HAZELNUT (*Corylus avellana* 'Jefferson')
Bacterial Blight; *Xanthomonas arboricola* pv. *corylina*

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Evaluation of copper-based products for control of bacterial blight on hazelnut, 2020 - 2024.

Bactericide treatments were arranged in a randomized complete block design in hedge rows of multi-stemmed Jefferson hazelnut. Trees were pruned to individual root systems with multiple stems such that trees were at least 1 foot apart. Each treatment consisted of 8 single tree replicates. Bactericides were applied to trees from two directions, until runoff, using a Stihl SG20-Pump-Style backpack sprayer equipped with a brass hollow cone nozzle. Approximately 2 gal of a spray suspension was used per 8 trees within each treatment. Bactericide treatments were applied on 22 Oct 2020. Trees were then inoculated on 16 Nov 2020 with two isolates of *Xanthomonas arboricola* pv. *corylina*. Inoculum was prepared using 0.5 g of freeze-dried cells of JL2005 (phylogroup of type strain) and 0.5 g of JL2600 (phylogroup 2) suspended and rehydrated in 1 liter of water for 60 minutes. This suspension and water was then added to a Stihl SG20-Pump-Style backpack sprayer to 10 liters for a final concentration of about 1×10^8 cfu/ml. The cell suspension was applied to treatment trees until bark was visibly damp or wet on a morning with temperatures in the 40s and with 0.09 inches of rain 24 hours after application. Several trees were not inoculated. All trees had already lost leaves. Makaze (3%) was tank mixed with Forfeit 280 (1.7 oz/gal) and applied as a general and/or spot treatment on 15 Jul 2020 and Makaze (3%) alone was applied 6 Mar 2021 for management of weeds. Trees were monitored for symptoms of bacterial blight during the spring of 2021. The number of dead buds/shoots per tree was determined on 17 May 2021. Only 6 replicates were used in the analysis due to interactions with previous applications the prior year.

The same trial was conducted on the same set of trees (6 reps only) in 2021. Bactericides were applied to trees using a Stihl SG20-Pump-Style backpack sprayer using approximately 1 gal of a spray suspension per 6 trees within each treatment. Bactericide treatments were applied on 15 Oct 2021 (50% leaf fall). Trees were then inoculated on 8 Nov 2021 (65-75% leaf fall) with the same isolates of *Xanthomonas arboricola* pv. *corylina*. The cell suspension was applied to treatment trees until bark was visibly damp or wet on a morning with temperatures in the high 30s to low 40s and with 0.08 inches of rain 24 hours after application. There were no herbicide applications in 2022 for management of weeds. Trees were monitored for symptoms of bacterial blight during the spring of 2022. The number of dead buds/shoots per tree was determined on 11 May 2022.

Again, the same trial was conducted on the same set of trees (6 reps only) in 2022. Bactericides, however, were applied to trees using a hydraulic handgun sprayer at approximately 100 psi such that 2.5 to 3.0 gal of a spray suspension was used per 6 trees within each treatment. Bactericide treatments were applied on 20 Oct 2022 (50% leaf fall). Trees were then inoculated using a Stihl SG20-Pump-Style backpack sprayer on 22 Nov 2022 (75-90% leaf fall) with the same isolates of *Xanthomonas arboricola* pv. *corylina*. The cell suspension was applied to treatment trees until bark was visibly damp or wet on a morning with temperatures in the low 40s to low 50s, a light drizzle towards the end of inoculation and with 0.14 inches of rain 24 hours after application. There were no herbicide applications in 2023 for management of weeds. Trees were monitored for symptoms of bacterial blight during the spring of 2023. The number of dead buds/shoots per tree was determined on 24 May, while the number of dead branches per tree was determined on 3 Aug.

Although this trial was not repeated in 2023, the same set of trees were monitored for symptoms of bacterial blight during the spring of 2024. The number of dead buds/shoots per tree was determined on 13 May, while the number of dead branches per tree was determined on 11 Jun. Treatments were also evaluated by calculating the area under disease progress curve (AUDPC) of dead buds/shoots per tree across the four years bacterial blight symptoms were monitored. AUDPC was calculated by multiplying the mean incidence from four observation dates by the number of days between observations ($\Sigma[Y_{i+1} + Y_i)/2][X_{i+1}-X_i]$ where Y_i is incidence of dead buds/shoots per tree in percent at i*th* observation and X_i is the day of the i*th* observations). Values calculated between each pair of observations are added together to obtain a total AUDPC.

Results

There were 4.5 inches of rain from bactericide application to inoculation in the fall of 2020. Rainfall during the dormant season 2020-21 was close to normal but followed by spring weather conditions that were abnormally warm and the second driest on record. Symptoms of bacterial blight started to develop on 7 May 2021 as random dieback of buds and a few shoots. Lowest bacterial blight was found on non-inoculated trees, which was significantly lower than all other treatments (Table 1). None of the copper-based bactericides developed significantly less bacterial blight than the inoculated control.

