

2015 Evaluation of Mechanical Weeders for Weed Removal and Crop Safety in Lettuce Production

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Summary: The current automated weeding machines use cameras to detect plants, and a computer to process the image and calculate which plants to keep and which to remove and then to activate a kill mechanism. The two machines used in these studies included the Robovator, Frank Poulsen Engineering, Denmark and Steketee IC Weeder, the Netherlands. They are capable of cultivating the seedline and removing weeds ordinarily missed by traditional cultivation (Photo 1): The Robovator (Photo 2) and Steketee (Photo 3). Both of these machines use a split knife (Photo 4) that closes in the seedline to remove unwanted plants and opens around the desirable 'keeper' plants leaving an island of uncultivated soil (Photo 5). Both machines were originally designed for use in transplanted crops and use a camera to detect the larger crop plants and regulate the opening and closing of the blades. In three of the evaluations the machines were used following thinning of the lettuce. On average there is a trend that the automated weeders reduced the stand of lettuce by 5.6%. This may be due to incidental damage from the knives opening or closing at the wrong time. This type of damage can be managed by adjustments on the machine that affect the aggressiveness of the blades. On average, mechanical weeders removed 51.4% of the weeds in the seedlines and reduced follow up hand weeding in the fields by 37.1%. Mechanical weeding technology has developed significantly over the past several years, and in these studies, these machines provide useful levels of weed control and reduce the amount of time it takes to remove all the weeds from lettuce production fields.

Methods: All trials were conducted in commercial lettuce production fields. The fields varied in planting configurations, weed pressure and variety of lettuce. Two different mechanical weeders were used in these studies: Robovator, Frank Poulsen Engineering, and Steketee IC Weeder. Pre mechanical weeding counts were made of lettuce plants and weeds and post mechanical weeding counts were made of the same parameters one to four days following mechanical cultivation. Mechanically weeded strips were the width of the bed by 30 to 100 feet long. Mechanically weeded strips were compared with paired strips that were not mechanically weeded to compare the safety of the mechanical weeder and their efficacy in removing weeds and thereby reducing subsequent hand weeding time. **Trial No. 1:** This trial utilized the Robovator mechanical weeder and was conducted south of Salinas in a commercial head lettuce field following thinning. The field was planted on 80 inch wide beds with 6 seedlines. The field was thinned with an automated thinner that used an herbicide to kill unwanted lettuce plants and weeds, however it was ineffective and there was a great deal of regrowth of the treated plants (Photo 6). Weed and lettuce plant counts were made on June 24, 2015 by counting weeds and lettuce plants in each seedline in three replicated 100 foot strips in the field. The field was weeded with the Robovator on June 25. Post weed and lettuce stand counts were made on July 1 by counting surviving weeds, lettuce plants and regrowing lettuce plants in the same area as the pre weeding evaluation areas. The Robovator treated plots were paired with adjacent beds that were hand weeded. Lettuce regrowth, follow up hand weeding time and yield were evaluated mechanically weeded and unweeded plots. Hand weeding evaluations were made by timing how long it took to weed the individual seedlines in each 100 foot evaluation area. **Trial No. 2:** This trial utilized the IC Steketee mechanical weeder and was conducted west of Castroville in a commercial head lettuce field following thinning. Pre mechanical weeding counts of lettuce and weeds were made on July 14 in three replicated 100 foot long strips of two 40-inch wide beds with 2 seedlines per bed. Mechanically weeded plots were paired with 100 foot long strips that were hand weeded.

Following mechanical weeding, the number of weeds and lettuce plants were counted, as well as time to do follow up weeding were done on July 15. Harvest evaluations were made on August 12. **Trial No. 3:** This trial utilized the Robovator mechanical weeder. This trial was conducted north west of Salinas in a commercial head lettuce field following thinning. Pre mechanical weeding lettuce and weed counts were made on July 20 in three replicated 100 foot long strips of an 80-inch wide bed with 5 seedlines. The plots were mechanically weeded with the Robovator. Mechanically weeded plots were paired with 100 foot long strips that were hand weeded. Following mechanical weeding, weeds and lettuce plants were counted on July 21. Time to hand weed the mechanically treated and untreated plots was measured on July 21. No harvest evaluation was made at this site. **Trial No. 4:** This trial utilized the Robovator mechanical weeder. This trial was conducted north San Juan Bautista a commercial transplanted organic romaine lettuce field. Pre mechanical weeding lettuce and weed counts were made on August 6 in three replicated 30 foot long strips of an 80-inch wide bed with 6 seedlines. The plots were mechanically weeded with the Robovator. Mechanically weeded plots were paired with 30 foot long strips that were hand weeded. Following mechanical weeding, weeds and lettuce plants were counted on August 7. Time to hand weed the mechanically treated and untreated plots was measured on August 7. Harvest evaluations were made on September 4.

