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PACKINGHOUSE NEWSLETTER

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REGISTRATION OF BIOLOGICAL PRODUCTS FOR POSTHARVEST DECAY CONTROL

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Interest in the development of living organisms for the control of diseases has resulted in the recent registration of two biological control agents for citrus decay control. Development of alternatives to chemicals has been spurred by concerns with fungicide chemical resistance among isolates of *Penicillium digitatum* (green mold), pesticide residues in food products, and regulatory and economic issues impacting registration.

The biological products that are available for commercial use are Aspire and BioSave™ 10. Aspire is a yeast (*Candida oleophila*), developed by Ecogen Inc., and BioSave™10 is a bacterium (*Pseudomonas syringae*), developed by EcoScience Corporation. These organisms were originally isolated from the surface of tomato and apple, respectively.

The biological control organisms are formulated into wettable powders which are suspended in water and agitated during application much like thiabendazole (TBZ) formulations. Several important differences between chemical and biological products must be kept in mind. The formulated biological control products must be stored under refrigeration, but they still will have a much shorter shelf-life than a postharvest chemical because they are living organisms. The treatment suspensions will have to be fresh and probably prepared on a daily basis. They can not be applied with pack waxes, soaps or sanitizers, such as chlorine, because these compounds would be lethal to the yeast or bacterial cells. The two biological products will, however, survive

in injuries to the fruit surface during the normal drying and waxing operations that follow the aqueous biological application. The organisms utilize nutrients released by the injured fruit tissue, and compete with wound pathogens, such as *P. digitatum*, to prevent them from establishing a successful infection. Control is not achieved by the production of toxic fungal chemicals. Non-chemical producing organisms were selected for development because chemicals would be impacted by the same expense and regulatory issues impacting registration of synthetic fungicides.

Several limitations have been observed with biologicals. They do not exhibit the degree of eradicant activity shown by postharvest chemicals. That is, chemical applications generally control infections that originate as much as 24 hours before treatment. With biologicals, that time is only a matter of a few hours. Biologicals do not suppress sporulation of *P. digitatum* and control soilage, such as obtained with applications of imazalil. In our trials to date, we have found that the biologicals do not usually provide as effective or consistent control of green mold as that achieved with chemicals, and they do not provide control of stem-end rot.

Registration of biological control products represents an additional tool for citrus decay control. How they may best be used by the industry--in combination with chemicals, in efforts to control fungicide resistance, and/or in applications for postharvest chemical-free fruit, are matters that will be judged through further experimentation and commercial evaluation.

SANITATION IN THE PACKINGHOUSE FOR CITRUS DECAY CONTROL

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Sanitation of the packinghouse is one of the most important and least expensive decay control practices associated with citrus fruit handling that should receive close attention in packinghouse management practices. Effective packinghouse sanitation provides additional insurance that quality fresh fruit will be consistently delivered to the buyer and consumer from one shipment to the next.

Sanitation is directed towards reducing the inoculum of decay fungi that can accumulate and proliferate in the packinghouse environment. These fungi are *Penicillium digitatum*, *Geotrichum candidum*, and *Phytophthora citrophthora*, the ones that cause green mold, sour rot, and brown rot, respectively. Complete eradication is not usually achievable, and is not necessary to obtain a significant reduction in decay, since a certain amount of inoculum is required at the infection site to induce disease. For example, controlled studies have shown that more than one green mold spore is usually required in an injury to produce a lesion. As the spore number is increased, the probability that infection will develop is greatly enhanced. Sanitation practices that maintain inoculum at low levels will greatly reduce the chances that successful infections will occur.

Inoculum of these three fungi can accumulate in any type of recirculated or containerized water source such as truck bin drenchers or soak or drench tanks. Spores of *Phytophthora* can be produced in water when the fungus grows on citrus fruit debris and sporulates. Green mold inoculum normally accumulates from airborne spores produced on moldy fruit. Sour rot inoculum is present in dirt and is produced by infected fruit that contain masses of spores and mycelium. The pallets, degreening and storage rooms, and packinghouse line are contaminated mostly by green mold and sour rot. Green mold contamination results from airborne spores and contact with infected fruit. Sour rot contamination occurs from soil and contact with infected soft and mushy fruit that commonly disintegrate as they pass over the washer or waxer brushes. Degreening and storage rooms are contaminated primarily by airborne green mold spores that originate from sporulating mycelium of the fungus on infected fruit.

