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Field Performance of Black Raspberry Cultivars in Western New York

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Abstract

Nine black raspberry (*Rubus occidentalis* L.) cultivars ('Allen', 'Black Hawk', 'Bristol', 'Haut', 'Huron', 'Jewel', 'Mac Black', 'Munger', and 'New Logan') were compared over four years (2006 to 2009) in a replicated field trial in western New York. Annual yields and fruit weights were recorded for each cultivar. 'Haut', 'Huron', and 'Jewel' had the highest mean cumulative yields over all four years, while ''Black Hawk' and 'Munger' had the lowest. However, based on the cultivar description of 'Black Hawk' compared to its physical characteristics and performance in this trial, it is likely this cultivar is not true to type and should be re-evaluated in the industry. Therefore this cultivar will be referred to as 'Black Hawk'^{NT} hereafter. 'Jewel' consistently had the greatest mean berry weight across all years, while 'Black Hawk'^{NT} had the lowest berry weight. Harvest began most years in the first week of July and was complete by the end of July; each cultivar typically produced for 14 to 21 days so that harvest across all cultivars averaged 28 days. 'Haut', 'Huron', and 'Jewel' black raspberry cultivars are best suited for production in western New York and other locations with similar climates based on their higher overall yield and mean fruit weight.

Black raspberry (*Rubus occidentalis* L.) production in the eastern United States (US) has a long history (Hedrick, 1925). However, production patterns shifted dramatically in the early 1900s due to disease, low yield, and competition from other crops (Bushway et al., 2008). The recent proliferation of farm-direct retail outlets and farmers' markets in the Northeast has increased demand for black raspberries for fresh consumption. Increased use of black raspberries in fruit wine production and other processed products have also heightened demand especially for locally grown fruit.

Additionally, recent research has highlighted that black raspberries are an especially good source of phytochemicals and antioxidants (Weber et al., 2008) as well as vitamins, minerals, and fiber. Medical research has further fueled interest in black raspberry for its potential health and anti-cancer benefits (Johnson et al., 2011; Stoner et al., 2007; Wang et al., 2014; Zhang et al., 2011). Laboratory studies have shown that black raspberries have extremely high levels of antioxidants, especially anthocyanins and other flavonoids (Dossett et al., 2010; Weber et al., 2008). This class of molecules helps to neutralize damaging free radicals, which may help to reduce the risk of certain types of cancer (Seeram, 2008). Tests in rats have shown reductions in cancerous tumor formation and cholesterol levels as well as possible anti-aging properties, perhaps due to the potent antioxidant capacity of black raspberries (Stoner et al., 2007). Human trials have been performed with black raspberry formulations on pre-cancerous oral lesions, esophageal cancer, and other cancers of the digestive tract (Kresty et al., 2006) with positive results. In addition to the potential health benefits, black raspberries are higher in sugar and contain less acid than red raspberries (Weber et al., 2008), have a sweeter, more subtle flavor, and command a premium price in the marketplace (Pritts and Heidenreich, 2012).

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Although US black raspberry production was centered in New York in the early 1920s, market conditions and production problems have reduced the eastern industry to a few hundred acres across the region. The majority of US production today is centered in Oregon and based on one cultivar, 'Munger', which was introduced in 1897 (Hedrick, 1925). However, the resurgence of interest in black raspberry in the Northeast, coupled with the region's favorable climate for black raspberry growth, could mean that the Northeast is ideal for increased production. Yet, little information on the performance of commercially available cultivars is available to growers.

The goal of this project was to compare yield and fruit weight of nine commercially available black raspberry cultivars to demonstrate the potential and suitability of black raspberry production in New York, and to determine which existing cultivars are best suited for New York production.

