Title: Assessment of copper fungicides and other materials for control of algal stem blotch of blueberry

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Public Abstract:

The warm, wet weather frequently typical across the Southeast U.S. can lead to significant diseases on blueberry that may not be present in cooler or dryer regions. One such disease is algal stem blotch, caused by the parasitic alga, *Cephaleuros virescens*. This disease affects blueberry in multiple states in the Southeast U.S., especially impacting blueberry production in Florida and Georgia. In addition to causing red blotches that appear on young blueberry stems, algal stem blotch can also result in significant chlorosis (leaf yellowing/whitening). If left unmanaged, recurrent algal stem blotch can significantly reduce plant vigor to the point where plants become unproductive due to significant defoliation and dieback. Unfortunately, as this disease is caused by an alga rather than a fungus, most fungicides are unlikely to have efficacy, limiting options for management. Copper hydroxide products have been previously recommended for control of algal stem blotch, but trial results from the field showing efficacy are limited, and additional materials with efficacy are sorely needed. On blackberry, potassium phosphite has been shown to have efficacy against orange cane blotch disease, which is also caused by *C. virescens*. To validate the use of copper hydroxide on blueberry for algal stem blotch control, and to assess whether potassium phosphite may also have efficacy, a two-year field study was conducted in a commercial blueberry field in southeastern Georgia during 2024 and 2025. Southern highbush blueberry cv. 'Farthing' plants were sprayed after harvest on a monthly basis during the summer and fall of both years with Kocide® 3000-O (copper hydroxide), ProPhyt® (Potassium phosphite), or were left untreated. Plant disease assessments conducted in fall 2025 indicated that both Kocide 3000-O and ProPhyt applications significantly reduced algal stem blotch severity and incidence in the treated plants. Findings provide valuable evidence of the efficacy of these products against this disease in blueberry production fields in the Southeast.

Introduction:

In the last few years, particularly wet weather across Georgia's blueberry production belt led to several disease issues, including severe problems with Phytophthora root rot and multiple reports of algal stem blotch in both 2021 and 2023 (Oliver 2021, 2023). While algal stem blotch had been identified in Georgia blueberries prior to 2021, it was previously only observed sporadically and had never been noted as a widespread issue in the state before 2021. Likewise in 2021, algal stem blotch was also

observed for the first time on blueberries in North Carolina (Bill Cline, *personal communication*). In Georgia, even more severe issues with algal stem blotch were observed during the 2023 growing season in several southern highbush locations (Oliver 2023), and, in summer 2024, symptoms on rabbiteye blueberries in Georgia were observed as well (**Figure 1**). As the name indicates, unlike the fungal, bacterial, or viral diseases that typically afflict crop plants, algal stem blotch is caused by an alga. Algal stem blotch is caused by *Cephaleuros virescens*, a parasitic algal species that also causes orange cane blotch (orange felt disease), a major disease of blackberries in the southeastern U.S. (Brannen 2017; Schilder 2017). Prior to 2021, the only place in the world where algal stem blotch of blueberry had been an important issue was in Florida, where it has been reported as a significant disease on southern highbush blueberries grown in the warm, wet conditions that favor algal growth and spread (Schilder 2017).

The primary symptoms of algal stem blotch include red blotches that appear on the juvenile stems of blueberry plants, and leaf yellowing/whitening (Schilder 2017; Phillips et al. 2018). The red blotches result from the alga growing beneath the stem cuticle (the outermost waxy layer of the stem). As infected stems age and become woody, these lesions become less obvious until the alga sporulates through the bark, forming felt-like mats of bright orange sporangiophores (algal spore-producing structures) (**Figure 1A**). In addition to these bright orange mats, the chlorosis (yellowing) or bleaching (whitening) of leaves (**Figure 1B,C,D**) caused by algal stem blotch can also be striking (Phillips et al. 2018). The chlorosis caused by algal stem blotch is typically more irregular (less uniform) and "blotchier" (sometimes speckled) compared to similar symptoms caused by nutrient deficiencies or other diseases, and is suspected to result from a toxin produced following algal colonization of the plant that is released into the infected stem. Plants severely affected by algal stem blotch can lack vigor and fail to regrow after summer pruning, and defoliation of affected stems is likely to occur. As such, repeated issues with algal stem blotch year after year can make blueberry plantings unproductive (Phillips et al. 2018).

