Evaluation of Eastern European Wine Grape Cultivars for Kentucky

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Introduction

Interest in producing grapes for wine in Kentucky has increased dramatically, with the number of new vineyards and wineries increasing from 16 to about 80 in five years. This was partially due to the cost-share program initiated by the Grape Industry Advisory Committee to help tobacco growers diversify their operations into other agricultural crops.

There are four types of grapes grown in the United States for wine: American (*Vitis labrusca*), Muscadine (*Vitis rotundifolia*), European (*Vitis vinifera*), and American French hybrids (*Vitis labrusca* x *V. vinifera*). Generally, Muscadine grapes are not well adapted to Kentucky's climate, and European grapes can survive Kentucky weather only with extra care in vine management. American grapes grow well, but fruit quality for wine is usually substandard. Many American French hybrids grow well, and fruit quality for wine is intermediate to the American and French parents. The majority of the wine from Europe and the West Coast of the United States is made from European grapes.

European grapes are not well adapted to the cold climate of Northern Europe. Vines are usually buried with soil or mulch to prevent winter injury, a very labor-intensive operation. Northern Europeans have crossed the *vinifera* with different *Vitis* species, including some from China. The resulting advanced selections have shown improved hardiness as well as outstanding fruit quality in Eastern Europe. The late Dr. Bob Goodman of the University of Missouri evaluated these selections in Eastern Europe and selected candidates based on winter hardiness, disease resistance, and fruit quality. These grapes were grown in Missouri under post-entry quarantine. In 1998, the first of these cultivars was distributed to selected land-grant institutions in the United States, including the University of Kentucky. This project is being conducted in cooperation with the Missouri State Fruit Experiment Station, SMSU, Mountain Grove, Missouri.

The objective of the project is to evaluate these selections in different regions of the United States. To participate in this project, the University of Kentucky signed an agreement specifying that no one could collect bud wood from this planting.

Material and Methods

Eighteen advanced selections were released from post-entry quarantine in the spring of 1998 and planted at the University of Kentucky Research and Education Center (UKREC), Princeton, Kentucky. The vines were set 8 ft. within rows spaced at 12 ft. apart. The planting stock was small-potted cuttings. These were trained to two leaders and tied to 5-ft. bamboo canes during the first year. During the second year, vines were trained to a high bilateral cordon system. The planting is trickle irrigated, and a 4-ft.-wide herbicide strip is maintained beneath the vines with mowed sod alleyways.

Beginning in 2000, yield, cluster weight, berry weight, pH, and Brix (% soluble solids) were recorded for each selection. The vines were balance-pruned according to the previous year's yields. In brief, in-balance pruning means that the final number of buds left on a vine is determined by the vine vigor and growth from the previous season, as measured by the weight of the wood removed. The harvested grapes were then distributed to cooperating wine makers, and the wine quality produced from these selections was evaluated twice.

During the spring of 2001, an additional selection of nine advanced varieties was released from post-entry quarantine and planted at the UKREC. The planting was established in an area previously used for a high-density apple planting. The remaining end posts were left in place and used for the grape trellising. Consequently, vines were spaced 8 ft. apart in rows 16 ft. apart. Other aspects of planting and training were similar to those of the 1998 planting described above. A number of the vines were killed during a late spring freeze. The surviving plants were trained to two leaders and tied to 5-ft. bamboo canes during the first year. Vines were not balance-pruned in 2003 because they did not have a crop in the previous season due to their poor growth after the late spring freeze.

In 2003, the same variables of yield and berry measurements were recorded as described for the vines planted in 1998. A few varieties yielded enough grapes to make wine. These grapes were distributed to cooperating wine makers, and the wine quality produced from these selections is being evaluated.

Results and Discussion

Yield and fruit quality components for grapes harvested in 2002 and 2003 are listed in Tables 1 and 2 (1998 planting) and Table 3 (2001 planting). Table 4 compares the fruit yields, soluble solids, and pH for the years 2001-2003 of the 1998 planting. Toldi, Malverina, Rubin Tairovski, and XIV-11-57 averaged the highest yields for years 2001-2003. The average fruit sugar content in 2001 was slightly lower with 17.5% soluble solids at harvest compared with 19.2 and 18.8 for the years 2002 and 2003, respectively. The average fruit pH at harvest was 3.3, 3.2, and 3.2 for 2001, 2002, and 2003, respectively.

Table 5 lists the wine tasting results for the 2000 vintage wines, tasted in 2001 and 2002, and the 2001 vintage wines, tasted in 2002. Wine makers for each variety are listed as well as the range of ratings among tasters and the comments from the most recent tasting. Wine made from the grapes harvested in 2000 was evaluated on 23 June 2001 and 20 October 2001. Members of the Kentucky Vineyard Society evaluated wine from the 2000 and 2001 harvests on 6 January 2003. Note that comments from the tastings are only for the most recent tasting. Comments for previous tasting evaluations are found in last year's report. Two wines received an excellent average rating, namely XIV-1-186 in 2001 and 2002 and Liza in 2001.

A summary of the wine evaluations is presented in Table 6. The two French American hybrid wine standards, Chambourcin and Vidal Blanc, received the highest average cumulative rankings so far. They are followed by 34-4-49, Laurot, Kozma 525, and XIV-1-186. All of these received a good average cumulative wine rating.

These data are considered preliminary, as it will take several years to fully evaluate these selections for wine quality and vine adaptation to Kentucky. The variety Burmunk grew very poorly and may not have adapted to Kentucky's climate. It is not included in this report. Less than 50% of the Burmunk vines survived, and no fruit was harvested in 2000 or 2001. Green June beetles destroyed the small amount of fruit produced in 2002. The Burmunk cultivar was removed from the planting in 2003.

Acknowledgments

The authors would like to express their appreciation for all the help that they received in this study from the many Kentucky Vineyard Society members who cooperated in making and evaluating these wines.

Table 1. 2002 yield and fruit quality results from the 1998 Eastern European wine grape variety trial at UKREC, Princeton, Kentucky.

Cultivar	Harvest Date	Number of Vines	Pruning Wt./Vine (lb)	Yield (T/A)[1]	Cluster Weight (g)	Berry Weight (g)	Soluble Solids (%)	pH
Malverina	8-12	11	1.72	4.8	613	1.45	20.5	3.3
Toldi	8-12	14	1.24	4.7	610	2.82	18.0	3.3
Kozma 525	8-27	14	4.17	3.4	622	1.34	18.8	3.4
XIV-11-57	8-12	10	2.57	3.1	277	0.72	15.2	3.1
Rubin Tairovski	8-8	14	1.23	2.7	739	1.10	22.7	3.2
XIV-1-86	8-8	14	1.29	2.4	414	1.61	18.4	3.3
Rani Riesling	8-21	14	1.99	2.3	572	1.13	18.4	3.1
Liza	9-5	14	1.89	2.0	304	0.89	20.6	3.1
Laurot	8-12	14	0.69	1.9	396	1.06	17.5	3.1
Bianca	8-1	30	0.89	1.5	81.7	1.02	19.0	3.1
34-4-49	9-5	14	0.28	1.1	422	1.20	19.1	3.0
I 31/67	8-8	12	0.62	0.8	422	1.20	18.8	3.3
Petra	8-8	11	0.52	0.5	254	0.86	18.6	3.1
Laurot	9-9	14	0.69	0.3	396	1.06	21.4	3.2
Kozma 55	9-5	26	0.29	0.3	455	1.16	21.0	3.2
M 39-9/74	8-12	14	0.68	0.3	356	1.61	14.4	2.7
XX-15-51	8-1	15	0.69	0.1	-	1.43	19.6	3.3
Iskorka	8-1	14	0.72	-	-	1.59	22.2	3.1

[1] Calculated tons per acre. Vines are on 8 x 12-ft. spacing, equivalent to 454 vines per acre. Data are sorted by yield from highest to lowest.

Table 2. 2003 yield and fruit quality results from the 1998 Eastern European wine grape cultivar trial at UKREC, Princeton, Kentucky.

Cultivar	Harvest Date	Number of Vines	Pruning Wt./Vine (lb)	Yield (T/A)[1]	Cluster Weight (g)	Berry Weight (g)	Soluble Solids (%)	pH
Toldi	8-19	14	2.0	10.5	287	1.72	16.4	3.1
Rubin Tairovski	9-5	15	2.2	10.3	228	1.88	20.0	3.4
Malverina	8-25	11	2.7	9.7	405	2.03	18.6	3.2
Bianca	8-14	30	2.0	8.1	112	2.26	17.6	3.1
XIV-11-57	8-26	11	2.0	6.8	228	1.29	18.0	3.3
Liza	9-8	14	2.9	6.2	171	1.26	21.2	3.3
Laurot	9-5	15	1.6	6.2	161	3.15	19.2	3.2
XX-15-51	8-7	15	1.4	6.1	138	0.34	18.4	3.2
Kozma 525	9-5	14	2.9	6.1	193	1.80	18.6	3.3
XIV-1-86	8-13	14	2.3	5.1	151	1.96	17.2	3.3
M39-9/74	8-19	14	1.8	5.0	265	2.40	18.0	3.1
34-4-49	9-10	14	0.7	4.9	208	1.67	19.8	3.2
Rani Riesling	9-5	14	2.0	4.3	128	1.51	22.6	3.3
Kozma 55	8-21	26	1.1	3.5	160	1.37	19.2	3.2
I 31/67	8-7	12	0.6	3.5	214	0.36	16.6	3.2
Petra	8-13	13	1.4	1.6	94	1.38	21.0	3.4
Iskorka	8-7	14	0.9	1.5	235	0.34	21.6	3.4

[1] Calculated tons per acre. Vines are on 8 x 12-ft. spacing, equivalent to 454 vines per acre. Data are sorted by yield from highest to lowest.

