Effects of Irrigation, Planting Depth, and Fungicide Seed Treatment on Sugarbeet Stand Establishment

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ABSTRACT

Effects of irrigation, planting depth, and fungicide seed treatment on seedling disease and stand quality in sugarbeet were evaluated in two field experiments arranged as three-factor randomized complete block designs. Stand establishment was improved greatly by planting into moisture compared to a post-plant irrigation, shallow compared to deep planting depth, and a fungicide seed treatment. Soil population densities of *Pythium* spp. (primarily *P. ultimum*) were high in both trials. A fungicide seed treatment with metalaxyl and thiram combined with shallow planting (2 cm) and pre- plant furrow irrigation was optimal for rapid and uniform seed germination and stand establishment.

Additional Key Words: *Beta vulgaris,* stand quality, damping-off, *Pythium* spp.

Poor stand establishment is one of the limiting factors in sugarbeet *(Beta vulgaris* L.) production in late spring in northern California. An unfavorable climate, coupled with soilborne diseases, often causes reduced seed germination and seedling emergence. In California, several soilborne plant pathogens (e.g., *Pythium* spp., *Rhizoctonia solani* Kühn, *Aphanomyces cochlioides* Drechs.) cause pre-emergence or post-emergence damping-off of sugarbeets (Leach, 1986). Our objective was to evaluate the effect of irrigation timing, planting depth, and a fungicide seed treatment on seedling disease and stand establishment of sugarbeet.

MATERIALS AND METHODS

Experimental design. Two experiments were conducted in 1993 at the University of California-Davis campus on Yolo silty clay loam soil. Treatments were arranged in a three-factor randomized complete block design, with a factorial arrangement. Treatments included pre- or post-plant irrigation, two planting depths, and with or without a fungicide seed treatment. In the irrigation treatment, half of the plots were furrow-irrigated 4 - 5 days before planting, whereas remaining plots were furrow-irrigated immediately after planting. Planting depths were at 4 cm (deep) or 2 cm (shallow). Within each irrigation treatment, half of the seeds were treated commercially with metalaxyl 25 WP (0.3 g a.i./kg seeds) and thiram 50 WP (2.5 g a.i./kg seeds), whereas the remaining seeds were nontreated.

Each plot consisted of two rows, with a two-row buffer between irrigated strips. Plots were 7.6 m long with a 3 m alley between plots. Two hundred seeds (Beta 4823, medium size, from Betaseed, Inc., Shakopee, MN) were planted in each row with a John Deere 71 Flex planter (John Deere & Co., Moline, IL) at a rate of 26 seeds per meter. Seedling stand was determined approximately 1 wk after seedling emergence when seedlings had their first true leaves. The number of seedlings in each row was counted, and the average seedling count of the two rows in each plot was used for statistical calculations. Treatments were replicated four times.

***Pythium* and *Rhizoctonia* population assays.** To measure *Pythium* and *Rhizoctonia* population densities, four soil cores (2 cm diameter x 20 cm deep) were collected from each plot (two cores per row) immediately after planting. Soil population densities of *Pythium* spp. were determined by soil dilution plating onto semiselective agar (Liddell, 1989). After suspending 10 g of soil in 50 ml sterile water, 10 ml of the suspension was pipetted into 40 ml of 0.2% water agar. One ml of the final solution then was pipetted onto each of three

9.0 cm-diameter petri dishes containing modified PARP medium (0.4 ml pimaricin, 0.25 g ampicillin, 0.01 g rifampicin, 0.025 g PCNB, and 17 g corn meal agar in 1 L of water). After the dishes were incubated at 25°C for 24 h, the number of colony-forming units (cfu) of fast growing *Pythium* spp. per gram of dry soil was determined. *Pythium* species were identified according to Plaats-Niterink (1981). Soil water content was determined by placing 10-g soil samples in a 90° C oven for 72 h.

A soil sieving method was used to obtain the population density of *R. solani* in the soil (Weinhold,1977). A 150-g soil sample was passed through a No. 45 (0.35-mm-mesh) sieve under running tap water to collect all organic debris. The debris was resuspended and then distributed onto five to eight Whatman No. 1 filter papers by filtering with a Buchner filter apparatus. Each filter paper was inverted and placed in a petri dish containing molten (40 -50°C) 1% water agar. Petri dishes were agitated to wash off the organic matter from the filter paper, and the filter paper then was removed. After incubating the dishes for 20 - 24 h at 25°C, *Rhizoctonia*-like colonies were counted and transferred to potato-dextrose agar for positive identification.

