WHAT IS WRONG WITH MY BLACKBERRY?

Identifying Fresh-Market Blackberry Disorders

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RESEARCH & EXTENSION
University of Arkansas System

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Identifying Fresh-Market Blackberry Disorders

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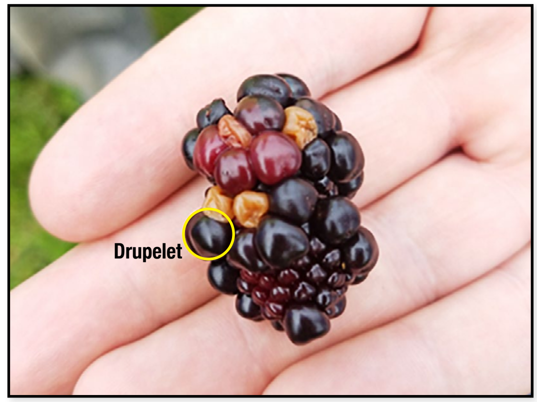
Introduction

Blackberries are resilient plants that can tolerate remarkable levels of pest pressure and still achieve decent yields. They are, however, susceptible to several diseases and insects that limit plant health, productivity, and fruit quality. The name blackberry is misleading as blackberries are not true berries but are instead an aggregate fruit. A true berry is formed from a single ovary in one flower, whereas a blackberry flower has more than 100 ovaries. Each pollinated ovary develops into a small drupelet (Figure 1). Blackberry fruits are composed of many drupelets held together by a torus (also known as a receptacle), the white inner structure of the berry. Blackberry fruit disorders tend to affect a single drupelet or a cluster of drupelets.

Figure 1: A blackberry fruit displaying multiple disorders.



Blackberry fruit can become misshapen, off-color, or deformed which makes fruit unappealing or inedible to the consumer (Figure 1). These disorders can be caused by living organisms (biotic disorders) or environmental factors (abiotic disorders). Conditions that could cause an abiotic disorder include temperature and humidity, while biotic disorders are caused by insects or disease-causing pathogens. Whether abiotic or biotic, visible symptoms of disorders can develop both before and after a blackberry is harvested. Noting when a symptom becomes visible can help identify the cause of the disorder. Preharvest disorders are visible while fruit is still developing on the plant and are easily spotted, and fruit can be discarded before or during harvest. Symptoms of postharvest disorders become visible after harvest when berries are in storage or during shipping. Postharvest disorders are often the result of improper fruit handling or fruit temperature management after harvest but can be intensified by field conditions prior to harvest.

The long, hot, and humid summers that often characterize much of the southeastern U.S. can accelerate the development and severity of many common blackberry disorders. Most fresh-market blackberries are harvested and sold commercially in clear, plastic clamshells, making the appearance of the blackberries important to the consumer. Commercial fresh-market blackberries must meet the standards established by the United States Department of Agriculture (USDA, 2021). Fruit that fails to meet these standards is rejected at the market and can result in large economic losses for growers. The following guide can help identify the cause of misshapen, off-color or odd-looking blackberries and where possible provide recommendations for how to prevent these fruit quality issues.

Preharvest Disorders

Abiotic Disorders:

Poor Drupelet Formation

Pollination

Poor drupelet formation most commonly occurs when flowers are incompletely pollinated (Figure 2). While blackberry flowers are self-fertile, pollen must be moved from the stamens to the pistils for pollination to occur (Figure 3). Each pollinated ovule will develop into an individual drupelet while unfertilized pistils will fail to fill or remain undersized (Andersen, 2020). Blackberry flowers can have 100-125 pistils; only 75-85 must be fertilized to get a large, well-formed berry. Passive transfer of pollen from anthers to pistils can occur with wind, however, insect pollinators such as bees will improve pollination and ensure good fruit size (Project IPC, 2023). Flower structures such as pistils and stamens remain viable for a short time, often less than 36 hours. Extended periods of cool, cloudy, or wet weather during flowering will limit or slow pollen movement, increasing the number of deformed berries for an extended period of the harvest season.

Figure 2: Poor drupelet formation resulting from incomplete pollination.
Photos from upper to lower provided by Erika Henderson (2) and Amanda McWhirt.

Figure 3: A blackberry flower. Yellow pistils surrounded by pollen bearing stamens.
Photos provided by Amanda McWhirt.