Table 3. 2003 yield and fruit quality results from the 2001 Eastern European wine grape cultivar trial at UKREC, Princeton, Kentucky.

Cultivar	Harvest Date	Number of Vines	Yield (T/A)[1]	Cluster Weight (g)	Berry Weight (g)	Soluble Solids (%)	pH
II 70/20	8-20	11	2.0	224	2.54	18.6	3.2
Nero	8-13	12	1.2	209	2.66	21.4	3.3
Ir 26/5	9-5	9	1.0	143	1.43	21.2	3.2
L4-9-18	8-13	11	0.9	195	1.35	16.0	3.0
Golubok	8-07	11	0.9	99	0.28	17.6	3.4
Bromariu	8-21	9	0.7	220	1.66	23.0	3.2
Demetra	8-21	8	0.7	104	1.00	21.4	3.4
I 55/8	8-20	8	0.3	150	1.69	19.6	3.3
Plai	8-21	8	0.1	114	1.33	22.4	3.4

[1] Calculated tons per acre. Vines are on 8 x 16-ft. spacing, equivalent to 340 vines per acre. Data are sorted by yield from highest to lowest.

Table 4. Yield summary, 2000-2002.

	Yield (T/A[1])				Soluble Solids (%)				pH			
Cultivar	**2001**	**2002[2]**	**2003**	**Avg.**	**2001**	**2002**	**2003**	**Avg.**	**2001**	**2002**	**2003**	**Avg.**
Whites												
Bianca	4.6	1.5	8.1	4.7	18.6	17.8	17.6	18.0	3.4	3.1	3.1	3.2
Iskorka	3.6	0.1	1.5	1.7	16.2	22.2	21.6	20.0	3.2	3.1	3.4	3.2
Liza	3.7	2.0	6.2	4.0	20.8	20.6	21.2	20.9	3.2	3.1	3.3	3.2
Malverina	7.6	5.7	9.7	7.7	17.8	20.5	18.6	19.0	3.3	3.3	3.2	3.3
Petra	2.0	0.5	1.6	1.4	15.0	18.6	21.0	18.2	3.2	3.1	3.3	3.2
Rani Riesling	3.0	2.3	10.3	5.2	19.0	18.4	18.4	18.6	3.2	3.1	3.2	3.2
Toldi	8.3	4.7	10.5	7.8	17.6	18.3	16.4	17.4	3.3	3.3	3.1	3.2
XIV-1-86	4.1	2.4	5.1	3.9	15.7	18.4	17.2	17.1	3.3	3.3	3.3	3.3
XX-15-51	4.2	0.1	6.1	3.5	18.2	19.6	18.4	18.7	3.2	3.3	3.2	3.2
34-4-49	3.1	1.3	4.9	3.1	16.7	19.1	19.8	18.5	3.2	3.0	3.2	3.1
Reds												
Kozma 55	1.5	0.3	3.5	1.8	19.2	21.0	19.2	19.8	3.4	3.2	3.2	3.3
Kozma 525	5.2	4.0	6.1	5.1	18.4	18.8	18.6	18.6	3.5	3.4	3.3	3.4
Laurot	3.5	2.6	6.2	4.1	17.8	21.4	19.2	19.5	3.2	3.1	3.2	3.1
Rubin Tairovski	6.5	2.7	10.3	6.5	17.6	22.7	20.0	20.1	3.2	3.2	3.4	3.3
I 31/67	2.0	0.8	3.5	2.1	18.2	18.8	16.6	17.9	3.5	3.3	3.2	3.3
M 39-9/74	3.1	0.4	5.0	2.8	17.9	14.4	18.0	16.8	3.3	2.7	3.1	3.0
XIV-11-57	6.4	3.1	6.8	5.4	13.1	15.2	18.0	15.4	3.1	3.1	3.3	3.2
Overall Averages	**4.3**	**2.0**	**6.2**	**4.2**	**17.5**	**19.2**	**18.8**	**18.5**	**3.3**	**3.2**	**3.2**	**3.2**

[1] Tons per acre. Vines are on 8 x 12-ft. spacing, equivalent to 454 vines per acre.
[2] Yields in 2002 were low due to a late spring frost, split set, and severe Japanese beetle infestation.

Table 5. Wine tasting results for the 2000 and 2001 vintage years.

Cultivar[1]	**Wine Maker**	**2001 Tasting Average Rating[2]**	**2002 Tasting Average Rating[2]**	**Range of Ratings[3]**	**Comments from Most Recent Tasting**
2000 Whites					
Bianca	D. Miller	9.7	9.0	6–14	Good body; some sugar would help balance
Iskorka	D. Miller	11.1	9.9	6–13	None
Liza	B. Meyer	15.0	8.5	2–13	Nice color, off aroma; disagreeable odor; lack of free nitrogen in must
Malverina	B. Meyer	12.7	10.4	7–14	None
Malverina	D. Miller	11.2	6.4	0–11	Unpleasant aroma, taste, aftertaste; not indicative of grapes
Petra	G. Thompson	12.8	10.2	6–15	High alcohol; too sweet; unbalanced
Toldi	B. Meyer	10.8	11.1	6–15	Good balance
XIV-1-86	B. Meyer	15.2		12-17	Sweet, spicy, cleansing sweet
XIV-1-86	G. Thompson	9.4	7.6	5–11	No taste
XIV-1-86	D. Miller	14.2	10.8	2–15	Good balance; unpleasant aroma; unpleasant taste; no aftertaste; short aftertaste
XX-15-51	G. Thompson	13.0	10.4	6–14	Needs sugar; citrus taste; sulfur aroma; good acidity, high alcohol
34-4-49	B. Meyer	11.6	11.9	5–15	Acid and sugar not balanced; best of the 2000 whites
Cayuga White (std)	B. Wilson	8.8		6-11	The best white from this trial, good acid, crisp, very pleasant, good for the long haul
Vidal Blanc (std)	C. Nelson	14.8		11–17	Well made, great balance; a “ringer” for a nice Vidal Blanc

continued

Table 5. Wine tasting results for the 2000 and 2001 vintage years (continued).

Cultivar[1]	Wine Maker	2001 Tasting Average Rating[2]	2002 Tasting Average Rating[2]	Range of Ratings[3]	Comments from Most Recent Tasting
2001 Whites					
Bianca (sweet)	K. Georgiev		9.0	4-12	None
Bianca (dry)	K. Georgiev		9.2	4-15	High acidity; peppery aftertaste
Iskorka	M. Dudley		3.1	0-7	Sulfur aroma; sulfur aroma; sulfur aroma; sulfur taste; acidic
Liza (Cote des Blanc Yeast)	E. Durbin		5.4	2-9	High acid; sulfur aroma; sauerkraut taste
Liza (Montrachet Yeast)	E. Durbin		5.1	2-13	Sour taste and aftertaste; high acid; off taste
Malverina	G. Thompson		10.9	5-15	Pale, acidic, grassy aroma; mint aroma
Rani Riesling	B. Meyer		10.5	4-14	High acid; high acid, variety of fragrances, some pine
XIV-1-86	B. Meyer		15.6	8-18	Best 2001 white; excellent; excellent, well balanced; some herb aroma
XX-15-51	M. Dudley		2.8	0-8	Vinegar taste; no taste; no color, no aftertaste; no color
34-4-49	G. Thompson		14.1	7-18	Would be excellent if vinified properly
Vidal Blanc (std)	C. Nelson		10.4	3-15	None
2000 Reds					
I31/67	E. O'Daniel	8.6	3.2	0-12	Oxidized; spoiled
Kozma 55	C. Nelson	8.8	12.2	5-20	Nutty, chocolate aroma, flat taste
Kozma 525	C. Nelson	11.2		8–17	Smooth, nice taste, peach aroma
Laurot	E. Durbin	12.8	12.2	7-18	None
M39-9/74	E. Durbin	11.5	11.9	8-16	Lemon, coriander taste; slightly acidic
Rubin Tairovski	E. O'Daniel	11.2	10.2	5–14	Brown color; off color; flat taste; light aroma; weak taste; licorice
XIV-11-57	E. O'Daniel	10.4	7.2	5-9	Cherry, cranberry taste but flat
Chambourcin (std)	B. Wilson	14.3		8–19	Chambourcin, bit light, good structure and tannins, still light on fruit but true taste, clean aftertaste, good balance, well made, nice pencil shaving tones, good color, varietal nose
2001 Reds					
I 31/67	C. Nelson		9.3	4-13	Smoky, woody; high tannins, no fruit; needs aging; good tannins
Kozma 55	B. Meyer		12.5	8-18	Hazelnut aroma; high alcohol and tannins; high acid
Kozma 525	E. Durbin		13.0	10-19	Good balance; fruit forward, good tannins; high acid
Laurot	G. Thompson		12.3	7-18	Apple, limburger taste; high acid; acidic, appealing color
M 39-9/74	C. Nelson		11.7	7-20	Floral aroma; very high acid; harsh; licorice, lavender aroma
Rubin Tairovski	E. O'Daniel		9.5	5-16	Cherry taste; good cherry taste; light aroma; low tannins
Rubin Tairovski (blended)	K. Georgiev		9.8	6-15	Light color; off color
XIV-11-57	E. O'Daniel		11.5	6-18	Fruity but bland; blush color; no tannins; light color; light tannins
Chambourcin (std)	C. Nelson		13.4	9-19	Full body, dill aftertaste; nice fruit, dill

[1] Cayuga White, Chambourcin, and Vidal Blanc were used as high-quality French American standards for comparison.
[2] Average rating: 0-5 = poor or objectionable, 6-8 = acceptable, 9-11 = pleasant, 12-14 = good, 15-17 = excellent, 18-20 = extraordinary. Each wine was evaluated by nine to 10 tasters: (2001) Jim Bravard, Danny Buechele, Dave Miller, Bud Mirus, Mickey Mirus, Butch Meyer, Dr. Chris Nelson, Eddie O'Daniel, Jay Pruce, Gina Pruce, Gari Thompson, and George Wessel; (2002) Lynda Hogan, Elmer Klaber, Tom Kohler, Jerry Kushner, Marilyn Kushner, Butch Meyer, Dave Miller, Ben O'Daniel, Gari Thompson, and James Wight.
[3] Range: 1st number = lowest score received, 2nd number = highest score received from most recent tasting.

