Garden, Paducah
- University of Kentucky Research and Education Center, Princeton
- Warren County Master Gardener Garden, Bowling Green
- Hardin County Master Gardener Garden, Elizabethtown
- Louisville Zoo, Louisville
- University of Kentucky Arboretum, Lexington
- Boone County Master Gardener Garden, Burlington
- Campbell County Master Gardener Garden, Highland Heights
- Pulaski County Master Gardener Garden, Somerset

Selected annual flowers were grown in Lexington and distributed to the demonstration gardens in May. The Master Gardeners and Extension agents planted the flowers in their trial gardens and evaluated them four times during the summer (mid-July, early August, late August, mid-September). All gardens were mulched with wood chip mulch; drip irrigation was used throughout the summer, and plants were fertilized during the summer. Plant performance (Table 1) was evaluated on a 1 to 5 scale with 1 = poor and 5 = excellent. The evaluation was based only on the individual gardener's determination of the quality of the plants. Although personal tastes are reflected in individual evaluations, the overall evaluation was accurate for the plant performance in each garden. The demonstration gardens seem to be a good educational activity for the Master Garden educational program. It is the goal of this program to allow Master Gardeners to see new flowers and compare them to the reliable annual flowers seen in Kentucky gardens.

Photos and details about plant performance are continually added to the Kentucky Garden Flowers Web site: <http://www.uky.edu/Ag/Horticulture/gardenflowers>. Also, going to the University of Kentucky home page <www.uky.edu> and searching for a plant will direct the reader to the Kentucky Garden Flowers location.

Table 1. Evaluations of annual flowers, 2002.

Variety	Scientific Name	Rating*
Spreading Petunia—'Wave Pink Improved'	*Petunia x hybrida*	4.7
Lantana—'Miss Huff'	*Lantana camara*	4.6
Mealy Cup Sage—'Victoria'	*Salvia farinacea*	4.5
Vinca—'Big Ruby'	*Catharanthus roseus*	4.5
Lantana—'Samantha'	*Lantana camara*	4.4
Lantana—'Patriot Sunburst'	*Lantana camara*	4.4
Summer Snapdragon—'AngelMist Purple'	*Angelonia angustifolia*	4.3
Lantana—'Patriot Cherry'	*Lantana camara*	4.3
Lantana—'Patriot Hot Country'	*Lantana camara*	4.3
Summer Snapdragon—'AngelMist Pink'	*Angelonia angustifolia*	4.3
Summer Snapdragon—'AngelMist Purple Stripe'	*Angelonia angustifolia*	4.3
Summer Snapdragon—'AngelMist Lavender'	*Angelonia angustifolia*	4.3
Lantana—'Weeping Lavender'	*Lantana camara*	4.3
Narrow Leaf Zinnia—'Crystal White'	*Zinnia angustifolia*	4.2
Lantana—'Patriot Hallelujah'	*Lantana camara*	4.2
Spreading Petunia—'Easy Wave Shell Pink'	*Petunia x hybrida*	4.1
Spreading Petunia—'Wave Blue'	*Petunia x hybrida*	4.0
Summer Snapdragon—'AngelMist White'	*Angelonia angustifolia*	3.9
French Marigold—'Aspen Red'	*Tagetes patula*	3.8
Lantana—'Patriot Cowboy'	*Lantana camara*	3.8
Lantana—'Patriot Desert Sunset'	*Lantana camara*	3.8
Lantana—'Patriot Dove Wings'	*Lantana camara*	3.8
Tooth Ache Plant—'Peek a Boo'	*Acmella (Spilanthes) oleracea*	3.7
Polka Dot Plant—'Rose Splash Select'	*Hypoestes phyllostachya*	3.7
Summer Snapdragon—'AngelMist Deep Plum'	*Angelonia angustifolia*	3.6
Spreading Petunia—'Easy Wave Cherry'	*Petunia x hybrida*	3.4
Spider Flower—'Sparkler White'	*Cleome hassleriana*	3.4
Brazilian Snapdragon	*Otacanthus azureus*	3.3
Spider Flower—'Sparkler Blush'	*Cleome hassleriana*	3.2
Spider Flower—'Sparkler Rose'	*Cleome hassleriana*	3.1
Globe Amaranth—'Gnome Mix'	*Gomphrena globosa*	3.0
Cupflower—'Summer Splash Blue'	*Nierembergia hippomanica*	2.8
Spider Flower—'Sparkler Lavender'	*Cleome hassleriana*	2.7
Wishbone Flower—'Summer Wave Blue'	*Torenia fournieri*	2.6
Cupflower—'Summer Splash White'	*Nierembergia hippomanica*	2.5
Flowering Tobacco—'Avalon Mix'	*Nicotiana x sanderae*	2.5
Flowering Tobacco—'Heaven Scent Mix'	*Nicotiana x sanderae*	2.4
Flowering Tobacco—'Domino Mix'	*Nicotiana x sanderae*	2.2
Flowering Tobacco—'Saratoga Mix'	*Nicotiana x sanderae*	1.9
Flowering Tobacco—'Havana Appleblossom'	*Nicotiana x sanderae*	1.8

* Rating of 1 to 5 with 1 = poor and 5 = excellent.

Perennial Garden Flower Trials, 1999-2002—University of Kentucky Horticulture Research Farm

Robert G. Anderson and Kirk Ranta, Department of Horticulture

Annual and perennial garden flowers have been evaluated for many years at the University of Kentucky. Trials have occurred at the University of Kentucky Arboretum since 1993. These trials were expanded at the Horticulture Research Farm in 1999 and 2000 with grants from the Kentucky Department of Agriculture and the Kentuckiana Greenhouse Association. Grants from the New Crop Opportunities Center allowed expansion of the trials to more than 20,000 square feet of trial gardens in Lexington. Additionally, demonstration gardens have been established at eight locations across the state (listed below).

The collection of perennials in our ongoing trials continues to expand. We have nearly 1,000 individual plants in the perennial trials, with more than 150 species and cultivars in the plots at the Horticulture Research Farm in Lexington. Our trials include the Perennial Plants of the Year from the Perennial Plant Association and some native plants. We now have three years' experience with some, so our ratings have many observations. However, our ratings should be used only as a guide to determine which perennials you might sell or use in Kentucky landscapes. In general, those that have grown well for two or more seasons are marked (++), and those that have not done too well are marked (-); those unmarked need more time to determine a rating.

Photos and details about plant performance are continually added to the Kentucky Garden Flowers Web site: <www.uky.edu/Ag/Horticulture/gardenflowers>. Also, going to the University of Kentucky home page <www.uky.edu> and searching for a plant will direct the reader to the Kentucky Garden Flowers location.

Mexican Hyssop

Agastache 'Tutti Frutti' ('01-'02) (**-**)

Arkansas Amsonia

Amsonia hubrectii ('01-'02) (**+**)

Artemisia

Artemisia absinthium 'Huntington Gardens' ('01) (**-**)

Aster

Aster apellus 'Triumph' ('00-'02) (**-**), *Aster laevis* 'Bluebird' ('00-'02) (**++**), *Aster latiflorus* 'Prince' ('00-'02), *Aster novi-belgii* 'Celeste' ('01-'02), *Aster novi-belgii* 'Purple Monarch' ('01-'02), *Aster novi-belgii* 'Snow Cushion' ('00-'02), *Aster novi-belgii* 'White Swan' ('00-'02) (**++**), *Aster novi-belgii* 'Winston Churchill' ('01-'02), *Aster novi-belgii* 'Woods Purple' ('00-'02), *Aster x frikarti* 'Monch' ('00-'02), *Aster oblongifolius* 'Raydon's Favorite' ('02), *Kalimeris mongolica* ('01-'02) (**++**), *Kalimeris mongolica* 'Variegata' ('00-'02) (++)

Astilbe

Astilbe 'Sprite' ('00-'02) (++)

Columbine

Aquilegia x hybrida 'Rose w/White Edge' ('02), 'Songbird Cardinal' ('02), 'Winky Red & White' ('02)

Cream False Indigo

Baptisia pendula ('01-'02)

Willowleaf Oxeye

Buphthalum salicifolium 'Sun Wheels' ('00-'02) (**-**)

English Daisy

Bellis perennis 'Galaxy Rose' ('02), 'Rose Border' ('02), 'Tasso Strawberry & Cream' ('02)

Feather Reed Grass

Calamagrostis acutifolia 'Karl Foerster' ('00-'02) (**++**), *Calamagrostis acutifolia* 'Overdam', ('02), Variegated Feather Reed Grass, *Calamagrostis brachytricha*, ('02), Korean Feather Reed Grass

River Oats, Northern Sea Oats

Chasmanthium latifolium (**++**) ('00-'02)

Garden Mums

Ajania pacificum 'Pink Ice' (**++**) ('00-'02), *Chrysanthemum* 'Hillside Pink' ('01-'02), *Chrysanthemum yezoense* ('00-'02), *Dendranthema rubellum* 'Clara Curtis' ('00-'02), *Dendranthema rubellum* 'Mary Stoker' ('00-'02)

Shasta Daisy

Chrysanthemum (Leucanthemum) x superbum 'Becky' ('02)

Cumberland Rosemary

Conradina verticillata

Coreopsis

Coreopsis 'Tequila Sunrise' ('01-'02), *Coreopsis grandiflora* 'Domino' ('02), *Coreopsis grandiflora* ' Early Sunrise' ('02), *Coreopsis lanceolata* 'Baby Sun' ('02)—Lanceleaf Coreopsis *Coreopsis rosea* 'American Dream' ('01-'02), *Coreopsis verticillata* 'Moonbeam' ('00-'02) (**++**)

Montbretia

Crocosmia crocosmiifolia 'Venus' ('00-'02)

Pinks

Dianthus allwoodii 'Doris' ('02)—Allwood Pink, *Dianthus allwoodii* 'Frosty Fire' ('02)—Allwood Pink, *Dianthus deltoides* 'Brilliant' ('01-'02)—Maiden Pink, *Dianthus gratianopolitanus* 'Bath's Pink' ('02) (**++**)—Cheddar Pink

Cone Flower

Echinacea pallida ('00-'02), *Echinacea paradoxa* ('00-'02), *Echinacea purpurea* ('00-'02) (**++**), *Echinacea purpurea* 'Magnus' ('00-'02) (**++**), *Echinacea simulata* ('00-'02), *Echinacea tennesseensis* ('00-'02) (**++**)

Silver Prairie Grass

Erianthus alopecuroides (‘00-‘02)

Oregon Fleabane

Erigeron ‘Azure Fairy’ (‘00-‘02) (**-**)

Hardy Ageratum

Eupatorium coelestinum (‘01-‘02) (**++**)

Joe Pye Weed

Eupatorium maculatum (‘00-‘02) (**++**), *Eupatorium maculatum* ‘Carin’ (‘02), *Eupatorium maculatum* ‘Gateway’ (‘02)

Hardy Fuchsia

Fuchsia magellanica ‘Ricartonii’ (‘02) (**-**)

Wand Flower

Gaura lindheimeri ‘Siskiyou Pink’ (‘01-‘02)

Cranesbill, Hardy Geranium

Geranium ‘Dusky Rose’ (‘00-‘02), *Geranium cantabrigiense* ‘Blokova’ (‘00-‘02), *Geranium cantabrigiense* ‘Karmina’ (‘00-‘02), *Geranium cinereum* ‘Ballerina’ (‘00-‘02), *Geranium clarkei* ‘Kasmir Purple’ (‘00-‘02), *Geranium maculata* ‘Claridge Druce’ (‘00-‘02), *Geranium phaeum* ‘Samobor’ (‘00-‘02)

Sneezeweed

Helenium ‘Coppella’ (+) (‘00-‘02)

Sun Rose

Helianthemum ‘Annabel’ (‘01-‘02) (**++**), *Helianthemum nummularium* ‘Double Red’ (‘01-‘02)

Sunflower

Helianthus angustifolius ‘Gold Lace’ (‘02), Swamp Sunflower, *Helianthus mollis* (‘00-‘02)—Downy Sunflower, *Heliopsis* ‘Loraine Sunshine’ (‘00-‘02) (**++**)—False Sunflower

Daylily

Hemerocallis ‘Stella d’Oro’ (‘01-‘02) (**++**)

Alum Root, Coral Bells

Heuchera x brizoides ‘Bressingham Hybrid’ (‘01-‘02), *Heuchera micrantha* ‘Palace Purple’ (**++**) (‘00-‘02)

Garden Hibiscus

Hibiscus moscheutos ‘Disco Bell Pink’ (‘00-‘02) (**++**), ‘Disco White’ (‘00-‘02) (**++**), ‘Kilimanjaro Red’ (‘01-‘02) (**++**), ‘Ranier Red’ (‘01-‘02) (**++**), ‘Mauna Kea’ (‘01-‘02) (**++**), ‘Etna Pink’ (‘01-‘02) (**++**), ‘Matterhorn’ (‘01-‘02) (**++**)

Crepe Myrtle

Lagerstroemia indica ‘Supersonic Mix’ (‘02)

Statice

Limonium latifolia (‘00-‘02)

Lobelia

Lobelia speciosa ‘Fan Burgundy’ (‘01-‘02)

Maltese Cross

Lychnis coronaria ‘Angel Blush’ (‘01-‘02), *Lychnis flos-jovis nana* ‘Peggy’ (‘01-‘02) (**-**)

Marshallia

Marshallia grandiflora (‘02)—Barbara’s buttons, *Marshallia mohrrii* (‘02)

Maiden Grass

Miscanthus sinensis ‘Morning Light’ (‘01-‘02) (**++**)

Bee Balm

Monarda didyma ‘Fireball’ (‘02)—Petite Bee Balm, ‘Jacob Cline’ (‘01-‘02), ‘Marshall’s Delight’ (‘01-‘02), ‘Pink Supreme’ (‘02)—Petite Bee Balm

Catmint

Calamintha nepeta ‘White Cloud’ (‘02)—Savory Calamint, *Nepeta* ‘Dawn to Dusk’ (‘00-‘02) (**++**), *Nepeta* ‘Subsessilis’ (‘00-‘02) (**++**), *Nepeta faassenii* ‘Six Hills Giant’ (‘00-‘02) (**++**), ‘Walker’s Low’ (‘02)

Ornamental Oregano

Origanum laevigatum ‘Herrenhausen’ (‘01-‘02) (**++**)

Wild Quinine

Parthenium integrifolium (‘00-‘02) (++)

Fountain Grass

Pennisetum alopecuroides ‘Hameln’ (‘01-‘02) (**++**)

Beard Tongue

Penstemon barbatus ‘Prairie Dusk’ (‘01-‘02), *Penstemon digitalis* ‘Husker Red’ (‘00-‘02) (**++**), *Penstemon fruticosa* ‘Purple Haze’ (‘01-‘02)

Russian Sage

Perovskia atriplicifolia (‘00-‘02) (**++**), ‘Little Spire’ (‘02)

Fleeceflower

Persicaria amplexicaule ‘Firetail’ (‘01-‘02), *Persicaria bistorta* ‘Superbum’ (‘01-‘02)

Garden Phlox

Phlox maculata ‘Miss Lingard’ (‘00-‘02) (**++**), ‘Natasha’ (‘00-‘02) (**++**)

Phlox paniculata ‘David’ (‘02), ‘Jill’ (‘02), ‘Margie’ (‘02), ‘Nicky’ (‘02), ‘Robert Poore’ (‘02), *Phlox pilosa* ‘Eco Happy Traveller’ (‘02)—Downy Phlox

Prairie Coneflower

Ratidiba columnifera ‘Mexican Hat’ (‘00-‘02) (**++**)

Black Eye Susan

Rudbeckia fulgida var. *sullivanti* ‘Goldsturm’ (‘00-‘02) (**++**)—Cone Flower, *Rudbeckia fulgida* var. *fulgida* (‘02)—Cone Flower, *Rudbeckia hirta* (‘02)—Black Eye Susan, ‘Autumn Colors’ (‘02), ‘Cordoba’ (‘02), ‘Goldilocks’ (‘02), ‘Indian Summer’ (‘02), ‘Prairie Sun’ (‘02), ‘Sonora’ (‘02), ‘Toto Gold’ (‘02), ‘Toto Lemon’ (‘02), ‘Toto Rustic’ (‘02), *Rudbeckia laciniata* ‘Herbstonne’ (‘02)—Cutleaf Cone Flower, *Rudbeckia occidentalis* (‘02) ‘Black Beauty’, *Rudbeckia subtomentosa* (‘00-‘02) (**++**)—Sweet Black Eye Susan, *Rudbeckia triloba* (‘00-‘02) (**++**)—Brown Eye Susan

Meadow Sage

Salvia 'Blue Hill' ('00-'02) (**+**), 'Blue Queen' ('00-'02) (**+**), 'May Night' ('00-'02) (**++**), 'Blue Hill' ('00-'02) (**+**), 'Snow Hill' ('00-'02) (**+**), *Salvia lyrata* 'Burgundy Bliss' ('00-'02) (**-**)

Pincushion Flower

Scabiosa caucasica 'Perfecta Alba' ('00-'02), *Scabiosa columbaria* 'Butterfly Blue' ('00-'02), 'Pink Mist (+)' ('00-'02)

