Efficacy of mancozeb, captan, copper and *Pseudomonas chlororaphis* for control of black rot and downy mildew of grape, 2025

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Mancozeb, a broad-spectrum contact fungicide, is under regulatory pressure in the U.S.A. and elsewhere. In Georgia, mancozeb has been utilized extensively for early-season management of grape diseases: Phomopsis cane and leaf spot, black rot, downy mildew and ripe rot, among others. Mancozeb does not generally develop resistance, due to its multi-site mode of action, so it is an important resistance-management tool in alternation or in tank mixes with other at-risk fungicides. While captan has been used by growers to target many of the same diseases, it has been utilized mainly for late-season diseases. The removal of the E.P.A. mancozeb tolerance for usage in grape production would necessitate application of more numerous, lower rates of captan in an attempt to provide a broad-spectrum fungicide throughout as much of the season as possible. Copper has not generally been utilized in Georgia due to lower efficacy, soil residue accumulation over time, and the potential for phytotoxicity. However, copper also would have significant importance in future spray programs if mancozeb were removed. Lastly, there are biological materials with purported activity on many grape diseases. They could also possibly add to the arsenal of materials needed for disease control. Among these, *Pseudomonas chlororaphis*, is one that should be reviewed.

In a field trial conducted in Watkinsville, Georgia (U.S.A) on 'Camminare Noir' vines, Captan 4L, Kocide 3000 (copper), and Howler Evo (*P. chlororaphis*) were reviewed for control of black rot and downy mildew. Mancozeb consistently provided lower disease levels than other treatments, but Captan 4L provided statistically equivalent control of both black rot and downy mildew. Kocide 3000, though providing efficacy against both pathogens, was not as efficacious as mancozeb. The biological product, Howler Evo, did not provide efficacy against either pathogen when compared to the untreated control. Additional testing will be required to confirm these results.

With the currently available fungicides, the loss of mancozeb may result in greater grape disease levels in Georgia and the Southeast as a whole. However, by incorporating low rates of captan and high copper rates, along with other fungicides, it may be possible to develop regimens with equivalent or near-equivalent efficacy, though this will result in higher fungicide resistance selection pressure on many of the available materials. Results from this trial will help growers determine which products are best to use for management strategies with these diseases in the future.

Keywords: Grapevine powdery mildew, black rot, mancozeb, captan, copper, *Pseudomonas chlororaphis*

Mancozeb is a long-standing, broad-spectrum fungicide that does not readily develop fungal resistance. In Georgia, U.S.A., it is utilized extensively for management of Phomopsis cane and leaf spot (*Phomopsis viticola*), downy mildew (*Plasmopora viticola*), black rot (*Phyllosticta* spp.), and ripe rot (*Colletotrichum* spp.) – among other diseases of grape. Recently, mancozeb has come under regulatory pressure. Should the tolerance for mancozeb in grape production be revoked, alternative fungicides would be needed to replace it. Therefore, a trial was conducted to review three alternative fungicides that could be incorporated into spray programs as potential mancozeb replacements. These included Captan 4L at the lowest rate allowed by label (required in order to expand the use of captan for as many applications as possible), Kocide 3000 at the highest rate allowed by label (an attempt to increase the efficacy of copper which is known to be less than that of mancozeb), and Howler Evo at the highest rate allowed (a biological fungicide consisting of formulated *Pseudomonas chlororaphis*). Manzate Prostick (mancozeb) was applied at a rate that is generally utilized by Georgia wine grape vineyard managers. All treatments were applied in a tank mix with Microthiol Disperss (sulfur), required to prevent powdery mildew but with limited to no activity against pathogens of interest. Microthiol Disperss was applied alone as well, and this treatment constituted the equivalent of an untreated control. Therefore, treatments were as follows: (1) Microthiol Disperss (2) Manzate Prostick + Microthiol Disperss; (3) Captan + Microthiol Disperss; (4) Kocide 3000 + Microthiol Disperss; and (5) Howler Evo + Microthiol Disperss. Treatments were administered in a 'Camminare Noir' block at the University of Georgia Durham Horticulture Farm in Watkinsville, Georgia (U.S.A.). Cultural practices used on site mimicked those used in commercial vineyards. The experimental design utilized a randomized complete block with six replications per treatment. Single plants were utilized for each replicant unit, and treatment plants were separated by an unsprayed buffer plant utilized to decrease spray drift. Treatments were applied with a CO_2 backpack sprayer equipped with one TT11002 (TeeJet Technologies, Wheaton, IL) nozzle, and rates were calculated to correspond with a 50 gal per acre total spray volume; applications were made five times (13 Apr, 26 Apr, 8 May, 19 May, and 31 May). Fruit clusters (ten per plant) were rated for black rot Incidence (% of clusters infected) and severity (% of clusters covered by black rot) on 2 Jun. Since incidence for black rot on fruit was near 100% for all treatments, only severity data is presented. Leaves (50 per plant) were rated for downy mildew incidence (% of leaves infected) and severity (% of leaf area covered) on 2 Jun. On 6 Jun, a field visual rating of general downy mildew disease severity was conducted for each treated plant, incorporating defoliation from downy mildew as well as severity on remaining leaves. SAS software (SAS Institute Inc., Cary, NC) was utilized for data analysis, and a Fisher's protected t test was utilized for treatment means separation.

