

CALIFORNIA LEAFY GREENS RESEARCH PROGRAM

April 1, 2020 – March 31, 2021

INTELLIGENT WEED MANAGEMENT FOR LEAFY GREENS

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ABSTRACT

Improvement in labor use efficiency is essential to long-term viability of vegetable production. This research included two autonomous weeders, NAÏO's Dino weeder and Farmwise's Titan weeder. These machines are both autonomous and both are capable of weeding around lettuce plants in the seedline. This is something new in California as all the weeders and lettuce thinners tested so far have had an on-board human driver. The NAÏO and Farmwise machines are controlled by an operator remotely. Successful development of this technology may lead towards "teams" of these machines – for example, three machines moving through a lettuce field doing the work of a handweeding crew of 15 people but operated by only one person. We evaluated the efficacy of these cultivators on weed control and hand weeding in lettuce as well as lettuce yields. Both the Dino and Titan autonomous cultivators-controlled weeds better than the standard cultivators in on-farm and field station trials and hand weeding times were reduced 22 to 34%. Both cultivators appear to be safe to lettuce and did not reduce yields.

OBJECTIVES

The long-term goal of this project is to provide leafy vegetable growers with tools and information that leads to cost-effective and labor-efficient weed management systems that will be sustainable in the future. The immediate objectives and deliverables were to evaluate the weed control efficacy of autonomous weeders in lettuce. Deliverables included evaluations of the potential labor savings of the autonomous weeders from NAÏO (France) and Farmwise (California). Data was presented at CLGRP meetings and in detail at extension meetings.

PROCEDURES

On farm trials. Two autonomous weeders were evaluated: the Dino (NAÏO Corp) equipped with finger weeders (Figure 1) and the Titan weeder from Farmwise equipped with paired cultivator knives that open and close (Figure 2). Cultivation was carried out following thinning (except Dino Trial No. 2 was cultivated prior to thinning) and were compared with standard cultivation

that leaves a 4-5-inch-wide band centered on the seedline. Pre and post cultivation weed, and lettuce stand counts were made in a 6-inch wide band centered on the seedline to measure cultivator efficacy. Hand weeding by commercial crews was timed to measure hours per acre to hand weed and harvest evaluations were conducted. Treatments at each site included 3 to 4 replicates. The data were pooled across sites. See Table 1 for trial details.



Figure 1. NAÏO Dino autonomous cultivator equipped with finger weeders.



Figure 2. Farmwise Titan autonomous cultivator equipped with paired cultivator knives.

Results: Overall, the auto weeders removed about twice the number from the 6-inch seedline band, and reduced subsequent time of hand weeding/double removal by 4 hours/acre while not reducing the stand of lettuce or mean head weight (Table 2). Autoweeders are not able to remove lettuce plant doubles from production fields and a hand crew is still needed to accomplish this

task. This creates a critical economic decision for the grower: when is it advantageous to utilize an autoweeder? Autoweeders do not yet eliminate the need for hand weeding but do reduce the time for subsequent hand weeding and removal of lettuce doubles. Figure 3 shows that the autoweeders provided the greatest benefit in reduced hand weeding times where weed densities are highest.

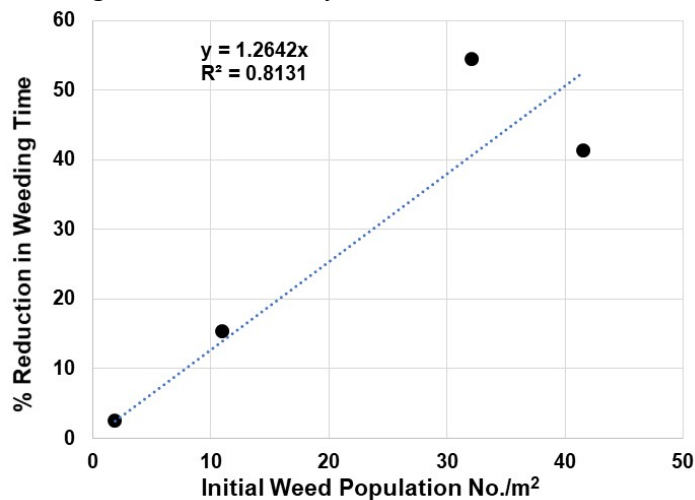
Table 1. Cultivation trial details during May to August 2020.