Table 6. Wine evaluation summary.

Cultivar[1]	2000 Vintage Average Rating[4] 2001 Tasting	2000 Vintage Average Rating[4] 2002 Tasting	2001 Vintage Average Rating[4] 2002 Tasting	Cumulative Average[5]
Whites				
Bianca	9.7	9.0	9.0	
Bianca (dry)			9.2	9.2
Iskorka	11.1	9.9	3.1	10.5
Liza	15.0	8.5	5.4	9.6
Malverina	12.7	10.4	10.9	
Malverina	11.2	6.4		10.3
Petra	12.8	10.2		11.5
Rani Riesling[2]			10.5	10.5
Toldi	10.8	11.1		11.0
XIV-186	15.2			
XIV-186	9.4	7.6		
XIV-186	14.2	10.8	15.6	12.1
XX-15-51	13.0	10.4	2.8	11.7
34-4-49	11.6	11.9	14.1	12.5
Cayuga White (std)	8.8			8.8
Vidal Blanc (std)	14.8		10.4	12.6
Reds				
I 31/67	8.6	3.2	9.3	9.0
Kozma 55	8.8	12.2	12.5	11.2
Kozma 525	11.2		13.0	12.1
Laurot	12.8	12.2	12.3	12.4
M 39-9/74	11.5	11.9	11.7	11.7
Rubin Tairovski	11.2	10.2	9.5	
Rubin Tairovski (blended)[3]			9.8	10.3
XIV-11-57	10.4	7.2	11.5	9.7
Chambourcin (std.)	14.3		13.4	13.9

[1] Where a variety is listed twice, it was either vinted by more than one wine maker in one year or produced in more than one style. Cayuga White, Chambourcin, and Vidal Blanc were used as standards of high-quality French American wines.
[2] The 2000 vintage wine was unsatisfactory, so it was not bottled.
[3] The small Rubin Tairovski yield wasn't sufficient to make wine and thus was blended with Chambourcin.
[4] Rating scale: 0-5 = poor or objectionable, 6-8 = acceptable, 9-11 = pleasant, 12-14 = good, 15-17 = excellent, 18-20 = extraordinary.
[5] Cumulative average: Average of all instances where a particular wine was evaluated; however, in several cases, values were not included in the average (i.e., where wine had spoiled following the first tasting or where there was a wine making problem).

2000 Wine Grape Cultivar Trial

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Introduction

There is increasing interest in growing grapes for wine production in Kentucky. Grapes have a potential for high income per acre on upland sites. Kentucky grape growers need varieties that are adapted to Kentucky's varied climates and are capable of sufficiently yielding high-quality grapes.

There are four types of wine grapes grown in the United States: American (*Vitis labrusca*), Muscadine (*Vitis rotundifolia*), European (*Vitis vinifera*), and American French hybrids (*Vitis labrusca x V. vinifera*). Generally, Muscadine and European grapes are not adapted to Kentucky's environment. On the other hand, American grapes grow well, but the wine is usually not to par with European wines. Many American French hybrids grow well, and wine quality is intermediate between that of the American and French parents. The majority of the wine from Europe and the West Coast of the United States is made from European grapes.

The objectives of this project are to evaluate wine grape cultivars grown in different regions of the United States and to establish a baseline of performance for comparison of other wine grape cultivars.

Material and Methods

Eight cultivars were planted in the spring of 2000 at the University of Kentucky Research and Education Center, Princeton, Kentucky. These included two American cultivars (Niagara and Norton), two American French hybrids (Chambourcin and Vidal Blanc), one recently released interspecific hybrid (Traminette), and three *vinifera* selections (Cabernet Franc, Pinot Noir, and Chardonnay). The planting was established in an area previously used for a high density apple planting. Consequently, rows were set at 12 ft. apart in order to use the end posts left from the previous apple planting. Vines were set at 8-ft. spacing within rows. Vines were trained to two leaders and tied to 5-ft. bamboo canes during the first year of growth. During the second year, vines were trained to a high bilateral cordon system. The planting was set up with trickle irrigation and a 4-ft.-wide herbicide strip beneath the vines with mowed sod alleyways.

During the spring of 2002, the *vinifera* cultivars were converted to the vertical shoot positioning system (VSP). This system typically conforms more appropriately to the vertical growth habit of *vinifera* cultivars. The trellis was changed to accommodate both training systems in the spring of 2003. The experimental design was a randomized block design with six replications.

The year 2003 was the first harvest year. Yield, cluster size (weight per cluster), berry size (weight per berry), Brix (percent soluble solids), and pH were the variables recorded for each wine grape cultivar. The harvested grapes were distributed to cooperating Kentucky wine makers. Later, the quality of the wine produced from these selections was evaluated in order to find a wine made from Kentucky-grown grapes.

Results and Discussion

Yield and fruit quality ratings for the 2003 harvest are listed in Table 1. These are preliminary data, as it will take several years to fully evaluate these selections for wine quality and vine adaptation to Kentucky's climates.

The leaves on all Norton vines became scorched in appearance in June 2003. Most leaves dropped completely from the vines, even though the vines were loaded with grapes. Consequently, all grapes were removed that month, and yield data were not included in this report.

Acknowledgments

The authors would like to express their appreciation for all the help that they received in this study from the Kentucky Vineyard Society members who cooperated in making and evaluating these wines.

Table 1. Yield and fruit quality measurements for the year 2003 from the 2000 wine grape cultivar trial at UKREC, Princeton, Kentucky.

Cultivar	Harvest Date	No. Vines	Pruning Weight per Vine (lb)	Yield (T/A)[1]	Cluster Weight (g)	Berry Weight (g)	Soluble Solids (%)	pH
Vidal Blanc	9-8	18	2.3	7.9	248	1.8	19.8	3.1
Cabernet Franc	9-10	16	4.3	7.0	235	1.9	20.0	3.4
Niagara	8-27	18	2.1	6.4	189	3.5	16.4	3.5
Chardonnay	9-8	18	2.4	5.7	234	1.5	21.1	3.3
Chambourcin	9-10	17	1.2	5.4	315	2.4	20.6	3.2
Traminette	8-26	15	2.5	4.7	156	1.8	20.4	3.1
Pinot Noir	8-19	16	3.4	3.0	116	1.2	19.6	3.3
Norton[2]	-	18	1.8	-	-	-	-	-
LSD 5%			0.8	2.3	47	0.22		

[1] Tons per acre. Vines are on 8 x 12-ft. spacing, equivalent to 454 vines per acre. Data are sorted by yield in decreasing order.
[2] Fruit from Norton was removed in June and discarded due to a defoliation problem with this cultivar.

Detection and Identification of *Xylella fastidiosa* Strains Causing Pierce's Disease of Grapes in Kentucky

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Introduction

Pierce's disease, caused by the bacterium *Xylella fastidiosa*, is a threat to grapes in California and in southern states from Florida to Texas. Disease symptoms vary with species and cultivar but are typified by browning of leaf margins and vine death due to the occlusion of xylem vessels by the pathogen. This disease is favored by the warm winters and long growing seasons of the southeastern United States. Pierce's disease was found for the first time in Kentucky two years ago (1,2) and last year, for the first time, in Southern Indiana (3).

Symptoms of Pierce's disease. Symptoms vary with the different host species and cultivars. Symptoms in spring and early summer include delayed shoot growth, leaf mottling, and dwarfing of new shoots. Late summer and fall symptoms are more dramatic and include burning, scorching, or drying of leaves; wilting or premature fruit color; and uneven cane maturity. Scorching begins near the leaf margin where tissues become completely desiccated and die. As summer progresses into fall, scorching progressively spreads inward in concentric zones until the entire leaf is affected. Leaves often fall from their petioles, leaving the petioles still attached to the shoot.

The disease progresses along the vine with symptoms developing in adjacent leaves along the shoot both above and below the initial infection point. Flower clusters on infected vines usually dry up. Late in the season, wood on affected canes fails to mature normally, leaving green "islands" of tissue, which persist into the dormant season and can be seen on canes throughout the winter. Shoot tips often die the first year the vine is infected. Initially, only one or a few canes on a vine show foliar and wood symptoms. Symptoms are more pronounced in vines that are stressed by high temperatures and drought.

Grape susceptibility and disease spread. Some grape cultivars are very susceptible, usually dying within two years. Most French (*vinifera*) varieties die within two to five years, while American (*labrusca*) varieties often live longer than five years. French-American hybrids are intermediate in susceptibility. Pierce's disease is spread by several types of sharpshooter leafhoppers, by spittlebugs, and by grafting.

Other hosts of *X. fastidiosa*. Trees, especially oaks, in Kentucky landscapes have suffered from bacterial leaf scorch disease for many years. It is also caused by *X. fastidiosa* but a different strain from the one that causes Pierce's disease. Leaf scorching symptoms associated with this disease annually appear in late summer. Symptoms are quite striking on pin and red oaks with individual leaves turning one-third to two-thirds brown on the leaf ends and margins. Leafhoppers or other xylem-feeding insects also vector the causal agent of bacterial leaf scorch. As far as is known, the grape pathogen is the same as, but not identical to, the tree leaf scorch pathogen. Thus, the disease would not be spread from trees to grapes. However, we have detected *X. fastidiosa* in wild grapes, but it is thought by some researchers to be the strain from oaks. Thus, there is a need to learn more about Pierce's disease and its relationship to other *Xylella* infections in Kentucky.