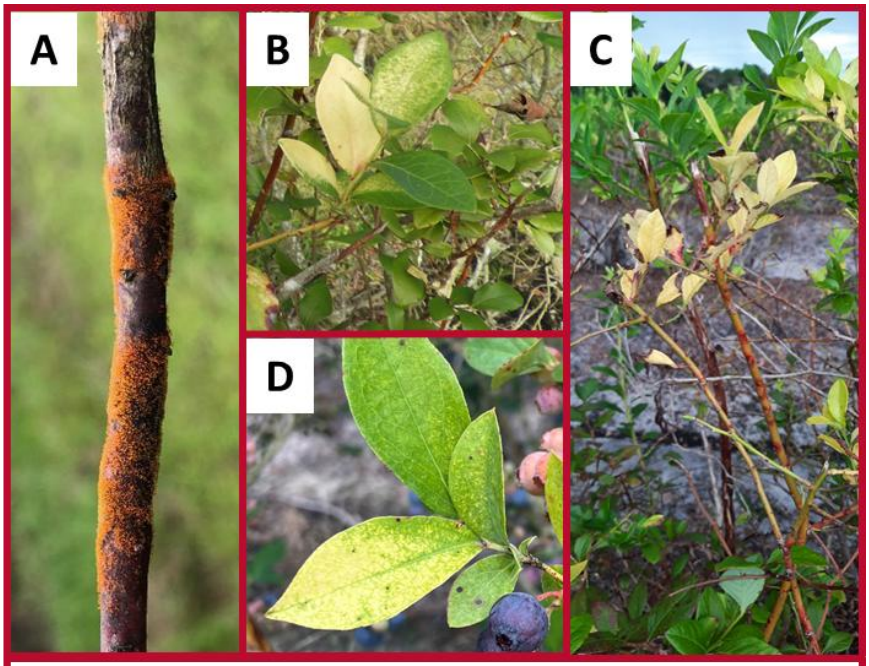

Figure 1. (A) Bright-orange mats of algal sporangiophores emerging from stem surface, (B) Chlorosis and bleaching of leaves on southern highbush stems in Georgia 2021, (C) Bleached leaves and red blotches on southern highbush plant in North Carolina 2021, (D) Symptoms on rabbiteye stem in Georgia 2024. Photo A from J. Price; Photo B from B. Hayes; Photo C from B. Cline; Photo D from J. Oliver.

Unfortunately, very little information exists regarding the control of algal stem blotch on blueberry. Since this disease is caused by an alga rather than a fungus, it is unlikely that most fungicides will be effective for management. Recommendations from the 2024 Florida Blueberry Integrated Pest

Management Guide (Harmon et al. 2024) suggest that sprays with copper-containing fungicides (such as Kocide® 3000-O) can help to reduce algal sporulation and thereby protect healthy canes from infection. However, these products are not useful for eradication of the disease or elimination of existing symptoms. Since algal stem blotch has not been previously widespread in Georgia or elsewhere in the southeastern U.S. prior to the most recent seasons, trial work examining the efficacy of copper applications for management of algal stem blotch of blueberry is very limited. While some copper products are labelled for use on blueberry, many blueberry growers in Georgia and elsewhere in the Southeast do not apply copper fungicides on a routine basis for disease control and may be unfamiliar with these products. As such, **blueberry growers dealing with algal stem blotch need information on the effective use of copper fungicides in blueberry. Likewise, research is needed regarding the effectiveness of other chemicals for algal stem blotch control.**

