Effects of Different Non-chemical Weed Control on the Yield and Quality of Onion (*Allium cepa* L.)

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Abstract

Four weed control methods were tested in two densities of onion sown from seeds and one density of onion grown from bulbs. They were pre-and post-emergence flaming in combination with one or two times inter-row cultivation for seed-sown, inter-row cultivation for bulb-grown onion, weed free and control (no weeding). There was no significant difference of dry matter production between high and low crop density at final harvest. High yield loss was observed for seed-sown onion under pre-and post-emergence flaming plus 2 times inter-row cultivation. However, one or two times inter-row cultivation produced high yield in onion grown from bulbs.

Introduction

Weeds compete with the crop for light, moisture, nutrients and space. They also increase the harvesting costs and serve as hosts for pests and diseases. As a result, yield losses occur in agricultural production. So, weed competition is always a problem in crop production especially if the crop growth rate is very slow at the beginning. Although herbicides can solve some of these problems, they also cause the negative effects, such as the development of resistant weeds, weed competition shift, environmental pollution and crop injuries. In addition, the residual effects of herbicides can be hazardous to the environment and human health. Due to over use of chemicals, different environmental problems are faced such as, loss of biodiversity and productivity, risk to human health and wild life through use of pesticide contaminated food and pollution of water sources (Merill, 1998). So, alternative ways to reduce chemicals by developing techniques that improve biological agriculture now seem to be the only way. The improved biological agriculture will help to supply pesticide free food while sustaining the environment. However, weed competition always becomes a serious problem where herbicides are not used. Due to their upright growth habit and low leaf areas, onions do hardly cover the soil until harvest. Consequently, weed competition in early growth stages seriously affects the yield and quality. Weeds between the rows can normally be controlled by inter-row cultivation. However, physical control of weeds growing between the plants in the row (intra-row) is a major problem, particularly in crops such as seeded onion and leek, carrot and sugar beet (Bond, 1991; Rasmussen and Ascard, 1995). Hand weeding is still widely used for controlling these weeds when the crop is grown organically, but this is very laborious and costly for the farmers. It becomes a problem in developing countries due to lack of labour especially in busy season. Therefore, it is very necessary to develop alternative methods of physical intra-row weed control in organically grown crops and in integrated systems where herbicide usage is minimized. Abu-Hamdeh (2003) observed that banded herbicide plus mechanical cultivation between the rows gave good crop yield in bean and barley compared with other cultivation methods alone. Hotte et al. (2000) also found that in carrots, herbicide use could be halved by band application of pre- and post-emergence herbicides on the row plus inter-row cultivation using a basket weeder in organic soil or a torsion weeder & spyders in mineral soil. This is because inter-row weeds were controlled with cultivation as a supplement to banded herbicides for intra-row weeds. This indicates that combination of two different weed control methods can give positive results instead of using only one because of their different efficacy in weed control. Alternatively, flaming is reported to control intra-row weeds and it is one of the possible ways to control intra-row weeds. Therefore, it is felt that it would be advantageous to combine flaming and inter-row cultivation in order to improve weed control strategies.

Crops generally are most competitive if they have vigorous growth, especially at stages when weeds are emerging in the field. Growing onion bulbs or transplants is one of the possibilities to improve crop vigour. Some reports have shown that onion grown from transplants can reduce yield loss compared with seed sown onion even without weeding. However, in vegetable production systems, information about the benefits of combining different physical weed control methods is very scarce. Vester (1986) also indicated that due to differences in technical efficiency of different weed control methods, their effectiveness may be improved by applying various combinations. Therefore, it is likely that cultural means may improve the outcome of physical weeding in vegetables by improving growth, competitiveness and robustness of crop plants more than that of the weeds. Basing upon the information, the following objective was developed:

- To analyse the effects of the combination of non-chemical weed control and crop competitive ability on yield and quality of onion

Materials and Methods

The experiment was carried out on a silty loam soil (80% silt, 10% sand, 10% clay, pH 6.5) at the experimental farm in Ruthe near Hannover, Germany from April to June, 2003. Four weed control systems were applied on two population densities of onion sown from seeds and one plant density of onion grown from bulbs. The plot size was 2 m x 11 m. Spacing (4 cm x 30 cm) was used for low density seed-sown and bulb-grown onion and spacing (3 cm x 30 cm) was used for high density seed-sown onion. There were 12 treatments in this experiment. The experimental plots were laid out by using randomised complete block design (RCBD) with four replications.