From trial initiation till trial termination, there were 25 days with rainfall, averaging 0.2 inches (range 0.01 - 1.5 inches), and temperatures averaging 69°F. These conditions were optimal for black rot and downy mildew development. As expected, Manzate Prostick substantially reduced both black rot and downy mildew disease levels (Supplementary Table S1). Captan 4L at the low rate provided disease control that was numerically less than but statistically equivalent to Manzate Prostick – an overall encouraging result. However, Kocide 3000 at the highest label rate, though providing substantive control of both downy mildew and black rot, did not provide equivalent control to that afforded by Manzate Prostick. Without addressing other complications limiting extensive use of copper (e.g., phytotoxicity concerns, environmental buildup), these results cast doubt that it can be utilized as a full replacement treatment for mancozeb. Though no significant phytotoxicity was observed in this trial, further testing under warmer weather conditions, common in Georgia, are needed. Unfortunately, Howler Evo did not provide efficacy against either disease in this trial. Overall, this trial would indicate that both captan and copper can be incorporated to at least in part replace mancozeb in spray programs if required. Through reducing rates of captan, thereby expanding the number of applications possible, and through adding copper as an additional fungicide, there are some broad-spectrum fungicide alternatives. Though encouraging overall, this trial did not provide data relative the efficacy of these fungicides for other key diseases which mancozeb currently addresses, namely Phomopsis and ripe rot. Additional testing is needed to confirm the results we observed in this trial, as well as additional testing on other pathogens/diseases and grapevine cultivars in Georgia.

Supplementary Table S1: Evaluation of mancozeb, captan, copper, and a *Pseudomonas chlororaphis* for management of black rot and downy mildew of grape.

Treatment and amount/A	**Application timing** [x]	**Fruit black rot severity (%)**[y]	**Downy mildew**		
			Leaf incidence (%)[z]	**Leaf severity (%)**[z]	**Whole plant severity (%)**[z]
Microthiol Disperss 3 lb	ABCDE	58.7 a	99.0 a	16.6 a	68.8 a
Microthiol Disperss 3lb + Manzate Prostick 3 lb	ABCDE	13.3 c	65.0 c	4.6 b	10.2 b
Microthiol Disperss 3lb + Captan 4L 0.75 qt	ABCDE	23.8 bc	77.7 bc	5.0 b	16.7 b
Microthiol Disperss 3lb + Kocide 3000 1.75 lb	ABCDE	33.0 b	85.7 ab	5.3 b	25.8 b
Microthiol Disperss 3lb + Howler Evo 7.5 lb	ABCDE	57.5 a	97.3 a	17.4 a	72.3 a
LSD ($\alpha = 0.05$)		17.7	14.4	4.6	18.1

[x]Treatment dates: A = 13 Apr, B = 26 Apr, C = 8 May, D = 19 May, E = 31 May.

[y]Fruit black rot severity (% of cluster area covered by black rot) was calculated from 10 representative grape clusters per plant. Means followed by the same letter are not significantly different when comparing each pair using a Fisher's protected LSD test of significance ($P \leq 0.05$).

[z]Downy mildew incidence (% of leaves with downy mildew) and severity (% of leaf area covered by downy mildew) was calculated from 50 leaves per plant. Whole plant severity is a subjective visual rating that incorporates total plant damage from downy mildew, to include defoliation. Means followed by the same letter are not significantly different when comparing each pair using a Fisher's protected LSD test of significance ($P \leq 0.05$).