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Yield Characteristics of Thorny Primocane-Fruiting Blackberries from the University of Arkansas Breeding Program Grown Under Organic Growing Conditions in Kentucky

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Abstract

Primocane-fruiting blackberries have the potential to produce a niche-market crop for blackberry growers from late summer until autumn frost as primocanes, and again as floricanes the following season. The objective of this study was to determine if advanced selections developed by the University of Arkansas (UA) Blackberry Breeding Program were superior to Prime-Jim® and Prime-Jan® in terms of yield and fruit size in Kentucky growing conditions and maintained with national organic program standards. In June 2006, six selections of primocane-fruiting blackberries from the UA breeding program (APF-27, APF-40, APF-41, APF-42, APF-46, and APF-77), the commercially available primocane-fruiting cultivars Prime-Jim® and Prime-Jan®, and the floricane fruiting cultivar 'Chickasaw' were planted at the Kentucky State University Research Farm using 6 month old tissue cultured plants. The planting was managed for both floricane and primocane production. In both 2007 and 2009, frost damage, winter injury, and anthracnose limited floricane fruit production. In the second season (2007), APF-40 had the greatest primocane yield, and berry weight was larger for APF-40 and APF-41 than other selections. In the third season (2008), APF-41 and APF-77 produced the largest floricane yield, and APF-41 and APF-40 had the largest berries of all selections. APF-27, Prime-Jan®, and APF-77 had greater primocane yields in the third season (2008) than APF-41 and Prime-Jim®; APF-40 and APF-41 tended to produced the largest berry weight. In the fourth season (2009), floricane yields were small for all selections; however, primocane yields and fruit weights were greater for all selections than for Prime-Jan®. 'Chickasaw' had higher yields and larger berry size than the primocane-fruiting selections. Prime-Jim® had consistently lower yields and berry sizes than the advanced selections. Prime-Jan® was superior to Prime-Jim®, but lower than APF-77 in terms of yield and berry size. Prime-Jan® can be recommended for home garden use. APF-77 (now marketed as Black Magic™ in the United States) can be recommended for home growers and has commercial value for local markets including pick-your-own or on-farm sales that require no or only limited fruit storage time.

Kentucky's climate is well-suited for blackberry production; winters are generally not severe, although there is disease pressure that comes with the high humidity and temperatures in the region. Wild blackberries have historically been widely harvested in Kentucky. However, small-scale commercial production for "U-Pick", Community Supported Agriculture (CSAs), and farmer's markets, has been emerging in recent years (10). The area planted in blackberry in Kentucky has increased from 35 ha in 2002 to 100 ha in 2007 (5, 13). Blackberry fruit often do not store or ship well, limiting market area, but the increasing demand for blackberries often exceeds supply in Kentucky (4). Blackberries are a perennial crop plant and have an advantage of being a long-term, permaculture farming system. With favorable growing conditions and proper care, a blackberry planting may produce for 8 to 12 years in Kentucky (5). The University of Kentucky has developed blackberry cost and return estimates to farmers that show

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blackberries are already a profitable crop for farmers in Kentucky and the surrounding region (4). However, growing blackberries organically using National Organic Program (NOP) standards provides the potential for growers to sell fruit at a higher price than conventionally grown fruit (7) noting that the organic market is the fastest-growing segment of US agriculture (6, 14).

Blackberry plants are unusual among fruit crops in that they have perennial root systems, but have biennial canes. There are two cane types, primocanes, or first year canes, which are usually vegetative, and floricanes, which are primocanes from the previous growing season. Floricanes flower and produce fruit during the second growing season, then die after fruiting and need to be removed. Primocane-fruiting blackberries have the potential to produce two crops per year, with a normal summer crop (floricane) and a later crop on the current season primocanes. Primocane-fruiting blackberries flower and fruit from mid-summer until autumn frost, depending on temperatures, plant health, and the location in which they are grown, and will then continue to flower and fruit as floricanes the following spring and summer growing season. Growers can reduce pruning costs by mowing canes in late winter to obtain a primocane crop only; this also may control anthracnose (*Elsinoe veneta* Burkh.), cane blight [*Leptosphaeria coniothyrium* (Fuckel) Sacc.] and *Botryosphaeria dothidea* (Moug.:Fr.) Ces. & De Not, and red-necked cane borer (*Agrilus ruficollis* Fabricius) without pesticides. Relying only on a primocane crop also avoids potential winter injury of floricanes.