In recent years, trial work done by the UGA-Tifton Fruit Pathology Laboratory on blackberries with orange cane blotch (which is caused by the same algal species as algal stem blotch of blueberry) has shown that foliar applications of ProPhyt (potassium phosphite) can reduce both the size and number of stem blotches on developing canes by up to 90% (Hemphill et al. 2019, 2020a, 2020b). However, it remains to be seen if this product would be effective for algal stem blotch control on blueberries. Given that ProPhyt (and other phosphonate fungicides such as K-Phite, etc.) are routinely used in southeastern U.S. blueberry production during the summer and fall for the effective management of leaf spots and Phytophthora root rot, trial work is sorely needed to determine if foliar applications of these products can reduce issues with algal stem blotch in blueberry as well. Accordingly, we conducted field trials over two growing seasons to examine the use of copper fungicides and phosphonate materials for the control of algal stem blotch in blueberries.

Materials and Methods:

Fungicide efficacy field trial. Chemicals were evaluated for control of algal stem blotch on plants of southern highbush blueberry cultivar 'Farthing' at a commercial blueberry farm near Blackshear, Georgia with a history of algal stem blotch. Three treatment programs were utilized: ProPhyt, Kocide 3000-O, and an untreated control. Treatments were applied to a randomized complete block design with five replicate plots per treatment. Each sprayed plot consisted of twenty blueberry plants with one or more untreated plants in between plots. All treatments were applied until runoff (equivalent to 75 gal water/A) using a CO_2 sprayer with cone nozzle at 40 psi. Applications were made over two growing seasons in the months following postharvest hedging activities (which occurred in Jun 2024 and Jun 2025). During 2024, treatment applications were made on 5 Jul, 9 Aug, and 9 Sep. During 2025, applications were made on 10 Jun, 10 Jul, 8 Aug, and 8 Sep 2025. Other than the treatments detailed above, treated rows were not sprayed with phosphonate fungicides (FRAC P07) or copper fungicides (FRAC M1) during either growing season. The application of insecticides, other fungicides, and cultural practices were otherwise consistent with southern highbush blueberry production methods commonly observed in the Southeast. In Oct 2024, treated plots were initially examined for the presence of algal stem blotch symptoms; however, since only minimal, scattered symptoms were found throughout the treated plots, plants were not assessed in 2024. The same plots treated in 2024 received the same treatment application during the 2025 growing season. On 25 Sep 2025, plants within each plot were assessed for algal stem blotch symptom incidence and symptom severity (**Figure 2**) on a per plot basis. Incidence data was analyzed using analysis of variance (ANOVA) followed by Tukey's honest

significant difference test (HSD) using the package agricolae in R (R v. 4.5.0, The R Foundation, Vienna, Austria).

