

Investigating Treatments for the Management of Macrophomina on California's Central Coast



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SUMMARY

Macrophomina crown rot is a serious concern for the California strawberry industry, especially as fumigation with methyl bromide is no longer possible. The continued establishment and maintenance of multiple field locations in different production regions for conducting *Macrophomina* trials is crucial for developing long-term sustainable disease management recommendations. The objectives of our research were to evaluate multiple potential disease management tactics involving host resistance screening and drip applied fungicides or biological products. In order to evaluate strawberry germplasm for resistance to *Macrophomina* crown rot, a total of 90 cultivars and elite selections chosen from both public and private breeding programs were planted in an artificially inoculated field during the 2016-2017 growing season. Crown rot severity and plant mortality were assessed over time in both inoculated and non-inoculated plots. Genotype susceptibility varied widely from 1 to 93% mortality. To evaluate several fungicides via chemigation, a total of nine products were applied as transplant dips and/or via drip irrigation at bi-weekly intervals for up to six applications. Treatment effects were measured by recording yield and plant mortality. No significant differences among treatments were detected. This proposal directly addresses these high priority research areas for the California coastal region: (1) farming without fumigants; (2) control of soilborne diseases; and (5) breeding for disease resistance.

INTRODUCTION

Crown rot, caused by the soilborne fungus *Macrophomina phaseolina*, is a damaging pathogen that has become established in California strawberry production areas (Koike et al., 2016). After introduction into a field, the pathogen can cause extensive plant decline and mortality. *Macrophomina phaseolina* can be difficult to manage due to its persistence in soil and crop residues as microsclerotia (Islam et al., 2012). Alternative methods, such as the use of drip-applied fungicides and host resistance, will be critical tools for managing this disease in the post-methyl bromide era. The objectives of our research were to evaluate multiple potential disease management tactics involving host resistance screening and drip applied fungicides or biological products.

MATERIALS AND METHODS

Host Resistance Screening. A replicated field trial was conducted to evaluate 90 cultivars and elite selections for resistance to *Macrophomina* crown rot. Strawberry germplasm was selected from six public and private breeding programs. The trial was conducted during the 2016-2017 growing season and consisted of 20-plant plots replicated four times, with a fifth non-inoculated replicate. On October 17, 2016, bare-root strawberry transplants were set in field 35b on the Cal Poly San Luis Obispo campus. Two weeks later, each plant in the inoculated plots received 5 grams of cornmeal-sand inoculum (Mihail, 1992) colonized with three isolates of locally sourced *M. phaseolina* placed at the crown-root interface. To evaluate the germplasm, disease incidence was determined by counting the number of dead plants ("plant mortality") in each plot. A plant was considered dead when 100% of the foliage was brown and dried up. Plant mortality was assessed every four weeks, then every two weeks once symptoms were observed; the last assessment occurred on July 24, 2017. Presence of the pathogen in symptomatic plants was confirmed by plating pieces of the internal crown tissue on acidified potato dextrose agar.

Chemigation Trial. Bare-root transplants of the day-neutral cultivar 'San Andreas' were set in the field on December 5, 2016 and inoculated two weeks after planting with 5 grams of cornmeal-sand inoculum (Mihail, 1992) colonized with three isolates of locally sourced *M. phaseolina* placed at the crown-root interface. Plots were arranged in a randomized complete block design 13.3 ft long with a 16 inch non-planted buffer at each end. Each bed consisted of four plant rows spaced 10 inches apart; plants within rows were spaced 16 inches apart. Each treatment was replicated four times. Beds were 12 inches high with two rows of Tri-Cal low-flow drip irrigation tape (0.34 gal/100 ft., 8-in. spacing between emitters) laid 1 inch below the soil surface and covered with a TIF (totally impermeable film) polyethylene mulch that was 1 mil thick, black on top and white on the reverse (Kibbutz Ginagar, Israel). Prior to planting, 160 bare root plants per treatment were immersed into 1 gal of water or dip-treatment solution, agitated for five minutes, drained and then separated into groups of 40 plants per plot. Blocks within the trial were plumbed with ¾" PVC schedule-40 laid in between the two plant rows on the left-hand side of bed with each plot having its own drip manifold equipped with a ¾" ball valve in order to apply treatments to individual plots. Treatments were injected at 10 psi using a small, battery operated pump delivering 0.64 gal/min/100 ft of drip tape. Application time proportion was similar to a chemigation set, charging drip lines and wetting soil with water for 25% of the time, followed by 50%, for treatment injection, and finished with a 25% volume flush. Each treatment took approximately 60 minutes to apply. Cumulative average yield per plot was recorded weekly from March 20 to June 19, 2017. Data were subjected to ANOVA and Tukey's HSD mean separation test and the Area Under the Disease Progress Curve (AUDPC) for plant mortality due to *Macrophomina* crown rot was calculated for each harvest using ARM version 2017.4 (Brookings, SD).