The first commercially available primocane-fruiting blackberry varieties, Prime-Jim® and Prime-Jan®, which are both thorny and erect, were released by the University of Arkansas in 2004 (1, 2). These selections have fruit that is usually not recommended for commercial shipping and, consequently, these selections have been generally recommended for homeowner use or commercial production for local use (1). Environment can affect both fruit size and quality of primocane-fruiting blackberries. Summer temperatures above 30°C (85°F) reduced fruit set, size and quality of fruit from primocanes, and reduced yield in areas with this temperature range in summer and fall (2, 8). The objective of this study was to determine if advanced selections developed by the University of Arkansas Blackberry Breeding Program were superior to Prime-Jim® and Prime-Jan® in terms of yield and fruit size under NOP growing conditions in Kentucky.

Materials and Methods

In June 2006, a blackberry selection and cultivar trial was established at Kentucky State University (KSU). Plants of two commercially available primocane-fruiting cultivars, Prime-Jim® and Prime-Jan® (both thorny erect, primocane-fruiting), Arkansas Primocane-Fruiting (APF) selections APF-27, APF-40, APF-41, APF-42, APF-46, and APF-77 (all thorny erect, primocane-fruiting advanced selections at the time of planting establishment), and the floricane fruiting selection 'Chickasaw' (thorny erect) were planted at the KSU Research and Demonstration Farm, in Frankfort, KY. Plants were arranged in a randomized complete block design, with four blocks, including five plants of each cultivar per block (total of 20 plants of each cultivar) in a 3 m (10 ft) plot. Spacing was 0.6 m (2 ft) between each plant, and 1.5 m (5 ft) between groups of 5 plants; with each row being 21.3 m (70 ft) in length. Rows were spaced 4.3 m (14 ft) apart. Although established on land that was not certified organic, the trial was managed with organic practices following the NOP standards. In late winter, plants were fertilized with NatureSafe (Griffin Industries, Cold Spring, KY) at 112 kg of N per ha or 0.3 kg (0.7 lb) per plant. Weed control was achieved by placing a 15-20 cm deep layer of straw around plants, adding straw when necessary and hand weeding. Plants were irrigated weekly with t-tape laid in the rows. This planting was managed for

both floricane and primocane fruit production in order to determine winter hardiness of floricanes for these selections in Kentucky.

Floricanes of the primocane selections began producing ripe fruit in mid-June, of the third year (2008), and ripe fruit were harvested from floricanes twice weekly until all floricane fruit had been harvested. Primocane harvest started in early August and continued until frost destroyed developing fruit and flowers, typically in late October. Berry size was determined by weighing 25 berries from each block of each selection at every harvest date. All selections had primocanes soft-tipped at 1 m in early June and again in September to promote lateral branching and flowering (9, 11, 12). Insect infestations and disease infections were evaluated weekly during flowering and harvest.

Results and Discussion

Primocane and floricane fruiting characteristics were collected over a 3-year period. During the summer of 2006, the first season after planting, plants grew vigorously, but only small quantities of primocane-fruit were produced by the selections and the fruit were not harvested in the year of planting. Freeze damage (approx -5°C) that occurred on April 4-10, 2007 prevented floricane production in the spring and summer of the second season (2007) when the first floricane crop is normally produced. Primocane-fruit production began in early August of the second season (2007) for most selections and continued until frost (Table 1). In the 2007 primocane crop, the selection APF-40 had the greatest yield (2912 kg·ha^{-1}) with Prime-Jim® displaying the smallest yield (330 kg·ha^{-1}) (Table 2). Berry weight from the selections APF-40 and APF-41 (about 3.9 g·berry^{-1}) was significantly larger than those of all other selections (Table 3). APF-42 was removed from the trial after the 2007 season due to undesirable berry characteristics of double drupelets and leaving several rows of drupelets on the plant when berries were harvested.

In June of 2008, APF-41 and APF-77

Table 1. Harvest dates (month/day) for the floricane cultivar 'Chickasaw', four advanced primocane-fruiting selections from the University of Arkansas Blackberry Breeding Program, and the primocane-fruiting cultivars Prime-Jan® and Prime-Jim® established at the Kentucky State University Research Farm in June 2006.