The objectives of this study were 1) to continue to survey Kentucky vineyards and the one in Southern Indiana for Pierce's disease; 2) to isolate *X. fastidiosa*, the causal agent, grow it in culture, and extract the DNA; and 3) to compare these DNA extracts with DNA *X. fastidiosa* isolates from other hosts, such as trees, with bacterial leaf scorch and Pierce's disease from other regions.

Materials and Methods

Grape leaves showing burning symptoms or dead areas were collected from vineyards statewide and in one Southern Indiana county and delivered to the UK Plant Disease Diagnostic Laboratory. Petioles from affected leaves were crushed with a sample extractor tool so that the extract could be tested for presence of the pathogen using an enzyme-linked immunosorbent assay (ELISA), developed for *X. fastidiosa* ("Pathoscreen-Xf," Agdia Inc., Elkhart, IN). Color reactions of the ELISA test were evaluated visually. A DNA extraction technique was developed so that a more sensitive assay could be used for detecting *X. fastidiosa* in grapes, trees, and leafhoppers. Bacterial DNA was analyzed using a polymerase chain reaction (PCR) method and a real-time rapid-cycling "Smart Cycler" machine.

Results and Discussion

Due to unusually cool and moist weather during the 2003 growing season, symptoms of bacterial leaf scorch and Pierce's disease appeared late in the year. Many vineyards were surveyed, and the few grape specimens suspected of being diseased were collected from several vineyards and assayed in the laboratory. No new Pierce's disease was found in Kentucky or Indiana in 2003.

Xylella fastidiosa was successfully grown in culture from grape and from mulberry. An infected grapevine and several infected cuttings are being grown in the greenhouse for inoculation studies. A reliable DNA extraction technique was developed for sensitive detection of the bacterium in leafhopper vectors of this disease and in host plant material. *X. fastidiosa* DNA was extracted from pin oak, maple, mulberry, and grape for further studies. Genomes for known strains of *X. fastidiosa* were analyzed, and regions were identified for sequencing analysis. Primers are being obtained so that PCR reactions using the primer sets can be optimized. Products of these PCR reactions can be compared with the DNA sequencing analyses of the Kentucky grape and tree strains. This PCR test should tell whether or not the grape strains of *X. fastidiosa* found here are the same or different from *X. fastidiosa* in landscape trees in the region and in grapes from other regions.

This disease can devastate grape production, and much more Kentucky research is needed. With an emerging grape industry in Kentucky, it is important that growers and county Extension agents be looking for this disease. UK Plant Disease Diagnostic Laboratory personnel can run the specialized tests needed to determine the presence of the Pierce's disease bacterium. Where the disease is isolated, removal of infected vines should minimize further spread.

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Highbush Blueberry Cultivar Trial in Western Kentucky

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Introduction

Blueberries are native to North America. They have recently been touted for their health benefits because of high levels of antioxidants. Highbush blueberries have been a good supplemental crop for Kentucky growers who want to use land not suitable for tillage. Kentucky has a small acreage of commercial blueberry production. This study was initiated in order to evaluate highbush blueberry varieties for adaptability to Kentucky soils and climatic conditions. This report updates earlier results, presented in previous issues of the *Fruit and Vegetable Research Report* (1).

Materials and Methods

This trial was established in the spring of 1993 at the UK College of Agriculture Research and Education Center, in Princeton, Kentucky. It consists of eight cultivars spaced 4 ft. apart within rows spaced 14 ft. apart. There are three bushes of each cultivar per replication. Prior to planting, the pH was reduced from above 6.0 to 5.4 with elemental sulfur. The planting is mulched yearly with sawdust and trickle-irrigated with 1 gallon/hr vortex emitters when necessary. The planting is netted during the last week of May, and fruit is harvested from the first week of June through the first week of July.

Cumulative yield from 1995 through 2003, the 2003 yield, and average percent ripe fruit by the end of the second week of June, for 2003, are shown in Table 1. Sierra, Nelson, and Duke have yielded the most to date. Between one-fourth and one-third of the fruit was ripe by the end of the second week of June in 2003 for all varieties except Nelson and Toro. These are the last to ripen and were only 2% and 19% ripe by the second week of June, respectively. Fruit harvest is generally finished for most cultivars by the end of June, except for Nelson, which is typically picked through the first week of July.

Table 1. Yield parameters of the highbush blueberry cultivar trial established in 1993 at UKREC, Princeton, Kentucky.

Cultivar[1]	Cumulative Yield 1995-2003 (lb/bush)	Yield in 2003		Percent Fruit Harvested by End of 2nd Week of June
		lb/bush	T/A[2]	
Sierra	78.5	17.6	6.8	30
Nelson	76.3	17.0	6.6	2
Duke	75.7	15.8	6.1	26
Toro	75.7	18.3	7.1	19
Bluecrop	74.8	18.3	7.1	27
BlueGold	73.0	22.5	6.8	30
Sunrise	52.6	15.8	6.1	27
Patriot	50.1	15.9	6.2	26
LSD (5%)	--	6.2	2.4	8

[1] In descending order of cumulative yield (1995-2003).
[2] Planting was established in April 1993. Plant spacing is 4 ft. between bushes in rows 14 ft. apart. There are three bushes per cultivar-rep combination. This is equivalent to 777 plants/A.

These findings can help growers who need to choose between the highest yielding blueberry cultivars and ones which, during their peak harvest time, do not conflict with harvesting and/or managing other crops.

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Blueberry Cultivar Trial—Eastern Kentucky

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Introduction

Although blueberries (*Vaccinium* spp.) are native fruits, Kentucky has limited commercial acreage. Blueberries have an excellent potential for local sales and U-pick operations. Recent research into the health benefits of small fruits, including blueberries, may help increase sales. Pharmaceutical companies are conducting more research on *Vaccinium*. Scientists attribute the blueberry's healing powers to the flavonoid anthocyanin, which is responsible for the blue color, found only in the peel. Anthocyanins and other flavonoids could help limit cancer development, cardiovascular disease, and glaucoma and poor night vision. As consumers become more food-conscious, they may eat more blueberries.

The high start-up cost for blueberries, approximately $4,000/A, is mainly due to land preparation, plant, and labor costs. However, after the plants reach maturity in approximately five years, the profits should steadily increase to as high as $6,000/A per year. The longevity of a properly managed blueberry field is similar to that of a well-managed apple orchard. Blueberries require acidic soils with a pH of 4.5 to 5.2, with good drainage and high organic matter. It is best to plant more than one cultivar to ensure good pollination and a continuous harvest. Harvest usually begins in early June and lasts well into July.

Materials and Methods

Two blueberry plantings were established in the fall of 1996 at the University of Kentucky Robinson Station in Quicksand and the Laurel Fork Demonstration Site. Cultivar growth, yield, and survival were compared between a normal silt loam site and a disturbed mine site. The plantings consisted of eight to 12 rows of various cultivars in a randomized block design. Plants were 4 ft. apart in raised beds 14 ft. apart. Drip irrigation with point source emitters (2 gph/plant) was installed shortly after planting. Plants were fertilized beginning in the spring of 1997. In 2003 one application of 5-20-20 (5 lb/100 ft. of row) was followed by one sidedressing of 5 lb ammonium sulfate/50 ft. of row at bloom and 5 lb of urea/row two weeks later). Netting was used at both sites to prevent loss due to birds.

Results

Twenty-one cultivars at Quicksand and 18 at Laurel Fork were tested, and results are shown in Tables 1 and 2, respectively. This year there were no late freezes, but Quicksand experienced heavy rain throughout the bloom period and much of the growing season. In general, berry size was larger than in past years. The early blooming and maturing cultivar Duke did better than previously but still suffered some cane dieback during the growing season. At Quicksand, Jersey, Toro, and Sierra suffered some plant loss due to Phytophthora root rot.

For the third year in a row, the blueberry plants at Laurel Fork out-yielded those at Quicksand. This is in contrast to the first harvest season when Quicksand was the more productive site. The Laurel Fork reclamation site is about 500 ft. higher in elevation than Quicksand and has much better air drainage. Moreover, based on time of apple tree bloom, plant development at Laurel Fork is about seven to 10 days behind that at Quicksand. However, the reason that the Laurel Fork blueberry site has out-yielded the Quicksand site is probably more complex than just an elevation difference. The pH at Laurel Fork has stayed lower than that at Quicksand, and the plants there have never shown iron chlorosis symptoms like those seen at Quicksand. Sawdust mulch has been used at Quicksand, while bark chips are used at Laurel Fork. The calcium present in the sawdust mulch may be causing some of the pH problems. The blueberries at Quicksand are irrigated from the Kentucky River, and there are some Phytophthora problems now there that are not at Laurel Fork. The mine site soil has very low residual nitrogen levels and should receive additional nitrogen for optimum yields. We plan to provide additional nitrogen through the irrigation system in 2004.

Table 1. Yield, average berry size, bush size, fruit quality ratings, and earliness of blueberry cultivars, Quicksand, Kentucky, 2003.

