

Weed Control by Flaming and Hot Steam in Apple Orchards

NABIL RIFAI¹, MAGDALENA LACKO-BARTOŠOVÁ², ROMAN SOMR²

¹Agricultural Engineering Department, N.S.A.C. Truro, Canada; ²Slovak Agricultural University, Nitra, Slovak Republic

Abstract

RIFAI N., LACKO-BARTOŠOVÁ M., SOMR R. (1999): Weed control by flaming and hot steam in apple orchards. *Pl. Protect. Sci.*, 35: 147–152.

Field experiments to investigate the efficacy of weed control by flaming, hot-steam and mulching on the natural weed flora at different developmental stages were conducted in apple orchards in Nova Scotia, Canada. The perennial weed most resistant to flaming was *Malva neglecta*, with no control at a total gas dose of 320 kg/ha. The effect of flaming on annual weeds depends mainly on the developmental stage of weed species and the propane dose required for the desired control level. To control annual weeds at later developmental stages (> 6 true leaves), single flame treatment with a propane dose of 54–40 kg/ha was not sufficient. For *Chenopodium album* three subsequent treatments were necessary for 95% control at a total propane dose of 162 kg per ha. For the flame control of *Taraxacum officinalis* the developmental stage is also crucial. If flame tolerant perennial weeds occurred in the orchard, only 76% weed reduction was achieved after four treatments and a total gas dose of 320 kg/ha. In an orchard with mainly annual weeds, three treatments and 162 kg/ha of propane controlled 95% of the weeds. The hot steam technology was not effective. An exposure time of 540 s at 150°C of the steam was not sufficient to control weeds. Mulching was a good alternative to reduce herbicide use, regardless of material used: coarse bark, saw-dust, hay.

Key words: ecological farming; apple orchards; flame weeding; hot steam weeding; mulching

Weeds are a major problem in agricultural production throughout the world. To maintain yields of crops, weeds must be controlled. Problems with herbicides, including ground water and surface water contamination, other off-site movement, and pesticide residues in food, has raised public awareness and caused restrictions of herbicide use. These problems have challenged weed scientists to consider alternative and integrated systems of weed management to reduce herbicide inputs and impacts.

Flame weeding is one of the alternatives to chemical weed control. It is used in organic farming for pre-emergence control in slow germinating row crops. In some heat tolerant crops, selective post-emergence flaming is also used. Selectivity can be obtained by directing the flame pattern toward the weeds and away from the crop. Although flame weeding has been used for many decades, the method is often associated with problems such as high energy consumption, low driving speed and irregular weed control. (ASCARD 1994; RIFAI *et al.* 1996).

Another alternative for non-chemical weed control is based on hot steam. Two companies, Waipuna Systems Ltd. from New Zealand, and Aqua Heat from Minneapolis M, USA, have developed equipment that delivers superheated water from a boom or spray nozzle attached to a

diesel – fired boiler. 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. According to RILEY (1995) this equipment can be used in windy or rainy conditions with no concern about drift, runoff or loss of efficacy.

A convenient alternative method for apple growers is mulching. It is labour intensive, but it reduces the use of chemical herbicides, and the results are long-lasting. Hay, sawdust and coarse bark can be used as mulching materials.

The objective of these studies was to determine the effectiveness of flaming, hot steam and mulching to reduce weeds in apple orchards.

MATERIALS AND METHODS

This study was initiated in 1997 as a cooperative project of the Agricultural Engineering Department, N.S.A.C. Truro, Nova Scotia, Canada, and the Slovak Agricultural University at Nitra with advisory assistance from Scotian Gold Cooperative Limited and the Horticultural Crops Advisory Services from Kentville Agricultural Center, Nova Scotia. Financial support for this project was ob-

tained from Agri-Future, Nova Scotia Fruit Growers Association and J. W. Mason & Sons Ltd. The prototype hot steam unit was supplied by Easy-Kleen Systems Ltd. Field experiments were carried out on Apple Lane Farm and Mountain Crest Farm, at Morristown, Nova Scotia. The experimental layout was a randomized blocks design, with four replicates for each experiment.