Genotypes	Year 2: 2007 Primocane	Year 2: 2007 50% harvest	Year 3: 2008 Floricane	Year 3: 2008 50% harvest	Year 3: 2008 Primocane	Year 3: 2008 50% harvest	Year 4: 2009 Floricane	Year : 2009 50% harvest	Year 4: 2009 Primocane	Year 4: 2009 50% harvest
APF-27	8/2 - 10/26	9/4	6/18 - 7/21	6/26	8/3 - 10/20	8/21	-	-	7/23 - 10/13	8/10
APF-40	8/6 - 10/26	8/30	6/18 - 8/1	6/30	8/3 - 10/20	8/25	-	-	7/23 - 10/13	8/13
APF-41	8/20 - 10/26	9/11	6/18 - 8/11	7/7	8/21 - 10/20	9/9	7/2 - 8/10	7/17	8/13 - 10/13	9/14
APF-77	8/2 - 10/26	9/24	6/18 - 7/28	6/30	8/3 - 10/20	8/25	-	-	7/23 - 10/13	8/13
Prime-Jan®	8/2 - 10/26	8/30	6/18 - 7/24	7/7	8/11 - 10/20	8/25	7/2 - 8/6	7/2	8/10 - 10/13	8/31
Prime-Jim®	8/2 - 10/26	8/30	6/18 - 7/21	6/30	8/7 - 10/20	9/2	7/2 - 8/3	7/9	8/6 - 10/13	8/20
'Chickasaw'	-	-	6/30 - 8/3	7/10	-	-	7/2 – 8/6	7/13	-	-

Table 2. Yield data for the floricane cultivar 'Chickasaw', four advanced primocane-fruiting selections from the University of Arkansas Blackberry Breeding Program, and the primocane-fruiting cultivars Prime-Jan® and Prime-Jim® that were established at the Kentucky State University Research Farm in June 2006.

	Yield (kg·ha^{-1})					
Genotype	Year 2: 2007 Floricane	Year 2: 2007 Primocane	Year 3: 2008 Floricane	Year 3: 2008 Primocane	Year 4: 2009 Floricane	Year 4: 2009 Primocane
APF-27	-	1675 bc[1]	1230 c	3369 a	-	4127 ab
APF-40	-	2912 a	2240 c	2183 bc	-	4113 ab
APF-41	-	1586 bc	4949 b	979 d	650 b	3882 ab
APF-77	-	1238 c	4167 b	2499 ab	-	4696 a
Prime-Jan®	-	1926 b	960 c	2245 abc	35 b	2822 bc
Prime-Jim®	-	330 d	2081 c	775 d	6 b	1558 c
'Chickasaw'	-	-	8826 a	-	2447 a	-

[1]Numbers followed by the same letter are not significantly different (Using Least Significant Difference P = 0.05) within a column.

produced larger floricane crops of 4949 and 4167 kg·ha^{-1}, respectively, than the other selections except for the floricane cultivar 'Chickasaw' (Table 2). The third season (2008) primocane crop began ripening in August. APF-27, Prime-Jan®, and APF-77 had larger primocane crops in the third season (2008) than APF-41 and Prime-Jim® and APF-40 and APF-41 tended to produce the largest fruit (Tables 2 and 3). Selections APF-27 and APF-77 had a two-fold increase in yield compared to 2007. Although APF-41 had a large floricane yield in 2008, the primocane yield was only about 25% of the floricane yield and was about 60% that of the 2007 primocane yield. Primocane fruit of APF-41 were large in size, but the primocane fruit of this selection were only 4.4 g on average compared to the 6.2 g on average for floricanes in 2008 (Table 3). Due to irrigation restrictions at the planting site, irrigation may have been insufficient for the summer drought conditions present in the summer of 2008. The drought conditions and high temperatures may have negatively impacted the primocane crop of all selections that year. Several selections had larger berry sizes and higher yields than Prime-Jan® and Prime-Jim®. 'Chickasaw' produced the highest yield (8826 kg·ha^{-1}) and a large berry size (5.4 g·berry^{-1}) (Tables 2 and 3). Yield and fruit size for Prime-Jan® and Prime-Jim® were both about half that reported in the cooler climate of Oregon, likely a result of the lower summer temperatures during fruit set on primocanes and fruit development (11).