Results: Trial No. 1: This trial had some problems which made mechanical weeding difficult. There was a great deal of regrowth of lettuce plants from the mechanical thinning operation that did not completely kill lettuce seedlings (Photo 6). Most of these unthinned lettuce plants were stunted and the Robovator was able to distinguish them from the larger keeper plants, and as a result, was able to remove a great deal of them. After the mechanical weeder passed through the plots, there were 11,774.6 regrowth lettuce plants/A in the mechanically weeded plots and 64,003.9 regrowth lettuce plants/A in the hand weeded plots which was an 81.6% reduction. There were fewer weeds following weeding with the Robovator, but there was also fewer lettuce plants in following weeding with the Robovator at this site (Table 1). Overall, there was a dramatic reduction in the number of hours to weed the lettuce following the Robovator: 7.4 vs 16.5 hrs/A ($P > 0.0016$). Another issue that may have reduced the effectiveness of the Robovator at this site was the evenness of the speed of the tractor. For some reason the tractor could not maintain a constant speed which made it difficult for the Robovator to work effectively and this may have contributed to some of the issues with the automated weed removal encountered at this site. **Trial No. 2:** There was no significant difference in the number of lettuce plants between mechanically weeded and hand weeded plots. There was also no difference in the number of weeds removed by the Mechanical thinner, but there is a trend showing a 74.7% reduction. Follow up hand weeding time was significantly reduced 36.8% after the use of the Robovator. There was not significant difference in the mean head weight between Robovator and hand weeded plots. **Trial No. 3:** There were significantly fewer lettuce plants in the mechanically weeded plots. Although there were very low numbers of weeds at this site, there was a strong trend indicating that the mechanical weeder removed 74.9% of the weeds in the plots and it took significantly less time to do follow up hand weeding in the mechanically weeded plots. No yield evaluation was carried out at this site. **Trial No. 4:** There was no significant difference in the number of lettuce plants between mechanically and hand weeded plots. There were 52.1% fewer plants in the mechanically weeded plots than hand weeded plots, and it took 22.2% less time to do follow up hand weeding of the plots.



Photo 1. Traditional cultivation



Photo 2. Robovator mechanical weeder



Photo 3. IC Steketee mechanical weeder



Photo 4. Knives in the open position



Photo 5. Uncultivated 'island'



Photo 6. Trial No. 1. Lettuce plants not killed by an automated thinner were stunted and regrew between the keeper plants.

Table 1. Evaluation of lettuce stand and number of weeds pre and post mechanical weeding

Pre vs Post mechanical weeder	Trial 1		Trial 2		Trial 3		Trial 4		Mean	
	Lettuce plants/A	Weed plants/A								
Pre weeding	35,263.6	3,662.4	31,763.3	2,405.0	37,538.4	261.4	44,879.3	48,038.5	37,361.15	13,591.83
Post weeding	31,078.1	2,746.8	30,701.7	606.7	36,122.3	65.4	43,136.2	22,984.0	35,259.58	6,600.73
Pr>treatment	0.0886	0.0728	0.1566	0.2860	0.0333	0.0955	0.1348	0.0637	---	---
LSD _{0.05}	NS	NS	NS	NS	187.6	NS	NS	4,661.8	---	---

Table 2. Follow up hand weeding following mechanical weeding vs no prior mechanical weeding

Treatment	Trial 1		Trial 2		Trial 3		Trial 4		Mean	
	Follow up hand weeding hrs/A	Mean Plant wt lbs	Follow up hand weeding hrs/A	Mean Plant wt lbs	Follow up hand weeding hrs/A	Mean Plant wt lbs	Follow up hand weeding hrs/A	Mean Plant wt lbs	Follow up hand weeding hrs/A	Mean Plant wt lbs
Mechanical weeder	7.4	1.81	3.6	2.21	3.6	---	9.8	1.16	6.1	1.73
No mechanical weeder	16.5	2.21	5.7	2.34	4.0	---	12.6	1.15	9.7	1.90
Pr>treatment	0.0016	0.0887	0.0007	0.3952	0.0617	---	0.2012	0.9798	---	---
LSD _{0.05}	0.3	NS	0.2	NS	0.1	---	NS	NS	---	---