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Blueberry and Blackberry Cultivar Evaluation in Missouri, 2011-2016

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Abstract

Thirteen highbush blueberry and fourteen erect to semi-erect blackberry cultivars were evaluated for productivity at Mountain Grove in south-central Missouri. The planting was established starting in 2009 on a Viraton silt loam soil. Soil was amended with organic matter and lime or sulfur to adjust pH. Plant spacing was 1.5 m (5 ft) in-row and 3.7 m (12 ft) between rows. Drip irrigation was installed and rows mulched with shredded bark. The highest yielding highbush blueberry cultivars were 'Aurora', 'Bluegold', 'Elliott', 'Legacy', and 'Liberty' at 3.4 kg (7.6 lb) per plant average (2011-2016). 'Bluecrop', a standard cultivar in Missouri, yielded just under 1.9 kg (4.2 lb) per plant average (2011-2016). Average fruit weight was 1.6 g for the thirteen cultivars. The highest yielding blackberry cultivars were 'Chester' and 'Triple Crown' at 3.9 kg (8.6 lb) per plant average (2011-2016). Average fruit weight was 5.9 g for the fourteen cultivars.

Introduction

Highbush blueberry is a North American species (*Vaccinium corymbosum* L.); however, its culture has spread to the temperate regions of South America, Europe, China, Japan, Australia, and New Zealand (Retamales and Hancock, 2012). Selections from the wild by Elizabeth White of Whitesbog, NJ and released cultivars from the USDA breeding work of Frederick Coville and George Darrow from the early to mid-1900's form the cultivar basis of modern day production (Hancock, 1989a; Retamales and Hancock, 2012). 'Rubel' a wild selection is still grown today. Breeding work continued from the 1960's through 2000 by Arlen Draper (USDA) and Paul Lyrene (University of Florida) (Hancock, 2009). The result was northern, intermediate, and southern adapted highbush blueberry cultivars (Hancock, 2006b; Hancock, 2009). Michigan and New Jersey are the major highbush blueberry producing states (Hanson and Hancock, 1990). Aside from highbush blueberry, both a substantial land area and harvest for fruit processing occurs from lowbush blueberry that grows in natural, wild stands in eastern North America (Hancock, 1989a; Retamales and Hancock, 2012). Highbush cultivar selection emphasis is on characters of fruit (bloom date, flavor, longer storage, expanded harvest) and plant (chilling requirement, cold tolerance, disease and pest resistance, machine harvestability) (Hancock, 1989a; Hancock, 2009, Moore, 1993).

Blackberry is widely distributed in the temperate regions of the world and wild fruit make-up a large part of production (Strik et al., 2007). Breeding has contributed greatly to its genetic improvement in the United States with Arkansas and Oregon leading in cultivar development (Clark and Finn, 2011). Dr. James Moore, released eight blackberry cultivars from 1964 to 1997 that were well adapted to the mid-continent United States, three of them being thornless (Clark, 1999). Cultivar selection emphasis is on characters of fruit (yield, size, soluble solids, retail shipping) and plant (thornlessness, primocane

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fruiting, disease resistance) (Clark, 2005; Clark and Finn, 2011).

Evaluation of small fruit cultivars has been an ongoing research project at the State Fruit Experiment Station of Missouri State University. Growers and the general public are interested in knowing about productive fruit cultivars for their plantings. The mid-continental climate of Missouri is suitable for temperate fruit species, but there are challenges in growing fruit in this climate. USDA Plant Hardiness Zones 5 and 6 encompass the state, so winter low temperature events and fluctuating temperatures during late winter can periodically damage fruit plants. Late spring frost is another hazard to fruit plants, although blueberry and blackberry are not prone to frost injury. Yearly precipitation is adequate for fruit plant growth; however, it can be unpredictable, going from adequate to excess to drought or in any combination of these in the same growing season. Rainfall assures a high relative humidity during the growing season which makes pests (weeds, diseases, insects) an ongoing problem for the fruit grower. Even with these challenges in fruit growing, there will always be individuals that want to grow fruit for local markets or home use. Bush and cane fruits in particular are popular choices because of their lower investment and precocious nature. Consequently, highbush blueberry and erect to semi-erect blackberry plantings were established to test the productivity of cultivars over six growing seasons.

