The Blackberry[1]

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Introduction

Blackberry (*Rubus* spp.), family Rosaceae (somatic number 21, 28, 35, 42, 56, 63, 70, 77, 84), is a deciduous crop that grows best in temperate climates. Several blackberry species are native to Florida. Wild blackberries are often harvested in Florida; however, they have several limitations, including comparatively small berries, lack of uniformity, low yield, and late maturation. The culture of improved blackberries in Florida is primarily limited to homeowner production, although there is some potential for "U-Pick" and local sales in north central and north Florida. Blackberry yields in many areas of the country may exceed 6,000 lb/acre; however, quantitative yield data from Florida are scarce. In Florida, blackberries typically ripen during May and June. They are extremely perishable, and as such, are very difficult to ship satisfactorily to distant markets. The major blackberry production areas in the United States are the Pacific Northwest, Michigan, and Arkansas.

Blackberry bushes may be erect or trailing with gradations in between. Although most blackberries produce shoots with thorns, many new cultivars are thornless. Historically, the cultivars 'Oklawaha', 'Flordagrand', and 'Brazos' have been recommended for Florida. However, many new blackberry cultivars are available from breeding programs, and they are increasingly appearing in the retail market. Some of the new blackberry cultivars are being tested by the University of Florida and are discussed in more detail below. The most promising new blackberry cultivars are from the University of Arkansas and are denoted by the names of Native American tribes (Andersen 2015). In Florida, they are only adapted to the northern parts of the state. Blackberries, like most deciduous fruit crops, require winter chilling to achieve uniform budbreak and normal fruit development the following spring. Drake and Clark (2000) reported that 'Arapaho' had a chilling requirement of 400–500 hours of exposure at 3°C, while the chilling requirement of 'Navaho' was 800–900 hours. 'Osage' and 'Natchez' appear to have a chilling requirement of 300 hours, while the chilling requirement of 'Ouachita' is estimated at 450 hours (J. Clark, personal communication). Warmund and Krumme (2005) ranked the lowest chilling requirement to the highest as follows: 'Kiowa', 'Arapaho', 'Shawnee', 'Navaho', 'Chickasaw', and 'Apache'. The primocane fruiting cultivar 'Prime-Ark', 'Prime-Jan', and

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'Prime-Jim', (Clark et al. 2005, Ruple et al. 2010) are not adapted to Florida.

Blackberry and raspberry plants produce an aggregate fruit that is derived from many ovaries from a single flower.The major difference between blackberries and raspberries is that when blackberry fruit are consumed, the receptacle of the inflorescence (known as a torus) is also consumed. By contrast, raspberries, when picked ripe, have a hollow center because the receptacle remains on the cane. Raspberries are not generally recommended for the southeastern United States and will be discussed only very briefly here. 'Dorman Red' is the only raspberry cultivar recommended for trial in Florida when grown as a perennial crop; however, berry flavor is poor to fair. 'Heritage' raspberry has been grown as an annual crop during the winter in southern parts of the state after it has received its chilling requirement during cold storage.

The remainder of this publication will be devoted to blackberries. The blackberry cultivars from the University of Arkansas breeding program, when grown in Florida, are only adapted to the northern part of the state. The University of Arkansas cultivars are self-fruitful.

Cultivars

'Apache' is an erect, thornless blackberry bush released and patented by the University of Arkansas. In Arkansas, it produces higher yields and larger fruit than 'Arapaho' and 'Navaho'. 'Berries are conical in shape with a glossy black finish. Soluble solids average 10 °Brix, and fruit firmness is acceptable. In Florida, 'Apache' produced a moderate yield and berry size (Tables 1 and 2). For additional information, consult Clark and Moore (1999a).

'Arapaho' is an erect, thornless blackberry bush released and patented by the University of Arkansas breeding program (Moore and Clark 1993). It has good fruit quality and ripens before 'Apache' and 'Navaho'. In Florida, it was moderately vigorous, produces a low to moderate yield, and a relatively small berry size. Yield characteristics at UF/IFAS NFREC-Monticello were as follows: yield 1.7 tons/acre, berry weight 4.5 g, and soluble solids 10 °Brix (Table 3).