Cultivar[1]	Fruit Yield (lb/bush)[2]	Berry Size (oz)[3]	Berry Size Rating[3]	Taste[4]	Appearance[5]	First Harvest Date	% Harvested[6] (first two harvests)
Sampson (NC2675*)	6.4 A	0.07 A	L	S	A+	6/10/03	69.7
Brigitta	6.2 A	0.06 BCDE	L	S	A+	6/17/03	45.1
Bluegold	6.2 A	0.06 DE	L	S	A	6/10/03	49.9
Bluejay	4.5 A	0.06 DE	M	S	A	6/05/03	69.5
NC1827*	4.3 A	0.03 G	S	ST	A+	6/24/03	33.8
Blueray	4.1 A	0.06 BCDE	L	S	A	6/10/03	58.4
Jersey	3.7 A	0.04 F	M	ST	A	6/12/03	48.7
Bluecrop	3.4 A	0.06 DE	ML	ST	A+	6/12/03	57.9
Reka	3.5 A	0.04 F	M	S	A	6/05/03	70.8
Duke	3.3 A	0.06 CDE	L	B	A+	6/05/03	81.5
NC1832*	3.3 A	0.03 FG	M	ST	A	6/24/03	33.2
Nelson	3.3 A	0.07 ABCD	ML	ST	A+	6/12/03	49.9
Patriot	3.2 A	0.05 E	ML	ST	A	6/05/03	69.5
Ozarkblue	3.1 A	0.07 A	L	S	A+	6/17/03	33.3
Ornablue	3.09 A	0.03 G	S	B	A	6/10/03	63.3
Sierra	2.98 A	0.06 E	L	ST	A	6/10/03	56.6
O'Neal*	2.31 A	0.06 DE	M	S	A	6/05/03	82.2
NC1852*	2.2 A	0.03 FG	M	S	A	6/17/03	53.7
Toro	2.1 A	0.07 A	L	S	A	6/05/03	62.2
NC2852*	1.9 A	0.03 FG	S	S	A	6/17/03	50.8
Spartan	1.1 A	0.07 ABC	L	B	A	6/10/03	70.6
MSD[7]	**5.3**	**0.0096**					

* These cultivars are one year younger than the other cultivars in the trial. Some cultivars were furnished by Hartman's Plant Company, P.O. Box 100, Lacota, MI 49063. Other cultivars were purchased from Fall Creek Farm & Nursery Inc., 39318 Jasper-Lowell Rd., Lowell, OR 97452.

[1] In descending order of yield.

[2] Means within a group followed by the same letter are not significantly different, LSD (P = 0.05).

[3] Size rated visually. S = small, M = medium, L = large, VL = very large.

[4] S = sweet, T = tart, B = bland.

[5] A- = below average, A = average, A+ = above average.

[6] Harvest dates 6/05, 6/10, 6/17, 6/24, 6/30, 7/09, 7/15; a 40-day harvest season.

[7] Minimum significant difference (P = 0.05).

Table 2. Yield, average berry size, bush size, fruit quality ratings, and earliness of blueberry cultivars, Laurel Fork, Kentucky, 2003.

Cultivar[1]	Fruit Yield (lb/bush)[2]	Berry Size (oz)[2]	Berry Size Rating[3]	Taste[4]	Appearance[5]	Date of First Harvest	% Harvested[6] (first two harvests)
Toro	9.8 A	0.08 A	L	S	A+	6/09/03	69.1
Reka	9.3 A	0.05 GF	M	S	A	6/09/03	80.5
Bluegold	8.3 AB	0.06 CDE	L	S	A	6/09/03	69.3
Bluecrop	8.0 ABC	0.08 AB	L	S	A+	6/09/03	75.8
Brigitta	8.0 ABCD	0.07 AB	L	S	A+	6/16/03	53.3
Patriot	7.3 ABCD	0.05 EF	M	SB	A	6/09/03	79.5
Nelson	7.2 ABCD	0.07 ABC	ML	S	A+	6/09/03	65.8
Sierra	7.1 ABCD	0.07 ABC	L	ST	A	6/09/03	70.4
Bluejay	5.8 BCDE	0.05 EFG	M	S	A	6/09/03	79.2
Duke	5.3 CDE	0.07 BCD	M	S	A	6/09/03	91.1
Blueray	5.3 CDE	0.08 A	L	S	A+	6/09/03	68
Ornablue	5.2 DE	0.04 GH	S	B	A	6/09/03	78.5
O'Neal*	3.5 EF	0.06 BCD	M	S	A	6/9/03	84
Sampson (NC2675*)	3.7 EF	0.07 BCD	L	S	A+	6/11/03	72.6
NC2852*	3.2 EFG	0.05 FG	M	SB	A	6/11/03	72.6
NC1827*	1.6 FG	0.03 H	S	S	A	6/19/03	56.7
NC1832*	1.6 FG	0.03 H	SM	ST	A	6/19/03	54.6
NC1852*	0.64 G	0.06	M	S	A	6/11/03	90.5
MSD[2]	**2.8**	**0.012**					

* These cultivars are one year younger than the other cultivars in the trial. Some cultivars were furnished by Hartman's Plant Company, P.O. Box 100, Lacota, MI 49063. Other cultivars were purchased from Fall Creek Farm & Nursery Inc., 39318 Jasper-Lowell Rd., Lowell, OR 97452.
[1] In descending order of yield.
[2] Means within a group followed by the same letter are not significantly different, LSD (P = 0.05).
[3] Size rated visually. S = small, M = medium, L = large, VL = very large.
[4] S = sweet, T = tart, B = bland.
[5] A- = below average, A = average, A+ = above average.
[6] Harvest dates 6/09, 6/16, 6/23, 6/30, 7/01, 7/08, 7/14; a 35-day harvest season.
[7] Minimum significant difference (P = 0.05).

At Quicksand, none of the cultivars produced a significantly higher yield than the others. This was due to variability in plant growth between replications in the plot. NC2675 (recently named Sampson) was the highest yielding cultivar. Others that yielded well were Brigitta, Bluegold, Bluejay, and NC1827. The two North Carolina cultivars, NC1832 and NC1827, have small to medium berries with a pleasant but distinctive taste. NC1832 tends to flower heavily and set fruit in the fall. Plants of all five North Carolina selections grew rapidly this summer and are much larger than the named highbush cultivars planted earlier. They did not show the iron chlorosis that occurred in many of the other cultivars. Sawdust mulch, with its high calcium content, may have contributed to some of the irregular growth in the plot. Late maturing Kentucky blueberries will require protective sprays to prevent Japanese beetle damage.

At Laurel Fork, Toro was the highest yielding cultivar, followed by Reka, Bluegold, Nelson, Bluecrop, Brigitta, Patriot, Nelson, and Sierra (Table 3). Toro, Brigitta, Sierra, Bluecrop, and Nelson produced the largest berries. At Quicksand, Sampson (NC2675), Nelson, Ozarkblue, Toro, and Spartan had the largest berries. The most attractive blueberries at Quicksand were Brigitta, NC1827, Bluecrop, Duke, Nelson, Ozarkblue, and Sampson. At Laurel Fork, Bluecrop, Toro, Brigitta, Nelson, Blueray, and Sampson were judged to be the most attractive. These results represent the fourth harvest of these cultivars after 5½ to 6½ years growth. Additional harvests and observations will determine which cultivars perform best over time in Kentucky.

Evaluation of Thornless Semi-Erect and Erect Blackberry Varieties and Training Systems for Kentucky, 2003

John Strang, April Satanek, John Snyder, Chris Smigell, Phillip Bush, and Darrell Slone, Department of Horticulture

Introduction

Blackberries continue to be popular with 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 Horticultural Research Farm in Lexington, Kentucky. One portion of the study has been designed to evaluate two cane training systems using a double-T four wire trellis for three thornless, semi-erect blackberry varieties. The second portion of the study is to evaluate 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 in spring 2000 into black plastic-mulched beds. Each plot consisted of three plants of either Hull Thornless, Triple Crown, or Chester spaced 8 ft. apart in the row with 12 ft. 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 ft. apart and the top two wires 4 ft. apart. Two training systems were used, a conventional system and the Oregon system. One plant of the three in each plot was harvested for yield.

In the conventional system, primocanes were tipped when they had extended 1 ft. 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 to 18 in. in length, and those that were within 18 in. 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 in. 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 ft. 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 variety of which two plants were harvested for yield. Metal fence posts were set every 9 ft., and plastic bailer twine was run on both sides of the supported treatment at a height of 3.5 ft.

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 fruiting canes were pruned severely to encourage development of more vigorous shoots for the following season. During the summers (2001-2003), primocanes were tipped at a height of about 3 ft. Spindly canes and those with red-necked cane borer swellings were removed in the spring. Laterals were cut back to 16 to 18 in. in length.

Plants were fertilized in February 2003 with calcium nitrate at the rate of 8 lb/100-ft. row (45 lb N/A). Irrigation was not needed in 2003. Weeds were controlled with a preemergent application of Devrinol, spot treatment with Roundup, and by hand weeding. Nova was used for disease control. Japanese and green June beetles were controlled with malathion. Bird pressure was severe early in 2002 and 2003, and an avian alarm was used.

Plants were harvested in 2001, 2002, and 2003. Data were collected for yield, fruit size, and fruit soluble solids. The 2002 season was hot and dry, while the 2003 season was cool and wet. Data are shown for the 2003 season.

Results and Discussion

In 2003 Chester and Hull Thornless semi-erect blackberries significantly out-yielded the Triple Crown variety (Table 1), while in 2002, there was no difference in yield between these varieties. Triple Crown produced the largest berries in both years, and these had a higher sugar content than those of Chester, which had a higher sugar content than Hull Thornless berries. There was no difference in the yield or berry soluble solids between the conventional and Oregon training systems (Table 2) as was also found in 2002, but berry size was slightly larger with conventional training. More detailed data analysis (data not shown) shows that the increase in berry size with the conventional system was primarily due to an increase in Hull Thornless berry size. Yields increased substantially for Chester and Hull Thornless in 2003, compared to 2002.

