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Abstract

Phosphorous acid is a fungicide that may have other plant health-inducing properties. A previous study showed greater vigor in blueberry plants treated with phosphorous acid. In the current study, old, low-vigor 'Woodard' rabbiteye blueberries were selected for renovation in 2017. The bushes had not been pruned or otherwise managed in several years. To test the hypothesis that adding phosphorous acid treatments (Agri-Fos) to the renovation process would increase plant vigor, three treatments were used: no addition of phosphorous acid, phosphorous acid applied as a drench at renovation pruning plus in the following spring, and drench plus monthly foliar applications of phosphorous acid after renovation pruning and again the following year. Renovation pruning was done at two height treatments on 14 July 2017: bushes were pruned at ground level and at 50 cm resulting in a 2 x 3 factorial. End of season shoot number was significantly different between the 50 cm cut and the ground level cut treatments (35.6 shoots/bush vs. 21.3 shoots/bush, respectively). However, shoot length was significantly greater for the ground cut (80.5 cm) vs. 50 cm cut (72.1 cm). Shoot diameters were not significantly different. Other factors such as first bud push after pruning and crop load rating were not significant. Yields were higher for the 50 cm cut treatment when compared to the ground level prune (318.7 g vs. 58.1 g, respectively) with similar results for average berry weight (1.78 g vs. 1.49 g, respectively). Interestingly, phenological development recordings of flower stage did not differ at stages 2 to 4, but were different in stages 5 and 6. Flower development on bushes in the 50 cm treatment was earlier by nine days at stage 5 and nine days at stage 6 compared to those in the ground cut treatment. There were no significant differences due to phosphorous acid treatments in any data evaluated, nor any significant interactions between phosphorous acid treatment and pruning height treatment. More time may be needed to ascertain any differences among phosphorous acid treatments as its effect may be induced rather than direct.

Index words. Agri-Fos, foliar application, fungicide, phenology, renovation

Introduction

Questions often arise from blueberry producers regarding pruning height. In Mississippi, rabbiteye blueberries (*Vaccinium virgatum*) are pruned immediately after harvest is finished, usually in late June or early July. A maintenance pruning strategy reduces the height of the bush by one-quarter to one-third. Regrowth during the summer is sufficient for resumption of fruiting in the following year; however, renovation is an entirely different process. Renovation pruning is stressful on a blueberry bush because plants are severely pruned to encourage new growth to replace old canes that have lost productivity due to age and poor management (Longstroth, 2015). Often, this process results in a lost year (or more) of fruit production while the plant recovers; however, if the recovery stress could be reduced, then perhaps a quicker return to fruiting could occur. One possible way to

reduce stress is the application of phosphorous acid (H_3PO_3), as it may act as a biostimulant (Gomez-Merino and Trejo-Tellez, 2015).

It has been established that phosphite (applied as phosphorous acid) can be used as a fungicide against plant diseases caused by oomycetes (Brunings et al., 2018; Hartman and Seebold, 2005). Previous studies showed greater vigor of blueberry plants growing in *Phytophthora cinnamomi* infested soils following treatment with phosphorous acid (Brannen et al., 2009; Smith and Miller-Butler, 2017). Phosphorous acid also may also have other plant health-inducing or biostimulant properties, but the potential of this type of application in blueberries has not been explored as it has in other crops. Reports of phosphite reducing plant stress and thus improving crop yield and fruit quality have been made in fruit crops like avocado (Lovatt, 2013), citrus (Albrigo, 1999; Lovatt, 1999), peach (Rickard, 2000), raspberry (Rickard, 2000), and strawberry (Moor et al., 2009). However, there are conflicting reports on why it is effective, i.e. whether it is related to the fungicidal properties (Thao and Yamakawa, 2009) or a combination of biochemical, molecular, and physiological responses (Gomez-Merino and Trejo-Tellez, 2015).

