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'Prime-Ark® Freedom' Primocane-fruiting Thornless Blackberry

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'Prime-Ark® Freedom' (to be U.S. plant-patented as 'APF-153T') is the world's first commercially released thornless primocane-fruiting blackberry (*Rubus* L. subgenus *Rubus* Watson). This novel development is intended primarily as a home garden or local market plant. This is the fourth in the University of Arkansas Prime-Ark® Brand Primocane Fruiting Blackberry cultivar line following the release of 'Prime-Jan'® and 'Prime-Jim'® in 2004 (Clark et al., 2005) and 'Prime-Ark® 45' in 2009 (Clark and Perkins-Veazie, 2011). All of the prior-released primocane-fruiting cultivars are thorny. This unique type of blackberry fruits on current-season canes (primocanes) and on second-season canes (floricanes), potentially providing for two cropping seasons, both traditional summer fruits in addition to late summer to fall production. In addition to having thornless canes, this new introduction produces very large berries with good flavor and is very early ripening on floricanes, the earliest of all Arkansas blackberries. Fruit of 'Prime-Ark® Freedom' does not exhibit exceptional postharvest storage potential, however, and it is not recommended for the shipping market.

Origin

'Prime-Ark® Freedom' resulted from a cross of A-2301 × APF-49T (Fig. 1) made in 2004 at the University of Arkansas Fruit Research Station, Clarksville (FRS). The original plant was selected in June 2007 from a population of 309 plants in a seedling field at the same location during evaluation of floricane fruits. It was tested as selection APF-153T. At the time of selection, it was noted to have very large fruit along with thornless canes, although the floricane crop was very light as a result of a spring freeze, which severely damaged flower buds, flowers, and small berries. Primocane fruiting was confirmed by examining the original selection plant later in the summer after flower buds were seen on primocanes.

The primocane-fruiting trait is recessive, as is thornlessness, and the combination of these two traits in this new cultivar took substantial time and effort to produce the expression of these traits in a tetraploid plant. The origin of the primocane-fruiting trait is the thorny genotype 'Hillquist', which was first used in crossing in the Arkansas program in 1967 (Fig. 1). Although the effort in primocane fruiting did not intensify in the Arkansas program until the mid- to late 1990s, most of the early primocane-fruiting germplasm in the program was thorny. Crossing among elite thornless, floricane-fruiting selections to bring enhanced fruit size and quality into the primocane-fruiting germplasm culminated in the first thornless cultivar with this unique fruiting habit.

Description and Performance

After selection, two, 6.1-m plots of 'Prime-Ark® Freedom' were established at FRS [west–central Arkansas, lat. 35°31′58″ N, long. 93°24′12″ W; U.S. Dept. of Agriculture (USDA) hardiness zone 7a] in the summer of 2007. Plots were established by moving the original plant along with planting root cuttings collected from the original plant. Observational data were taken on the selection in these plots at the time of floricane fruiting in 2009 and continued through 2013. Unfortunately, the plots of 'Prime-Ark® Freedom' were located in a very wet area of the selection field and plot establishment and plant performance were very poor. However, a limited number of fruits was produced on the plants, and the size and quality were noted and the selection was quickly placed in a replicated site elsewhere at FRS. Also in the selection field were single plots of comparison primocane-fruiting cultivars Prime-Jan®, Prime-Jim®, and Prime-Ark® 45 along with the floricane-fruiting cultivars Natchez, Osage, and Ouachita from which observational data were collected during this same evaluation period. In all plantings, standard cultural practices for erect blackberry production were used including annual pre-emergence and post-emergence herbicide applications and annual spring nitrogen fertilization (56 kg·ha^{-1} N) using ammonium nitrate. The primocane genotypes received another application of 23 kg·ha^{-1} N after the floricane crop was completed, which was in early July. All genotypes had primocanes tipped at 1.1-m height two times each season usually in mid-June and late July or early August. Dormant pruning of primocane-fruiting genotypes consisted of removing dead floricanes and also removing primocane tissue to a point below the fruiting/flowering area on the primocanes. All primocane-fruiting genotypes were allowed to produce floricane and primocane crops in these plots. Floricane-fruiting genotypes received dormant pruning, which consisted of removing dead floricanes and pruning lateral branches to ≈0.4 m in length. All plantings received a single application of liquid lime sulfur (94 L·ha^{-1}) at budbreak for control of anthracnose [*Elsinoë veneta* (Burkh.) Jenkins]. This was the only fungicide applied to any plantings in any year. Raspberry crown borer (*Pennisetia marginata* Harris) was controlled by a single application of a labeled insecticide in October of each year. All plots were irrigated as needed using overhead sprinkler irrigation.