Kaffir Lily

Schizostylis coccinea ('00-'02)

Sedum

Sedum spectabile 'Autumn Joy' ('00-'02) (**++**), 'Brilliant' ('00-'02), 'Stardust' ('02), *Sedum spurium* 'Vera Jameson' ('00-'02) (**++**)

Goldenrod

Solidago rugosa 'Fireworks' ('02)

Meadowsweet

Spirea latifolia ('00-'02) (**++**)

Prairie Dropseed

Sporobolis heterolepis ('02)

Stokes Aster

Stokesia laevis 'Blue Danube' ('00-'02) (**-**), 'Klaus Jellito' ('00-'02), 'Mary Gregory' ('00-'02) (**-**), 'Omega Skyrocket' ('02), 'Purple Parasols' ('00-'02), 'Silver Moon' (**-**) ('00-'02)

Mulleins

Verbascum 'Helen Johnson' ('00-'02), *Verbascum* 'Jackie' ('00-'02)

Speedwells

Veronica 'Fascination' ('00-'02), *Veronica* 'Giles van Hess' ('00-'02), *Veronica* 'Goodness Grows' ('00-'02), *Veronica* 'Spring Dew', *Veronica* 'Waterperry' ('01-'02), *Veronica* 'White Jolanda' ('00-'02) (**++**), *Veronica alpinia* 'Alba' ('01-'02) (**++**), *Veronica austriaca* 'Crater Lake Blue'('00-'02), *Veronica longifolia* 'Sunny Border Blue' ('00-'02) (**++**), *Veronica peduncularis* 'Georgia Blue' ('01-'02) (**+**), *Veronica spicata* 'Blue Carpet' ('02), 'Icicle' ('00-'02) (**+**), 'Noah Williams' ('00-'02), 'Red Fox' ('00-'02), 'Rose' ('02), 'Sightseeing' ('02)

We wish to thank the Extension agents and Master Gardeners at all our garden locations for all their help with these trials. Please take some time next year to visit these trial and demonstration gardens:

- Purchase Area Master Gardener Garden, Paducah
- University of Kentucky Research and Education Center, Princeton
- Warren County Master Gardener Garden, Bowling Green
- Hardin County Master Gardener Garden, Elizabethtown
- Louisville Zoo, Louisville
- University of Kentucky Arboretum, Lexington
- Boone County Master Gardener Garden, Burlington
- Campbell County Master Gardener Garden, Highland Heights
- Pulaski County Master Gardener Garden, Somerset

Evaluate and Determine Fresh Yield of Approximately 15 Species and Cultivars of Lettuces, Greens, and Herbs for Seasonal Production in Kentucky Tobacco Greenhouses

Robert G. Anderson, Department of Horticulture

Introduction

Lettuces, greens, and herbs are specialty crops for specialty markets. These crops may be quickly adaptable to the float beds common in tobacco greenhouses. In response to grower interest and the rapidly expanding market for organic produce, relatively soluble organic fertilizers were evaluated for the growth of Bibb and Grand Rapids lettuces in float beds in the spring and fall of 2000.

Materials and Methods

Plants were grown in plastic soufflé cups (50 ml) with holes cut in the bottom. These cups were placed into holes (plant density of 35 m^{-2}) in polystyrene sheets (2.5 x 85 x 120 cm), and the sheets were allowed to float on the water surface of the float bed. Commercial organic fertilizers derived from fish waste (Mermaid's Fish Powder, GreenAll Fish Emulsion), digested seaweed (Algamin, EcoNutrients), bat guano, and a formulated organic fertilizer (Omega, from bonemeal, bloodmeal, and rock phosphate) were compared to a standard inorganic fertilizer (16-2-10 N-P-K) maintained in the water at 1.2 mS cm^{-1}. Dissolved oxygen was maintained at a minimum of 4 ppm in all treatments. Lettuce ('Ostinata', 'Diamond Gem', 'Red Sails', 'Oakleaf') fresh and dry weights were determined after four weeks of fertilizer treatment. Weekly water analyses determined available NO_3, NH_4, P, K, Ca, Mg, Fe, S, B, Mn, Zn, Mo, pH, EC, and alkalinity.

Results

Organic fertilizers did not produce plants comparable to the inorganic fertilizer control during the four-week production period. Fish waste and digested seaweed were of little value for lettuce production. Commercial quality lettuce could be produced in bat guano and the formulated fertilizer but would require 10 to 20 days longer than inorganic fertilizer.

The high organic content of the fish waste dramatically reduced available oxygen in the water, so the lettuce roots could not grow in the water. Overall nutrient content of the fish waste products was low to moderate and very low in the digested seaweed. These fertilizers offer only limited hope for commercial production. Also, the nutrient levels in the bat guano and formulated fertilizer solutions were comparable or higher than those in the inorganic fertilizer. These fertilizers are good sources of nitrate, so the lettuce grew reasonably well.

Conclusion

These preliminary studies demonstrated that significant additional work is necessary to develop a system to utilize organic fertilizers for greenhouse production of lettuce in float beds. A formulated fertilizer seems to be the best approach to the development of a reliable nutrient solution. The Omega fertilizer was a good start but had too much P, which caused Ca and Mg deficiencies. The nutrient solution should be monitored constantly, but it would require a great deal of work to determine what additions can stabilize the nutrient levels and pH. Also these additives must meet organic certifications standards. There appeared to be lettuce variety responses to the fertilizers and the float bed system, so many varieties would have to be evaluated. In addition, visual differences in disease infection occurred among the fertilizer treatments used.

Yield of Brassica ‘Mei Qing Choi’ and ‘Tatsoi’ in Hydroponic Greenhouse Production

Robert G. Anderson, Department of Horticulture

Introduction

Kentucky has more than 30 acres of greenhouses with modified pond or tank hydroponic beds for “float” tobacco transplant production. These facilities could be used to grow other crops during the fall, winter, and spring. Previous work has demonstrated that lettuces can be easily grown in such production systems (1,3). This study evaluated production of two types of pac choi, ‘Mei Qing Choi’ and ‘Tatsoi’ that could be grown in the same system and sold in Asian vegetable markets.

Materials and Methods

Plants were grown in two ways in this study. In the first system, plants floated in holes (35) cut in six 90-cm x 55-cm x 2.5-cm polystyrene sheets. The holes were 4 cm in diameter and spaced 8 x 9 cm. In the second system, plants were placed in contact with a capillary mat draped over small rectangles of 2.5-cm polystyrene (5 cm x 5 cm). The capillary mat absorbed water from the hydroponic solution to satisfy the plants’ needs. The capillary mat system was used to determine if sufficient oxygen would be available to the plants’ root system in non-aerated hydroponic ponds.

Six 1.08 m^2 wooden hydroponic ponds or tanks were built in two rows of three on one side of a 9- x 18-m naturally ventilated sidewall plastic greenhouse. Tanks were lined with black polyethylene and filled with water to a depth of 15 cm to make a tank volume of approximately 164 L. Electric water pumps were placed in three tanks to oxygenate the water; previous work demonstrated that oxygen levels would be maintained at 4 to 6 ppm with this procedure. Brassica plants were grown in 29-ml plastic soufflé cups (Solo Cup Company, Urbana, IL) that had holes drilled in the bottom. A commercial inorganic fertilizer (Peter’s 20N-4P-16.6K, Scotts, Maryville, OH) was added to the water in each tank and maintained at an EC of 1.2 dSm^{-1} (approximately 160 ppm NO_3-N).

Seed of ‘Mei Qing Choi’ pac choi (*Brassica rapa Chinensis* group) and ‘Tatsoi’ (*Brassica rapa Narinosa* group) were purchased from Johnny’s Selected Seeds, Albion, Maine. A single crop was grown in February 2001. Seeds were sown (Jan. 15) in the cups and germinated at an average daily temperature of 25°C. Seedlings were fertigated twice per week with 150 ppm 20-4-16.6 inorganic fertilizer before placement in the hydroponic tanks. The plants were placed in the hydroponic ponds on Feb. 5 and grew under natural light conditions. The greenhouse had a heat set-point of 16°C and a ventilation set-point of 24°C. Plants were harvested from the tanks on March 7, and dry weights were measured for nine plants in each replicate. Plants were grown with and without aeration with three replicates in a randomized complete block.

Results and Discussion

Thirty days was sufficient to grow high-quality heads of ‘Tatsoi’ and ‘Mei Qing Choi’ pac choi. ‘Mei Qing’ has a relatively typical pac choi head with large, nearly white, thick petioles. On the other hand, ‘Tatsoi’ forms a loose head of long thickened petioles with dark green leaf blades. It seems both would be fine for stir fry cooking and salads, but petioles of ‘Tatsoi’ are similar in form to celery, rather than a pac choi.

Aeration of the hydroponic solution is clearly necessary for the production of these plants. Dry weights were nearly double for those plants in aerated treatments compared to those in non-aerated treatments, typical of a tobacco "float" bed (Table 1). Aeration is just as important for lettuce in tank or "float" bed production (1,2). In planning this experiment, it was thought that plants grown on the capillary mat would be similar in aerated and non-aerated treatments and that these treatments would be similar to the floating plants in the aerated solution. This did not occur (Table 1). The plants were too top heavy to maintain good contact with the capillary mat to receive sufficient water for normal growth. This system needs to be redesigned to re-evaluate the use of capillary mats with non-aerated hydroponic solutions. Although aeration is somewhat difficult to arrange for "float" beds, it is critical to the success of vegetable plant production in this type of hydroponic system.

Table 1. Mean shoot dry weight (g) and standard error of 'Mei Qing' and 'Tatsoi' *brassica* grown with inorganic fertilizer.

	Aerated		Non-Aerated	
***Brassica* Cultivar**	**Floating**	**Capillary Mat**	**Floating**	**Capillary Mat**
Mei Qing	3.97 ± .22	2.54 ± .16	1.98 ± .10	1.79 ± .11
Tatsoi	3.55 ± .20	2.19 ± .17	1.84 ± .10	1.34 ± .08

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Aesculus parviflora Propagation by Layering

Robert E. McNiel and Steve Elkins, Department of Horticulture

Introduction

Aesculus parviflora (bottlebrush buckeye) has made many recommended plant lists during recent times. However, few plants are available on a regular basis in the nursery trade. Seed was the main method of propagation until the 1990s when Bir and Barnes (2) established a protocol for cutting propagation. Fordham (4), in his discussion of propagation of bottlebrush buckeye, devoted his explanation to seed, except for a final comment that root cuttings and root suckers can be a source. Seed availability, timing, or facilities may still limit this plant from being propagated in significant numbers by either seed or cuttings.

Layering has been recommended as a form of propagation for plants forming suckers by several authors during the 1900s (1,8). While addressing layering in one form or another, neither Mahlstede and Haber (7), Macdonald (6), Dirr and Heuser (3), nor Hartman et al. (5) define layering as a technique for bottlebrush buckeye. Bailey (1) addresses the benefits of wounding during the layering process. As a means of producing large numbers of bottlebrush buckeye with limited facilities and less dependence on timing, we looked at mound layering as an alternative method of propagation.

Materials and Methods

Aesculus parviflora plants were planted on the University of Kentucky Horticulture Research Farm during the early 1990s in north/south rows. During 1998 the plants were bush-hogged to the ground. Multi-stem regrowth occurred during 1999 and 2000. In August 2000, research was initiated to determine if rapid propagation could occur by mound layering *Aesculus parviflora* . Sawdust was row mounded 18 inches deep and 3 feet wide around 41 plants. Starting in August 2000, three stems on 10 randomly selected plants were treated on a monthly basis. Treatments included cutting into non-rooting one- or two-year old stems near the base, treating with No. 3 Hormex, and keeping the stem gapped with a section of toothpick. A drip irrigation system was installed in the plot and scheduled to run 20 minutes twice a day at 9:00 a.m. and 2:00 p.m. One-GPH emitters were spaced every 2 feet along 2-inch diameter lines. Irrigation was turned off during the dormant months.

Results and Discussion

During March 2001, plants treated each of the previous months were evaluated for rooting. Plants treated during August 2000 had roots formed at the wound site on 29 of 30 stems. Plants treated in September 2000 had roots formed at the wound site on eight of 30 stems. No roots were found on stems treated during October through February. During November 2001, plants were again evaluated for rooting. Rooting had occurred on all plants treated through May 2001 (Table 1). The tendency was for more stems rooting (99%) for months (August, September, April, May) when treatments were on plants that were in active growth than when treated plants (84%) were in their dormant period (October through March). A plant was left untreated, and during March 2001 three plants were completely pruned back to within 3 inches of the ground for comparison to the treated plants. At the November 2001 harvest time, the unpruned plant had 14 stems that were rooted, and the three pruned plants generated a total of 68 rooted stems on current season growth. No other wounding or hormone treatment occurred on these four plants. Stems on these plants rooted with the sawdust treatment of mound layering and irrigation. The other 37 original plants were also producing new stems during 2001. Between untreated old growth stems and new growth stems, an additional 617 rooted stems were removed from these 37 plants, an average of 16.7 rooted stems per plant.

Table 1. Stems rooted and successfully established as a liner during month by month treatment.

Month	Rooted Stems	Survival in the Liner Stage
August, 00	30	28
September, 00	30	25
October, 00	25	22
November, 00	26	19
December, 00	25	19
January, 01	27	16
February, 01	25	23
March, 01	23	21
April, 01	30	27
May, 01	29	24

Rooted stems had either new coarse or fine roots. Coarse roots were most common, and it was suspected that stems with fine roots might not survive. This was not tracked as to root type, but survival of rooted stems as liners was recorded. Rooted stems were placed in 3-quart containers and overwintered in an unheated Quonset house. Eighty-three percent of the stems from treated plants leafed out and developed into the liner stage (Table 1). Ninety-three percent of the stems from untreated plants leafed out and developed into the liner stage.

Conclusion

Rapid propagation of *Aesculus parviflora* through mound layering is very feasible. Mound-layering without wounding and hormone treatment will generate rooted shoots. Stems that do not root under normal mound-layering techniques will benefit from wounding and hormone treatment.

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Pruning Influence on Shoot Development with Container-Grown *Aesculus parviflora*

Robert E. McNiel and Kirk Ranta, Department of Horticulture

Introduction

Aesculus parviflora (bottlebrush buckeye) has been awarded elite status by being named to several outstanding-plant lists or to state plant-recognition programs. Individual plants displayed in retail settings have not always had comparable sales appeal. Instead of irregular or tall lanky growth, it was thought that lower branched and more uniform plants would be more acceptable by the buying public. Research was established to evaluate stem number, placement, and length as influenced by pruning plants during production. Seeds were collected from *Aesculus parviflora* and planted on the University of Kentucky Horticulture Research Farm during the fall of 2000. The resulting seedlings (6 to 30 inches tall) were harvested in November 2001 and individually placed in 3-quart containers. Plants were overwintered in a 13- x 48-foot unheated Quonset house covered with opaque poly. During February 2002, 130 plants were divided into three groups of 40+ plants. Three treatments consisted of unpruned stems, stems cut back to within 2 inches of the substrate line, and stems cut back to within 6 inches of the substrate line. Data were analyzed by analysis of variance using the General Linear Models Procedure (SAS).

Results and Discussion

During June 2002, data were collected as new stem counts originating from two positions on the remaining plant: originating above substrate line or from the base or below the substrate line.

The average number of shoots per plant was determined by averaging the count from two positions on the plant (above and below the substrate line) (Table 1). Unpruned plants showed apical dominance within the population. This resulted in the fewest shoots per plant (0.81) as many terminal buds continued to elongate without producing many additional shoots either above or below the substrate line. Pruning encouraged additional bud break whether pruned at 2 or 6 inches. Plants pruned at 6 inches had more of the stem remaining and thus had more buds. This yielded more total shoots (1.97) than plants pruned at 2 inches (1.58) (Table 1).

Plants pruned at 2 inches produced more shoots below the substrate line (1.90) than above the substrate line (1.26) (Table 3). Plants pruned at 6 inches produced more shoots from above the substrate line (2.47) than below the substrate line (1.47) (Table 4). For shoots that were produced, pruning did not influence average new shoot length (Table 1). Average new shoot length (inches) on unpruned plants did not differ from lengths on plants pruned at 2 or 6 inches (Table 1). Average total shoot length did present differences among treatments. On unpruned plants, average total shoot growth from below the substrate line (13.00) exceeded shoot growth originating above the substrate line (4.67) (Table 2). For plants pruned at 2 inches, no difference occurred for shoot growth for the below (14.75) and above (12.37) substrate positions (Table 3). For plants pruned at 6 inches, average total shoot length above substrate level (15.28) was statistically different from average total shoot length below substrate level (12.73) (Table 4).

Plants that were pruned did not produce flower buds, regardless of pruning height (data not shown). Unpruned plants did occasionally produce flower buds.

Table 1. Average total number of shoots per plant (including above and below the substrate counts) and average length of those shoots for three pruning treatments on *Aesculus parviflora*.

Pruning Treatment	Number of Shoots[y]	Average Length of Shoots[z] (in.)
Unpruned	0.81 C	5.17 A
Pruned at 2 inches	1.58 B	5.93 A
Pruned at 6 inches	1.97 A	6.20 A

[y] Means with the same letter for each variable are similar at $p \leq 0.01$; n = 260.

