

# CALIFORNIA LEAFY GREENS RESEARCH PROGRAM

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## PHYSICAL PEST MANAGEMENT FOR LEAFY GREENS USING INTELLIGENT CULTIVATORS AND SOIL DISINFESTATION WITH STEAM

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### ABSTRACT

Labor use efficiency improvement is essential to the long-term viability of vegetable production. This research included two autonomous weeders, NAÏO's Dino weeder and Farmwise's Titan weeder and Stout's tractor mounted automated weeder. All these cultivators are capable of weeding around lettuce plants in the seedline. The NAÏO and Farmwise machines are controlled by an operator remotely and the Stout cultivator is guided by the tractor driver. Successful development of this technology may lead towards "teams" of these machines – for example, three autonomous weeders moving through a lettuce field, supervised by one person, could potentially do the work of a handweeding crew of 15 people. We evaluated the efficacy of these cultivators on weed control and hand weeding in lettuce as well as lettuce yields. All three autonomous cultivators-controlled weeds better than the standard cultivators in on-farm and field station trials. The cultivators appear to be safe to lettuce and did not reduce yields.

A band steam applicator from the University of Arizona was evaluated in lettuce. This device reduced weeds in the treated area, reduced hand weeding times and incidence of lettuce drop as well as increased yields.

### OBJECTIVES

1. Evaluate the weed control efficacy of automated weeders in lettuce.
2. Evaluate soil disinfestation with band steam in lettuce and spinach for control of soilborne diseases and weeds.

### PROCEDURES

#### Automated cultivators

Automated intra-row cultivators were evaluated in commercial fields and field station trials. The Farmwise and Stout cultivators can differentiate between lettuce plants and weeds. Their control systems select lettuce plants for protection while simultaneously selecting weeds for removal. The NAÏO Dino cultivator uses GPS guidance to cultivate between the crop rows much the same way a traditional tractor mounted cultivator operates, except the NAÏO machine operates autonomously without a driver. The NAÏO Dino cultivator uses finger weeders and torsion weeders which allow them to get very close to the crop plant.

**Methods:** Trials were conducted with three automated weeder machines: three trials with the Farmwise Titan cultivator, four with the Stout cultivators equipped with knives that opened and closed around the crop and two trials with the NAÏO Dino robotic platform equipped with finger weeders or torsion weeders. Automated weeding was carried out following thinning (except for the NAÏO Dino trials that were cultivated prior to lettuce thinning) and were compared with standard cultivation which leaves a 4-5-inch-wide band around the seedline. PRE and POST cultivation weed, and lettuce stand counts were made in a 6-inch wide band around the seedline to determine the efficacy of cultivation. Hand weeding by commercial crews was timed to determine hours per acre to weed and harvest evaluations were conducted. Trials were replicated 4 times and arranged in a randomized complete block design.

**Results:** The Farmwise Titan removed 32 to 69% of the weeds in the seedline weeds compared to 0% for the standard cultivator on commercial farms (Trials 1 and 2) and 91% of the weeds in a field station study compared to 67% for the standard cultivator (Table 1). Weeding times with the Titan ranged from 9.8 to 10.9 hours/A compared to 11.2 to 23.4 hours/A for the standard cultivator (Table 1). The Stout cultivator removed between 53 to 99% of the weeds. On commercial farms (Trials 3, 4 and 5) the weeding times with the Stout cultivator ranged from 4.6 to 8.6 hours/A compared to 10.1 to 11.5 hours/A for the standard cultivator (Table 2). In the Hartnell field station study the Stout cultivator removed 89% of the weeds in the seedline compared to 0% for the standard cultivator. Hand weeding times on the field station were 30.4 hours for Stout compared to 78.3 hours for the standard cultivator (Table 2). The Dino was tested at a commercial farm near Gonzales and at the Hartnell research farm. In the Gonzales study Dino removed 60% of the weeds compared to 0% for grower standard which was to not cultivate the high density planting. At that site hand weeding times were 7.4 and 11.9 hours/A in the Dino and grower standard plots, respectively. At Hartnell, Dino removed 62% of the weeds compared to 42% for the standard. Hand weeding times were 17.8 and 30.5 hr./A in Dino and standard treatments respectively (Table 3).

