Research Report to the Organic Farming Research Foundation

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Title: Evaluation of Alternative Cultivators for Vegetable Production

Principle Investigator:
Richard Smith, Vegetable Crop and Weed Science Farm Advisor
University of California Cooperative Extension
1432 Abbott Street, Salinas, CA 93901
831-759-7350; 831-758-3018 FAX; rifsmith(@ucdavis.edu email

Cooperating Investigator:
Steve Fennimore, Extension Vegetable Weed Specialist
Dept. of Vegetable Crops, University of California, Davis
1636 E. Alisal, Salinas, CA 93901
831-755-2896; 831-755-2814; safennimore(@ucdavis.edu email

Cooperating Growers:
David Bunn, Crown Packing
Phil Foster, Phil Foster Ranches
Mike Thorp, Tanimura and Antle

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Project Summary

The brush hoe cultivator (Bartchi Fobro Co., Switzerland) was evaluated for weed control cool-season vegetables in the Salinas Valley. The brush hoe was compared with conventional vegetable cultivators in seven on-farm trials. The brush hoe cultivated closer to the seed row than the conventional cultivators used by the growers. It left uncultivated strips 2 7/8 inch wide while conventional cultivators generally left uncultivated strips four inches wide. The brush hoe provided comparable or improved weed control over conventional cultivation. Under high weed densities, the brush hoe also reduced weeding/thinning time by over four hours per acre. At lower weed densities (i.e. 1.5 - 2.0 weeds per foot of row) the brush hoe may provide improved weed control but this may not always translate to a reduction in hoeing time. Conventional cultivators used in these studies traveled at speeds of 4-5 mph and the brush hoe in these trials traveled at 2.5-3 mph. The brush hoe also required an additional person to steer the implement in order cultivate close to the seedline. As a result the brush hoe may not offer economic advantages to large-scale vegetable operations, but may have a niche in operations with limited access to labor and/or in situations with high weed densities.

Introduction

Weeds were listed in the 1997 National Organic Farmer's Survey as the number one production issue (1). Weeds are important because they can negatively impact yield as well as the economics of crop production. The more a grower is able to reduce weed pressure the more economical it is to produce crops. Cultural practices and various techniques used by organic vegetable growers (e.g. cultivation, flaming, solarization, mulches, use of transplants and pre-germination of weed seeds) to produce vegetables often provide an opportunity for the crop to gain an advantage over weeds and out-compete them for nutrients, light and water (2). All of these techniques help reduce hand-weeding costs and make crop production more efficient. In spite of these efforts, organic growers frequently, but not always, have higher weeding costs than conventional producers (3,4,5). For instance, average weeding cost for organically produced onions in San Benito County versus conventionally produced onions in Imperial County were $683.02 and $196.85, respectively.

There have been new innovations in weeding technology as well as rekindled interest in older cultivation techniques in recent years that are worth investigating. Colquhoun and Bellinder (6,7) investigated the Bezzerides torsion weeder, the brush hoe, the budding finger weeder and various flex tined cultivators. Their investigations indicate that these alternative cultivators show promise for vegetable production. However, the conditions under which they tested these implements (flat bed culture and rain irrigated) are not directly applicable to raised-bed and irrigated vegetable culture used in the West. In addition, the implements were tested on tougher stemmed vegetables such as sweet corn and string beans rather than on delicate stemmed vegetables such as lettuce and broccoli. Their investigations laid important groundwork and, based on their evaluations, it appears that the most promising alternative cultivator for vegetable culture in the Salinas Valley is the brush hoe (Baertchi Fobro Corp., Switzerland). The Bezzerides torsion weeder was also considered as a possible cultivation tool for Salinas Valley vegetables. However, after meeting with company representative and closely examining how the implement functioned, it was decided that it would potentially be too damaging to tender lettuce and broccoli seedlings and evaluations of this implement were not pursued in these studies.

Vegetables in the Salinas Valley as well as many other areas of the California and the West utilize forty-inch beds on which one or more lines of the crop a sown mechanically. The mechanically sown lines of the crop facilitate mechanical cultivation. Typically 80% of the bed is cultivated in lettuce and cole crop production. Usually two four-inch wide strips containing the seedlines are left uncultivated. Hand crews typically remove the weeds that remain in these strips; weeding costs can vary from $50 to $200+/acre to remove weeds from the uncultivated strips (8). If the uncultivated strips could be narrower, then potentially weeding costs could be reduced. Our interest in the brush hoe was strengthened by a visit to a farm in Stockton where the brush hoe was cultivating down to 1 7/8-inch wide strips. Encouraged by the efficiency and safety of the brush hoe to the crops, we bought a unit and used it to conduct these studies.

