2015 Southern Region Small Fruit Consortium Progress Report

Title: Evaluation of Harvest Time/Temperature and Storage Temperature on Postharvest Incidence of Red Drupelet Reversion Development and Firmness of Blackberries

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Objectives:

The main objective of this project was to determine the impact of field temperature and time of harvest on the development of red drupelet reversion and firmness of blackberry fruits during postharvest storage on a range of genotypes, including commercial cultivars.

A second objective was to determine postharvest storage temperature on the development of red drupelet reversion and firmness on a firm breeding selections and a commercial cultivar.

Specific objectives

1. To determine the impact of harvest time on postharvest development of red drupelet reversion.
2. To determine the impact of temperature at harvest on postharvest development red drupelet reversion.
3. To quantify the effects of time of harvest and temperature at harvest on flesh firmness.
4. To determine the impact of storage temperature on red drupelet reversion and firmness.
5. To identify genotypes within the breeding program with a high tolerance for postharvest development red drupelet reversion.

Justification and Description:

Blackberry (*Rubus* L. subgenus *Rubus* Watson) is a member of the *Rosaceae* family. Blackberry fruit is commonly sold fresh or as a processed product. In 2011, U.S. blackberry production was evaluated at $43.2 million, with 4.0 million pounds sold as fresh fruit and 49.2 million pounds sold as processed product (Giesler and Morgan, 2012). Blackberries for the shipping market have become an important crop for the southern US, with substantial acreages in several southern states including Georgia, North Carolina, South Carolina, and Arkansas.

Red drupelet reversion (or simply referred to as reversion) is a postharvest disorder expressed in blackberry fruits in which some drupelets change from black to red after harvest. This is among the most important postharvest issues in the shipping blackberry industry as well as retention of firmness of berries. It is hypothesized that reversion occurs when fruits are exposed to a rapid change of temperatures that contributes to the breaking apart of cell membranes, primarily the vacuole membrane. Approximately 90% of mature cell volume is occupied by the vacuole, a cell organelle that is dynamic, multifunctional, and the organelle provides the primary site of macromolecule storage and turnover (Fontes et al., 2011). This organelle accumulates sugars, aromas, flavors, ions, and water; all these compounds are transported across the tonoplast (vacuole membrane) by a specific transporter protein (Fontes et al., 2011). When the vacuole membrane is interrupted, its contents can leak into the cytoplasm changing the cytoplasm pH.

This rapid change of temperatures often happens very soon after harvest, when growers often harvest fruit during the hot periods of the day, and then the fruit is rapidly transferred to cold storage for postharvest handling. Therefore, berry temperatures can undergo a change from up to 40 to 0°C in a short period and this is thought to contribute to reversion development.

Reversion has a negative impact for growers and shippers, because fruits having red drupelets are unattractive to consumers and can be rejected by shippers and marketers. So far, there is no chemical treatment or clear handling protocol to reduce or avoid this problem. There appears to be two areas of focus to determine a solution for this problem. The first one is to learn more about and try to improve management of temperatures from harvest to postharvest handling. A second solution is to breed for cultivars that have lowers levels of reversion. Recent work in the Arkansas program has identified genotypes with improved retention of black color along with very high firmness. The best solution, however, will likely be a combination of both which implies a more complete understanding of the problem.

If fruit was harvested for postharvest storage potential over a range of temperatures (by harvesting later in the day), including those above 30^{o}C, the higher temperature harvest potential would be determined. This information could be very important in making recommendations about how to manage the harvest of released cultivars and to identify new breeding selections that show tolerance to higher temperatures resulting in improved postharvest handling cultivars.

Therefore, the principal goal of this project was to develop a better understanding of color reversion and postharvest firmness under different harvest temperatures across a range of genotypes and to simulate the conditions of a commercial-grower field and postharvest storage temperatures. Further, we hoped to be able to determine if the high firmness genotype in the breeding program was able to resist reversion and potentially allow a broader harvest period with assurance that reversion is reduced or eliminated with this fruit characteristic.

Methodology

The experiments were conducted in June and July 2015 at the University of Arkansas Fruit Research Station in Clarksville. Harvested fruits were attained from blackberry plants that were grown with cultural components including annual routine commercial plant management practices including fertilization, weed control, and irrigation.

The work was done by undergraduate honors student Jack McCoy and mentored by J R Clark and Alejandra Salgado.

Study 1

Genotypes used in this study were the cultivars Natchez, Ouachita, Osage, Prime-Ark® 45, Prime-Ark® Traveler, Black Magic™/APF-77 and advanced selections A-2450 and A-2453. These include a range of fruit textures.

