North American Bramble Growers Research Foundation (NABGRF) Grant Annual Report

Continued evaluation of algicides for management of orange felt and fungicides for control of cane blight diseases of blackberry

Principal Investigator
Phillip M. Brannen
Extension Plant Pathologist – Fruits
Department of Plant Pathology
2106 Miller Plant Sciences
University of Georgia
Athens, GA 30602
Phone: (706) 542-1250
FAX: (706) 542 4102
Email: pbrannen@uga.edu

Collaborator
Jeremy Taylor
Agricultural Extension Agent
162 West Thigpen Avenue
Lakeland, GA 31635
Phone: (229) 482-3895
FAX: (229) 482-2654
Email: jeremyt@uga.edu

Collaborator
Eddie Beasley
Agricultural Extension Agent
100 Berrien Coop Ext
Nashville, GA31639
Phone: (229) 686-5431
Email: eddie52@uga.edu

Collaborator
Frances Browne
Graduate Student- University of Georgia
3108 Miller Plant Sciences
University of Georgia
Athens, Ga 30602
Phone: (229) 344-2831
Email: fbrowne@uga.edu

Objectives: 1) Evaluate algicides and fungicides for control of orange felt and cane blight on blackberries; 2) Analyze the relationship between cane blight and cane blotch infections.

Justification and Description: New cultivars of blackberries with exceptional qualities have recently emerged from breeding programs at the University of Arkansas. The enticing possibilities of yield and profit have caused the bramble (blackberry and raspberry) industry to thrive in the southern United States. The industry has experienced a 60% increase in production since the 1990's. All aspects of the market have increased including small scale, medium scale, as well as large scale operations. Cultivars vary in growth habit, fruiting habit, and presence or absence of thorns. These characteristics are important in manageability as well as yield.

Blackberry industry expansion has allowed for new locations to be cultivated with this popular fruit. Many southeastern locations have increased temperatures and humidity as compared to traditional bramble industry centers, and this has resulted in an increase in disease from some known pathogens (e.g. cane blight) and increase of unknown or infrequent diseases (e.g. orange felt [aka orange cane blotch]).

Orange felt is a limiting disease causing distress to blackberries situated in the southern United States, especially in southern Georgia and Florida. The causal agent of this growing disease is a parasitic alga known as *Cephaleuros virescens*, known to prevail in subtropical and tropical regions. The disease is most often observed in wet, humid and hot climates. The exact effects of *Cephaleuros virescens* on blackberry are not fully researched, but infected plants decline if sufficient symptoms are observed. Possible reasons for decline include cane girdling or secondary infections from other pathogens; cracking on the cane, observed in orange felt lesions, may allow other opportunistic fungi, such as *Leptosphaeria* or *Botryosphaeria*, to invade the plant. *Cephaleuros virescens* has been observed to colonize the space between the epidermal cells of the host plant; significant damaged tissue has also been found in the plant cortex region. This observation lends further credence to the theory that the algae may cause girdling of the plant, possibly causing direct death of the host.

The colonies of *Cephaleuros virescens* appear to form where zoospores from the previous summer have landed. Continuous spread from floricane to primocane is required for additional years of colony production. *C. virescens* is filamentous and begins new infections by spreading to form a colony. After maturation in mid-summer, sporangiophores begin to emerge, and these contain several zoosporangia (Figure 1 A). The zoosporangia contain the zoospores needed for future infections. Each mobile zoospore can produce new colonies of this destructive algae. The route of infection is thought to occur through splashing from rain, carrying the zoospores to a new location. A full disease cycle can be completed in 8-9 months.

Orange felt is often mistaken as rust as the colonies form yellow, disk shaped spots on the cane (Figure 1 B). The orange spots eventually develop into blotches on the cane that resemble velvet. Under wet and humid conditions, the spots on the cane have been observed to coalesce, leading to full coverage of the cane. Colonies appear in late spring and gradually advance throughout summer and fall.

Figure 1. Clusters of *Cephaleuros virescens* sporangiophores (A) and yellow to orange velvet-like colonies formed by C. virescens on a thornless blackberry cane (B). When actively sporulating, the zoosporangia are borne on stalks which give the “orange felt” appearance associated with the disease.

