Evaluation of an Automated Lettuce Thinner

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Objective: Evaluate spray-ready products for effectiveness in removal of lettuce with an automated thinner in a single-pass operation

Methods. A lettuce thinning and weeding study was initiated August 23, 2012 west of Salinas, CA. The experimental design was a randomized complete block design with four treatments and four replications and the soil at the site was Cropley silty clay. Treatments included using an automated thinner to spray three different materials to kill seedlings and a hand thinning control. Spray products included 75% AN20, 7% v/v Scythe and 10% v/v sulfuric acid. Each plot was one 40-inch bed wide by 660 ft long.

The University of Arizona/Blue River Technology lettuce thinner was calibrated to spray 126 GPA applying 4-inch bands to twin row 40-inch lettuce beds. The machine was used to thin lettuce on Aug. 23, 2012 when the plants were at the 1-2 leaf stage of growth and approximately 0.9 inches in diameter. Machine travel speed was 0.6 mph. Lettuce was thinned by hand on Aug. 28 and the time it took to thin each plot was recorded. The number of "doubles" (closely spaced seedlings within 1.5 inch of each other) were counted after thinning. All plots were hand weeded on September 11 and the time to remove weeds and double lettuce seedlings that had been missed during the thinning operation was recorded. Yield evaluation was conducted on October 23 by harvesting 32 heads per plot and weighing them for untrimmed biomass and then trimming them to marketable heads and reweighing.

Results

Scythe and AN 20 were found to be ineffective at killing lettuce seedlings at the application rates and concentration levels used (data not shown). Use of sulfuric acid with the University of Arizona/Blue River Technology lettuce thinner reduced the lettuce stand from 169,272 plants/A to 34,343 (Table 1). Labor requirements to thin by machine and hand were 1.2 and 4.6 hrs/A respectively. However, there were 7,139 doubles/A in the machine thinned with sulfuric acid treatment compared to 24 double/A in the hand thinned treatment. A probable explanation for the machine's poor double removal rate was that the unsprayed "safety zone" before and after the "saved" plant was excessive and closely spaced plants were not killed. The subsequent hand weed and double removal operation took 5.7 hours/A to in the machine thinned treatment as compared to 2.8 hrs/A in the hand thinned treatment. The total time to thin and weed the lettuce was 7.4 hours/A in the standard operation vs 6.9 hours/A in the machine thinned operation.

Table 1. Thinning and weeding evaluations based on timing of commercial hand crew (660 linear feet of row)

Treatments	Pre-thin plants/A	Thin hrs/A	Post thin plants/A	Post thin doubles/A remaining	Weed and double removal hrs/A	Plants/A after weed/ double removal	Total time thin/ weed Hrs/A	Yield untrimmed Tons/A	Head Weight lbs/head	Yield Market Tons/A
	Aug 23	Aug 28	Aug 30	Aug 30	Sep 11	Sep 25		Oct. 23		
Hand	167,129	4.6	30,253	24	2.8	29,504	7.4	44.9	3.04	27.1
Machine	169,272	1.2	34,343	7,139	5.7	26,792	6.9	41.3	3.08	25.1
Pr>F treat	0.6712	Na	0.05	0.01	0.0001	0.07	na	0.1034	0.6488	0.0018
LSD (0.05)	Ns	Na	3,886	2,902	0.21	3,201	na	ns	ns	0.60

Although the automated thinner used in this trial was 1 bed wide and traveled at 0.6 mph, it is expected that a commercial machine would be 4 beds wide and travel at 1.5 mph. Projecting development of such a machine, operating costs of machine thinning with sulfuric acid are estimated at $46/A ($7/A material, $11/A machine labor, $28/A fuel, labor, repairs) and require an additional 1.2 hours/A or $15/A hand labor for a total practice cost of $61/A (table 2). This is essentially the same cost as hand thinning (the current grower standard), which is estimated at $57/A using a total of 4.6 hand labor hours/A. When evaluating total practice costs, including weeding and doubles removal, costs/A for an automated lettuce thinner are higher than the grower standard at $132 and $92 respectively (table 2). However, the hand labor requirements associated with an automated thinner would be reduced by roughly 75% as compared to the grower standard, and may therefore be a helpful alternative when labor availability is constrained.

There were fewer total plants/A in the automated thinner treatment following removal of the doubles. There was no difference in mean head weight between treatments, but the lower plant count of the automated thinner reduced total overall and marketable yield in that treatment (table 1). Ultimately, this resulted in lower net returns to growers above operating costs for the automated lettuce thinner as compared to the grower standard of hand thinning and weeding (table 3). Two areas in which machine performance improvements may beneficially impact cost estimates are increased machine speeds and enhanced thinning precision. If these two improvements could be realized, an automated lettuce thinner may be more attractive to growers from an operation and economic perspective.

Table 2. Estimated Operating Costs for Thinning, and Removing Weeds and Doubles Post Thinning – 2012

	Thinner: 0.6 mph – 4 bed unit					Thinner: 1.5 mph – 4 bed unit[1]				
Method	Material	Thinning labor	Weeding labor	F L R[2]	*Total*[3]	Material	Thinning labor[2]	Weeding labor	F L R[3]	*Total*[4]
	Costs $/acre									
Hand	0	57	35	0	*92*	0	57	35	0	*92*
Machine	7	24+15	70	61	*177*	7	11+15	70	28	*132*

1 Costs are included for a 4-bed automated thinning machine traveling at speed of 1.5 mph since this is the expected rate of travel for a commercial machine.
2 Machine + non-machine (field) labor.
3 Fuel, lube, repairs
4 Total includes interest on operating capital

Table 3. Estimated Operating Costs and Net Returns for an Automated Lettuce Thinner as Compared to Hand Thinning – 2012

	Thinner: 0.6 mph – 4-bed unit				Thinner: 1.5 mph – 4-bed unit			
	Yield	Gross Ret[1]	Op Costs	Net Ret[2]	Yield	Gross Ret[1]	Op Costs	Net Ret[2]
	T/acre	$/acre			T/acre	$/acre		
Hand	27.08	11,969	92	11,877	27.08	11,969	92	11,877
Machine	25.08	11,085	177	10,908	25.08	11,085	132	10,953

[1] Gross returns = experimental yield in tons/acre x $442/ton.
(2011 price for lettuce – bulk leaf – Monterey County Crop Report Crop Report).
[2] Net returns above estimated operating costs (gross returns – operating costs)

Calculation Assumptions:
Equipment Investment Cost:
New equipment; estimated investment costs of $150,000.

Material Cost:
- Field Grade Sulfuric Acid application rate: 2.5 gal/acre; $2.04/gal

Labor Cost†:
Machine‡: $19.53/hr
Non-Machine: $12.33/hr
† Both machine and non-machine labor includes 37% taxes/benefits package.

‡ Labor for operations with machinery are 20% higher than actual operation time noted above to account for the extra labor involved in equipment set up, moving, maintenance, work breaks and field repair.

Fuel Cost:
Diesel: $3.43/gal
Fuel use for .6 mph = 5.56 gal/acre; fuel use for 1.5 mph = 2.59 gal/acre