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Mechanical in-row cultivation in row crops

By J ASCARD

Department of Agricultural Engineering
Swedish University of Agricultural Sciences
Box 66, S-230 53 Alnarp, Sweden
E-mail: Johan.Ascard@lt.slu.se

and R R B BELLINDER

Department of Fruit and Vegetable Science
Cornell University
134 Plant Science Building, Ithaca, NY 14853USA
E-mail: rrb3@cornell.edu

Summary

The effects of in-row cultivation were evaluated in onions and sugar beets. Early postemergence cultivation caused severe plant losses, but later cultivations caused less damage. Generally, higher driving speed gave better weed control, and small or no additional crop damage. In onions, weed control was better and yield reductions were greater with both the Einböck spring-tine harrow and the Buddingh rubber finger weeder than with the Bezzerides torsion weeder. Labour for hand weeding was roughly halved by the in-row cultivations compared with treatments that were only cultivated between rows. In sugar beets, weed control and yield were similar when replacing the last of the three herbicide applications with two spring-tine harrowings. Yield was significantly lower when two or all three herbicide applications were replaced by weed harrowing. The plant losses were small when the sugar beets were harrowed at the 6-8 leaf stage.

Introduction

Although weeds between the crop rows can normally be controlled by ordinary row crop cultivation, weeds in the crop row constitute a major problem. Weed harrows with flexible tines are most common for selective in-row cultivation, although other implements can also be used (Brusko, 1989; Fogelberg & Johansson, 1993). There are however, limited reports on the effects of these implements. Weed harrowing in row crops is usually recommended only as a preemergence treatment, however Baumann (1992) and Colquhoun & Bellinder (1995) found that selective postemergence weed harrowing is possible in early growth stages of different row crops.

Onions are very sensitive to early season weed competition and may require much hand weeding if other weed control measures are inadequate. Similarly onions are sensitive to early cultivation at crop emergence and soon after but are more tolerant when in the 1- to 2-leaf stage (Baumann, 1994; Melander & Hartvig,1995).

Before the introduction of chemical herbicides, weed harrowing was frequently used in sugar beets. Today most sugar beets, especially in northern Europe are drilled to a stand and are not thinned. Therefore any plant stand reduction may affect yield. Wevers et al. (1993) showed that spring-tine harrowing caused significant plant losses when sugar beets had 2-4 leaves or less, but

less damage when beets had 4-6 leaves. Cultivation intensity, i.e. tine pressure and driving speed greatly influenced the extent of the plant losses (van de Zande & Kouwenhoven, 1994). Westerdijk et al. (1994) found that two low-dose herbicide applications followed by two weed harrowings resulted in weed control similar to multiple low-dose applications of herbicides without cultivation. When spring-tine harrowing began in the 6-8 leaf stage the plant losses were about 5%.

This paper presents results from a joint project, carried out in onions and sugar beets at Cornell University. The general aim was to evaluate the weed control effect and selectivity of different tools for in-row cultivation. In onions three different implements were evaluated and in beets the objective was to replace post-emergence herbicide applications with in-row cultivation.

Materials and methods

Two field experiments were conducted in 1994 on an Eel Silt loam soil near Ithaca, NY, USA. Both experiments were sown at a relatively wide row spacing of 76 cm (30 in) due to machinery constraints. Onions are usually grown at narrower row distance, but one of the in-row cultivators (Buddingh) required a minimum of 76 cm between the rows.

Experimental design was a randomised block with four replicates. Plots measured 3 x 9 m. The fields were fertilised, ploughed, disked and seedbed harrowed according to normal practices. *Galinsoga ciliata* (Rafin.) S.F. Blake was the predominant weed species. In the sugar beet experiment, *Amaranthus retroflexus* L. was also a major species. Numbers of weeds and crop plants were counted in-row in four 0.125 m^2 (1.25 x 0.10 m) quadrats in each plot before and after each in-row cultivation. Herbicides were applied with a tractor mounted sprayer with flat fan nozzles (Teejet, 8003LF) that delivered 260 L/ha at 200 kPa.

