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The comparison of thermal and mechanical systems of weed control

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Abstract. In ecological farming weed control after sowing time is pursued by mechanical, and recently, by thermal means. In thermal weed control both the surface of the soil and the roots of cultural plants remain undisturbed, however, the l cultured plant experiences a thermal shock. This combination of factors has a positive influence on productivity. Data for the comparable efficiency of thermal and mechanical weed control research results in 2001–2003 and 2005 are presented. 16 weeds were destroyed. Thermal weed control for annual weeds is 22.5% more effective in comparison with the mechanical method, however the latter is 32% more effective for perennial weeds.

Key words: thermal weed control, weeds, technology

INTRODUCTION

In the last decade a trend towards conservation agriculture has become more and more distinct worldwide even though it requires comparatively more manual labour. On ecological farms, weeds that emerge after sowing are exterminated by mechanical removal, and by physical processes such as harrowing and inter-row cultivation. Mechanical weeding unavoidably injures both the roots and aboveground parts of cultured plants. reducing productivity (Lisek, 2001).

The application of thermal weed control processes is increasing, and utilization of flaming by gas, hot water and liquid water vapour procedures is rapidly expanding. (Ascard, 1995; Sirvydas et al., 2003). Thermal weed extermination is based on thermal energy exchange and balance in a high temperature medium. Raising the plant temperature to more than 58°C assures a lethal outcome for the weed. The biological struggle of the plant against the unusual effects ofsuch a high temperature medium takes place, the duration of which depends upon the mass of plant tissues involved and the thermodynamic properties of the thermal medium applied. In liquid water vapor, weeds with smaller biometric dimensions reach the lethal level in 0.5–2 s; larger weeds undergo thermal stress in the same time frame. As a result, productivity of sown crops is increased (Vasinauskiene, 2004). Data in literature on extermination of various weed plants in high temperature media were not found.

The aim of this work is to establish the comparable efficiency of mechanical and thermal weeding and the sensitivity of weeds to high temperature liquid water vapour medium.

MATERIALS AND METHODS

Length of a basic experimental patch – 4 m, width – 2 m. Onions "Centurion F_1" were sown every 25 cm in spaces between rows and every 7 cm between seedlings. The basic patch area taken into account was 4.5 m². The experiment was repeated six times.

In the first variant weeds were removed manually 3 times. This is the traditional way of weeding. The he first time weed removal occurred just after mass shooting, when first and second leaves had appeared. Weeds were removed the second and the third time at the same stage of appearance of the first to second leaves. In the second variant weeds were exterminated using liquid water vapour two times during the vegetative season. Duration of the thermal exposure was 2 seconds. Thermal weed extermination was carried out in the entire basic patch without protection for onions from the exposure to liquid water vapour. For the first time weeds are removed just after mass shooting in the stage of appearance of the first to second leaf. Thermal liquid water vapour was used for the second time shooting in the stage of appearance of the first to second leaf. Weeds were counted in each patch before thermal weed control procedures in all experimental patches, and in four locations in each patch having an area of 0.25 m², sort-composition analysis of weeds was carried out. Weed reduction percent values according to weed groups were established for different weed control technologies.

In 2005, remaining weeds in the carrot crop area were counted on the fourth day after extermination and sort-composition was not determined. Weeds were exterminated just sprouting in the seed-lobe growth stage.

RESULTS AND DISCUSSION

Investigations of thermal weed control using various weed extermination technologies have shown that different sorts of weeds are destroyed to different extents. In 2002–2003 weeds Stellaria media L. Vill., Chaenorhinum minus (L) Lange, Galinsoga parviflora Car were destroyed completely (up to 100%) while after the simple mechanical removal, on average 29.7 to 0.64 unit m^{-2} weeds remained although disturbed. Thermal weed control leaves the soil structure unchanged without activating new weed sprouting. Weed extermination efficiency for separate weed control technologies is presented in Table 1.

In the experiments in 2001–2003, 16 kinds of prominent weeds were investigated;37.5% were perennial and 62.5% were short–lasting weeds. Their biological properties determine the extermination procedures of short age and of monocotyledonous (Fig. 1A, 1B) and perennial (Fig. 2) weeds using liquid water vapour medium.

