Acta fytotechnica et zootechnica, Vol. 4, 2001, No 5
Proceedings of the International Scientific Conference on the Occasion of the 55th Anniversary of the Slovak Agricultural University in Nitra

PERFORMANCE OF TWO THERMAL WEEDERS IN APPLE ORCHARDS

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Summary

During 2 years, two methods field trials to investigate the efficacy of flame weeding and hot-steaming were conducted in apple orchards, in Nova Scotia-Morristown, Canada. At Flaming the most resistant perennial weeds were *Taraxacum officinale* Weber and *Leontodon autumnalis* L.. From annual weeds the most vigorous species was *Polygonum aviculare* L.. Flame weeding gave good reduction of annual species in early growth stages (to 6 true leaves) and at lower driving speeds. In 1999, the hot-steam treatments were less effective at perennial weeds. The efficiency of the 2nd treatment was higher 1 week after treatment, than 2 weeks after treatment. The most resistant species were *Linaria vulgaris* Mill. and *Polygonum aviculare.* In 1998 this technology wasn't effective, too. An exposure time of 540 s at 150ºC of the steam wasn't sufficient to control weeds.

Key words: weed control, apple orchard, flame, hot-steam.

Introduction

Weeds are a major problem in the agricultural production throughout the world and according to Rasmussen *et al.* (1995) especially in organic farming systems. It is difficult to quantify the impact of weeds on crop yields, a risk of high crop losses (20%) from high weed pressure is possible. Problems with herbicides, including underground and surface water contamination, pesticide residues in food, has sparked public awareness and restrictions of herbicide use.
Flame weeding is one of the alternatives to chemical weed control. Thermal weed control, which relies on heating plants until the cells burst (at 70-80ºC), is particularly valuable for pre-em. weeding in crops such as carrots, parsley and leeks, that are slow to germinate. Another alternative for non-chemical weed control is hot–steam based technology. Two companies have developed equipment that delivers superheated water from a boom or spray nozzle attached to a diesel – fired boiler. According to Riley (1995) this equipment can be used in windy or rainy conditions with no concern about drift, run off or loss of efficacy. The high pressure and hot water damages the cellular structure and kills weeds within several hours or a few days. First signs of the effectiveness are change of leaf colour and plant withering. The objectives of these studies are to determine the effectiveness for flaming and hot–steaming on weed regulation in apple orchards.

Material and methods

This study was initiated in 1998 for 2 years period as a co-operative project of Agricultural Engineering Department, in Truro, Nova Scotia and the Slovak Agricultural University in Nitra – Department of Agricultural systems. Field experiments were carried out on Apple Lane farm /ALF/ and Mountain Crest farm /MCF/ in Morristown, Nova Scotia. The experimental layout was a randomised blocks design, with three replicates for each experiment. At assessment, number of weeds were recorded in area of 0,5 m^2 (converted on the 1 m^2, later), which was randomly placed within each plot. Control plots with no weed control were included in each experiment.

Experiment I.

Post-emergence flaming

The flame treatments were performed with Reinert gas - propane weeder (made in Germany) in tree rows from both sides, at a gas pressure of 0,3 MPa. Flaming was conducted in 7 day intervals, three times (treatments T_1-first, T_2-second, T_3-third). The gas propane doses of single treatment were regulated by the tractor driving speed (2, 3, 4 $km.h^{-1}$) and were 35,0; 23,0 and 17,0 $kg.ha^{-1}$ respectively. Angle of burners position was adjusted at 40º to ground surface (4 burners parallely–closely one by one). Above ground level of burners was 0,14 m.

Experiment II.

Post-emergence hot-steaming

In 1999, the treatments were realised with prototype hot-steam machine (developed in Nova Scotia College-Agricultural Engineering Department in Truro, Canada), at the temperature of 150ºC and 1 $km.h^{-1}$ driving speed and above ground level was 0,15 m. Hot steam applications were carried out in 7 day intervals (altogether two treatments were applied in each plot). After 2nd treatment two weed counts were done in 7 and 14 days interval. In 1998, the treatments were performed with the Easy Kleen hot steam unit, at a pressure of 1 MPa and temperature of 150ºC. The exposure time was increased from 2 to 6 and 9 min in six day intervals (three treatments were applied in each plot). The effectiveness of each application on prevalent weed species was assessed before and after each treatment.