Floricane fruit ratings were taken for all genotypes based on a rating scale of 1 to 10, where 10 = best, for 5 years (2009–13) for firmness (as measured subjectively by hand in the field on eight to 10 berries with a rating of 10 indicating very firm) and flavor (subjectively rated by tasting berries in the field with 10 being exceptional flavor).

A replicated trial was established at FRS in May of 2010. This trial consisted of two replications. Plots in these trials were 3.1 m in length containing five plants produced from adventitious shoots produced from root cuttings spaced at 0.6-m intervals. The cultivars Prime-Ark® 45, Natchez, Osage, and Ouachita were included for comparison in the trial. Cultural management of this trial was the same as described previously with the exception of drip irrigation being used and in 2013, insecticides labeled for commercial use in Arkansas were used for spotted-wing drosophila (*Drosophila suzukii* Matsumura) control. Data for 10% and 50% floricane bloom and floricane first, peak, and last harvest dates along with average berry weight (25 berries measured at three harvest dates for each replication) and yield were recorded for 2011–13, although in 2013, data for 'Natchez', 'Osage', and 'Ouachita' were not collected. Data for replicated trials were analyzed for each year separately as a randomized complete block by the GLM procedure of SAS (SAS Institute, Inc., Cary, NC) and means separated by least square means for 2011 and *t* test for 2012 and 2013.

Postharvest evaluations were done on floricane fruits for 'Prime-Ark® Freedom' and several other cultivars for 2010–13 for fruit from FRS. The procedures used were developed over a multiyear period in the 1990s where various measurements were taken to develop a system for genotype evaluation for potential shipping (Clark and Perkins-Veazie, 2011). Dry, shiny-black berries (not treated with preharvest fungicides) were harvested in the morning into hinged, clear, vented, polyethylene 260-g clamshell containers (Century

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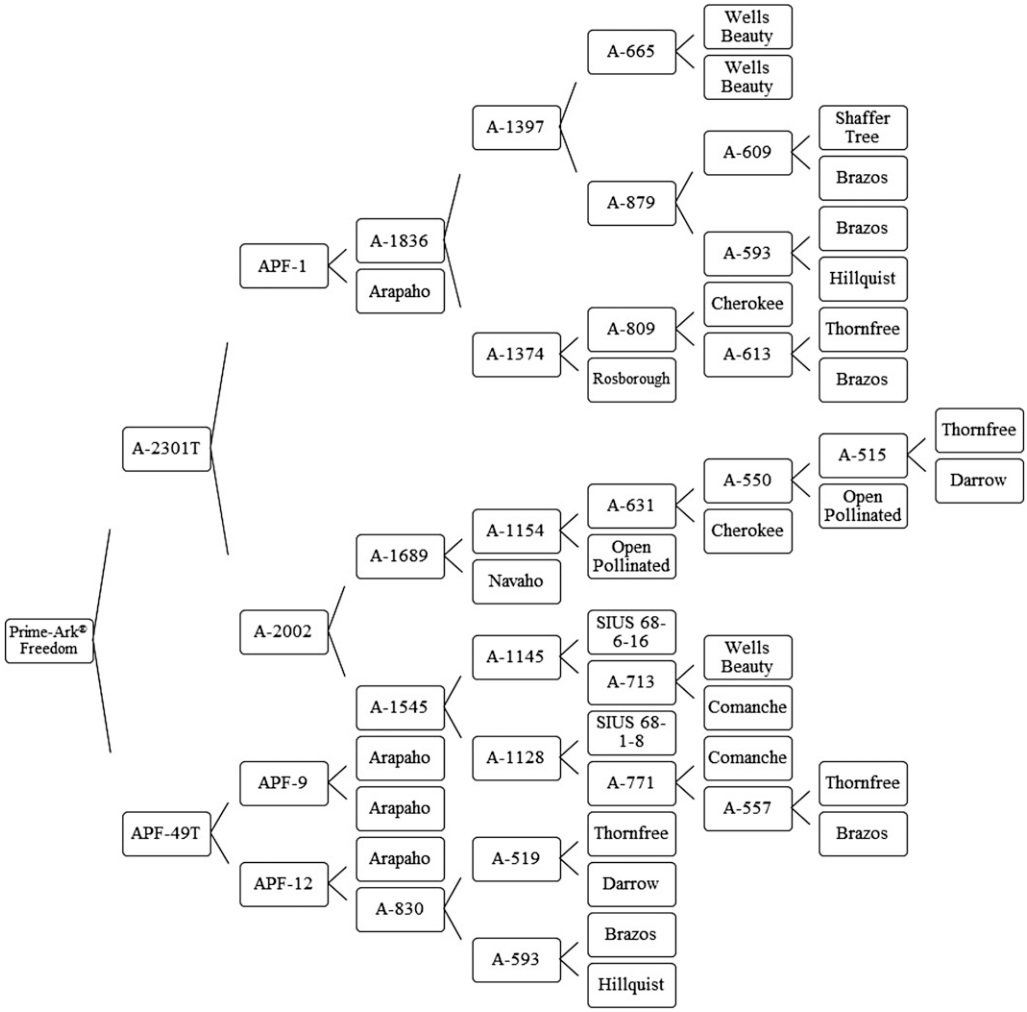