Virus and Nutrient Disorders

Poor drupelet formation can also be caused by plant viruses or a boron deficiency (Figure 4). Plant viruses can be a major issue for blackberry production in the Southeast. Over time viruses can build up in the crop resulting in a slow decline in crop health and yields. Fruit quality will also decline, often characterized by small 'crumbly' berries with poor drupelet set and drupelet fill. Acquiring plants from a reputable nursery that supplies healthy, virus-tested plants will help avoid these issues. Boron levels in the plant can be monitored through annual sampling of nutrients in plant tissue (Strik, 2017). If a deficiency is present, boron should be applied just prior to bloom in the spring.

Figure 4: Poor berry formation caused by a suspected plant virus.
Photo provided by Taunya Ernst.

Sunscald

Sunscald or sunburn results when fruit is exposed to direct sunlight and often occurs when air temperatures exceed 90°F. Symptoms are characterized by multiple adjacent drupelets, always on the sun-exposed side of the fruit, turning white and eventually changing to brown giving the berry a "blanched" or "cooked" appearance (Figure 5). Sunscald and white drupelet disorder (see next section) are often present at the same time.

Maintaining good plant health can ensure sufficient leaf cover to protect berries from direct sunlight. Movable or rotating trellis systems can reduce the occurrence of sunscald (McWhirt et al., 2019). In 2010, growers in the Southeast United States reported a 30% loss in fresh market Apache blackberry production to sunburn and white drupe (Takeda et al., 2013).

White Drupelet Disorder

Commonly known as white drupe, this disorder is characterized by individual or scattered white-colored drupelets on fruit that have otherwise developed normally (Figure 6). While resistant cultivars are available, environmental conditions can cause white drupe to appear in any cultivar (Stafne et al., 2017). Climatic conditions often associated with white drupe include a drop in humidity with an increase in air temperature. This reduction in moisture increases the solar radiation directly contacting berries. Trellising that reduces fruit exposure to direct light and

Figure 5: Sunscald on blackberry fruit.
Photos from left to right provided by Taunya Ernst (2) and Amanda McWhirt.

high air temperatures can prevent white drupe (Stafne et al., 2017; Takeda et al., 2013). White drupe and sunscald are similar in appearance and occur due to similar climatic conditions; the primary distinction between the two disorders is the severity and number of drupelets affected. In addition, there appears to be a genetic component to white drupe, as some cultivars like Apache are more prone to developing the disorder than others, whereas all cultivars may develop sunscald when climatic conditions are conducive to the disorder.

Methods for prevention of white drupe are similar to those for sunscald. Movable or rotating trellis systems can significantly reduce white drupe (Takeda et al., 2013). Selecting cultivars that are resistant can also reduce the occurrence of this disorder.

Double Berry

Double berry is when two fused berries form from a single flower (Figure 7). Double berry is primarily an issue with primocane-fruiting cultivars. In addition to a cultivar susceptibility, double berries have been observed when high temperatures are recorded just prior to or during flowering (field observations by Dr. John Clark). Prime-Ark® Freedom and Prime-Ark® 45 are very susceptible to forming double berries while Prime-Ark® Traveler shows resistance to this abiotic disorder. The relationship between high temperatures at bloom and this disorder is important for Arkansas and other Southeast growers as primocane fruiting blackberries generally flower between June and August. Drupelets on double berries will ripen normally and berries can still be sold locally at farmers markets or pick-your-own farms.

Figure 6: White drupelet disorder on blackberries.
Photos from left to right provided by Aaron Cato, Amanda McWhirt and Taunya Ernst.

Other Environmental Stresses

Cold temperatures during winter and spring can damage or kill developing blackberry buds and canes (Figure 8). Blackberry cultivars tolerate winter temperatures during dormancy differently but generally, temperatures at or below 0-10°F in midwinter can kill or injure canes (Takeda, 2017). Swelling buds or open flowers are subject to damage or death when spring temperatures drop to 27°F or below (Takeda, 2017). Frequent and heavy rains during bloom or harvest increase the incidence of disease,

