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Spraying to Suppress Coffee Leaf Rust (*Hemileia vastatrix*) in Hawai'i

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Coffee Leaf Rust (CLR), *Hemileia vastatrix*, has been identified in Hawai'i. This disease of coffee will cause defoliation, reduced berry size, branch, and tree death. Infections typically start on the lower portion of the tree before reaching the higher leaves. The first symptoms are small, pale yellow spots on the upper surface of leaves (Fig. 1A). On the undersides of leaves, infectious spores appear resembling a patch of yellow- to dark orange-colored powder (Fig. 1B, Fig. 2). These young lesions steadily increase in size, with the center of the lesion turning necrotic and brown [1]. Stem and berry infection are rare, but CLR can also affect young seedlings.

Why spray to suppress coffee leaf rust?

Over a three- to five-month period, one CLR lesion can produce upwards of 400,000 spores that become airborne and easily spread throughout a farm and between farms. If left untreated, berry production and foliage losses caused by CLR on non-resistant coffee varieties can be significant, ranging between 30% and 80% [4,5]. Yield is completely lost when the tree is killed.

Figure 1: Coffee leaf rust on the upper leaf surface (top) and lower leaf surface (bottom) of coffee.

Plant susceptibility to CLR attack increases with berry yield and host density [4]. Field sanitation, proper pruning, fertility, CLR monitoring, and early detection are key for reducing this pathogen threat to tree health and production. When applied properly, and at <5% infection rate of total farm foliage, contact fungicides can be helpful in protecting coffee trees from initial and increased disease severity [10]. Physical removal, containment, and destruction of leaves and branches displaying lesions can help to reduce CLR inoculum and infection [2].

Only contact fungicides have been available for Hawai'i coffee producers; however, on May 19, 2021, Priaxor® Xemium® Brand Fungicide, a translaminar (localized systemic) fungicide, was approved for use on coffee in Hawai'i under an Environmental Protection Agency Section 18 Emergency Exemption. Information about this product is not included in this publication. Contact your statewide coffee agent to learn about Priaxor Xemium and its Section 18 use requirements and directions. See page 4 for contact details.

Brackets e.g. [2], correspond to literature citations found in the Literature Cited section. This publication is expected to evolve as more is learned about coffee leaf rust in Hawai'i.

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Figure 2: Close-up of powder-like coffee leaf rust spores on the underside of a coffee leaf.

No other systemic fungicides are currently available for Hawai'i producers to use on coffee for CLR control. This document provides suggestions for producers on the use of fungicides for both the suppression of CLR on farms and to reduce establishment severity of the pathogen. Special attention is needed for pesticide resistance management to fungicides with product rotation and proper use. Additional CLR information can be found at www.HawaiiCoffeeEd.com/clr.

Table 1 provides a list of fungicides approved by the Hawai'i Department of Agriculture for use on coffee in Hawai'i, and lists CLR on the label. Although there are other fungicides approved for use in Hawai'i, unless coffee is listed on the label, you should not use these products on your coffee crop. Failure to adhere to pesticide regulations could result in legal action and fines by regulatory authorities.

Suggestions for Preventative and Suppression Spray Applications

THE LABEL IS THE LAW. READ AND FOLLOW PRODUCT LABELS FOR ALL PESTICIDES.

PRODUCT ROTATION IS HIGHLY RECOMMENDED TO REDUCE THE RISK OF PESTICIDE RESISTANCE BY COFFEE LEAF RUST AND OTHER DISEASES.

Personal protective equipment (PPE):

- Follow the label for proper use of PPEs.
  - o Disposable PPEs may be a consideration for use.

Type of sprayer:

- According to experts at CIRAD, a French agricultural research center, motorized sprayers should not be used for initial CLR treatments to contain spores [3].
  - o Spores may become airborne and spread if using a high-pressure sprayer.
  - o Reduce sprayer pressure or change the nozzle to create larger droplets as needed.
- Water quantity per acre will depend on individual spray calibration for your trees and farm.
  - o Calibrate your sprayer by following the examples and directions in publications for sprayer calibration [7-9].