Materials and Methods

A replicated trial of nine black raspberry cultivars was established in 2005 in a randomized complete block design at Cornell University's New York State Agricultural Experiment Station in Geneva, NY (lat. 42°52'N, long. 77°02'W). The cultivars included 'Allen', 'Black Hawk'[NT], 'Bristol', 'Haut', 'Huron', 'Jewel', 'Mac Black', 'Munger', and 'New Logan'. Plants of each cultivar were sourced from commercial nurseries and planted on flat ground in a Honeoye fine sandy loam soil with approximately 2% slope in three 12-plant replicates in a randomized complete block design spaced 0.6 m within row and 3 m between rows. A two-wire V-trellis was installed after planting and drip irrigation was provided to supplement natural rainfall to 25 mm of water per week prior to bloom and fruit development as well as following harvest. Supplemental water was provided to equal 51 mm of water per week during the fruit development period through harvest. Fertilization followed standard recommendations from the Bramble Production Guide (Pritts et al., 1989) and the Raspberry and Blackberry Production Guide (Bushway et al., 2008) and weed control followed the Cornell Pest Management Guidelines (www.ipmguidelines.org) for raspberries.

Total yield and average fruit weight were calculated for four harvest seasons, 2006 through 2009, and cumulatively across all four seasons. Yield was calculated on a grams per plant basis and converted to $kg \cdot ha^{-1}$ based on 5,380 plants$\cdot ha^{-1}$ at the above spacing. Fruit were harvested every other day, Monday through Friday, for each plot. For mean fruit calculations, random 10-fruit samples were taken at each harvest date for each cultivar being harvested. Mean fruit weight values over the whole season were calculated for each year, and total mean fruit weight values across all four years were calculated. All mean yield and fruit weight values for each cultivar were subjected to one-way analysis of variance (ANOVA) and mean separation by Duncan's multiple range test ($P \leq 0.05$) using Microsoft Excel v.14 software (Microsoft Corp., Redmond, WA) following the procedures of Gomez and Gomez (1984). The date of first harvest, 50% harvest, and last harvest were also recorded each year for each cultivar. Air temperature and rainfall measurements were collected at the New York State Agricultural Experiment Station Research North Farm weather station approximately 3 km from the trial site to identify any gross differences in annual weather conditions.

Results and Discussion

Black raspberry yields were highest in 2008 and 2009, at 4,310 $kg \cdot ha^{-1}$ for both years (Table 1). Yields for 2006 and 2007 were considerably less, at 1,780 and 2,210 $kg \cdot ha^{-1}$, respectively, (Table 1) across all cultivars. Low first year (2006) yield was expected because few fruiting canes typically grow during the establishment year. Higher yields were expected in the second year (2007), the first year with mature plants, but

Table 1. Mean yields of nine black raspberry cultivars in a field trial at Geneva, NY over four harvest seasons.

Cultivar	Mean yield[z, y] (kg·ha^{-1})[x]				Mean cumulative yield[y] (kg·ha^{-1})[x]
	2006	2007	2008	2009	
Haut	3,640 a	3,780 a	4,200 b	6,340 a	17,960 a
Jewel	2,890 ab	3,390 ab	5,820 ab	5,250 ab	17,350 a
Huron	1,800 bc	1,630 cd	7,690 a	5,750 ab	16,870 a
Allen	1,780 bc	1,370 d	4,120 bc	6,460 a	13,730 ab
Bristol	1,470 bc	2,650 abc	5,180 b	4,220 ab	13,530 ab
Mac Black	1,560 bc	2,130 cd	4,840 b	3,620 bc	12,150 b
New Logan	1,000 c	2,220 bcd	3,660 bcd	4,720 ab	11,590 b
Black Hawk^{NT}	1,480 bc	1,490 cd	1,750 cd	1,240 c	5,960 c
Munger	370 c	1,190 d	1,510 d	1,180 c	4,240 c
Mean[w]	1,780	2,210	4,310	4,310	

[z] There were three repetitions per cultivar for each of the four years (2006, 2007, 2008, and 2009).
[y] Means within columns followed by the same letter are not significantly different as determined by Duncan's multiple range test at $P \leq 0.05$.
[x] Multiply kg·ha^{-1} by 0.89 for equivalent lb·ac^{-1}.
[w] Yearly mean across all cultivars.

