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Title. Assessing blackberry fruit quality as influenced by foliar sprays of calcium and salicylic acid

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Public Abstract.

The objective of this study was to investigate the effect of multiple pre-harvest foliar calcium (Ca) and salicylic acid (SA) treatments on the post-harvest blackberry fruit quality and yield. An additional treatment of shade cloth was included in Virginia (VA). The study in VA was conducted in a completely randomized design with three replicates per treatment and on two varieties- Prime-Ark® Traveler and Prime-Ark® Freedom in established plots at the Hampton Roads Agricultural Research and Extension Center in Virginia Beach, VA. Treatments included **1.** Non-treated control treated with water spray when treatments 2 and 3 were made. **2.** Ca (Nutri-Cal®, CSI Chemical Corporation, Bondurant, IA) spray at 2 fl oz./gallon at floricane-flowering and fruiting season. The four applications of Nutri-Cal® were made on 15 June, 24 June, 1 July, and 13 July 2021. **3.** Salicylic acid spray was made twice on 15 June and 13 July. **4.** Shade cloth with 30% light reduction effect were installed on 2 June and stayed on until 27 Sept. 2021. In Arkansas, at a grower's location, floricane fruit on Prime Ark® Traveler and Osage cultivars were treated with i) Ca and ii) water (non-treated control) on four plants per replicate and treatments were replicated four times. Applications of both Nutri-Cal® (2 fl. oz./ gal) and water were made on 20 May, 28 May, 4 June, 11 June, and 18 June. In VA, we found no treatment differences on U.S. No, 1 yield, U.S. No. 2 yield, total marketable and non-marketable yield, fruit size, pH and post-harvest shelf life for both cultivars. For 'Prime-Ark® Freedom' shade cloth had significantly lower White drupelet disorder (WDD) fresh fruit biomass for the treatment duration period compared to Ca treatment. For 'Prime-Ark® Traveler' shade cloth treated fruits had lower Total soluble solids (TSS) content compared to other treatments. For 'Prime-Ark® Freedom', shade cloth treated fruits had the lowest TSS content but not significantly different than the Ca treatment. For 'Prime-Ark® Freedom', shade cloth treatment had the least firm fruits but those were not significantly different from the non-treated control. In Arkansas, the application foliar calcium did not impact any measured characteristic of fruit quality or post-harvest quality in Arkansas. Cultivar effects were observed for pH, TA and fruit

firmness. No cultivar by treatment interaction was significant at $P<0.05$ for any measured variable.

Objective. **1.** To investigate the effect of multiple pre-harvest foliar calcium (CA) and salicylic acid (SA) treatments on the post-harvest blackberry fruit quality and yield. **2.** Disseminate findings to blackberry growers via grower meetings, presentations, and small fruit newsletter.

Justification and Description. Blackberries (*Rubus* spp.) are low in calories and rich in vitamins, minerals and anthocyanins. One of the obstacles is that blackberry is a very highly **perishable** fruit.

Pre-harvest foliar sprays [e.g. salicylic acid (SA), or calcium (Ca) product such as calcium chloride] have been proven to be an effective way of extending shelf life for fruits marketed for direct consumption (Champa et al, 2015; Abbasi et al, 2013). Calcium plays an important role in fruit firmness (Sams, 1999). The interactions that affect the uptake of Ca in the plant are so complex that cultural practices are unlikely to increase Ca levels in fruit, without a direct Ca application on the fruit either pre-picked or after harvest (Bangerth, 1979; Hanson et al., 1993). Salicyclic acid is an endogenous plant growth regulator and is classified as a growth promoter. It plays an important role in regulating plant growth and development under stress (Hayat et al., 2010). Grape berry quality parameters such as color, flavor, astringency, and bitterness are influenced by SA (Chamkha et al., 2003). Salicylic acid has positively reduced fruit respiration, weight loss, decay and softening rate of strawberry during storage (Babalar et al. 2007; Shafiee et al. 2010). Investigating post-harvest quality of blackberry as affected by foliar treatments in this request will provide timely and valuable growing guidelines for the berry industry to achieve **extended post-harvest storage**.

Methods.

Objective 1.