Objectives:

Evaluate weed control, efficiency, speed and economics of the brush hoe in comparison with growers standard cultivation equipment on cool season vegetables in the Salinas Valley.

Materials and Methods:

Seven trials were conducted in cooperation with organic growers in the Salinas Valley and the surrounding area in the summer of 2000: 1) head lettuce No. 1, a direct seeded trial cultivated on May 6 and thinned/weeded on May 11; 2) head lettuce No. 2 a transplanted trial cultivated on July 17 and weeded on July 24; 3) Romaine lettuce a transplanted trial cultivated on July 17 and weeded on July 24; 4) broccoli No. 1 a direct seeded trial cultivated on August 8 and thinned/weeded on August 9; 5) broccoli No. 2 a direct seeded trial cultivated on August 8 and thinned/weeded on August 8; 6) celery, a transplanted trial cultivated on August 24 and weeded on September 1; and 7) kale, a direct seeded trial cultivated on October 2 and thinned/weeded on October 13. Plots consisted of paired plots comparing the brush hoe and conventional cultivation. Plots consisted of four 40-inch rows by the length of the field. The brush hoe cultivator was adjusted to cultivate a strip 2 7/8-inch wide. Conventional cultivators utilized standard four-inch wide strips in all trials, except the broccoli trials, which utilized three-inch wide strips. All cultivations were carried out according to -grower's standard practices for early-season cultivation. Four to six subplots ten feet long were established in each cultivation treatment. Pre and post-cultivation weed counts were made in the subplots to determine pre and post-cultivation weed densities. All data was converted to weeds per square meter and weeds per linear foot of row to facilitate comparisons between trials (weeds per foot of row may be easier for growers to visualize). Following cultivation, four to six 100-foot subplots were established in each cultivation treatment, and thinning/weeding times were determined. Weeding time data was converted to hours per acre to weed to facilitate comparison between trials, as well as the economics of the cultivation treatments. Because of differences in cultural practices and weeding operations direct seeded and transplanted trials were statistically analyzed separately. All pre and post weed counts and weeding times were statistically analyzed by comparing means with t-tests ($P<0.05$), brush hoe vs. conventional cultivation trends were analyzed using regression analysis.

Results:

Direct Seeded Trials: *Head lettuce No. 1*: The brush hoe controlled a greater percentage of shepherdspurse *(Capsella bursa pastoris),* but there was no difference in hoeing times between the two cultivation treatments (table 1). *Broccoli No. 1*: Standard cultivation controlled a greater percentage of stinging nettle *(Urtica urens)* than the brush hoe but there was no difference in percent total weeds controlled by the two cultivators treatments (table 2). It took 2.4 hours/A less to weed/thin the broccoli with the conventional cultivator than with the brush hoe cultivator. *Broccoli No. 2:* Standard cultivation controlled a greater percentage of stinging nettle than the brush hoe and generally had lower total weed densities than the brush hoe cultivation treatment (table 3). It took 1.6 hours/A less to weed/thin the broccoli in the conventional cultivation treatment than with the brush hoe cultivation. Kale: The brush hoe cultivated treatments had reduced percent of Chickweed *(Stellaria media),* Henbit *(Lamium amplexicaule) and* total weeds, as well as weed densities than conventional cultivation (table 4). The brush hoe reduced thinning/weeding time by 4.1 hours/A over standard cultivation. Over all direct seeded trials, there is a strong relationship between post cultivation weed densities and hours/A to thin/weed: hours/A vs. weeds/ft of row ($r = 0.74$, $R2 = 54.\ 1$, $P<0.01$).

Transplanted Trials: Head Lettuce No. 2: The brush hoe reduced a the percent of Shepherds purse and total weeds, as well as reduced the hours per acre to weed the lettuce by 3.8 hours over standard cultivation (table *5). Romaine lettuce:* The brush hoe reduced the percent nettle and total weeds, but no statistical differences were seen in the hours/A to weed the two cultivation treatments (table 6). *Celery:* The brush hoe reduced the percent nettle and total weeds, but no differences were seen in hours/A to weed the cultivation treatments (table 7). Over all trials there was a poor to weak relationship between the weed densities and hours/A to weed: hours/A vs. weeds/ft of row ($r = 0.21$, $R2 = 4.4$, $P<0.10$).