Table 1. Thornless semi-erect blackberry variety yield, average berry weight, and soluble solids, 2003 harvest.

Variety	Yield[1] (lb/A)	Avg. Berry Wt.[1] (g)	Soluble Solids[1] (%)
Chester	24,905 a	6.1 b	9.2 b
Hull Thornless	21,941 a	6.2 b	7.7 c
Triple Crown	11,082 b	7.8 a	10.7 a

[1] Means within a column followed by the same letter are not significantly different (Duncan Waller LSD P = 0.05).

Table 2. Thornless semi-erect blackberry yield, average berry weight, and soluble solids based on training system, 2003 harvest.

Training System	Yield[1] (lb/A)	Avg. Berry Wt.[1] (g)	Soluble Solids[1] (%)
Conventional	16,835 a	6.6 a	9.3 a
Oregon system	21,784 a	6.2 b	9.2 a

[1] Means within a column followed by the same letter are not significantly different (Duncan Waller LSD P = 0.05).

The Apache thornless erect variety far out-yielded the Arapaho variety in 2003 (Table 3). It also produced considerably larger berries with higher soluble solids contents than Arapaho. These results are quite different from those of 2002, when there was no difference in yield, berry weight, or soluble solids content between Apache and Arapaho. In 2000, the statistical analysis was affected by the discovery that several of the Apache and Arapaho plants had been mixed up at planting, and some data were unusable. Berry weight for Apache thornless erect berries averaged 8.1 grams, while that of Triple Crown, the largest of the semi-erect berries, averaged 7.8 grams.

There were no significant differences in yield, average berry weight, or soluble solids between the no-trellis and string-trellis treatments for the erect thornless varieties (Table 4). However, there was a trend toward a higher yield for the string-trellis treatment. These data are still confounded by the mix-up at planting of the Apache and Arapaho plants, and we hope that the trends will show a significant difference in the 2004 yields. As in 2002, Apache had the more attractive fruit of the two varieties. The first, mid- and last harvest dates in 2003 for all the varieties can be found in Table 5.

Table 3. Thornless erect blackberry variety yield, average berry weight, and soluble solids, 2003 harvest.

Variety	Yield[1] (lb/A)	Avg. Berry Wt.[1] (g)	Soluble Solids[1] (%)
Apache	7,851 a	8.1 a	9.8 a
Arapaho	1,248 b	3.3 b	9.3 b

[1] Means within a column followed by the same letter are not significantly different (Duncan Waller LSD P = 0.05).

Table 4. Thornless erect blackberry yield, average berry weight, and soluble solids based on training system, 2003 harvest.

Training System	Yield[1] (lb/a)	Avg. Berry Wt.[1] (g)	Soluble Solids[1] (%)
No trellis	3,071 a	6.6 a	9.5 a
String trellis	6,028 a	7.8 a	9.8 a

[1] Means within a column followed by the same letter are not significantly different (Duncan Waller LSD P = 0.05).

Table 5. Harvest date data, 2003 harvest.

Variety	First Harvest	Mid-Point[1]	Last Harvest
Arapaho	June 26	July 8	Aug. 14
Apache	July 8	July 26	Aug. 14
Triple Crown	July 1	July 25	Sept. 4
Hull Thornless	July 1	July 28	Sept. 4
Chester	July 8	Aug 7	Sept. 9

[1] Date on which half of the berries were harvested, based on berry weight.

Acknowledgments

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2002 and 2003 Blackberry Cultivar Trial

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Introduction

Blackberry (*Rubus* spp.), a native plant, grows well in Kentucky. Improved blackberry cultivars offer a high-value crop for Kentucky agricultural producers looking to diversify production. Blackberries have lower establishment and labor costs than many horticultural enterprises. This experiment was begun to evaluate the performance of newer blackberry cultivars in Western Kentucky's climate.

Materials and Methods

In the spring of 2000, a blackberry cultivar trial was established at the University of Kentucky Research and Education Center, Princeton, Kentucky. The experimental design consisted of five cultivars (Apache, Arapaho, Chickasaw, Kiowa, and Navaho) and five replications arranged in a randomized complete block design. Five rows or replications, each consisting of five cultivars per row, were spaced 14 ft. apart. Rows were 70 ft. long with 10 ft. for each cultivar and a 5-ft. grass buffer areas between cultivars. Six plants were spaced 2 ft. apart within each plot. Plants looked fine throughout the 2000 season. In the spring of 2001, all Navaho plants started to develop symptoms of Tobacco Ring Spot Virus. These plants were removed during the fall of 2001 after laboratory confirmation of the virus infection. Chickasaw plants developed systems of Impatiens Necrotic Spot Virus in 2002 and were removed that fall, after harvest.

Plots were harvested from 18 June through 1 August in 2002, and from 26 June through 4 August in 2003. Harvesting was every two to six days, depending on berry ripeness. Yield and berry weight (weight of 50 berries per plot) measurements were collected at each harvest, and the total yield and average berry weight calculated (Table 1).

All cultivars ripened about two weeks earlier in 2003 than in 2002. In addition, yields in 2003 were at least half those observed in 2002. In general, the plants were healthy and grew well. We attribute this significant drop in yields to excessive fall pruning of canes infested with the red-necked cane borer.

Arapaho continues to be an early-ripening variety but has yielded the least in both years. Conversely, Apache was the last to ripen but yielded the most fruit in both years. Kiowa and Chickasaw were intermediate between Apache and Arapaho in yield and ripening date in 2002, and Kiowa was intermediate in yield in 2003. Arapaho had the smallest berry weight in both years. Among the other varieties, berry weight was not statistically different.

Table 1. Yield parameters of the blackberry cultivar trial established in 2000 at UKREC, Princeton, Kentucky.

	Yield (lb/A)		Berry Size (grams/berry)		Harvest Periods	
Cultivar*	**2002**	**2003**	**2002**	**2003**	**2002**	**2003**
Apache	9,801	3,525	7.6	7.0	6/27-8/1	7/9-8/4
Kiowa	7,499	3,194	8.7	6.7	6/18-8/1	6/26-8/4
Chickasaw	6,192	NA	7.0	NA	6/18-7/26	NA
Arapaho	3,454	807	3.5	2.6	6/18-7/12	6/26-8/4
LSD (5%)	2,987	1,130	0.9	1.6	NA	NA

* Cultivars listed in descending order by yield in 2003.

Blackberry Cultivar Evaluation

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Introduction

Blackberry (*Rubus* spp.), a native plant, grows well in Kentucky. Improved blackberry cultivars offer a high-value crop for Kentucky agricultural producers looking to diversify production. Blackberries can be used for fresh or processed consumption, wine production, and medicinal purposes. Blackberries have lower establishment and labor costs than many horticultural enterprises. It is also important to note that blackberries may be grown on hilly land and strip-mine sites and have a low erosion potential when grown in sod strips. Blackberries can be grown on a large scale and mechanically harvested, or they may be grown on a small scale and hand-harvested.

Materials and Methods

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

Results

Many thorny and thornless blackberry cultivars tend to deharden and break dormancy early in Quicksand, where 10° to 20°F in March and April may follow 60° to 70°F in January and February. This weather pattern occurs at least once every four to 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 well under our growing conditions because they are slow to break bud and remain dormant later into the spring. Even so, their floricanes can be winter-injured. Table 1 shows the bloom development and floricane injury for both years. Floricanes showing winter injury tend to die during warm weather prior to harvest, reducing yield and berry quality (Table 2). Sometimes the entire plant dies by the end of summer.

Table 1. Results of two-year blackberry bloom and floricane evaluation, Quicksand, Kentucky.

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

[1] Selections preceded by an "A" are unreleased breeding selections and are not for sale at the time of this reporting.
[2] Number of reps out of five showing winter injury.

Table 2. 2003 blackberry cultivar plant survival rating, Quicksand, Kentucky.

Cultivar[1,2]	Date Rated	Plant[3] No./Year '00	'01	'03	Avg. No. Flori-Canes[4]	Avg. % Floricane Injury[5]	Avg. No. Primo-canes[6]	Disease Rating[7]	Comments
A1963 T	7/28	6	5.8	5.6	18.0	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 plts
A1857 T	7/28	6	6.0	5.0	10.6	90	8.8	-	3 reps dying
A1854	7/28	6	5.0	3.2	-	-	-	-	5 reps dying
A1960 T	7/28	6	6.0	3.6	6.4	92	5.8	-	5 reps dying
A1689 T	7/28	4	2.4	4	5.2	74	12.0	-	2 reps dying plts
Ouachita (A1905 T)	7/28	6	5.2	4.8	14.2	88	11.6	-	4 reps good regrowth
Navaho	7/28	4	4.0	2.4	5.2	57	4.6	-	5 reps dying out
Kiowa	7/28	6	4.6	5	10.0	90	7.6	DB	3 reps dying out
Shawnee	7/28	6	5.6	5.8	11.4	92	13.0	DB	good regrowth
Triple Crown	7/28	3	3.0	3.6	7.2	1	9.4	0	5 reps healthy

[1] Selections preceded by an "A" are unreleased breeding selections and are not for sale at the time of this reporting.
[2] T = thornless cultivar.
[3] Number of live plants/rep.
[4] Numbers of floricanes present.
[5] % injury or death to floricanes: 0 = no injury,1 = 10-20% death, 5 = 80-100 death.
[6] Primocanes per rep.
[7] Presence of disease: DB = Double Blossom; 0 = no disease, "-" = unknown disease.

The 12 cultivars being tested at Quicksand were evaluated three years after planting for plant survival (Table 3). A grower who invests $2,700 to $3,300 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 some of the cultivars with poor stands.

