

Blackberry Production Systems – a Worldwide Perspective

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Abstract

There are generally three types of blackberry: the erect (e.g. ‘Navaho’, ‘Ouachita’); semi-erect (e.g. ‘Chester Thornless’, ‘Loch Ness’); and trailing (e.g. ‘Marion’, ‘Boysen’). All types can be grown for fresh and processed markets, although the trailing types with their small seed (pyrene) size and aromatic flavor are considered superior for processed markets. The largest blackberry production regions are Mexico, Europe (particularly Serbia), and the USA (particularly Oregon) where the predominant types grown are erect, semi-erect, and trailing, respectively. Production systems for these types of blackberries differ with modifications in some regions depending on historical production differences, cultivar, and harvest method. Trailing blackberries are generally trained to a two- to three-wire trellis. Primocanes are either carefully managed under the canopy for every-year production or are left un-managed in the on-year of alternate year (AY) production systems. AY production systems are most common in Oregon where they are used to maximize cold tolerance and minimize cane disease. Primocane suppression techniques are used to maximize machine-harvest efficiency, while training techniques can be utilized to increase yield and cold hardiness. Erect blackberries are generally grown in hand-harvested fresh market production systems. The type of trellis used, the extent of cane training (tying or no tying), and the degree of main cane tipping and the amount and frequency of branch cane shortening in erect blackberry varies with region. In Mexico, specialized production systems, which use chemical defoliant, pruning, and growth regulators, have been developed to extend the season for erect blackberry cultivars such as ‘Tupy’. Semi-erect blackberries are generally grown on a more elaborate trellis, sometimes with a divided canopy. Depending on production region, primocanes may be summer pruned to a high (~1.7 m) or low (~0.5 m) height to encourage branching; management of branches differs among regions. Recently, annual-fruiting, erect blackberries have been trialed by commercial growers in many production regions. Early evidence indicates this type of blackberry may offer advantages for out-of-season production in warmer climates, provided the plantings are pruned and managed well. As demand for blackberries continues to increase, new cultivars are being developed including primocane- or annual-fruiting, erect types and hybrids between erect, semi-erect, and trailing types that require modifications in the traditional pruning and training systems.

INTRODUCTION

There are generally three classifications of blackberries, based on cane architecture: trailing (e.g. ‘Marion’, ‘Obsidian’), erect (e.g. ‘Navaho’, ‘Ouachita’), and semi-erect (e.g. ‘Chester Thornless’, ‘Loch Ness’). Erect blackberries produce primocanes from buds at the base of floricanes at the crown or from buds on roots, whereas trailing and semi-erect types only produce new primocanes from buds on the crown. Trailing and semi-erect blackberries are biennial fruiting, whereas erect blackberries can be biennial or annual fruiting. We have included ‘Tupy’, the most common cultivar grown in Mexico, as an erect type, even though its parentage includes

erect and trailing types. Hybrids between the red raspberry and blackberry that are grown commercially (e.g. 'Boysen', 'Logan') are considered trailing blackberry types due to their growth habit.

Primocanes emerge in the spring and grow rapidly at suitable temperatures. Erect and semi-erect blackberries produce primocanes that grow upright, with vigor dependent on cultivar and growing conditions. The primocanes of trailing blackberry are not self-supporting and will grow along the ground. Canes will continue to grow in length until cold weather in the fall limits their development or dormancy occurs.

In general, flower bud initiation in blackberry occurs under short days and low temperatures. However, the time of flower bud initiation and pattern of development on the cane can vary with growing location and blackberry type or cultivar (Stanley et al., 1999; Takeda et al., 2002a, b).

Blackberry plantings generally have a life span of 15 to 20 years. Plantings are established in the spring using plants propagated by tissue culture or root cuttings, depending on type of blackberry grown. Blackberries are tolerant of a wide range of soil pH (4.5 to 7.5) and soil types, although growth is improved under conditions of good soil drainage.