Survey of the three year period data for harvesting period (Fig. 1A) shows that mechanical extermination left on the average 29% of weeds to grow, while extermination using liquid water vapour left only 6.5% of weeds Thermal extermination of short age weeds using liquid water vapour is effective enough. We can see from (Fig. 1B) that short age monocotyledonous weeds (Echinochloa crus-galli (L.) Pal. Beauv., Poa annua L.) have greater resistance to liquid vapour medium.

Efficient extermination of monocotyledonous weeds is determined mainly by their biological properties and growth stages. Extermination of monocotyledonous weeds is most successful in the growth stages of sprouting-first leaf. Count of weed numbers during onion harvesting time showed that weed extermination left 28–40% of perennial weed plants not destroyed, while thermal extermination using liquid water vapour left 26–72% (Fig. 2). Thermal weed extermination destroys only the aboveground part of the weed plant and this influences the revival of the perennial weeds. In 2001 experiments among weeds species *Sonchus arvensis* L., and *Elytrigia repens* (L.) prevailed in number and this influenced the great variation of weed quantities (unit m^{-2}).

In 2005, thermal weed control was carried out in the carrot crop area 8 days after sowing. Weeds were exterminated during the sprouting phase (Fig. 3A). With the use of mechanical weed control, 72.66% of weeds were destroyed, while after thermal control procedures 98.82% of weeds were destroyed (Fig. 3B).

During mechanical weed extermination in most cases they are not exterminated in close proximity to the cultured plant. During thermal extermination weeds are flushed by liquid water vapour completely and they are exterminated even in the closest proximity of the plant.

Table 1. Number of weed plants (unit m^{-2}) during harvesting after mechanical and thermal weeding.

Weeds species	Mechanical weed control			Thermal weed control		
	2001	2002	2003	2001	2002	2003
	$\bar{x} \pm S_{\bar{x}}$					
Chenopodium album L.	3.33±0.82	0.89±0.42	4.31±0.93	1.50±0.55	0.00±0.00	1.33±0.52
Atriplex patula L.	1.33±0.52	34.64±2.63	14.00±1.67	0.33±0.52	0.83±0.41	0.00±0.00
Stellaria media L. Vill.	1.50±0.55	1.56±0.56	2.97±0.77	0.17±0.41	0.00±0.00	0.00±0.00
Veronica Spp.	1.33±0.52	2.00±0.63	1.56±0.56	0.00±0.00	0.83±0.41	0.83±0.41
Chaenorhinum minus (L.) Lange	1.50±0.55	0.64±0.36	0.64±0.36	0.33±0.82	0.00±0.00	0.00±0.00
Galinsoga parviflora Car.	1.33±0.52	0.75±0.39	1.75±0.59	0.00±0.00	0.00±0.00	0.00±0.00
Matricaria inodora (L.)	0.83±0.41	6.00±1.10	0.89±0.42	0.00±0.00	8.83±1.33	5.50±1.05
Echinochloa crus-galli (L.) Pal. Beauv.	2.83±0.75	6.75±1.16	7.75±1.25	1.50±1.05	11.33±1.51	9.50±1.38
Poa annua L.	7.33±1.21	58.22±3.41	39.31±2.80	7.00±5.40	18.83±1.94	91.33±4.27
Capsella bursa pastoris Moench	1.33±0.52	6.22±1.12	3.75±0.87	1.33±1.37	1.50±0.55	1.33±0.52
Equisetum arvense L.	0.83±0.41	2.00±0.63	13.56±1.65	0.17±0.41	1.33±0.52	4.00±089
Mentha arvensis L.	1.33±0.52	1.56±0.56	1.75±0.59	0.50±0.84	0.00±0.00	3.33±0.82
Plantago major L.	1.33±0.52	12.89±1.61	18.00±1.90	0.17±0.41	3.33±0.82	4.83±0.98
Elytrigia repens (L.)	1.50±0.55	3.75±0.87	0.89±0.42	12.67±9.03	9.50±1.38	3.50±0.84
Carsium arvense (L.) scop.	2.00±0.63	3.56±0.84	16.22±1.80	6.67±6.15	2.83±0.75	11.50±1.52
Sonchus arvensis L.	5.33±1.03	4.75±0.97	8.89±1.33	12.00±6.54	10.83±1.47	11.50±1.52