Experiment I - Post-emergence Flaming (both farms)

The flame treatments were performed with a Reinert flame weeder in tree rows from both sides, at a gas pressure of 0.15 MPa. The gas propane doses of a single treatment were regulated by the driving speed of the tractor (2, 3 and 4 km/h) and were 80, 54 and 40 kg/ha respectively. Flaming occurred in an active width of 1.0 m. Post-emergence flame weeding was done up to four times in 5-7 day intervals at Mountain Crest Farm (treatments: T₁ - single; T₂ - two times; T₃ - three times; T₄ - four times), and the total gas doses of four treatments (T₄) were 320 kg per ha at 2 km/h driving speed and 216 kg/ha at 3 km/h driving speed. At Apple Lane Farm flame-weeding was applied three times (treatments: T₁ - single; T₂ - two times; T₃ - three times) at three driving speeds (2, 3 and 4 km/h) and total gas doses of 240, 162 and 120 kg/ha at treatment T₃. To assess the effect, the number of weeds were recorded in area of 1 m², which was randomly placed within each plot. For *Chenopodium album* L. and *Amaranthus* spp. observations of the effect of single flaming were made at different developmental stages of weeds at 2, 3 and 4 km/h driving speeds.

Experiment II - Post-emergence Hot Steam

The treatments were performed with the Easy Kleen hot steam unit, at a pressure of 1 MPa and temperature of 150°C. 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. The number of weeds was recorded in an area of 1 m² in each replicate.

Experiment III - Mulching

Materials for mulching were: coarse bark, sawdust and hay. The objective of this experiment was to prolong the effect of herbicides. Simazine and Paraquat were used before mulching and on the control plot.

RESULTS AND DISCUSSION

Flaming is usually most effective on smaller plants at the seed leaf stage, but differences between annual and perennial weeds can be expected. The control effect in practice also depends on weather and technical parameters of the machine. According to PARISH (1989), the effectiveness of a gas burner depended on its design, angle to the horizontal, and the height of the burner above the ground.

Experiment I

In the 10 year old apple orchard at the Mountain Crest Farm the prevailing weed species were the perennial *Tara-*

Table 1. Effect of flaming on weeds in an apple orchard, Mountain Crest Farm, Morristown

Driving speed [km/h]	Treatments	Weed counting	Weed species			Total number of weeds per m ²	Percentage of	
			<i>Taraxacum officinalis</i>	<i>Malva neglecta</i>	<i>Amaranthus</i> spp.		reduction	reduction to T ₁
2	T ₁	before	7.60	1.33	6.33	15.26		
		after	4.60	1.33	3.33	9.26	39.3	39.3
	T ₂	before	4.60	1.33	3.33	9.26		
		after	2.33	1.33	2.00	5.66	38.9	62.9
	T ₃	before	2.33	1.33	2.00	5.66		
		after	2.33	1.33	2.00	5.66	0.0	62.9
	T ₄	before	2.33	1.33	2.00	5.66		
		after	2.33	1.33	0.00	3.66	35.3	76.0
	% of reduction to T ₁			69.3	0.0	100.0		
	3	T ₁	before	19.60	2.00	3.33	24.93	
after			12.30	2.00	0.00	14.30	42.6	42.6
T ₂		before	12.30	2.00	0.00	14.30		
		after	8.30	2.00	0.00	10.30	28.0	58.7
T ₃		before	8.30	2.00	0.00	10.30		
		after	8.00	2.00	0.00	10.00	2.9	59.9
T ₄		before	8.00	2.00	0.00	10.00		
		after	4.33	2.00	0.00	6.33	36.7	74.6
% of reduction to T ₁			77.9	0.0	100.0			

xacum officinalis and *Malva neglecta*, and the annual *Amaranthus* ssp. (Table 1). The total reduction of weeds after four treatments did not differ significantly between the two driving speeds used. At 2 km/h and a total gas dose of 320 kg/ha only a 1.4% higher weed reduction was achieved than with 3 km/h, where the weeds were reduced by 74.6%. The most resistant weed was *Malva neglecta*, in which 0% control was recorded. Better control was achieved in *Taraxacum officinalis*; two flammings were sufficient for 96% control at 2 km/h, but at 3 km/h four flammings were required for 77.9% control. The population of *Amaranthus* ssp. was completely killed at a widely ranging dose of 54–320 kg/ha, depending mainly on the developmental stage of the weed and the extent of emergence after each treatment.

