Evaluation of Strawberry Genotypes for Susceptibility to Anthracnose Crown Rot

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SUMMARY

Due to the sporadic nature of anthracnose epidemics, most strawberry breeding programs place little emphasis on susceptibility of cultivars to the disease. A recent anthracnose epidemic in the 2015-2016 season highlighted this fact. In this experiment, 59 genotypes from five breeding programs were screened for susceptibility to anthracnose. Results showed a wide range of susceptibility among all genotypes and for genotypes within each breeding program (7.5 to 100% plant mortality; average = 58.0%). Most plant mortality occurred between three and ten weeks after planting. These results show that high levels of anthracnose resistance exist in currently available cultivars and elite breeding lines. This information can be used by growers and breeding programs to help manage anthracnose through host plant resistance. This work addresses three of the six high priority research areas that the California Strawberry Commission has established: (2) Farming without fumigants; (3) Management of soilborne disease; and (6) Breeding for disease resistance.

Introduction

During the 2015-2016 and 2002-2003 strawberry seasons, the California strawberry industry experienced anthracnose epidemics. The Santa Maria and Oxnard areas were severely affected and experienced great economic losses in their summer plantings (Gaines, 2005). In response to the epidemic, the industry increased field scouting, improved nursery sanitation measures, reduced overhead irrigation and modified fungicide spray programs. *Colletotrichum acutatum*, the causal agent of anthracnose, is a cosmopolitan fungus that causes important economic losses to a broad range of crops. In California and Europe, *C. acutatum* is the primary source of infection on strawberry plants and fruit (Garrido et al., 2016; Peres et al., 2005). All parts of the strawberry plant are susceptible, causing necrosis and blight symptoms on tissues such as leaves, petioles, flowers or even roots, resulting in plant mortality of up to 50% in well managed fields (Peres et al., 2005; Turechek et al., 2006; Rahman et al., 2015). A common anthracnose symptom is lesions on ripe fruit (Freeman et al., 1998; Peres et al., 2010) which often contain orange-salmon or black sunken lesions that make the fruit unmarketable (Rahman et al., 2013).

In strawberries, most research on *C. acutatum* focuses on the differentiation between species of the pathogen, population dynamics and chemical control (Curry et al., 2002; Daugovish and Gubler, 2006; Eastburn and Gubler, 1990; Peres et al., 2005). Compared to other soilborne pathogens affecting strawberries, *C. acutatum* is a poor soil inhabitant, surviving in the soil for nine to 11 months (Eastburn and Gubler, 1990). Due to the relatively short persistence of *C. acutatum* in soil, the best way to manage anthracnose is through preventative measures that ensure disease-free planting stock. The primary form of infection for *C. acutatum* in a grower's field is through the introduction of the disease on transplants from the nursery (Delp and Milholland, 1980; Peres et al., 2005). The disease is easily overlooked due to quiescent and asymptomatic infections that make it difficult for nurseries to detect ¬the pathogen on transplants. When *C. acutatum* is introduced into a fruit grower's field, it easily spreads through splashing water from overhead irrigation or rain (Madden et al., 1992; Yang et al., 1992).

Another means of managing anthracnose is through the use of host plant resistance. Historically, breeding programs have not emphasized resistance to anthracnose. Thus, there is insufficient information about the susceptibility to anthracnose in currently used cultivars. In this study we assessed the susceptibility of a total of 105 strawberry cultivars and elite breeding lines that were tested over two years (2018 and 2019). A total of 76 strawberry cultivars and elite breeding lines/selections were included in the field evaluation for year one of the trial. For year two, 59 cultivars and elite breeding lines were included. Thirty of the 105 strawberry cultivars and elite breeding lines were tested both years. Results shown below are from year two (2019-2020) data and from the 30 cultivars that were tested both years.