There were 4.74 inches of rain from bactericide application to inoculation in the fall of 2021. Rainfall during the dormant season 2021-22 was 5.4 inches below normal but spring weather conditions were very wet with the second wettest spring on record. Symptoms of bacterial blight started to develop on 2 May 2022 as random dieback of buds and a few shoots. Lowest bacterial blight was found on non-inoculated trees, however, the number of dead shoots on trees treated with Badge X2 or SC was not significantly different (Table 1). None of the copper-based bactericides developed significantly less bacterial blight than the inoculated control.

In 2022, there were 7.16 inches of rain from bactericide application to inoculation. Rainfall during the dormant season 2022-23 was 3.18 inches below normal. Symptoms of bacterial blight started to develop on 15 May 2023 as random dieback of buds and a few shoots. Lowest bacterial blight was found on non-inoculated trees (Table 1). Trees treated with Previsto had significantly more bacterial blight than all other treatments (Table 1). Trees treated with Kocide had significantly less bacterial blight than inoculated control trees (Table 1). There were no differences in the number of dead branches among the various treatments (Table 2).

Rainfall during the dormant season (Oct 2023 to Mar 2024) was 4.1 inches above normal. Symptoms of bacterial blight started to develop on 29 Apr 2024 as random dieback of buds and a few shoots. Lowest bacterial blight was found on non-inoculated trees (Table 1). Trees treated with Previsto or Badge SC had significantly more bacterial blight than non-treated/inoculated trees. Trees treated with Kocide had significantly less AUDPC than inoculated control trees while trees treated with Previsto had significantly higher AUDPC than non-treated/inoculated trees (Table 2). AUDPC for trees treated with Kocide was not significantly different than non-inoculated control trees. There were no differences in the number of dead branches among the various treatments (Table 2).

Conclusions

Bacterial blight trials have indicated the need for copper applications early in the life of a tree from nursery to orchard and to avoid the product Previsto. Trials over the last 4 years resulted in less disease than expected indicating that either bacterial blight has not been a problem or we may still need to refine our inoculation methods. Future research will look at inoculation timing to help develop protocols for testing bactericidal treatments.

Table 1. Dead shoots found on trees the spring after inoculation [Y] the previous fall.

Treatment and Rate/100 gal water	Dead shoots per tree [Z]							
	17 May 2021		11 May 2022		24 May 2023		13 May 2024	
Non-treated and non-inoculated …….....	0.2	c	8.5	c	8.3	d	12.5	d
Non-treated but Inoculated…….....	3.3	ab	45.0	ab	52.5	b	21.3	c
Previsto at 4 qt then Inoculated ……	4.5	a	50.5	a	98.3	a	44.2	ab
Badge X2 at 10.5 lb plus Stylet Oil at 1 pt then Inoculated ……	3.0	ab	19.0	bc	46.5	bc	28.7	bc
Badge SC at 10.5 pt plus Stylet Oil at 1 pt then Inoculated ……	2.7	b	13.2	bc	44.0	b	52.7	a
Kocide 3000 at 10.5 lb plus Stylet Oil at 1 pt then Inoculated ……	1.7	b	19.5	ab	22.0	c	27.8	bc

[Y] Bactericide treatments and inoculations only occurred in the falls of 2020, 2021and 2022. Treatments were not conducted in the fall of 2023.

[Z] Analysis of variance is based on log (x+1) transformation of only 6 replicates. Means followed by the same letter do not differ significantly based on Fisher's protected LSD (*P=0.05*).

Table 2. Area under the disease progress curve (AUDPC) of dead shoots per tree across the four years (2021-2024) bacterial blight symptoms were monitored and number of dead branches in 2023 and 2024.

Treatment and Rate/100 gal water	AUDPC [X]		Dead branches per tree [Y]	
			3 Aug 2023	11 Jun 2024
Non-treated and non-inoculated …….....	8,466	d	0.2	1.0
Non-treated but Inoculated…….....	39,457	b	0.8	2.8
Previsto at 4 qt then Inoculated ……	63,277	a	0.3	4.5
Badge X2 at 10.5 lb plus Stylet Oil at 1 pt then Inoculated ……	29,724	bc	0.7	2.8
Badge SC at 10.5 pt plus Stylet Oil at 1 pt then Inoculated ……	31,013	bc	0.5	2.3
Kocide 3000 at 10.5 lb plus Stylet Oil at 1 pt then Inoculated ……	20,556	cd	0.0	1.5

[X] Means followed by the same letter do not differ significantly based on Fisher's protected LSD (P=0.05). Means without letters are not significantly different.

[Y] Analysis of variance is based on log (x+1) transformation of 6 replicates. Means without letters are not significantly different based on Fisher's protected LSD (*P=0.05*).