Results and discussion

Experiment I.: Total reduction of perennial weeds after three treatments was 45,1% at driving speed of 2 km.h^{-1} and total gas dose (TGD) of 105 kg.ha^{-1}. There was almost no difference in weed reduction between driving speeds of 3 and 4 km. h^{-1}, where 4,6% and 4,0% efficacy was achieved, at TGD of 69,0 kg.ha^{-1}and 51,0 kg.ha^{-1}respectively. At driving speed of 2 km.h^{-1} the 3rd treatment with 34,7% weed reduction was the most effective. The most resistant perennial weeds were *Taraxacum officinale* and *Leontodon autumnalis* L.. Excellent results were achieved with annuals, in particular at lowest speed, with reduction from 61,9 to 100,0%. The efficacy of single treatment depends on the driving speeds and decreases in the order of 2, 3 and 4 km.h^{-1}. The driving speed of 4 km.h^{-1} and the lowest TGD (51,0 kg.ha^{-1}) was less effective. The most sensitive species was *Lamium amplexicaule* L. (100,0% of reduction), however the most resistant weed was *Polygonum aviculare* L. with 62,0% reduction at lowest speed and 0,0% reduction at highest speed and growth stage of 8 and more true leaves. According to Ascard (1995), the tolerance of different plants towards flaming depends on factors such as the presence of protective layers of hair and wax, lignification, conditions of water status, developmental stage, type of plant habit (upright, prostrate, creeping), protection of growth points. Weed species with prostrate and creeping habit (*Capsella bursa pastoris*, *Poa annua*, *Chamomilla suaveolens*) at later developmental stages (five leaves and more) could not be controlled with one treatment regardless of the gas rate, because of their capacity for regrowth.
Experiment II.: In 1999, it is clear that hot-steam treatment was less effective technology, because total reduction of all species was lower – 58,2% after T_1 and 67,7% 1 week after T_2. At perennial weeds - *Epilobium ciliatum* Raf., *Malva rotundifolia* L. and *Plantago major* L. was minimum 70,0% reduction achieved, what can be explained by young growth stage of plants. The 1st treatment was at about of 33,5% more effective than the 2nd. Efficiency of the 2nd treatment was higher 1 week after treatment, than 2 weeks after treatment. The most resistant species were *Linaria vulgaris* Mill. and *Polygonum aviculare*. Low reduction of *Amaranthus retroflexus* was influenced by the extent of weed re-emergence before 2nd treatment and at *Chenopodium album* by the older growth stage. The results showed, that for higher reduction of vigorous weeds and for a longer time effect, the repetition of treatment is necessary, already 2 weeks after previous treatment. In 1998, the hot steam treatment was ineffective as an alternative method of weed control. Though the weeds were stunted after treatment, they were not killed. Perennial weeds (*Taraxacum officinale*) were hardly affected by hot steam in spite of their quite early stage of growth. After the 1st steam application and an exposure time of 120 s, only a 12,1% reduction of weeds was achieved. The 2nd application was even less effective, only 5,3% of weeds were eliminated, and after the 3rd treatment there was germination and young plants developed. Daar (1994) writes, that one hot-steam treatment kills most annual weeds and young perennials. Top growth of older perennials can be killed in one or two treatments, but impact on roots may be minimal unless repeated kill of top growth is employed to starve roots of nutrients. Riley (1995) pointed out, that the use of a hot steam machine may not be practical or ecologically sound in dry areas. The hot steam system is most effective when used within an integrated programme using a variety of cultural, physical, mechanical and biological tactics to solve the weed problem.
This study on the use of flame weeding and hot-steam technique in apple orchards have shown the following results during 2 years:

– very flame tolerant perennial weeds were *Taraxacum officinale* Weber and *Leontodon autumnalis* L. in which very low weed reduction (44,9% and 30,3%) was achieved at 2 km.h^{-1}, after 3rd treatment (T_3) and at total gas dose of 105,0 kg.ha^{-1}. The most vigorous annual species was *Polygonum aviculare* L., in which 0,0% reduction was at higher speeds, because this weed was in growth stage of 8 to more true leaves,
– in 1999, the most resistant species against the hot-steam were *Linaria vulgaris* Mill. (24,2% reduction after T_1; 54,5% 1 week after T_2) and *Polygonum aviculare* (9,1% reduction); in 1998, the most resistant species against the hot-steam was *Amaranthus retroflexus* L., in which 0,0% reduction was achieved after the 3rd treatment and an exposure time of 540 s,
– weed effect of flaming and hot-steaming depends on the weed species and their growth stage, propane dose, ground speed, adjustment of gas pressure, angle of burners position, uneven of soil and on a driver ability to drive machine without tree damage, on the actual atmospheric conditions etc.,

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