Yield and berry weight of the three thorny cultivars tested are shown in Tables 5 and 6. Kiowa yielded the highest on average (5,675 lb/A) and had the least visible cane injury. Unfortunately, Kiowa is very susceptible to the double blossom fungal disease. In a warm, humid climate, it would be hard to raise Kiowa without a good fungicide spray program. Kiowa also tends to lie down, hindering picking and mowing. The selection A1854 had a tremendous fruit set in 2002, but the injured floricanes in all five reps slowly died back or lost vigor, resulting in a smaller and fewer berries. The plants did not recover and have died out (Table 3). 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.

Table 3. Blackberry cultivar plant survivals two years after planting, Quicksand, Kentucky.

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	120

[1] Selections preceded by an "A" are unreleased breeding selections and are not for sale at the time of this reporting.
[2] Plant survival is based on number of live plants in five replications on 7/28/03. Some cultivars continued to have plants die into the fall (Navaho, 1 rep of Ouachita).

The highest yielding thornless blackberry (Tables 5 and 6) was Triple Crown (8,102 lb/A) followed by A1689 with a two-year average of 5,173 lb/A, and Ouachita (A1905) with a 4,919 lb/A average. The cultivars A1857, Navaho, and A2049 suffered severe floricane injury and plant death. In 2003 the Navaho fruit were too small and dried to sell. The Navaho plants did not produce new canes and died out in the fall of 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 in the past two years (Tables 5 and 6). Additional tests are needed to determine the long-term suitability of cultivars to our soil and climate 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, Kentucky.

Cultivar/ Selection[1]	Harv. Start[2]	Harv. Days[3]	Lb Fruit/A	Fruit Wt. (oz)	Taste[4]	Appearance[5]	% SS[6]	Disease Rating[7]	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					

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

Table 5. 2002 thornless blackberry cultivar evaluation, Quicksand, Kentucky.

Cultivar/ Selection[1]	Harv. Start[2]	Harv. Days[3]	Lb Fruit/A	Fruit Wt. (oz)	Taste[4]	Appearance[5]	% SS[6]	Disease Rating[7]	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					

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

Table 6. 2003 blackberry cultivar evaluation, Quicksand, Kentucky.

Cultivar/ Selection[1]	Harv. Start[2]	Harv. Days[3]	Lb Fruit/A	Fruit Size (oz)	Taste[4]	Appearance[5]
A1963	6/18	33	2843	0.175	S	A
A1539	6/18	37	6178	0.189	S	A
A2049	6/18	22	703	0.19	ST	A-
A1857	6/18	22	4945	0.159	ST	A
A1854	6/18	22	3908	0.122	ST	A
A1960	6/18	37	2242	0.151	ST	A
A1689	6/18	37	5552	0.212	S	A
Ouachita (A1905)	6/18	37	6366	0.173	ST	A
Navaho	6/18	37	1577	0.087	ST	A
Kiowa	6/18	37	4165	0.312	ST	A+
Shawnee	6/18	37	7123	0.118	ST	A+
Triple Crown	7/10	45	8581	0.122	S	A+

[1] Selections preceded by an "A" are unreleased breeding selections and are not for sale at the time of this reporting.
[2] The first day of harvest for that cultivar.
[3] The number of days between first and last harvest for each cultivar.
[4] Taste of fresh fruit: T = tart, S = sweet, B = bland.
[5] Appearance: A- = below average, A = average, A+ = above average.

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 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 patches. 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 shoots are stunted or misshapen and pale green to yellowish. The leaf edges may have a bronze color. The undersides of leaves of these infected shoots bear tiny orange pustules, visible with a hand lens. In a few weeks, the undersides 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 is caused by the fungus *Cercosporella rubi*. It mainly affects blackberries and only rarely red 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 nearby wild blackberries. 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

Extension personnel surveyed selected and representative commercial blackberry plantings and wild brambles statewide, as opportunities occurred, on field visits 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 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 reports of the diseases were recorded.

Results and Discussion

During the past 20 years blackberry orange rust has been observed in 30 Kentucky counties (Table 1). The disease appears to be distributed throughout the state wherever blackberries are grown. Western, central, and eastern regions of Kentucky are equally represented in the survey. The survey this year doubled the number of counties reporting orange rust compared to grower and county Extension 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). However, it appears that 11 to 20 years ago the disease was

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

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

* Previously reported in this county.

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 in this county.

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.

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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2003 Berry Packaging and Consumer Evaluations

Matt Ernst and Tim Woods, Department of Agricultural Economics

Introduction

Packaging is a vital part of effectively marketing small fruit directly to consumers. Proper packaging can be a significant variable cost. Kentucky small fruit producers have encountered challenges in 1) accessing various types of packaging, 2) identifying packaging that satisfies consumers, and 3) adding value to small fruit sales.

Using blueberries as the focus crop, survey and case studies were conducted for different berry packaging and marketing options in 2003. Package size and material type were expected to vary in appeal within different market channels. A determination of feasible package types and a preliminary evaluation of returns observed by package type in different markets helps producers better plan their packaging purchases. Several new containers specifically targeted toward pick-your-own (PYO) patrons and high-end retail customers are available. Demand for these containers was also evaluated.

This report summarizes what was determined about common small packaging options from berry consumers and producers. The University of Kentucky's New Crop Opportunities Center as well as a 2003 Southern Region SARE On-Farm Research Grant, "Kentucky Blueberry Market Development," provided funding for this study.

Methodology

Several Kentucky producers marketing berries at on-farm stands, PYO, direct-to-local grocery, and farmers' markets were given a variety of berry containers during 2003. These included fiber pulp, paperboard, plastic clamshell, bulk-corrugated, and wooden hallock band containers. One-pint containers were evaluated for all materials. The paperboard, clamshell, and wooden hallock band containers were also evaluated in half-pints. One-quart fiber pulp, paperboard, and clamshell containers were also evaluated. Bulk containers (2.5-lb clamshells, 5- and 10-lb corrugated) were also evaluated.

PYO operations. Pick Your Own markets were also given carriers for quart and pint containers. Customers were asked to field test this equipment and to tell the proprietors what they observed.

Prices of blueberries in bulk packaging (5- and 10-pound corrugated cardboard containers) were evaluated against 12-pint blueberry flats at the Fairview Produce Auction.

Producers were asked a series of evaluation questions after harvesting and packing berries into various containers. In addition, customers at the farmers' market and on-farm markets completed a questionnaire that included questions about container preferences. On-farm customers were formally and informally surveyed about their PYO harvest equipment options.

Results and Discussion

Containers

Fiber pulp containers. Green and blue fiber pulp containers have been a standby for small fruit growers. Along with plastic mesh baskets, they are usually the cheapest containers. Customers are used to purchasing berries in them. Most fiber pulp containers are recyclable with other paper products, and berry customers surveyed in all Kentucky markets continue to rate recyclable containers as being important or very important (Table 1).

Producers were familiar with fiber pulp containers. Producers noted that these containers are easy to pick into and held adequate amounts of blueberries. Fiber pulp containers are also

Table 1. Importance of recyclable containers to blueberry consumers.

Whether Berry Containers Are Recyclable	Lexington Farmers' Market	Central Ky. On-Farm Market	Metcalfe County Grocery
Not important	15%	12%	33%
Important	31%	37%	33%
Very important	54%	51%	34%
No. of respondents	**102**	**51**	**27**

especially suited for brambles because the fiber pulp absorbs juices. However, the containers will disintegrate in high-moisture harvest or packing conditions (e.g., rain). Fiber pulp containers also store well in coolers when storage is required.

Paperboard/chipboard containers. Few Kentucky producers had tried packing berries in white/brown paperboard containers before 2003. These are slightly more expensive per unit than fiber pulp and plastic baskets. However, they were observed to be very attractive to customers. Paperboard containers are less expensive than many plastic clamshell containers of similar size.

Producers observed that, on a weight basis, the paperboard containers held more than the same sizes of fiber pulp containers. One disadvantage of the paperboard/chipboard containers is that they do not absorb bramble juices. Fruit also tended to "settle" if refrigerated overnight in the paperboard containers.

Customers surveyed at on-farm markets rated paperboard containers as their favorite; anecdotal evidence from farmers' market customers reinforced this preference.

Plastic clamshells. Plastic clamshells are the berry industry standard. Clamshells have advantages over baskets. Clamshells are a one-piece container with a lid and can be easily stacked. They are also waterproof. They are preferred by produce retailers as the industry standard. The plastic clamshells used in this trial were all manufactured from No. 1 PETE plastic, the same material used to make soft drink bottles. Some clamshells, however, are manufactured out of plastics not so widely recycled. Producers should note that the ability to recycle containers appears to be important to many customers.

A disadvantage with plastic clamshells comes at the farm market level. Consumers tend to associate plastic containers with "grocery store" berries. One successful way around this problem was to use clamshells with detachable lids. Berries were displayed in a clamshell container without a lid, then it was put on after the customer bought the berries. Some customers commented that they liked being able to see through the package to determine berry quality.

Plastic clamshells require a pad in the bottom to absorb bramble juices, adding an additional packaging cost of about one cent per container. Clamshells with lids, though easily stackable, are much more difficult to pick berries directly into.

Wooden baskets. Wooden containers are frequently used at farmers' markets and on-farm retail stands as a display container targeted at high-end customers. One-pint and 1-quart wooden berry baskets frequently cost more than other container types. Many producers thus prefer to use wooden containers solely for displaying produce.

Two kinds of wooden containers new to Kentucky were evaluated in 2003. These were a ½-pt wooden hallock band container and a 3-pt (1/8-peck) wooden basket with a handle. They cost $0.10 per ½-pt and $2.00 per basket.