Treatments

T_1 – Low density seed-sown onion with pre-emergence flaming + 2 times inter-row cultivation
T_2 – Low density seed-sown onion with pre-and post-emergence flaming + 2 times inter-row cultivation
T_3 – Low density seed-sown onion with hand weeding
T_4 – Low density seed-sown onion without weeding (Control)
T_5 – High density seed-sown onion with pre-emergence flaming + 2 times inter-row cultivation
T_6 – High density seed-sown onion with pre-and post-emergence flaming + 2 times inter-row cultivation
T_7 – High density seed-sown with hand weeding
T_8 – High density seed-sown onion without weeding (Control)
T_9 – Bulb-grown onion with 2 times inter-row cultivation
T_{10} – Bulb-grown onion with 1 time inter-row cultivation
T_{11} – Bulb-grown onion with hand weeding
T_{12} – Bulb-grown onion without weeding (Control)

Onion seeds (cv. Stuttgarter Riesen) were sown in the seedbed by using precision planter and onion sets were grown directly by hand. Pre-emergence flaming was applied before crop emergence and post-emergence flaming was applied at whip stage of crop. First inter-row cultivation by duck-foot share was done at one true-leaf stage of crop and second cultivation by duck-foot share plus spring tine at 2-3 leaf stage of crop. The same treatments except flaming were applied for bulb-grown onion. The effects of weed control treatments were evaluated by counting the number of weeds and crop plants 2 days before and after the treatments and reassessment was followed by successive harvests. Types of weed species found in the experimental plots were noted and six common weed species were analysed for the assessment. For quality grading of bulbs, marketable bulbs were selected basing upon the parameters such as normal skin colour, small neck thickness, unbolted plants and bulb diameter larger than 4 cm. The ones that did not fit such parameters were considered as non-marketable.

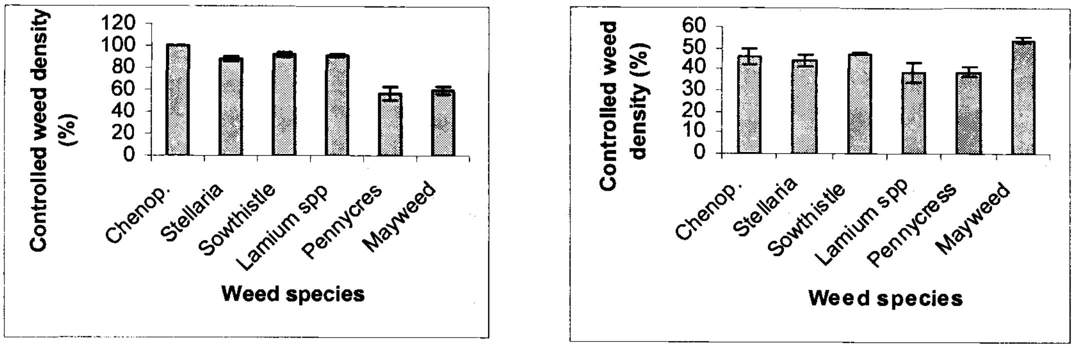
All data were analysed by using SAS statistical package (SAS/STAT, 1990) for regression analysis and analysis of variances (ANOVA). Differences between the mean values were measured by using Tukey test at a significance level of 0.05.

Results and Discussion

Percentage of controlled weed density in respect to flaming and inter-row cultivation

Twenty-two weed species were observed in the experimental plot. Among them, six common weed species were analysed for assessment of weed control methods. The common weed species were from 10 to 50% of total weed density and other weed species were not more than 5 % of total weed density. It was observed that second time flaming can control 100% percentage of *Chenopodium* spp and followed by 91.8% in Sowthistle (*Sonchus oleraceus*), 90.1 % in *Lamium* spp, 87.9 % in Common chick weed (*Stellaria media*), 59.3% in Scentless Mayweed (*Matricaria chamomilla*) and 56.4% in Field pennycress (*Thlapsi arvense* L.). The percentage of controlled weed density in *Matricaria chamomilla* and *Thlapsi arvense* L. was significantly lower than that in *Chenopodium* spp, *Sonchus oleraceus*, *Stellaria media* and *Lamium* spp because these two species were of rosette type when they were young especially at 2-4 leaf stage. When 2nd time (post-emergence) flaming was done, their growing points were protected by large leaves and so flaming burnt the upper larger leaves, however, the growing point was still alive after flaming. They started to become green and survive again 2-3 days after flaming. Ascard (1995) also reported that weed species with unprotected growing points and thin leaves such as *Chenopodium album* L., *Stellaria media* (L.) Vill and *Urtica urens* L. are very susceptible to flaming but a creeping habit and protected growth point could not be killed completely by one treatment, regardless of the rate or developmental stage. He also observed that species with protected growing points such as *Capsella bursa-pastoris* (L.) Medic and *Chamomilla suaveolens* (P.) Rydb were tolerant due to regrowth after flaming.