Recommended control of orange cane blotch in the past has consisted of applications of copper sprays. The use of copper at a management strategy may have undesired effects on the target crop, as significant copper injury can occur when drying conditions in insufficient. This consequence complicates applications during the times of infections for orange cane blotch. Most labels do not allow applications during these periods. In addition, recent research has shown that copper is not as effective on blackberry as it is on other commodities, such as citrus or blueberry. Additional control strategies are needed for management of orange cane blotch. Efficacy data is essential for evaluation of successful fungicides and algicides.

Wounds caused by *C. virescens* may possibly lead to cane blight infections. Dark red to purple lesions are often observed on canes in plants diagnosed with cane blight. Symptoms first appear under the epidermis and extend down the cane by spring. The lesions will often turn a gray color later in the season. These dramatic lesions can causing girdling of the cane which leads to plant death. Cellulose is removed from phloem fibers during infection, causing the cane to weaken.

The causal agent of cane blight (Fig 2 A) is *Leptosphaeria coniothyrium*, a common fungus also known to cause stem canker of ornamentals. Pseudothecia and pycnidia, fruiting structures of the fungus, are often observed and reside in dead bark tissue (Figure 2 B). *Leptosphaeria conionthyrium* also produced conidia and ascospores for reproduction. Old floricanes serve as an overwintering surface and must be removed to avoid sources of inoculum and prevent future infections. Injured primocane tissue is infected by spores produced from spring to fall. Improperly pruned primocanes or injured plants due to machinery, insect damage, freeze injury, and herbicide damage are more susceptible to cane blight. Establishment of infection is exacerbated by rainfall following injury. Sufficient infection of primocanes leads to bud failure and cane dieback in floricanes the following year (Figure 2 A). Efficacy data for fungicides is not available so future research is needed to develop control methods for both cane blight as well as orange cane blotch.

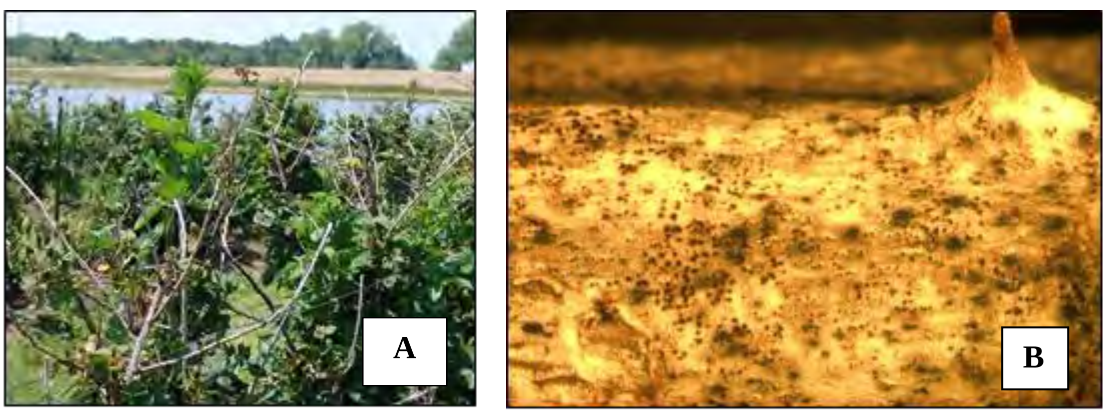

Figure 2. Symptoms (A) and signs (B) of cane blight. Following infection, dead and dying floricanes are observed in the spring and summer. Dead canes may have a silvery to gray appearance. Damage is generally associated with pruning cuts, especially large ones. With a hand lens, small, black, pepper-like specks can be seen on the surface of the dead tissue. These are the fruiting structures for the fungus (pseudothecia and/or pycnidia).

Proposed Research: 1. Efficacy of materials for management of cane blight and orange felt. The following treatments were designed to address the efficacy of materials for cane blight and orange felt management; these treatments were in part selected based on prior trials and the efficacy of the materials. Two test sites were selected for the spray trials (Berrien and Lanier Counties). A third site (Clinch County) was subsequently added for the orange felt trials due to limited disease in the Berrien County site. Treatments were applied to a randomized complete block design. Five replications of each treatment were conducted, and each replication consisted of a single plant. Fungicide applications were made with a backpack sprayer to runoff at multiple application dates. A minimum of one plant was skipped between spray plants to minimize plot-to-plot spray drift. Variables to be measured will include incidence and severity of both diseases.