RESULTS

Host Resistance Screening. The first wilt symptoms due to infection by *M. phaseolina* were observed May 5, roughly 200 days after planting. The majority of plant mortality occurred after June 15, when air temperatures exceeded 90 F (32 C) for several days. Of the cultivars tested, a wide range of susceptibility was observed (Figure. 1). Elite selection UC-J and a 'Proprietary' variety, were the most susceptible genotypes to crown rot, with more than 90% mortality by July 24, 2017. Elite selection UC-V and two 'Proprietary' cultivars were the most tolerant genotypes to *Macrophomina* crown rot, with less than 5% mortality by July 24, 2017. The cultivar 'Radiance' was not included in the dataset, since *Phytophthora cactorum* was isolated consistently from multiple symptomatic plants in early February.

Chemigation Trial. Similar to the cultivar trial, plant mortality occurred late in the season approximately two months after the last product application. No differences were observed among treatments for the reduction of plant mortality or cumulative yield (Table 1).

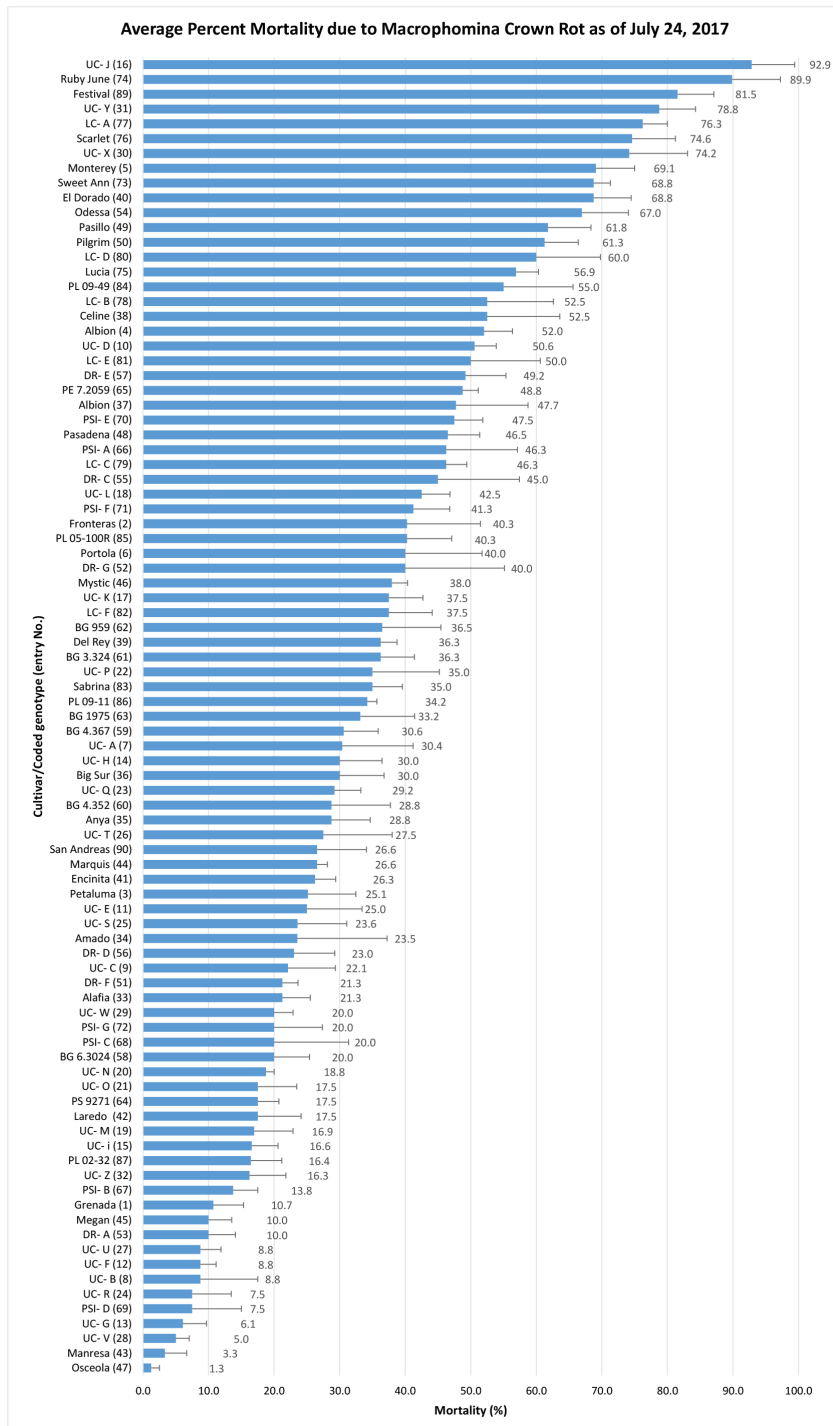


Figure 1. Average percent plant mortality due to *Macrophomina* crown rot as of July 24, 2017. Cultivars are representative of public and private breeding programs. Error bars represent the standard error of the mean. Statistical differences by pairwise comparisons are not shown.

Table 1. Treatments and results of the chemigation trial

Treatment (Dip, Drench Rate)	Sequence ^z	Yield (lb) ^y	Final Mortality (%)	AUDPC Incidence ^w
Zivion 10.34% SC (500 ppm a.i.).....	ABCDEFGF	42.8 a ^x	46.7 a	313.9 a
Velum One 41% SC (–, 6.5 fl oz/a).....	B	48.1 a	52.0 a	279.6 a
Pristine 38% WDG (–, 23 oz/a).....	BCDEFG	49.2 a	43.1 a	264.7 a
MBI 110 (1% v/v, 4 qt/a).....	A, BCDEFG	44.5 a	43.6 a	273.0 a
Merivon 52.52% SC (–, 11 fl oz/a).....	BCDEFG	49.8 a	41.7 a	224.7 a
Serenade Hi CFU 15% SC (0.4% v/v, –).....	A	46.5 a	43.1 a	286.8 a
