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Primocane Yield of 'Prime-Ark® 45' and 'Prime-Jan®' Blackberries Grown Using USDA National Organic Program Practices in Kentucky

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Abstract

Primocane-fruiting blackberries have the potential to produce a niche-market crop for growers from late summer until autumn frost on primocanes, and again as floricanes the following season. 'Prime-Ark® 45' was recently released by the University of Arkansas and this cultivar may be suitable for commercial production in Kentucky and surrounding areas; however, this selection has not been tested in a multi-year study in this climate and associated disease pressures of this region. The objective of this study was to determine if 'Prime-Ark® 45' was superior to 'Prime-Jan®' in terms of yield and berry size in Kentucky growing conditions and when maintained using National Organic Program standards. In April 2010, a blackberry cultivar trial was established at Kentucky State University (KSU). Plants of the commercially available primocane-fruiting, thorny erect cultivars 'Prime-Jan®' and 'Prime-Ark® 45' were planted on certified organic land and managed with organic practices following the National Organic Program standards at the KSU Research and Demonstration Farm, in Frankfort, KY. The planting was managed for primocane production only. 'Prime-Ark® 45' out-yielded 'Prime-Jan®' by a three- to four-fold margin in all three years of the study. Berry weight ranged from 25% to 70% heavier for 'Prime-Ark® 45' in each year of the study. In 2011 and 2012, high summer temperatures likely reduced drupelet set and subsequent fruit size and yield. In 2013, summer temperatures were mild and both cultivars had higher yield and larger fruit size compared to 2011 and 2012.

With generally non-severe winters, Kentucky has a climate that is well-suited for blackberry production. However, high humidity and temperatures in the region can lead to increased disease pressure. Commercial blackberry growers are mainly focused on small-scale production for "U-Pick", Community Supported Agriculture (CSAs) and farmer's markets (Strik et al., 2008b). The area planted in berry crops in Kentucky has increased from 636 farms with 312 ha in 2007 to 844 farms with 350 ha in 2012 (USDA, 2012). Blackberry fruit often do not store or ship well, limiting market area, but the increasing demand for blackberries often exceeds supply in Kentucky (Ernst et al., 2008). Blackberries are a perennial crop and have an advantage of being a long-term, farming system. With favorable growing conditions and proper care, a blackberry planting can produce for 8 to 12 years in Kentucky (Jones et al., 2005). The University of Kentucky developed blackberry cost and return estimates to farmers that show blackberries are a profitable crop for farmers in Kentucky and the surrounding region (Ernst et al., 2008). 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 (Geisler and Morgan, 2012; Oberholtzer et al., 2005; USDA, 2014). Organic produc-

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tion is also the fastest-growing segment of US agriculture (Oberholtzer et al., 2005; Willer and Yussefi, 2004).

Blackberry plants have two cane types: primocanes, or first year canes, which are usually vegetative, and become floricanes upon budbreak after the dormant season; and floricanes, which flower and produce fruit during the second growing season, then die after fruiting and may 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 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.

Some of the disease problems that have been reported to limit blackberry production in Kentucky are anthracnose and cane cankers [*Elsinoe veneta* (Burkh.) Jenkins, *Leptosphaeria coniothyrium* (Fuckel) Sacc., and *Botryosphaeria dothidea* (Moug.) Ces. & De Not.], two species of orange rust [*Gymnoconia nitens* (Schwein.) F. Kern & Thurst. and *Arthuriomyces peckianus* (Howe) Cummins & Y. Hirats.], double blossom [*Cercosporella rubi* (G. Winter) Plakidas], phytophthora root rot (*Phytophthora* spp.), verticillium wilt (*Verticillium albo-atrum* Reinke & Berthold), grey mold fruit rot (*Botrytis cinerea* Pers.) and viral diseases (Jones et al., 2005). Potential insect pests are the Japanese beetle (*Popillia japonica* Newman), green June beetle (*Cotinis nitida* Linnaeus), and occasionally rednecked cane borer (*Agrilus rufi collis* Fabricius) and raspberry crown borer (*Pennisetia marginata* Harris) (Jones et al., 2005). Both borers can cause canes to die or become weakened so they cannot support a crop the following season. Several species of stink bugs can be a pest on blackberries including: 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* Kirkaldy); rice stink bug, (*Oebalus pugnax* Fabricius); and the red-shouldered stink bug, (*Thyanta custator* Fabricius). Spider mites (*Tetranychus urticae* Koch) and aphids (*Aphis* spp.) are two other insect pests that can impact production in Kentucky (Jones et al., 2006). Spotted wing drosophila (*Drosophila suzukii* Matsumura) was found in Kentucky in 2012 and can be a very destructive pest to softer skinned fruits such as blackberries and raspberries (Cole et al., 2014).