Where and what to spray:

- Spray the entire coffee tree, with emphasis on the undersides and topsides of the leaves.
  - o A CLR spore produces a germ tube (germinates) that enters the plant via the stomata, which are found on the undersides of leaves [5].
- Spray all producing, non-producing, and seedling coffee plants.
  - o Good spray coverage is important.
  - o A slowed walking pace and deliberate spray application may be necessary to achieve complete coverage of the tree foliage and leaf surfaces.
- Consult the label about intentional ground spraying.
  - o Field sanitation and early detection of CLR is

important.
  - o CLR mycelium require a living host tissue or cell to remain alive; however, its urediniospores can survive about six weeks and through dry periods [1].
- Reduce the development of pesticide resistance to the products listed in Table 1.
  - o It will be more difficult to control diseases with resistance to approved fungicides.
  - o Alternate and rotate the use of fungicides in different FRAC groups, as listed in Table 1.
    - This typically applies to the use of all pesticides, unless noted on the label.
  - o For example, if you use a blue product like Serenade ASO (FRAC Group 44) for your first application, then use a yellow product, such as Kocide 3000 (FRAC Group M1), for your next application. Then, switch back to Serenade or rotate to a pink product (FRAC Group BM 02). Avoid using the same-colored product in back-to-back applications.
  - o If your farm is certified organic, an example for rotation is to use a pink product like DoubleNickel LC, then use a yellow product like Badge X2 next. Then, switch back to DoubleNickel LC or rotate to a blue product. Again, avoid using the same-colored product in back-to-back applications.

When to spray:
- Avoid spraying during rain, drought, or high heat, if possible.
- Follow the product label for frequency of application.

Other additions to the fungicide:
- Consult with the product label before mixing and combining other products with the fungicide.
  - o Some pesticide products are not compatible with certain additives, such as those noted below.
  - o If the mixture of products causes phytotoxicity on the coffee trees, stop applications immediately.
- Sticker/spreader
  - o Stickers help the product to adhere to the surface and remain on the plant following application
  - o Spreaders and adjuvants help with dispersal and coverage by reducing water surface tension and allowing the droplets to spread and cover more surface area on leaves, branches, berries, etc.
  - o A spreader could improve spray coverage.
  - o If anticipating rain, a sticker and spreader could improve spray adhesion and coverage.
- Foliar fertilizers
  - o Consult with the fungicide and foliar fertilizer labels.
- Approved *Beauveria bassiana* products
  - o Review the product label and the BioWorks Botani-Gard® compatibility chart.
  - o https://www.bioworksinc.com/wp-content/uploads/products/shared/botanigard-tank-mix-compatibility.pdf
  - o According to the above link, tests were not carried out to evaluate impact on the partner product integrity or for plant phytotoxicity.

Spraying to control anthracnose (*Colletotrichum* sp.) and cercospora leaf spot and berry blotch (*Cercospora coffeicola*) [5] on coffee, as well as CLR:
- Spraying to control *Colletotrichum* sp., another fungal disease on coffee in Hawai'i, may require higher rates than necessary for CLR. Consult the product label.
- Conduct annual or biennial leaf tissue and soil sample tests to determine and prevent plant and soil toxicities when applying copper-based and other products.

Other important considerations:
- Maintain proper record keeping of pesticide use.
- Re-entry interval (REI) following a spray application.
  - o Follow the required REI, being especially mindful of pickers and when they will enter the field for harvest.
  - o Also, follow any restrictions regarding application before crop harvest. This is typically referred to on the label as the Pre-Harvest Interval, or PHI.
- pH of spray solution.
  - o Labels may have warnings for phytotoxicity with low (or high) pH of the spray solution.
- Minimum and maximum rates per application.
  - o Follow the label rate. Underuse of a product can cause pesticide resistance by the pest or disease and additional losses if spray applications are ineffective.
  - o Overuse of a product can cause plant, soil, and environmental toxicities and hazards, is a violation of product use, and has increased costs to the producer.
- Maximum applications per year or season.

- o Follow the label instructions.
- o Again, overuse of a product can cause plant, soil, and environmental toxicities and hazards, is a violation of product use, and has increased costs to the producer.

ALWAYS READ AND FOLLOW THE PESTICIDE PRODUCT LABEL DIRECTIONS.

If you have questions, contact your local Cooperative Extension or statewide coffee agent, Andrea Kawabata, at andreak@hawaii.edu. Texts and photos can be sent to (415) 604-1511.

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Literature Cited:

1. Arneson, P.A. 2011. "Coffee rust". *The Plant Health Instructor.* DOI: 10.1094/PHI-I-2000-0718-02. http://www.apsnet.org/edcenter/intropp/lessons/fungi/Basidiomycetes/Pages/CoffeeRust.aspx
2. Avelino, J., and Savary, S. 2004. Effects of crop management patterns on coffee rust epidemics. *Plant Pathology*, 53, 541–547. https://bsppjournals.onlinelibrary.wiley.com/doi/full/10.1111/j.1365-3059.2004.01067.x
3. Keith, L. Personal communications. 2 November 2020.
4. Koehler, J. 2018. Coffee rust threatens Latin American crop; 150 years ago, it wiped out an empire. NPR. https://www.npr.org/sections/thesalt/2018/10/16/649155664/coffee-rust-threatens-latin-american-crop-150-years-ago-it-wiped-out-an-empire
5. Kushalappa, A.C. and A.B. Eskes (eds). 1989. *Coffee Rust: Epidemiology, Resistance and Management*. CRC Press, Boca Raton, Florida. 345 pp.
6. Nelson, S.C. 2008. Cercospora leaf spot and berry blotch of coffee. Honolulu (HI): University of Hawai'i. 6p. (*Plant Disease Series*; PD-41). https://www.ctahr.hawaii.edu/oc/freepubs/pdf/PD-41.pdf
7. Thap, C. 2010. Using and calibrating backpack sprayers. In: Montana State University's *Big Sky Small Acres Magazine*. pp. 10-11. https://apps.msuextension.org/magazine/assets/docs/Using and Calibrating Backpack Sprayers.pdf
8. Uyeda, J., M. Kawate, J. Coughlin, J. Kam, J. Sugano, S. Fukuda, R. Shimabuku, and K.H. Wang. 2015. Sprayer calibration using the 1/128th method for motorized backpack mist sprayer systems. Honolulu (HI): University of Hawai'i. 5p. (*Pesticide Risk Reduction Education Series*; PRRE-9). https://www.ctahr.hawaii.edu/oc/freepubs/pdf/PRRE-9.pdf
9. Uyeda, J., J. Sugano, S. Fukuda, M. Kawate, R. Shimabuku, and K.H. Wang. 2013. Sprayer calibration using the 1/128th method for handheld spray gun systems. Honolulu (HI): University of Hawai'i. 4p. (*Pesticide Risk Reduction Education Series*; PRRE-7). https://www.ctahr.hawaii.edu/oc/freepubs/pdf/PRRE-7.pdf
10. Zambolim, L. 2016. Current status and management of coffee leaf rust in Brazil. *Trop. Plant Pathol.* 41, 1–8. https://doi.org/10.1007/s40858-016-0065-9

Table 1. List of fungicides currently licensed by the Hawaii Department of Agriculture with directions for use on coffee grown in Hawaii for the control of CLR. Licensed products and label changes happen frequently. Refer to http://npirspublic.ceris.purdue.edu/state/state_menu.aspx?state=HI or https://opendata.hawaii.gov/ for currently licensed products and their approval labels (8/27/21). Note that DoubleNickel LC and 55 have been corrected as a FRAC Group 44 (blue) product.

Trade Name (*organic product)	**Active Ingredients**	**FRAC Group**	**EPA Reg. No.**	**Labels**	**Re-entry interval REI (hrs)**	**Compatibility with BotaniGard®[1]**	**Coffee Leaf Rust *H. vastatrix* Rate (per acre)**	**Est. Cost[4] per Application/Acre**	
								Low Rate	**High Rate**
DoubleNickel LC Biofungicide*	*Bacillus amyloliquefaciens strain D747*	44	70051-107	Label	4	Yes[2]	0.5-6.0 qts	$7.50	$90.00
DoubleNickel 55 Biofungicide*	*Bacillus amyloliquefaciens strain D747*	44	70051-108	Label	4	Yes[2]	0.25-3.0 lbs	$9.63	$115.50
Serenade ASO*	QST 713 strain of *Bacillus subtilis*	44	264-1152	Label	4	Yes, but NOT at 8 qt/100 gal (see chart)	2.0-4.0 qts	$23.50	$47.00
Badge SC	Copper oxychloride + Copper hydroxide	M1	80289-3-10163	Label	48	Yes[2]	1.0-3.0 pints	$5.88	$17.63
Badge X2*	Copper oxychloride + Copper hydroxide	M1	80289-12	Label	48	Yes[3]	1.0-3.0 lbs	$9.50	$28.50
Badge X2*	Copper oxychloride + Copper hydroxide	M1	80289-12-10163	Label	48	Yes[3]	1.0-3.0 lbs	$12.00	$36.00
Basic Copper 53	Basic copper sulfate	M1	45002-8	Label	48	Yes[3]	2.0 lbs	$12.00	
Champ Formula 2 Flowable Agricultural Fungicide/Bactericide	Copper hydroxide	M1	55146-64	Label	48	Yes[2]	1.33-2.66 pints	$7.48	$9.84
Champ WG Agricultural Fungicide	Copper hydroxide	M1	55146-1	Label	48	Pending	2.0-4.0 lbs	$17.00	$34.00
ChampION++ Fungicide/Bactericide	Copper hydroxide	M1	55146-115	Label	48	Yes[3]	0.75-1.75 lbs	$6.38	$14.88
Cueva Fungicide Concentrate*	Copper octanoate	M1	67702-2-70051	Label	4	Not physically compatible at 2.0 gal/100 gal water[3]	0.5-2.0 gals	$30.00	$120.00