Only three selections had any floricane crop in the fourth year (2009), with APF-41 producing the highest yields and the largest berries (Tables 2 and 3). The small floricane crop was likely the result of a combination of multiple factors including: 1) the drought conditions in 2008 which reduced primocane growth and subsequent yield in 2009, 2) winter injury to canes in January and February (-19.3°C on 26 Jan., 2009), 3) problems with control of anthracnose canker that damaged some canes, and 4) reduced plant reserves as a result of a full floricane and primocane crop

in 2008. In 2009, primocane-fruit production began in late July for most selections while APF-41 and Prime-Jan® did not ripen until mid-August. All the advanced primocane-fruiting selections and Prime-Jan® had higher primocane yields relative to floricane yields; however, Prime-Jim® had less primocane yield compared to the other selections, and most of the advanced primocane-fruiting selections had larger fruit than Prime-Jim® 'Chickasaw' had the largest floricane yield, but yield in 2009 was lower than the primocane crops for all other cultivars except Prime-Jim® (Table 2).

Fruit quality, defined as berry size and soluble solids concentration, differed among selections and with season. The berry size of 'Chickasaw' was larger compared to berries produced during the floricane season, but small when compared to berries produced during the primocane season (Table 3). Prime-Jan® had the lowest soluble solids (10.3%) of the primocane-fruiting selections and APF-41 the highest (14.0%) (data not shown). 'Chickasaw' soluble solids averaged 9.2%, lower than those of the primocane-fruiting selections.

This planting was grown using NOP standards. Some disease and pest problems were noted in the planting. Anthracnose and cane cankers (*Elsinoe veneta, Leptosphaeria coniothyrium*, and *Botryosphaeria dothidea*) damaged a number of canes in 2009. In Kentucky, orange rust, caused by the fungus *Gymnoconia nitens* (Schweinitz) F. Kern & Thurston can attack blackberries and the fungus *Arthuriomyces peckianus* (Howe), causing identical symptoms, may also be involved. Orange rust is quite prevalent in Kentucky. However, even with the high orange rust pressure only one plant of 'Prime-Jan®' displayed infected leaves in 2008 (the first reported infection of this cultivar with this disease). During wet periods, a small number of fruit were infected with botrytis fruit rot (*Botrytis cinerea* Pers.). Some drupelet damage was noted each year and was likely the result of Japanese beetle (*Popillia japonica* Newman), green june beetle (*Cotinis nitida*

Table 3. Fruit weights for the floricane cultivar 'Chickasaw', four advanced primocane-fruiting selections from the University of Arkansas Blackberry Breeding Program, and the primocane-fruiting cultivars Prime-Jan® and Prime-Jim® that were established at the Kentucky State University Research Farm in June 2006.

	Average fruit weight (g)					
Genotype	Year 2: 2007 Floricane	Year 2: 2007 Primocane	Year 3: 2008 Floricane	Year 3: 2008 Primocane	Year 4: 2009 Floricane	Year 4: 2009 Primocane
APF-27	-	3.0 b[1]	3.6 c	3.5 bc	-	5.3 abc
APF-40	-	4.0 a	5.0 b	3.9 ab	-	5.9 ab
APF-41	-	3.9 a	6.2 a	4.4 a	5.1 a	6.3 a
APF-77	-	3.3 b	3.8 c	3.9 ab	-	5.9 ab
Prime-Jan®	-	3.3 b	4.0 c	3.2 cd	1.7 b	4.9 bc
Prime-Jim®	-	2.0 c	3.6 c	2.7 d	0.6 bc	4.2 c
'Chickasaw'	-	-	5.4 ab	-	4.5 a	-

[1]Numbers followed by the same letter are not significantly different (Using Least Significant Difference P = 0.05) within a column.

Linnaeus), and several species of stinkbugs: brown stink bug, *Euschistus servus* Say; one spotted stink bug, *E. variolarius* Beauv.; green stink bug, *Acrosternum hilare* Say; twice-stabbed stink bug, *Cosmopepla lintneriana* Thomas; rice stink bug, *Oebalus pugnax* Fabricius; and the red-shouldered stink bug, *Thyanta custator* Fabricius. Some fruit was also damaged and eaten by birds. Although not noted in the planting, rednecked cane borer (*Agrilus ruficollis* Fabricius) is common in Kentucky. Winter mowing of these selections for primocane fruit production only can also be used to control this insect without the use of chemicals. White-tailed deer (*Odocoileus virginianus* Zimmermann) would occasionally browse on cane tips in winter and spring when other forage choices were scarce. Damage was noticeable, but never severe, and solar powered electric fencing effectively discouraged deer from entering the planting.