We presently have a choice of three compounds for sanitizing purposes. These are hot water (at least 160°F), chlorine, and quaternary ammonium (quats). If steam-water mixing systems are used, the temperature of the water must be verified since steam vapor may be observed at lower than the 160°F temperature. Chlorine is labeled for application to equipment and to fruit, and quaternary ammonium is only approved for application to equipment. Chlorine is less expensive than quaternary ammonium, but it is corrosive to metal and can weaken wood with extended use because of its delignifying activity. Quats are by nature wetting agents, and thus have built-in detergency properties. They are effective penetrants of porous surfaces, non-corrosive, except for to aluminum and electronics (such as controls of electronic sizers) and more stable in the presence of organic matter than chlorine. Since chlorine is rapidly inactivated by organic matter, it must be continually metered into the water during use in drenchers or soak tanks to maintain free available chlorine at a minimum of 50 ppm. Activity of chlorine is dependent upon the presence of hypochlorous acid (HOCl), which is controlled by pH. Hypochlorous acid is more biocidal than the hypochlorite ion (-OCl); it is 50 to 80 times more active, and it predominates in solutions at pH ranges of 6.5 to 7.5. Therefore, solutions of chlorine should be maintained near pH 7.0.

Penicillium digitatum is the only decay pathogen that is disseminated by air currents in the packinghouse. Because of this nature, large populations of spores produced by sporulating mycelium on infected fruit can be present in the packinghouse facilities. The highest spore counts in a packinghouse are usually present at the dump where they are released when degreened fruit are dumped on the line, and in storage rooms where the fungus has ample time to sporulate on infected fruit. A significant reduction in decay has been noted when the dump and primary grade areas, where decayed fruit are first encountered, are spatially separated from the rest of the packingline and loading facilities. Exhaust fans at a totally enclosed dump can be used to remove spores from the packinghouse, and the packingline can be designed so prevailing wind currents do not spread spores from the degreening and dump areas to the rest of the line. A sanitizing spray of chlorine can be applied to spore-contaminated fruit immediately after dumping to reduce the inoculum load. Exposures for 2 minutes are much more effective than short durations of only 15 seconds.

SANITIZING PROCEDURES

1. Monitor harvesting practices to assure decayed and split fruit are not placed in pallet bins.

2. Dirt and debris should be removed from the pallets and they should be sanitized with chlorine or quat after dumping before returning the pallet to the grove for another picking.

3. All decayed fruit should be removed from the line after the dump to minimize contamination of the packingline.

4. The first part of the packing line from the dump through the waxer brushes should be cleaned daily. Thorough washing with ambient water and detergent alone will remove a significant amount of inoculum, but additional sanitation can be achieved by following the washing with a spray of sanitizer, particularly during periods of high inoculum pressure (visible decayed fruit in pallets and on the line). Keep in mind that chlorine and quat are much more effective when applied after removal of dirt by washing.

5. Applications of SOPP during washing help to control decay by direct fungicidal action and by keeping the washer brushes in a sanitary condition.

6. All fruit and trash should be removed daily to prevent green mold from sporulating on waste fruit.

7. Service companies should routinely sample packinghouse atmospheres to monitor the level of the green mold spore population and its degree of fungicide resistance.

8. Degreening and storage rooms should be washed and sanitized, particularly when significant numbers of fruit are observed with green mold sporulating on the surface. Sanitizers can be applied in rooms with misting equipment (humidification systems, sprayers, etc.).

9. Never repack cartons with green mold fruit in the packinghouse. Green mold spores are disseminated into the atmosphere by the repacking process, and frequently these spores possess resistance to the postharvest fungicides.

10. All fungicides and sanitizers must be applied at labeled rates.

AVAILABLE PUBLICATIONS

Available from Dr. W. Wardowski, CREC, 700 Experiment Station Road, Lake Alfred, Florida 33850

Market Diseases and Blemishes of Florida Citrus Fruit, by A. A. McCornack and G. E. Brown. 1991. Florida Department of Citrus.

Postharvest Decay Control Recommendations for Florida Citrus Fruit, by W. F. Wardowski and G. E. Brown. 1993. Circular 359-A. University of Florida, IFAS, Florida Cooperative Extension Service.