Data analysis. Seedling survival, soil moisture content, and *Pythium* and *Rhizoctonia* soil population densities from both experiments were analyzed by analysis of variance, least significant difference (LSD) mean separation, orthogonal contrasts for class comparisions, and Bartlett's test for homogeneity of variances with the Statistical Analysis System 6.04 (SAS Institute, Cary, NC).

RESULTS

Timing of irrigation, planting depth, and fungicide. Stand establishment was significantly improved ($P < 0.01$) when seeds were treated with the fungicides and planted into moisture at a shallow depth (Fig. 1). Because variances between trials were homogeneous, and there were no significant differences between trials, results of the two trials were combined. Shallow placement of the seeds increased stands by 59% compared to the deep planting, and the use of treated seeds increased stand counts by 58%. Pre-plant irrigation also increased seedling survival by 23% compared to post-plant irrigation. There were no significant interactions among irrigation, planting depth, and seed treatment.

Fungicide seed treatment significantly ($P < 0.01$) improved stands by 73 - 114% when seeds were planted deep (4 cm) and by 17 - 40% when planted shallow (2 cm) (Fig. 2). The timing of irrigation did not significantly affect stands planted with nontreated seeds, even though the pre-plant irrigation slightly increased seedling survival (12% in

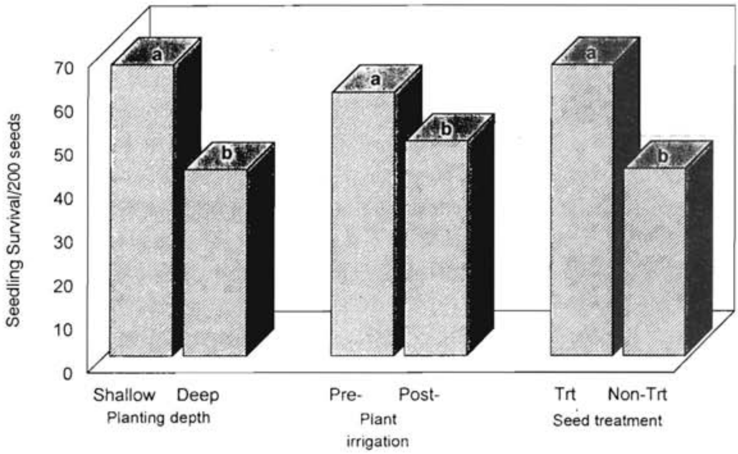

Figure 1. Overall effects of irrigation, planting depth, and fungicide seed treatment on stand quality in sugarbeet. Means within each pair of columns are significantly different *($P < 0.01$)* according to LSD mean separation.

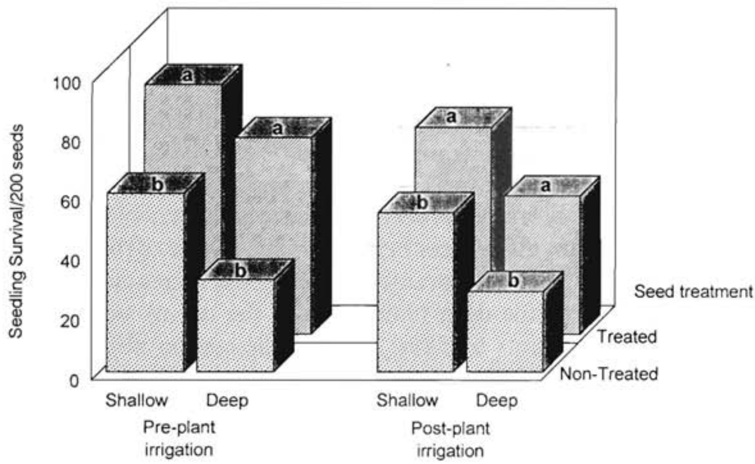

Figure 2. Effects of irrigation and planting depth on fungicide seed treatment in sugarbeet establishment. Means within columns are significantly different *($P < 0.01$)* according to LSD mean separation.

shallow planting, and 15% in deep planting). When fungicide-treated seeds were planted deep, pre-plant irrigation increased stands by 38% compared to post-irrigation treatment. When treated seeds were planted shallow, pre-plant irrigation also increased stands 21% compared to post-plant irrigation.