'Brazos' is an erect, thorny blackberry cultivar released by the Texas Agricultural Experiment Station (Lewis 1959). Yields have generally been high in north Florida and south Georgia. The fruit are medium in size and high in acidity. 'Brazos' is mostly used for jams, jellies, and baking. 'Brazos' is self-fruitful and generally ripens from mid-May to late May. Rosette disease (double blossom) is a serious problem. This disease contributes to productivity loss in 'Brazos' blackberry plants with age.

'Chickasaw' was released in 1999 by the University of Arkansas. It is an erect, thorny blackberry bush that is among the highest-yielding cultivars in Arkansas. Berries are long and cylindrical. In Arkansas, berry weight is about 7–10 g, and firmness is rated high. Berries are sweet, averaging about 9–10 °Brix. Quantitative yield data are not available for Florida. 'Chickasaw' has better postharvest keeping quality than 'Shawnee'. For more information, refer to Clark and Moore (1999b).

'Choctaw' is an erect, thorny, high-yielding blackberry cultivar from the University of Arkansas. The fruit are medium in size (about 5 g) and moderately sweet in flavor. This cultivar is most noted for early ripening, small seed size, and good flavor. This cultivar has been replaced by newer cultivars from the University of Arkansas breeding program. Consult Moore and Clark (1989a) for more information.

'Flordagrand' was released in 1964 by the University of Florida for home and local markets. 'Flordagrand' is adapted to central Florida, where it is evergreen in growth habit and requires a pollenizer. 'Flordagrand' has a trailing growth habit. The berries are oblong in shape, shiny black in color, and average just over 5 g. The berries are tart in favor (high in acidity), and soluble solids average 8 °Brix. It is not often grown any longer. For more information, refer to Shoemaker et al. (1964).

'Kiowa' is an erect, thorny cultivar released and patented by the University of Arkansas breeding program. In Arkansas, a large fruit size (> 10 g) is maintained throughout the season. It has good firmness and flavor and averages 10 °Brix. In Florida, plant vigor and yield was moderate and berry size is rather small (Tables 1 and 2). For more information, consult Moore and Clark (1996).

'Natchez' is an erect, thornless blackberry released and patented by the University of Arkansas. 'Natchez' has produced very high yields in Arkansas and is expected to replace 'Arapaho'. In Arkansas, berry size is medium to high (5–8 g) with an 8.7 °Brix. Berries are very firm and attractive. In Florida, 'Natchez' plant vigor and yield are relatively high, although in 2013 plants produced a very high yield that contributed to low vigor and yield in 2014 (Table 1). 'Natchez' produces a berry size that is moderate in size (Table 2). For more information, consult Clark and Moore (2008).

'Navaho' is an erect, thornless blackberry cultivar released and patented by the University of Arkansas breeding program. Yields in Arkansas are moderate to high. In Florida, it produced about 1.8 tons/acre or slightly higher than that of 'Arapaho' (Table 3). The berries are small to moderate in size (3.5–4 g) and moderately sweet in flavor (9 °Brix). Disadvantages include late ripening and a prolonged ripening period. Consult Moore and Clark (1989b) for more information.

'Oklawaha' was released by the University of Florida in 1964. It is semi-evergreen to evergreen and has a trailing growth habit. 'Oklawaha' requires trellising. It was released as a pollenizer for 'Flordagrand'. Similarly, 'Oklawaha' is self-unfruitful and requires a pollenizer. Berries are moderate in size. Soluble solids average about 8 °Brix. It is not often grown any longer. Refer to Shoemaker and Westgate (1964) for more information.

'Ouachita' is an erect-growing, thornless cultivar released and patented by the University of Arkansas breeding program (Clark and Moore 2005). It is expected to do well where 'Apache', 'Arapaho', and 'Navaho' have performed well. Desirable characteristics of 'Ouachita' in Arkansas include consistent high yields, large fruit size, and good postharvest shelf life. Fruit averages about 10 °Brix and is larger than that of 'Arapaho' and 'Navaho.' In Florida, plant vigor and yields were relatively high, and berry size was moderate (Tables 1 and 2). For more information, consult Clark and Moore (2005).