Fig. 1. Pedigree of 'Prime-Ark® Freedom' blackberry.

Corrugated Container, Kilgore, TX). Each clamshell contained on average 20 berries. Two clamshells were gathered from each genotype usually at two consecutive harvest dates (usually resulting in four replications). The berries were then stored at 5 °C, 80% relative humidity for 7 d. Subjective evaluations were made for firmness, presence or absence of visible mold, leak, or reddening. Each berry was removed from the container, determined to be firm (1) to falling apart (5) by using finger pressure between thumb and forefinger and placed in rows for each firmness rating. Percent soft berries were those in the 4 and 5 rating categories. Each berry was rolled gently on a white paper towel and counted as leaky if juice spots appeared. The berries were rated on a yes/no scale for presence of red drupelets in clusters of three or more in 2010, 2011, and 2012. In 2013 berries were rated as having red drupelets if only a single drupelet showed red development. All ratings were converted to percentages based on the total number of fruit in the clamshell. The variables of percent berries decayed, with leakage, and soft were used in a calculation for marketability. The overall performance value was calculated as: 100 – {sum [% decayed + % soft (3-, 4-, and 5-rated berries) + % leaky]}. Postharvest data were analyzed by analysis of variance by year and means separated by *t* test.

Table 1. Floricane yield and berry weight (average weight of 25 berries measured three times each year) of two primocane-fruiting and three floricane-fruiting blackberry genotypes in a replicated trial at the University of Arkansas Fruit Research Station, Clarksville, established in 2010.

	Yield (kg·ha^{-1})			Wt/berry (g)		
Cultivar	2011[z]	2012[y]	2013[y]	2011[z]	2012[y]	2013[y]
			Floricane harvests			
Prime-Ark® Freedom[x]	6,258 b	10,740 a	17,529 a	9.2 a	8.7 a	12.6 a
Natchez	19,773 a	19,448 a	—	7.6 b	7.3 b	—
Osage	13,681 ab	14,461 a	—	5.0 c	5.1 d	—
Ouachita	12,076 ab	15,716 a	—	5.5 c	5.8 c	—
Prime-Ark® 45[x]	7,866 b	13,238 a	23,501 a	5.5 c	5.4 cd	6.2 b
			Primocane harvests			
Prime-Ark® Freedom	—	911 a	2,893 a	—	7.5 a	8.8 a
Prime-Ark® 45	—	214 a	3,663 a	—	4.8 b	5.8 b

[z]Mean separation within columns by least square means ($P < 0.05$).
[y]Mean separation within columns by *t* test ($P \leq 0.05$).
[x]Floricane harvested fruits only.