Cane Blight Treatments

1. Untreated Control
2. Pristine @ 23 oz/A
3. Rally @ 2.5 oz/A
4. Switch @ 14 oz/A
5. Prophyt @ 4 pints/A

Orange Felt Treatments

1. Untreated control
2. Kocide 3000 (copper hydroxide)
3. Prophyt (potassium phosphite)
4. Dithane (zinc ion and manganese EBDC)
5. Prophyt + Kocide 3000
6. Prophyt + Dithane
7. Kocide + Dithane
8. Oxidate (hydrogen dioxide)
9. Oxidate + Kocide 3000
10. Oxidate + Prophyt

2. Details of the process have yet to be determined, but inoculations of cane blight on existing orange cane blotch infections will also be conducted in 2016 to determine the potential relationship between the two diseases. If orange felt infections are a primary cause of cane blight infections, proper control of the algal infections may serve as an additional control for cane blight. This work will be conducted at a minimum of three sites.

Results: Though numerous fungicide applications have been made, we do not have results to date for the cane blight trials, as the data will be taken in the spring of 2016. We also hope to conduct the project with cane blight and cane blotch (interaction) in the spring of this year. We have collected fall data for the orange felt trials (Tables 1 and 2), though only one of the locations provided significant disease to allow for analysis in the fall. Based on a review of the literature and limited efficacy observed in previous trials, we attempted combinations of materials to broaden the total efficacy of algicides. Two different factorial analyses of the data from this location provided a clear conclusion: Prophyt (a potassium phospite product) is the only material that shows consistent suppression of this algal pathogen. Kocide (copper), Oxidate (hydrogen dioxide + peroxyacetic acid) nor Dithane (mancozeb; not registered for blackberries) provided significant suppression. This is unfortunate, as we need rotation partners for potassium phosphite products. The good news is that this material is not as likely to develop resistance as others. As we learn more about the epidemiology, we may be able to reduce the number of applications to one or two critical timed applications. We are also reviewing the epidemiology of the disease, so we hope this information will lend to better IPM methods.

Table 1. Orange cane blotch severity over time following application of Kocide (copper) as compared to other potential algicides (Lanier County, GA).

	Average orange cane blotch disease severity (%)^{z}								
	18 Sep 2015			16 Oct 2015			6 Nov 2015		
Other products	No Kocide	Kocide	Average	No Kocide	Kocide	Average	No Kocide	Kocide	Average
None	4.5	2.6	3.6 ab	10.9	7.3	9.1	20.8	15.8	18.3 a
Oxidate	4.4	3.8	4.1 a	8.1	9.3	8.7	15.2	17.5	16.4 ab
Dithane	3.7	3.2	3.4 ab	7.1	6.3	6.7	11.1	16.8	14.0 b
Prophyt	2.4	1.3	1.8 b	8.9	7.0	8.0	8.9	10.3	9.6 c
Average	3.8 ^{x}	2.7		8.8	7.4		14.0	15.1	

^{z}Average of five replications.

^{x}Means followed by different letters are significantly different when using Fisher's protected LSD test (P=0.05).

Table 2. Orange cane blotch severity over time following application of Prophyt (potassium phosphite) as compared to other potential algicides (Lanier County, GA).

	Average orange cane blotch disease severity (%)^{z}								
	18 Sep 2015			16 Oct 2015			6 Nov 2015		
Other products	No Prophyt	Prophyt	Average	No Prophyt	Prophyt	Average	No Prophyt	Prophyt	Average
None	4.5	2.4	3.5	10.9	8.9	9.9	20.8	8.9	14.9
Oxidate	4.4	3.1	3.8	8.2	8.1	8.1	15.2	15.0	15.1
Kocide	2.7	1.3	2.0	7.3	7.0	7.1	15.8	10.3	13.0
Dithane	3.7	2.3	3.0	7.1	8.4	7.8	11.1	11.7	11.4
Average	3.8 a^{x}	2.3 b		8.4	8.1		15.8 a	11.5 b	

^{z}Average of five replications.

^{x}Means followed by different letters are significantly different when using Fisher's protected LSD test (P=0.05).

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