'Osage' is a recently patented cultivar from the University of Arkansas breeding program (Clark 2013). It is an erect, thornless cultivar with excellent post harvest quality. In Arkansas, yield and berry size is medium (5g), with a soluble solids of 10 °Brix. 'Osage' has not yet been tested in north Florida. For more information consult Clark (2013).

'Shawnee' is a 1984 release from the University of Arkansas breeding program. It has a prolonged ripening during which time the fruit retain a large size. This cultivar has been largely replaced by 'Choctaw', 'Chickasaw,' and 'Kiowa' and the newer thornless cultivars discussed above.

'Tupi' is a thorny, semi-erect blackberry that was developed in Brazil and is the most common commercial blackberry cultivar in Mexico. In low-chilling areas of Mexico, flower bud development is promoted by chemical defoliation and application of gibberellic acid. 'Tupi' produces a large fruit with a good sugar/acid balance. In Florida, 'Tupi' was relatively high in vigor. It was moderately productive with a berry size of 4.9 g (Tables 1 and 2).

Site Selection and Site Preparation

Ideally, a prospective commercial blackberry grower should select a site with good air and water drainage. Low-lying areas should be avoided to minimize the probability of flood injury during periods of excess rainfall and frost injury to flowers and newly developing fruit. Blossoms can be injured by temperatures below 28°F to 30°F. For the homeowner, site selection is often limited by availability and practicality. The site should be located conveniently to a source of water as the period of fruit ripening is often quite dry in many parts of the state. Hilltops often accord the grower improved air circulation during the growing season and can be a prime location if the soil has not been eroded by previous agricultural use.

Prior to planting, in-row strips about 5 feet wide can be treated with an herbicide such as glyphosate to kill all weeds and vegetation. In-row strips should be thoroughly disked to at least a depth of 1 foot. In some regions of the country, green manure crops are grown on the site and plowed under. Although blackberries do well in most soils, deep, well-drained soils are ideal. Blackberries perform best at a soil pH between 5.5 and 6.5. In general, to increase pH 1 unit, mix 5 lb of dolomitic lime with 100 square feet of soil. To decrease pH 1 unit, mix 1 to 2 lb of elemental sulfur with 100 square feet of soil. In addition, components of the irrigation system should be in place to provide water once the blackberries are planted. Drip irrigation, as compared to overhead irrigation, minimizes subsequent weed control efforts, which can be a substantial portion of the labor involved in cultivating blackberries. Polyethylene mulch or landscape fabric can serve as an excellent means of weed control.

Planting and Spacing

Planting is best performed from December through February. Upon arrival, bare-root plants should be kept moist but not wet. If these plants arrive prior to the anticipated planting date, they can be stored in the refrigerator (in small quantities) or heeled in a trench (in larger quantities) to stay moist. To heel plants in, simply dig a trench and cover the roots with damp soil. During planting, do not allow the blackberry roots to dry out. Cut back the shoots to about 6 inches in length and plant to the same depth they were in the nursery. Spread the roots around the hole, but try to avoid excessive root bending. Remove air pockets by compacting the soil.

Plant spacing is cultivar dependent. In general, blackberries are spaced from 2 to 5 feet apart within a row and 10 to

15 feet between rows, depending on plant vigor and farm machinery limitations.

Pollination

Blackberry fruit is borne on the current year's growth with usually 10–20 flowers per cluster. Blackberries and raspberries produce an aggregate fruit with individual pistils that form drupelets. To obtain a large, well-formed berry, most of the individual pistils in an inflorescence must be pollinated. Drupelets only form around fertilized ovules. Thus, berry size for a given cultivar is dependent on the number of seeds. Inadequate pollination results in smaller or imperfect fruit because not all seeds and drupelets are formed. Blackberries range from completely self-fruitful to completely self-unfruitful. Most erect blackberries (including all the Native American–named Arkansas blackberries) are self-fruitful and do not require a pollenizer. Blackberry flowers produce nectar and pollen that attract bees, which serve as pollinators. Honey derived from blackberry flowers is reported to be light in color and high in quality.

Bloom date for most cultivars is during early March, although 'Oklawaha' and 'Flordagrand' may bloom as early as mid-February. Bloom date tends to be earlier as one progresses farther south. Frost injury can be a problem in some locations. Open flowers can be injured by temperatures of 28°F to 30°F or less. Sprinkler irrigation can be employed to reduce the risk of freeze injury.