At the Apple Lane Farm (Table 2) better results of weed control were achieved with flaming than at the Mountain Crest Farm. The prevailing weed species were annuals, such as *Chenopodium album*, *Polygonum aviculare* and *Amaranthus* ssp., while the only perennial weed was *Taraxacum officinalis*. A 95% reduction in weed numbers was achieved at driving speeds of 2 and 3 km/h, with little difference. The most effective first flaming with a weed reduction of 72.3% was at the dose of 54 kg/ha at 3 km/h. At this driving speed all weeds were completely killed after three flammings, except *Chenopodium album* where 95.2% control was achieved with a total dose of 162 kg/ha.

This result is influenced by the later developmental stage of *Chenopodium album*, with over eight true leaves present. At this stage only 41% weed reduction was recorded for this species at a single treatment. The driving speed of 4 km/h and the lowest total dose of gas (120 kg/ha) was less effective, with only 77.9% reduction after three flammings.

The population of *Chenopodium album* was only reduced by about 84%, and the suppression of other weed species was not sufficient, because of regrowth and a high extent of new weed development after treatments. 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, condition of water status, developmental stage, type of plant habit (upright, prostrate, creeping), protection of growth points. *Chenopodium album* is considered a sensitive species, with unprotected growth points and thin leaves. At a stage of one to four leaves it can be completely killed at rates of 20–50 kg/ha, but at later stages considerably higher rates are required (50–200 kg/ha). At the Apple Lane Farm the dominant species was *Chenopodium album*. The effect of a single flaming at different developmental stages of *Chenopodium album* and three driving speeds is shown in Table 3. This weed was completely killed by a single treatment at the stage of four to six true leaves, at a driving speed of 2 km/h. An 80% weed reduction was achieved with 2 and 3 km/ha driving speeds

Table 2. Effect of flaming on weeds in an apple orchard, Apple Lane Farm, Morristown

Driving speed [km/h]	Treatments	Weed counting	Weed species					Total number of weeds per m ²	Percentage of reduction	
			<i>Chenopodium album</i>	<i>Taraxacum officinalis</i>	<i>Amaranthus</i> ssp.	<i>Polygonum aviculare</i>	others		reduction	to T ₁
2	T ₁	before	65.33	1.00	6.66	0.33	3.34	76.66		
		after	36.00	0.00	1.33	0.33	0.34	38.00	50.43	50.43
	T ₂	before	36.00	0.00	1.33	0.33	0.34	38.00		
		after	7.66	0.00	0.00	0.00	0.00	7.66	79.84	90.00
	T ₃	before	7.66	0.00	0.00	0.00	0.00	7.66		
		after	1.33	0.00	0.00	0.00	0.00	1.33	82.64	98.27
	% of reduction to T ₁			97.96	100.0	100.00	100.00	100.00		
	3	T ₁	before	96.00	3.00	2.00	0.33	2.33	103.66	
after			26.66	0.00	0.66	0.00	1.33	28.65	72.36	72.36
T ₂		before	26.66	0.00	0.66	0.00	1.33	28.65		
		after	11.00	0.00	0.66	0.00	0.00	11.66	59.30	88.75
T ₃		before	11.00	0.00	0.66	0.00	0.00	11.66		
		after	4.60	0.00	0.00	0.00	0.00	4.66	60.03	95.50
% of reduction to T ₁			95.21	100.00	100.00	100.00	100.00			
4		T ₁	before	80.33	1.33	1.33	0.00	3.04	86.03	
	after		54.66	0.33	0.66	0.00	0.68	56.33	34.52	34.52
	T ₂	before	54.66	0.33	0.66	0.00	3.01	58.66		
		after	30.33	0.00	0.66	0.00	0.68	31.67	46.01	63.19
	T ₃	before	30.33	0.00	0.66	0.00	11.00	41.99		
		after	12.66	0.00	0.00	0.00	6.33	18.99	54.77	77.93
	% of reduction to T ₁			84.24	100.00	100.00	-	+51.97		