PRODUCTION SYSTEMS

Trailing Blackberries

Trailing blackberries are typically grown at an in-row spacing of 0.9 to 1.5 m with 3 m between rows. Most are grown on a trellis with the canes wrapped around 2 to 3 wires. Yield ranges from 8 to 12 t/ha, depending on cultivar, growing region, and harvest method. The most widely grown cultivars for processing are 'Marion', 'Black Diamond', 'Thornless Evergreen', 'Silvan', and 'Boysen' (Ore., USA; Chile), and for the fresh market 'Obsidian' (Ore. and Cal., USA; northwestern Europe) and 'Karaka Black' (Australia; New Zealand) are common cultivars. Approximately 90% of world production of this type of blackberry is processed and most is produced in Oregon, USA. The factors that most limit the range of trailing blackberries are cold hardiness, summer heat, and wind. For example, 'Marion' blackberry is considered to have a maximum bud hardiness of -10°C when dormant and -4°C during the acclimation or deacclimation phase; 'Marion' has an estimated chilling requirement of 300 hours making this cultivar sensitive to fluctuating winter temperatures (Strik et al., 1994; Bell et al., 1995b).

Trailing blackberries can be grown in every-year (EY) or alternate-year (AY) production systems. In EY production, new primocanes are trained along the ground, under the canopy, while the floricanes are on the wire producing the current season crop. After fruit harvest, the dead floricanes are removed and the primocanes trained onto the trellis wires in August or February. Most growers train primocanes in February, leaving canes more protected from cold through most of the winter. However, training in August improves yield as much as 45% through greater bud break and more fruit per lateral compared to February training (Bell et al., 1995a).

In AY production systems, plants fruit every other year. In the "on-year" floricanes produce a crop and primocanes are not managed. In October, the dead floricanes and the primocanes are pruned by machine at the crown. The following "off-year" primocanes are trained to the trellis as they grow. The yield of an AY field is about 80% of an EY field over a two year period, depending on cultivar. Primocanes following an off-year in an AY system are more cold-hardy than primocanes that grew in the presence of floricanes (Bell et al., 1995b; Cortell and Strik, 1997), are easier to train, and have less cane disease than in EY systems. Some growers are cutting the first flush of primocanes back to the crown in the off year (~30 cm tall) to increase yield and cold hardiness (Bell et al., 1995b). In Oregon, USA, about 40% of the trailing blackberry production is grown in AY systems, while these types are typically grown in EY systems, trained after harvest, in other regions.

Harvesting with over-the-row machines is most common for processing. Harvest

frequency is about every 5 to 7 days, depending on cultivar and weather conditions. Thorns (loose in product when rubbed off thorny canes or as thorny, non-senescent petioles that fall in during harvest) can be a serious contaminant in thorny cultivars that are machine harvested. Growers use machine harvesters equipped with brushes to remove most of remaining leaves and petioles on primocanes in late winter (Strik and Buller, 2002). The thornless cultivar, 'Black Diamond', is becoming more common for processing. Primocane suppression in EY and the fruiting year of AY systems is a common tool to improve machine harvest efficiency in Oregon and in New Zealand (Stanley et al., 1999).

Trailing blackberries for fresh market are harvested by hand. Production systems have been developed to reduce environmental damage to fruit. For example, shade cloth or plastic-covered tunnels are used to minimize sun damage to fruit in some regions. In colder regions of the USA, a Rotatable Cross-Arm trellis (RCA) and cane training techniques are being used to bring the over-wintering canes down near the soil surface where they can be covered with floating rowcovers to protect against extreme cold temperatures (Takeda and Phillips, 2011). Canopy manipulation with the RCA may also be used to protect trailing, erect, and semi-erect fruit from sun damage (Takeda, pers. commun.).

Semi-Erect

Semi-erect blackberries are typically grown at an in row spacing of 1.0 to 1.8 m with 3 to 3.6 m between rows. Yield ranges from about 20 to 30 t/ha. The most common cultivars grown are 'Chester Thornless', 'Čačanska Bestrna', 'Loch Ness', 'Triple Crown', 'Hull Thornless', and 'Thornfree'. Plants are typically trained to a multiple-wire trellis, although some growers used a divided ("V") trellis. Primocanes are usually tipped during the growing season to encourage branching. Tipping height varies from 0.45 m to 1.8 m, depending on grower or region. Primocane branches are either shortened in winter or are trained in their entirety on the trellis. Dead floricanes are removed after harvest or in winter. While these blackberry cultivars are generally considered late-season, fresh market types and are hand harvested, harvesting by hand or machine for processing occurs in some regions (e.g. China, Serbia).

While it is not common commercially, there have been some trials on manipulating the fruiting season of semi-erect blackberries in tunnels or the greenhouse (Bal and Meesters, 1995). 'Loch Ness' can be double cropped in a greenhouse by cutting back the fruiting laterals immediately after the last fruit is harvested; secondary laterals emerge from basal lateral buds and from buds on the main cane which results in a second crop about two months later (Pitsioudis et al., 2009).