Virginia. This study was carried out in a completely randomized design with three replicates per treatment and on two varieties- Prime-Ark® Traveler and Prime-Ark® Freedom at established plots at the Hampton Roads Agricultural Research and Extension Center in Virginia Beach, VA. Each replicate had three plants on a T-post trellis. Plants were spaced 4 ft. center to center, in raised beds. Furrow space between two beds was 8 ft. Plants were maintained and drip fertigated as per the Southeast regional caneberry production guide (Fernandez et al., 2016). Treatments included **1.** Non-treated control treated with water spray when treatments 2 and 3 were made. **2.** Ca (Nutri-Cal®, CSI Chemical Corporation, Bondurant, IA) spray at 2 fl. oz/gallon sprayed four times during floricane-bearing season at 10 to 14 days interval between applications. The four applications of Nutri-Cal® were made on 15 June, 24 June, 1 July, and 13 July 2021. **3.** Salicylic acid spray was made twice, once during floricane-flowering and harvest season. Salicylic acid (2.0 mM, Sigma Aldrich Co., USA) was dissolved in a small amount of ethanol and mixed in adequate water as described by Champa et al. (2015) to spray on appropriate treatment plants. Tween 20 surfactant was added to the SA mixture at 0.1% to create better flowability and better foliar surface retention. The two applications of SA were made on 15 June and 13 July in early mornings. **4.** Shade cloths with 30% light reduction effect were installed on 2 June.

Arkansas. Applications were made to floricane fruit on Prime Ark® Traveler and Osage cultivars at a grower's location in White County, AR (zone 7b). Four replications of treated (calcium) and un-treated (water) were applied to four plant plots for both cultivars. Applications of both Nutri-Cal® foliar calcium (30z/ gal) and water were made at: 20 May, 28 May, 4 June, 11 June and 18 of June. The first sprays started at small green fruit and 10% flower on both cultivars and the last spray occurred at black fruit. Applications of calcium and water were applied using a pump sprayer and made to ensure good coverage but not to drip.

Data collection.

Virginia. Blackberry picking was done 2-3 times per week during the growing season. After picking berries; data were collected on crop yield, fruit size, fruit firmness, pH, and total soluble solids (TSS). These parameters were evaluated on floricane bearing fruits. Blackberries from each treatment plots were collected for crop yield, which were then sorted based on grade levels: U.S. No. 1 and U.S. No. 2, non-marketable others and non-marketable white drupelet disorder/sun-scald (USDA, 2016). Fruit size was determined once per harvest week by measuring the length and width of ten U.S. No. 1 fruits per replicate using a Vernier caliper scale. Total Soluble Solids, pH, and fruit firmness were also determined on those same fruits. Additionally, post-harvest shelf life data was collected by placing U.S. No. 1 fruits in vented 6 oz. berry clamshells by treatments and replicated three times during harvest season. Blackberry fruits were placed in the refrigerator at 40 °F at 65% relative humidity, and the storage life was evaluated at 0,7, and 14 days. The weight loss of the fruit was measured by subtracting the clamshell weight on day 14 from the clamshell weight on day 0. The percentage of red cell regression and drupelets damaged were also visually observed.

Arkansas. Fruits were harvested twice per week and post-harvest data that included pH, titratable acidity and fruit firmness was evaluated 5 times during the harvest season in AR.

Objective 2. Disseminate findings to blackberry growers via grower meetings, presentations, and small fruit newsletter.

We plan to repeat the study in VA during the 2021-22 growing season and hope to present two-year findings to growers via presentations and publications in newsletters. Objective two is pending.

Data analysis. Data was analyzed by looking at treatment effects on various parameters including U.S grade 1 yield, U.S grade 2 yield, total marketable yield, total non-marketable yield, effect on white drupelets disorder (WDD), fruit size, fruit firmness, pH, TSS. Since Nutri-Cal® and SA treatments were applied from 6/16/21-7/13/21; the data used for analyzed is also from the same time frame, from 6/16 to 7/23/21 (10 days after last treatment). Data analysis was conducted using JMP software and One-way ANOVA was chosen as the statistic method. Mean separation was done using Tukey's HSD test at alpha=0.05. We checked the data for normality and homogeneity of variance assumptions and transformed data as appropriate.

Results. Virginia. We found no significant treatment differences on yield U.S. grade No. 1, U.S. grade No. 2, total marketable and non-marketable yield, fruit size, pH and post-harvest shelf life for both cultivars. We did find significant treatment differences for 'Prime-Ark® Freedom' on white drupelets disorder (WDD). Shade cloth had significantly lower WDD compared to Ca treatment (P=0.0112).

We found significant treatment differences for TSS content for both cultivars. For 'Prime-Ark® Traveler', shade cloth treated fruits had lower TSS content compared to other treatments (P=0.0088). For 'Prime-Ark® Freedom', SA treatment had the highest TSS content but was not significantly different than non-treated control. Shade cloth treated fruits had the lowest TSS content but not significantly different than the Ca treatment. Another significant difference was found for Prime-Ark® Freedom firmness. Shade cloth treatment had the least firm fruits but those were not significantly different from the non-treated control.

Arkansas. The application of foliar Ca was not found to impact any measured characteristic of fruit quality or post-harvest quality in Arkansas. Cultivar effects were observed for pH, TA and fruit firmness. No cultivar x treatment interaction was significant at $p<0.05$ for any measured variable. Foliar application of Ca starting at small green fruit set did not improve any of the measured fruit quality characteristics for either cultivar evaluated in Central Arkansas.