Economic Aspects of Physical Intra-Row Weed Control in Seeded Onions

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Hand weeding is still widely used in Northern Europe as the primary method for controlling weeds growing between the crop plants in the row (intra-row) in organic vegetables, such as seeded onions and leek, and carrots. Weeds between the crop rows (inter-row) can normally be controlled satisfactorily by inter-row cultivations.

Danish and Swedish vegetable growers commonly spend 100-300 h ha^{-1} to hand-weed onions and carrots (Ascard, 1990; Nielsen and Larsen, 1991), but the time may reach 500 h ha^{-1} in particularly weedy situations (Melander, unpublished). This is an appreciable financial burden in organic vegetable growing. Therefore, research has been conducted in recent years looking for effective physical intra-row weed control methods. New results have shown that combining pre-emergence flaming with post-emergence brush weeding can control more than 80% of intra-row weeds in seeded onions and kale without significantly damaging the crop (Melander, 1998). However, such a strategy is based on the use of special and expensive machinery. To the grower, this means considerable machinery investments.

The objective of this paper is to compare the economics of physical intra-row weeding and pure hand-weeding, exemplified respectively by two weed management systems for seeded onions grown in single rows with 50 cm row spacing.

Materials and Methods

Weed management systems considered

In the first system (S_1), intra-row weed control uses only hand weeding, while inter-row weeding is based on conventional hoeing with no extra need for manual weed removal.

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In the second system (S_2), pre-emergence flaming and post-emergence brush weeding are used to control intra-row weeds, while hand weeding is used to control weeds that survive the physical methods. As in S_1, inter-row weeds are controlled by conventional hoeing but with fewer passes, because the physical intra-row methods also control inter-row weeds. Brush weeding is done with a three-row vertical-axis rotary brush weeder. This implement is described in detail in Melander (1997). Results and experience obtained from former and current field experiments (Melander, 1998, and unpublished data) have shown that a strategy starting with pre-emergence flaming followed by two brush weedings may give 80-90% intra-row weed control. The first pass with the brush weeder is done when the onions are 5-8 cm tall, the second when they are approximately 10 cm tall. The adjustments of the brush weeder appropriate for seeded onions at the two treatment times are described in detail in Melander (1998). Re-emerging weeds and weeds surviving the physical methods have to be removed manually.

Equations used for the economic analysis

The annual costs T_C (\$ ha^{-1}) for each system, S_1 and S_2, were calculated from the following basic equation:

$$T_C = E_1 + E_2 + \ldots\ldots\ E_N + H_W \qquad (1)$$

where E is cost for weeding with implement 1, 2 and up to number N, respectively, and H_W is the cost for hand weeding of weeds surviving physical weed control.

E was calculated as:

$$E = O_E + P_N(V_C + M_C + T_E) \qquad (2)$$

where O_E is overhead expense, P_N is number of passes, V_C is the variable cost, M_C is the cost for manual operation of the implement, and T_E is the tractor cost. V_C includes the costs of repairs, maintenance, and gas consumption when flaming. O_E was calculated according to a commonly used annuity formula:

$$O_E = [I_C(r/(1-(1+r)^{-R_P}))]/A \qquad (3)$$

where I_C (\$) is the initial cost for the implement, r (%) is the interest rate, A (ha) is the area to be treated annually, and R_P is the repayment period in years. T_E was calculated as:

$$T_E = (T_H + T_W)/W_C \qquad (4)$$

where T_H (\$ h^{-1}) is cost per tractor working hour (which includes expenses for investment, repairs, maintenance, insurance, and fuel consumption), T_W (\$ h^{-1}) is the labour wage, and W_C (ha h^{-1}) is the working capacity of the implement (including 20% time for turnings). M_C was calculated as:

$$M_C = N_P T_W / W_C \qquad (5)$$

where N_P is the number of persons needed to operate the implement. The cost of hand weeding was calculated as:

$$Hw = [a + bW_D(1- W_E)]\ T_W \qquad (6)$$

where a and b are parameters from linear regression between time consumption for hand weeding and increasing weed density W_D (plant/m^{-2}), and W_E is the overall percentage weed control effect of the physical methods used in system S_2. (W_E is 0 in system S_1.) Parameter a (h ha^{-1}) reflects the time it takes to move along the rows looking for weeds, and b (h m^2 $plant^{-1}$ ha^{-1}) is the time for hand weeding per unit plant density. Further details about the economic aspects of mechanical weeding can be found in Weber (1997).

Parameter values

The parameter values presented in Table 1 were all fixed values in the calculations. All prices are Danish levels, but the currency is the US dollar (\$). The parameter values were obtained from: field experiments conducted previously (Melander, 1997, 1998); ongoing field experiments (Melander, unpublished); the Ph.D. dissertation of Weber (1997); and information from the Danish Machine Pool Organisation and the Danish Agricultural Advisory Centre. Parameter values for A, W_D, W_E, and T_W were all varied as shown in Figure 1. (T_W =15 \$ h^{-1} corresponds to the Danish minimum wage for adult labour).

Results and Discussion

The size of the area treated annually has a strong influence on the economics of using physical intra-row weeding as shown in Figure 1. The cost-savings when using system S_2 compared with system S_1 are either small or even negative when only small areas are grown. This is because the high investment in machinery is only used on a small area. However, a high weed density changes the economics strongly, as system S_2 becomes economically beneficial even on smaller areas. The cost for hand weeding is the major reason, because high weed numbers require many hours of hand weeding, which overshadows the cost for machinery investment and use.

Table 1. Fixed parameter values used in the economic analysis (equations 1-6). All prices are Danish levels.

