

SOIL PEST CONTROL IN VEGETABLES WITH STRATEGIC STEAM PLACEMENT

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Abstract. Soil disinfestation with steam is an alternative to soil fumigation, but there have been only limited attempts to scale-up steam application for field use in vegetable crops. The objective of this study was to compare vegetable productivity in lettuce, onion and spinach grown in steamed soils vs. non-steamed soils. A custom-built steam applicator equipped with a low-pressure 1,000 kg/hour steam generator was tested in strawberry at Salinas, CA during 2023. This applicator applies steam in 4 inch wide bands prior to crop planting. The objective of the steam application was to heat the soil above 70°C for at least 20 min. Soil samples were collected before and after steam application, and the crops were monitored for disease and weed control during production and yields at normal harvest. Steam controls weeds and boosts yields when disease pressure is present.

Band steam evaluation in lettuce

Introduction. Three trials were initiated in the Soledad region in 2023 with the primary objective of evaluating the impact of band steam treatment on weed control and soilborne pathogens in lettuce fields. Our focus was to assess the efficacy of the steam applicator as a potential alternative to fumigation for managing soilborne pests in lettuce fields. By examining the results obtained from these trials, we aim to gain valuable insights into the effectiveness of this approach and its potential applicability in sustainable agriculture practices.

Methods. The experimental design incorporated a randomized complete block design (RCBD) comprising both a band steam treatment and a no steam control group across all trials. Trial details are in Table 1. The steam applicator used for the trials was built at the Keithly Williams shop at Yuma, AZ. The first weed density assessment was conducted on July 19, 2023, encompassing all beds to assess total weed presence. All three trials were conducted in commercial fields near Soledad CA.

Weed densities. Weed counts for the three lettuce trials were collected five weeks after the steam treatment and two to three weeks after planting. For each steam trial two 80 inch beds 1200 ft long received steam injections in six 4-inch wide bands aligned with where lettuce was seeded in a subsequent operation. Within each bed, two sections 30ft long were not treated with steam to serve as control treatments. Weed counts were recorded for every bed.

Statistics: Analysis of variance (ANOVA) and mean separation with least significant differences were performed using Rstudio Notebook (R Studio,

Boston, MA). ANOVA and mean separation using Fisher's Protected LSDs were performed at a significance level of $P=0.05$.

Results. In trial 1, a significant difference was found between the steam-only treatment and the control treatment, with weed densities of 36.1 and 381.5 weeds per acre, respectively ($P= .000167$). Similarly, in trial 2, a significant difference was observed between the steam and control treatments, with weed densities of 459.76 and 2743.39 weeds per acre, respectively ($P=2.47e-07$). Lastly, in trial 3 there was also a significant difference between the steam and control treatments with weed densities of 67.69 and 305.07 weeds per acre, respectively ($P=0.0102$). Lettuce yield was obtained from trial 2, but there wasn't a statistically significant difference between steam and control treatments with lettuce yields of 33.32 and 29.06 tons per acre, respectively ($P=.103$)

Table 1. Critical dates for all trials done in Soledad, CA.

| Trial/Crop | Preplant/Steam | Planting | Weed density assessments | Pre Soil Sample | Post Soil Sample |
|------------|----------------|----------|-------------------------------|-----------------|------------------|
| 1. Lettuce | 6.16.23 | 6.25.23 | 7.19.23 7.31.23 | 6.16.23 | 7.17.23 |
| 2. Lettuce | 6.30.23 | 7.5.23 | 7.19.23 7.27.23 7.31.23 | 6.29.23 | 6.30.23 |
| 3. Lettuce | 6.28.23 | 7.7.23 | 7.31.23 8.7.23 | 6.28.23 | 6.29.23 |

Table 2. Weed Density Assessment from Soledad, CA; month after steam treatment.ⁱ

| Treatments | Total weed densities | | |
|----------------|-------------------------------|--------------------------------|-------------------------------|
| | Lettuce trial 1 ⁱⁱ | Lettuce trial 2 ⁱⁱⁱ | Lettuce trial 3 ⁱⁱ |
| Steam Only | 36.10b | 459.76 b | 67.69 b |
| Control | 381.53 a | 2743.39 a | 305.07 a |
| <i>P</i> Value | .000167 * | 2.47e-07 * | 0.0102* |

ⁱMean separation by Fisher's Protected LSDs. Means followed by the same letter within columns do not differ significantly at 5% level.

ⁱⁱtwo assessments were conducted

ⁱⁱⁱthree assessments were conducted

Preliminary conclusions. During the initial weed assessment, lettuce trials 1, 2, and 3 exhibited lower weed densities with the implementation of steam

applications, and this difference was statistically significant in all three cases. Marketable yield was obtained from trial 2, but there wasn't a statistically significant difference. Nevertheless, there was lower yield observed in the control treatments than the steam applications.

Integrated steam/herbicide evaluation in bulb onion

Steam was injected into raised with a custom built steam applicator to determine if soil disinfestation with steam could be an alternative to Dacthal herbicide. Treatments included steam, Dacthal 8 pt/A, Nortron 1 pt/A all applied alone, and a second set of treatments included steam, Dacthal, and Nortron, each followed by Goaltender at 6 oz/A followed by bromoxynil at 1 pt/A. Hand weeded and weedy checks were included. Herbicides were applied in 30 GPA with a CO₂ backpack sprayer equipped with 8002 flat fan nozzles. The steam applicator was equipped with a steel bed shaper and injectors that placed 7 PSI steam 3" below the soil surface. Trial design was a RCBD and treatments were replicated 4 times.

Steam was applied June 7, 2023. Onion was seeded June 9, 2023. Dacthal and Nortron were applied June 12, 2023. Goaltender was applied July 10, 2023 and Bromoxynil was applied July 17, 2023.

Data collected were weed density counts and crop injury estimates. Data were analyzed using ARM, and mean separation utilized LSD's.

Weed control with Steam alone was as good or better than Dacthal or Nortron alone (Table 3). All of the treatments with sequential Goaltender and Bromoxynil were effective on weeds. Onion was not injured by Steam, Dacthal or Nortron. Onion injury from sequential treatments of Goaltender and Bromoxynil were comparable. Onion harvest will occur in October 2023 (Table 3).

Summary

Steam disinfestation provided better weed control than Dacthal at 8 pints/A. However more work is needed to develop a steam applicator that will be cost effective in onion.

Table 3. Weed control and crop injury assessments in bulb onion.

| Treatment | Rate/A | Shepherd's- purse | Total weeds | Phyto 3 d | Phyto 7 d |
|--|----------------------|------------------------------|------------------------|----------------------|------------------|
| | | # /100 ft ² | | 0 = safe, 100 = dead | |
| Weed free | 0 | 0 d | 0 c | 0 c | 0 b |
| Weedy | 0 | 964 a | 2785 a | 0 c | 0 b |
| Steam | 70°C | 11 d | 143 c | 0 c | 0 b |
| Steam Goaltender Bromoxynil | 70°C 6 oz 1 pt | 0 d | 71 c | 35 a | 23.8 a |
| Dacthal | 8 pt | 368 bc | 585 c | 0 c | 0 b |
| Dacthal Goaltender Bromoxynil | 8 pt 6 oz 1 pt | 50 cd | 50 c | 27.5 b | 21.3 a |
| Nortron | 1 pt | 643 ab | 1392 b | 0 c | 0 b |
| Nortron Goaltender Bromoxynil | 1 pt 6 oz 1 pt | 39 cd | 253 c | 30 ab | 22.5 a |
| LSD 0.05 | | 356 | 593 | 5.47 | 5.11 |