lower-than-average rainfall most likely contributed to the relatively low yield in 2007 (Table 1), despite supplemental irrigation. In 2007, rainfall from flower development through harvest (May through July) totaled 147 mm, while in the other three years it averaged 286 mm. Additionally, although mean temperatures across the four seasons did not vary significantly (data not shown), maximum temperatures in 2007 were the highest of the four years with four days over 33˚C at the end of June and peaking during the harvest season at 35˚C on 10 July 2007. By comparison, maximum daily temperatures during the other harvest seasons were 32.8˚C in 2006, 32.3˚C in 2008, and only 29.4˚C in 2009. With this combination of high temperatures and below-average rainfall in 2007, supplemental irrigation was likely inadequate to maximize berry development.

Over the four harvest seasons, 'Haut', 'Jewel', and 'Huron' had the highest mean cumulative yields, while 'Munger' and 'Black Hawk'^{NT} had the lowest (Table 1). 'Munger' exhibited extensive winter damage and thus had less fruiting wood, which most likely accounted for the low yields. 'Black Hawk'^{NT} had similar berry numbers relative to other cultivars, but its mean berry weight was so low that it reduced overall yield. The higher yields of the top cultivars compare favorably to open field production of primocane fruiting red raspberries (Weber et al., 2005b), but are considerably lower than those produced by most floricane red raspberry cultivars grown in western NY (Weber et al., 2005a).

Fruit weight in 2006 was greater than in the other three years, averaging 1.9 g compared to 1.5 g for both 2007 and 2008 and 1.4 g in 2009 (Table 2). Larger fruit are commonly observed in the first harvest season of black raspberries as fruit load is generally low in comparison to plant vigor, which allows for larger fruit size development. 'Jewel' consistently had the largest fruit by weight, being the only cultivar that averaged over 2.0 g in three of the four seasons (Table 2). 'Black Hawk'^{NT} had the smallest fruit, averaging 1.0 g across all four seasons. Other cultivars with larger fruit were 'Huron', 'Haut', and 'Mac Black' (Table 2). Considering yield and berry weight data, 'Haut', 'Huron', and 'Jewel' black raspberry cultivars are best suited for

Table 2. Mean black raspberry fruit weights of nine black raspberry cultivars over four harvest seasons at Geneva, NY.

Cultivar	Mean fruit weight[z, y] (g)				Four-year mean fruit weight[y, x] (g)
	2006	2007	2008	2009	
Jewel	2.7 a	2.1 a	2.3 a	1.9 a	2.3 a
Huron	2.2 abc	1.9 b	1.7 bc	1.7 b	1.9 b
Mac Black	2.3 ab	1.5 cd	1.7 b	1.5 c	1.8 b
Haut	2.0 bc	1.6 c	1.8 b	1.6 bc	1.7 b
Allen	1.8 bcd	1.4 de	1.5 cd	1.5 c	1.5 c
Bristol	1.7 cd	1.5 cd	1.3 d	1.2 d	1.4 cd
Munger	1.7 cd	1.2 f	1.3 d	1.3 d	1.4 cd
New Logan	1.7 cd	1.3 ef	1.3 d	1.2 de	1.3 d
Black Hawk[NT]	1.3 d	0.7 g	0.9 e	1.0 e	1.0 e
Mean[w]	1.9	1.5	1.5	1.4	

[z] There were 3 repetitions per cultivar for each of the four years (2006, 2007, 2008, and 2009).
[y] Means within columns followed by the same letter are not significantly different as determined by Duncan's multiple range test at $P \leq 0.05$.
[x] Mean across all four years (2006, 2007, 2008, and 2009).
[w] Yearly mean across all cultivars.

production in western New York and other locations with a similar temperate climate such as the central and upper Midwestern US, central to northern Europe and the United Kingdom.