An additional site of evaluation was a single, 10-plant plot (6.1 m) of 'Prime-Ark® Freedom' located in Watsonville, CA (lat. 36°54′37″ N, long. 121°45′20″ W; USDA hardiness zone 9) with primocane-fruiting data collected in 2011 and 2012 on plants established in 2010. Canes were managed with primocanes double-tipped, first at 50 cm and then subsequent branches tipped at ≈50 cm. Data for harvest period, yield per plant, average berry weight, soluble solids, and postharvest performance (using a similar system as described previously except decay was not recorded) were collected from these plots in 2011–12.

Floricane yields of 'Prime-Ark® Freedom' in 2011 were comparable to 'Prime-Ark®

45', 'Osage', and 'Ouachita' but lower than 'Natchez' (Table 1) in the replicated trial. For 2012, yields among all cultivars were similar and usually higher than in 2011. For 2013, yields were similar for 'Prime-Ark® Freedom' and 'Prime-Ark® 45' and were substantially higher than other years. Although the floricane yields of 'Prime-Ark® Freedom' were generally less (either statistically significant or numerically) than those for the most productive floricane-fruiting cultivars, the floricane yield was substantial and commercially acceptable. Primocane yields were very disappointing at FRS for both primocane-fruiting cultivars, and this is the result of very high summer temperatures from June into September in 2011 (where no primocane yields were recorded) and 2012. Primocane yields for both cultivars were similar and much greater in 2013 compared with 2012, and this was the result of much more moderate daytime high temperatures in July and August of 2013. It has been shown in field observation in Arkansas, and in a controlled-environment study in Ohio, that high temperatures reduce bud and bloom development and result in low productivity, small berries, and low-quality fruit in primocane-fruiting blackberries (Clark and Perkins-Veazie, 2011; Stanton et al., 2007). Therefore, growers of 'Prime-Ark® Freedom' or other primocane-fruiting cultivars should be aware of this substantial limitation in these genotypes. One positive aspect of the reduced primocane production is that this results in substantial yield potential if the canes are retained for the floricane crop the next year. 'Prime-Ark® 45' has been found to have substantial commercial production potential when fruited by growers on floricanes (personal observation from grower reports).

Yield data from the California trial indicated substantial promise for 'Prime-Ark® Freedom' because it produced 5.6 and 4.2 kg/plant in 2011 and 2012, respectively, which translates to a commercial yield potential using 7,200 plants per hectare of over 30,000 to 40,000 kg·ha^{-1}, substantially more than the yield for 'Prime-Ark® Freedom' in Arkansas. Although there was no comparison cultivar in this trial, yields of 'Prime-Ark® Freedom' were comparable to those found for 'Prime-Ark® 45' on primocanes in a prior trial (Clark and Perkins-Veazie, 2011). This site has very moderate temperatures, usually with midday highs from 22 to 25 °C in August for example, much lower than that experienced in Arkansas. The moderate temperatures allowed for much better expression of the primocane-fruiting trait and thus higher yield potential.

Average floricane berry weight of 'Prime-Ark® Freedom' ranged from 8.7 to 12.6 g in the FRS replicated trial (Table 1), significantly larger than all other entries including the large-fruited 'Natchez'. This is a very noteworthy attribute and one that will greatly enhance its desirability as either a home garden or local sales cultivar because large fruit is preferred by many consumers. For primocane berries, weight in Arkansas was slightly less for 'Prime-Ark® Freedom' (7.5 and 8.8 g in 2012 and 2013, respectively) compared with the floricane fruits of the same cultivar and was significantly larger than 'Prime-Ark® 45'. In California, primocane berry weight was observed to be much higher than that found in Arkansas, just over 16 g in 2011 and 13 g in 2012. In a prior report, 'Prime-Ark® 45' was reported to average just over 7 g/berry on primocanes at this same location in 2008 (Clark and Perkins-Veazie, 2011).

Fruit of 'Prime-Ark® Freedom' is elongated to blocky and attractive with a glossy, black finish (Figs. 2 and 3). Fruit shape varies on primocanes and can be reduced in

Fig. 2. 'Prime-Ark® Freedom' with fruits on floricane, Fruit Research Station, Clarksville, AR.

