A WINTER PROTECTION SYSTEM FOR BLACKBERRIES

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Summary. Little commercial blackberry production exists in areas with severe winters (minimum winter temperatures below – 15 °C). In this study, we evaluated the combination of unique primocane training and cane positioning techniques, a modified rotatable cross-arm (RCA) trellis system, and covering plants with insulation material in winter to overcome the lack of cold hardiness in 'Siskiyou', a trailing cane blackberry from Oregon in Kearneysville, WV (39º Latitude N, USDA Plant Hardiness Zone Map 6b, with average annual minimum temperature range of – 17.8 to – 20.5 °C). RCA trellis assembly has an upright post and a long cross-arm with a mechanism at the top of the post that permits the cross-arm to be pivoted and rotated as much as 220 degrees. A special cane training practice spatially separated primocanes and floricanes. Alter tying primocanes to trellis wires and rotating the cross-arms to below horizontal, tied canes were positioned close to the ground which allowed them to be covered with floating row cover (FRC) and polyethylene plastic (PE) during the winter months. Covers were removed in early spring. The canes remained in the horizontal orientation until bloom which resulted in the flowering laterals to grow upright. After bloom, the cross-arm was rotated to slightly beyond vertical. In this position, the fruit was one side of the row and could be harvested more efficiently. The daily minimum temperatures under the FRC+PE cover and two layers of FRC were about 3 ºC higher than in the open. The cover also provided protection against the wind. Bud and cane damage under FRC+PE or two layers of FRC was significantly less than for unprotected plants. 'Siskiyou' plants in covered plots produced 3 to 5 times more fruit than plants in the open. Harvesting of 'Siskiyou' fruit occurred during the red raspberry harvest season or two to three weeks earlier than that for 'Chester Thornless' and 'Triple Crown' eastern thornless blackberries. Our findings suggest that trailing 'Siskiyou' blackberry that lack winter hardiness may grow satisfactorily and produce fruit by mitigating the adverse effect of

low temperatures and winds with our unique trellis system and winter protection system. Cane manipulation and placement of winter protection material were performed with little difficulty by the use of RCA trellis system. The trailing blackberries could be included for fruit production in the eastern United States. With addition of cultivars such as 'Siskiyou', there is a potential for early-season high-quality blackberry production in this region.

Blackberry production for the fresh fruit market is growing in the United States. Commercial acreage has increased rapidly, most notably in California and Georgia. However, its production is limited in areas where sub-zero temperatures are common during the winter. In colder regions, the interest in growing blackberries in colder regions remains high among small and part-time farmers looking for crops with a market niche and the potential for high returns on investment. In New Hampshire, for example, the price for locally grown blackberries has been $3.00 per pint (William Lord, personal communication). It may be possible to overcome the lack of cold hardiness with nominal winter protection and thus meet the local demand for fresh blackberries.

For cultivated blackberries to thrive in northern states, the following criteria need to be met: a) new varieties with greater winter hardiness and chill requirement, or early-season primocane fruiting habit; b) protected cultivation under glass or using a pot production system; c) a simple, low cost technique for modifying the micro-environment to protect blackberry canes to some extent from low winter temperatures; and d) a trellis design and cane training techniques to improve harvest efficiency and be compatible with the winter protection strategy. In short, the goal is to have systems to lessen environmental stress or to mitigate conditions that are unfavorable for growth. These strategies involve crop improvement through breeding and biotechnology to adapt the plant to the environmental limitations and physical modification of the crop environment to decrease weather-related stresses.

Although it is understood that a new approach will need economic and technological analyses, the discussion in this paper is limited to the potential use of a specific trellis system and cane training technique for protecting blackberry plants by modifying the aerial environment. A trellis system called the "rotatable cross arm" (RCA) trellis and cane training technique was developed to aid mechanical harvesting of fresh market quality fruit of eastern thornless blackberries with the USDA bramble harvester (Takeda and Peterson, 1999). The RCA trellis system consists of a short post and a long cross-arm that can be rotated about a pivot point at the top of the post. It is similar in design to one of the variations of shift trellis designs described by Stiles (1999) at Virginia Tech. The RCA trellis system allows the floricanes and primocanes to be spatially apart on the trellis. It positions more than 90% of the fruit on one side of a narrow canopy and underneath the cross arm and improves hand harvest efficiency by 30% or more (Takeda et al., 2003b).