In regions where semi-erect blackberries are grown for high-value, late-season fresh fruit, shade nets or tunnels are used to protect fruit from sun or rain damage.

Erect

This type of blackberry is established 0.8 to 2 m apart in rows 3 m apart. The most common floricanes cultivars grown are 'Navaho', 'Ouachita', 'Arapaho', and 'Natchez'. Yields range from 8 to 10 t/ha. In "traditional" planting systems, primocanes are tipped at about 1m to encourage branching. Branches are either shortened in the winter, by machine, or are machine-hedged during the growing season once or twice, followed by winter pruning. After fruit harvest or in the winter, dead floricanes are removed by pruning, depending on incidence of cane disease. In some production regions, like Oregon, dead floricanes may be left in the planting to save labor costs. While erect blackberries may be grown as a "hedge" without a permanent trellis, it is currently more common to have a more permanent trellis with multiple wires to train primocanes. Fruit are harvested by hand, primarily for fresh market, every three to five days. Shade structures to protect fruit are used in some warmer production regions, whereas commercial trials are underway in the USA on use of a Rotatable Cross Arm trellis system to produce blackberries under more extreme winter and summer temperatures

(Takeda, pers. commun.).

In Mexico, specialized production systems have been developed to extend the season for ‘Tupy’, the most widely grown cultivar. Plantings are mowed to crown height and burned in winter. Primocanes are encouraged to grow using irrigation and fertilization. Flower buds are stimulated to develop using cultural methods and applications of phosphoric acid and ethrel. About 5-7 months after primocane emergence, growth is slowed using applications of copper sulfate, urea, and mineral oil. Plants are hedged and then defoliated (a combination of urea, ammonium sulfate, copper sulfate, and mineral oil). Gibberellic acid and a cytokinin are used to promote bud break. Fruit harvest begins about 90 to 100 days after defoliation. After the first crop is finished, growers may prune to remove the portion of the cane that fruited, and repeat the bud break stimulation treatments to obtain a second crop; this may be repeated for a third crop, however yield is reduced for each successive crop (Lopez-Medina, personal communication). Using these methods, the Mexican fruiting season extends from mid-October to early May for the export market and May through June for local markets. Production of erect and semi-erect cultivars for fresh market in Chile has declined because growers cannot compete with Mexican production (Bañados, personal communication).

Annual, primocane-fruiting erect blackberries, such as ‘Prime-Ark 45®’ (Clark and Perkins-Veazie, 2011) can be grown for a double-crop (floricane in early summer plus primocane in late-summer through autumn) or a single-crop (primocane only). Worldwide, these are mainly being tested for an annual, primocane crop.

Soft-tipping the primocane of annual blackberries at 1 m induced branching and increased flower and fruit number and yield three-fold without affecting fruiting season (Strik et al., 2008). A double-tip, where branches are further shortened, has been shown to increase yield (Thompson et al., 2009). Genotype, rate of flowering, and climate may affect best pruning methods (Strik, personal observation).

Cultural practices may be used to manipulate the fruiting season. Use of spun-bound row covers from late winter, before primocane emergence, through ~0.6 m primocane height advanced flowering and fruiting by two weeks in Oregon (Strik et al., 2008), but had no impact in North Carolina, USA (Fernandez and Ballington, 2010). In plants where primocanes were mowed back to ground level when height averaged ~0.5 m, fruit production was delayed by about four weeks (Thompson et al., 2009). Producing primocane-fruiting blackberry in an un-heated tunnel extended the harvest season about three weeks in Oregon’s temperate climate (Thompson et al., 2009). Growth and production ceased due to cool night temperatures even though there were many flower buds, flowers, and immature fruit present (Strik, pers. obsn.).

Genotypes of annual-fruiting blackberry are being grown in evaluation trials in many production regions. Cultivars that are less sensitive to high temperature effects on fruit set (Stanton et al., 2007), sun damage of fruit, can be manipulated to fruit during high-value market seasons, and are thornless are desired.

IRRIGATION

In most regions, drip irrigation systems are used in fresh market plantings. In some regions, under-canopy mist or micro-jet sprinklers are used to reduce heat stress damage to fruit (Strik, personal observation). Cultivars that are grown for processing are irrigated using overhead sprinkler or drip systems. In Oregon, there are some farms that are not irrigated. Floricanes and primocanes had differing water potentials during the growing and fruiting season, indicating that these canes may compete for water under dry soil conditions (Bryla and Strik, 2008).