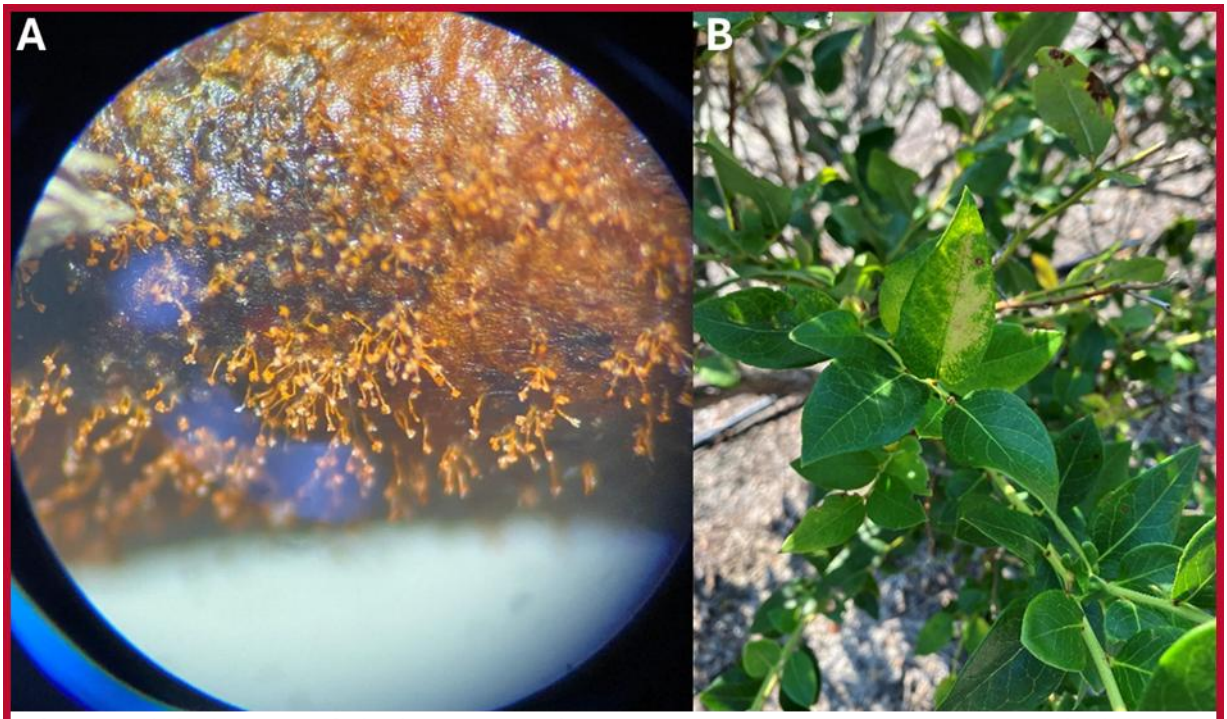

Figure 2. (A) Close up of algal sporangiophores present on symptomatic terminals, (B) Symptomatic terminal showing chlorosis/speckling/bleaching typical of algal stem blotch. Photo A by L. Pandey. Photo B by J. Oliver.

Results:

Algal stem blotch incidence and severity assessments. Conditions were adequate for disease development, with 100% of the plants within the untreated control plots showing symptoms at the time of assessment in Sep 2025. By contrast, the plots treated with ProPhyt and Kocide 3000-O had a significantly lower incidence of algal stem blotch symptoms (**Table 1**) relative to the untreated control plots. The lowest average incidence (8.9%) was observed in the plots treated with Kocide 3000-O, and this incidence was significantly lower than the average incidence for the plots treated with ProPhyt

Table 1. Summary of symptom incidence and severity as assessed on 25 Sep 2025.

Treatment and amount/A	Application timing[z]	Symptom Incidence[y] (% Symptomatic Plants/Total)	Overall Severity[x] (Symptomatic Terminals per Plant)	Symptomatic Plant Severity[w] (Sympt. Terminals per Sympt. Plant)
Untreated control	----	100.0 a	16.0 a	16.0 a
ProPhyt 4 pt	1-7	33.3 b	0.5 b	1.4 b
Kocide 3000-O 3.5 lb	1-7	8.9 c	0.1 b	1.2 b

[z]Applications were made on: (1) 5 Jul 2024, (2) 9 Aug 2024, (3) 9 Sep 2024, (4) 10 Jun 2025, (5) 10 Jul 2025, (6) 8 Aug 2025, and (7) 8 Sep 2025.

[y]Average incidence of algal stem blotch symptoms (% of plants with each plot showing symptoms) including chlorotic/bleached/sp eckled leaves

[x]Overall severity of algal stem blotch symptoms (symptomatic terminals per plant) across all evaluated plants per plot.

[w]Severity of algal stem blotch symptoms (symptomatic terminals per plant) across only the symptomatic plants within each plot.

Means in each column followed by the same letter are not significantly different according to the Tukey's honest significant difference test (HSD) (α=0.05).

(33.3%). In terms of disease severity (number of symptomatic terminals per plant and number of symptomatic terminals per symptomatic plant), both the ProPhyt and the Kocide 3000-O treatments resulted in a significant reduction relative to the untreated control. Minor signs of phytotoxicity (leaf burn) were evident in some of the plots treated with Kocide 3000-O as well as some of the plots treated with ProPhyt. This was attributed to some of the applications with these materials having been made to plants in direct sun at high summer temperatures during 2025.