Growers of primocane-fruiting blackberries can reduce pruning costs and labor by mowing canes in late winter to obtain a primocane crop only; this also may control cane blight, and red-necked cane borer without pesticides. Relying only on a primocane crop also avoids potential winter injury of floricanes.

The first commercially available primocane-fruiting blackberry cultivars, 'Prime-Jim®' and 'Prime-Jan®' are thorny and erect and were released by the University of Arkansas in 2004 (Clark et al., 2005; Clark, 2008). However, these selections have fruit that is usually not recommended for commercial shipping and, consequently, these selections have been recommended for homeowner use or commercial production for local use (Clark, 2008). Lowe et al. (2012) conducted a primocane-fruiting blackberry trial in Kentucky with 'Prime-Jim®' and 'Prime-Jan®' and additional selections from University of Arkansas breeding program (APF-27, APF-40, APF-41, APF-42, APF-46, and 'Black Magic™' [tested as APF-77]). 'Prime-Jan®' was superior to 'Prime-Jim®', but lower than 'Black Magic™' in terms of yield and berry size. However, 'Prime-Jan®' can only be recommended for home garden use due to soft fruit. 'Black Magic™' was also found to be suitable for home growers and may have some commercial value for local markets including pick-your-own or on-farm sales that require limited to no fruit storage time.

'Prime-Ark® 45' was recently released by

the University of Arkansas and they have suggested that it is suitable for commercial production (Clark and Perkins-Veazie, 2011); however, this selection has not been tested in a multi-year study in the climate and disease pressure found in Kentucky. The environment can affect fruit size and quality of primocane-fruiting blackberries. Summer temperatures above 30°C, which are common during the summer and fall in central Kentucky, reduced fruit set, size and quality of fruit from primocanes, and reduced yields in 'Prime-Jan®' and 'Prime-Jim®' (Clark et al., 2005, Stanton et al., 2007). The objective of this study was to determine if 'Prime-Ark® 45' is superior to 'Prime-Jan®' in terms of yield and fruit size in Kentucky growing conditions and when maintained with National Organic Program standards.

Materials and Methods

In April 2010, a blackberry cultivar trial was established at Kentucky State University (KSU). Plants of the commercially available primocane-fruiting, thorny, erect cultivars 'Prime-Jan®' and 'Prime-Ark® 45' were planted at the KSU Research and Demonstration Farm, in Frankfort, Kentucky. Plants were arranged in a randomized complete block design, with four blocks, including five plants of each cultivar per block (total of 20 plants of each cultivar) in a 3 m long plot. Spacing was 0.6 m between each plant, and 1.5 m between five plant plots. Rows were spaced 4.3 m apart. This trial was planted on certified organic land and managed with organic practices following the National Organic Program standards. In early spring, plants were fertilized with NatureSafe 10N-2P-8K All Season Fertilizer (Griffin Industries, Cold Spring, KY) at 112 kg of N per ha or 0.3 kg (0.7 lb) per plant. A 15-20 cm layer of straw around plants was used for weed control with straw being added as necessary. Hand weeding was used for supplemental weed control. Plants were irrigated with drip tape laid in row at a rate of 3.35 L per hour per m for 18 h each week. No pesticides were applied to the planting during the study. This planting was managed for primocane production only; canes were cut and removed from the planting in late winter of each year.