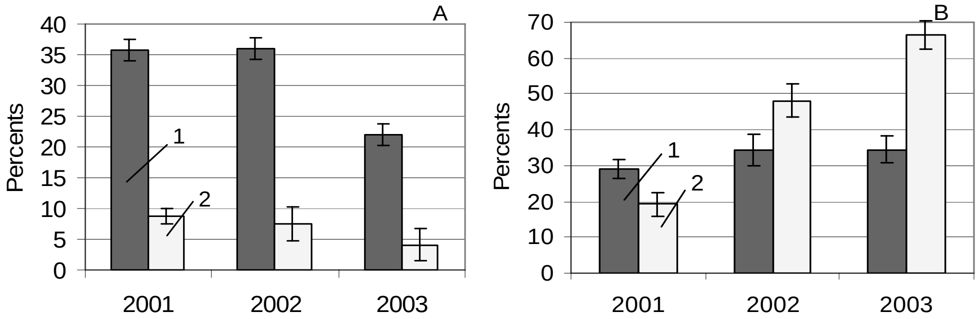

Fig. 1. Percentage of non-destroyed weeds for different weed thermal control technologies: 1–mechanical weed control, 2–thermal weed control. A–short age weeds, B–short age monocotyledonous weeds.

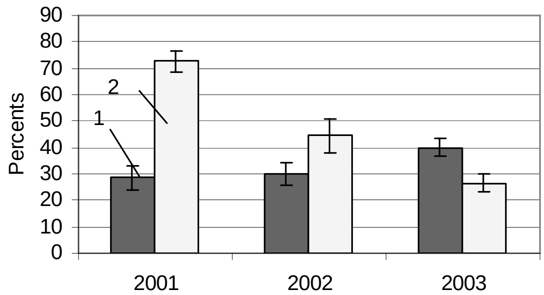

Fig. 2. Percentage of remaining perennial weeds after mechanical and thermal weed control procedures: 1–mechanical weed control, 2–thermal weed control.

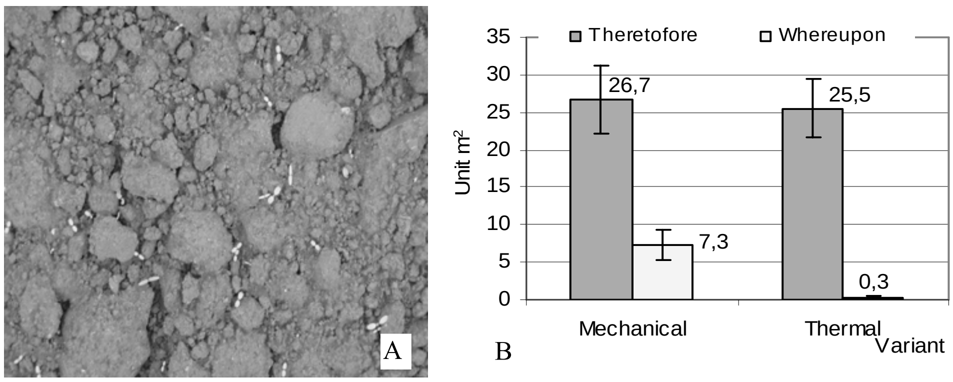

Fig. 3. Comparison of various weeds extermination technologies: A–view before weed extermination, B–comparison of thermal and mechanical weed termination efficiencies.

CONCLUSIONS

Thermal weed extermination is more advantageous if compared with mechanical one in properly cultured soils. Thermal weed control for short age weeds is 22.5% more effective in comparison with mechanical way. Mechanical removal is 32 % more effective for perennial weeds. Thermal weed extermination by liquid water vapour is applied at the shooting stage. Shooting weeds are destroyed in the closest proximity of the cultured plant. In the crop area of onions grown by seedlings during vegetative season weeds should be exterminated two times. In the carrot crop area weeds during vegetative season should be exterminated three times. Duration of exposure to liquid water vapour media is 2 seconds.

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