Conclusions and Discussion:

All trials were conducted as paired plots that were sub-sampled to replicate the observations. This experimental design made it difficult to obtain equal initial weed densities for both cultivation treatments. For instance, in broccoli trials 1 and 2, the brush hoe plots began with 2.86 and 1.96 times the weed density of the conventional cultivation plots, respectively. However, the final weed densities for the brush hoe in broccoli trials 1 and 2 had 2.72 and 2.86 times the weed densities, respectively. These results make interpretation difficult, but they seem to indicate that the two cultivators have comparable weed control efficacy, which is logical given that the brush hoe and the conventional cultivator used in these two trials leave uncultivated strips of nearly equal widths, 2 7/8 and 3 inches wide, respectively. The brush hoe had clear a clear advantage over conventional cultivation where weed densities are high (i.e. 12.9 to 27.3 weeds/foot), as in the kale trial. In this example the brush hoe reduced thinning/weeding time per acre by 4.1 hours, which if total labor costs are $10.00/A the saving would be $41.00 per acre. However, in head lettuce trial No. 1 weed densities ranged from 9.1 to 10.3 weeds per foot of row and no significant savings in weeding times were seen.

Transplanted crops present a different scenario to weeding crews. The transplants must be hoed around rather than relying upon the rhythmic action of the hoe used in thinning/weeding operations. This is substantiated by the fact that there were poor to weak correlations between weed densities, either weeds/m2 or per foot of row, in transplanted crops. All three trials with transplanted crops had very low weed densities, ranging from 1.3 to 2.1 weeds per foot. Given these scenarios however, there was a general increase in the time to weed conventionally vs. brush hoe cultivated plots, but the savings were less than 2 hours per acre, yielding less than $20.00 per acre savings.

The key issue for the adoption of the brush hoe as an improvement in weed- control efforts by organic growers is the efficiency and economics of its use. Conventional cultivators in the Salinas Valley typically travel at speeds of 4-5 miles per hour and can cultivate up to 45 acres per day. In the trials that we conducted the top speed that we traveled was 2.5-3 miles per hour. In addition, the brush hoe required an additional driver to steer the implement to allow for close cultivation. Close cultivation can be achieved with conventional cultivation as well, but at reduced speeds. An advantage that the brush hoe provides is that the action of the brushes do not shear and fracture the soil as can occur when cultivation knives and sweeps pass through the soil. We were not able to measure relative yields in these trials, but nci obvious differences in growth and yield were observed between the brush hoe and conventional cultivation. The brush hoe may have more applicability to small operations that have minimal access to hand labor where close cultivation may pay off in time and money saved in subsequent weeding operations, These trials indicated that it clearly can save the grower money under high weed pressure.

The following are comments that growers made regarding the brush hoe:

- Needs a hydraulic motor, because of constraints of the PTO system It may have advantages for 80-inch bed culture
- Organic lettuce growers frequently use transplants to reduce problems with lettuce aphid and the brush hoe may have trouble cultivating close to these larger plants
- Standard cultivators are designed to adjust to the heights of individual beds, however the brush hoe has a shaft that spans the beds and had trouble adjusting to uneven beds
- It did not tear the bed down as much on the first cultivation which may be a advantage
- It did not seem to have problems with heavy and/or wet soils conditions

Outreach:
The brush hoe was demonstrated at the 1999 and 2000 U.C. sponsored Salinas Valley Weed Day (July 20, 1999 and July 26, 2000, respectively). Results of the brush hoe trials were discussed at the Salinas Valley Weed School (November 29, 2000); the Agricultural Conference and Trade Show in Gilroy (December 14, 2000); the California Weed Science Society meeting in Monterey (January 8, 2001) and the Salinas Valley Commodity Series: Cole Crops (January 16, 2000). The brush hoe trials were reported in an article in the Monterey County Crop Notes newsletter (see attached) and in Ag Alert (September, 2000).

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Direct Seed Trials

Table 1. Head lettuce No. 1. Percent weed control of selected and total weeds, weeds per unit area (post cultivation) and hours per acre to weed and thin.