Materials and Methods

A field trial was established in the 2019-2020 season at Cal Poly to evaluate 59 strawberry genotypes for susceptibility to anthracnose caused by *C. acutatum*. Strawberry genotypes were selected from five breeding programs: University of California Davis, University of Florida, Plant Sciences, Inc., Lassen Canyon Nursery, Inc., and Driscoll's. Bare-root transplants were set in the field on October 23, 2019. Three local anthracnose isolates (CA-1, CA-15 and CA-140) were used to make a spore suspension containing 1 × 106 conidia/ml. Immediately prior to planting, transplants were inoculated by agitating 10 bare-root transplants in 100 ml of this spore suspension for 1 minute. The experimental design was a completely randomized block design with four inoculated replicates and one non-inoculated plot per genotype. Each plot consisted of ten plants. Plant mortality assessments began when the first disease symptoms were observed and continued at weekly intervals until April 29, 2020. Plant mortality was determined by counting the number of dead plants in each plot. A plant was considered dead when it was 100% percent necrotic. The experiment was conducted at field 25, block 8 of the Cal Poly Horticultural Crops farm on the Cal Poly San Luis Obispo campus located in San Luis Obispo, California (35°18'14.2"N 120°40'30.1"W).

Results

The first disease symptoms were necrosis and wilt and were first detected at three weeks after planting. The majority of plant mortality occurred by January 1, 2020, 63 days after planting when plants were still young. At this time, 80.6% of the total mortality occurred. Average plant mortality across all 59 genotypes was 58.0%. A wide range of susceptibility was observed among all genotypes and within each breeding program (Figures 1 and 2). 'Monterey', 'Warrior' 'UC-9' and 'UC-5' are genotypes that were highly susceptible, showing 100% mortality. Elite breeding lines 'bg 9.3128', 'bg 4.367' and 'bg 4.352' were resistant with 7.5% mortality.

A total of 30 cultivars were tested in both years of the experiment (Figure 3). Breeding programs from Plant Sciences, Inc., Driscoll's, University of California, Davis, University of Florida and Planasa had, 8, 7, 7, 6 and 2 genotypes common to both years, respectively. Looking at all genotypes common to both years, 21 cultivars had a difference in final plant mortality at or below 20% between years. 'Del Rey' and 'Ruby June' differed dramatically (>50% mortality) between years. In year one, 'Ruby June' was resistant with 25.0% mortality while 'Del Rey' was moderately susceptible with 66.7% mortality. In year two, 'Ruby June' was susceptible with 80.0% mortality while 'Del Rey' was resistant with 10.0% mortality.

Discussion

All five breeding programs contained genotypes that are resistant and susceptible to anthracnose. The methods used to inoculate and grow plants produced high levels of disease, allowing for the determination of anthracnose susceptibility in a large number of strawberry genotypes. While some genotypes died within three to four weeks after transplanting, others took four to five months, but still reached high levels of mortality. Other cultivars remained resistant through the entire season.

With the availability of a wide range of susceptibility to anthracnose, growers can use this information to select cultivars with an appropriate level of resistance. Researchers can use this information to design experiments where anthracnose susceptibility is key. Understanding host resistance can allow for nurseries to identify susceptible and resistant cultivars to anthracnose allowing them to modify irrigation practices and controls if suspected of having anthracnose in the field. Breeding programs can also benefit from these results by incorporating them into breeding decisions regarding resistance to anthracnose. By doing this categorization, breeding programs can market current cultivars and guide breeding efforts for maximum benefits. Since we saw that there were some cultivars that were stunted compared to their respective non-inoculated plots (no data presented), for future research, plant measurements between the non-inoculated and inoculated should be taken to better address the disease occurrence and presence (Salinas et al., *unpublished*).