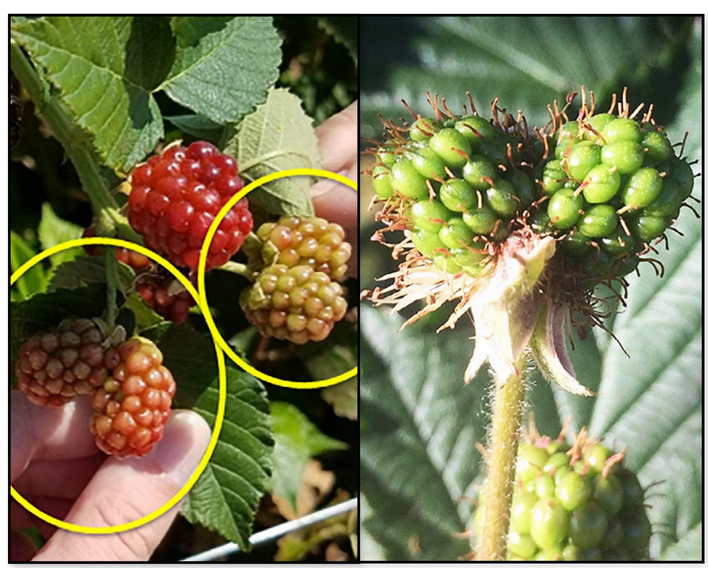
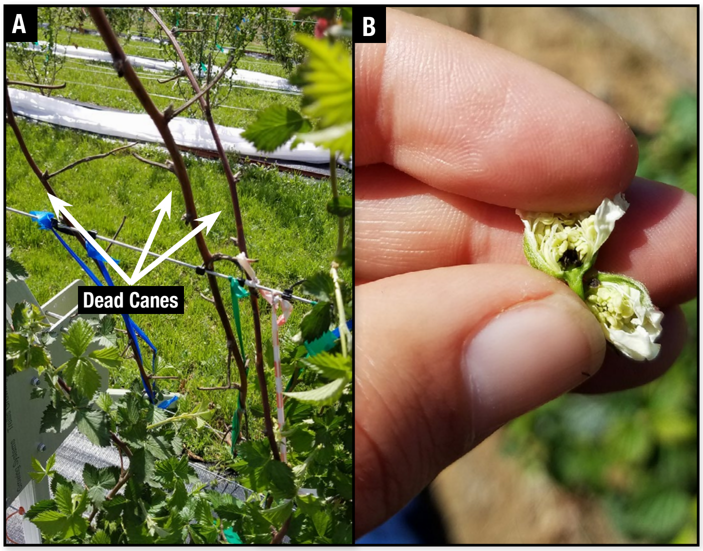


Figure 7: Double berries on a blackberry plant.
Photos from left to right provided by Amanda McWhirt and Erika Henderson.

Figure 8: Blackberry canes killed by cold winter temperatures (A). Black center of a blackberry flower indicating cold damage from a late spring frost (B).
Photos provided by Taunya Ernst.



and berries harvested wet (during or after a rain event) also have much higher rates of postharvest decay and a shorter shelf life.

Biotic Disorders: Diseases

Anthracnose

Anthracnose is a common fungal disease that affects blackberry leaves, petioles, flower buds, canes, and fruit. Infected drupelets will have sunken discolored (tan) spots on individual or groups of drupelets, and berries will become crumbly (Figure 9) (Travis and Williamson, 2017). Symptoms on canes or leaves begin as small purplish spots which enlarge over time and become sunken with ash-gray centers (Figure 10). Larger spots, referred to as cankers, can become large enough to girdle and kill sections of canes or defoliate plants (Travis and Williamson, 2017). Symptoms initially appear on first-year canes and enlarge into cracks and cankers during the dormant season and into the early spring on second-year canes. Spores

Figure 9: Blackberry fruit infected by anthracnose, the tan/brown dry drupelets.
Photos from left to right provided by Aaron Cato, Amanda McWhirt and Erika Henderson.