Materials and Methods

The fruit cultivars were evaluated at the State Fruit Experiment Station of Missouri State University at Mountain Grove, MO. The soil is a Viraton series, cherty silt loam soil with 2 to 5 percent slope. A fragipan occurs at 60 to 90 cm (24 to 36 in) depth with moderate water permeability above the fragipan and very low in the pan and below. This layer limits rooting depth for small fruit plants and slows internal drainage during high rainfall periods. Consequently, berms 1.2 m (4 ft) wide by 15 cm (6 in) high in center were formed using a disc implement along intended plant rows to enhance surface drainage. Water holding capacity of the soil is low because of the shallow depth to the fragipan. Drip irrigation was used during periods of inadequate rainfall.

Soil reaction varies with depth from 6.5 to 4.5. Organic matter content also varies from 3.0 to 0.5%. This soil is not suitable for highbush blueberry culture without amending soil pH and organic matter. Conversely, blackberries are suited to this soil. Soil pH was adjusted to 4.7 for blueberry and 6.7 for blackberry prior to planting. Before planting, cover crops were incorporated to increase organic matter to 2.4% for blackberry and 2.9% for blueberry. Fertilizer was applied to bring phosphorus and potassium to maintenance levels [67 kg/ha (60 lb/A) available P and 280 kg/ha (250 lb/A) exchangeable K]. Calcium, magnesium, and sulfur are typically adequate in native soil. Nitrogen as ammonium sulfate for blueberry and urea for blackberry was applied in one or two split applications annually starting at 45 kg/ha (40 lb/A) in 2009 and increasing to 110 kg/A (100 lb/A) in 2016. Sphagnum peat moss at 3.8 L (1 gal) was mixed into each blueberry planting hole. Plant rows of blueberry and blackberry were mulched with shredded bark.

Thirteen highbush blueberry (*Vaccinium corymbosum* L.) and fourteen erect to semi-erect blackberry (*Rubus* hybrids) were planted in 2009 (Tables 1 and 2). Eleven blackberry cultivars were floricane fruiting types. The three primocane fruiting blackberries were managed for their summer crops (Table 2). Blueberry and blackberry plant spacing was 1.5 m (5 ft) in-row by 3.7 m (12 ft) between rows. The cultivars were in randomized complete blocks with four, two-plant replications.

Blueberry plants were allowed to grow the first two seasons with only minimal pruning cuts to direct growth. Light to moderate pruning was done thereafter, removing 10 to

Table 1. Northern highbush blueberry cultivars, year introduced, origin, and harvest season planted at Mountain Grove, MO, 2009-2016.

Cultivar	Year introduced	Origin	Harvest season
Arlen	2001	NC-USDA	late
Aurora	2003	Michigan	late
Bluecrop	1952	NJ-USDA	mid
Bluegold	1989	NJ-USDA	mid
Chandler	1994	NJ-USDA	late-mid
Draper	2003	Michigan	early-mid
Duke	1987	NJ-USDA	early
Elliott	1974	MI-USDA	late
Hannah's Choice	2000	NJ-USDA	early
Legacy	1993	MD-USDA	late
Liberty	2003	Michigan	late
Nelson	1988	NJ-USDA	late-mid
Rubel	1912	wild selection	late

20% of the oldest canes. Blackberry plants were managed as biennial canes. Primocanes and floricanes were trained between wires of a double-T trellis. Primocanes were topped at 1.5-1.8 m (5-6 ft) height.

Tall fescue (*Festuca arundinacea* Shreb.) grass was the permanent sod in the row middles. Plant rows were treated with oryzalin, diuron, or simazine at varying rates depending on the age of the plantings for pre-emergence weed control during the evaluation. Sethoxydim or glyphosate were used for post-emergence spot treatment of grass and mixed weed species, respectively during the evaluation.

Plantings were harvested one to two times per week over a four to six week bearing period. Fruit weight harvested per plant was recorded at each picking. Weight of 50 blueberries and 25 blackberries were recorded at each picking. A one-way analysis of variance was performed on the data by year using SPSS Statistics (IBM Corp., Armonk, NY 10504) and means were separated by Tukey-Kramer HSD (P=0.05).