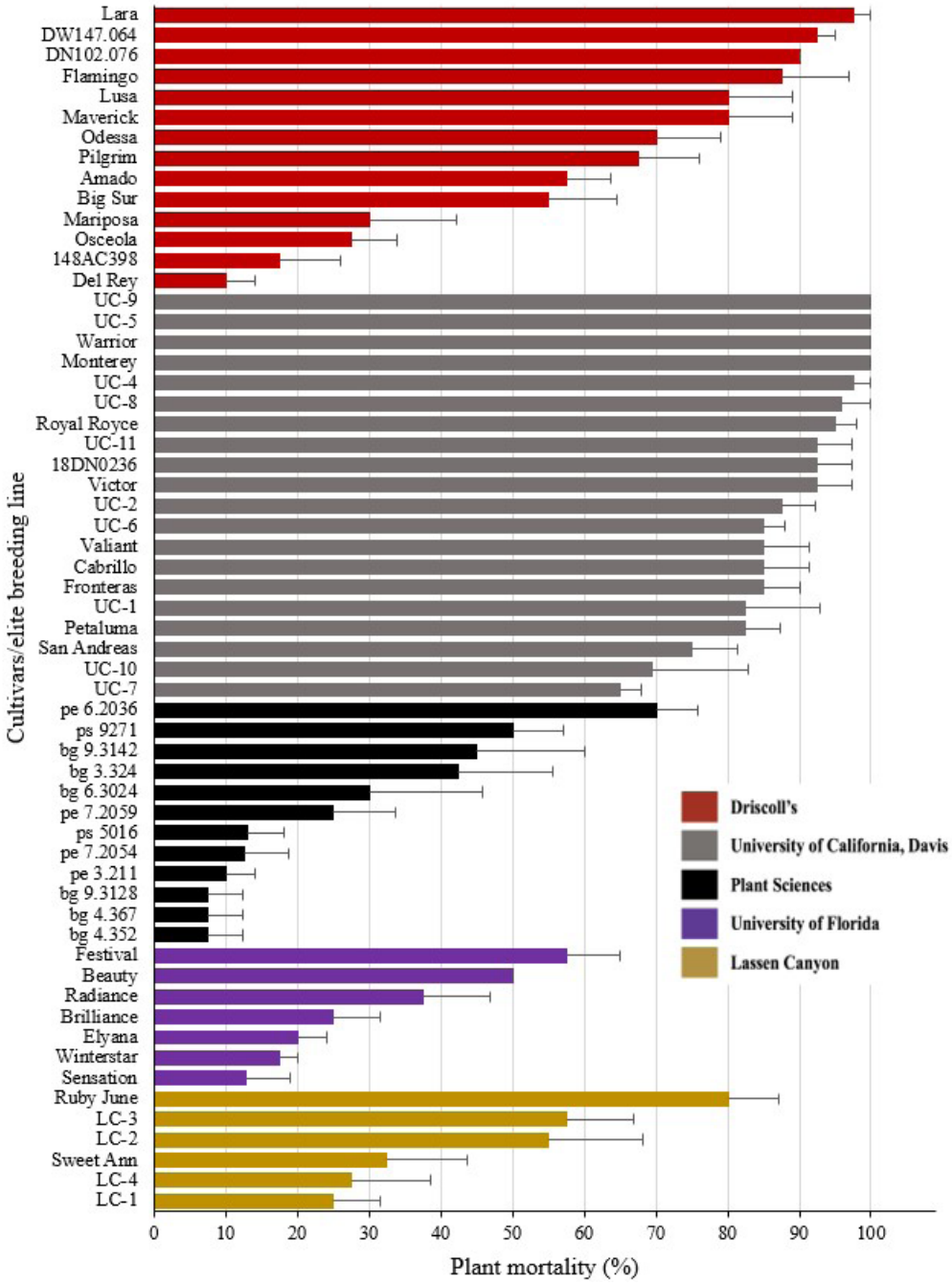

Figure 1. Average percent mortality due to anthracnose as of April 29, 2020, 188 days after inoculation, sorted from highest to lowest within breeding programs. Average values are derived from percent mortality of four replicate plots. Error bars are standard error of the mean.