FERTILIZATION

Blackberries have relatively low dry weight and nitrogen (N) accumulation per hectare, likely due to the 3 m row spacing. For example, the cumulative total yield of ‘Kotata’ trailing blackberry fruit was 1.6 kg of dry matter per plant (2.2 t/ha; Mohadjer et

al., 2001). Above-ground dry weight of mature 'Kotata' trailing blackberry was 4.6 t/ha in late autumn (Mohadjer et al., 2001). Roots accounted for 41% of the dry weight of potted 'Chester Thornless' (Malik et al., 1991) and 26% of the total dry weight (excluding fruit) of 'Arapaho' (Naraguma et al., 1999).

A review of nitrogen (N) research in *Rubus* was done by Strik (2008). In blackberry, the impact of N fertilization rate on yield has varied with type of blackberry, region, and, likely, soil type (Nelson and Martin, 1986; Rincon and Salas, 1987; Archbold et al., 1989; Naraguma and Clark, 1998; Mohadjer et al., 2001). Current fertilizer recommendations vary with production region (Pritts and Handley, 1989; Hart et al., 2006).

Growers typically base N fertilization decisions on results of tissue analysis of primocane leaves taken in late July to early August (northern hemisphere), soil tests every few years, and observations of annual growth (cane number, diameter, and height and fruiting lateral length), yield, color of leaves, and fruit quality (amount of rot and drupelet set). Many growers are collecting nutrient concentration in leaf tissue throughout the season with a goal of better managing plant growth, yield, and quality through improved fertilization.

In field-grown trailing blackberry, Mohadjer et al. (2001) reported the N removed from the field was 33 kg/ha in harvested fruit, 14 kg/ha in floricanes prunings in October, and 5 kg/ha in senescing primocane leaves, for a total of 52 kg/ha per year of N. Pruning floricanes in August instead of October reduced plant recovery of N by 27 kg/ha, as previously reported in red raspberry (Rempel et al., 2004).

The nitrogen concentration of ripe fruit of fertilized plants has ranged from 1.4 to 1.6% in 'Kotata' trailing blackberry (Mohadjer et al., 2001), and 1.5 to 1.6% in 'Arapaho' erect blackberry (Alleyne and Clark, 1997). Nitrogen fertilization rate had little effect on fruit pH, titratable acidity, and soluble solids in 'Thornless Evergreen' blackberry and had no consistent effect on fruit firmness (Nelson and Martin, 1986). In 'Arapaho' blackberry, increasing N fertilization rates increased fruit N concentration and pH, but had no effect on percent soluble solids, titratable acidity, and sugar-acid ratio (Alleyne and Clark, 1997).

In blackberry, lateral growth and fruit production is supported with stored N while primocane growth is more dependent on new fertilizer N (Malik et al., 1991; Naraguma et al., 1999; Mohadjer et al., 2001) exogenous N.

FUTURE DIRECTIONS AND NEEDS

Continued growth of the blackberry market and production systems will be greatly affected by cultivar development. Cultivars that have improved flavor, sweetness, are firm with an improved shelf-life, and are thornless (particularly for processing) would expand the market and production. Cultivars or genotypes respond to macro- and micro-climatic differences, thus testing in various climates or production regions is critical. It is likely that global companies will continue to extend the blackberry fruiting season using a palate of blackberry types, cultivars, production methods, and growing regions.

As tunnel or shade production increases in some regions, research is needed on how associated changes in plant vigor and source-sink relationships in these altered micro-climates affect plant water and nutrient status and cultural management.

A better understanding is needed of how plant water status, plant nutrition, and other cultural factors affect flower bud initiation and development, flowering time, and fruit quality in blackberry.

While primocane or annual-fruiting blackberries offer a great deal of potential for extended season production, a great deal still needs to be learned about how to manage these for economical, high-quality yield at the desired time in various production regions. At this time, it is difficult to project whether primocane-fruiting blackberry cultivars will be able to "compete" with fruit production of semi-erect blackberries from temperate climates (Aug. – Oct.) and 'Tupy' from Mexico (Oct. – June) and Spain. Things may change in the future if the production system for 'Tupy' is found to be un-sustainable or

marketers and consumers are impressed with a new blackberry cultivar that has a flavor and sweetness that surpasses that of 'Chester Thornless' and 'Tupy'.

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