Propagation

Leafy Stem Cuttings

This is the most feasible method to propagate large quantities of plants. Leafy stem cuttings may be propagated from the apical 4–6 inches of cane when the cane is succulent but still firm. Application of Rootone® to the cut stem can also improve rooting efficiency. Cuttings should be placed to a depth of 2 inches in a perlite and peat or peat and sand mixture. The cuttings should be misted, especially in the two- to four-week period before the roots are formed. It is important to promote good water drainage.

Root Cuttings

All blackberries can be propagated by root cuttings. This is the fastest method to produce new plants. Cut roots ¼–½ inch in diameter into 6-inch pieces. They can be directly planted in the new location, grown as a potted plant, or placed in a plastic bag in a refrigerator. When planted directly in the field, uneven stands often result during the first year. Potted plants can be grown in the nursery for up to one year. When planted in soil, they should be covered with 2–4 inches of soil. Planting is best accomplished during the winter. Substantial quantities of suitable roots can be had by plowing a furrow and severing the roots adjacent to the mother plant.

Suckering

The easiest and most rapid method to propagate blackberry is to utilize the suckers that naturally form from roots. Simply sever the sucker from the point of attachment with the mother plant and move it to its desired location. Removing suckers has minimal or no impact on the mother plant. Genetically thorny blackberry cultivars will remain thorny, and genetically thornless blackberry cultivars will remain thornless whether propagated from stem cuttings, root cuttings, or suckers.

Tip Layering

Semi-erect or trailing blackberries can be propagated by tip layering. Tip layering sometimes occurs in nature and is a viable method for the homeowner to propagate relatively few plants. The technique is to bring first-year vegetative shoots into contact with the ground and cover the shoot under approximately 3 inches of soil. A more efficient method of tip layering is to remove the shoot apex to induce lateral branching. Next, during the summer, dig a 3-inch-deep hole that slopes toward the mother plant and vertically away from the plant. Place the terminal end of the shoot in the hole and cover the shoot with three inches of soil. By the fall, the shoots will have produced roots and the plant can be transplanted.

Fertilization

Blackberries do not require much fertilizer in most soils in north Florida. Blackberry roots are located close to the surface, and excess fertilizer can burn leaves or even kill plants. Fertilizer can be applied in an 18-inch ring surrounding a plant, or it can be applied parallel to the row 12–18 inches from the row center. Fertilization with 10-10-10 N-P-K with micronutrients is satisfactory. Do not apply fertilizer at planting in the winter; rather, wait until late spring or summer. Fertilization applied during planting may not only be injurious to the plant, but it may also be wasted because the roots are not yet sufficiently distributed in a row. During the establishment year, fertilize with about ¼ lb per plant or up to 5 lb per 100 feet of row. During the second year and thereafter, fertilize in the winter and in the summer (after harvest) with ¼–½ lb per plant or about 10 lb per 100 feet of row.

Irrigation

Irrigation is a requirement for consistent blackberry production in north and north central Florida and is most critical during the establishment year. Irrigation and weed control are the two most important cultural practices during the establishment year. Drip irrigation is preferable to overhead irrigation because drip irrigation conserves water, does not wet blackberry foliage (which can enhance dis- ease), and does not promote excessive weed growth. Drip irrigation can be in the form of biwall tubing or ¾-inch poly tubing either buried or on the ground surface. In the case of poly tubing, run 1 gallon per hour emitters (spaced 3–5 feet apart) for two to four hours per day. Irrigation frequency can vary from once every two days during a summer drought to not at all from November through March. Soils with a high water-holding capacity require less frequent irrigation than sandy soils. Organic mulches, such as mushroom compost mulch, pine straw, or pine bark, further enhance water conservation.

Training and Pruning

Erect or Semi-Erect Blackberries

Blackberry plants are perennial plants that can live for many years. In Florida, plantings usually remain productive for 4 to 7 years.