The ½-pt wooden container was simply too small for most berry customers. One farmers' market vendor did sell some black raspberries in these, as well as some shell-out peas. Customers commented favorably on the appearance of these containers.

The purpose of testing the 3-pt wooden basket with a handle was to see if it would increase the volume of berries purchased at a farm market or farmers' market. Only one of more than 100 blueberry buyers surveyed at the Lexington Farmers' Market bought more than 2 pints of berries in a single trip. A 3-pt basket costs about $1.70 greater than three berry baskets. If the producer's margin were greater per pint than this cost, investing in these baskets would be worthwhile. Customers at the farmers' market and on-farm market where these baskets were tested really liked these containers and appeared willing to pay extra for berries purchased in them.

It is critical when marketing berries in larger containers that customers understand what they can do with 3 pints of berries. Simply tying a pie recipe requiring 3 pints of berries onto a 3-pt basket can make the customer purchase one more pint than they normally would. This is a recommended strategy for farmers' market and on-farm vendors using containers larger than a quart.

Corrugated boxes. Blueberries can be packaged in 5- and 10-lb corrugated boxes without sacrificing fruit quality. They are ideal for bulk sales. They require less time to pack and are less expensive than pint or quart containers.

Bulk blueberry boxes were tested at the Fairview Produce Auction in Western Kentucky in 2003. At first, buyers were unfamiliar with these packages, but some sold throughout the season. These containers are an ideal and cost-effective package for larger blueberry orders and are strongly recommended for wholesale and bulk marketing.

Harvest Equipment

Pick Your Own (PYO). PYO berry producers can provide containers for customers or require them to supply their own. The most successful PYO marketers will have containers available for customers.

PYO customers also frequently bring children to harvest small fruit. Larger, "harness"-style picking containers used by cherry pickers will not work for smaller customers. The most effective containers for children are simply small buckets purchased from most farm or produce supply companies.

Lightweight metal carriers coated with baked-on white enamel are also available for field harvest. These carriers hold six to eight 1-qt containers. They are quite easily transported to the field, are easy to clean, and are stackable. Two styles of these were evaluated, both receiving favorable feedback from producers and customers. Producers also found them to be useful as a row marker. Producers also found these carriers effective for displaying product at on-farm stands.

A lightweight metal carrier that straps around the waist and holds three 1-pt containers or two 1-qt containers was also evaluated. This carrier is not useful on smaller bushes (3 to 4 ft), as the berries will easily spill out of the carrier if the picker leans over. Customers wishing to pick only a few pints or quarts of berries may find this carrier useful when plants are taller.

These field carriers are recommended for producers as a harvest aid to PYO customers. Producers interested in using these carriers should seek to purchase them directly from a manufacturer in order to save considerable markup costs. In 2003, these carriers cost $6 to $9 apiece when purchased from manufacturers, compared to $10 to $15 from retailers.

Blueberry Produce Auction Prices

Buyers at the produce auction tended to be small wholesalers and small on-farm marketers. The best returns in this market appeared to be for pint and quart clamshells (Table 2). Producers received superior returns for ½-pt containers selling directly to customers. This opportunity is not evident selling closer to wholesale-type markets.

The larger corrugated boxes outperformed the ½-pt and 2.5-lb clamshells. Foodservice buyers and buyers interested in repacking also buy the large boxes at auction. The lower packaging cost per pound appears to translate into decent returns but generally not as strong as selling in pints or quarts for general sale at auction. Desired packaging and market outlets for direct sales to foodservice vendors need to be further explored.

Conclusions

Berry containers can affect harvest efficiency, consumer purchase decisions, and wholesale buyer preference. Summary recommendations for the berry containers evaluated during 2003 are reported in Table 3. Harvest equipment used, especially that offered for PYO customer use, can affect the ease and efficiency of berry harvest.

Producers should continue to experiment with new containers and harvest equipment, upon availability, to find the best matches for their operation and customers. Further studies could evaluate other sizes and kinds of containers and identify optimum berry packaging for direct sales to foodservices.

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Table 2. Blueberry prices at the Fairview Produce Auction, 2003.

Container	Price Range per Container ($/unit)	Price Range/Lb (0.8 lb/pint)	Season Volume (units)	Packaging Cost/Lb	Gross Returns/Lb after Packaging Cost
½-pt plastic clamshell	$0.90	$1.44	60	$0.35	$1.09
1-pt plastic clamshell	$1.30 - $2.42	$1.63 - $3.03	1,092	$0.17	$1.46 - $2.86
1-qt plastic clamshell	$3.25- $3.75	$2.03 - $2.34	96	$0.20	$1.83 - $2.14
2.5-lb clamshell	$3.75 - $4.50	$1.50 - $1.80	44	$0.20	$1.30 - $1.60
5-lb corrugated	$6.50 - $10.00; some $12.00	$1.30 - $2.40	49	$0.10	$1.20 - $1.90
10-lb corrugated	$15.00 - $19.80; some $24.00	$1.50 - $2.40	30	$0.08	$1.42 - $1.90

Table 3. Berry container observations and recommendations.

Material	Berries Recommended	Observed Advantages	Observed Disadvantages	Market Channel Recommendations
Fiber pulp (green)	All berries	Picking ease Absorbs bramble juice Consumer familiarity	Fruit can spill Disintegrate in high moisture	On-farm, farmers' market, PYO
Paperboard (white/brown)	Blueberries, strawberries	Consumers find attractive More weight capacity per container	Fruit can spill Availability/cost Fruit settles when in cooler	On-farm, farmers' market
#1 PETE plastic clamshell (1/2 pint, 1 pint, 1 quart)	All berries; brambles require food pad	Lids/stackable Moisture-resistant	Customers associate with grocery market Cost/availability Brambles require absorbent pad	All markets
Wooden hallock band (1/2 pint)	Possibly for specialty berries	Consumers find attractive Expense comparable to paper/pulp products	Consumers view as small capacity	Upscale markets, possibly for specialty berries
1/8 peck (3 pt) wooden basket w/handle	Blueberries	Many customers like it Handle for carrying	Requires recipe attachment—consumers unsure how to use 3 pts of berries	On-farm, farmers' market
2/2.5-lb clamshell	Blueberries	Lid and stackable	New size for buyers	Bulk wholesale, possibly direct to foodservice
5-lb and 10-lb corrugated (blueberry)	Blueberries	Cheaper packaging cost Easier packing	Bulk sales option only	On-farm, bulk wholesale (restaurant, auction, repackers)

Evaluation of Raised Bed Strawberry Production With and Without Plastic, 2003

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Introduction

There is considerable interest in the plastic-mulched strawberry production system in the Midwest and Kentucky. Unfortunately, most research trials in this region have not shown that yields are sufficient to justify the input costs. This trial was established to evaluate production with black and white plastic mulch and on bare ground.

Materials and Methods

Raised beds were formed, covered with black plastic, and fumigated by puncturing cans of methyl bromide beneath the plastic on 29 August 2002. Sections of the plastic were cut away to produce the bare ground plots, and white plastic was laid over the black plastic to form the white plastic mulch plots.

Chandler strawberry plants were set 11 September 2002 on raised beds using a waterwheel setter. Each plant received roughly one cup of 20-10-20 starter solution at planting. Treatments consisted of bare ground, white plastic mulch, and black plastic mulch in a randomized block design with five replications. Guard row plants were set using the Allstar and Camarosa varieties on bare ground. Chandler and Camarosa are day neutral varieties, and Allstar is a short day variety. Each plot was 20 ft. long and consisted of a double row of plants spaced 12 in. apart in the row with 12 in. between rows.

Plug plants were grown by Davon Crest Farms Inc., Hurlock, Maryland, and were shipped and planted with a paper coffee filter wrapped around the root system. Immediately after transplanting, plants were irrigated with an overhead gun for several days until they were established. Trickle irrigation was later used as necessary, based on soil tensiometer readings. Plants were fertigated three times with a total of 53 lb N/A.

Devrinol and spot sprays of glyphosate were used for weed control between the beds. Benlate was used for disease control.

The planting was covered with a floating row cover on 10 December, and this was removed on 20 March. The floating row cover was again placed over the beds to protect the blooms from frost on 22 April. No frost injury to blooms was noted in the planting.

Harvest began on 9 May, and plants were harvested two to three times per week throughout the harvest season. Data for fruit yield and weight of 15 randomly selected berries were collected at each harvest.

Table 1. Effect of plastic mulch type and variety on strawberry yield and berry weight.

Treatment	Yield[1] (lb/A)	Avg. Berry Wt.[1] (g)
Black plastic Chandler	12780 a	275 a
Bare ground, Allstar	10468 ab	265 ab
Bare ground, Camarosa	10232 ab	256 ab
Bare ground, Chandler	9712 ab	248 b
White plastic, Chandler	8064 b	261 ab

[1] Means within a column followed by the same letter are not significantly different (Duncan-Waller LSD, P = 0.05).

Results and Discussion

The black plastic mulch treatment yielded more than the white plastic mulch treatment for the Chandler variety (Table 1). However, neither of these differed from the bare ground treatment for the three varieties. Average berry weight was largest for Chandler on black plastic mulch and smallest for Chandler on bare ground. There was no difference in berry size between these treatments and the remaining treatments.

Analysis of the data for the harvest midpoint did not show any significant differences between treatments. However, there was a tendency for the black plastic and bare ground treatments to produce slightly earlier than the white plastic treatment.

The "economic rule of thumb" for plastic-mulched strawberry systems is that yields should be 1 lb/plant or 15,000 lb/acre to break even. The yields in this study did not come close to this yield, again showing that it is difficult to economically justify this cultural system in the Midwest.

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