	Brush Hoe Cultivator	Standard Cultivator	Difference
Shepherdspurse Control (%)	51.4	37.2	14.2*
Nettle Control (%)	29.9	24.1	5.8
Groundsel Control (%)	41.9	53.2	-11.3
Total Weed Control (%)	30.6	17.2	13.3
Weeds per Square Meter	84.5	95.2	10.7
Weeds per Foot of Row	9.1	10.3	1.2
Hours per Acre to Weed	11.1	10.5	-0.6

* Significant difference P=0.05

Table 2. Broccoli No. 1. Percent weed control of selected and total weeds, weeds per unit area (post cultivation) and hours per acre to weed and thin.

	Brush Hoe Cultivator	Standard Cultivator	Difference
Shepherdspurse Control (%)	53.5	50.0	3.5
Nettle Control (%)	74.2	46.2	28.0*
Nettleleaf Control (%)	34.3	52.7	-18.4
Total Weed Control (%)	58.6	56.4	2.5
Weeds per Square Meter	80.4	29.6	-50.8
Weeds per Foot of Row	7.5	2.8	4.7
Hours per Acre to Weed	6.8	4.4	-2.4

* Significant difference P=0.05

Table 3. Broccoli No. 2. Percent weed control of selected and total weeds, weeds per unit area (post cultivation) and hours per acre to weed and thin.

	Brush Hoe Cultivator	Standard Cultivator	Difference
Shepherdspurse Control (%)	59.2	66.7	-7.5
Nettle Control (%)	20.2	84.2	-64.0*
Nettleleaf Control (%)	57.1	71.4	-14.3
Total Weed Control (%)	55.4	69.5	-14.1
Weeds per Square Meter	125.2	43.7	-81.5*
Weeds per Foot of Row	11.6	4.1	-7.5*
Hours per Acre to Weed	7.8	6.2	1.6

* Significant difference P=0.05

Table 4. Kale. Percent weed control of selected and total weeds, weeds per unit area (post cultivation) and hours per acre to weed and thin.

	Brush Hoe Cultivator	Standard Cultivator	Difference
Chickweed Control (%)	78.9	44.9	34.0*
Henbit Control (%)	54.7	33.6	21.1*
Total Weed Control (%)	60.7	38.4	22.3*
Weeds per Square Meter	118.5	251.4	132.9*
Weeds per Foot of Row	12.9	27.3	14.4*
Hours per Acre to Weed	15.8	19.9	4.1*

* Significant difference P=0.05

Transplanted Crops

Table 5. Head lettuce No. 2. Percent weed control of selected and total weeds, weeds per unit area (post cultivation) and hours per acre to weed and thin.

	Brush Hoe Cultivator	Standard Cultivator	Difference
Shepherdspurse Control (%)	51.4	37.2	14.2*
Nettle Control (%)	29.9	24.1	5.8
Groundsel Control (%)	41.9	53.2	-11.3
Total Weed Control (%)	75.6	49.6	26.0*
Weeds per Square Meter	13.9	22.6	8.4
Weeds per Foot of Row	1.3	2.1	0.7
Hours per Acre to Weed	7.3	11.1	3.8*

* Significant difference P=0.05

Table 6. Romaine lettuce. Percent weed control of selected and total weeds, weeds per unit area (post cultivation) and hours per acre to weed and thin.

	Brush Hoe Cultivator	Standard Cultivator	Difference
Shepherdspurse Control (%)	80.1	92.3	-12.2
Nettle Control (%)	78.9	30.0	48.9*
Groundsel Control (%)	75.0	50.0	25.0
Total Weed Control (%)	78.7	40.7	38.0
Weeds per Square Meter	13.9	17.6	3.7
Weeds per Foot of Row	1.3	1.6	0.3
Hours per Acre to Weed	8.8	10.0	1.2

* Significant difference P=0.05

Table 7. Celery. Percent weed control of selected and total weeds, weeds per unit area (post cultivation) and hours per acre to weed and thin.

	Brush Hoe Cultivator	Standard Cultivator	Difference
Nettle Control (%)	61.5	50.5	11.0*
Henbit Control (%)	71.4	53.6	17.8
Total Weed Control (%)	63.9	52.5	11.4
Weeds per Square Meter	9.8	13.2	3.4
Weeds per Foot of Row	1.4	1.8	0.4
Hours per Acre to Weed	5.9	5.9	0.0

* Significant difference P=0.05