Shiny-black fruits free of any defects of each genotype were harvested into 0.24 L clamshells at 7:00 $_{\text{AM}}$, 10:00 $_{\text{AM}}$, 1:00 $_{\text{PM}}$, and 4:00 $_{\text{PM}}$ each day. Two replicates were harvested at each harvest time and harvest was repeated for each genotype. Also, at each time fruit and leaf temperature was recorded prior to harvest (this measurement added as recommended in the SRSFC grant review process). Fruit was moved immediately following harvest to cold storage for 7 days at 5°C. After storage, fruit was firmness and red drupelet reversion was evaluated. Fruit Firmness was measured using an iCon Texture Analyzer (Texture Technologies Corp. Hamilton, MA) with N (Newtons) the value generated in the measurements.

- Compression: fruit compression was performed by placing 10 individual fruits horizontally on a flat surface using a cylindrical and plane probe of 7.6 cm diameter.
- Drupelet penetration: drupelet skin firmness was assessed using a probe of 1 mm diameter. For this, three drupelets of similar shape and size were measured on each of the 10 berries.

Red drupelet reversion was rated using the following scale on all fruits harvested.

RD_0: fruits with no red drupelets after cold storage.
RD_1-3: fruits having one to three red drupelets after cold storage.
RD>4: fruits having 4 or more red drupelets scattered on the fruit after cold storage.

Study 2

Genotypes used for study 2 were A-2453T and Osage, both with good postharvest storage capacity. Shiny-black fruits free of any defects of each genotype were harvested into 0.24 L clamshells at 7:00 $_{\text{AM}}$ and 1:00 $_{\text{PM.}}$ Four replicates were harvested at each time and harvest was repeated for each genotype. Fruit and leaf temperature was recorded prior to harvest. Fruit was moved to storage immediately after harvest for 7 days and stored at 1°C and 5°C. After 7 days, fruit was removed from storage and evaluated for firmness and red drupelet reversion using the same protocol as study 1.

Results and Discussion

The field and storage aspects of the study have been completed successfully. The season provided for an adequate crop of berries for all genotypes. The season was rather rainy, creating difficulty some days in harvesting dry fruits. A full statistical analysis of data and assessment of results/conclusions is still underway at this time. However, preliminary results have been evaluated and some major tentative findings can be derived.

Study 1

Study 1 showed significant differences among genotypes and time of harvest for firmness as measured by compression (drupelet penetration results were less conclusive). For overall firmness among genotypes, Black Magic™ (APF-77), a commercial cultivar that is documented to be soft, showed the lowest firmness (4.2 N), Prime-Ark® Traveler (6.9 N) and A-2450 (7.8 N) were firmer, and A-2453 (9.4 N) was the firmest. The A-2453 selection is a "crispy"-textured berry which was anticipated to have the firmest texture out of the selected genotypes.

Firmness as related to time of harvest was also analyzed. According to firmness data collected, significant differences among harvests were only seen between 10:00 AM and 4:00 PM. This supports the idea that later harvests (after extended exposure to higher temperatures) can impact firmness, but the initial findings did not fully follow what was anticipated of firmness being reduced consistently with harvests and subsequent higher temperatures later in the day. Closer examination by genotype is ongoing with this data.

Genotype distribution was similar to firmness for red drupelet reversion with Black Magic™ (APF-77) (72%) showing the greatest amount of reversion and A-2453 (22%) the least. More importantly, reversion over time showed significant differences between 7:00 AM and all other times. A significant correlation between red drupelet reversion, genotype, and time is being examined with this data.

Temperature and how it related to the variables will be analyzed further through additional statistical procedures.

Study 2

Study 2, which used A-2453T and Osage, harvested at 7:00 AM and 1:00 PM, and stored for 7 days at two temperatures, showed few treatment effects in the initial data analysis. Both of these genotypes have been shown to have very good storage potential, but it was anticipated that the crispy A-2453T would reveal better storage. Further data analysis is underway for both firmness and reversion data. As in Study 1, temperature and relationship to the variable data will be further analyzed.

Conclusion

Although data analysis is not yet completed, it is becoming clear from the results of this study the significant effects of harvest time and genotype on blackberry firmness and red drupelet reversion. Final results should provide important information on harvest time for blackberry. It will also confirm the value of the "crispy" textured fruit, such as A-2453, in postharvest storage.

Impact Statement

Results of this study will provide important information on the effect of harvest time on postharvest characteristics of blackberry such as firmness and red drupelet reversion. It will also help the University of Arkansas Fruit Breeding Program in making selections to minimize incidence of red drupelet reversion in postharvest storage.

Literature Cited

Fontes N., H. Geron, and S. Delrot. 2011. Grape berry vacuole: a complex and heterogeneous membrane system specialized in the accumulation of solutes. Amer. J. Enol. Viticul. 62:270-279.

Geisler, M. and K. Morgan. 2012. Blackberries. Agricultural marketing resource center. 25 October 2014. < http://www.agmrc.org/commodities__products/fruits/blackberries/>.