when the weed had six to eight true leaves. At a later stage (> eight true leaves) only 41% control was recorded at 3 km/h. At higher driving speed (4 km/h), the dose of 40 kg/ha was not sufficient to control *Chenopodium album*. In field conditions only weeds at later developmental stages were found and that is the reason why the overall reduction was only 27%. While plants with six to eight true leaves were killed up to 40.8%, those with more than eight leaves were not controlled at all. The above-ground parts of the plants (mainly leaves) were only partly desiccated and sensitive parts were not damaged.

ASCARD (1995) had pointed out, that 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 gas rate, because of their capacity for regrowth. The gas dose and number of treatments have to be adjusted to the weed flora present, the developmental stage of weeds and the desired control level.

Experiment II

Hot water technology offers many benefits over chemical herbicide applications, as it eliminates potential expo-

sure of human and wildlife to pesticide residues. In some studies (DAAR 1995) this system was as effective as the herbicide Roundup after 41–49 days. Just one treatment eliminated the annual weeds and grasses, but several treatments were necessary to control certain perennial weeds. In contrast, in our experiments the hot steam treatment was ineffective as an alternative method of weed control (Table 4). Though the weeds were stunted after treatment, they were not killed. Perennial weeds (*Taraxacum officinalis*) were hardly affected by hot steam in spite of their quite early stage of growth. After the first steam application and an exposure time of 120 s, only a 12.1% reduction of weeds was achieved. The second application was even less effective, only 5.3% of weeds were eliminated, and after the third treatment there was germination and young plants developed. Obviously, the steam generator that we used did not have the technical parameters to be effective. For an efficient control of weeds the steam unit has to be modified before use in a second season.

RILEY (1995) had indicated that treatment by hot steam may not be practical or ecologically sound in dry areas. Some believe that direct searing of weeds with infrared heat or propane flammers is more energy efficient and preferable to hot steam, although it is unclear whether there

Table 3. Effect of flaming at different developmental stages of weeds

Driving speed	Developmental stages of weeds	Weed counting	Weed species		Total number of weeds per m ²	Percentage of reduction
			<i>Chenopodium album</i>	<i>Amaranthus</i> sp.		
2 km/h	2–4 true leaves	before	–	–	–	–
		after	–	–	–	–
	4–6 true leaves	before	96	6	102	–
		after	0	3	3	97.06
	6–8 true leaves	before	100	–	100	–
		after	20	–	20	80.00
> 8 true leaves	before	–	14	14	–	
	after	–	1	1	92.86	
% of reduction			89.80	80.00	88.89	–
3 km/h	2–4 true leaves	before	–	3	3	–
		after	–	0	0	100.00
	4–6 true leaves	before	–	3	3	–
		after	–	1	1	66.66
	6–8 true leaves	before	110	–	110	–
		after	20	–	20	81.82
>8 true leaves	before	68	–	68	–	
	after	40	–	40	41.18	
% of reduction			66.29	83.33	66.85	–
4 km/h	2–4 true leaves	before	–	–	–	–
		after	–	–	–	–
	4–6 true leaves	before	–	2	2	–
		after	–	0	0	100.00
	6–8 true leaves	before	98	–	98	–
		after	58	–	58	40.82
>8 true leaves	before	49	–	49	–	
	after	49	–	49	0.00	
% of reduction			27.21	100.00	28.19	–

Table 4. Efficacy of hot steam in weed control

Exposure time [s]	Weed counting	Prevailing weed species		Other species	Total number of weeds per m ²	Percentage of reduction
		<i>Taraxacum officinalis</i>	<i>Amaranthus</i> ssp.			
120	before	23.33	4.33	8	35.66	12.1
	after	25.33	4.33	1.67	31.33	
360	before	25.33	4.33	1.67	31.33	5.3
	after	18.33	4.33	7	29.66	
540	before	18.33	4.33	7	29.66	+2.2
	after	18.33	4.33	7.67	30.33	

are data to substantiate this. In any case, for large-scale applications, the hot steam technology is not yet cost-effective.