Several selections had larger berry sizes and higher yields than 'Prime-Jan®' and 'Prime-Jim®' during the first three seasons after establishment. APF-77 had high yields, large berry size, and excellent flavor, and excellent characteristics for home garden use. However, APF-77 has commercial value for local markets including pick-your-own or on-farm sales that require no or only limited fruit storage time. APF-41 also had a large berry and produced larger yields than many other selections in this trial. Although not included in this trial, Prime-Ark® 45 has been released by UA and has been recommended for commercial production by UA (3). This selection is under evaluation in a separate trial at KSU. All primocane-fruiting selections produced lower yields than 'Chickasaw' (a traditional floricane-fruiting selection). In 2008, when full floricane and primocane crops were set, 'Chickasaw' produced 8826 kg·ha^{-1}. APF-77, the highest yielding primocane-fruiting selection had a total yield (floricane + primocane) of 6665 kg·ha^{-1}, approximately 2100 kg·ha^{-1} lower than 'Chickasaw'. If primocane-fruiting selections were mowed and only a primocane crop produced, expected yields would be around 4500 kg·ha^{-1} (based on primocane only crops produced by selections in 2009), much lower than 'Chickasaw'. However, primocane-fruiting selections start producing a primocane crop later in the year and produce berries for an extended harvest period (Table 1).

In conclusion, 'Prime-Jan®'can be recommended for home garden use in Kentucky. APF-77 (now marketed as Black Magic™ in the United States) can be recommended for home growers and has commercial value for local markets including pick-your-own or on-farm sales that require no or only limited fruit storage time. Prime-Jim® cannot be recommend for growers in Kentucky due to low yields and small berry size We successfully produced floricane and primocane blackberries in Kentucky using NOP practices.

Literature Cited

1. Clark, J.R. 2008. Primocane-fruiting blackberry breeding. HortScience 43:1637-1639.
2. Clark, J.R., J. N. Moore, J. Lopez-Medina, C. Finn, P. Perkins-Veazie. 2005. 'Prime-Jan' ('APF-8') and 'Prime-Jim' ('APF-12') primocane-fruiting blackberries. HortScience 40:852-855.
3. Clark, J.R. and P. Perkins-Veazie. 2011. 'APF-45' primocane-fruiting blackberry. HortScience 46:670-673.
4. Ernst, M., T. Woods, J. Strang, and T. Jones, 2008. 2008 Kentucky blackberry cost and return estimates (ID-149). University of Kentucky, Extension Publication. (http://www.ca.uky.edu/agc/pubs/id/id149/ID149.PDF).
5. Jones, R.T., G.R. Brown, and J.G. Strang. 2005. Growing blackberries & raspberries in Kentucky (HO-15). University of Kentucky, Extension Publication.
6. Oberholtzer, Lydia, Caroline Demitri and Catherine Greene. 2005. Price premiums hold on as US organic market expands. Electronic Outlook Report from the Economic Research Service, VGS-308-01. USDA. http://www.ers.usda.gov/publications/vgs/may05/VGS30801/VGS30801.pdf
7. Rodale Institute. Organic Price Report. Available online: http://www.rodaleinstitute.org/Organic-Price-Report. Accessed 11/22/2011.
8. Stanton, M.A., J. C. Scheerens, R. C. Funt, and J. R. Clark. 2007. Floral competence of primocane-

fruiting blackberries Prime-Jan and Prime-Jim grown at three temperature regimens. HortScience 42: 508 - 513.
9. Strik, B.C., C.E. Finn, J.R. Clark, and G. Buller. 2008. Management of primocane-fruiting blackberry to maximize yield and extend the fruiting season.Acta Hort. 777:423-428.
10. Strik, B.C., Finn, C.E., Clark, J.R. and M. Pilar Bañados, M. 2008. Worldwide production of blackberries. Acta Hort. 777:209-218
11. Strik, B.C.and E. Thompson. 2009. Primocane-fruiting Blackberries: Potential for Extending Harvest Season and Production Regions. HortScience 44:23–24.
12. Thompson, E., B. C. Strik, J. R. Clark, and C. E. Finn. 2009. Flowering and Fruiting Patterns of Primocane-fruiting Blackberries. HortScience 42:1174-1176.
13. United States Department of Agriculture. 2007 Census of Agriculture. February 2009. <http://www.agcensus.usda.gov>.
14. Willer, Helga and Minou Yussefi. 2004. The World of Organic Agriculture - Statistics and emerging trends 2004. International Federation of Organic Agriculture Movements, DE-53117 Bonn.

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