Discussion:

Algal stem blotch emerged as a widespread disease issue in southern Georgia during 2021 and was also found in North Carolina for the first time during 2021 on southern highbush blueberries. Furthermore, reports of algal stem blotch in Georgia increased in 2023 have been increasing in subsequent growing seasons. As such, blueberry growers in the Southeast need information on the management of this disease. **Based upon the results from the field trial conducted in Georgia during 2024 and 2025, both Kocide 3000-O and ProPhyt appear to have efficacy against algal stem blotch when used on a monthly basis after harvest.** The use of each of these products dramatically reduced observed algal stem blotch severity (number of chlorotic terminals per plant) by over 90% relative to the untreated control plots. Likewise, disease incidence (percentage of symptomatic plants with at least one chlorotic terminal) was reduced by both treatments, including an over 90% reduction in algal stem blotch incidence in the Kocide 3000-O treated plots and an over 66% reduction in incidence in the ProPhyt treated plots. Taken together, this suggests that the use of either of these fungicides after harvest may reduce algal stem blotch, with Kocide 3000-O seemingly having somewhat more efficacy against this disease than ProPhyt.

Of note, this trial was conducted over two growing seasons with after harvest applications being made to the same plants during both 2024 and 2025. When plants were first examined for algal stem blotch symptoms in fall 2024, incidence was fairly minimal and sporadic; however, by fall 2025, incidence on plants in the untreated control plots was 100%. It is unclear whether this increase was the result of particularly favorable conditions for algal stem blotch development during the 2025 season or if this disease just took more than one year to build up to significant levels to allow for visual trial evaluation. As such, the specific impacts of sprays made during a single growing season during this trial could not be determined. All that can be concluded is that over the two-year trial period, disease was dramatically reduced within the treated plots relative to the untreated control plots. Nonetheless, given the biology of the algal pathogen causing this disease and the modes of action of the tested fungicides, **it seems likely that multi-season (and repeated) applications are necessary to achieve noticeable control.** Though the interactions between the alga (*C. virescens*) and the host (blueberry) are not well-understood, it is assumed that the alga spreads to new parts of the plant via sporulation and then grows as a parasite beneath the plant (stem/twig) surface until such a time as it begins sporulating again. While it is growing (protected) beneath the stem cuticle, it is unlikely that (non-systemic) copper fungicides such as Kocide would have much of an impact on the pathogen. Therefore, the benefits of applications with these materials are likely going to be confined to controlling the pathogen when it emerges to sporulate and/or preventing subsequent infection by the algal spores. Given this, it would make sense that repeated applications with Kocide may be necessary to limit the spread of the alga within and between plants because control would rely on protecting unaffected plants or plant parts from new infections throughout the sporulation period (and especially during the summer plant growth period that occurs following postharvest hedging and pruning activities). While potassium phosphite (ProPhyt)

may have some direct effects on the alga as well, this fungicide has a different mode of action than Kocide and is known to also act systemically within the plant to stimulate plant defenses. As such, it may be capable of acting to reduce algal growth while the alga remains hidden between the plant cuticle and/or by priming the plant's defenses and preventing subsequent spore infection of new plant parts. In either case, just as with Kocide, repeated applications with ProPhyt may be necessary to protect the plant throughout the algal growth and sporulation period. Ultimately, additional research will be necessary to understand the specific impacts that applications with each of these material have on algal stem blotch disease progression and development. Understanding these impacts may allow for even more targeted and effective use of these materials against algal stem blotch disease in blueberry.

