Evaluation of sanitation practices and sanitizing agents for managing soilborne pathogens

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Root diseases such as Macrophomina root rot, Fusarium wilt, Verticillium wilt, and Phytophthora crown/root rot are major threats to California strawberry production because they reduce plant vigor, decrease yield, and increase management costs. One important way they spread is through the movement of contaminated soil on tractors, equipment, vehicles, and workers' footwear. As a result, sanitation is an important management practice for limiting the movement of soilborne pathogens between fields. This project evaluated sanitation practices using three complementary approaches: an industry survey, field observations, and laboratory experiments. A survey of strawberry industry stakeholders in the Santa Maria district, representing approximately 93% of the district's strawberry acreage, found that most respondents considered sanitation to be an effective strategy for reducing pathogen spread. However, the time and cost required to implement sanitation consistently were identified as the primary barriers. Pressure washing was the most commonly reported method for removing soil from tractors and tillage equipment (Fig. 1). A field evaluation examined where soil accumulates on vehicles and the time required for cleaning under commercial conditions. Soil was most commonly retained in wheel wells, undercarriages, and bumpers (Fig. 2). High-pressure water with 15° angle effectively removed dried and compacted soil, and approximately 15 minutes were required to remove all visible soil from a heavily contaminated truck.

Laboratory assays evaluated the efficacy of the following labeled rates of sanitizing agents against pathogen isolates from different strawberry districts: Agrowlyte® (hypochlorous acid, 0.05%), bleach (sodium hypochlorite, 8.25%), ethanol (ethyl alcohol, 70%), Lysol® (o-Benzyl-p-chorophenol, 5.5%), MG 4-Quat® (quaternary ammonia compounds, <5.0%), Oxidate® (hydrogen peroxide, 27.1%), Physan 20® (quaternary ammonia compounds, 20%), Virkon™ S® (potassium peroxymonosulfate, 21.41%), and a control treatment using sterile DI water. Responses of *Macrophomina phaseolina* varied among isolates, although ethanol consistently provided the greatest reduction in pathogen growth, with bleach and Lysol also providing moderate suppression (Fig. 3). For *Fusarium oxysporum* f. sp. *fragariae* race 1, all treatments with the exception of Agrowlyte® showed complete inhibition. Growth inhibition of *Verticillium dahliae* was most consistent with bleach, ethanol, Lysol®, and Physan 20® treatments, although response varied across isolates (Fig. 4). A preliminary trial was also conducted to assess the efficacy of bleach and ethanol against oospores of *Phytophthora cactorum,* which demonstrated complete growth inhibition. Together, these findings demonstrate that thorough vehicle soil removal, combined with appropriate sanitizing agents, can provide a practical approach for reducing the spread of soilborne pathogens and improving disease management in strawberry production systems.

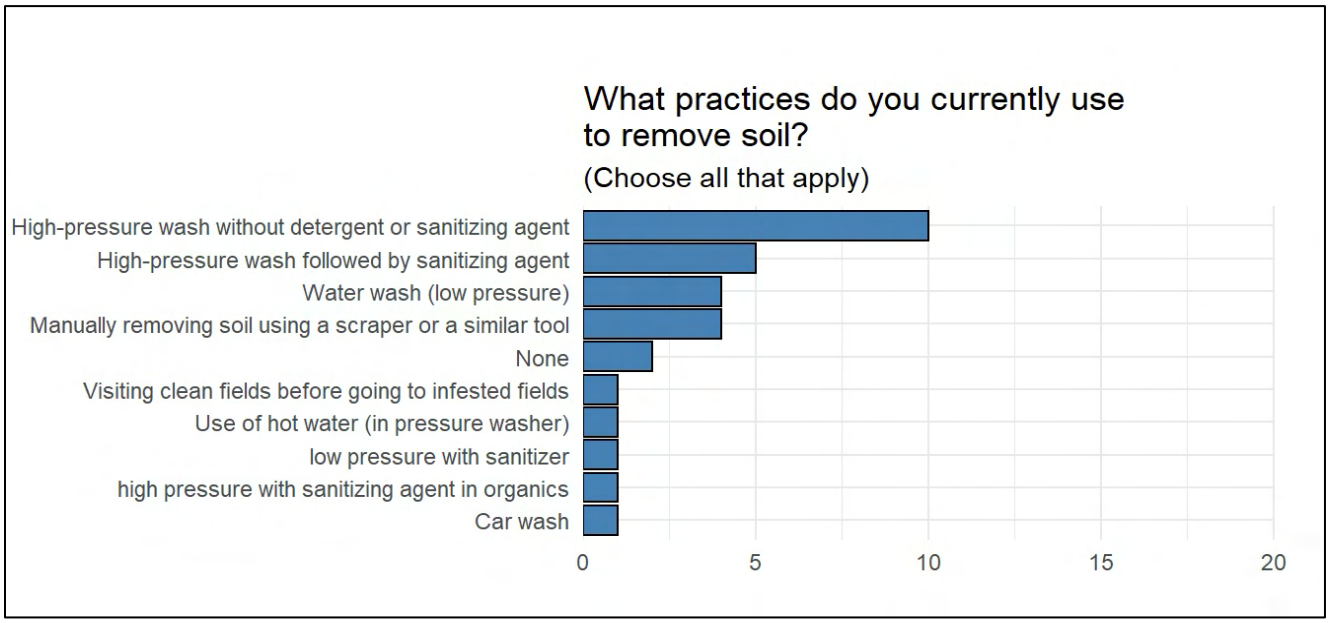


Figure 1. Current physical and chemical methods used by surveyed participants to remove soil from agricultural equipment and tools. Horizontal bars indicate the frequency of selection for each method.