Fig. 3. 'Prime-Ark® Freedom' with fruits on primocane, Watsonville, CA.

Table 2. Plant and fruit characteristics of five blackberry genotypes at the University of Arkansas Fruit Research Station, Clarksville, with data collected from 2010 replicated planting and observational plots.

	Cultivar				
Characteristic	Prime-Ark® Freedom	Natchez	Osage	Ouachita	Prime-Ark® 45
			2011		
Floricane bloom date[z]					
10% bloom	13 Apr.	2 Apr.	19 Apr.	27 Apr.	20 Apr.
50% bloom	16 Apr.	20 Apr.	25 Apr.	4 May	26 Apr.
			2012		
Floricane bloom date[z,y]					
10% bloom	26 Mar.	2 Apr.	2 Apr.	5 Apr.	27 Mar.
50% bloom	1 Apr.	4 Apr.	5 Apr.	11 Apr.	2 Apr.
			2013		
Floricane bloom date[z,y]					
10% bloom	19 Apr.	—	—	—	20 Apr.
50% bloom	25 Apr.	—	—	—	26 Apr.
			2011		
Floricane harvest date[z]					
First	28 May	6 June	9 June	13 June	6 June
Peak	6 June	13 June	20 June	28 June	18 June
Last	20 June	7 July	25 July	25 July	18 July
			2012		
Floricane harvest date[z]					
First	6 May	17 May	21 May	24 May	17 May
Peak	21 May	29 May	29 May	5 June	29 May
Last	8 June	25 June	25 June	28 June	28 June
			2013		
Floricane harvest date[z]					
First	4 June	—	—	—	13 June
Peak	17 June	—	—	—	1 July
Last	27 June	—	—	—	16 July
Fruit[x]					
Firmness[w]	7.6 (0.6)	7.8 (0.5)	8.2 (0.5)	8.6 (0.6)	8.2 (0.5)
Flavor[w]	7.6 (0.6)	7.0 (0.7)	8.2 (0.5)	8.6 (0.6)	7.6 (0.6)
Soluble solids (%)[v]	9.7 (1.1)	11.3 (2.5)	11.8 (0.8)	11.6 (1.5)	10.8 (0.7)

[z]Data from 2010 replicated trial.
[y]2012 bloom data are shown as the median of two replicated blocks of data from a 2010 planted replicated trial.
[x]Rating scale of 1 to 10 where 10 = best.
[w]Means of 5 years, 2009–13, with data collected on observational plots with (SD).
[v]The mean soluble solids data from 2011, 2012, and 2013 are represented with (SD).

Table 3. Postharvest evaluations of Prime-Ark® Freedom compared with other blackberry genotypes from 2010–13 in Clarksville, AR (7 d in cold storage at ≈5 °C).

Genotype	No.	Overall[z]	Red (%)[y]	Leak (%)[x]	Decay (%)[w]	Soft (%)[v]
			2010			
Prime-Ark® Freedom	2	38.9 ab[u]	0.0 a	44.4 a	0.0 a	0.0 a
Natchez	6	21.2 b	5.03 a	27.7 a	0.0 a	16.33 bc
Ouachita	6	55.1 ab	0.0 a	20.4 a	1.6 a	2.5 a
Prime-Ark® 45	4	72.7 a	0.0 a	19.9 a	0.0 a	0.0 a
Prime-Jan	4	25.4 b	6.8 a	35.0 a	2.9 a	3.0 a
Tupy	4	–23.29 c	5.2 a	56.3 b	3.1 a	26.0 c
			2011			
Prime-Ark® Freedom	4	–19.8 c	0.0 a	67.8 a	7.8 a	14.8 ab
Natchez	6	23.8 b	0.0 a	30.8 bc	0.0 a	6.3 bc
Ouachita	4	56.0 ab	1.5 a	18.5 c	2.3 a	1.0 c
Prime-Ark® 45	6	54.5 a	0.5 a	20.8 c	1.0 a	4.3 bc
Prime-Jan	6	–6.8 c	0.5 a	37.0 b	5.2 a	23.3 a
			2012			
Prime-Ark® Freedom	4	39.3 a	19.3 a	34.0 a-h	1.3 a	5.0 a
Natchez	6	76.3 a	7.7 ab	17.3 e-i	0.0 a	0.0 a
Ouachita	8	63.9 a	4.0 b	16.8 e-i	0.0 a	1.8 a
Prime-Ark® 45	8	72.0 a	2.6 b	15.4 ghi	0.9 a	0.9 a
Tupy	4	35.0 a	10.5 ab	32.5 a-h	0.0 a	6.3 a
			2013			
Prime-Ark® Freedom	6	31.3 ab	64.8 a	35.8 a	14.8 ab	2.3 b
Natchez	5	42.2 a	50.2 ab	14.2 a	0.0 b	13.8 ab
Ouachita	4	11.0 ab	32.0 b	21.0 a	6.0 ab	35.3 ab
Prime-Ark® 45	4	16.8 ab	16.8 b	27.0 a	4.8 ab	20.0 ab
Tupy	4	–63.5 b	47.3 ab	50.3 a	26.8 a	61.5 a