The harvest season across all cultivars was as short as 26 days (3 to 28 July) in 2006 and as long as 33 days (30 June to 1 August) in 2008, with the average length of the season being 28 days. 'Black Hawk'[NT], 'New Logan', and 'Allen' had the highest yield in the first week of harvest followed closely by 'Bristol' (data not shown). 'Mac Black' was clearly the latest cultivar, with harvest beginning up to 14 days after 'Black Hawk'[NT], 'New Logan', and 'Allen' and continuing 10 days after 'Jewel' and 'Haut' (data not shown). For individual cultivars, 'Haut' and 'Allen' had the longest mean harvest season length (21.0 and 20.8 days, respectively) and 'Black Hawk'[NT] had the shortest (14.0 days) (Table 3). Total mean harvest season length per cultivar across all years was just less than 18 days (Table 3). This is a similar harvest period for individual floricane red raspberries which are harvested during a similar period (Weber et al., 2005a). However, fewer floricane black cultivars are available and only one primocane fruiting cultivar, 'Niwot' (US Plant Patent Pending, Application #US 13/999,827), is commercially available so the overall black raspberry season is less than half that of the red raspberry season in NY when both primocane and floricane cultivars are considered. Additional primocane and floricane black raspberry cultivars are needed to expand the season and open up additional market windows for growers. Even with premium pricing for black raspberries, advances in production practices including optimizing planting density and protected culture as well as new cultivars are needed to make black raspberries more competitive and attractive to growers.

It may also be difficult for growers to find some of the cultivars tested, and it is important for growers to obtain plants from a trusted nursery source. Recent studies have cast doubt on the identity of black raspberry cultivars available from different commercial sources (Dossett et al., 2012a). An earlier analysis of genetic similarity among 16 black

Table 3. Comparison of black raspberry cultivar harvest dates and harvest season length over four harvest seasons at Geneva, NY.

Cultivar	First harvest date[z]	50% harvest date[z]	Final harvest date[z]	Mean harvest season length[y,x] (days)
New Logan	30 Jun - 3 Jul	6 Jul - 11 Jul	15 Jul - 17 Jul	15.8 bc
Black Hawk[NT]	30 Jun - 3 Jul	5 Jul - 11 Jul	12 Jul - 21 Jul	14.0 c
Bristol	30 Jun - 5 Jul	6 Jul - 11 Jul	15 Jul - 21 Jul	17.3 abc
Allen	30 Jun - 3 Jul	7 Jul - 14 Jul	17 Jul - 24 Jul	20.8 a
Munger	30 Jun - 5 Jul	11 Jul - 14 Jul	17 Jul - 21 Jul	18.8 ab
Haut	2 Jul - 5 Jul	9 Jul - 13 Jul	20 Jul - 26 Jul	21.0 a
Jewel	2 Jul - 7 Jul	11 Jul - 14 Jul	20 Jul - 26 Jul	19.0 ab
Huron	6 Jul - 9 Jul	11 Jul - 13 Jul	17 Jul - 26 Jul	15.5 bc
Mac Black	7 Jul - 16 Jul	18 Jul - 24 Jul	28 Jul - Aug 1	18.8 ab
			Mean[w]	17.9

[z] Range of earliest harvest date to latest harvest date across all four years of the field trial, 2006, 2007, 2008, and 2009.
[y] Mean harvest season length across all four years of the field trial, 2006, 2007, 2008, and 2009.
[x] Means within the same column followed by the same letter are not significantly different as determined by Duncan's multiple range test at $P \leq 0.05$.
[w] Total mean harvest season length across all cultivars and years.

raspberry cultivars (including seven of the cultivars in this trial) using random amplified polymorphic DNA (RAPD) markers showed a very close relationship among genotypes, with an average of 81% similarity (Weber, 2003). 'Munger' and 'New Logan' showed the highest similarity of the tested cultivars at 98% (Weber, 2003). In a genetic fingerprinting study using simple sequence repeat (SSR) markers, Dossett et al. (2012b) found that the 'Bristol', 'Cumberland', 'Munger', 'New Logan', 'Shuttleworth' and 'Plum Farmer' accessions in the USDA National Clonal Germplasm Repository in Corvallis, OR could not be differentiated with these markers and that 'Allen', 'Haut', 'Huron' and 'Jewel' had markers inconsistent with their published pedigrees indicating the possible misidentification of parental cultivars in the past or in the current cultivars in the industry. Further, in a wider study of nursery sources of plants Dossett et al. (2012a) found that while 'Jewel', 'Bristol' and 'Mac Black' had consistent genetic fingerprints from different nursery sources, 'Munger' and 'Allen' were inconsistent and 'Black Hawk' had the same fingerprint as 'Jewel'. These studies highlight the need for accurate cultivar identification and the importance of purchasing plants from a reliable nursery source.