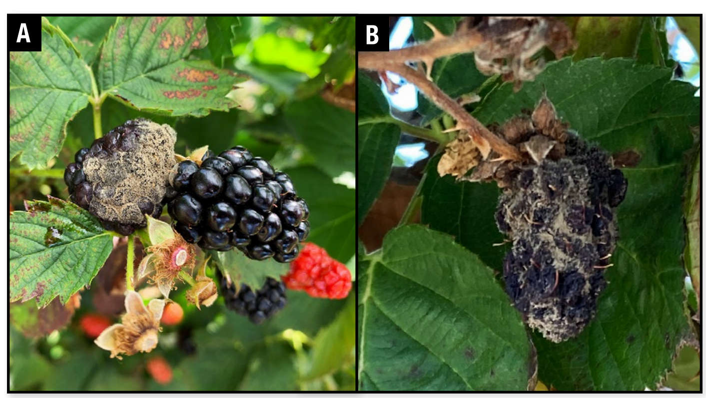
from cane lesions move to leaves and fruit of second-year canes, ultimately causing dry drupelets. Spores will also infect new canes as they emerge. Warm, wet conditions with minimal air circulation can accelerate the growth and spread of anthracnose spores. A good trellis system can improve intracanopy air movement and light penetration, which reduces humidity and will dry foliage more quickly. This will reduce the spread of spores. Other cultural practices, such as the selection of resistant cultivars, physical removal of infected canes, and avoiding overhead irrigation, can be effective in controlling the spread of anthracnose. A lime sulfur or Sulforix® spray in the late winter, just after bud break, is critical in preventing anthracnose from infecting canes and fruits. If anthracnose is discovered in a planting, an additional fungicide application should be added to the fungicide protection schedule (Travis and Williamson, 2017).

Figure 10: Blackberry cane with anthracnose cankers.
Photo provided by Aaron Cato.

Grey Mold/ Botrytis

Arkansas often experiences frequent heavy rains during the bloom and harvest period. These conditions are perfect for the growth and spread of botrytis (grey mold), a common pre- and post-harvest fungal disease in fruits. Infected flowers or fruit will become covered by a soft, light brown mold (Figure 11). As conditions dry, infected tissue will shrivel, dry out, and become a source of inoculum for further infection (Bristow and Williamson, 2017). Spores can overwinter on infected tissue. Removing and burning infected plant tissue will decrease inoculum sources. Flowers are very suspectable to infection, with

Figure 11: Botrytis growing on blackberry fruit (A). Shriveled blackberry with botrytis spores (B).
Photos from left to right provided by Aaron Cato and Erika Henderson.



visual symptoms of the disease not becoming visible until the ripe fruit stage. No cultural practice can fully prevent botrytis if environmental conditions are right for fungal growth (Bristow and Williamson, 2017). However, trellising can promote better air movement which will dry plant tissue more quickly, lowering the occurrence of botrytis and slow the spread of the disease. Fungicide applications should begin when 10% of flowers have opened and continue into harvest if conditions remain conducive for the fungus growth. Berries harvested wet (during or after a rain event) experience much higher rates of postharvest infection and have a shorter shelf life.

Biotic Disorders: Insects

Spotted-wing Drosophila (SWD)

Spotted-wing drosophila (Drosophilia suzukkii) (SWD) is an invasive fruit fly initially introduced to the United States in the early 2000s. The first SWD populations were observed in Arkansas in 2012. Unlike many native fruit flies which impact fruit post-harvest, SWD can infest undamaged ripening or ripe fruit in the field before harvest. This invasive pest has significantly impacted soft fruit production in the United States. In 2008, California alone estimated a 50% loss of marketable blackberry and raspberry yields due to SWD, an $89.9 million loss in revenue (Bolda et al., 2010).

Adult SWD females have large, serrated ovipositors (saw-like appendage on the abdomen) that allow them to penetrate the soft outer skin of blackberries, and other soft fruit and insert eggs inside the developing berry (Figure 12). When the eggs hatch, a maggot develops and feeds inside the ripening fruit (Rebollar-Alviter and Williams, 2017). Berries with actively feeding larvae can be identified by the presence of soft, broken, and leaking drupelets (Figure 12). At harvest if larvae are small, it can be difficult to ascertain if a berry has been infested, but larvae will continue to develop after harvest and may be visible to consumers who later purchase the fruit.

Figure 12: Spotted-wing drosophila damage on a blackberry (A). SWD larva on a blackberry fruit (B) and an egg under the blackberry skin (C).
Photos from left to right provided by Erika Henderson, Lizzy Herrera and Taunya Ernst.