Experiment in onions

Onions (*Allium cepa* L.), cv. Oro Grande, were sown on 13 May with 50 seeds per row metre. Herbicides used were paraquat (Gramoxone Extra 2.5 WS, 300 g a.i./L, Zeneca) and oxyfluorfen (Goal 1.6EC, 190 g a.i./L, Rohm & Haas). All plots were treated preemergence with paraquat (0.28 kg a.i./ha). In the "chemical standard" treatment, oxyfluorfen (0.045 kg a.i./ ha) was applied, when the onions had three leaves. The in-row cultivation tools were used twice, when the onions had 1 true leaf (2-5 cm tall) and 2-4 leaves (10-20 cm tall). At the first in-row cultivation, *G. ciliata* had 0-1 true-leaf and *A. retroflexus* had two true leaves. At the second in-row cultivation, the weeds had 0-2 true leaves.

Three in-row cultivators were used in the onion experiment; an Einböck spring-tine harrow (tines 7 mm) from Austria, a Buddingh Model C Rubber finger weeder from Michigan, and a Bezzerides Torsion weeder (tines 9 mm) from California (Fig. 1).

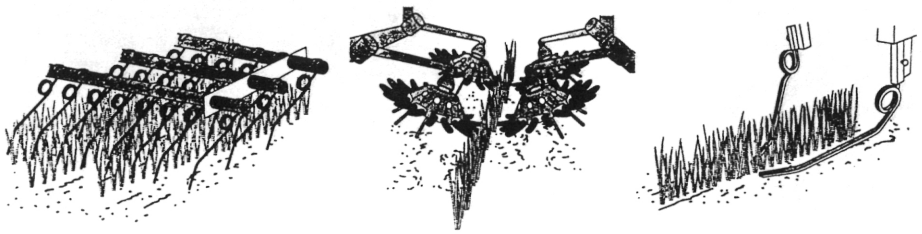

Fig. 1. The Einböck spring-tine harrow (left), the Buddingh rubber finger weeder (middle) and the Bezzerides torsion weeder (right).

All in-row cultivators were driven at two cultivation intensities, regulated by the driving speed. For the spring-tine harrow, driving speeds were 3 and 6 km/h for the low and high cultivation intensities, respectively. The cultivation depth varied between 0 and 4 cm.

For the finger weeder, at the first cultivation, both pairs of finger wheels were 2.5 cm apart. At the second cultivation, the rear pair were moved together so that the fingers were just touching each other. For the torsion weeder, the tines were 7.5 cm apart. The working depth with both tools was 1-3 cm and driving speeds were 2 and 4 km/h at the first cultivation, and 2.5 and 5.0 km/h at the second cultivation.

All plots were hand weeded after each in-row cultivation and the labour for hand weeding was recorded for each plot. All plots were between-row cultivated three times. Onions were harvested on 6 September.

Experiment in sugar beets

Sugar beets *(Beta vulgaris* L.*)*, cv. Maribo 862, were sown on 21 May with 8.7 seeds per metre. Herbicides and weed harrowing were applied in different combinations (Table 2). Herbicides were applied postemergence of the crop in low doses on an "as needed" basis, when new weeds were in the cotyledon stage, according to standard recommendations. Herbicides used were desmedipham (Betanex 1.3 EC, 160 g a.i./L , AgrEvo), desmedipham + phenmedipham (Betamix 1.3 EC, 80 + 80 g a.i./L, AgrEvo) and ethofumesate (Nortron 4.2 SC, 500 g a.i./L, AgrEvo). In the first treatment, desmedipham (0.13 kg a.i./ha) was applied at the cotyledon stage of the crop. The second and third applications were combinations of desmedipham, phenmedipham and ethofumesate (0.18 + 0.18 + 0.18 kg/ha at 0-2 leaves; 0.28 + 0.28 + 0.28 kg/ha at 6-8 leaves).