Weed System	Method	P_N	N_P	W_C (ha/h)	I_C ($)	R_P (y)	r (%)	V_C ($/ha)	T_H ($/h)	a (h/ha)	b (h m^2 pl^{-1} ha^{-1})
S_1	hoe	4	0	1.20	5,199	10	8	2.1	9.2	-	-
	hand	-	-	-	-	-	-	-	-	28.2	0.93
S_2	flame	1	0	1.44	15,150	10	8	note 2	9.2	-	-
	brush	2	1	0.24	8,778	10	8	11.6	9.2	-	-
	hoe	2	0	1.20	5,199	10	8	2.1	9.2	-	-
	hand	-	-	-	-	-	-	-	-	28.2	0.93

[2]V_C was calculated as: $V_C = (527/A) + 46$, where $527 is the annual fixed cost for required overhauling and repairs and $46 is the cost of gas per ha (gas consumption is 50 kg ha^{-1}).

Less successful physical weeding resulting in lower weed control effects than the optimal 80% will generally reduce the benefits of system S_2. This is particularly evident at the low wage level and low weed density. At the low wage level, the benefits of system S_2 are present only for larger treated areas with high weed infestations. For countries with wage levels much lower than those presented here, it is questionable whether larger machine investments for weed control in vegetables could be profitable at all.

The present analysis does not account for other aspects, such as the release of time and manpower that the mechanisation of intra-row weed control would cause. In many parts of Northern Europe, where it might be difficult to find enough labour for hand weeding, physical intra-row weed control could increase the possibilities for growing more profitable organic vegetables and thereby improving income.

Conclusions

Physical intra-row weed control methods, such as flaming and vertical brush weeding, can reduce considerably the time required for hand weeding in seeded onions. The economic benefits of these techniques compared with pure hand weeding are very great in situations where: labour wages are high (North European level), the annual area grown with onions is relatively large, and the weed infestation level is high. In contrast, the methods become uneconomical when wages and the area treated annually are low, unless the weed density is extremely high or the machinery costs can be lowered considerably.

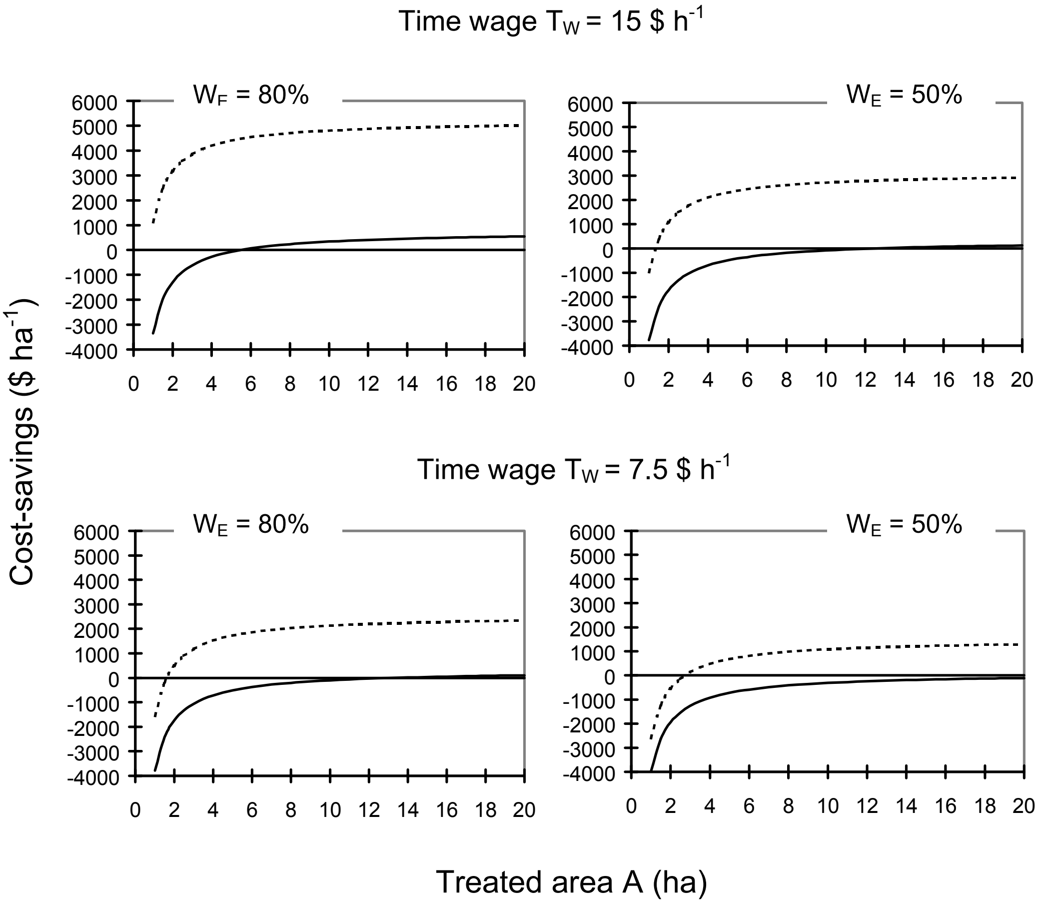

Figure 1. Graphic presentation of the cost savings when using weed management system S_2 compared with pure hand weeding S_1 for weed control in seeded onions. The analysis was done according to equations 1-6. W_E is the percentage effectiveness of physical intra-row weeding. The dotted and full-drawn lines are high (500 plants m^{-2}) and low (100 plants m^{-2}) weed densities, respectively.

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