Planting depths affected seedling stands regardless of irrigation treatment or fungicide seed treatment (Fig.2). The relative benefit of planting shallow was greater with nontreated seed than with treated seed. Shallow planting increased stand counts 94 - 99% in nontreated seeds, and 27 - 50% in treated seeds. There were no significant differences in stand counts between nontreated seeds planted shallow and treated seeds planted deep. Soil water content at planting was 14.9% when plots were pre-irrigated and 8.0% before irrigation.

***Pythium* and *Rhizoctonia* population densities.** Soil population densities of *Pythium* spp. were high in both trials. In the first trial, population densities ranged from 286 to 398 cfu/g soil. In the second trial, soil population densities ranged from 144 to 239 cfu/g soil. *Pythium ultimum* was the predominant species of *Pythium* isolated, representing 70% of all *Pythium* species isolated. *Pythium oligandrum* and *P. irregulare* occasionally were isolated. Population densities of *R. solani* were low, ranging from 0 to 0.4 cfu/100 g soil in the first trial and 0 to 1.2 cfu/100 g soil in the second trial.

Irrigation timing significantly affected *Pythium* densities. In the first trial, pre-plant irrigation increased *Pythium* population density from 314 to 371 cfu/g soil. In the second trial, *Pythium* population density was increased from 173 to 210 cfu/g soil.

DISCUSSION

Rapid and uniform germination of seeds is an important prerequisite for obtaining satisfactory stands in sugarbeet. With the exception of seed quality, seed germination is dependent mostly upon soil climatic factors. Of the soil factors known to affect germination and emergence of sugarbeet seedlings, soil moisture is one of the most important factors (Hills, et al., 1985). As early as the 1950's, researchers demonstrated that the soil moisture requirement for satisfactory seedling emergence of sugarbeet in sandy loam soil was 12 - 21% (Hunter, et al., 1950; Stout, et al., 1956). Others (K. J. Fornstorm, H. W. Hough, and J. Partridge, unpublished data) also indicated that there were significant positive linear correlations between seedling emergence of sugarbeet and low soil moisture content. We demonstrated that pre-plant irrigation improved stands by 23% when compared to post-plant irrigation (Fig. 1). Apparently, pre-plant irrigation met the water demands for seed germination and emergence, and minimized seedling disease. In contrast, post-plant irrigation resulted in very high soil moisture and infection by soilborne plant pathogens like *Pythium* spp. The high soil moisture provided a suitable environment for rapid growth of *Pythium* spp. (Hendrix, et al., 1973). Post-plant irrigation also may reduce soil temperature (Robinson, et al., 1966), which slows seed germination and provides an environment conducive to *Pythium* spp. Another potential problem with post-irrigation is the tendency of some soil types to form a hard crust upon drying, which makes it more difficult for tender seedlings to emerge.

In our study, planting depth had a stronger impact on stand quality than timing of irrigation. Shallow planting (2 cm) increased stands by 59% when compared to the deep planting (4 cm) (Fig. 1). This result was consistent with the report by Wilson, et al.(1990) who found that more sugarbeet seedlings emerged as the depth of planting decreased from 4.5 - 1.6 cm. Deeper planting may slow plant emergence, thereby, predisposing the seedlings to soilborne pathogens. Moreover, seeds planted deep must consume more energy to emerge than when planted shallow.

Although the relationship between *Pythium* population density in naturally infested soil and incidence of seedling disease under field conditions is unknown (Stanghellini, 1974), reduced stands in the field (below 45% in this study) probably were attributed to severe *Pythium* infection, because sugarbeet seeds used in the study germinated normally (85%) in laboratory germination tests and *Pythium* spp. consistently were isolated from the seedlings; *P. ultimum* primarily causes pre-emergence damping-off in sugarbeet (Leach, 1986), and, in previous greenhouse tests conducted by the authors, *P. ultimum* caused 5 - 30% pre-emergence damping-off of sugarbeet at an inoculum density of only 40 - 60 cfu/g soil. Therefore, fungicide seed treatments are warranted in fields where high populations of soilborne pathogens are known to be present. Although irrigation treatment had the least effect on stand establishment, it, too, was an important factor. In many parts of the world, a pre-plant irrigation is a standard recommendation in areas where the soil profile is dry before planting (Musick, at al., 1990).

ACKNOWLEDGMENTS

We thank Dr. Gail Nishimoto for her careful assistance with field plot design and statistical analysis.

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