**Table 1.** Post cultivation percent weed control and handweeding times with the Farmwise Titan cultivator.

Cultivator	Trial 1		Trial 2		Hartnell farm	
	% control	Hr./A	% control	Hr./A	% control	Hr./A
Titan	69 a	10.9 b	32 a	9.8 b	91	10.6 b
Standard	0 b	19.9 a	0 b	11.2 a	67	23.4 a

**Table 2.** Post cultivation percent weed control and handweeding times with the Stout cultivator.

Cultivator	Trial 3		Trial 4		Trial 5		Hartnell farm	
	% control	Hr./A	% control	Hr./A	% control	Hr./A	% control	Hr./A
Stout	98 a	4.6 b	53 a	8.6	99 a	4.6 b	89 a	30.4 b
Standard	2 b	11.4 a	2 b	10.1	0 b	11.5 a	0 b	78.3 a

**Table 3.** Post cultivation percent weed control and handweeding times with the NAÏO Dino cultivator.

Cultivator	Gonzales		Hartnell farm	
	% control	Hr./A	% control	Hr./A
Dino	60 a	7.4 b	62	17.8 b
Standard	0 b	11.9 a	42	30.5 a

### Band Steam

Preplant injection of steam into a 6 inch band aligned with the seedline, results in weed and disease control in the band. Injection of steam into the soil with a moving applicator such that the soil temperature reaches 150-160°F for 20 minutes will control weed seed and soilborne disease propagules. The goal of this project is to develop a practical commercial steam applicator that is cost effective.

**Methods.** Steam was applied with the University of Arizona steam applicator July 7, 2021 (Fig. 1). The applicator injected steam into two 4-inch-wide bands by 3 inches deep on 40-inch beds, prior to planting lettuce. The steam raised the soil temperature in the seedlines above the target temperature of 158°F for at least 20 minutes. Lettuce was planted 5 days after steaming. The trial was arranged in a randomized complete block design with 4 replicates. Data collected were weed densities, hand weeding times, diseased plant counts, and lettuce yield.

**Results.** Weed densities were reduced by 100%, and hand weeding times were reduced by 91%, and lettuce yields in steam were 42.9 tons per acre compared to 30.4 tons per acre ( $P=0.0347$ ) in the no steam control. Lettuce drop was reduced by 60% (Table 4).

**Table 4.** Effect of band steam application on weed densities, hand weeding time, lettuce drop and lettuce yield at Salinas, CA.

Treatment	Weeds 1,000/A	Weed time Hr./A	Lettuce drop 1,000/A	Yield tons/A
Steam	0 b	9.8 b	1.3 b	42.3 a
No steam	536.8 a	117.9 a	3.2 a	30.4 b

Gross revenues in plantings that were previously treated with steam a band centered on the seed line increased by \$1,798 to \$7,245 per acre when including the savings from reduced hand weeding. Given that the cost of steam application was \$971 per acre all these trials saw net benefits from steam ranging from \$827 to \$6,274 per acre (Guerra 2021).



**Figure 1.** University of Arizona steam applicator treating soil at the Hartnell research site July, 2021.

**Summary.** Both the Stout and Titan autonomous cultivators-controlled weeds better than the standard cultivators in on-farm and field station trials. Both cultivators appear to be safe to lettuce and not reduce yields. The NAÏO Dino cultivator operates autonomously but does not have a weed/crop detection system and operates more like a traditional tractor-mounted cultivator. However, the Dino is an autonomous cultivator and has the potential to be used more widely as labor costs increase and use of autonomous vehicles becomes more widespread in agriculture.

Band steam application reduces weeds, handweeding time, and suppresses lettuce drop. The next step is to develop a commercial steam applicator.

### **Reference**

Guerra, N. 2021. Banded Steaming for Weed and Disease Control in California Vegetables. MS Thesis, University of California, Davis.