The purpose of this study was to determine if the application of phosphorous acid would have a beneficial effect on blueberry plant growth and yield when pruned at two different height levels in *Phytophthora*-free soil.

Materials and Methods

Low-vigor 'Woodard' blueberry bushes, 20+ years old, were renovated on 14 July 2017 after fruiting was complete by cutting back to the soil line or to 50 cm above the soil line. Experimental design was a 2 x 3 factorial with two renovation cut treatments, three spray treatments, and three blocks. Each cutting treatment had nine replications. Drench and drench plus spray treatments of phosphorous acid (Agri-Fos, AgBio, Loganholme, Queensland, Australia) were also included: 1. No Agri-Fos application, 2. Agri-Fos drench applied immediately after renovation prune and again in March 2018, and 3. Agri-Fos drench applied immediately after renovation prune, then monthly foliar applications during the summer and following spring. The rate of soil drench application was 0.75 tsp (4ml) per 6 gal (22.7 L) of water applied to a 6 ft x 4 ft (1.8 m x 1.2 m) area around each bush. The rate of foliar application was 3 tsp (14.8 ml) in 1 gal (3.8 L) of water applied in August and September 2017 and again in March, April, and May 2018. All plants were fertilized equivalent to a rate of 100 lb N/acre (112.1 kg N/ha) on 14 July 2017 and again on 26 February 2018.

Data collected were days to bud push after renovation cut, number of shoots produced at end of first year, shoot length and diameter, crop load rating, flower phenology, plant yield, and average berry weight. Data were analyzed by analysis of variance in JMP (ver. 12, SAS, Cary, NC). When appropriate, means were separated using Tukey's Honest Significant Difference (HSD) at $P \leq 0.05$.

Results

The renovation pruning cuts were made on 14 July 2017. The number of days after pruning treatment to first bud push (new growth) was not significant for any treatment. Shoot growth measurements were taken after leaf drop in the fall to assess plant vigor (Table 1). End of season shoot number was significantly different between the 50 cm cut treatment and the ground level cut treatment (35.6 vs. 21.3, respectively). However, shoot length was greater for the ground cut treatment (80.5 cm) vs. the 50 cm cut treatment (72.1 cm). Shoot diameters were not significantly different.

Table 1. Growth measurement data of renovated 'Woodard' rabbiteye blueberry pruned at two height levels and subjected to three phosphorous acid spray treatments.

Treatment	**Days to bud push[z]**	**Shoots produced (#)**	**Avg. shoot length (cm)**	**Avg. shoot diameter (mm)**
Prune Height				
Ground level	18.2	21.3	80.5	4.6
50 cm	17.1	35.6	72.1	4.7
Spray application				
Drench only	18.9	31.4	80.9	4.8
Drench + Foliar	17.2	24.2	74.6	4.9
None	16.7	28.5	73.4	4.4
Significance (P<0.05)				
Prune height	0.68	0.003	0.02	0.83
Spray application	0.60	0.17	0.21	0.25
Prune x Spray	0.76	0.28	0.41	0.66

[z]After renovation pruning cuts made on 14 July 2017.

Spray application treatments and interactions were not significant for flower development. Advancement of flower development was favored by the 50 cm pruning treatment, especially at stages 5 (flowers separated but not open) and 6 (flowers open) (Table 2). Interestingly, phenological development recordings of flower stage (Spiers, 1978) did not differ at stages 2 to 4 and 7, but were different in stages 5 and 6. The 50 cm pruning cut treatment flower development was earlier by nine days at stage 5 and nine days at stage 6. Even though stages 3, 4, and 7 were not significant at $P \leq 0.05$, they were consistently earlier than the ground level pruning treatment.

Table 2. Flowering phenology in 2018 of renovated 'Woodard' rabbiteye blueberry plants pruned at two height levels and subjected to three phosphorous acid spray treatments.