[z] Means with the same letter for each variable are similar at $p \leq 0.01$; n = 182.

Table 2. Total number of shoots and average total shoot length produced at two positions on plants that were not pruned.[z]

Position	Number of Shoots	Average Total Shoot Length (in.)
Above substrate	1.30 A	4.67 B
Below substrate	0.32 B	13.00 A

[z] Means in the same column with the same letter for each variable are similar at $p \leq 0.01$; n = 182.

Table 3. Total number of shoots and average total shoot length produced at two positions on plants that were pruned at 2 inches.[z]

Position	Number of Shoots	Average Total Shoot Length (in.)
Above substrate	1.26 B	12.37 A
Below substrate	1.90 A	14.75 A

[z] Means in the same column with the same letter for each variable are similar at $p \leq 0.01$; n = 182.

Table 4. Total number of shoots and average total shoot length produced at two positions on plants that were pruned at 6 inches.[z]

Position	Number of Shoots	Average Total Shoot Length (in.)
Above substrate	2.47 A	15.28 A
Below substrate	1.47 B	12.73 B

[z] Means in the same column with the same letter for each variable are similar at $p \leq 0.01$; n = 182.

Significance to Industry

Plant branch height, compactness, and uniformity can be influenced by pruning *Aesculus parviflora* during container production practices. Pruning at 2 or 6 inches above the substrate line increased branching and improved the quality of the plant versus those unpruned. Pruning at 2 inches above the substrate line increased the number of stems arising from the base versus pruning at 6 inches. This should benefit the appearance of plants marketed in 3- or 4-quart container sizes. Work is continuing to see if either of these pruning heights will influence plant quality when it is moved to 3-gallon or larger production sizes. By achieving better quality in plant appearance through more stem development and lower branching, *Aesculus parviflora* may have better sales appeal at the retail level.

Acknowledgment

Statistical analysis was completed with the assistance of Dr. John Snyder, Department of Horticulture, University of Kentucky.

Evaluation of Cultural Practices for Container Production of Passion Flowers

Stephen Berberich, Robert Geneve, and Mark A. Williams, Department of Horticulture

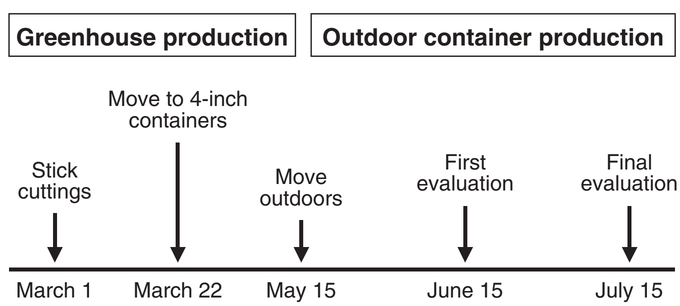
Introduction

Passion flowers are members of the genus *Passiflora* and are among the most exotic flowers in cultivation. The *Passiflora* genus includes more than 450 species that, with rare exception, are tropical or sub-tropical flowering vines that climb with tendrils. Given the many passion flower species and hybrids, there is much variation to the color and shape of the flowers and foliage (5). Although most passion flowers are easily propagated from cuttings (2), there is little information available to growers about the cultural practices necessary for successful nursery production of these vines.

The overall objective of this project is to produce tropical vines with unusual flowers for the summer garden center container market using standard outdoor nursery production (Figure 1). This requires cultural practices that maximize growth and flower production.

In the summer of 2001, a preliminary study carried out using *Passiflora* 'Blue Bouquet' determined that fertilizer concentration had a significant impact on shoot length. Accordingly, the objective of the current study was to evaluate effect of increasing fertilizer concentrations on shoot length, flower number, and bio-mass in several cultivars from diverse genetic backgrounds.

Figure 1. Production schedule for single-season container-grown passion flowers in Kentucky.



Four cultivars, *Passiflora* 'Blue Bouquet', *P.* 'Amethyst', *P.* 'Fledermouse', and *P.* 'Lady Margaret' were propagated from two node cuttings taken in early March and treated with indole-3-butyric acid (IBA) (1,000 ppm in talc) and stuck in Oasis rooting cubes. Cuttings were placed in an intermittent mist bed (5 sec. every 10 min.) with bottom heat (75°F). After three weeks, cuttings were moved to 4-

inch plastic containers with a peat/bark medium (Scott's Metro Mix 360) and placed in the greenhouse. The greenhouse was maintained with day/night temperatures at 78/68°F. Plants were fertilized with a 100 ppm fertilizer solution (Peter's 20-10-20) at each watering.

Plants were moved to 5-quart containers (Nursery Supplies, Inc. Classic 500) in Barky Beaver (Professional Grow Mix, Moss, TN) southern pine bark substrate on May 15, 2002, and moved to the outdoor nursery and placed on trickle irrigation. Each container was treated with slow-release fertilizer (Osmocote 14-14-14) at 15, 20, or 25 g per container. The plants were harvested after two months of growth in the nursery (July 15) and evaluated for number of shoots, shoot length, number of nodes, dry weight, and number of flowers.

Results and Discussion

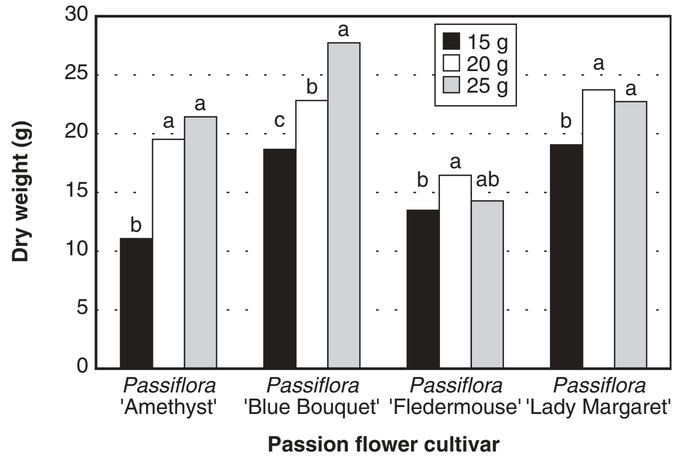
All cultivars except *P.* 'Fledermouse' produced greater shoot length (Figure 2) and biomass (Figure 3) with 25 compared to 15 g of fertilizer. *P.* 'Amethyst' and *P.* 'Blue Bouquet' showed the most significant increase in shoot length (72% and 50%, respectively) and biomass (92% and 49%, respectively).

However, the results for flower numbers were quite different. *P.* 'Fledermouse' and *P.* 'Blue Bouquet' showed no increase in flowering at higher levels of fertilizer. Conversely, *P.* 'Amethyst' showed a 93% increase in flower number when fertilizer was increased from 15 g to 25 g and *P.* 'Lady Margaret' showed a 15% increase in flower number with the same increase in fertilizer (Figure 4).

One likely reason for these data is depletion of fertilizer toward the end of the production cycle. Controlled-release fertilizers such as Osmocote can increase nutrient release by as much as 30% for every 10°C increase in temperature (4). Therefore, nutrient loss can be quite severe during hot weather. During the nursery production phase, with the containers in direct sunlight, they can build up considerable heat, and the substrate temperature can rise well above ambient temperature (1). Furthermore, although the manufacturers' recommended rate of fertilizer for this size container is 14 grams, because of the high growth rate of passion flowers, a much higher concentration may be necessary. Due to nutrient leaching and the effect of increased temperatures on the controlled release fertilizers, multiple applications may be necessary to prevent nutrient supply depletion as the season progresses (3).

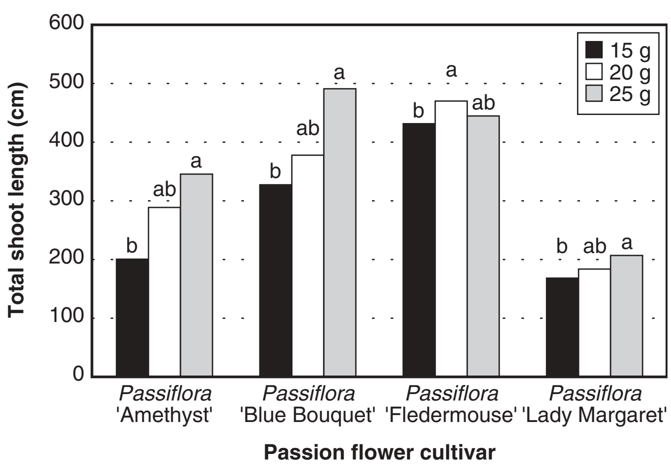
The differences in the data for flower numbers may be due to the genetic diversity of the plants studied. It is quite possible that some of these varieties will not flower early in the season regardless of cultural practices. Indeed, this is the most likely explanation for the results collected for

Figure 3. Passion flower dry weight after two months treated with different levels of fertilizer (Osmocote 14-14-14).



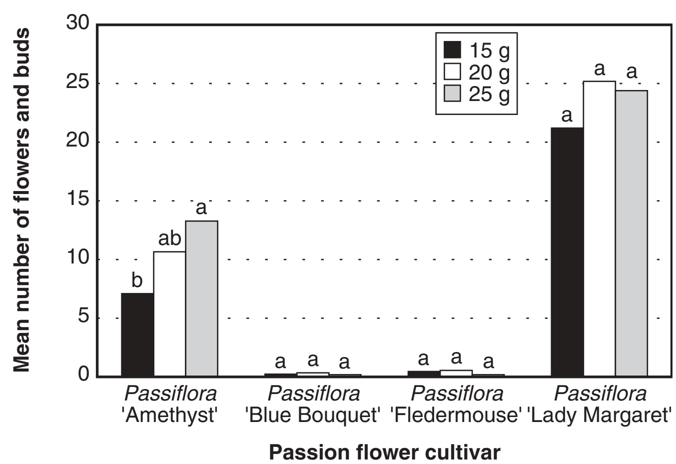
Columns with the same letter are not significantly different. (Tukey's HSD, P ≤ 0.05)

Figure 2. Passion flower total shoot length after two months treated with different levels of fertilizer (Osmocote 14-14-14).



Columns with the same letter are not significantly different. (Tukey's HSD, P ≤ 0.05)

Figure 4. Mean number of flowers after two months treated with different levels of fertilizer (Osmocote 14-14-14).



Columns with the same letter are not significantly different. (Tukey's HSD, P ≤ 0.05) flowering of *P.* 'Fledermouse' and *P.* 'Blue Bouquet'. Further evaluation is needed to determine if flowering is influenced by cultural practices or if flowering in these varieties is a factor of the plants' genetics.

Although *P.* 'Lady Margaret' had the shortest shoot length of all varieties tested, it had the greatest number of flowers, and it had the highest biomass relative to shoot length. It produced a plant with much heavier shoots and leaves along with increased flowering. The increase in fertilizer concentration resulted in an increase in shoot length, flower number, and biomass for *P.* 'Amethyst'. Two varieties, *P.* 'Fledermouse' and *P.* 'Blue Bouquet', produced long shoots; however, neither one had a significant number of flowers. Indeed, many of these plants had no flowers at all in time allowed by the given production schedule. Ultimately, *P.* 'Lady Margaret' and *P.* 'Amethyst' showed the greatest potential and were most productive when grown using this production scheme.

Conclusion

This study has shown that selected varieties of passion flower can be successfully grown in Kentucky as a single-season crop using the production schedule presented above. Acceptable plants can be raised in the two-month production scheme in an outdoor nursery using one application of 25 g of Osmocote 14-14-14 fertilizer. These plants have good potential as high-value, container-produced plants for patio or garden use in a market where customers are looking for exotic, tropical vines.

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Evaluation of Coneflower (*Echinacea*) Species for Nursery Production under Field Conditions

Jenny Heringer Vires, Robert Geneve, and Robert Anderson, Department of Horticulture

Introduction

There are nine species of coneflower (*Echinacea*), all native to central or eastern North America. Only purple coneflower (*Echinacea purpurea*) is extensively cultivated in nurseries. Coneflowers are hardy herbaceous perennials in the *Asteraceae* family. They produce large, terminal composite flowers with an outer ring of showy ray florets. These florets can be various shades of purple, white, or yellow. The numerous, inner central disk florets form the characteristic "cone" for this genus and are subtended with a stiff bract that is usually pigmented yellow and provides an interesting contrast with the showy ray florets. Plants bloom over a long period in the summer. Purple coneflower has been used in formal and informal perennial plantings and is the mainstay of naturalized prairie wildflower mixtures. It is also effective as a cut flower. Coneflowers are also the main ingredient in the medicinal herb preparation sold as *Echinacea*. It is currently the top-selling over-the-counter herb supplement in a multimillion dollar industry. *Echinacea* is touted for its immunostimulatory and antibacterial properties. Although all parts of the plant contain the pharmaceutical compounds, the dried root has the most commercial value for drug extraction.

The objective of this study was to evaluate the cultural requirements for production of coneflower species under field conditions in Kentucky either for nursery production or drug extraction. The species evaluated in this study are listed in Table 1.

Table 1. Root biomass in field-grown *Echinacea* species after one season.

Coneflower Species	Overall Plant Dry Weight (g/plant)
Echinacea purpurea (open pollinated)	124.3
Echinacea purpurea cv. Bravado	115.6
Echinacea purpurea cv. Bright Star	122.5
Echinacea purpurea cv. Clio	122.4
Echinacea purpurea cv. Magnus	115.6
Echinacea purpurea cv. White Swan	87.5
Echinacea angustifolia	26.6
Echinacea pallida	79.1
Echinacea paradoxa	65.5
Echinacea tennesseensis	120.0

Materials and Methods

Seeds for all species were stratified between two and eight weeks prior to sowing in plug flats under standard greenhouse conditions. Eight-week-old seedlings were transplanted to the field in raised beds with drip irrigation in May. Plants were spaced 8 inches apart on center with two rows of plants per raised bed. Each raised bed was on a 2-foot spacing to facilitate mechanical weeding between beds. Weeds were removed by hand from raised beds. Plants received approximately 1 inch of water per week. Plants were harvested in October and evaluated for biomass production.

Treatments included fertilizer application and flower bud removal and were applied only to the *Echinacea purpurea* open pollinated and *Echinacea purpurea* cv. Magnus. For the fertilizer treatment, half the plants were fertilized once in May with 20-20-20 Peter's soluble fertilizer through the irrigation line, while the other plants were fertilized twice with the second application in July at the same fertigation rate. Within each of these fertilization groups, plants either were allowed to flower normally or the flower buds were removed as they appeared once a week.

Results and Discussion

All species and cultivars evaluated in this study produced plants of acceptable size and commercial quality except *Echinacea angustifolia* (Table 1). This species did not establish as robustly as the other species and experienced the greatest mortality. In this group, two species currently not widely available in the nursery trade stood out for their unique horticultural qualities. These were *Echinacea tennesseensis* and *Echinacea paradoxa*. *Echinacea tennesseensis* produced more flowers than any of the other species tested. They were similar in size, color (more mauve than purple), and shape to flowers in purple coneflower (*Echinacea purpurea*), but they were produced on long, wiry stems that appear to be heliotropic (following the sun). The vegetative portion of the plants were also more spreading and low growing compared to the other species in this trial, but in-flower plants reached a height of 3 feet. We believe that this plant has enormous commercial potential for the herbaceous perennial market. Not only does it have numerous ornamental qualities as a garden and cut flower plant, but it is also a Kentucky native plant that is on the Federal Endangered Species list, which should add to the marketability of this species.

Echinacea paradoxa is the most unusual member of this genus. It is the only *Echinacea* with yellow flowers. It is the least recognizable of the coneflowers and is not usually listed in even comprehensive herbaceous perennial references. It produces a clear yellow flower on strong, erect plants that are 2.5 to 3 feet tall. Its market appeal should be in the unique color, flowering time, and strong growth habit that separate it from other coneflowers and near relatives like *Rudbeckia*. All *Echinacea purpurea* cultivars produced commercially acceptable plants. 'White Swan,' a white-flowering purple coneflower, was the smallest cultivar, while 'Clio' and open pollinated derived plants had the highest biomass. By preventing plants from flowering, there was a significant increase in root biomass. Plants responded to the first fertilization, but there was no significant increase in biomass associated with the second fertilizer application.

Conclusion

Several species of *Echinacea* not usually found in production nurseries were evaluated for growth under field conditions. Two (*Echinacea tennesseensis* and *Echinacea paradoxa*) have potential for mass production. These plants have unique horticultural characteristics not found in the commonly cultivated purple coneflower (*Echinacea purpurea*) and could be used to exploit a market niche for nurseries interested in new plants native to North America.

Irrigation and Pruning Influence Hydrangea Dried Cut Flower Production

Winston Dunwell, Dwight Wolfe, Robert McNiel, and Sharon Bale, Department of Horticulture

Introduction

Cut flowers from field-grown hydrangeas are a potential alternative source of income for Kentucky growers, and early production can increase financial returns on one's investment. Typically, *H. macrophylla* cultivars are grown for the cut flower market, while other species such as *H. arborescens* (smooth hydrangea), *H. paniculata* (panicled hydrangea), and *H. quercifolia* (oak leaf hydrangea) have been grown as landscape plants (1, 2). Interest has been expressed in *H. arborescens* and *H. paniculata* as fresh cut and dried flowers by wholesale distributors (6). Expansion of the cut flower production mix to include these *Hydrangea* species could create specialty-niche markets for Kentucky growers.