Algal Stem Blotch Management Recommendations:

Based on these trial results, blueberry growers dealing with algal stem blotch should be aware that both of these materials (Kocide 3000-O and ProPhyt) have the potential to provide control of algal stem blotch (**Table 2**). Kocide 3000-O (copper hydroxide) is OMRI-listed product that can be used in both conventional and organic blueberry production settings. Kocide 3000-O has a section 2(EE) recommendation which specifies its use for control of algal stem blotch (*C. virescens*) on blueberry in Alabama, Florida, Georgia, North Carolina, and South Carolina. This recommendation specifies starting applications *after* harvest on a monthly interval. By contrast, ProPhyt (potassium phosphite) is not OMRI-listed and its label does not specifically include algal stem blotch. However, conventional blueberry growers in the Southeast typically apply this product for control of Phytophthora root rot and leaf spots (Septoria and Alternaria), and the label indicates that foliar sprays of ProPhyt should be made on a 14 to 21 day interval depending on the disease being targeted. Our field trial results suggest that if blueberry growers make foliar applications of ProPhyt after harvest for control of Phytophthora and leaf spots in the manner indicated on the label, they would likely also see control of algal stem blotch as well.

Table 2. Information on fungicides utilized in field trials for control of algal stem blotch.

Product	Amount of Formulation per Acre	Efficacy	Re-entry Interval (REI)	Preharvest Interval (PHI)	Comments
Kocide 3000-O (copper hydroxide)	1.75-3.5 lb	Good	48 hrs	0 days	**A 2(ee) recommendation is available for algal stem blotch in AL, FL, GA, NC, and SC.** Start applications after harvest on a monthly interval. Thorough spray coverage of plant foliage will result in best performance. Apply at the first sight of algal stem blotch. **Do not mix with Aliette, any phosphonate fungicide, or any acidifying agents.**[1] Do not exceed 28 lb. per acre per year. Kocide 3000-O is **OMRI-listed**. **FRAC M1**.
ProPhyt (potassium phosphite)	4 pt	Good	4 hrs	0 days	Algal stem blotch is not specifically on the label; however, when applied as a foliar spray for other diseases after harvest, suppression of algal stem blotch has been observed. **Do not tank mix with copper and foliar fertilizers, and do not apply in acidic water or add acidifying agents, as foliage/fruit damage could be a result**[2]**.** Plant injury may occur. **FRAC P07.**

[1]See the Kocide 3000 label for additional precautions and instructions. Severe phytotoxicity (plant injury) may result if this product is applied in a manner that is inconsistent with the label instructions. Do not apply when wind speed favors drift beyond area intended for treatment. If Kocide® 3000-O is applied in a spray solution having a pH of less than 6.5, phytotoxicity may occur. Do not tank mix Kocide® 3000-O with "Aliette" fungicide for use on any registered crops unless appropriate precautions have been taken to buffer the spray solution because severe phytotoxicity may result.

[2]See the ProPhyt label for additional precautions and instructions. Severe phytotoxicity (plant injury) may result if this product is applied in a manner that is inconsistent with the label instructions. When tank-mixing this product with others, test the mix on a small area to ensure that phytotoxicity does not occur. Do not apply ProPhyt to plants under stress, including water stress, or during severe weather conditions such as high or very low temperatures. When applying ProPhyt, be sure the spray solution has a pH > 5.5 to limit the possibility of phytotoxicity to the crop.

Additional Questions Regarding Algal Stem Blotch Management:

What about interactions between these fungicides?

In the trial described in this report, either Kocide 3000-O or ProPhyt were applied to plants in each treatment plot. None of the plants in this trial received applications of both materials. Given the efficacy of both of these materials in this trial, blueberry growers may be interested in knowing whether these materials could be used in combination or in alternation to achieve superior control, especially in fields with severe algal stem blotch issues. Unfortunately, both of these products are known to cause phytotoxicity (plant injury) if used in a manner inconsistent with their labelling. The label for Kocide 3000-O specifically states that phytotoxicity may occur if it is mixed in a spray solution with a pH of less than 6.5. Also, the label indicates that tank mixes of Kocide and the phosphonate fungicide Aliette® can be problematic, and the corresponding label for Aliette® also mentions the possibility of phytotoxicity if applied to foliage with copper residues. Though the ProPhyt label does not specifically mention copper-related precautions, it does include several precautions regarding tank mixes as well as a prohibition against applying the product to plants under heat or water stress. (In our trials, we observed some leaf burn [phytotoxicity] following applications with each of these materials which we attributed to the applications being made during hot, dry summer weather in southern Georgia.) Accordingly, growers are encouraged to exercise *significant caution* regarding tank mixes with these fungicides or when applying these materials in close proximity to one another. It remains to be seen if a spray program utilizing both of these materials in alternation across the season would be beneficial for algal stem blotch control.