Results and Discussion

Blackberry is well adapted to the mid-continent, temperate climate of Missouri; whereas, highbush blueberry is marginally adapted. The latter can be successfully grown on good sites when its exacting cultural requirements are met. On poorer sites, blueberry is short lived. Regardless, both fruits can be a challenge to grow with the unpredictable weather that Missouri experiences as a mid-continent state. The rise of new pests such as Spotted Wing Drosophila (*Drosophila suzukii*) along with rainfall and high humidity during the growing season requires a grower to have a regular spray program (Asplen et al., 2015). Organic production is not possible.

The usual start of bloom is mid-April for blueberry and early-May for blackberry.

Table 2. Blackberry cultivars, year introduced, origin, characteristics, and harvest season planted at Mountain Grove, MO, 2009-2016.

Cultivar	Year introduced	Origin	Characteristics	Harvest season
Apache	1998	Arkansas	erect, floricane, thornless	late
Arapaho	1992	Arkansas	erect, floricane, thornless	early-mid
Chester	1985	SIU-USDA	semi-erect, floricane, thornless	late
Chickasaw	1998	Arkansas	erect, floricane, thorny	mid
Kiowa	1996	Arkansas	erect, floricane, thorny	mid
Loch Ness	1987	SCRI-UK	semi-erect, floricane, thornless	early
Natchez	2008	Arkansas	semi-erect, floricane, thornless	early
Navaho	1989	Arkansas	erect, floricane, thornless	late-mid
Osage	2012	Arkansas	erect, floricane, thornless	early-mid
Ouachita	2003	Arkansas	erect, floricane, thornless	mid
Prime-Ark 45	2009	Arkansas	erect, primocane, thorny	late
Prime-Jim	2004	Arkansas	semi-erect, primocane, thorny	mid
Prime-Jan	2004	Arkansas	semi-erect, primocane, thorny	mid
Triple Crown	1996	MD-USDA	semi-erect, floricane, thornless	mid

Table 3. Yield (kg) per plant of highbush blueberry cultivars at Mountain Grove, MO, 2011-2016.

Cultivar	2011		2012		2013		2014		2015		2016		2011-16 mean	2011-16 cumulative
Arlen	0.53	abcd	0.95	bcd	2.33	ab	2.87	ab	2.49	ab	3.63	abc	2.13	12.80
Aurora	1.02	abc	1.48	abc	3.86	ab	4.16	ab	4.31	a	6.92	a	3.63	21.75
Bluecrop	0.59	abcd	1.29	abcd	1.83	ab	3.08	ab	1.37	ab	3.07	abc	1.87	11.23
Bluegold	1.25	a	1.56	abc	3.62	ab	5.49	a	4.29	a	5.29	abc	3.58	21.50
Chandler	0.24	cd	0.06	d	2.56	ab	3.86	ab	1.97	ab	3.54	abc	2.04	12.23
Draper	0.28	bcd	1.35	abc	2.38	ab	3.69	ab	2.77	ab	4.66	abc	2.52	15.13
Duke	0.28	bcd	0.84	bcd	2.03	ab	1.97	ab	1.96	ab	1.54	bc	1.44	8.62
Elliott	0.57	abcd	2.19	a	3.63	ab	2.99	ab	4.14	a	5.89	ab	3.24	19.41
Hannah's Choice	0.27	bcd	1.44	abc	1.75	ab	2.46	ab	3.84	ab	1.61	bc	1.90	11.37
Legacy	0.90	abc	2.04	ab	3.85	ab	4.20	ab	3.97	ab	5.35	abc	3.39	20.31
Liberty	1.07	ab	1.85	abc	4.11	a	5.02	a	3.10	ab	5.05	abc	3.37	20.20
Nelson	0.05	d	0.89	bcd	1.12	b	2.17	ab	2.93	ab	4.91	abc	2.01	12.07
Rubel	0.29	bcd	0.73	cd	2.45	ab	2.98	ab	3.16	ab	4.20	abc	2.30	13.81
Mean	0.56		1.28		2.73		3.46		3.10		4.28		2.57	15.42

[z]Means in a column not followed by a common letter are significantly different by Tukey-Kramer HSD, $P \leq 0.05$.