A hydrangea cut flower cultivar trial was established at the University of Kentucky Research and Education Center, Princeton, Kentucky, in the spring of 1998 (4,5,7). The planting consisted of 12 plants each of nine cultivars allocated to 12 rows (blocks) in a randomized block design. The nine cultivars included one *H. arborescens* cultivar ('Annabelle'), one *H. quercifolia* cultivar ('Alice'), and seven *H. paniculata* cultivars ('Boskoop', 'Pink Diamond', 'Unique', 'Kyushu', 'Tardiva', 'Pee Wee', and 'White Moth'). A planting with trickle irrigation was established in the spring of 1999. It consisted of six *H. paniculata* cultivars ('Pink Diamond', 'Unique', 'Kyushu', 'Tardiva', 'Pee Wee', and 'White Moth') allocated to eight rows (blocks) in a randomized block design. In the fall of 2000, alternate rows of each planting were pruned to ground level. The number of stems per plant, stem length, and bloom length were recorded.

Results and Discussion

'Alice', 'Annabelle', and 'Boskoop' were not included in the irrigated planting. Pruning significantly affected the average number of stems per plant for all cultivars except for 'Annabelle' and 'White Moth', which showed no significant response to pruning (Table 1). 'Kyushu' and 'Pee Wee' produced the largest numbers of stems when pruned and irrigated. Not pruning the plants resulted in stems less than the 36 inches in length needed for the cut flower market (2).

Pruning 'White Moth' under irrigation resulted in vigorous long stems (Table 2) that tended to continue growing and not produce blooms. 'White Moth' plants that were pruned and not irrigated also did not produce any blooms. *H. quercifolia* flowers on year-old wood (3) and, as expected, the pruned plants of 'Alice' did not flower (Table 3).

'Kyushu' was the only cultivar that produced significantly longer blooms when not pruned. This was true for both the irrigated and non-irrigated plantings. A limiting factor to marketability of 'Kyushu' may be the observation that blooms do not have as many showy sterile flowers as 'Pink Diamond', 'Unique', or 'Pee Wee'.

Conclusions

Under the conditions found in this study, 'White Moth' does not appear to be a good *H. paniculata* cultivar for hydrangea cut flower production. All other *Hydrangea* cultivars show potential for producing white fresh and tan dried cut flowers. The 'Kyushu' characteristics of producing large numbers of stems (115) and longer blooms (8.7 inches) when not pruned and irrigated needs to be studied further. Modifying production practices could result in a plant that produces large blooms and has a stem of adequate length for a specialty market.

Table 1. Number of stems per plant as affected by pruning and cultivar for irrigated and non-irrigated plantings of *Hydrangea* cultivars at the UK Research and Education Center, Princeton, Kentucky.

	Pruned	Not Pruned	Mean	Pruned	Not Pruned	Mean
	Non-Irrigated Planting			Irrigated Planting		
Cultivar	Average Number of Stems per Plant					
Alice	0.0	23.4 *[1]	13.4			
Annabelle	14.2	16.7 ns	15.4			
Boskoop	7.8	29.0 *	19.3			
Kyushu	11.3	54.0 *	32.7	14.8	115.5 *	65.1
Pee Wee	5.0	24.3 *	14.7	12.8	112.0 *	62.4
Pink Diamond	11.2	41.3 *	26.3	19.8	49.5 *	34.6
Tardiva	7.5	21.7 *	14.6	12.0	95.8 *	53.9
Unique	18.2	37.0 *	27.6	24.8	86.3 *	55.5
White Moth	0.3	0.8 ns	0.5	1.3	4.3 ns	2.8
Mean	- -	- -	18.6	- -	- -	45.7
LSD (P = 0.05)	- -	- -	7.4	- -	- -	20.9

1 "*" and "ns" indicate that mean in previous adjacent column is either significant or not significant, respectively, at the 0.05 probability level from mean in column.

Table 2. Average stem length as affected by pruning and cultivar for irrigated and non-irrigated plantings of *Hydrangea* cultivars at the UK Research and Education Center, Princeton, Kentucky.

	Pruned	Not Pruned	Mean	Pruned	Not Pruned	Mean
	Non-Irrigated Planting			Irrigated Planting		
Cultivar	Average Length (in.) per Stem					
Alice	- -	10.0	9.9			
Annabelle	20.5	18.4 ns[1]	19.5			
Boskoop	30.2	16.1 *	22.5			
Kyushu	41.4	17.3 *	29.4	54.3	17.0 *	35.6
Pee Wee	43.3	15.3 *	29.5	52.4	14.9 *	33.7
Pink Diamond	35.8	16.0 *	25.9	39.2	17.1 *	28.1
Tardiva	38.2	16.2 *	27.2	50.8	19.5 *	35.2
Unique	33.2	15.5 *	24.3	38.7	18.6 *	28.6
White Moth	- -	12.9	13.0	78.2	16.6 *	37.2
Mean	- -	- -	24.4	- -	- -	32.9
LSD (P = 0.05)	- -	- -	3.8	- -	- -	3.9

1 "*" and "ns" indicate that mean in previous adjacent column is either significant or not significant, respectively, at the 0.05 probability level from mean in column.

Table 3. Average bloom length as affected by pruning and cultivar for irrigated and non-irrigated plantings of *Hydrangea* cultivars at the UK Research and Education Center, Princeton, Kentucky.

	Pruned	Not Pruned	Mean	Pruned	Not Pruned	Mean
	Non-Irrigated Planting			Irrigated Planting		
Cultivar	Average Bloom Length (in.)					
Alice	- -	3.5	3.6			
Annabelle	3.5	3.1 ns[1]	3.3			
Boskoop	5.3	3.4 *	4.2			
Kyushu	5.0	7.2 *	6.1	7.2	8.7 *	8.0
Pee Wee	5.0	4.1 ns	4.5	7.5	5.5 *	6.5
Pink Diamond	6.8	5.0 *	5.9	7.3	5.3 *	6.3
Tardiva	5.5	3.9	4.7	8.1	5.8 *	6.9
Unique	5.0	3.4 *	4.2	7.7	4.6 *	6.2
White Moth	- -	5.4	5.3	7.2	5.5 *	6.0
Mean	- -	- -	4.7	- -	- -	6.7
LSD (P = 0.05)	- -	- -	1.2	- -	- -	0.9

1 "*" and "ns" indicate that mean in previous adjacent column is either significant or not significant, respectively, at the 0.05 probability level from mean in column.

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Extended Vase Life for Cut Stems of *Hydrangea paniculata*

Todd Leeson, Sharon Bale, R. Terry Jones, Winston Dunwell, and Robert McNiel, Department of Horticulture

Introduction

Hydrangea paniculata is available as a cut stem from the Holland market. Some *H. paniculata* are available in this country as a cut stem through farmers' markets. A national commercial wholesale source of this stem is not readily available. *H. macrophylla* cultivars are the flowers that are usually grown for the cut flower market. The other hydrangea species—*H. arborescens*, smooth hydrangea; *H. paniculata*, panicled hydrangea; and *H. quercifolia*, oakleaf hydrangea—have been grown for landscape plants (1). Therefore, the ability to produce quality field-grown cut stems of the *H. paniculata* flower has the potential to offer an alternative income source to Kentucky farmers.

In 2001, preliminary studies were conducted at the University of Kentucky to determine the effects of irrigation and pruning influence on hydrangea for fresh cut flower production (2). Cutting the existing *H. paniculata* shrubs back in the fall produced strong straight stems the next season that had potential for the cut stem market. This study was to see the overall effects of floral hydrating and preserving solutions in dry cold storage (34°C) versus no storage of *H. paniculata* cut flower stems.

In 1999, a hydrangea cut flower cultivar trial was established at the University of Kentucky Research and Education Center at Quicksand, Kentucky (2). In the late spring, summer, and fall of 2002, a study was conducted on three cultivars—*H. paniculata* 'Pink Diamond', *H.* 'Unique', and *H.* 'Tardiva'. No information could be found on the best floral preservative to be used on these plants, nor was there any information on the effects dry storage would have on these stems. Dry storage in a cooler could mimic the effects of shipping time as well as the ability of a wholesale florist to "hold" the plant material.

Stems of *H. paniculata* cultivars 'Pink Diamond', 'Unique', and 'Tardiva' were harvested when the first or second row of sterile florets were fully opened. Sixty stems were cut, 30 of which were placed in a hydrating solution (Hydraplus) and then placed in a control using just tap water with a pH of 7.2 (Treatment 1), Aquaplus per package directions (Treatment 2), and Aquaplus with the addition of Flora Novus-XL solution in equal parts (Treatment 3). The other 30 stems were hydrated and stored dry for three days in a cooler (34°C). On the fourth day stems were recut, hydrated, and placed in a control using just tap water with a pH of 7.2 (Treatment 4), Aquaplus per package directions (Treatment 5), and Aquaplus with the addition of Flora Novus-XL solution in equal parts (Treatment 6). Stems remained in the treatments until the stem tips wilted or the sterile florets turned brown and the flowers were no longer of any commercial value. For example, if the stem in vase 3 failed to rehydrate and remained wilted after initial treatment, the vase life was considered zero days. If sterile florets started browning on the third day, vase life was over and considered to be three days.

Results and Discussion

No data were taken regarding stem length. A standard floral shipping box was used for dry storage and served as the gauge of acceptable stem length. In every case 3 to 4 feet of stem was cut off in order for the stems to fit in the florist box. Stem length is not an issue. The vase life of hydrangea determined by this study was of an acceptable length (Table 1). Dry cold storage for three days does not seem to affect the vase life of 'Pink Diamond', 'Unique', and 'Tardiva' (Table 1). There also does not seem to be an apparent difference in vase life of various cultivars used in this experiment. Cultivars of 'Unique' and 'Pink Diamond' were cut on the dates of Aug. 9 and Aug. 23, while the cultivar 'Tardiva' was cut on Oct. 9 (Table 1). The stems were then observed to determine what the average vase life was from the date they were cut off the plant. The

Table 1. *Hydrangea paniculata* flower vase life results.

Date	Trt 1	Trt 2	Trt 3	Trt 4*	Trt 5*	Trt 6*
8/09/02	5.35	6.1	6.95	5.45	5.8	6.5
8/23/02	5.2	6.5	6.6	4.8	5.7	6.5
10/09/02	5.57	6.3	7.26	5.23	6	6.8
Average	**5.37**	**6.3**	**6.94**	**5.2**	**5.8**	**6.6**

* Indicates cold storage treatments.

stems that were stored dry in a cooler were stored in the cooler for three days, but those three days were subtracted from the overall days to simulate transportation. If the stem showed a nine-day vase life, it was actually a six-day consumer vase life. More work needs to be done to determine the maximum vase life and dry storage time for *H. paniculata*.

Additional work should be done to determine the maximum vase life of *H. paniculata*. First, how long can these flowers remain in dry cold storage before their viability is adversely affected? The pH of the tap water used in the control was very high (7.2). Would vase life be lengthened by altering the water pH? Does shipping and storage in a solution versus dry cold storage make a significant difference in vase life?

Significance to Industry

This study showed that *H. paniculata* cultivars have the potential to be fresh cut flowers. This study could potentially develop a wholesale fresh cut flower market for *H. paniculata*. Changing production practices, storage methods, and observing flowers in different preservation solutions can result in a fresh cut flower market for hydrangea not normally available to growers interested in alternative incomes.

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2. Dunwell Winston, Dwight Wolfe, and June Johnston. 2001. Hydrangeas for cut flowers: 2000 observations. UK Nursery and Landscape Program 2001 Research Report, PR-450:8-9.

Kentucky Native Plant Evaluation

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Introduction

Plants native to Kentucky are already well known in the nursery landscape industry. Dogwoods, oaks, maples, ashes, and rhododendrons are a few of the woody plants; purple coneflowers, trilliums, phlox, lilies, and black-eyed Susans are a few of the many Kentucky perennial native plants used in landscapes. Kentucky native plants have characteristics that add to the aesthetics, and to the biodiversity, of residential, industrial, institutional, and recreational landscapes. Government agencies and academics alike have called for increased use of “regionally native” plants. A Kentucky native plant evaluation has been established at the University of Kentucky Nursery Crops Development Center at Princeton.

Results and Discussion

Native plants are sought out and found in the wild in Kentucky, seed are collected, plants are produced from the seed, and those plants are placed into the University of Kentucky Research and Education Center Botanic Garden and/or the Nursery Crops Development Center research nursery for evaluation of their potential as landscape plants. Desirable characteristics include long bloom period, good clean (disease and insect damage-free) foliage, environmental tolerance, and a commercially acceptable means of propagation.

Significance to Industry

Indian Pink, *Spigelia marilandica*, has the greatest potential for development as a mass produced landscape plant because of its long bloom period and ease of propagation. The development of a source of *Quercus phellos*, willow oak, of a Kentucky provenance with tolerances of Midwestern environmental conditions will be advantageous to Kentucky nurseries over currently available seed from provenances of the deep South. *Cunila origanoides*, dittany, shows potential as a landscape plant.

Table 1 contains individual plant evaluation information. The bolded scientific names indicate native plants that show significant promise as landscape plants.

Table 1. Kentucky native plants in evaluation at the UK Research and Education Center, Princeton, Kentucky.

Scientific Name	Common Name	Notable Ornamental Characteristic	Evaluation Results	Current Status	Future Evaluation and Research Efforts
Ascelpias tuberosa	Butterfly Weed	Bright orange bloom, attracts butterflies	Native equal to cultivars	Off-station[1] landscapes and butterfly garden	Maintain in landscape for public viewing
Amsonia tabernaemontana	Blue-star, Amsonia, Blue Dogbane	Pale blue spring flowers	Easily propagated from seed or by division	UKRECBG[2]	Cutting propagation and distribution

continued

Table 1. Kentucky native plants in evaluation at the UK Research and Education Center, Princeton, Kentucky.

Scientific Name	Common Name	Notable Ornamental Characteristic	Evaluation Results	Current Status	Future Evaluation and Research Efforts
Anemonella thalictroides	Rue Anemone	Fine-textured plant, dainty flower	Spring bloomer	UKRECBG	Further evaluation in a better drained site
Arisaema atrorubens	Jack in the Pulpit, Indian Turnip	Unique flower and fruit	None to date	Seed source located	Propagate and evaluate as landscape plant
Arisaema dracontium	Green Dragon	Unusual leaf and flower	None to date	Seed source located	Propagate and evaluate as landscape plant
Cephalanthus occidentalis	Buttonbush	Summer flowering woody shrub; very tolerant of wet feet	Attractive glossy foliage; uniquely round flower	In landscape and nursery	Evaluate invasiveness
Cimicifuga racemosa	Black Snakeroot, Black Cohosh	Striking tall white spike flowers in fall	Prone to scorch/dieback in nursery and landscape environment	In two landscape sites and research nursery	Determine best landscape environment; collect seed from plants in other sites
Cunila origanoides	Dittany	Rounded small plant of 18 inches; small purple flowers in late summer-fall	Attractive; divides easily	In research nursery	Continue landscape evaluation; develop protocol for container production
Erythronium americanum	Yellow Trout-Lily	Aesthetic foliage and flower	Very short bloom and foliage show	Unable to grow bulb in container	Protocol to store and plant bulbs to landscape
Euphorbia corollata	Flowering Spurge	Attractive small white bracts	Not complete	In containers	Evaluate for landscape use and invasiveness
Hydrangea arborescens	Wild Hydrangea, Smooth Hydrangea	Corymbs with few showy sterile flowers	Fairly long bloom period; flushes new growth in July; leaf spot	In nursery and landscape	The parent species of 'Annabelle' is worth continued seedling evaluation
Hymenocallis occidentalis	Spider-Lily	Stunning white bloom in late July-early August	Seems tolerant of landscape environment	UKRECBG landscape	Expand evaluation from current shaded site
Hypericum spathulatum	Shrubby St. John's-Wort	Yellow spring bloom and good foliage	Vigorous, requires pruning	UKRECBG	Stop evaluation; maintain in UKRECBG for public viewing
Kalmia latifolia	Mountain Laurel	Magnificent spring bloom	Native stands seem susceptible to leaf spot; tolerant of Western Kentucky environs	Not in evaluation	Collect seed; grow a collection of plants; evaluate for flower color and leaf spot susceptibility
Lillium superbum	Turk's-Cap Lily	Late summer red-orange bloom of great aesthetic value	Difficult to establish	Not established	Further evaluation and production protocol study warranted
Lonicera sempervirens	Trumpet Honeysuckle	Full-season red trumpet-shaped bloom	Excellent bloom, foliage, and habit	UKREC vine collection	Propagate for distribution and continued evaluation
Monarda fistulosa	Monarda or Bergamot	Pale blue spring flowers	Susceptible to powdery mildew	UKRECBG	Maintain in native plants garden
Nyssa Sylvatica	Blackgum	Glossy foliage; red-orange fall foliage	Great variation in seedlings	UKRECBG	Develop and protect name of a selected clone with weeping habit
Passiflora incarnata	Passion Flower	Unique purple-white flower on perennial vine but considered a weed (2)	Attractive flower; re-seeds	UKREC vine collection	Potential as pot plant
Polygonum biflorum	Solomon's Seal	Attractive habit and spring bloom	Species not as vigorous as cultivars; produces fruit	UKRECBG	Continue evaluation in new site
Pycnanthenum incanum	Hoary Mountain-Mint	White leaves subtend a small bloom	Grows well in landscape, spreading	UKRECBG	Continue evaluation

continued

Table 1. Kentucky native plants in evaluation at the UK Research and Education Center, Princeton, Kentucky.