Typically, bare-root blackberry plants are 6–12 inches in length. Container-grown plants are more variable in size and stature. During the establishment year, blackberry plants produce shoots from the buds and perhaps from root suckers adjacent to the crown of the plant. The tendency for a blackberry to produce suckers and expand beyond the crown is cultivar dependent. During the first year, shoots elongate but do not produce berries. They are known as primocanes. The following year they become the fruiting canes and are known as floricanes. For erect or semi-erect blackberries, it is advisable to cut the tip off primocanes after they reach a height of 30–36 inches to promote lateral branching. Especially vigorous canes may benefit from two or three tippings. Tipping should be performed as early as possible in the season to ensure that the flower bud initiation process is complete prior to the onset of dormancy. Cutting the tip off primocanes to promote lateral branching and enhance flower bud initiation increases yield considerably. After fruiting, floricanes dry up and die. Primocanes bear fruit the following year. It is advisable to prune out and remove all floricanes at the ground or crown level after fruiting. Ideally in a healthy blackberry stand, five to six canes should exist per foot of row, and blackberries can form a solid hedgerow. A trellis can be established to help keep canes upright and off the ground. The trellis can be constructed using two parallel wires about three feet above the ground running the length of the row.

Recently, primocane-fruiting blackberry cultivars ('Prime-Jim', 'Prime-Jan', and 'Prime-Ark') have been released from the University of Arkansas. They grow like the other erect cultivars; however, the canes that emerge in spring flower in midsummer and fruit in the fall. Although they have not been tested in Florida, they appear best adapted to cool climates.

Some growers mow the entire planting at a height of about 1 foot after harvest to invigorate blackberry plants. The major reason for mowing is to reduce the hand labor associated with removing the dead floricanes. If plots are mowed it is likely that yield will be reduced the following year because the primocanes are partially removed along with the dead floricanes. One option is to mow every three or four years, or mow a percentage of the planting every year so that a yield reduction is spread over a several year period.

Trailing Blackberries or Dewberries

Trailing blackberries, such as 'Flordagrand' and 'Oklawaha', require a trellis. Otherwise, canes (and berries) tend to make contact with the ground. Many trellis designs have been used by commercial blackberry growers. End posts should be 7 ½–8 feet long, buried at least 3 feet deep, and well anchored. Interior posts may be smaller. Post spacing should be about 20 feet apart. Galvanized wire #9–#12 should be stapled loosely to the posts. One may construct a single-wire system with wire about 5 ½ feet above the ground or a two-wire vertical system with wires 2 ½ and 5 ½ feet above the ground. Three-wire systems have also been used. Blackberry canes can be gradually wrapped around the wires, and/or canes can be attached to the wire with string. Alternatively, in the case of a two-wire vertical system, canes can be interwoven between the upper and lower wires. The tips of canes should be pinched off to promote lateral branching, as in the case of erect blackberries. However, with trailing blackberries, canes are generally longer (40–48 inches when they are tipped).

Production and Harvesting

Harvest seasons are cultivar and location dependent. The harvest season of most cultivars lasts about three to four weeks. 'Oklawaha' and 'Flordagrand' ripen during April and May. 'Brazos' and the Arkansas cultivars generally ripen from mid-May through mid-July. The harvest season can be

prolonged substantially by including cultivars with different ripening dates.

In Florida, blackberries are generally harvested by hand once or twice a week during the harvest period. They turn from red to black before they are fully ripe. Blackberries are extremely perishable and must be handled with care. Growers often pick fruit during the early morning or even at night when temperatures are low. Blackberries should be marketed immediately after picking or refrigerated at 32°F–40°F.

Quantitative yield data are limited for blackberry plants in Florida. 'Flordagrand' and 'Oklawaha' have been reported to produce 3–8 pints per plant or 1.5–4 lb/plant in Florida (Shoemaker and Westgate 1964; Shoemaker et al. 1964). In Texas, 'Brazos' has produced 6,500–6,800 lb/acre (Lewis 1959). In Arkansas, the average yield of thorny cultivars ('Chickasaw', 'Choctaw', 'Shawnee', and 'Kiowa') and thornless cultivars ('Apache', 'Arapaho', and 'Navaho') has varied considerably (approximately 4,000–12,000 lb/ acre) depending on location and year. In a planting at the UF/IFAS NFREC–Quincy, I estimate a full crop to be about three lbs per plant (5,225 lbs/ acre). Average yield varied between 39% and 70% of a full crop (Table 1). Thus, average yield estimates varied between 2,000 lb/acre ('Arapaho') and 3,700 lbs/acre ('Ouachita') at a plant spacing of 2.5 and 10 feet within and between rows, respectively. For simplicity's sake I believe that one pound of fruit per foot of row (4,356 lb/acre) is a rough estimate of blackberry production in north Florida. Average berry weight across all Arkansas cultivars was about 4.3 g (Table 2), which was significantly less than that reported in Arkansas. However, average soluble solids (10.1°Brix) were similar in Florida to that reported in Arkansas.

