Effect of Harvest Time on Red Drupelet Reversion in Blackberry (*Rubus* subgenus *Rubus*)

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Introduction

Red drupelet reversion is a postharvest disorder that happens when black drupelets turn red during or after cold storage (Finn and Clark, 2012) (Fig. 1). This condition can negatively impact consumer preferences that favor glossy and uniform black drupelets (Threlfall et al., 2016). Almost 40% blackberries produced are lost due to postharvest mishandling and red drupelet reversion (Pritts and Handley, 1989). There has been some speculation that the cause of red drupelet reversion is due to an intracellular change in pH stemming from physical and temperature-related damage to the cell wall and the vacuolar membrane (Salgado and Clark, 2016).

The University of Arkansas (UA) blackberry breeding program has conducted research to discover genetic and cultural solutions to reduce the incidence and severity of red drupelet reversion. Salgado and Clark (2016) found that new 'crispy' textured genotypes developed from the program had lower rates of reversion than softer genotypes. McCoy et al. (2016) also conducted a small one-year study that included harvesting berries at different times of day and suggested that harvesting berries at earlier, cooler times resulted in lower rates of reversion.

The objectives of this study were to:

- Evaluate the incidence of red drupelet reversion after a week of cold storage for seven UA genotypes harvested at different times of the same day during the 2018 and 2019 growing seasons
- Determine whether fruit firmness is correlated to the incidence of red drupelet reversion

Fig. 1. Blackberries exhibiting red drupelet reversion will have a non-uniform distribution of red drupelets that can give off an unripe appearance

Materials and Methods

- Fruit was harvested in June of 2018 and 2019 at four different times: 7:00 a.m., 10:00 a.m., 1:00 p.m., and 4:00 p.m.
- Two harvest dates took place per harvest season during peak ripeness separated roughly by one week
- Seven genotypes were harvested that reflect the range of fruit firmness for blackberries developed at the UA breeding program: A-2453, 'Black Magic™', 'Natchez', 'Ouachita', 'Osage', 'Prime-Ark® 45', and 'Prime-Ark® Traveler'
- Two 0.24 L vented clamshells were filled for each genotype per harvest time before being placed in cold storage for seven days at 5 ºC
- Fruit temperature at harvest was taken from an average of five subsamples per clamshell using an infrared temperature meter (Raytek Raynger ST)
- Fruit was subjectively evaluated at room temperature after seven days of cold storage to determine the percentage of reverted berries per clamshell. Berries with three or more reverted drupelets were considered reverted
- Firmness was analyzed on ten randomly selected berries from each clamshell using a TA.XTplus Texture Analyzer (Texture Technologies Corp. Hamilton, MA) with a cylindrical plane probe 7.6 cm in diameter (Fig. 2)
- Three randomly selected berries per clamshell were used to evaluate for composition analysis such as total soluble solids, pH, and titratable acidity

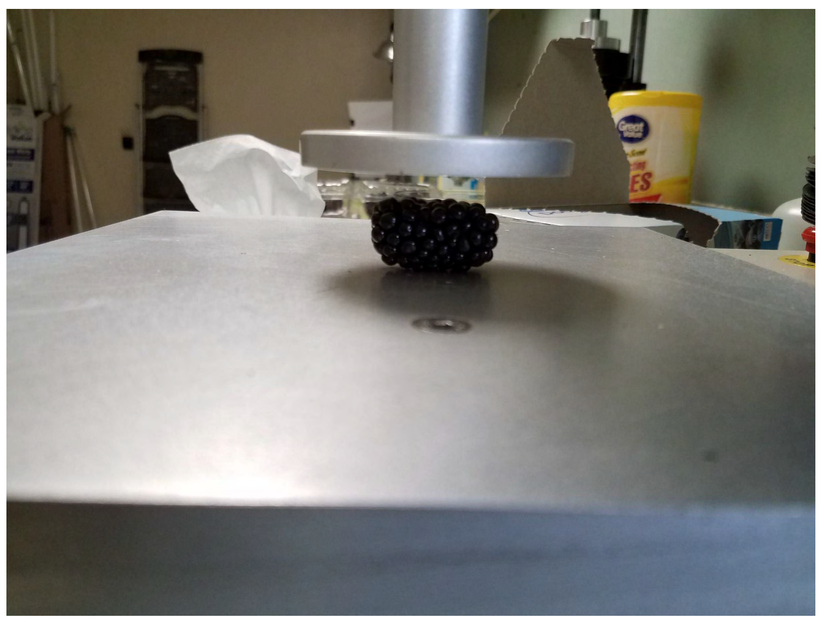

Fig. 2. Firmness (N) was measured by compression on ten berries per experimental unit using a TA.XTplus texture analyzer

Statistical Model

- Analysis of variance was performed with the data analyzed as a three-way factorial completely randomized design using the GLIMMIX Procedure in SAS v. 9.4 (SAS Institute, Inc., Cary, N.C.)
- Clamshells served as the experimental units with genotype, harvest time, year, and their respective interaction terms serving as fixed effects
- Harvest date was nested within year and considered a random effect
- Mean separation was performed using Tukey's Honestly Significant Difference (HSD) at an alpha level of 0.05
- Pearson's correlation coefficient was used to test the significance of the correlation between the severity of red drupelet reversion and the firmness of each genotype

Time	Berry Temp. °F	Mean % RDR
7:00 a.m.	74.1 a	4.9 a
10:00 a.m.	86.4 b	8.3 ab
1:00 p.m.	91.4 c	13.2 b
4:00 p.m.	91.1 c	11.9 b
P value	*0.0001*	*0.0001*