Can these fungicides be used at other times of the year to control algal stem blotch?

In the trial described in this report, applications with either Kocide 3000-O or ProPhyt were made after harvest on a monthly basis to reduce algal stem blotch. Blueberry growers experiencing significant issues with algal stem blotch may ask if additional applications made during other times of the year would provide additional efficacy. Regarding this question, it should be noted that the main label for Kocide 3000-O only specifies applications to blueberry during the fall (for Bacterial Canker) or during the dormant period before blooms open (for Fruit Rot, Phomopsis, and Twig Blight). Furthermore, the 2(ee) recommendation only includes applications made after harvest. As such, the label does not appear to allow for applications of Kocide 3000-O between when blooms open and after harvest, and it seems unlikely that Kocide applications made before bloom (during the dormant period) would have any impact on this algal pathogen as it overwinters beneath the plant cuticle. By contrast, the label for ProPhyt does not appear to have the same restrictions related to applications during the bloom and fruiting period, as growers can utilize this product for Phytophthora root rot or leaf spot control beginning at the pink bud stage, through cover sprays, and then also post-harvest. However, additional trial work would be necessary to determine if ProPhyt applications made during the spring (prior to harvest) would have a significant impact on algal stem blotch disease.

What about using other similar products for algal stem blotch control?

In the trial described in this report, only Kocide 3000-O or PhoPhyt were utilized. However, other fungicide products that include the same or closely-related active ingredients (copper hydroxide, potassium phosphite, or other phosphonate fungicides) are labelled for use on blueberry. Growers may ask if similar products may also be expected to provide similar control of this disease issue. Ultimately, the answer to this question is that we do not know for sure. Often, products with the same (or very

similar) active ingredients demonstrate similar effectiveness against particular pathogens or diseases. For example, previous work has demonstrated that both ProPhyt and K-Phite (another phosphonate fungicide from the same Mode-of-Action class [P07]) have efficacy in blueberry against Phytophthora root rot, and it is assumed that other products within this same group likely have similar efficacies. In Florida, blueberry growers sometimes utilize additional copper hydroxide materials besides Kocide 3000-O, and they have indicated that they have observed some of these materials to have similar efficacy against algal stem blotch. Nonetheless, active ingredient concentrations and delivery methods can vary between products and this can affect efficacy in some cases. As such, additional data from the field would be necessary before additional products could be specifically recommended for algal stem blotch control.

What about 'foliar' versus 'drip' applications of similar products?

While some similar fungicides (including some phosphonate fungicides) are labelled for application via drip irrigation, the labels for both Kocide 3000-O and ProPhyt only specify applications to foliage (leaves). Even if additional trial work were carried out to indicate that similar fungicides (like other phosphonate fungicides) had efficacy against algal stem blotch, applications of these products made via drip irrigation may not have efficacy. The efficacy of these materials would likely depend on the relative contributions of contact vs. systemic activity, and at this time we lack a sufficient understanding of the mechanism behind the activity of phosphonate materials versus algal stem blotch to make an informed prediction. As such, blueberry growers utilizing phosphonate fungicide applications via 'drip' applications should not assume that these products will demonstrate the efficacy against algal stem blotch that was provided by foliar applications in this field trial.

Future Directions:

Trial findings will be incorporated into future recommendations for algal stem blotch management and will be disseminated to southeastern U.S. blueberry growers via extension presentations and publications, including in future editions of the Southeast Regional Blueberry Integrated Management Guide and/or the Southeast Regional Organic Blueberry Pest Management Guide, as appropriate.

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