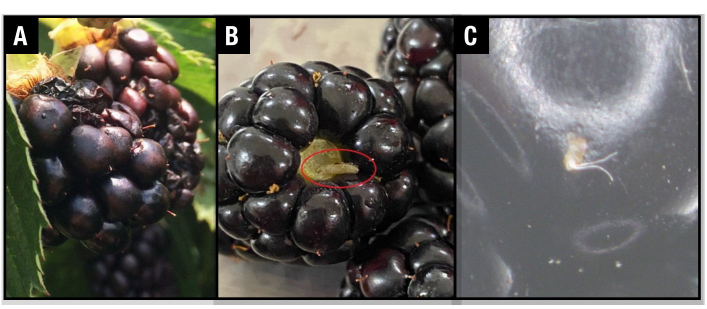
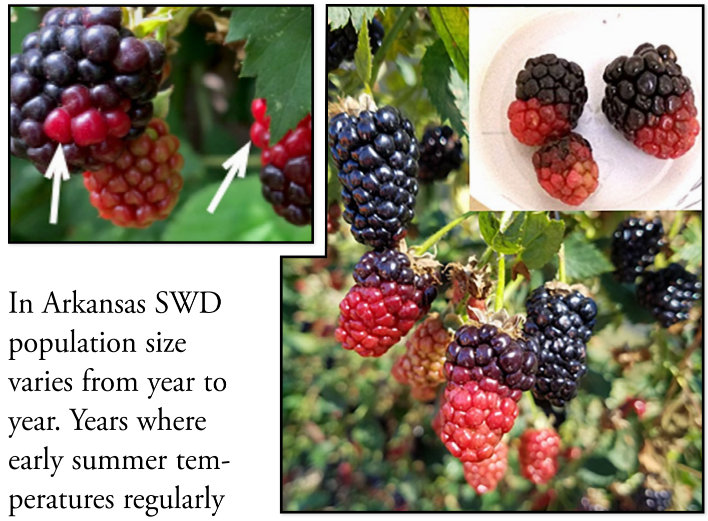


Figure 13: Photo of blackberries suspected to have redberry mite. This mite has not been confirmed in Arkansas.
Photos from left to right provided by Caron et al.,2018 and Amanda McWhirt.



In Arkansas SWD population size varies from year to year. Years where early summer temperatures regularly exceed 90°F often experience much lower SWD pest pressure. However, there is zero tolerance for SWD infestation of fruit in fresh markets, and as a result growers must take a very proactive approach to dealing with this pest. Preventive management and regular monitoring are required to control this pest. Detecting a single SWD fly in monitoring traps should trigger a protective spray program (Loeb et al., 2019).

Cultural practices can help reduce SWD population sizes. Harvesting berries regularly, as often as every two days, and removal of unmarketable fruit from the field can reduce reproduction and survival of adult flies (Isaacs et al., 2013). Cooling berries to storage temperatures (32-34°F), as quickly as possible after harvest can halt larval development. In blackberry fields, adult SWD prefer to live in the dense, humid parts of a blackberry canopy. Modifying training and trellising systems to reduce favorable breeding environments can help reduce population size (Schöneberg et. al., 2021). For example, fewer SWD eggs per berry have been observed in trials using the rotating cross arm (RCA) trellis (Henderson, 2020). While cultural management strategies are necessary to lower SWD pressure, a weekly insecticide spray program is necessary to achieve acceptable control (Babu et al., 2022). Consult the MP-144 guide (https://www.uaex.uada.edu/publications/mp-144.aspx) for a list of registered products. SWD can infest early ripening fruit when populations are high. This necessitates insecticide applications at least 10 days prior to the first harvest. Subsequent applications should continue at least every 7-10 days throughout the harvest season.

Redberry Mites

Though not confirmed to be a pest in Arkansas, symptoms matching redberry mite (Acalitus essigi) damage (Figure 13) have potentially been observed over the past few years. These microscopic mites can be difficult to see, even with the aid of a 20-30x hand lens (Caron et al., 2018). A red berry mite feeding at the base of a developing drupelet will inject a toxin that causes a small cluster of drupelets on a berry to remain hard and bright red while the remaining drupelets develop normally (Caron et al., 2018). Impacted drupelets never ripen while the rest of the berry rots, making the fruit unmarketable. Populations of red berry mites become larger as the season progresses making late bearing cultivars more susceptible to this pest. When symptoms become visible, chemical applications are ineffective. Lime sulfur applications at leaf bud swell (before buds open) and again just before flowers open can be effective to prevent damage. Two or three applications of a horticultural oil, such as Stylet Oil, when fruit are green or pink has been shown to be an effective preventive method. Be aware that phototoxicity is a concern if lime sulfur and horticultural oil is applied within 30 days of each other, or if temperatures exceed 80-85°F (Caron et al., 2018).