The percentage of controlled weed density of *Chenopodium* spp, *Sonchus oleraceus*, *Stellaria media* and *Lamium* spp were not significantly different from each other (Figure 1). Thus, it was noted that flaming can control 85.7% of total weed species. The percentage of controlled weed density by inter-row cultivation was not significantly different from each other among the species. However, it was found that about 50% of total weed species can be controlled by inter-row cultivation. This is because inter-row cultivation controls only inter-row weeds but not intra-row ones.The weeds standing within the rows got more chance for light, space and nutrients and became very vigorous. Bond and Burston (1996) also found that hoeing treatments removed only the



(a) (b)

Figure 1. Percentage of controlled weed density by (a) flaming (b) inter-row cultivation according to weed species.

inter-row weeds so that the weeds left within the crop row can be highly competitive and may reduce yield like un-weeded crop. The onions themselves are unlikely to suppress the within-row weeds effectively, even if grown at high density in salad onion.

Dry Matter Production

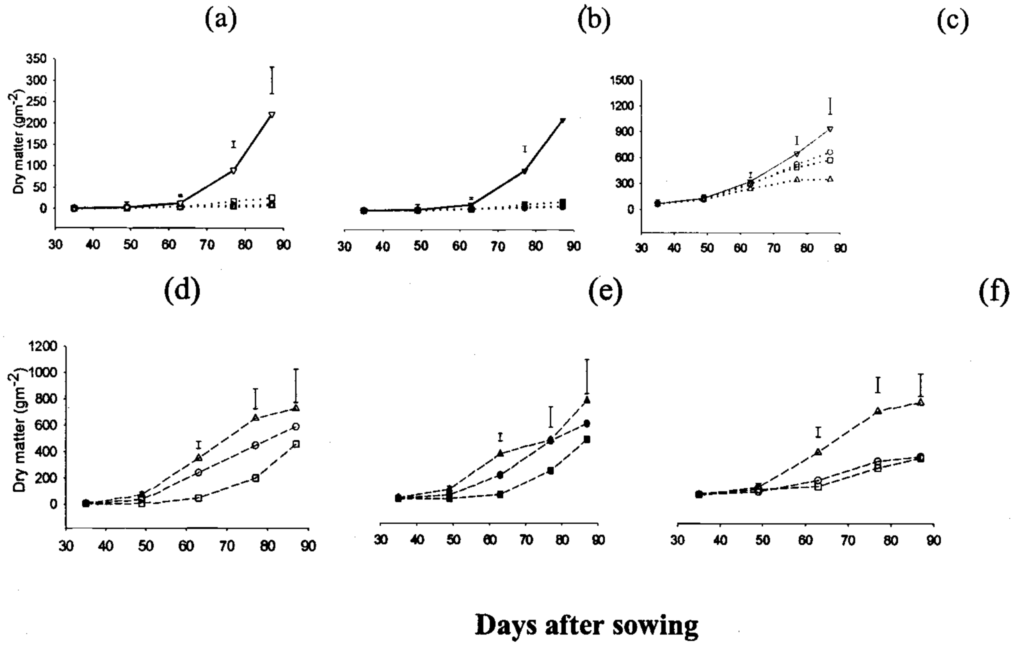


Figure 2. Dry mater production of crops (a-c) and weeds (d-f). Dotted line represents crop in crop-weed mixture; solid line represents mono crop and dashed line means weed in crop weed mixture. Open symbol indicates low sowing density and closed symbol indicates high sowing density. (○) 1- flaming + 2- inter-row cultivations, (□) 2-flamings + 2-inter row cultivations, (∇) weed free, (Δ) control. Bars indicate ± s.e. (a, b, d, e seed-sown onion and c, f bulb-grown onion).

Total biomass of crops in hand weeded and non-weeded treatments did not differ significantly in onion sown from seeds in both densities 35 days after sowing (Figure 2). However, at later harvests, (49 DAS, 63 DAS, 77 DAS and 87 DAS), hand weeded treatment had higher crop dry matter than the other treatments in both densities. From 35-49 DAS, crop from pre-and post-emergence flaming produced low dry matter significantly than the others. In the case of weeds, non weeded treatment produced significantly higher dry matter followed by one time flaming while two times flaming was the least in dry matter content. This is because post-emergence flaming reduces not only weed biomass but also affects the crop. Especially, the growth rate of crop significantly reduced about one month soon after post emergence flaming. They became stronger one month after post emergence flaming. During this duration, another flushes of weed came out with very high growth rates. The newly emerged weeds were more vigorous, grew very quickly due to low weed number, hence they easily covered the crop at the end. It was observed that at the time when the crop plants are stronger, the weeds become equally stronger because the growth rate of weed is very high compared to that of the crop. Another reason is that some weed species cannot be controlled by only one time flaming.