Table 1. continued

Trade Name (*organic product)	Active Ingredients	FRAC Group	EPA Reg. No.	Labels	Re-entry interval REI (hrs)	Compatibility with BotaniGard®[1]	Coffee Leaf Rust *H. vastatrix* Rate (per acre)	Est. Cost[4] per Application/Acre	
								Low Rate	High Rate
Cuprofix Ultra 40 Disperss	Basic copper sulfate	M1	70506-201	Label	12	Pending	1.25-3.0 lbs	$6.88	$16.50
Cuproxat Flowable Copper Fungicide	Basic copper sulfate	M1	35935-3	Label	48	Yes[3]	2.5-6.0 pints	$50.00	$120.00
DuPont Kocide 2000 Fungicide/Bactericide	Copper hydroxide	M1	352-656	Label	48	Yes[3]	1.5-3.0 lbs		
Kalmor Fungicide/Bactericide*	Copper hydroxide	M1	91411-11-59807	Label	48	Yes[3]	0.75-1.75 lbs	$19.13	$44.63
Kentan DF	Copper hydroxide	M1	80289-2	Label	48	Pending	2.0-4.0 lbs	$11.00	$22.00
Kocide 2000	Copper hydroxide	M1	91411-1-70051	Label	48	Yes[3]	1.5-3.0 lbs	$8.25	$16.50
Kocide 2000-O*	Copper hydroxide	M1	91411-10-70051	Label	48	Yes[3]	1.5-3.0 lbs		
Kocide 3000	Copper hydroxide	M1	91411-2-70051	Label	48	Yes[3]	0.75-1.75 lbs	$9.00	$21.00
Kocide 3000-O*	Copper hydroxide	M1	91411-11-70051	Label	48	Yes[2]	0.75-1.75 lbs	$9.00	$21.00
Kocide HCu	Copper hydroxide	M1	91411-12-70051	Label	48	Pending	3.0-4.2 lbs		
Mastercop Bactericide/Fungicide*	Copper sulfate pentahydrate	M1	55272-18-66222	Label	48	Yes[2]	0.5-1.5 pints	$7.13	$21.38
Nu-Cop HB	Copper hydroxide	M1	42750-132	Label	48	Pending	1.0-2.0 lbs	$12.00	$24.00
Nu-Cop 30HB	Copper hydroxide	M1	42750-281	Label	48	Yes[2]	0.75-1.75 lbs	$9.00	$21.00
Previsto Fungicide-Bactericide*	Copper hydroxide	M1	10163-330	Label	48	Pending	2.0-4.0 qts	$32.50	$65.00

Table 1. continued

Trade Name (*organic product)	Active Ingredients	FRAC Group	EPA Reg. No.	Labels	Re-entry interval REI (hrs)	Compatibility with BotaniGard®[1]	Coffee Leaf Rust *H. vastatrix* Rate (per acre)	Est. Cost[4] per Application/Acre	
								Low Rate	High Rate
OxiDate 2.0*	Hydrogen Dioxide + Peroxyacetic Acid	Not classified	70299-12	Label	Until dried	No	0.25% to 1.0%	Gals. water needed/A $58.00/gal	
OxiDate 5.0*	Hydrogen Dioxide + Peroxyacetic Acid	Not classified	70299-28	Label	Until dried	No	0.25% to 1.0%	Gals. water needed/A $62.60/gal	
Priaxor Xemium Brand Fungicide	Fluxapyroxad + Pyraclostrobin	7, 11	7969-311	Label; Section 18 Label	12	No	7.14 fl oz	$33.47	
Timorex Act*	Tea Tree Oil	F7	86182-3-88783	Label	4	Pending	13.0-35.0 fl oz		

[1] See the BioWorks BotaniGard® Compatibility Chart here. "Pending" means that the exact product was not listed as tested by BioWorks. Per email from BioWorks dated 11/2/20 and 12/6/21, these products still need to be tested for compatibility with *Beauveria bassiana*. Results will be forthcoming.
[2] Per email from BioWorks dated 11/2/20 and 1/14/21, these products have been determined compatible with BotaniGard®.
[3] Per email from BioWorks dated 11/24/21 and 12/6/21– Badge X2 tested and found compatible at 11.0 lb/acre per 100 gal water; Phyton 27 (Copper Sulphate Pentahydrate), similar to Basic Copper 53 and Cuproxat Flowable Copper Fungicide was found compatible at 25 fl oz/100 gal water; Cueva Fungicide Concentrate was not found to be physically compatible at 2.0 gal/100 gal water, but did not show any impact when sprayed on *B. bassiana* growing colonies, which means that a rotation of both products would not necessarily affect the efficacy of BotaniGard® in the field; Kocide 3000 (copper hydroxide) is compatible at 16 lb/100 gal water.
[4] Estimated costs are based on local retail prices and are for the fungicide only (Nov. 2020; Oct. 2021).

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