In sugar beets, only the Einböck spring-tine harrow was used for in-row cultivation. One preemergence weed harrowing was planned but was cancelled due to wet weather. Weed harrowings were carried out when, the beets had 0-2 , 6-8 and 8-12 true leaves, respectively. The harrowings were performed at two intensity levels, varying driving speed and tine pressure. At the low cultivation intensity (CI) the driving speed was 3 km/h and the cultivation depth 0-4 cm. For high CI the speed was 6 km/h and depth was 2-4 cm.

All plots were between-row cultivated twice. The last assessment of weeds and beets was done 22 July, 3 weeks after the last in-row cultivation. Sugar beets were harvested on 22 September and fresh weights were recorded, but the beets could not be processed.

Results

Experiment in onions

Early in-row cultivation at the 1-true leaf stage of the onions, reduced onion stands by one third (Table 1). However, a later cultivation when the onions had 2-4 leaves (10-20 cm tall), reduced the onion stand by only a few percent. Higher driving speeds seemed to give better weed control, and little or no additional crop damage. The spring-tine harrow and rubber finger weeder controlled weeds better, but also reduced yield more than the torsion weeder. The harrow and the finger weeder also caused a high proportion of onions with thick necks. The torsion weeder caused no significant yield reduction. The yield level was generally low, largely due to the wide row spacing. Labour time for hand weeding was roughly halved by the in-row cultivations compared with the treatments receiving only between-row cultivation.

Table 1. Effects of in-row cultivation in onions

Treatments	First cultivation % Reduction Weeds	First cultivation % Reduction Onion	Second cultivation % Reduction Weeds	Second cultivation % Reduction Onion	Hand weeding total labour h/ha	Yield t/ha Gross	Yield t/ha Marketable
Check	-	-	-	-	58	19.2	16.1
Chemical standard	-	-	64	2.5	52	18.8	16.0
Flex-tine harrow, Low[1]	63	34	50	3.5	32	11.9	9.0
Flex-tine harrow, High	64	39	61	9.5	28	8.1	6.3
Rubber finger, Low	76	49	40	1.0	22	11.1	8.3
Rubber finger, High	79	35	61	2.5	21	11.7	8.4
Torsion weeder, Low	47	31	27	3.3	29	17.5	15.1
Torsion weeder, High	53	27	52	3.2	28	16.9	14.7
LSD (0.05)	24	15	56	4.3	19	5.6	5.5
Significance (n.s. = p>0.05)	n.s.	n.s.	n.s.	*	**	**	**
Check	80/m^2	20/m	29/m^2	15/m			

[1] Each tool was driven at low and high driving speed

Experiment in sugar beets

Weed control and sugar beet yield were similar when replacing the last of the three herbicide applications with two harrowings (Table 2). Yield was 15 to 40% lower when two or all three herbicide applications were replaced by weed harrowing. Sugar beet stands were severely reduced when harrowing began when sugarbeets had 0-2 true leaves. However, the sugar beet stands were not significantly reduced when harrowing began at 6-8 leaves. When cultivated at 8-12 leaves at high cultivation intensity, beet stand reduction was slightly greater than when cultivated at 6-8 leaves because larger beets were uprooted by the tines. Weed control and yield was generally higher at higher driving speed than at lower driving speed.

Table 2. Effects of different combinations of weed harrowing and herbicides in sugarbeets