Figure 2. Visual evidence of soil and mud accumulation on a Ford F-150 pickup truck following agricultural operations. Panels highlight key high-risk vectors for cross-ranch pathogen transport: front wheel well and tire tread (A), rear bumper and tire tread (B), interior liner of the rear wheel well (C), and rear bumper and exhaust (D).

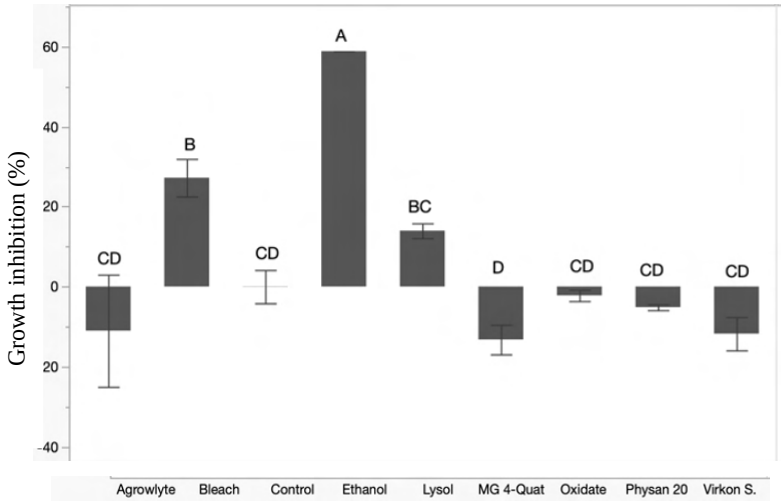


Figure 3. Mean percent inhibition of mycelial growth of *Macrophomina phaseolina* isolate Mp 96, following exposure to eight sanitizer and disinfectant treatments. Error bars represent ±SEM. Bars sharing the same letter are not significantly different (Tukey's HSD, α = 0.05).

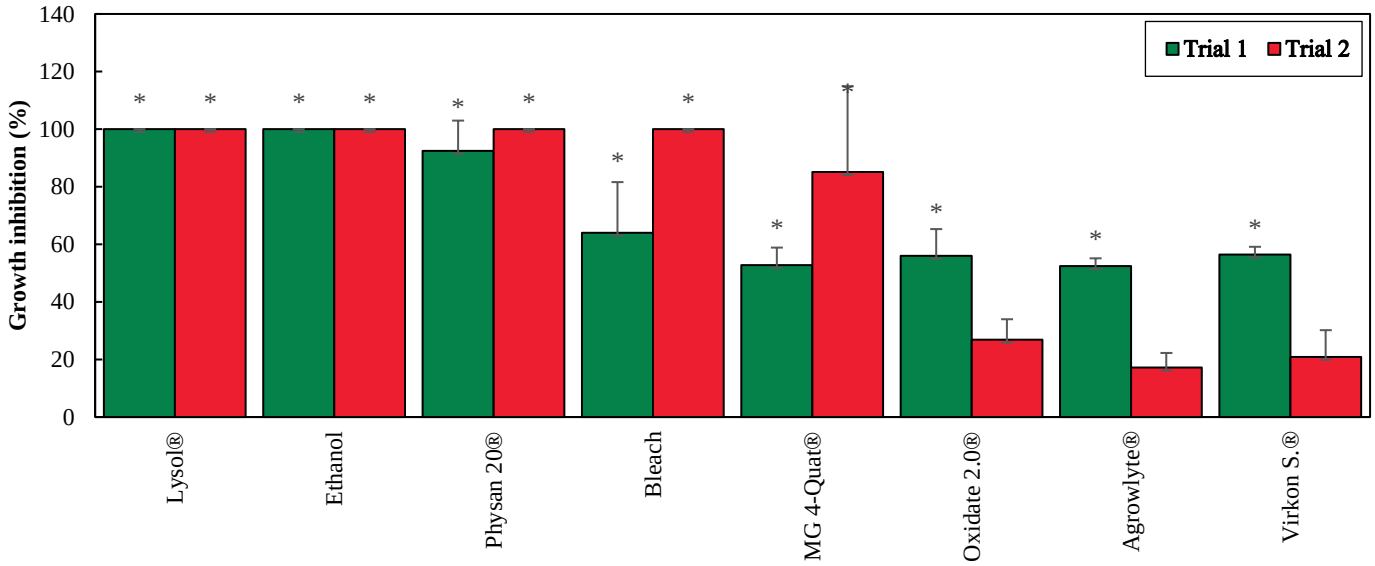


Figure 4. Percent growth inhibition of a *Verticillium dahliae* isolate from San Luis Obispo relative to the untreated control for each sanitizing treatment. Error bars represent the standard deviation. Asterisks indicate the mean colony diameter is statistically different from the control at $P < 0.05$ based on Dunnett's test.