Because of the high risk that redberry mite spray programs could cause phototoxicity, Arkansas growers should be cautious when diagnosing red berry mite damage. It is not uncommon to see asynchronous maturation of drupelets on blackberry that is not caused by redberry mites. In these cases, all drupelets will eventually mature making the berry marketable. If red berry mite is suspected, berries can be tagged or marked and monitored to see if red drupelets remain undeveloped over a period of 7-10 days.

Stink bugs

Stink bugs can feed on green, red, or black fruit. Usually, stink bugs do not physically damage the drupelets while they feed, though they can pierce a drupelet while reaching for the torus (white tissue behind the drupelet). Visible damage, when it occurs, is generally localized to one or two drupelets (Figure 14). The real issue comes from the foul-smelling defense chemical that they can release into the fruit while feeding (Cato, 2022). Affected fruit will taste exactly like a stink bug smells. Large stink bug populations increase the chance of a consumer eating a foul-tasting berry and not purchasing more fruit. Stink bugs can be found in blackberry fields every year but may not always have numbers high enough to be an issue. Growers should monitor stinkbug population size with scouting. Chemical treatment is recommended when a stink bug can be found on every second or third plant (Cato, 2022). When chemical treatment is necessary, make applications while most of the population are nymphs, before they mature to adults. Stink bug nymphs are more vulnerable to pesticides than adults. See the MP-144 insecticide recommendation guide for a list of products that are registered for stink bug management.

Figure 14: Stinkbug nymphs emerging on a blackberry (Left), stinkbug adult on a blackberry (Center) and Blackberry drupelets damaged by stinkbug feeding (Right).

Photos from left to right provided by Lizzy Herrera and Aaron Cato (2).

Postharvest Disorders

Abiotic Disorders

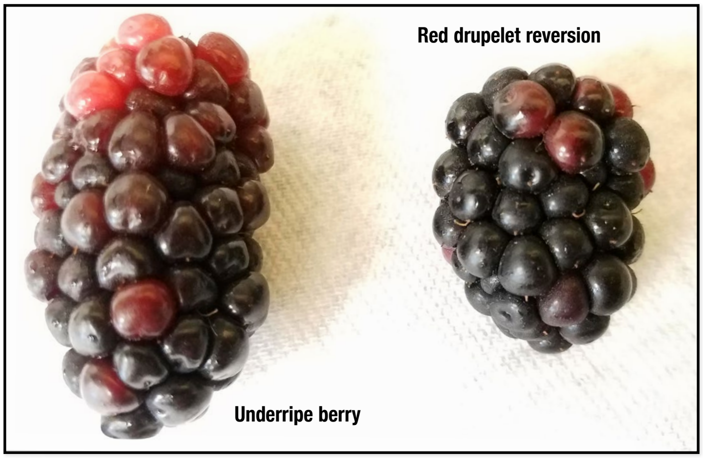
Red drupelet reversion

Red drupelet reversion is also known as red-cell reversion or red drupelet disorder and is characterized by fully black drupelets reverting partially or completely from black back to red after harvest (Figure 15). Reversion can be isolated to a single drupelet or may affect many drupelets on a berry. While reversion does not alter berry flavor, the red coloration gives fruit the appearance of being unripe (Figure 16), negatively affecting the marketability of the fruit (Threlfall et al., 2020; Threlfall et al., 2021). Affected drupelets also soften, impacting postharvest shelf life. While mechanical injury during or after harvest is associated with the expression of this disorder, genetic and abiotic factors also heavily affect the presence and severity of red drupelet reversion (Edgley et al., 2020). While the exact cause of this disorder is not fully

Figure 15: Blackberry berries with several drupelets that have regressed to red.

Photos from upper to lower provided by Amanda McWhirt and Sarah Cato.

Figure 16: The red drupelets on an unripe blackberry compared to drupelets that have reverted back to red after fully coloring.
Photo provided by Taunya Ernst.



understood, warm temperatures during harvest (above 73°F), rapid temperature changes after harvest, unsuitable storage temperature, and excess nitrogen fertilizer can contribute to an increase in severity of this disorder (Armour et al, 2021; Edgley et al., 2020).