Scientific Name	Common Name	Notable Ornamental Characteristic	Evaluation Results	Current Status	Future Evaluation and Research Efforts
Quercus phellos	Willow Oak	Tolerant of soil environments; small leaves	Easy to grow from seed; seeds not consistently produced	Seedlings in evaluation for selection of superior plant(s)	Continue seed collection from Kentucky provenances
Rudbeckia species	Black-Eyed Susan	Attractive, well-known summer flower	Tolerant of dry environs; variation in flower color and size	Discontinue cultivar evaluation (1)	Continue development with seedlings from natives
Silene virginica	Fire Pink	Bright red spring flower	“Fleeting” in garden	Dropped from evaluation	n/a
Sabatia angularis	Rose Gentian, Rose Pink	Late summer pink flowering plant of uniform habit	Difficult to maintain in landscape	Continue to seek seed sources	Reestablish in research nursery; protocol for use as an annual
Sanguinaria canadensis	Bloodroot	White spring flowering	Bloom period short; foliage attractive	Maintain in evaluation	Examine container production potential
Spigelia marilandica	Indian Pink	Bright red flower with yellow throat	Long bloom period; full-season foliage	Continue in UKRECBG; establish stock plant bed	Greatest potential as an underutilized Kentucky native
Vernonia gigantea	Tall Ironweed	Fantastic purple late summer/fall flowers in a large cluster	Stunning bloom frequently on attractive dark stems	Extremely invasive	Eliminate from evaluation site
Viola pubescens Alton	Smooth Yellow Violet	Yellow spring bloom	Bloom above and separate from foliage	Evaluate in UKRECBG	Investigate invasiveness

1 Plants considered potentially invasive are evaluated off-station.

2 UKRECBG = University of Kentucky Research and Education Center Botanic Garden at Princeton.

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Online Resources

Invasive Weeds of Kentucky and Adjacent States, Kentucky. <http://plants.usda.gov/cgi_bin/invasive_one.cgi?pub=KY>.

InvasiveSpecies.gov What’s in My Neighborhood: Kentucky. <http://invasivespecies.gov/geog/state/ky.shtml>.

Wildflowers of Western Kentucky. <http://knps.org/Wildflowers/flora.htm>.

Bell and Specialty Pepper Evaluations for Bacterial Spot Resistance, Yield, and Quality

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Introduction

After completing a three-year (1995-97) evaluation of bell pepper cultivars under induced bacterial spot (*Xanthomonas campestris* pv. *vesicatoria* or Xcv) and bacterial spot-free environments, we began a new series of trials in 2000 to compare new cultivars with previously recommended cultivars that were either highly resistant ('Boynton Bell') and/or that had very attractive fruits ('X3R Wizard'). While spot resistant pepper cultivars with the *Bs2* gene (resistance to Xcv races 1, 2, and 3) gained widespread acceptance in the state, a number of new resistant cultivars had been released since 1997. In addition to bells, we also wanted to screen a large number of hot and specialty peppers, some of which also carry the *Bs2* gene. Out-of-state buyers have expressed a strong interest in sourcing hot and specialty peppers from Kentucky. Bell varieties were tested again in replicated trials at two locations in 2001, while hot and specialty peppers were observed for a second year in non-replicated "RACE" trials at the same locations.

Materials and Methods

Near duplicate trials were planted at the Horticulture Research Farm in Lexington (LEX) and at an isolated location in Eastern Kentucky at the Robinson Experiment Station in Quicksand (QSND). Sixteen bell and 46 hot and specialty pepper cultivars were seeded in the greenhouse at LEX on 26 March. Seedlings were grown in 72-cell plastic trays and transplanted to the field on 16 May (LEX). Fourteen of the same bell cultivars and all of the same hot/specialty cultivars were transplanted at QSND on 29-30 May. Each LEX trial received 62 lb N/A prior to planting supplemented by an additional 38 lb N/A divided into three weekly fertigations from 27 June to 12 July (100 lb N/A season total). Trials at QSND received preplant applications of 50 lb N/A supplemented by 60 lb N/A divided into four fertigations applied from 13 June to 20 July (110 lb N/A season total). Phosphorus and potassium were applied prior to planting at both locations according to soil test recommendations.

Plots at both locations consisted of 16 plants in double rows with four replications in a randomized complete block design for bells and in single plots for hot and specialty peppers. All were planted on raised beds with black plastic mulch and drip irrigation. Plants of all cultivars were spaced 12 inches apart in the row with 15 inches between the two rows on each bed. Beds were 6 feet apart from center to center. A tank mix of maneb + fixed copper was applied weekly for bacterial spot (BLS) protection at Lexington.

No preventive fungicide treatments were applied at QSND in order to encourage the development of a natural BLS epidemic. No insecticides were required in the field at LEX or QSND. A pheromone trap for adult male European corn borers was placed adjacent to the trial field at LEX.

Thirteen new bell cultivars with the *Bs2* gene were compared with resistant controls 'Boynton Bell' and 'X3R Wizard' and with a susceptible control, 'King Arthur' (*Bs1* only, Table 1). The 13 new cultivars included seven from the 2000 trial and six that were tested for the first time in 2001. Mature green fruits were harvested four times in LEX and twice at QSND.

Marketable fruits were graded and weighed according to size class (U.S. No. 1 extra large, large, medium). We also weighed misshapen fruits that could be marketed to foodservice as "choppers" (LEX only). Yields in each size class were multiplied by their respective wholesale market prices to determine gross returns ("income") for each cultivar. The income variable has been a good indicator of a cultivar's overall performance, taking into account yields of the different size classes and their price differentials. Prices from 2000 were also used for the 2001 trials.

Hot and specialty peppers included a group of 13 jalapeño cultivars of which two had the *Bs2* resistance gene ('X3R Ixtapa' and 'El Rey'= SAX 7603) and others claiming multiple virus resistance (Table 3). These were compared with 'Mitla'. Other pepper types included were three serrano cultivars, six anaheim cultivars, seven poblano/ancho cultivars (entry SVR 35-4845-7 has the *Bs2* gene), four Italian/cubanelle cultivars, four hot banana/wax cultivars (X3R Hot Spot and SVR 35-4846-7 with *Bs2* gene), six sweet banana/wax cultivars ('Pageant', 'Sweet Spot', and PX 35-4360-7 with *Bs2* gene), two fresno cultivars, and two pepperoncini cultivars (Tables 4 and 5).

Fruit appearance ratings. All bell pepper fruits harvested from all replications at the second harvest (July 19) at LEX were laid out in the field for careful examination and quality ratings. All fruits from single plots of hot and specialty pepper cultivars were evaluated in the same way at LEX on July 30. Bell pepper fruits from two replications were evaluated at QSND (Aug. 9, first harvest). Overall appearance ratings took several things into account (in order of importance): overall attractiveness, shape, smoothness, degree of "flattening" (bell cultivars only), color, and uniformity of shape.

Plant support requirements. Some of the hot and specialty pepper cultivars required staking and tying in these trials that used close spacings, double rows, and plastic mulch with drip irrigation. All specialty cultivars at LEX were inspected at maximum fruit load to determine if staking and tying were needed; those requiring support are indicated in Tables 4 and 5. Tomato stakes (shorter stakes

Table 1. Yields, gross returns, and appearance of bell pepper cultivars under bacterial spot free conditions in Lexington, Kentucky; yield and returns data are means of four replications.

Cultivar	Total Mkt. Yield[z] (T/A)	% XL +Large[y]	Income[x] ($/A)	Shape Unif.[w]	Overall Appear.[v]	No. of Lobes[u]	Fruit Color	Comments
X3R Aristotle	25.0	89	10180	4	7	3	dark green	Most fruits longer than wide
King Arthur	22.5	88	9079	3	5	4	light-med green	Deep blossom-end cavities
4 Star	22.2	86	9111	3.5	6	4	light-med green	
Boynton Bell	21.7	92	9003	3	5	3	med-dark green	~15% of fruits 2-lobed (pointed)
Corvette	20.6	88	8407	3	6	3 & 4	med-dark green	~10% elongated (2-lobed)
X3R Red Knight	20.5	90	8428	3	5	4	med-dark green	
SP 6112	20.2	78	8087	4	6	3	med green	
Conquest	20.0	85	8021	2	5	3 & 4	light-med green	Deep stem-end cavities, many misshapes
Orion	20.0	93	8219	4	6	4	med-dark green	
Lexington	19.8	87	8022	3.5	6	3	dark green	
PR99Y-3	19.5	87	7947	3	5	3 & 4	med green	Many misshapen fruits
Defiance	18.7	87	7568	4	7	3 & 4	dark green	
X3R Ironsides	18.4	92	7585	4	6	3	med green	~5% w/deep stem-end cavities
X3R Wizard	18.0	92	7447	3	6	3 & 4	dark green	
RPP 9430	17.3	89	7029	3	6	4	med-dark green	~10% of fruits elongated
ACX 209	17.2	89	7035	3.5	6	3	med green	
Waller-Duncan LSD ($P < 0.05$)	5.2	7	2133					

z Total marketable yield included yields of U.S. Fancy and No. 1 fruits of medium (> 2.5-inch diameter) size and larger, plus misshapen but sound fruit that could be sold as “choppers” to foodservice buyers.

y Percentage of total yield that was extra-large (> 3.5-inch diameter) and large (> 3-inch diameter but ≤ 3.5-inch diameter).

x Income = gross returns per acre; average 2000 season local wholesale prices were multiplied by yields from different size/grade categories: $0.21/lb for extra-large and large, $0.16/lb for mediums, and $0.13/lb for “choppers,” i.e., misshapen fruits.

w Average visual uniformity of fruit shape where 1 = least uniform, 5 = completely uniform.

v Visual fruit appearance rating where 1 = worst, 9 = best, taking into account overall attractiveness, shape, smoothness, degree of flattening, color, and shape uniformity; all fruits from all four replications observed at the second harvest (July 19).

u 3 & 4 = about half and half 3- and 4-lobed; 3 = mostly 3-lobed; 4 = mostly 4-lobed.

could also have been used) were driven into the ground at the four corners of individual plots; plants were “fenced in” by running a string (tomato twine) around these four stakes. A single stringing was adequate for some cultivars, while others required two or three successive stringings.

Inoculation and disease assessment. As in previous years, LEX plots were sprayed weekly with copper + maneb to help protect against bacterial spot, while QSND plots were left unsprayed to encourage the development of a natural epidemic. June weather conditions in QSND were very favorable for BLS epidemic development, and a natural epidemic did occur early in the season. Bell and specialty cultivars were assessed only once at QSND for BLS symptoms on June 28. Symptoms were extensive and severe on some cultivars in the hot and specialty trial by that date. BLS symptoms were scored as follows: 0 = no symptoms, 1 = very few (trace) symptoms visible, 2 = symptoms obvious but not extensive, and 4 = extensive symptoms (plants severely affected). These observations were made prior to the inoculation attempt described below.

In order to encourage a more uniform BLS epidemic within the trial, an attempt was made to inoculate all bell cultivars with inoculum collected from the hot pepper trial. About 300 leaves with typical symptoms were collected at random from various susceptible cultivars within the hot pepper trial plot on 27 June. These were placed in a plastic bucket with sufficient distilled water to cover the leaves. The mixture was stirred for about 10 minutes with a wooden stick to enhance extraction of the bacteria, making an effort to crush some leaves on the side of the bucket. The mixture was then poured through a cotton bag to remove leaf debris and squeezed by hand. Two gallons of this mixture were diluted further with water to make a total volume of 4 gallons. This mixture was applied uniformly to all plants in the bell pepper trial using a hand-operated sprayer. The inoculation attempt was made in the late afternoon, within 15 minutes of the extraction. Heavy rains had preceded the inoculation attempt; the ground and foliage were wet during the inoculation and remained wet until mid-morning the following day. We considered this procedure to be a relatively simple means of ensuring more uniform epidemics using only races of the bacterium already found within the trial. We have successfully used this method in trials with other crops in the past.

About three hours after the inoculations, some of the mixture remaining in the sprayer was applied to pepper seedlings growing in a greenhouse on the Lexington campus. These seedlings developed extensive BLS symptoms within 10 days.

Results and Discussion

As in previous years, we wanted to encourage disease and evaluate resistance at QSND while keeping the LEX trial free of bacterial spot. No bacterial spot symptoms were observed in the bell or hot/specialty trials in LEX.

Bell cultivars. Total marketable yields, gross incomes, and fruit quality characteristics for bell cultivars grown without bacterial spot at LEX are shown in Table 1. Although yields were somewhat lower than in 2000, most of the cultivars were high yielding (20 to 25 tons/acre) at LEX with nine that were not significantly different from the top yielding cultivar X3R Aristotle (Table 1). The cultivars 'Aristotle', 'King Arthur' (bacterial spot susceptible), '4 Star', 'Boynton Bell', and 'Lexington' were also in this category in the 2000 LEX trial.

Yields, income, and fruit quality characteristics for most of the same cultivars grown at QSND are shown in Table 2. While an early bacterial spot epidemic did occur in the trial at this location, it had ended abruptly and inexplicably by the second week in July. No new bacterial spot lesions developed in the field at QSND after the inoculation attempt. In fact, all bacterial spot activity suddenly stopped in both the inoculated trial and the adjacent hot pepper trial that had not been inoculated. The reasons for this failure are not understood but may be the result of environmental factors. Night temperatures below 61°F are known to suppress bacterial spot development regardless of daytime temperatures. Nights were unusually cool from 12-17 July (57°F was the average night temperature for that period). In addition, although the plots were still soaked from heavy rains prior to inoculation, rainfall did not occur again until eight days after the inoculation.

There were no statistically significant differences among cultivars for total marketable yields or gross incomes at QSND. Marketable yields ranged from 13 to 18 tons per acre (Table 2). Some of the highest yielding cultivars at

Table 2. Yields, gross returns, and appearance of bell pepper cultivars at Quicksand, Kentucky; yield and returns data are means of four replications. All cultivars except King Arthur have the *Bs2* gene for resistance to bacterial spot races 1, 2, and 3.

Cultivar	Total Mkt. Yield[z] (T/A)	% XL +Large[y]	Income[x] ($/A)	Shape Unif.[w]	Overall Appear.[v]	No. of Lobes[u]	Fruit Color	Comments
4 Star	18.4	86	7496					
X3R Red Knight	18.0	90	7344	3	6	3	med green	Earlier maturing; some red fruits
Defiance	17.8	87	7256	3.5	7	3 & 4	med-dark green	Nice blocky fruits
X3R Aristotle	17.4	90	7164	3	5	3	med-dark green	Some 2-lobed fruits
RPP 9430	17.3	88	7105					
X3R Ironsides	16.7	83	6794	2	5	3	light-med green	Some 2-lobed
PR99Y-3	16.0	86	6508	3	5	3	light-med green	Deep stem end; some 2-lobed
Conquest	15.9	91	6560	3	5	3	med green	Slightly elongated; some red fruits
Orion	15.8	86	6486	3	5	3	med green	
SP 6112	15.5	81	6290	3	5	3	med-dark green	Many small fruits
Corvette	15.1	86	6194	3.5	5	3	med green	Some 2-lobed
Boynton Bell	14.9	77	5978	3	5	3	med green	
ACX 209	14.7	82	5994	3	5	2,3,4	med green	Many 2- & 3-lobed fruits; elongated
King Arthur	14.3	77	5746	2	4	3 & 4	med green	
Lexington	13.6	82	5520	3	5	3	dark green	Many small and flattened fruits
X3R Wizard	12.8	90	5289	4	6	3 & 4	dark green	Nice; slightly elongated
Waller-Duncan LSD (P < 0.05)	ns	12.2	ns					

z Total marketable yield included yields of U.S. Fancy and No. 1 fruits of medium (> 2.5-inch diameter) size and larger.

y Percentage of total yield that was extra-large (> 3.5-inch diameter) and large (> 3-inch diameter but ≤ 3.5-inch diameter).

x Income = gross returns per acre; average 2000 season local wholesale prices were multiplied by yields from different size/grade categories: $0.21/lb for extra-large and large, $0.16/lb for mediums.

w Average visual uniformity of fruit shape where 1 = least uniform, 5 = completely uniform.

v Visual fruit appearance rating where 1 = worst, 9 = best, taking into account overall attractiveness, shape, smoothness, degree of flattening, color, and shape uniformity; all fruits from two replications observed at the first harvest (Aug. 9).

u 3 & 4 = about half and half 3- and 4-lobed; 3 = mostly 3-lobed; 4 = mostly 4-lobed; 2, 3, 4 = about equal numbers of 2-, 3-, and 4-lobed.