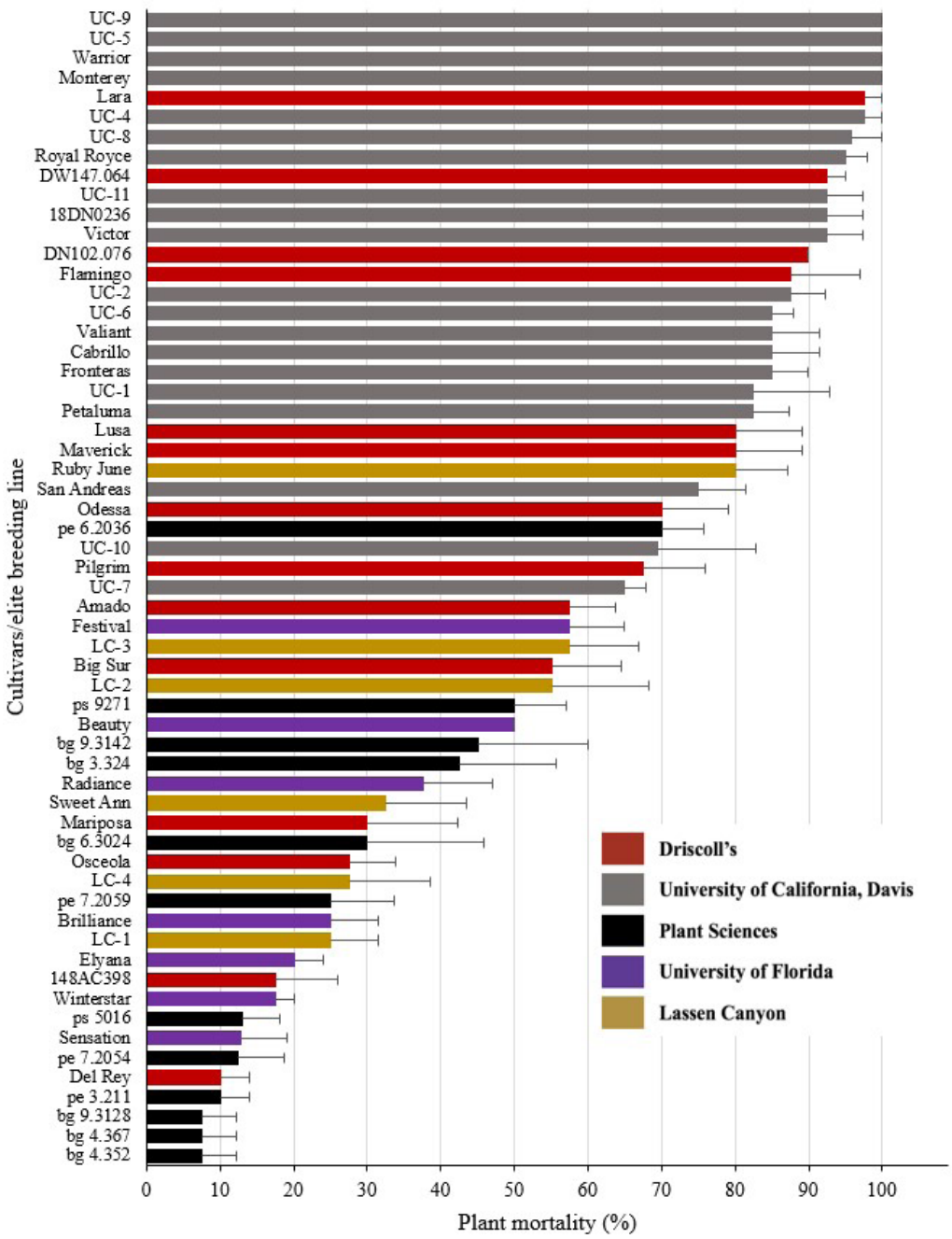

Figure 2. Average percent mortality due to anthracnose as of April 29, 2020, 188 days after inoculation, sorted from highest to lowest. Average values are derived from percent mortality of four replicate plots. Error bars are standard error of the mean.