Primocanes began producing fruit in 2011. Primocane harvest started in late July or 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. Primocanes were soft-tipped at 1 m from early June through mid-September to promote lateral branching and flowering (Strik et al., 2008a, Strik and Thompson, 2009; Thompson et al., 2009). Insect infestations and disease infections were evaluated weekly during flowering and harvest. Data were recorded and ANOVA and LSD means separation were performed using CoStat Statistical Software (CoHort Software, Monterey, CA).

Results and Discussion

'Prime-Ark® 45' out-yielded 'Prime-Jan®' by over a three to four-fold margin in all three years. 'Prime-Jan®' yields varied from 641-3701 kg·ha^{-1} while 'Prime-Ark® 45' yields varied from 2479-9869 kg·ha^{-1} (Table 1). In previous studies conducted in Arkansas, 'Prime-Ark® 45' yields ranged from 986-5071 kg·ha^{-1} and 'Prime-Jan®' 412-3048 kg·ha^{-1} (Clark et al., 2005; Clark and Perkins-Veazie, 2011). The tendency for higher yields in Kentucky is likely the results of lower summer temperatures and managing the planting for primocane only production, in contrast to the Arkansas plantings that were managed for both floricane and primocane production. Lowe et al. (2012) showed that primocane crops tended to be larger when a floricane crop was not produced. 'Prime-Jan®' plantings in Oregon had much higher yields (4103-17,179 kg·ha^{-1}) than what was produced in either Kentucky or Arkansas, likely due to the mild climate (Clarke et al., 2005).

Berry sizes were also larger for 'Prime-Ark® 45' in the three years examined.

Table 1. Yield, average fruit weights, and harvest dates (month/day) for the primocane-fruiting cultivars 'Prime-Jan®' and 'Prime-Ark® 45' established at the Kentucky State University Research Farm in April 2010.

	Yield (kg·ha^{-1})			Fruit weight (g)			Harvest dates (start to end, month/day)		
Cultivars	2011	2012	2013	2011	2012	2013	2011	2012	2013
Prime-Jan®	1032 b[1]	641 b	3701 b	2.2 b	2.6 b	3.5 b	8/11-10/29	7/26-10/11	7/18-10/22
Prime-Ark® 45	4372 a	2479 a	9869 a	3.8 a	3.3 a	4.7 a	8/11-10/29	7/26-10/11	8/1-10/22

[1] Means within a column followed by the same letter are not significantly different, P > 0.05, by least significant difference test.
[2] There was a significant interaction between cultivar and year (P = 0.0017).

'Prime-Jan®' berry size ranged from 2.2-3.5 g while 'Prime-Ark® 45' ranged from 3.8-4.7 g (Table 1). Berry sizes for 'Prime-Ark® 45' in Arkansas plantings (4.3-5.2 g) were similar to those in Kentucky, while berry sizes for 'Prime-Jan®' (2.0-5.2 g) in Arkansas reached a larger size than what was produced in Kentucky (Clark et al., 2005; Clark and Perkins-Veazie, 2011). Berry sizes were exceptional (7.8-10.6 g) for 'Prime-Jan®' plantings in Oregon, likely due to the mild climate (Clark et al., 2005).

Typically harvest began from mid-July (2013) to late July (2012) or early August (2011) and ended with frost in mid-late October for all years. In 2011 and 2012 both cultivars began producing at the same time. In 2013, 'Prime-Jan®' began producing approximately two weeks before 'Prime-Ark® 45' (Table 1). In Arkansas, 'Prime-Jan®' had a harvest start date of 18 July while 'Prime-Ark® 45' had a harvest date of 8 August (Clark et al., 2005; Clark and Perkins-Veazie, 2011). 'Prime-Ark® 45' had a 3 week later harvest start date in Arkansas, however this only occurred once in Kentucky in 2013. While both cultivars were still flowering and fruiting when a killing frost occurred in all three years examined, the rate of fruit production slows down as the season progresses. Lowe et al. (2012) found that primocane fruiting selections have produced 50% of their total primocane yield for the season approximately 3 weeks after the first primocane fruit are ripe. Since the majority of the crop is harvested early in the season, the amount lost due to frost is minimal.