For training primocanes on the RCA trellis, the terminal end of primocanes must be bent and tied to a primocane training wire about 22-inches above the ground, just below the pivot point of the cross-arm, when they are about 30-inches tall. This cane manipulation forces the primocanes to grow horizontally in the direction of the row. Once the primocanes extend to the adjacent plant, they are tipped. When the primocanes are oriented horizontally more lateral canes develop along the length of the main cane compared to those canes trained in upright orientation. It is important to promote the growth of lateral branches because fruit production is dictated by their numbers (Takeda et al., 2003a, 2003b). Also, when the main canes are bent as described here, the entire plant canopy can be rotated with little risk of damaging or breaking the main canes. Generally, mature, upright canes are too stiff (limited elasticity), so that it is difficult to bend them more than 45-degrees from vertical while maintaining a small radius about the bend point. Immature green primocanes are usually elastic and can be bent more than 90 degrees before they break. Once the lateral canes are tied to the trellis wires, the cross arms can be rotated so that the lateral canes are oriented below horizontal in winter or raised to a diagonal in late spring in preparation for harvest. This manipulation can be achieved without breaking the floricanes because the force applied to the cane bent cane is a torsion (e.g. twisting). Mature canes can withstand

some amount of twisting about the bend point (~ 150-degree rotation of the horizontal portion relative to the vertical, basal portion.

Among 'Chester Thornless' plants trained to the RCA trellis system, plants with two- and six-floricanes produced 19 and 22.7 lbs. of fruit on each plant and berry weight was similar (Takeda et al., 2003b). In summary, a plant in which the vegetative growth was limited to the first two primocanes to emerge from the crown had fewer nodes and flower clusters, but larger flower clusters. Since berry weight was similar in the 2- and 6-floricane plants, crop productivity was also similar. Limiting the primocanes to two on each plant has two added economic benefits: a) less labor inputs are needed for primocane training and floricane removal, and b) the training phase can be finished before fruit harvest (Takeda 2003a).

Harper et al. (1999) reported that about 100 labor-hours per acre were needed for floricane pruning and removal, and primocane training and suckering when five or six primocanes on each plant were retained. When only two primocanes were retained the labor-hours needed for cane training and pruning was cut by 50%. Also, according to a grower cooperator, hand harvesting the black raspberry on the RCA trellis needed only 70% of the time needed to pick those in a hedge-row configuration (Jim Burda, personal communication). New trellis designs and cane training procedures have improved hand harvesting of eastern thornless blackberries. These improvements have improved the quality of harvested fruit and cut the labor hours needed to train and tie primocanes, without sacrificing plant productivity.

Low temperature injury has limited the expansion of blackberry production into more northern latitudes. For example, there are no cold hardy thornless cultivars that produce consistently under a New England or Midwest winter condition. At "rest", dormant blackberry buds can withstand temperatures as low as –9.5 ºF., but most blackberries have low chilling requirements (200 – 600 hrs below 45 ºF) and can have their rest requirements met in most years by mid-December in areas where winter comes early. After rest completion blackberries de-acclimate rapidly and can resume growth with exposure to warm temperatures. De-acclimated buds are far more susceptible to low temperature injury. Breeders must develop cultivars which have high chilling requirements (~1,700 hrs) of red raspberries, low temperature

tolerance, thornlessness, combined with a need for more days of warm temperatures (growing degree hours) in early spring to break bud.

In the absence of suitable, winter hardy, high-chill requirement blackberry varieties, one may modify the aerial environment to decrease winter injury and improve the potential of sustained crop production. A protection system must prevent the temperatures of buds from falling below -10 ºF during mid winter, but once the buds are de-acclimated in late winter, it must reduce the exposure of canes and buds to high temperatures with low labor input. Western trailing and eastern erect blackberries are adapted to canopy manipulation of the RCA trellis. Based on the recent research on trellis technology, we hypothesized that the RCA trellis and cane training system could provide a practical technique for growing and protecting blackberries through severe winter conditions. During the fruiting phase, the cross arms of the trellis can be rotated to angle the floricanes into a position that makes the fruit easily accessible for harvesting. The same cross-arms can be rotated to reposition or lower primocanes in the fall close to the ground. When canes are positioned near the ground, much of the planting could be protected by snow or by applying a protective cover over the plants as their height would be decreased from over six to about 2 feet.

A study was performed to evaluate the combination of simple cultural practices, a modified RCA trellis system, and covering plants with insulation material in winter to overcome the lack of cold hardiness in blackberries.

MATERIALS AND METHODS

The study included two trailing (‘Siskiyou’ and ‘Boysenberry’) and two semi-erect (‘Apache’ and ‘Triple Crown’) blackberries that have been established at Kearneysville, WV (39º Latitude N). Nursery mature transplants were established 5 feet apart in fabric covered raised beds. The rows were 12-feet apart running in the north-south direction. The RCA trellis assembly has an upright post and a long cross-arm with a mechanism at the top of the post that permits the cross-arm to be pivoted and rotated as much

as 180 degrees (Takeda and Peterson, 1999). A special cane training practice (Takeda et al, 2003a) spatially separated primocanes and floricanes. After tying canes to trellis wires and rotating the cross-arms to below horizontal, tied canes were positioned close to the ground (Fig 1A). The plants were then covered with a fabric (floating row cover) alone or with the floating row cover (FRC) and polyethylene plastic (PE) sheet together in early December (Fig. 1B). Covers were removed in early March and canes remained in the horizontal position until bloom, encouraging flowering laterals to grow upright. After bloom, the cross-arms were raised and pushed beyond vertical or about 70 degrees above horizontal (Figs. 1C and 1D). This positioned the fruit on one side of the row and allowed the newly emerged primocanes to be tied to the training wire.