In the current trial, however, the physical characteristics of the fruit and plants generally matched published descriptions of the cultivars. Additionally, the yield, fruit size, and harvest date data were significantly different among the cultivars tested. When considering all of this information, the authors are confident that the cultivars in this study are generally true to type (with the exception of 'Black Hawk'[NT]) and are at least different genotypes from each other. 'Black Hawk'[NT] was different from the other cultivars but did not match its published description or the description of other known varieties. Its thin, weepy canes and small fruit is similar to that observed in wild type germplasm that has been evaluated in the Cornell breeding program in recent years. It is possibly a chance seedling from a hybridization with a wild type that was then propagated. These hybrids tend to be very vigorous and such a hybrid might stand out in a propagation field. As wild black raspberries are common in the regions where most black raspberries are

field propagated, such a scenario is possible. Growers would be advised to consult with their nursery and/or plant a small test block of their own prior to large-scale planting to ensure cultivar identity in cases where there is doubt. The differential black raspberry cultivar characteristics observed in this trial and from published sources are outlined in Table 4 to aid in identification.

Table 4. Characteristics of nine black raspberry cultivars based on field observations in a replicated field trial in Geneva, NY and published descriptions.

Cultivar	Parentage	Release institution and year	Harvest season	Fruit characteristics	Distinguishing characteristics
Allen	Bristol x Cumberland	Cornell University 1963	Early-mid	Medium-sized; attractive, shiny black color; good eating quality	Reliably produce a small number of primocane flowers in the fall
Black Hawk[NT]	Unknown	Unknown	Early	Small and glossy; good firmness; similar to wild type fruit	Resistant to anthracnose; highly suscepitble to Verticillium wilt; very thin, weepy canes
Black Hawk[z]	Quillen x Black Pearl	Iowa State Univ. 1954	Early	Medium large, shiny black with bloom between drupelets	Higher yield than 'Bristol'; good vigor
Bristol	Watson Prolific x Honeysweet	Cornell University 1934	Early	Medium-sized and firm; excellent flavor.	Vigorous and cold hardy. Susceptible to anthracnose and tolerant to powdery mildew
Haut	Manteo x (Bristol x Bristol)	Univ. of Maryland; 1987	Mid	Medium-sized, firm fruit; dark black, attractive, but soft	Vigorous and productive
Huron	Rachel x Dundee	Cornell University 1965	Late-mid	Medium- to large-sized fruit; relatively firm and glossy	Moderately resistant to anthracnose
Jewel	(Bristol x Dundee) x Dundee	Cornell Univ. 1973	Mid	Largest fruit of available cultivars; fruit are firm, glossy, and flavorful	More disease-resistant than other cultivars; sunscald can be a problem in hot seasons
Mac Black	Parentage unknown	Michigan (private release) ~2000	Late	Medium-large sized; moderately firm; uniform in shape and size.	Very upright canes. Reliably produce a small number of primocane flowers in the fall.
Munger	Schaffer open pollinated	Ohio; (private release) 1987	Early-mid	Medium-sized; shiny black fruit; good flavor and firmness	Susceptible to winter injury; susceptible to mosaic virus
New Logan	Unknown wild parentage	Illinois; (private release) 1915	Early	Medium-sized; uniform in shape and size	Resistant to leaf curl virus but susceptible to anthracnose

[z] The description of the true 'Black Hawk' cultivar comes from the original release reference, Lantz and Denisen (1954).

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