Temperatures were above normal in 2011 during extended periods of the summer and fall; there were 64 out of 122 d with a daily high temperature above 30°C from June through September. The average high in July was 31.4°C and only 3 d in that month had high temperatures that were below 30°C. In 2012, there were extreme high temperatures during extended periods of the summer and fall; there were 64 out of 122 d with a daily high temperature above 30°C from June through September. The average high in July was 33°C with 3 d that the temperature was over 38°C, and 5 d in that month had high temperatures that were below 30°C. As in 2011, visual inspections of the developing fruit on inflorescences of both cultivars indicated that high temperatures reduced drupelet set in 'Prime-Jan®' to a greater extent than 'Prime-Ark® 45' (Fig. 1). Yields and berry sizes for both cultivars were the smallest in 2012 (Table 1). In contrast, growing conditions in 2013 were mild compared to 2011 and 2012; there were only 40 out of 122 d with a daily high temperature above 30°C from June through September. The average high in July was 28°C. Both cultivars had the highest yields and largest berry sizes in 2013 (Table 1). This finding confirms prior observations and confirms the benefit of reduced temperatures in achieving higher yields with this type of blackberry.

This planting was managed using NOP standards. Some disease and pest problems were noted in the planting. Anthracnose and cane cankers were observed on some canes. Orange rust is quite prevalent in Kentucky, however, even with the high orange rust pressure, no infected plants were observed. During wet periods, a small number of fruit were infected with botrytis fruit rot. Some drupelet

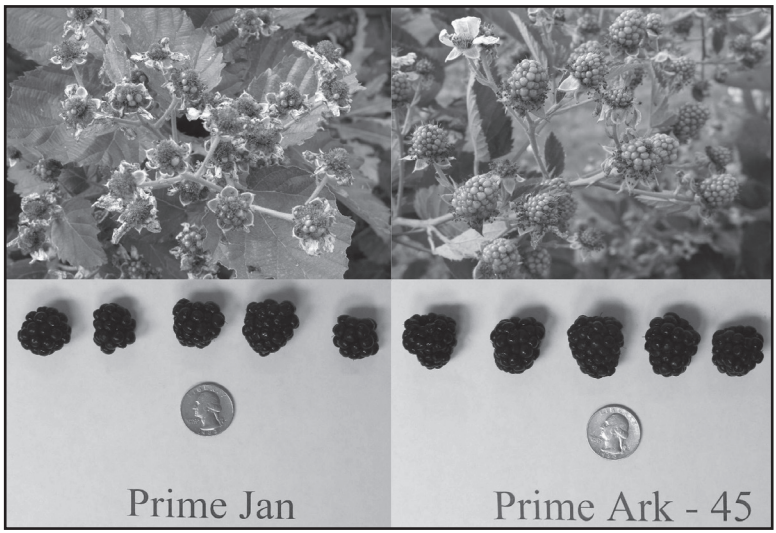

Fig. 1. Examples of drupelet set on 23 August 2011 and ripe fruit size for the primocane-fruiting cultivars 'Prime-Jan®' (left photos) and 'Prime-Ark® 45' (right photos) established at the Kentucky State University Research Farm in April 2010.

damage was noted each year and was likely the result of Japanese beetle, green June beetle, and several species of stinkbugs. Some fruit was also damaged and eaten by birds. Although not noted in the planting, red-necked cane borer is common in Kentucky. Winter mowing of these selections for primocane fruit production helps 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.

Environment can affect fruit size and quality of primocane-fruiting blackberries. Summer temperatures above 30°C reduced fruit set, size, and quality of fruit from primocanes, and reduced yield in areas with this temperature range in summer and fall (Clark et al., 2005, Stanton et al., 2007). Summer temperatures ranged from mild to extreme for the three years examined. The year 2012 had the highest summer temperatures, and yield and berry size were the smallest for both cultivars that year. The 2013 growing season had the lowest summer temperatures, and both cultivars produced their highest yields and largest berries that year. Despite temperature variations in the three years examined, 'Prime-Ark® 45' had larger berry size and higher yields than 'Prime-Jan®' in all years.