Table 1. An average of berry temperature and % berries reverted by harvest time of day

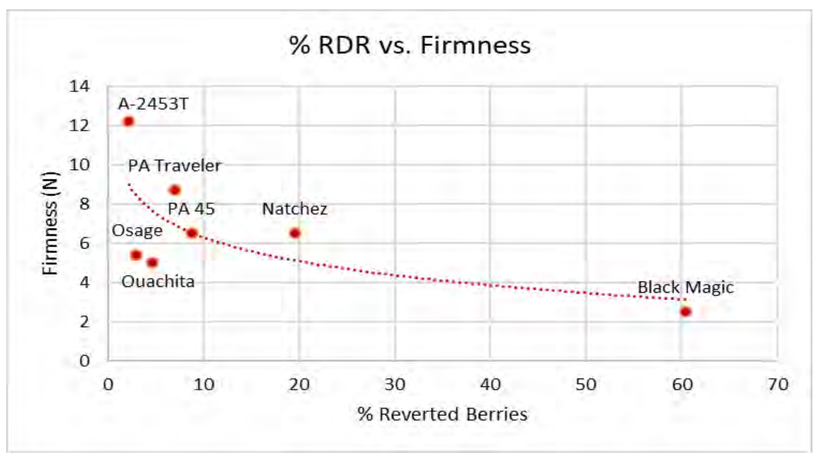

Fig. 5. Regression plot between % red drupelet reversion and average berry firmness per genotype

Results

- Blackberries harvested at earlier times showed a lower severity of reversion with the 7:00 a.m. harvest having the least (Table 1)
- A-2453T was significantly firmer than all other genotypes and experienced the least reversion, whereas Black Magic™ was the softest and had the most reversion (Fig. 3 and 4)
- No significant differences were detected between harvest times for soluble solids content, pH, or titratable acidity
- There was a 46% negative correlation between firmness and reversion at a p-value of 0.0001 (Fig. 5)

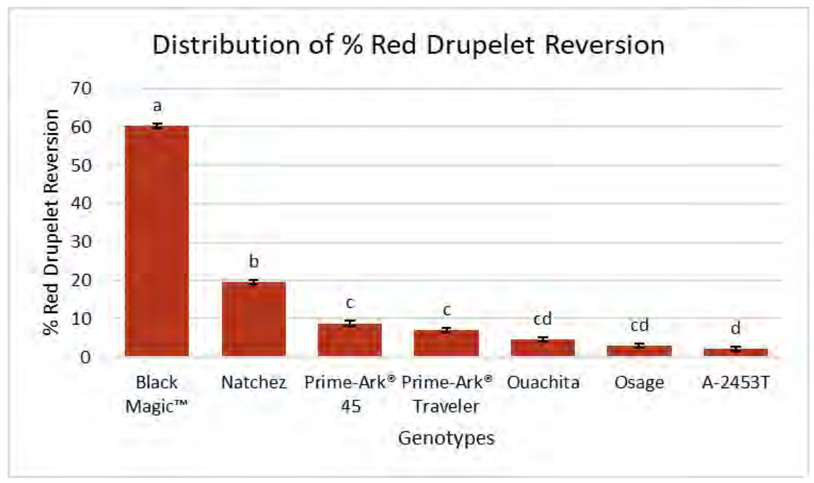

Fig. 3. Distribution for the incidence of red drupelet reversion per genotype

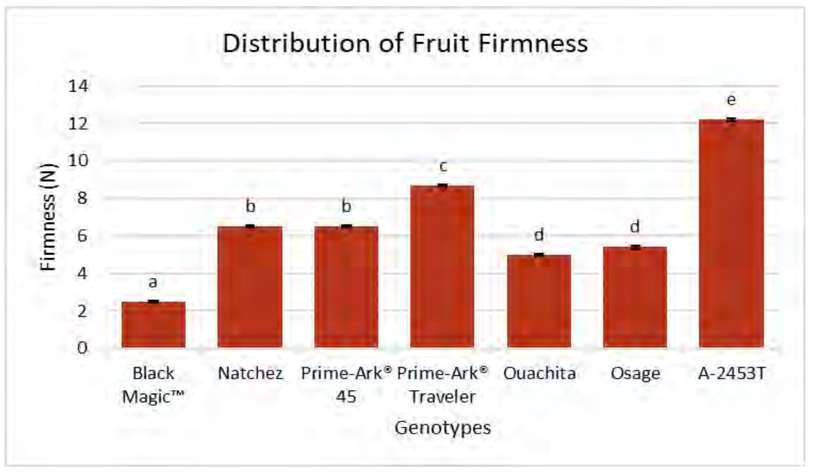

Fig. 4. Distribution for average fruit firmness per genotype

Conclusions

- This study supports the theory that harvesting at earlier (cooler) times of day can significantly reduce the incidence of red drupelet reversion
- Firmer genotypes can additionally reduce reversion rates
- These results further support findings from similar studies testing for firmness and reversion such as Salgado and Clark (2016), McCoy et al. (2016), and Yin (2017)
- Harvest times not having a significant difference with any of the composition analyses indicate that the berries were harvested at uniform ripeness
- Since there is a 46% negative correlation between firmness and reversion, other factors might influence reversion rates such as anthocyanin content, ripeness, nitrogen uptake etc.
- A high-performance liquid chromatography analysis (HPLC) is currently underway to determine if the incidence of red drupelet reversion is influenced by varying levels of anthocyanins that are genotype-specific
- Future research to discover the underlying genetic causes of 'crispiness' is recommended to develop more reversion-resistant varieties

References

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