QSND were also in the highest yielding group of varieties tested at LEX: '4 Star', 'X3R Aristotle', and 'X3R Red Knight'. Yields appeared to have been affected by the early bacterial spot epidemic. The cultivars 'King Arthur' and 'X3R Wizard' were among the lowest yielding at this location; these cultivars have been among the most susceptible in previous trials exposed to natural and induced BLS epidemics at QSND.

Scores for BLS symptom development from the 28 June assessment were extremely variable (C.V. = 116%), and no statistically significant differences were detected among cultivars (data not shown). This single assessment did not provide enough information to make valid comparisons for BLS resistance among cultivars. 'Conquest', a cultivar containing the *Bs2* gene, had the highest average score for BLS symptoms at this first and only assessment date.

While BLS symptoms had nearly disappeared by the third week in July, leaf spots caused by *Phyllosticta* sp. were evident on many of the bell and specialty cultivars by July 11.

Fruit quality characteristics for bell cultivars are also shown in Tables 1 and 2. The cultivars 'Aristotle' and 'Defiance' received the highest fruit appearance ratings at LEX, which were better than ratings for 'X3R Wizard'. 'Aristotle', 'Lexington', 'Defiance', and 'X3R Wizard' had the darkest green fruits in the LEX trial. 'Defiance', 'X3R Wizard', and 'X3R Red Knight' received the best appearance scores at QSND. Many other cultivars received acceptable appearance ratings (6 or above at LEX or 5 and above at QSND), while 'King Arthur', 'Boynton Bell', 'X3R Red Knight', 'Conquest', and 'PR99Y-3' were rated lower than the others at LEX. 'X3R Aristotle' scored lower in overall appearance at QSND than at LEX. The cultivar 'King Arthur' had the lowest score at QSND. 'King Arthur' has had consistently low fruit appearance scores in a number of trials; we consider it and similar cultivars better suited to foodservice markets.

Cultivars that were the highest yielding and that had acceptable or better fruit quality ratings at both locations included 'X3R Aristotle', '4 Star', and 'Orion'. A possible disadvantage of a cultivar like '4 Star' was its light to medium green-colored fruits (also light green in the 2000 trial); it may be difficult to market these lighter-colored cultivars when buyers have become accustomed to receiving those with darker fruits like 'X3R Wizard'.

Jalapenos. Yields and fruit characteristics of the 13 jalapeno pepper cultivars grown in single plots at LEX and QSND are shown in Table 3. Two of these cultivars carried the *Bs2* gene for bacterial spot resistance. Most jalapeño cultivars had high marketable yields at LEX ranging from 14 to 27 tons per acre with three cultivars exceeding 'Mitla' (Table 3). Among these 'Coyame', 'Summer Heat 6000', and 'RPP 7042-VP' had the most attractive fruits.

Table 3. Yields from single plots of jalapeno pepper cultivars at Lexington (LEX) and Quicksand (QSND) with fruit characteristics from Lexington, Kentucky, 2001.

Cultivar (Resistance Gene)	Mkt. Yield (T/A)		Fruit Characteristics							
	LEX	QSND	BLS[z]	Cracking[y]	Average[x] Ln. (in.)	Diam. (in.)	Wt. (g)	Appear. Rating[w]	Color[v]	Comments
Coyame	27.4	--[u]	2	3	3.2	1.3	34	7	mg-dg	~10-20% slightly crescent-shaped
X3R Ixtapa (*Bs2*)	26.1	10.4	2	3	3.2	1.3	28	6	mg-dg	Some stubby, misshapen (~2%); ~10% purpling
RPP 7042-VP	24.9	19.2	2	4	3.3	1.1	25	7	mg	
Summer Heat 6000	23.6	19.8	2	3	3.4	1.3	34	7	mg-dg	Nice; ~50% very slightly curved
Mitla	23.4	20.1		3	2.9	1.1	24	7	mg-dg	Nice
El Rey (*Bs2*)	23.1	12.9	1	3	3.1	1.3	35	5	mg	Taper not always smooth
Torreon	22.9	20.7	2	3	3.3	1.2	27	6	mg-dg	
Ballpark	21.7	16.2	2	2	3.6	1.0	28	6	mg-dg	Some crescent-shaped (~10-15%)
Grande	21.4	18.0	4	3	3.2	1.2	30	6	mg	~5% with purple areas (anthocyanin)
HMX 3677	21.3	16.1	2	4	3.0	1.3	26	7	dg	
Hybrid No. 7	21.2	22.3	2	2	3.3	1.3	31	6	mg	~10% crescent-shaped
Jalandro	20.8	12.2		1	3.3	1.6	40	4	mg	
HMX 3676	13.9	16.1	2	3	2.7	1.2	31	7	mg-dg	Nice; some fruits lightly curved

z Bacterial spot symptoms were observed in some plots at Quicksand and may have affected yields of those cultivars: "1" = plots with mild infection, "2" = plots with mild to moderate infections, "4" = plots that had severe infections. A blank in this column indicates that no symptoms were observed; blanks or numbers do not imply resistance or tolerance.

y Extent of cracking in jalapeno fruits where 0 = none; 5 = very extensive, over entire fruit surface (Lexington trial); some cracking may be a desirable trait in Hispanic markets.

x Average of a sample of 10 fruits (length and width); average fruit weight = marketable yields divided by number of fruits (entire season, Lexington).

w Visual fruit appearance ratings where 1 = worst, 9 = best, taking into account overall attractiveness, shape, color, and uniformity (Lexington).

v mg = medium green; dg = dark green (Lexington trial).

u Data not available from Quicksand for this cultivar.

Cultivars were exposed to a natural bacterial spot epidemic early in the season at QSND; however, the epidemic had nearly disappeared by mid-July, and only a single assessment for symptoms was obtained. Unlike results from the 2000 jalapeño trial, the two cultivars with the *Bs2* gene and 'Jalandro' appeared to be most affected by this short-lived epidemic (Table 3).

Serranos. Marketable yields for the three serrano cultivars at LEX ranged from 15 to 22 tons per acre with 'Tuxtlas' and 'Serrano del Sol' having the highest yields and most attractive fruits (Table 4). 'Tuxtlas' was also the highest yielding and most attractive serrano in 2000.

Anaheims. Yields of the six anaheim cultivars ranged from 15 to 31 tons per acre at LEX; 'Navojoa' was the highest yielding, while PX-35-4606-7 and 'Anaheim TMR 23' had the most attractive fruits (Table 4). 'Navojoa' was also highest yielding at QSND in spite of severe BLS symptoms early in the season (Table 4).

Poblano/anchos. Yields among the seven poblano cultivars at LEX ranged from 4 to 21 tons per acre. The cultivar 'Ancho Villa' was again (as in 2000) the highest yielding with the largest fruit size (Table 4); fruits of this cultivar, however, were lighter colored, which could possibly be a disadvantage in some markets. The only entry with the *Bs2* gene for resistance to bacterial spot (SVR 35-4845-7) was high yielding and had the highest appearance rating at LEX. Most poblano/ancho cultivars are quite susceptible to bacterial spot, and yields at QSND may have been affected by the early epidemic at this location (Table 4). 'Mulato Isleno' had very low yields at both locations.

Table 4. Yields from single plots of specialty pepper cultivars at Lexington (LEX) and Quicksand (QSND) with fruit characteristics from Lexington, Kentucky, 2001.

	Mkt. Yield			Fruit Characteristics						
	LEX	QSND		Average[x]						
Type Cultivar	(T/A)		Bac. Spot[y]	Ln. (in.)	Diam. (in.)	Wt. (g)	Appear. Rating[w]	Color[v]	Plant Support[u]	Comments
Serrano										
Tuxtlas	22.4	--[z]		2.9	0.8	12	7	mg	req'd.	~20% slightly crescent-shaped
Serrano del Sol	21.0	17.4		3.1	0.8	11	7	mg	req'd.	Nice, slightly crescent-shaped
Tampico Fiesta	15.3	13.7	2	2.9	0.6	7	6	lg-mg	req'd.	~50% slightly crescent-shaped
Anaheim										
Navojoa	31.0	23.3	4	8	1.7	65	5	lg-mg	ben.	~30% "C"-shaped
Garden Salsa	24.6	13.7	2	6.9	1.5	48	6	mg	req'd.	~30% "C"-shaped, many culls from blossom-end decay
Sahuaro	18.7	12.4		6.7	2.1	73	5	lg	req'd.	10-20% "C"-shaped, many culls from blossom-end decay
PX-35-4606-7	18.3	19.6		7.3	2.0	69	7	mg	ben.	Nice
Anaheim TMR 23	17.7	11.7	2	7.0	1.9	59	6	lg	req'd.	~20% "C"-shaped, some blossom end decay
Joe E. Parker	14.8	21.3		6.3	1.7	59	4	lg	req'd.	~40% "C"-shaped
Poblano/ancho										
Ancho Villa	21.0	12.3	2	5.4	3.0	133	6	lg-mg	req'd.	Lighter colored than most
SVR 35-4845-7 (*Bs2*)	17.2	10.7	4	4.9	2.8	94	7	dg	req'd.	Very nice
Ancho Ranchero	14.6	11.6	2	5.1	2.9	99	4	lg-dg	req'd.	Highly variable
Ancho San Martin	11.4	11.4		4.7	2.7	70	6	mg-dg	req'd.	Many culls from blossom-end decay
Mulato Costeno	10.3	10.6		3.9	2.4	67	6	dg	req'd.	Small fruit size
PS 13194	9.7	10.2	1	4.5	2.6	90	6	mg-dg	req'd.	Variable sizes; many culls from blossom-end decay
Mulato Isleno	3.9	3.9		4.3	2.3	54	5	dg	req'd.	Small fruit size; very low yield
Italian/cubanelle										
Aruba	28.3	15.6	1	7.5	3.0	137	5	lg-py	ben.	~20% apostrophe-shaped
ACX 500	24.2	9.4	2	7.5	2.8	115	5	py	req'd.	~40% apostrophe-shaped; nice color
Corno Di Toro	18.4	16.5	4	6.6	2.3	107	6	lg-mg	ben.	~10% apostrophe-shaped
Key West (*Bs2*)	16.7	22.0	1	7.1	2.9	116	4	lg	ben.	~40% apostrophe-shaped

z Data not available from Quicksand for this cultivar.

y Bacterial spot symptoms were observed in some plots at Quicksand and may have affected yields of those cultivars: "1" = plots with mild infection, "2" = plots with mild to moderate infections, "4" = plots that had severe infections. A blank in this column indicates that no symptoms were observed; blanks or numbers do not imply resistance or tolerance.

x Average of a sample of 10 fruits (length and width); average fruit weight based on marketable yields divided by number of fruits (entire season, Lexington).

w Visual fruit appearance ratings where 1 = worst, 9 = best, taking into account overall attractiveness, shape, color, and uniformity (Lexington).

v Lg = light green; mg = medium green; dg = dark green; vdg = very dark green; gy = greenish yellow; py = pale yellow; ly = lemon yellow.

u Staking with one or more strings may be required using double rows on plastic with drip as indicated by "req'd." = cultivars requiring staking/support; "ben." = cultivars that may benefit from staking.

Italian/cubanelles. Yields for the four Italian/cubanelle or frying peppers ranged from 17 to 28 tons per acre at LEX (Table 4). 'Aruba' had the highest yield and largest fruit size followed by 'ACX 500'. As in 2000, 'Corno di Toro' was considered to have the most attractive fruits although they were light to medium green instead of the typical light green or pale yellow. 'Key West', a new cultivar with resistance to bacterial spot, appeared to be unaffected by the early epidemic at QSND (Table 4).

Hot banana/wax. Two hot banana cultivars and 'Santa Fe Grande' were tested. 'X3R Hot Spot' (with the *Bs2* gene) had the highest marketable yield and good appearance ratings at LEX (26 tons/acre, Table 5). Both 'Inferno' and 'Santa Fe Grande' had severe symptoms of bacterial spot associated with the early epidemic at QSND.

Sweet banana/wax. The six sweet banana or sweet wax cultivars included two with the *Bs2* gene ('Pageant' and PX 35-4360-7); yields at LEX ranged from 21 to 32 tons per acre (Table 5). PX 35-4360-7 was the highest yielding entry at both locations and had the most attractive fruits. Most cultivars had many "C"- or apostrophe-shaped fruits. 'Market Sweet' was high yielding at LEX but exhibited severe BLS symptoms during the brief epidemic at QSND.

Fresno and pepperoncini. Two fresno cultivars, one with upright fruits and one with pendant fruits, were included in the trials. Marketable yield was higher and fruit size larger for the upright type (Table 5). 'Pepperoncini' from Rupp Seed Company was the highest yielding of the two pepperoncini types tested at LEX. PX 17494 had more attractive fruits at LEX and had higher yields at QSND. The authors are not familiar with market requirements for pepperoncini types; these are usually brined and sold with pizza. Perhaps "C"-shaped pepperoncini fruits could be as desirable as straight fruits.

Pepper types, cultivars, and bacterial spot risk. Kentucky pepper growers experienced periodic devastating bacterial spot epidemics prior to the widespread planting of resistant cultivars after 1995. There is a growing interest in Kentucky and other states in growing hot and specialty pepper cultivars, many of which do not carry any major resistance genes. While there is a significant risk of bacterial spot epidemics associated with the production of some

Table 5. Yields from single plots of specialty pepper cultivars at Lexington (LEX) and Quicksand (QSND) with fruit characteristics from Lexington, Kentucky, 2001.

Type / Cultivar	Mkt. Yield LEX (T/A)	Mkt. Yield QSND (T/A)	BLS[z]	Average[y] Ln. (in.)	Average[y] Diam. (in.)	Average[y] Wt. (g)	Appear. Rating[x]	Color[w]	Plant Support[v]	Comments
Hot banana/wax										
X3R Hot Spot (*Bs2*)	26.2	23.5		6.3	1.6	54	6	py	ben.	
Inferno	25.6	17.7	4	7.0	1.6	64	4	py	ben.	Over 50% short and apostrophe-shaped
Santa Fe Grande	16.8	14.5	4	2.9	1.1	19	7	py	poss.	Very nice; jalapeno size and shape
Sweet banana/wax										
PX 35-4360-7 (*Bs2*)	32.5	26.8	2	6.5	1.6	58	7	py	req'd.	~50% "C"/apostrophe-shaped; many w/blossom end decay
Market Sweet	28.7	15.9	4	6.8	1.8	65	4	py-lg	poss.	Over 50% short and "C"/apostrophe-shaped
Sweet Spot	24.5	17.6	2	6.9	1.8	58	5	py	ben.	Many culls
Pageant (*Bs2*)	23.6	18.3		6.2	1.7	70	4	py	poss.	Over 50% short and "C"/apostrophe-shaped
Banana Supreme	23.5	14.9	2	6.2	1.8	65	5	py	poss.	~50% short and "C"/apostrophe-shaped
Bounty	21.3	20.1	2	7.1	1.6	76	5	py	ben.	~50% short and "C"/apostrophe-shaped
Fresno										
Grande (upright)	7.2	15.0				22			poss.	
Supreme (pendant)	4.7	3.9	2			19			req'd.	
Pepperoncini										
Pepperoncini	17.6	11.5	2	3.9	1.5	39	6	lg-mg	req'd.	~40% "C"-shaped
PX 17494	12.5	14.8	1	3.3	1.3	18	7	lg	req'd.	Mostly straight, more uniform

z Bacterial spot symptoms were observed in some plots at Quicksand and may have affected yields of those cultivars: "1" = plots with mild infection, "2" = plots with mild to moderate infections, "4" = plots that had severe infections. A blank in this column indicates that no symptoms were observed; blanks or numbers do not imply resistance or tolerance.

y Average from a sample of 10 fruits (length and width); average fruit weight based on marketable yields divided by number of fruits (entire season, Lexington).

x Visual fruit appearance ratings where 1 = worst, 9 = best, taking into account overall attractiveness, shape, color, and uniformity (Lexington).

w Lg = light green; mg = medium green; dg = dark green; vdg = very dark green; gy = greenish yellow; py = pale yellow; ly = lemon yellow.

v Staking with one or more strings may be required using double rows on plastic with drip as indicated by "req'd." = cultivars requiring staking/support; "ben." = cultivars that may benefit from staking; "poss." = cultivars that possibly need staking under windy conditions or with heavy fruit loads.

of these cultivars, others can be grown with less likelihood of disaster, especially with a sound spray regimen. Relative bacterial spot risks for various pepper types and cultivars were estimated after the 2000 trials and are shown in Table 6. Our recommendation remains that growers use resistant cultivars whenever possible *in conjunction with* copper + maneb preventive spray programs.

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Table 6. Tentative ranking of pepper types and cultivars by their relative susceptibility to bacterial spot (based on results from trials at Quicksand, Kentucky, in 2000).