Commerical retail stores have a low tolerance for reversion and may reject shipments with high rates of red drupelet reversion. USDA guidelines and standards for grade 1 fresh-market blackberries require firm, well-colored and well-developed berries that are 99% free from any mold or decay (USDA, 2021). Berries with individual or multiple red drupelets are considered damaged and will score lower. The quality of fresh-market blackberries must be maintained from harvest, through storage, shipping, and until purchased by a consumer. Threlfall et al. (2021) showed that consumers preferred blackberries in clamshells that had no red drupelet reversion.

Prevention is key to managing this disorder and avoiding financial loss. Some methods that have been successful in preventing or reducing red cell regression include:

- Harvest early in the morning before 10 a.m., while berry temperature is cool.
- Protect berries from excess heat in the field; a movable trellis system that rotates to shade fruit or placing shade covers over rows are effective methods.
- Train harvesters to limit physical damage by gently harvesting and placing fruit into containers.
- Implement stepwise cooling or acclimation (cool berries to room temperature before placing them in a cooler).
- A proper nutritional management program that avoids excess nitrogen applications.
- Use blackberry cultivars that exhibit resistance to red drupelet reversion.

Rain damage (Figure 17) can be similar in appearance to red drupelet reversion but will show up in the field before harvest and entire sides of fruit will be impacted. Ripe fruit impacted by heavy rains will be soft and leaky, and un-marketable.

Decay and Leakage

Postharvest decay or leakage of a berry determines postharvest storage shelf life. Mold growth and crushed or damaged drupelets are visual indicators of decaying berries (Figure 18, 19) (Cavender et al., 2019). More difficult to spot, seemly undamaged berries can begin leaking from individual drupelets, which is usually accompanied by a softening of the fruit (Cavender et al., 2019). Since blackberries do not ripen after harvest, harvesting fruit at a firmer pre-ripe stage of development to extend shelf life is not an option. Field conditions such as rain and air temperature at harvest can increase the rate of postharvest decay and leakage (Perkins-Veazie and Fernandez, 2013). Excessive nitrogen fertilizer applications in-season or irrigating within 8 hours of harvest can soften berries and shorten shelf life (Figure 18). Improper postharvest storage conditions will also impact the rate of berry decay and leakage (Perkins-Veazie and Fernandez, 2013).

Figure 17: Preharvest rain damage to ripe fruit.
Photo provided by Amanda McWhirt.

The simplest method to slow postharvest decay and leakage is to select cultivars that perform well in the climate and produce firmer berries (Perkins-Veazie and Fernandez, 2013; Salgado and Clark., 2016). The target market will also determine the firmness needed and the desired shelf life. Softer fruit will be fine for a local market where distance from

Figure 18: Postharvest storage leakage on blackberries.
Photo provided by Renee Threlfall.

the field to consumer is comparatively short when compared to commercial markets. Fruit destined for distant markets needs to be firmer to reduce damage in shipping. Newer cultivars such as Osage, Ouachita, and Sweet-Ark® Ponca produce firm fruit and would be good cultivars for shipping markets (Perkins-Veazie and Fernandez, 2013).

Figure 19: Postharvest botrytis on stored blackberries after 21 days.
Photo provided by Carmen Johns.

Postharvest storage conditions with temperatures between 31-32°F and humidity between 90-95% will slow berry decay and extend shelf life (Madrid and Beaudry, 2020). Slightly increasing carbon dioxide (CO_2) and lowering oxygen (O_2) levels during storage can also slow decay (Perkins-Veazie and Fernandez, 2013). Avoid packaging fruit that is already softening or decaying with good berries, as decaying fruit will accelerate decay of the other fruit in the clamshell (Figure 19).

Conclusion

Fresh-market blackberry producers must be aware of consumer expectations and perceptions of visual quality of blackberry fruit. Research indicates that consumers prefer a glossy blackberry that is uniform in size and has few to no blemishes (Threlfall et al., 2020, 2021). Producing a consistently high-quality product begins with effective cultural management of the crop in the field and continues through proper storage and shipment of the fruit. Culling berries with visible disorders and removing the fruit from the field during harvesting will reduce places for pathogens or insects to populate which will improve future fruit quality. While the causes of some blackberry fruit disorders are out of the grower's control, the selection of resistant cultivars, utilization of trellising, effective integrated pest management, and timely pesticide applications will help growers provide quality fresh-market blackberries season-long.

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