Bio-Tam 4% WP (0.25 lb/gal, 2.5 lb/a).....	A, BCDEFG	43.4 a	51.6 a	282.4 a
Regalia 5 % SC (0.25% v/v, 52 fl oz/ac).....	A, BCDEFG	47.1 a	42.0 a	259.9 a
Serenade ASO 1.34% SC (2% v/v, –).....	A	44.7 a	48.1 a	286.8 a
Non-Treated	ABCDEFGF	48.6 a	41.8 a	222.4 a
Tukey's HSD		9.6	20.0	122.4

^zApplication timing sequence: A. December 5, 2016 - Dip, B. January 31, 2017, C. February 14, 2017, D. February 28, 2017, E. March 14, 2017, F. March 28, 2017, G. April 11, 2017-Drenches.

^yCumulative average yield per plot (40 plants) taken from March 20, 2017 to June 19, 2017.

^xNumbers within a column followed by the same letter are not significantly different ($\alpha=0.05$) according to Tukey's HSD simultaneous comparison of 95% confidence intervals calculated using ARM version 2017.4.

^wArea Under the Disease Progress Curve of *Macrophomina* crown rot incidence was calculated using ARM version 2017.4.

DISCUSSION

All breeding programs contained both tolerant and susceptible germplasm to *Macrophomina* crown rot. The plant response observed in this trial was in agreement with the literature (Zveibil et al., 2012) that damage due to *M. phaseolina* occurred late in the season and was exacerbated by high temperatures during the months of June and July. This cornmeal-sand inoculation method provided consistent, but not overwhelming, pressure for field evaluation of host resistance to *M. phaseolina*. Although no treatment differences were observed in the chemigation trial, increasing the treatment interval from two to four weeks, increasing the number of applications, delaying the drench application start dates, or a combination of these may improve product performance. These data can serve as both a guide to growers for managing *Macrophomina* crown rot, and for the development of new resistant cultivars for existing breeding programs.

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