Treatments	Herbicide applications	Spring-tine harrowing	Weed reduction Number %	Weed reduction Weight %	Sugarbeets (x 1000) plants/ha	Sugarbeets Yield t/ha
In-row weedy check	-	-	-	-	65	20
Chemical standard	I+II+III	-	96	100	92	44
0 herb. appl. + 3 cult. low CI[1]	-	0[a]+1+2+3	44	3	48	27
0 herb. appl. + 3 cult. high CI	-	0[a]+1+2+3	80	47	67	37
1 herb. appl. + 3 cult. low CI	I	1+2+3	95	88	50	32
1 herb. appl. + 3 cult. high CI	I	1+2+3	83	74	47	36
2 herb. appl. + 2 cult. low CI	I+II	2+3	94	95	85	42
2 herb. appl. + 2 cult. high CI	I+II	2+3	96	99	82	45
3 herb. appl. + 1 cult. low CI	I+II+III	3	97	99	86	44
3 herb. appl. + 1 cult. high CI	I+II+III	3	98	100	80	46
LSD (0.05)			20	46	17	10
Significance			***	**	***	***
Check			453/m^2	2060 g/m^2		

[a] the preemergence weed harrowing was cancelled due to rain

[1] Low Cultivation Intensity (CI): 3 km/h, 0-4 cm cultivation depth. High CI: 6 km/h, 2-4 cm depth

Discussion

In onions, an integrated approach with one early herbicide application followed by two in-row cultivations with the torsion weeder significantly reduced labour for hand weeding without significant yield loss. Although weed control was better with the spring-tine harrow and the finger weeder, the yield reductions with these tools were unacceptable. This significant yield reduction with spring-tine harrowing is contrary to the reported results of post-emergence harrowing by Melander and Hartvig (1995). The discrepancy is probably caused by the earlier treatment and higher cultivation intensity (as judged by the weed control) in the present study.

Hand weeding was used in onions since it was not possible to control the weeds effectively with cultivation and herbicides in any of the treatments. The chemical standard treatment received one herbicide application more than the other treatments. Oxyfluorfen was applied according to New York State recommendations, but the weeds were too large at that date and the application had no effect on the time required for hand weeding. In northern Europe it is a common practice to use multiple low dose applications of herbicides in early growth stages. These usually provide good weed control but also may injure the crop.

When using post-emergence in-row cultivation, effective pre-emergence and early post-emergence weed control is necessary to give the onions a competitive advantage over the weeds. For early weed control, herbicides and flaming can be used. Weeds escaping early control measures have to be weeded by hand, since selective in-row cultivation is only effective on small weeds.

In the absence of herbicides, post-emergence selective flaming in onions can be used (Ascard, 1989), but mechanical in-row cultivation is an interesting alternative, since mechanical methods are cheaper and require less energy.

In sugar beets, the last of the three herbicide applications could be replaced by spring-tine harrowing without yield reduction. The effects on beet stands and yields largely agree with the results of similar studies in the Netherlands (Westerdijk et al., 1994; Wevers, 1995; Wevers et al., 1993) and in Sweden (unpublished). Westerdijk et al. (1994) showed that after two herbicide applications, continued weed control using spring-tine harrowing could be used from the 4- to 6-leaf stage of the beets without yield loss. It is, however, important that the spring-tine harrowing is carried out every time when new weeds are in the cotyledon stage.

Sugar beet stands can be reduced to some extent without yield reduction as long as the initial plant density is high enough. In sugar beets, spring-tine harrowing can be carried out safely in the 6-leaf stage. The above-mentioned Dutch and Swedish studies imply that in-row cultivation can be carried out already at the 4-leaf stage, with little stand reduction, as long as the cultivation intensity is relatively low. In the present study, the last weed harrowing at the 8-12-leaf stage caused relatively large plant losses and could probably have been replaced by ordinary row crop cultivation. The plant losses with this third cultivation did not however, result in any significant yield reduction. Weed harrowing offers the potential to replace some of the relatively expensive sugar beet herbicides.

Generally, the torsion weeder is a promising tool for early postemergence cultivation because it has high selectivity, however, due to the wide spacing between the tines weed control was relatively low in onions. In a similar study in sugar beets in Sweden (unpublished), weed control with a torsion weeder was similar and selectivity higher than with a spring-tine harrow or a rubber finger weeder. In addition, the torsion weeder is inexpensive and it can easily be mounted on a row crop cultivator. One critical requirement, however, for successful in-row cultivation with both torsion and finger weeder is accurate steering.

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