BLS Risk	Group[z]	Resistance Gene(s)	% BLS[y]	Cultivars[x]
Lowest	resistant jalapeños	*Bs2*	3-22	X3R Ixtapa, El Rey
	tolerant serranos	—	3-10	Tampico Fiesta, Serrano Chili
	most resistant bells[w]	*Bs2*	8-13	X3R Ironsides, Peninsula, X3R Chalice, X3R Aristotle, X3R Red Knight
	resistant hot banana	*Bs2*	17	X3R Hot Spot
	tolerant habanero	—	22	Habanero (Hollar Seed Co.)
	tolerant cubanelle	—	40	Aruba
	tolerant hot bananas/wax	—	40-52	Hungarian Yellow Wax, ACX 400, Romanian Hot Hybrid
	tolerant cayenne (misc.)	—	62	Mesilla
	tolerant poblanos/anchos	—	62-67	Ancho San Martin, Ancho Villa
	less resistant bells[w]	*Bs2*	63-71	X3R Wizard, Bennington
	tolerant sweet bananas/wax	*Bs2*	62-75	Pageant, Market Sweet, Sweet Banana
	susceptible cubanelles	—	67-77	Biscayne, ACX 500, Giant Aconcagua, Corno di Toro
	susceptible hot bananas/wax	—	65-80	Hungarian Heat, Inferno
	susceptible anaheims	—	72-80	Mexiheim, Garden Salsa, Anaheim TMR 23
	susceptible bells	*Bs1*, *Bs3*[v]	80-82	King Arthur, Merlin, Consul, Vivaldi, Guardian, Sentinel
	susceptible jalapeños	—	80-87	Mitla, Tam Jalapeño No.1, Delicias, Perfecto, Summer Heat 5000
Highest	susceptible poblanos/anchos	—	72-85	Ancho Ranchero

z Cultivars within types (bells, jalapeños, or hot/specialty types in Tables 4 and 5) grouped as: 1) "resistant" = having *Bs2* gene and high yielding with fewer symptoms and defoliation overall than 2) "tolerant" = having no major resistance gene but with considerably fewer symptoms and yielding more marketable fruits than 3) "susceptible" = little to no marketable yield with extensive foliar symptoms and defoliation.

y % BLS = range of the average percentages of leaves with bacterial spot symptoms under severe epidemic conditions at Quicksand in 2000; data were from two assessment dates and one or more cultivars.

x Not all cultivars tested are listed; others may be equally resistant, tolerant, or susceptible.

w Bell cultivars that were the "most resistant" with highest yields and gross returns. "Less resistant bells" are those cultivars (with or without *Bs2*) that had relatively high area under disease progress curve (AUDPC) values (data not presented here), % BLS, and defoliation in 2000.

v Cultivars having *Bs1, Bs3,* or both with no major resistance genes in 1995 trials.

High Tunnel Production for Cold-Season Crops

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Introduction

After traveling throughout the world, the plasticulture technique known as high tunneling has returned to the University of Kentucky. Begun in the 1950s by researchers such as E. M. Emmert, the use of simply constructed plastic tunnels has been used in areas ranging from Turkey to Egypt to China. Researchers at the University of Kentucky are revitalizing this half-century old technology and looking at ways to make it better. While other universities publish plans and guidelines for large-scale tunnels, which often include a kit, the UK tunnels are low-cost and, when possible, rely on commonly available materials. Kentucky's mild winter enables the use of simpler tunnels. The goal of this research is to determine a production system for low-cost high tunnels to allow Kentucky farmers to produce high-quality produce off-season for local markets.

A high tunnel is a plastic-covered house, usually Quonset in shape. There is no electricity for heating or ventilation, and the only external link is irrigation. Construction of the main frame can vary. The frame can be made from many types of material—steel, PVC, or wood. The tunnel itself should have two end walls, with a door either at both ends or at least a window on the end opposite the door for ventilation. A clear 6-mil plastic is preferable and will be durable throughout the year. When the season is over, the tunnel can be dismantled for the next year or moved to another site.

High tunnels are used primarily as a season-extending technology. The sunnier days Kentucky experiences in March and April can warm up tunnels to grow warm-season crops such as tomatoes and cucumbers. In the fall, when the days are shorter and the threat of frost is prevalent, tunnels can capture heat from the sun during the day and protect plants. We hope to stretch the window of production by producing a marketable crop of cold-season vegetables throughout the winter.

High tunnels work by trapping the heat of the sun inside the plastic tunnel. During the winter, this could provide temperatures suitable for cold-season crops. At night, enough heat has been trapped inside the tunnels to mitigate the coolness of the night temperatures. A fine layer of condensation may also build up on the walls and ceiling of the tunnel, which also helps to trap heat at night.

Materials and Methods

At the Horticulture Research Farm in Lexington, four high tunnels were constructed in early November 2002. The experiment was replicated with identical rows outside the tunnels. Each of the tunnels was built with a single layer of 6-mil clear plastic, braced by painted PVC pipe, and wooden ends. The tunnels measured 10 feet wide by 40 feet long by 6 feet high. Each tunnel had two main rows set in a randomized block design. Within each tunnel one row was covered by an inner tunnel, made of bent PVC in a half circle and clear 6-mil plastic about 2 feet high, constructed to add further protection to the plants. It was feared that this double layer of plastic would restrict the amount of light already limited by the extreme cloudiness of Kentucky winters, limiting it to only ~80% of the photosynthetically active radiation (PAR) available. Due to extreme wetness in November and December of 2002, our cold-season crops did not get planted until mid-December. In each house (including one tunnel within a tunnel) and one outside plot, sensors were placed to monitor ground temperature, air temperature, humidity, and PAR at 30-minute intervals. In a random design, spinach, kale, and lettuce were planted based on recommended spacing.

Results

Preliminary findings show that greater yields were seen in the double-tunneled replications than in the plots covered only by the tunnel itself (Table 1). This trend continued until the outside temperature became what most would consider more appropriate for the growth of spinach (50° to 64°F). At this time, spinach grown outside a tunnel had yields that began to equal or exceed yields of spinach grown in a tunnel.

Table 1. Yields of spinach from single and double tunnels.

Weight of Spinach (g)

		Weight	No. of Plants Harvested	Average Weight of Plants
REP 1				
Harvest 1[1]	one cover	61.48 g	11	5.59 g
	two cover	515.37 g	12	42.95 g
Harvest 2[2]	one cover	225.08 g	11	20.46 g
	two cover	332.01 g	12	27.67 g
Harvest 3[3]	one cover	316.70 g	11	28.79 g
	two cover	320.95 g	12	26.75 g
REP 2				
Harvest 1	one cover	216.18 g	12	18.02 g
	two cover	447.02 g	10	44.70 g
Harvest 2	one cover	573.17 g	12	47.76 g
	two cover	632.37 g	10	63.24 g
Harvest 3	one cover	152.48 g	10	15.25 g
	two cover	143.05 g	5	28.61 g
REP 3				
Harvest 1	one cover	127.94 g	10	12.79 g
	two cover	528.84 g	11	48.07 g
Harvest 2	one cover	629.78 g	10	62.98 g
	two cover	522.35 g	11	47.49 g
Harvest 3	one cover	408.91 g	10	40.89 g
	two cover	164.83 g	11	14.98 g
REP 4				
Harvest 1	one cover	187.98 g	12	15.67 g
	two cover	462.67 g	11	42.06 g
Harvest 2	one cover	680.77 g	12	56.73 g
	two cover	523.10 g	11	47.55 g
Harvest 3	one cover	257.25 g	12	21.44 g
	two cover	124.05 g	8	15.51 g
REP 5				
Harvest 1	no harvest			
Harvest 2	no harvest			
Harvest 3		343.49 g	11	31.23 g

[1] Harvest 1: 3/3/2003
[2] Harvest 2: 3/15/2003
[3] Harvest 3: 3/26/2003

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Yield and Powdery Mildew Resistance of Fall-Harvested Summer Squash

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Introduction

Although squash from late-summer plantings often achieve the highest market prices, fungal and virus diseases frequently cause serious damage in fall-harvested squash and are considered important barriers to profitable production in Kentucky and surrounding states.

Mixed virus infections commonly occur in fall-harvested summer squash in Kentucky. Watermelon mosaic virus (WMV, formerly WMV-2), zucchini yellow mosaic virus (ZYMV), squash mosaic virus (SqMV), cucumber mosaic virus (CMV), and papaya ringspot virus (PRSV, formerly WMV-1) have all occurred in Kentucky at one time or another and in most other southeastern states. Although the dominant virus(es) varies from site to site and from year to year, WMV has been the most frequently detected virus in summer squash (present in more than 90% of samples tested) during the last 11 years in Kentucky. Virus epidemics are often severe in late-summer plantings and total destruction of the crop is not uncommon.

Effective virus resistance and tolerance were found among new transgenic (GMO) and conventionally bred cultivars tested in a fall-harvested trial in 1997 in Kentucky (see *1996-97 Kentucky Vegetable Crop Research Report*). Although transgenic cultivars have become more popular with some growers since then, most yellow straightneck squash growers in Kentucky depend on cultivars with the precocious yellow (Py) gene for late-season production. These cultivars mask the greening effect in summer squash fruits when plants are infected by CMV or WMV but not if plants are infected by PRSV or ZYMV. In some areas, precocious yellow squash have reportedly been more difficult to market because of buyer preference for green, rather than yellow fruit peduncles found in cultivars with the Py gene. Kentucky growers and marketers have not had difficulty marketing squash with this trait. Production of yellow crookneck squash, grown primarily in the southern part of Kentucky for southern markets, has been very risky without disease-resistant cultivars.

It was our intention to evaluate cultivars and breeding lines for yield and virus resistance in a fall-harvested trial. Because there was a near absence of virus diseases this year, cultivars and breeding lines were evaluated for marketable yield, powdery mildew (PM) resistance, and fruit appearance.

Materials and Methods

Thirty-four summer squash cultivars or advanced breeding lines (16 zucchini, nine yellow straightneck, and nine yellow semi-crookneck or crookneck entries) were evaluated at the University of Kentucky Horticulture Research Farm in Lexington in the late summer and fall of 2002. These included several of the best performing cultivars from the 1997 trial. Most cultural practices were according to our current commercial recommendations for Kentucky. Seeds were sown in the greenhouse on 18 July in 72-cell plastic trays and transplanted to the field on 6 Aug. Each plot consisted of eight plants spaced 18 inches apart in a single row on 6-inch high raised beds with white-on-black plastic mulch and drip irrigation. Beds were 6 feet apart from center to center. All 34 entries were planted together in a randomized complete block design with four replications. Cultivars of each type (zucchinis, yellow straightneck, or yellow crookneck) were grouped together within each block. Blocks consisted of two long rows with 16 or 17 entries per row. Single rows of the disease-susceptible cultivar Dixie were planted on both sides of each block to enhance natural disease buildup and uniform spread throughout the trial.

Sixty-five pounds of N/A were applied prior to planting, while an additional 18 lb N/A were applied in three fertigations for a season total of 83 lb N/A. All P and K were applied preplant according to recommendations based on soil tests. Quadris was applied on Aug. 7, 14, and 30 for fungal disease control; a tank mix of Nova and Bravo was applied on Sept. 9 and 26. The systemic insecticide Admire was applied two days after transplanting as a post-transplant drench for cucumber beetle control. Two subsequent applications of Pounce were made for later season cucumber beetle and squash vine borer control.

Plots were harvested three days per week (MWF) from 27 Aug. until 4 Oct. for a total of 16 harvests. Fruits were counted and weighed after grading into either marketable fruit or culls. Marketable yield was expressed in terms of the number of half-bushel boxes per acre by dividing the total weight of marketable fruit per acre by 21 lb. Following an analysis of variance, average yields and disease ratings were compared using Waller-Duncan's K-ratio T-test ($P = 0.05$).

Fruit quality ratings. All fruits of each trial entry harvested from all four replications were graded and laid out on tables for careful examination and quality rating on 11 and 20 Sept. Fruits were assessed for type, color, and overall appearance. Yellow squash type (straightneck, semi-crookneck, or crookneck) was determined based on our own observations rather than seed company descriptions. Yellow squash color was rated on a 1 to 5 scale with 1 = pale yellow with greenish tint and 5 = bright golden yellow. Zucchini squash color was scored from 1 = light green to 5 = very dark green, nearly black. Appearance was rated on a 1 to 9 scale with 1 = worst and 9 = best, taking into account, in order of importance, overall attractiveness, shape, uniformity of shape, and color.

Disease assessments. Plants were visually assessed for the extent of PM symptoms on leaves (both upper and lower surfaces) and stems on 11 Sept. and 7 Oct. Although we did not identify PM species in this trial, mixtures of *Sphaerotheca fuliginea* and *Erysiphe cichoracearum* are usually found in late-summer squash plantings; both species were identified in the 1997 trial.

Results and Discussion

This harvest season was exceptional in that only a few of the more than 2,000 plants in the trial field showed any virus symptoms or yielded unmarketable fruits having virus symptoms. This was in spite of the presence of other cucurbit trials, which were planted earlier at the same location, and in spite of the extensive planting of a susceptible cultivar within the trial field. Commercial squash growers in Central and Western Kentucky also reported very low virus incidence in 2002. Midsummer drought led to a decline in clover and other host plants, and this may have resulted in the low virus incidence.

Yellow straightnecks. As was the case in 1997, conventionally bred hybrids having the precocious yellow gene were in the highest yielding group of yellow straightneck squash cultivars: Sunray, Multipik, Fortune, and Monet were not significantly different from the highest yielding Precious II (Table 1). Multipik and Fortune were also in this highest yielding group in 1997 when virus incidence was high. While lower yielding, Cougar and Seneca Supreme had the best fruit appearance scores among straightnecks (Table 1).

Powdery mildew symptoms were first observed inside leaf canopies of some cultivars in mid-September. Sunray exhibited exceptional PM resistance, while Precious II also had PM resistance that was significantly better than the resistance of other cultivars in this group; Fortune and Multipik appeared to be the most susceptible to PM among the straightnecks tested (Table 1). In the absence of virus diseases, transgenic cultivars Conqueror III and Liberator III were the lowest yielding in the group and were susceptible to PM; these cultivars also had the lowest appearance scores (Table 1). Transgenics were among the highest yielders in 1997 when virus pressure was very high.

Yellow crooknecks. While transgenic cultivars Prelude II and Destiny III were clearly superior among yellow crook-

Table 1. Yields and powdery mildew assessments for yellow straightneck, crookneck, and zucchini squash cultivars, breeding lines; data are means of four replications; appearance ratings are averages from two assessments of all fruits harvested from four replications.

Entry	Type[z]	Mkt. Yield Boxes/A[y]	Powdery Mildew[x] 11 Sept.	7 Oct.	Avg.	Appear. Rating[w]
I. Yellow straightneck and slight semi-crookneck:						
Precious II	SN-Py	1660	1.8	0.7	1.2	5.5
Sunray	SN/sCN-Py	1536	0.1	0.4	0.3	6.5
Multipik	SN-Py	1526	3.0	3.7	3.4	6.5
Fortune	SN-Py	1513	3.7	3.2	3.5	6.5
Monet	SN-Py	1511	2.5	3.5	3	6.5
Goldbar	SN	1475	2.5	2.7	2.6	5.5
Cougar	SN/sCN-Py	1369	2.6	2.7	2.7	7.0
Seneca Supreme	SN-Py	1327	2.6	2.7	2.7	7.0
Lioness	SN	1281	2.7	1.0	1.9	5.0
Conqueror III	SN,Tg-3+	1262	2.6	2.5	2.6	4.5
Liberator III	SN,Tg-3	1219	3.0	3.2	3.1	4.0
II. Yellow semi-crookneck or crookneck:						
Medallion	sCN/CN	1663	3.2	3.0	3.1	5.5
Sunglo	sCN/CN	1495	0.2	0.5	0.4	5.5
Prelude II	CN	1462	0.0	0.1	0.1	5.5
Gentry	sCN	1450	2.6	3.5	3.1	5.5
Dixie	CN	1384	3.9	3.5	3.7	5.5
Destiny III	sCN/CN,Tg-3	1267	3.5	3.5	3.5	6.0
Pic-N-Pic	CN	1101	3.7	3.7	3.7	6.0
Waller-Duncan LSD (all yellow squash, P = 0.05).		220	0.6	0.7	0.6	---
III. Zucchini:						
HMX 710	Z	1722	0.0	0.0	0.0	7.0
Zucchini Elite	Z	1694	3.3	2.3	2.8	6.0
SVT 4620327	Z, Tg-3	1686	0.4	0.0	0.2	5.5
Cashflow	Z	1635	4.2	4.2	4.2	6.5
Lynx	Z	1567	4.0	2.7	3.4	5.0
Dividend	Z	1517	3.5	3.0	3.2	6.0
Spineless Beauty	Z	1466	4.0	3.0	3.5	5.5
9523	Z	1445	4.3	4.3	4.3	6.5
Revenue	Z	1276	3.5	3.5	3.5	5.5
Robuster	Z	1262	4.0	4.4	4.2	5.5
Senator	Z	1215	3.2	2.2	2.7	6.0
AXC 34	Z	1207	4.7	3.5	4.1	6.0
Tigress	Z	1172	2.0	1.7	1.8	6.5
Independence II	Z,Tg-2	1146	4.0	2.5	3.2	5.0
Seasons	Z	1130	4.5	4.0	4.2	5.0
ACX 45	Z	1123	5.0	4.2	4.6	5.5
Waller-Duncan LSD (zucchinis, P = 0.05)		326	0.6	1.3	0.7	--

[z] All entries from conventional breeding programs except for: Tg = transgenic for resistance to two (Tg-2) or three (Tg-3) viruses; Tg-3+ = transgenic for three viruses with resistance to the fourth (PRSV) obtained through conventional breeding. Type descriptions based on our observations on 11 and 20 Sept.: SN = straightneck, CN = crookneck, sCN = semi-crookneck; some cultivars that we considered semi-crookneck are considered straightneck by the seed company and are included in the straightneck grouping; Py = has precocious yellow gene to mask virus symptoms.