Fruit usually begin to ripening in early June for blueberry and early July for blackberry. Yields were determined from two-plant plots. Consequently, a conservative estimate of yield extrapolated to greater plant numbers or larger acreage should be made from per plant yields. Hancock et al. (1997) suggested that commercial strawberry growers might expect about one-half to two-thirds of cultivar trial yields. This assumption might also be made for other small fruits.

This trial included highbush cultivars 'Bluecrop', 'Duke', 'Elliott', and 'Rubel' that have become standards in the industry (Strik et al., 2007). 'Bluecrop' and 'Rubel' were the result of breeding and selection efforts of Frederick Coville in the early 1900's (Hancock, 2006a). 'Duke' and 'Elliott' were later releases from the USDA breeding program under Arlen Draper (Hancock, 2009). USDA and Michigan cultivar releases from 1973 and on can be compared to the industry standards. In most cases the cumulative yields met or exceeded those standards in this trial.

Blueberry yield per plant increased through 2016 for most cultivars, but could be quite variable across cultivars within years (Table 3). No or few significant differences occurred across cultivars within years. Yields for most cultivars were similar in the last three years of the trial. The highest yielding cultivars were 'Aurora', 'Bluegold', 'Elliott', 'Legacy', and 'Liberty'; all averaged at least 3.4 kg (7.6 lb) per plant and 20.6 kg (45.5 lb) cumulative (2011-2016). 'Arlen', 'Bluecrop', 'Chandler', 'Draper', 'Hannah's Choice', 'Nelson', and 'Rubel' were moderate yielding. Yield for these seven cultivars averaged 2.1 kg (4.7 lb) per plant and 12.7 kg (27.9 lb) cumulative (2011-2016). 'Duke' was the remaining lowest yielding cultivar and should not be considered in Missouri based on the better yielding cultivars unless its early bearing is desired.

Berry weights varied from year to year depending on yield (Table 4). Berry weights were highest for 'Arlen', 'Aurora', 'Chandler', and 'Nelson' (2011-2016). Berries averaged 1.8 to 2.0 g; these were noticeably larger and more desirable for home or market growers. Berry weights averaged 1.4 to 1.6 g for 'Bluecrop', 'Draper', 'Duke', 'Elliott', 'Hannah's Choice', 'Legacy', and 'Liberty'. Berry weights for 'Bluegold' and 'Rubel' were 1.0 to 1.3 g, respectively. There is a place for small blueberries in the food processing industry. Berries 1.5 g or larger are desirable for the fresh market.

A cultivar trial conducted at Simcoe, Ontario from 1994 through 2001 had 'Bluecrop', 'Bluegold', 'Duke', 'Elliott', and 'Nelson' among others (Dale and Hancock, 2005). For these five cultivars, average yield was 1.6 kg (3.4 lb) per plant and average berry weight was 1.4 g. They recommended 'Duke' and 'Nelson' from that trial. 'Nelson'

Table 4. Berry weight (g) of highbush blueberry cultivars at Mountain Grove, MO, 2011-2016.