Trial No.	Bed Configuration	Lettuce Type	Weed/stand Pre-Count Date	Weed/stand Post Count Date	Harvest Date
Dino Cultivator					
1	5-SL, 80"	Romine	May 15	May 18	June 15
2	5-SL, 80"	Romaine	May 21	May 22 ¹	July 2
Titan Cultivator					
1	6-SL ¹ , 80"	Romaine	June 8	June 12	July 14
2	5-SL, 80"	Green leaf	June 15	June 19	July 14
3	6-SL, 80"	Romaine	June 22	June 24	July 28
4	5-SL, 80"	Head	July 10	July 15	August 10
5	6-SL, 80"	Romaine	July 27	July 29	August 25

Table 2. Weed control and harvest evaluations with the auto and standard cultivators

Response Variable	Autoweeder	Standard Cultivation	P-value
Weeds Removed (%)	59.2	31.5	< 0.001
Weeding time (Hrs./A)	7.3	11.0	0.195
Lettuce Stand Post Cultivation (%)	98.7	99.9	0.160
Mean head wt. (lbs.)	1.8	1.8	0.913

Figure 3. Relationship between initial weed population and the reduction in subsequent hand weeding time of lettuce by auto weeder.



Field station trial

Methods. The trial was conducted at the USDA-ARS/UC Hartnell research farm in Salinas, CA, and utilized a randomized complete block design, with four replicates. Each plot consisted of two 40-in wide beds by 125' long. Romaine lettuce (cv. R-32) was seeded June 19, 2020. Pronamide (Kerb SC) at 1.0 lbs. ai/A was applied to half of the plots on June 22, 2020 and the other half of the plots were not treated with Kerb. The plot was sprinkler irrigated until crop emergence; after which the crop was drip irrigated until harvest. Cultivation was performed July 10, 2020 either with the DINO (Figure 1) or the standard cultivator. The crop was fertilized by drip injection of AN20 @ 30-37 lbs. N/Ac twice during the trial.

Weed densities and lettuce stand counts were measured pre-cultivation (PRE) on June 9 and post-cultivation (POST) on June 13, 2020. Thinning and hand weeding times were measured June 14, 2020. A second timed weeding was measured on June 23, 2020. Lettuce was harvested on August 25, 2020. All weed and crop assessment data were subjected to analysis of variance using Agricultural Research Manager and mean separation was performed using LSD's (P=0.05). The data were also subjected to factorial analysis to measure the main effects of cultivator type.

Results

The DINO cultivator removed a greater percentage of weeds than the standard cultivator, and also had 22% shorter hand weeding times than the standard cultivator (Table 3). There were no differences in lettuce stands or yields between the DINO and standard cultivator.

Table 3. Effect of cultivation type and pronamide rate on weed control, lettuce stand, number of Romaine heads per acre and weight per head.

Cultivator	Kerb	Weed control	Stand reduction	Weed time	Lettuce heads	Lettuce head wt.
	Lbs. ai/A	-----%-----		Hours/acre	1,000/acre	grams
Dino	0	60 ab	19	24.4 b	26.1	794
Dino	1	81 a	12	12.7 c	22.5	765
Standard	0	32 b	12	32.9 a	22.5	710
Standard	1	39 b	7	14.7 c	28.1	836
F value		0.0195	0.63	0.0003	0.40	0.61
Main effects of cultivator						
Dino		70 a	15	18.5 b	24.3	779
Standard		35 b	9	23.8 a	25.3	773
F-value		0.0048	0.37	0.0352	0.72	0.93

Summary. Both the Dino 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.