[z]Overall ratings are used as an indicator of performance after 7 d in the cooler. Overall is calculated as: 100 – {sum[% decayed + % soft (3-, 4-, and 5-rated berries) + % leaky]}.
[y]The berries were rated on a yes/no scale for presence of red drupelets in clusters of three or more in 2010, 2011, and 2012 and expressed as the percentage of berries with this red drupelet development. In 2013 berries were rated as having red drupelets if only a single drupelet showed red development; again percentage of berries are reported.
[x]The berries were rated on a yes/no scale for presence of leakiness and the percent exhibiting leakiness is reported.
[w]The berries were rated on a yes/no scale for presence of decay with the percentage of berries with decay reported.
[v]The berries were rated on a 1 to 5 scale for softness, where 1 = firm and 5 = collapsed berry, very leaky. Means represent the percentage of berries that scored a 4 or 5.
[u]Means followed by the same letter are not significantly different ($P > 0.05$) by t test.
n = number of clamshells/replications evaluated after storage.

glossiness and color as a result of heat in Arkansas but is uniform in more suitable environments. Also observed in Arkansas were numerous double fruits on primocanes, more common than seen on 'Prime-Ark® 45', and this is thought to be related to high temperatures during flower development. Soluble solids concentration for floricane fruits over 5 years averaged 9.7% for 'Prime-Ark® Freedom', slightly lower than the comparison cultivars (Table 2). Soluble solid values for 'Prime-Ark® Freedom' primocane fruits from the California test site were 10.8% in 2011 and 11.0% in 2012 (data not shown). Flavor ratings for 'Prime-Ark® Freedom' averaged 7.6, the same as for 'Prime-Ark® 45', near that for 'Natchez (7.8), but lower than 'Ouachita' (8.6) and 'Osage' (8.2) (Table 2). Flavor comments over the years in both Arkansas and California indicated berries were routinely sweet in flavor, although occasionally were noted as tart in both locations. Field firmness ratings averaged 7.6 for 'Prime-Ark® Freedom', near the 7.8 rating for 'Natchez', but lower than that of the other cultivars (Table 2).

Postharvest evaluations for floricane fruits stored for 7 d at FRS indicated variable performance for 'Prime-Ark® Freedom' (Table 3). For all years except 2013, 'Prime-Ark® Freedom' had either significantly or numerically lower overall ratings compared with 'Prime-Ark® 45', indicating limited consistent shipping potential. Berry leak was the primary variable that 'Prime-Ark® Freedom' had poor ratings for with some concerns for soft berries. In 2012 and 2013, berry reddening was a concern. In postharvest evaluations in California, berry reddening and soft ratings were limiting and in some instances more common than the data from Arkansas (data now shown). Based on these data, 'Prime-Ark® Freedom' is not recommended for the shipping market because it does not appear to have the same shipping potential of excellent shipping cultivars such as 'Ouachita' and 'Prime-Ark® 45'. In all comparisons of postharvest evaluations of 'Prime-Ark® Freedom' and 'Tupy', 'Prime-Ark® Freedom' was comparable or better in postharvest performance. Because 'Tupy' is the most widely grown fresh-market blackberry in the world as a result of extensive production in central Mexico, one might conclude that 'Prime-Ark® Freedom' has comparable or better postharvest potential. That cannot be confirmed without a comparison of berries from the cultivars grown in that production region. The data shown here indicate that 'Prime-Ark® Freedom' should be acceptable for pick-your-own operations or possibly local marketing where 7-d or longer storage potential is not required.