Cultivar	2011		2012		2013		2014		2015		2016		2011-16 mean
Arlen	1.87	abc	1.92	ab	1.52	bcd	1.93	abc	1.68	abcd	1.74	a	1.78
Aurora	2.28	ab	1.94	ab	1.49	bcd	1.97	abc	1.44	bcd	1.63	ab	1.79
Bluecrop	1.45	bcd	1.67	bc	1.33	bcd	1.54	bcd	1.41	bcd	1.46	abc	1.48
Bluegold	1.38	cd	1.17	de	1.39	bcd	1.16	cd	1.47	abcd	1.24	bcd	1.30
Chandler	2.38	a	0.92	e	2.43	a	2.56	a	2.01	a	1.63	ab	1.99
Draper	2.03	abc	1.32	cde	1.45	bcd	1.66	abcd	1.93	ab	1.35	abcd	1.62
Duke	2.38	a	1.35	cde	1.22	bcd	1.41	bcd	1.44	bcd	0.90	d	1.45
Elliott	1.66	abcd	1.58	bcd	1.35	bcd	1.36	bcd	1.20	cd	1.47	abc	1.44
Hannah's Choice	2.04	abc	1.33	cde	1.83	ab	1.65	abcd	2.00	a	1.13	cd	1.66
Legacy	1.85	abc	1.49	bcd	1.53	bcd	1.54	bcd	1.87	ab	1.33	abcd	1.60
Liberty	1.73	abcd	1.53	bcd	1.20	bcd	1.62	abcd	1.51	abcd	1.28	abcd	1.48
Nelson	2.36	a	2.28	a	1.61	bc	2.22	ab	1.74	abc	1.66	ab	1.98
Rubel	0.94	d	1.24	cde	0.89	d	0.82	d	1.24	cd	1.08	cd	1.04
Mean	1.87		1.52		1.48		1.65		1.61		1.38		1.58

[z]Means in a column not followed by a common letter are significantly different by Tukey-Kramer HSD, P ≤ 0.05.

appears to be productive in Missouri. 'Elliott' was the most productive cultivar out of six in Michigan (Hancock, 1989b). 'Bluecrop' and 'Rubel' were common to that trial and this one. They attributed productivity of 'Elliott' to more fruiting laterals per cane, more flowers per bud, and higher fruit set. 'Elliott' appears to be productive in Missouri. Hancock (2006b) stated that the use of *V. darrowi* in the breeding of intermediate and southern types of highbush blueberry resulted in greater climate adaption. He gave intermediate type examples of 'Arlen', 'Legacy', and 'Ozarkblue'. Presumably, these would be better adapted to Missouri. 'Arlen' and 'Legacy' were in this trial. 'Legacy' and 'Ozarkblue' were evaluated in a previous trial at the station and both were productive cultivars with respective average yields of 4.4 kg (9.7 lb) and 3.5 kg (7.7 lb) per plant over eight years (Kaps et al., 2010).

Blackberry yield per plant was variable across cultivars within years, and over the years of the trial (Table 5). For most, but not all cultivars, yields increased through 2015 and declined in 2016. 'Chester' and 'Triple Crown' were the highest yielding cultivars; these averaged 3.9 kg (8.6 lb) per plant and 23.5 kg (51.8 lb) cumulative (2011-2016). 'Apache', 'Kiowa', 'Loch Ness', 'Natchez', 'Navaho', 'Osage', 'Ouachita', and 'Prime-Ark 45' were moderate yielding. Yield for these eight cultivars averaged 2.1 kg (4.7 lb) per plant and 12.7 kg (27.9 lb) cumulative (2011-2016). 'Arapaho', 'Chickasaw', 'Prime-Jim', and 'Prime-Jan' were lowest yielding and should not be considered in Missouri based on better

Table 5. Yield (kg) per plant of blackberry cultivars at Mountain Grove, MO, 2011-2016.

Cultivar	2011		2012		2013		2014		2015		2016		2011-16 mean	2011-16 cumulative
Apache	1.48	bcd	1.45	abc	1.56	bc	2.63	ab	3.18	bc	1.87	ab	2.03	12.17
Arapaho	0.15	f	0.69	cde	1.89	bc	1.10	b	1.51	cd	1.03	ab	1.06	6.37
Chester	3.16	a	1.09	bcde	5.23	a	6.15	a	6.70	a	3.54	a	4.31	25.87
Chickasaw	0.29	ef	1.19	abcde	0.77	c	1.42	b	0.65	cd	1.54	ab	0.98	5.86
Kiowa	1.24	bcde	1.39	abcd	1.57	bc	4.75	ab	2.67	bcd	3.33	a	2.49	14.95
Loch Ness	0.44	def	1.38	abcde	2.59	b	2.91	ab	4.73	ab	3.66	a	2.62	15.71
Natchez	0.83	cdef	0.95	cde	1.78	bc	4.10	ab	4.54	ab	1.98	ab	2.36	14.18
Navaho	1.75	bc	1.31	abcde	0.98	bc	4.38	ab	2.59	bcd	1.87	ab	2.15	12.88
Osage	0.34	ef	1.29	abcde	1.26	bc	3.07	ab	2.81	bcd	1.71	ab	1.75	10.48
Ouachita	0.92	bcdef	1.80	ab	0.97	bc	2.57	ab	2.33	bcd	1.58	ab	1.70	10.17
Prime-Ark 45	1.32	bcde	1.49	abc	1.79	bc	3.52	ab	1.46	cd	1.45	ab	1.84	11.03
Prime-Jim	1.07	bcdef	0.56	e	0.83	bc	0.93	b	0.37	d	0.43	b	0.70	4.19
Prime-Jan	0.64	def	0.96	cde	0.80	bc	1.19	b	1.65	cd	0.65	b	0.98	5.89
Triple Crown	1.92	b	1.95	a	2.39	bc	4.52	ab	6.99	a	3.30	a	3.51	21.07
Mean	1.11		1.25		1.74		3.09		3.01		2.00		2.03	12.20