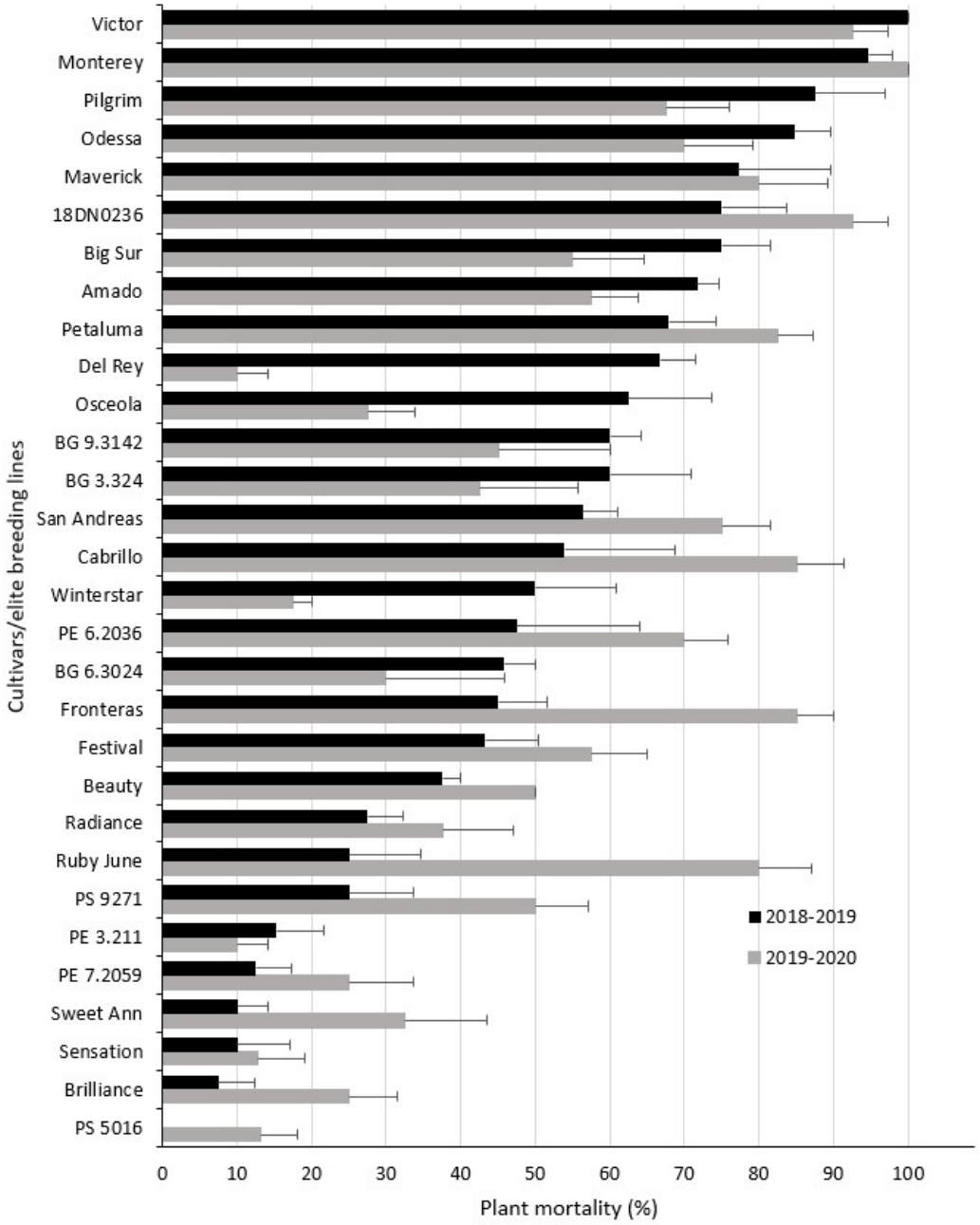

Figure 3. Two-year average percent mortality due to anthracnose as of April 29, 2019 and April 29, 2020 (184 and 188 days after inoculation, respectively). Cultivars and elite breeding lines are sorted from highest to lowest based on results in year one (2018-2019). Average values are derived from percent mortality of four replicate plots. Error bars are standard error of the mean.

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