[y] Number of half-bushel (21lb = 9.52 kg) boxes per acre.

[x] Visual rating scale from 0 = no symptoms to 5 = extensive symptoms on entire plants; ratings took into account the percentage of upper and lower leaf and stem surfaces that were covered by powdery mildew symptoms; assessed by W. Nesmith on 11 Sept. and 7 Oct. (three days after final harvest).

[w] Appearance ratings where 1 = worst, 9 = best, taking into account, in order of importance, overall attractiveness, shape, and color.

neck entries in 1997 under intense virus pressure, only Prelude II was among the highest yielding crookneck cultivars in 2002. Conventionally bred cultivars Sunglo and Gentry were also not significantly different in yields from the highest yielding Medallion among crooknecks (Table 1). Both Sunglo and Prelude II showed an exceptional degree of PM resistance, while the other cultivars in this group were much more susceptible (Table 1). Lower-yielding Destiny III and Pic-N-Pic had the best appearance scores, while appearance scores for the other cultivars in this group were deemed acceptable (Table 2).

Zucchinis. One transgenic and six conventionally bred zucchini cultivars were in the highest yielding group that were not significantly different from highest yielding line HMX 0710; these included Zucchini Elite, SVT 04620327 (transgenic virus resistance), Cashflow, Lynx, Dividend, Spineless Beauty, and Sunseeds 9523 (Table 1). Dividend was also in the highest yielding group in 1997. As in 1997, the transgenic virus-resistant Independence II was among the lowest yielding zucchini cultivars. Appearance ratings were highest for HMX 0710, Cashflow, Sunseeds 9523, and Tigress; fruit from a single observation plot of Tigress also

Table 2. Fruit color, appearance, and other observations for yellow straightneck, crookneck, and zucchini squash cultivars and breeding lines; ratings are averages from two assessments (11 and 20 Sept., 2002); all fruits bulked from four replications at each of the two harvests.

Entry	Type[z]	Color[y]	Appear. Rating[x]	Shape/Comments/Suitability
Precious II	SN-Py	2.7	5.5	Very long with long, thick neck; pale yellow w/greenish tint at blossom end; 50% curved
Sunray	SN/sCN-PY	3.0	6.5	Elongated teardrop shape; very slight crook; good color
Multipik	SN-Py	3.2	6.5	Long teardrop shape
Fortune	SN-Py	3.0	6.5	Medium long teardrop shape; 20% curved
Monet	SN-Py	3.5	6.5	Teardrop shape; nice color
Goldbar	SN	2.0	5.5	Long w/very slight crook in most; greenish cast
Cougar	SN/sCN-Py	3.0	7.0	Long teardrop shape; slight crook
Seneca Supreme	SN-Py	3.0	7.0	Teardrop shape; attractive
Lioness	SN	1.5	5.0	Long w/slight crooks; greenish cast in smallest fruits
Conqueror III	SN	1.5	4.5	Very long, thin; 50% slightly curved; greenish cast
Liberator III	SN	1.5	4.0	Very long, thin; 50% slightly curved; greenish cast
Medallion	sCN/CN	3.5	5.5	Good color; medium thick neck
Sunglo	sCN/CN	2.0	5.5	Medium thick neck; pale w/greenish cast
Prelude II	CN	2.0	5.5	Medium thick neck; greenish cast
Gentry	sCN	3.5	5.5	Medium thick neck; shape somewhat variable
Dixie	CN	2.0	5.5	Thick neck; greenish cast
Destiny III	sCN/CN	2.0	6.0	Medium thick neck; greenish cast
Pic-N-Pic	CN	2.7	6.0	Thinner neck than most; greenish cast in smallest fruits
HMX 0710	Z	3.0	7.0	Medium dark green; 50% w/slight curve and very slight taper (almost cylindrical
Zucchini Elite	Z	3.0	6.0	Medium green; 50% w/slight curve; larger diam. blossom end (slight taper)
SVT 04620327	Z	3.7	5.5	Medium dark green; 50% w/slight curve; many with slight and occasionally uneven taper
Cashflow	Z	3.0	6.5	Medium green; 40% w/slight curve; very slight taper
Lynx	Z	3.7	5.0	Medium green; 60% w/slight to moderate curve; slight taper
Dividend	Z	3.0	6.0	Light to medium green; 20% w/slight curve; slight taper, nearly perfectly cylindrical; very nice looking
Spineless Beauty	Z	3.7	5.5	Medium dark green; angular fruit; mostly slightly curved and tapered (larger blossom end)
9523	Z	4.0	6.5	Medium dark green; most slightly curved; strong taper (larger blossom end); attractive glossy color
Revenue	Z	3.0	5.5	Light to medium green; slightly larger blossom end; most slightly curved
Robuster	Z	3.0	5.5	Medium green; 20% curved w/very slight taper
Senator	Z	2.5	6.0	Light to medium green; heavily speckled; most slightly curved with smooth taper; one plant with off-type fruits in this trial
AXC 34	Z	3.0	6.0	Light to medium green; mostly slightly curved w/very slight taper
Tigress	Z	2.0	6.5	Gray-green speckled; 50% slightly curved; tapered; one plant with off-type fruits in this trial
Independence II	Z	2.7	5.0	Medium green; most fruits slightly curved and tapered
Seasons	Z	4.2	5.0	Medium dark green; 40-50% slightly curved, straight to very slight taper; shape not uniform
ACX 45	Z	4.7	5.5	Very dark green; most slightly curved; no taper

z Type descriptions based on our observations on 11 and 20 Sept. (SN = straightneck, SN-Py = straightneck with precocious yellow gene, CN = crookneck, sCN = semi-crookneck); some cultivars that we considered semi-crookneck may be considered straightneck by the seed company.

y Color ratings for yellow squash: 1 = pale yellow with greenish tint; 5 = bright golden yellow. Color ratings for zucchini: 1 = lightest green; 5 = nearly black.

x Appearance ratings: 1 = worst; 9 = best, taking into account, in order of importance, overall attractiveness, shape, and color.

had high appearance ratings in 1997. Plots of both Tigress and Senator, however, had a single plant (of the 32 plants of each cultivar that were grown for the trial) that yielded off-type fruits. Zucchini Elite, Dividend, Senator, and ACX 34 also had good appearance ratings (Tables 1 and 2); Zucchini Elite, Dividend, and Senator had high scores in the 1997 trial.

PM resistance was exceptionally high in breeding lines HMX 0710 (no symptoms) and SVT 04620327; Tigress also appeared to be resistant or tolerant to PM. PM ratings were significantly lower for HMX 0710, SVT 04620327, and Tigress than for the other zucchini cultivars. Neither of the two numbered breeding lines had been named/released at the time of this writing.

Results from the 1997 fall-harvested trial at this location together with those from similar trials in other states demonstrated that transgenic virus-resistant squash cultivars could provide excellent resistance to two or more of the viruses involved in mixed infections in the southeastern United States. Transgenic zucchini line SVT 04620327 and transgenic crookneck Prelude II both have high levels of PM resistance and performed well in this trial; the other transgenic cultivars did not perform as well in 2002 in the absence of significant virus pressure and under epidemic powdery mildew conditions.

Marketable yields in late plantings can be expected to vary considerably among cultivars from year to year and location to location depending on the resistance package in the cultivar, diseases present in the field, and the growth stage at which the crop becomes infected. Precocious yellow straightneck cultivars remain an excellent choice for high yields and masking of green fruit symptoms associated with moderate epidemics of WMV and CMV. New straightneck cultivars Precious II, Sunray, Monet, and Cougar are recommended for small-scale trial by growers; Sunray and Precious II should provide valuable levels of PM resistance. Fortune and Multipik will remain on our list of suggested cultivars for Kentucky growers in spite of their susceptibility to PM. While lower yielding in this trial, transgenic virus resistant cultivars should perform considerably better in most late-summer plantings when virus diseases are serious risks for growers.

New crookneck cultivars Medallion and Sunglo are recommended for grower trial. Prelude II will remain the only transgenic crookneck on our list of suggested cultivars. New standouts among zucchinis recommended for grower trial are HMX 0710 (not yet released) for its high yields of attractive fruits and exceptional PM resistance. Cashflow, SVT 04620327 (not released), Lynx, and Sunseeds 9523 are also recommended for growers' trials. High levels of PM resistance are now available in cultivars of all three types of summer squash grown in Kentucky. PM resistance should be considered together with virus resistance, fruit appearance, and other horticultural characteristics in selecting cultivars for late-summer production.

The Potential of *Capsicum baccatum* as a New Crop for Kentucky Farmers

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Introduction

Bell pepper production has a long history in Kentucky, and pepper remains an important crop for Kentucky vegetable growers. One reason for this long history of pepper production is that Kentucky producers have a reputation for growing high-quality peppers. Over the years, shifts in production have occurred. Twenty years ago, most of the peppers were open pollinated varieties, planted late on bare ground in single rows, were not irrigated, and were harvested red to be canned. Now common production practices include the use of hybrid varieties resistant to disease, planted on raised beds through plastic mulch. Irrigation and fertilization are provided through trickle lines. Planting occurs early in the season, and peppers are harvested green for the fresh market. Production of specialty peppers such as jalapeno, anaheim, and serrano is also becoming more common in Kentucky. There is no doubt that Kentucky farmers can produce high- quality peppers, reflecting their skills for managing and marketing peppers. A goal of this project is to build on these skills, providing new opportunities for Kentucky farmers.

The scientific name of the common bell pepper and most specialty peppers is *Capsicum annuum*. A close relative of this species is *Capsicum baccatum*. *C. baccatum* is not commonly grown in the United States; however, it has been grown in South America, mainly by indigenous people. So, *C. baccatum* is not an undomesticated species but is a species with which we have less experience.

Prior to the establishment of this research project, the core collection of *C. baccatum* was grown at the University of Kentucky Horticulture Research Farm in 2000. A core collection represents the breadth and depth of genetic variability available in the species. We noted that there were some novel characteristics present in certain members of this species. As a result of funding by the New Crop Opportunities Center, we have been able to begin to evaluate whether these novel characters might provide the basis for a new crop for Kentucky farmers.

Based on our initial evaluation in 2000, we determined that certain lines of *C. baccatum* might have value as ornamental plants, and other lines, due mainly to the shape of the fruit, might have value as a novelty pepper.

The main ornamental characteristics that were present were numbers of fruit per node, leaf variegation, branching pattern, and fruit color and shape. The main culinary characters present were a novel fruit shape (Figure 1) and variation in pungency. The illustrated fruit shape is very distinctive and may lend itself to use as the base for an hors d'oeuvre.

Objectives

Since we have little experience with the species *C. baccatum*, one objective is learning how to best grow these particular lines. Another objective includes evaluation of yield, shape, flavor, pungency, earliness, and for ornamental lines, fruit color, stem length, number of fruit, degree of variegation, plant shape and size, etc.

The third objective is to select, mainly by pure line selection, for characteristics that may improve the potential of this species for Kentucky farmers. A fourth objective is to evaluate market potential for these novel crops.

Materials and Methods

In 2002, approximately 40 different lines of *C. baccatum* were grown (five plants per plot) at the Horticulture Research Farm. The seed was obtained from the USDA germplasm collection in Griffin, Georgia. All plots were single row, raised beds with trickle irrigation and black plastic mulch. Fifty pounds of N/A was applied at planting, and this was supplemented with 40 lb N/A during the season, applied through irrigation. These small plots mainly provided material for preliminary evaluation of potential use as ornamental plants. Fifteen plots containing 40 to 70 plants each provided material for evaluation of culinary quality. The source of this material was either single plant selections of lines that were field grown in 2000 or had been acquired from USDA or were purchased from Pepper Gal, Fort Lauderdale, Florida. All lines were seeded in the greenhouse in early April and were planted in the field in early June. At the time of planting, the weather was unusually hot and dry. After approximately four weeks of growth, plants were staked using a modified Florida weave system. Lines planted for ornamental value were evaluated visually. These evaluations included plant stature, fruit color, and degree of fruitfulness, foliage color, and any other notable characteristics. Fruit from the culinary lines were harvested when mature. Because of unusual and late fruit set due to environmental conditions, seed were saved from early fruit as a selection for earliness and fruiting under adverse environmental conditions. Later fruit was harvested and sent to several chefs, in Kentucky and elsewhere, for their preliminary evaluation of quality and potential desirability as a base for an hors d'oeuvre.

For 2003, four experiments were planted in the field. All plots were planted on raised beds 6 feet apart, with black plastic mulch and trickle irrigation. Normal methods for insect and disease control and supplemental fertigation were used. Prior to planting, N at the rate of 25 lb/A was broadcast on the plots.

For the ornamental pepper, six segregating breeding lines were planted in the field. Characters segregating in these lines include type and degree of variegation, plant stature, fruit color and shape, fruit per node, fruit size, stem length, earliness, as well as other characters. These characters will be evaluated with an eye toward use as either a potted ornamental, or for the large-statured plants, for use as cut stems in the floral trade. Ornamental peppers were planted in black plastic-mulched, trickle-irrigated, double rows on raised beds. Plants were 15 inches apart in the row and between double rows. Beds were 6 feet apart center to center.

For the culinary peppers, three distinct experiments were planted. The culinary peppers, due to their larger plant size, were planted in single rows in the center of the bed, at a spacing of 12 inches between plants. One experiment was designed to evaluate the effect of N-fertility at planting. The experimental design was a randomized complete block with four replications and four rates of N (25, 50, 100, and 200 lb of N/A). Plots were 20 feet long. Data to be collected include yield, earliness, leaf size, and plant height.

Another experiment was designed to provide estimates of yields among lines of culinary *C. baccatum* . The experimental design was a randomized complete block with four replications and 14 lines of 15 plants each. Data to be collected include yield, earliness, plant height, and fruit characteristics including shape, pungency, size and color, and overall quality rating. Data from this experiment will be used to calculate potential returns from culinary *C. baccatum*.

The third experiment was aimed at genetic improvement of horticultural characteristics, including yield, earliness, and fruit quality. Fourteen lines of culinary *C. baccatum* were planted in a randomized complete block experiment with two replications. Plant numbers per plot ranged from 36 to 142 plants per plot, depending on the line. This experiment will allow for pure line selection for earliness and yield and will also provide fruit for culinary evaluation and for development of tools or methods for culinary preparation. Harvested fruit will be sent to chefs in Kentucky and elsewhere in the United States for culinary evaluation.

Results

Culinary Peppers, 2002

When peppers were planted in the field, conditions were hot and dry. As a result, about 40 to 60% of pepper plants were severely injured by desiccation. For most of the injured plants, axillary buds near the base of the plant developed and allowed the survival of most plants. However, growth and subsequent harvest were severely delayed. Harvest began about Sept. 1.

The culinary peppers produced were distinct in appearance (Figure 1) and flavor. This particular shape is not currently available commercially. Samples of the culinary peppers were distributed to a small number of chefs in late summer. Those chefs having "high end" clientele were especially interested and used them stuffed with various ingredients as appetizers. The product was equally desirable when consumed fresh or cooked. Those chefs having a more general clientele were not as interested because of the preparation time involved in cleaning the center from the pepper.

The novel appearance of the peppers attracted a great deal of attention, and the taste was distinct from that of other peppers.

Based on the results in 2002, a group of master chefs has expressed interest in helping determine which color, shape, and taste qualities would be the most desirable to chefs as well as the general consumer. Their input will help to ensure the selection of a marketable product and grading guidelines.

Ornamental Peppers, 2002

Two types of variegation were identified, stippled and sectored. Genes for branching and fruit number per node were also isolated. Variation in fruit color and size were noted. Several lines were selected for additional study. Some of these lines have potential as cut stems. Others have potential as pot plants.

Culinary and Ornamental Peppers, 2003

Results were not available at the time this report was written.

Conclusions

Because of the novel shape, flavor, and texture of the culinary peppers, they will have a ready market. However, the size of this market remains to be determined. In this regard, the initial response from the chefs concerning the potential of culinary *C. baccatum* was very gratifying. Additional research is needed to: 1) determine whether these peppers will be a profitable crop for Kentucky farmers; 2) identify potential production problems; 3) better adapt the lines to Kentucky conditions through breeding by pure line selection; 4) explore market potential; and 5) identify methods or tools that will allow for easier preparation of the raw product.

With regard to ornamental peppers, the economic potential of these lines needs to be established. Furthermore, additional breeding needs to take place, in order to provide pure lines for release.