Yield and berry characteristics of 'Arapaho' and 'Navaho' were evaluated in 1994 in a planting at the UF/IFAS NFREC–Monticello (Table 3). Plant spacing was 2 feet within a row and 10 feet between rows. The treatments were as follows: 1) pine bark mulch, 2) plastic mulch, 3) mushroom compost mulch, and 4) no mulch. Yield varied from 1.1 to 2.0 lb/bush or 2,483–4,312 lb/acre for 'Arapaho' and 1.3–2.2 lb/bush or 2,787–4,704 lb/acre for 'Navaho'. Thus, yields were on the low end of that reported from Arkansas. Yields were lowest for the pine bark mulch and highest for the plastic mulch treatment for both cultivars. 'Arapaho' berries were larger than 'Navaho.' In addition, 'Navaho' exhibited a reduction in berry size from first to last harvest. 'Arapaho' berries also tended to be sweeter and less acidic than 'Navaho'. Mulch treatment had no or a very slight influence on berry weight, soluble solids, pH, and titratable acidity.

Weed Control

It is extremely difficult to gain control of weed problems in a blackberry planting. Methods to control weeds in blackberry plants include mulching, cultivation, herbicides, and mowing. The yield results of a mulching trial conducted at the UF/IFAS NFREC–Monticello were discussed above. The plastic mulch treatment was the most effective in controlling weeds, followed by pine bark. Mushroom compost and bare soil treatments were equally prone to weed problems. Polypropylene weed fabric has been used with success at the UF/IFAS NFREC–Quincy. A width of 5 to 6 feet is ideal. Cultivation, whether it be by hoeing or disking, should be very shallow and no more than 2 inches in depth. Blackberry roots are very shallow and easily injured by deeper cultivation. Contact your local UF/IFAS Extension agent concerning specific herbicides that can be applied to control weeds in blackberry plants. It is beneficial to mow grass in between blackberry rows to enhance air circulation and minimize the seeding of in-row strips.

Insects

Several insect species attack blackberries, such as the strawberry weevil, the red-necked cane borer, thrips, gall midges, stink bugs, and beetles. Some of these insects are occasional pests of blackberry and seldom require control. Control measures for insects may not be required in some regions. Contact your county Extension agent for current pesticides and rates.

Diseases

Diseases incited by different disease organisms are a common problem in blackberry. All the following diseases are caused by fungi except crown gall, which is caused by a bacterium. Consult your county Extension agent for current pesticides and rates. Sanitation and cultural control methods are described below.

Anthracnose

This disease has a very broad host range. Anthracnose appears as small, purplish lesions on canes. The lesions enlarge, and the center turns a grayish color with purplish margins. The canes may turn dark, crack, and eventually die. Cultural control includes removing and burning all infective canes as well as the floricanes after fruiting.

Leaf Spot

Leaf spot appears on the foliage as dark red spots with a whitish center. It occurs to some extent in all blackberry plants and tends to weaken the plants. Proper sanitation procedures, as mentioned above, should be followed.

Crown Gall

This disease is caused by a soilborne bacterium that results in plant tumors in the crown of the plant. It spreads by entering open wounds. When young, crown galls can resemble a russet potato in appearance, but they eventually turn dark with age. Crown gall reduces stand productivity; once a field is infected, it could stay infected for many years. Do not take cuttings from any plant that shows evidence of crown gall, and remove infected plants. Also be careful to disinfect pruning tools after use on plants where crown gall may be a factor.

Rosette (Double Blossom)

Double blossom is a serious fungal disease in the southeastern United States. It infects 'Brazos' and wild blackberry. Some erect thorny cultivars developed in Arkansas are susceptible, although most thornless cultivars are resistant.