[z]Means in a column not followed by a common letter are significantly different by Tukey-Kramer HSD, P ≤ 0.05.

Table 6. Fruit weight (g) of blackberry cultivars at Mountain Grove, MO, 2011-2016.

Cultivar	2011		2012		2013		2014		2015		2016		2011-16 mean
Apache	7.15	bc	6.30	bcd	7.14	b	6.65	bc	8.49	abc	7.82	ab	7.26
Arapaho	4.83	de	5.04	cde	3.65	e	4.67	cdef	5.42	de	4.76	bcde	4.73
Chester	5.19	cde	5.06	cde	4.76	cde	4.41	def	5.06	de	5.42	bcde	4.98
Chickasaw	7.23	abc	6.78	bc	6.17	bcd	5.57	cdef	5.59	cde	6.42	abcd	6.29
Kiowa	8.73	ab	9.09	a	9.81	a	10.09	a	10.02	a	10.28	a	9.67
Loch Ness	5.90	cde	4.48	de	4.57	de	4.19	def	4.82	de	4.53	bcde	4.75
Natchez	9.30	a	7.13	ab	6.82	bc	8.00	b	8.78	ab	7.23	abc	7.88
Navaho	4.44	de	4.28	e	4.86	cde	3.71	f	4.38	de	4.81	bcde	4.41
Osage	7.09	bc	5.45	bcde	4.20	de	5.72	cdef	5.36	de	5.20	bcde	5.50
Ouachita	5.87	cde	5.20	bcde	4.86	cde	5.58	cdef	5.51	cde	4.83	bcde	5.31
Prime-Ark 45	6.10	cd	6.18	bcde	5.20	bcde	5.89	cde	7.07	abcd	6.51	abcd	6.16
Prime-Jim	4.79	de	4.81	cde	3.80	e	4.82	cdef	4.96	de	4.40	bcde	4.60
Prime-Jan	6.35	cd	4.99	cde	3.62	e	3.97	ef	3.94	e	3.94	cde	4.47
Triple Crown	7.25	abc	6.64	bc	7.07	b	6.57	bc	7.06	abcd	7.04	abc	6.94
Mean	6.44		5.82		5.47		5.70		6.18		5.94		5.92

[z]Means in a column not followed by a common letter are significantly different by Tukey-Kramer HSD, P ≤ 0.05.

yielding cultivars. Additionally, the thorny cultivars 'Chickasaw', 'Kiowa', 'Prime-Ark 45', 'Prime-Jim', and 'Prime-Jan' would likely not be considered by home or market growers in Missouri considering the better yielding thornless cultivars.

Fruit weight was highest for 'Kiowa' at 9.7 g, one of the high yielding, thorny cultivars that would likely not be considered by home or market growers (2011-2016) (Table 6). 'Apache', 'Natchez', and 'Triple Crown' had the next highest fruit weight average of 7.4 g (2011-2016). Fruit weight averages of the remaining cultivars were 4 to 6 g. Larger fruit size is always appealing to both picker and consumer, so this could be a determining factor in cultivar selection assuming that yield is reasonably good. 'Apache', 'Natchez', and 'Triple Crown' fall into this latter category.

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