Floricane bloom dates for 'Prime-Ark® Freedom' were usually earlier than all comparison cultivars (Table 2). This could indicate a lower chilling requirement for this cultivar but that has not been confirmed during the evaluations as a result of the FRS site being a high-chill location.

Floricane first harvest date for 'Prime-Ark® Freedom' was the earliest of any cultivars in the replicated trials, 9 to 11 d earlier than the early-ripening 'Natchez' and 16 to 18 d before 'Ouachita' (Table 2). This exceptionally early floricane harvest date should make this cultivar very attractive to homeowners and local marketers because it provides very early fruit, earlier than any prior Arkansas thornless blackberry cultivar.

Primocane first bloom date for 'Prime-Ark® Freedom' was difficult to fully assess during evaluation in Arkansas. The major limitations were that the original plot of this cultivar did not establish well at FRS as a result of a poor site and plant performance was not good, and the 2011 and 2012 seasons were exceptionally hot at FRS and this led to poor primocane flowering in the replicated trial plots. However, generally the primocane bloom date ranged from late June to early July at FRS, earlier than 'Prime-Ark® 45' by up to 14 d (data not shown). Limited primocane bloom was seen later in the season into August to October in some years, particularly 2013, indicating the potential for the late summer to fall crop if improved temperature conditions occurred. Primocane bloom date was not recorded for the California test site.

Primocane first ripe fruit date was also difficult to fully determine for 'Prime-Ark® Freedom' in Arkansas. Observations indicated that first ripe fruit was 18 to 20 July on tipped primocanes at FRS, although fruit amount was limited, and ripened earlier than an average date reported for 'Prime-Ark® 45' of 8 Aug. (Clark and Perkins-Veazie, 2011). More substantial data were recorded in 2011 at the California test site where 'Prime-Ark® Freedom' began harvest ≈10 to 15 Aug. with harvest extending into early October compared with 'Prime-Ark® 45', which was reported to begin harvest from 20 Aug. to 19 Sept., depending on cane tipping management. This performance could also be of particular importance in more northern areas of the United States in that late-ripening fruit of primocane blackberries may be frost-damaged in the upper Midwest or similar climates.

Canes of 'Prime-Ark® Freedom' are very erect, similar to 'Ouachita' and more erect than 'Natchez' (data not shown). Vigor rating of 'Prime-Ark®' Freedom' was low in the FRS plants established in the poor site but showed good vigor on a more appropriate site at FRS. In California the plants were

observed to be very vigorous. No orange rust [caused by *Gymnoconia nitens* (Shwein.) F. Kern & H.W. Thurston] was observed on 'Prime-Ark® Freedom' in any evaluations, although infected plants were seen within 30 to 50 m of data collection plots in each year of evaluation. 'Prime-Ark® Freedom' berries or canes have not been observed to be susceptible to anthracnose at FRS where a single spray of lime sulfur was applied. Reaction of 'Prime-Ark® Freedom' to rosette/double blossom [*Cercosporella rubi* (Wint.) Plakidas] has not been conducted because this disease did not occur at any of the test sites. It is hoped that it has resistance to this disease as exhibited by other Arkansas thornless blackberry cultivars.

'Prime-Ark® Freedom' is an exciting development because it is the first thornless plant of this blackberry type released for commercial introduction in the world. Its potential to produce two crops each year, both being early to very early in ripening, is another unique attribute of this cultivar. Its exceptional fruit size should make it a very noteworthy blackberry for home gardeners or local market growers. 'Prime-Ark® Freedom' is recommended for home garden use and local market trials to determine overall adaptation and use in diverse climates.

Availability

An application for a U.S. plant patent has been filed for 'Prime-Ark® Freedom'. Nurseries will be licensed in the United States and other countries for propagation; a list of these can be attained from John R. Clark (jrclark@uark.edu).

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