Many trailing blackberries also appear to be resistant. Double blossom disease is very distinctive. It starts as an abnormal flowering stage followed by a "witch's broom" stage in which tightly clustered shoots form in bunches. In certain plants, cutting back infected canes to the ground after harvest and burning them seems to prevent serious infection. Fungal spores on the flowers of the infected floricanes infect the buds on the vegetative primocanes. Once the fungus enters the primocane, it becomes systemic, and next-season floricanes show symptoms early in the growing season.

Orange Rust

Orange rust starts out as bright orange masses of spores on the underside of the leaves in the spring. It is systemic and can last from year to year. It is first noticeable on expanding leaves in the spring. The spores are disseminated in early to mid-spring, and they are spread great distances to adjacent canes and plants. Once plant crowns are infected, orange rust becomes systemic, and the entire plant needs to be removed. In the summer, plants appear to outgrow the infection, but that is not the case. The only solution is to remove and burn infected plants.

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Table 1. Plant vigor and yield estimates of blackberry cultivars from 2012–2014.

	Plant Vigor*			Yield*			
Cv	**2013**	**2014**	**Avg.**	**2012**	**2013**	**2014**	**Avg.**
'Apache'	7.0	6.5	6.8	4.1	6.2	4.0	4.7
'Arapaho'	3.9	4.6	4.3	2.5	4.3	5.0	3.9
'Kiowa'	5.0	5.1	5.1	4.9	5.3	5.1	4.8
'Natchez'	7.5	5.5	6.5	6.2	9.2	2.6	5.9
'Ouachita'	6.8	6.8	6.8	6.4	7.4	1.7	5.2
'Tupi'	6.7	6.5	6.6	3.8	6.7	5.3	5.4

*Plant vigor and yield estimates are based on a scale of 1 to 10, with 10 being the highest. Yield rating of 10 is estimated to be 3.0 lb/plant (5,225 lb/acre at a spacing 2.5 by 10 feet within and between rows, repectively).

Table 2. Berry weight and soluble solids of blackberry cultivars from 2012–2014.

	Berry wt. (g)				Soluble Solids (°Brix)			
Cv	**2012**	**2013**	**2014**	**Avg.**	**2012**	**2013**	**2014**	**Avg.**
'Apache'	4.6	7.7	3.2	5.1	10.7	11.5	9.6	10.6
'Arapaho'	2.9	5.2	2.6	3.6	12.0	10.9	11.1	11.3
'Kiowa'	4.5	5.3	2.0	3.9	8.3	6.4	10.3	8.3
'Natchez'	4.3	6.2	3.0	4.5	10.5	8.1	9.9	9.5
'Ouachita'	4.3	6.4	2.7	4.4	12.2	9.2	10.5	10.6
'Tupi'	4.1	7.1	3.6	4.9	11.0	9.7	11.2	10.6

Table 3. Yield and berry quality of two thornless blackberry cultivars subjected to pine bark, plastic, or mushroom compost mulch, or no mulch.

	Yield per bush (lb)[zy]	Yield per acre (lb)	Avg berry wt[x] (g)	Soluble solids (°Brix)	pH	Titratable acidity
'Arapaho'						
Pine bark mulch	1.14	2483	4.51	10.2	3.50	0.82
Plastic mulch	1.98	4312	4.59	9.4	3.48	0.74
Mushroom compost mulch	1.65	3594	4.53	9.4	3.50	0.88
No mulch	1.39	3027	4.20	10.5	3.49	0.82
'Navaho'						
Pine bark mulch	1.28	2787	3.85	9.1	3.26	1.06
Plastic mulch	2.16	4704	3.82	8.6	3.35	0.96
Mushroom compost mulch	1.56	3398	3.51	8.6	3.29	1.19
No mulch	1.72	3737	3.57	9.4	3.41	1.01

[z] Harvest period was from 3 to 22 June for 'Arapaho' and from 16 June to 22 July for 'Navaho'.
[y] Yield was determined on 10 plants of each treatment. Plants were spaced 2 by 10 feet within and between rows, respectively.
[x] Average berry weight from first to last harvest declined from 4.58 to 4.29 g for 'Arapaho' and from 4.34 to 2.31 g for 'Navaho'.