The University of Arkansas blackberry breeding program already recommends that commercial producers plant 'Prime-Ark® 45' instead of 'Prime-Jan®', due to the superior shipping quality of the firmer fruit of 'Prime-Ark® 45'. Our study confirmed that 'Prime-Ark® 45' yielded well in Kentucky and produces larger berries than 'Prime-Jan®' with yield and berry sizes similar to 'Triple Crown' (Lowe et al., 2008). 'Prime-Ark® 45' should be considered by commercial growers interested in producing primocane-fruiting blackberries and home garden use in Kentucky. 'Prime-Ark® 45' has commercial value for local markets including farmer's markets, pick-your-own, on-farm sales, and CSA's. 'Prime-Jan®' cannot be recommended

for growers in Kentucky due to low yields and small berry size during high summer temperatures. We successfully produced primocane blackberries in Kentucky using NOP practices; however, the recent spotted wing drosophila invasion presents a new challenge with their ability to lay eggs in undamaged fruit and difficulty in controlling them using pesticidal sprays (Cole et al., 2014).

Literature Cited

Clark, J.R. 2008. Primocane-fruiting blackberry breeding. HortScience 43:1637-1639.

Clark, J.R., J.N. Moore, J. Lopez-Medina, C. Finn, and P. Perkins-Veazie. 2005. 'Prime-Jan' ('APF-8') and 'Prime-Jim' ('APF-12') primocane-fruiting blackberries. HortScience 40:852-855.

Clark, J.R. and P. Perkins-Veazie. 2011. 'APF-45' primocane-fruiting blackberry. HortScience 46:670-673.

Cole, J., P. Lucas, and R. Bessin. 2014. Spotted wing drosophila, biology, identification and monitoring (ENTFACT-229). Univ. of Kentucky, Ext. Pub.

Ernst, M., T. Woods, J. Strang, and T. Jones, 2008. 2008 Kentucky blackberry cost and return estimates (ID-149). Univ. of Kentucky, Ext. Pub. <http://www.ca.uky.edu/agc/pubs/id/id149/ID149.PDF>.

Geisler, Malinda and K. Morgan. 2012. Agricultural Marketing Resource Center: Blackberries. October 2014. <http://www.agmrc.org/commodities__products/fruits/blackberries/>.

Jones, R.T. and J.G. Strang. 2005. Growing blackberries & raspberries in Kentucky (HO-15). Univ. of Kentucky. Ext. Pub.

Lowe, J.D., K.W. Pomper, S.B. Crabtree, J.R. Clark, and J.G. Strang. 2008. University of Arkansas floricane-fruiting blackberry trial in Kentucky. 2008 Frt. Veg. Res. Rpt. PR-572: 20.

Lowe, J.D., K.W. Pomper, S.B. Crabtree, J.R. Clark, and J.G. Strang. 2012. Yield characteristics of thorny primocane fruiting blackberries from the University of Arkansas breeding program grown under organic growing conditions in Kentucky. J. Amer. Pomol. Soc. 66:2-7.

Oberholtzer, Lydia, C. Demitri, and C. 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>

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.

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.

Strik, B.C., C.E. Finn, J.R. Clark, and M. Pilar Bañados. 2008. Worldwide production of blackberries. Acta Hort. 777:209-218.

Strik, B.C. and E. Thompson. 2009. Primocane-fruiting blackberries: Potential for extending harvest season and production regions. HortScience 44:23–24.

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.

United States Department of Agriculture. 2014. Agricultural Marketing Service. National Organic Program Handbook. October 2014. <http://www.ams.usda.gov/AMSv1.0/ams.fetchTemplateData.do?template=TemplateR&navID=NationalOrganicProgram&leftNav=NationalOrganicProgram&page=NOPProgramHandbook&description=Program%20Handbook&acct=noppub>

United States Department of Agriculture. 2012 Census of Agriculture. February 2014. <http://www.agcensus.usda.gov>.

Willer, H. and M. Yussefi. 2004. The World of Organic Agriculture - Statistics and emerging trends 2004. International Federation of Organic Agriculture Movements, DE-53117 Bonn.