RESULTS AND DISCUSSION

The results of our study showed that 'Apache' and 'Triple Crown' blackberries did not benefit from winter protection covers. Covered and unprotected plants showed little bud damage and produced the same yield. The minimum daily temperatures remained above 0 °F from December 2004 to March 2005. Normally erect cultivars do not show winter damage until the temperature drops below -4 °F (Warmund et al., 1992). In January and February 2005, the daily minimum temperatures under the FRC+PE cover treatment were about 6 ºF higher than in the open. The FRC and FRC + PE covers may also have protected canes against the wind and desiccation.

In trailing blackberries, tissue damage in plants protected with a FRC+PE cover was significantly less than for unprotected plants. In 'Siskiyou' blackberry, more than 90% of the axillary buds on lateral canes were killed in unprotected plants compared to only 20% in plants covered with FRC + PE (Table 1). 'Siskiyou' plants that were not protected produced less than 3 lbs. of fruit per plant compared to about 10 lbs. in plants that were covered with FRC alone or in combination with PE. More fruit were harvested from 'Boysenberry' blackberries that were protected compared to plants in the open. But, the fruit of 'Boysenberry' had poor drupe development especially among those at the distal end. 'Siskiyou' plants

that were covered in winter started to flower much earlier compared to unprotected plants (Table 1), thus harvesting started on June 20 during the red raspberry harvest season or two to three weeks earlier than that for ‘Triple Crown’ eastern blackberry.

Trailing blackberries that lack winter hardiness may grow satisfactorily in the mid-Atlantic coast region and produce fruit if the adverse effect of low temperatures and winds can be mitigated with a winter protection system (Fig. 1D). The trailing blackberries could be included for fruit production in the eastern United States if practical cultural techniques for improving their winter survival become available. With addition of cultivars such as ‘Siskiyou’, there is a potential for early-season high-quality blackberry production in this region.

The RCA trellis allows the placement of canes close to the ground in winter which makes for an easy installation of protective covers over the canes. This cover has the potential for reducing low-temperature stress and to mitigate conditions that are unfavorable for growth. For additional winter protection, straw mulch can be deposited on top of the horizontally oriented lateral canes and around the base of the main canes. If snowfall occurs it can provide added insulation. In using the RCA trellis for winter protection, the pivot point of the rotatable cross-arm should be about 24 in above the ground.

The sequence of pruning and positioning of the cross arms are as follows. After harvest is finished, the spent floricanes are removed from the trellis and the lateral canes that have developed on the primocanes are tied to the wires on the cross-arm. In early winter, the cross arm can are rotated away from the harvest position to tie the remaining laterals that have grown to the other side of the row. The cross arms are then rotated further so that the tip of the cross arm touches the ground. The rotation of cross-arms positions all canes at the height of the pivot point or close to the ground. The cross-arms are left in the horizontal orientation so that the flower laterals that emerge from the axillary buds on the tied canes will grow upward. Once the flower buds begin to open, the cross arms are lifted all the way back to their harvest position. The RCA trellis design helps with the re-positioning of the canes without sacrificing the production capacity of the plant and can position nearly all the fruit on one side of the row.

The combination of winter mulch, row cover, and snow cover over the canes and canes positioned close to the ground can theoretically maintain the nightly minimum bud temperatures 6 to 10 ^{o}F above ambient temperatures. It is suggested that growers pay attention to voles and other rodents under the protective covers and take proper measures to manage these pests.

Will these rather simple production modifications allow blackberries to be grown successfully in northern states? Higher capital investment on the trellis material can off-set labor needs and raise crop productivity. We have shown that the RCA trellis system can be used to manipulate the canes with little cane breakage and position fruit to improve harvest efficiency. Whether incorporating this trellis system for blackberry production in northern states will be successful depends on its profitability. For example, the price structure for fresh blackberries in New Hampshire is good (>$3.00/pint) (William Lord, personal communication). Additional field trials will be conducted in Maine, New Hampshire, and Utah to evaluate alternative cultural techniques for improving the sustainability of blackberry production at sites with adverse winter conditions.

Blackberry fruit are delicate and care must be taken for long-distance transport.

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Table 1. The effects of winter protection cover on bud and cane damage and crop productivity in 'Siskiyou' trailing blackberry.

	% Alive			Yield
Cover treatment	Cane	Bud	First bloom	(lbs./plant)
None	19	4	May 22	2.9
Floating row cover	56	40	May 15	10.6
Floating row cover + plastic sheet	86	80	May 11	8.6

Fig. 1. Photographs taken from winter protection studies conducted in 2004 and 2005. (A) The cross arms can be rotated about a pivot point at the top of the post. Note canes are tied down and the cross-arms are in their winter position. (B) Protected covers are placed over some plants. (C) 'Siskiyou' plants that were not protected. Note spring growth is absent on floricanes. (D) 'Siskiyou' plants that were protected with a floating row cover. Lateral canes are full of fruit.