Treatment	**Flower Stage**					
	2	3	4	5	6	7
Prune Height						
Ground level	Feb 17[z]	Feb 24	Mar 1	Mar 11	Mar 18	Mar 31
50 cm	Feb 17	Feb 22	Feb 26	Mar 2	Mar 9	Mar 26
Spray Application						
Drench only	Feb 16	Feb 23	Feb 28	Mar 6	Mar 15	Mar 29
Drench + Foliar	Feb 16	Feb 22	Feb 26	Mar 4	Mar 10	Mar 26
None	Feb 18	Feb 23	Feb 28	Mar 7	Mar 16	Mar 29
Significance (P<0.05)						
Prune height	0.91	0.24	0.06	0.01	0.02	0.07
Spray application	0.69	0.86	0.83	0.87	0.57	0.65

Prune x Spray	0.44	0.29	0.44	0.57	0.84	0.96

[z]All flower stage data were taken as day of year and converted to calendar date.

Crop load rating (late April 2018) was not significant; however, once fruit was harvested the 50 cm pruning treatment had significantly more fruit (Table 3). Yields were higher for the 50cm pruning treatment when compared to the ground level prune (318.7 g vs. 58.1 g, respectively). The 50 cm pruning treatment also had heavier fruit.

Table 3. Fruit production and crop load rating in 2018 of renovated 'Woodard' rabbiteye blueberry bushes pruned at two height levels and subjected to three phosphorous acid spray treatments.

Treatment	**Crop load rating[z]**	**Avg. yield (g)**	**Avg. berry weight (g)**
Prune Height			
Ground level	3.0	58.1	1.49
50 cm	4.4	318.7	1.78
Spray application			
Drench only	4.0	170.1	1.79
Drench + Foliar	3.7	183.9	1.56
None	3.3	205.0	1.56
Significance (P<0.05)			
Prune height	0.10	0.01	0.02
Spray application	0.78	0.95	0.13
Prune x Spray	0.59	0.65	0.48

[z]Rating based on a visual scale of 1 = no crop to 10 = heavy crop load.

There were no differences due to phosphorous acid treatments in any data evaluated, nor any interactions of phosphorous acid treatment with pruning height.

Discussion

Renovation pruning of rabbiteye blueberry bushes at height of 50 cm provided a source of mature wood and nutrient reserves to push new shoot growth and fruit set. Even though buds pushed at similar times after pruning, fewer canes were produced by bushes cut to the ground. Pruning height made a significant difference in the amount of fruit that was harvested in the following year, with bushes pruned at the 50 cm height producing more than five times the amount of fruit compared to bushes pruned at ground level. Therefore, leaving a portion of the old cane improved the following year's harvest in these 'Woodard' rabbiteye blueberries, similar to what was reported by Austin and Brightwell (1984), but they also stated that fruit size (berry weight) was larger with more severe pruning. Our results do not align with their statement, as berry weights in our study were greater from bushes pruned at 50 cm than from bushes cut at ground level.

No phosphorous acid treatment had an effect on any measured parameter. Smith and Miller-Butler (2017) and Brannen et al. (2009) showed a positive health effect from applying phosphorous acid to extend blueberry plant life when infected with *Phytophthora* root rot. However, in our study, there was no observable benefit from any application of phosphorous acid in the absence of *Phytophthora*. This is consistent with the results of Broschat (2006) and Thao et al. (2008) in

ornamental plants and spinach (*Spinacia oleracea)*, respectively. However, as Gomez-Merino and Trejo-Tellez (2015) stated, success may depend upon finding the proper method and timing of application coinciding with the ideal plant phenological stage.

Conclusions

A renovation pruning height of 50 cm increased yield and fruit weight significantly over the ground level cut. It also produced more shoots and hastened harvest. Thus, it may be beneficial to not renovate 'Woodard' blueberry bushes back to the soil line if harvest of berries is desired in the following year. The application of phosphorous acid showed no benefit, whether applied as a drench or foliar. More time may be needed to ascertain any differences as it may not have direct, but rather induced, effects on plant growth and yield.

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