For bulb-grown onion, dry matter production of crop was not significantly different from each other from 35-63 DAS. From 63-87 DAS, weed free plot produced the highest dry matter significantly among the treatments (Figure 2).

Yield and Quality

Table 1. Onion yield and yield loss percentage

Treatment	Marketable Yield (tons/ha)	Non-Marketable Yield (%)	Total Yield Loss (%)
SlH_1	-	100 a	98.83 a
$SlF_2 + H_2$	-	100 a	95.42 a
SlM	15.85 d	21.8 b	-
SlC	-	100 a	98.49 a
ShH_1	-	100 a	97.47 a
$ShF_2 + H_2$	-	100 a	95.19 a
ShM	15.63 d	24.8 b	-
ShC	-	100 a	97.15 a
BH_1	32.55 b	9.67 de	12.96 c
BH_2	28.47 b	14.9 dc	18.10 c
BM	39.00 a	4.80 e	-
BC	23.47 c	20.0 bc	28.3 b

(The same letters in the same column are not statistically different at 0.05 level.) (S-seed, B-bulb, l-low density, h-high density, H_1- harrowing by spring tine + one time duck foot share, H_2-harrowing by spring tine+ two times duck foot share, M-weed free, C-control)

High yield loss percentage was observed in all treatments from onion sown from seeds in both years. It was the same like no weed control in both densities and so no marketable onion yield could be obtained in these treatments (spring tine plus one time duck foot share; spring tine plus two times duck foot share, no weeding). The highest yield loss was observed in SlH_1 and followed by SlC, ShH_1, ShC and the lowest yield loss was in $ShF_2 + H_2$. However, the percentage of yield loss was not significantly different among them (spring tine plus one time duck foot share; spring tine plus two times duck foot share, no weeding) for seed-sown onion (Table 1). It indicated that pre-and post-emergence flaming plus inter-row cultivation were not enough to get good onion yield if onions were sown from seeds. This may be because of very slow growth rate of onion and high growth rate of weeds and so the weeds can easily compete with onions.

For bulb grown onion, a yield of 39 tons/ha of onion bulbs was obtained from weed free treatment and followed by 32.55 tons/ha for one time inter-row cultivation, 28.47 tons/ha for two times inter-row cultivation and 29.36 tons/ha was found in control (no weeding). In the case of yield loss percent, non-weeded plot gave highest yield loss significantly compared with others for bulb grown onion (i.e. one time inter-row, two times inter-row) (Table 1). However, their yield losses were much less compared with seed sown onion in both experiments. These results indicate that one or two times application of spring tine plus duck foot share and control are very effective if onions were grown from bulbs. This may be because of high competitive ability of crop when they are first grown. Rasmussen & Rasmussen (2000) showed that crop seed vigour is particularly important in early establishment in wheat growing. These findings also agree with Caruso (2000). He found that control treatment (no weeding) causes 39.3% yield reduction compared with weed-free treatment when onions are grown from transplants. Babiker and Ahmed (1986) also pointed out that no weeding treatment reduced the yield by 26-48% and only once hand weeding 42 days after transplanting reduced the yield loss to 15% if the onions were grown from transplants. These results indicated that crop vigour is very important at an early establishment of the crop to get high competitive ability against the weeds. Marketable yield of seed-sown onion in weed-free treatment was relatively lower than bulb-grown onion because they were not fully matured compared with bulb-grown onion at final harvest.

Conclusion

Cultivation methods can control inter-row weeds but not intra-row weeds, resulting in severe yield reduction if onions are grown from seeds. These methods favor onion grown from bulbs and high yield can be obtained whether one or two times inter-row cultivation is used. High non-marketable yield in non-weeded plot is due to higher small-sized bulbs. Flaming can reduce weed density significantly at the time of application though it cannot control some rosette type weed species. The efficiency depends on time of application, weed size, plant age and type of flame burners. The reduced yield is due to later flushes of weed and slow growth rate of crop after flaming. Onion yield can be obtained to some extent if it is grown from bulbs even where it is not weeded. Therefore, high competitive ability of the crop is very important to compete against the weeds. High yield loss percentage in seed sown onion observed in this research indicates that further research is still necessary to find a way for effective weed control in order to get high yield when onion is grown from seed. Bulb grown onion can be one of the alternatives to reduce chemicals due to weed infestation.

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