The hot steam system may be effective when used within an integrated programme using a variety of cultural, physical, mechanical and biological practices to solve the weed problem.

Experiment III

Three mulching materials were used: coarse bark, sawdust and hay. Herbicides were used before mulching in all plots, including the control plot. The effect of mulching on weed suppression was checked after a period of one month (Table 5). All mulching materials suppressed the growth of weeds in comparison with the control, where new annual weeds started to emerge and regrowth of perennials took place. There were no differences in efficacy of weed suppression between the mulching materials. With mulching, the number of chemical applications could be lowered to only one or two, instead of the three or four commonly used in apple orchards. In addition to weed suppression, mulch will be beneficial by preserving soil moisture and increasing the organic matter in soil.

To conclude, this study on the use of flame weeding, hot-steam technique and mulching in apple orchards showed the following results:

The efficacy of flaming in perennial fruit crops depends on the composition of the weed flora and occurrence of perennial weeds with high flame tolerance.

The ability of perennial weeds to regrow after flaming is high and species specific.

Malva neglecta was a very flame tolerant species that was not controlled even after four treatments with a total propane dose of 320 kg/ha.

The effect of flaming on annual weeds depends mainly on the developmental stage of the species and the propane dose required for the desired level of control.

A single flaming with a propane dose of 54–40 kg/ha was not sufficient to control annual weeds at later developmental stages (> six true leaves), e.g. three treatments were necessary for 95% control of *Chenopodium album* with a total propane dose of 162 kg/ha.

In the control of *Taraxacum officinalis* the developmental stage is also crucial. Small plants can be controlled by a single flaming and gas dose of 54 kg/ha. As the plants get larger, the control becomes less effective. On intermediate plants there was 78% control with four treatments and a total gas dose of 216 kg/ha; on larger ones 69% control was achieved by four flammings with a total gas consumption of 320 kg/ha.

In an apple orchard where flame tolerant perennial weeds occurred, only 76% weed reduction was achieved after four flammings and a total propane dose of 320 kg/ha.

In an orchard with mainly annual weeds at different developmental stages, 95% weed reduction was obtained with three treatments and a dose of 162 kg/ha of propane.

The hot-steam technology was not effective in this study. Even an exposure time of 540 s and steam temperature of 150°C was not able to control the weeds.

Mulching, regardless of material used (coarse bark, sawdust, hay), seems to be a good alternative to reduce herbicide use in apple orchards.

Table 5. Effect of mulching on weed control

Mulch material	Weed species			Other weeds	Total number of weeds per m ²
	<i>Taraxacum officinalis</i>	<i>Malva neglecta</i>	<i>Amaranthus</i> ssp.		
Control	35.0	0.33	1.66	2.67	39.66
Coarse bark	0.0	0.0	0.0	0.0	0.0
Sawdust	0.0	0.0	0.0	0.0	0.0
	<i>Chenopodium album</i>	<i>Taraxacum officinalis</i>	<i>Amaranthus</i> ssp.		
Control	124.33	8.66	7.66	20.01	160.66
Hay	0.0	0.0	0.0	0.0	0.0

References

- ASCARD J. (1994): Dose-response models for flame weeding in relation to plant size and density. *Weed Res.*, **34**: 377–385.
- ASCARD J. (1995): Effects of flame weeding on weed species at different developmental stages. *Weed Res.*, **35**: 397–411.
- DAAR S. (1995): New technology harnesses hot water to kill weeds. *The Practitioner in New Zealand*: 4.
- PARISH S. (1989): Investigations into thermal techniques for weed control. In: *Proc. 11th Int. Cong. CIGR, Dublin*: 2151–2156.
- RILEY B. (1995): Hot water: A "Cool" new weed control method. *J. Pesticide Reform*, **15**: 9.
- RIFAI M. N., LACKO-BARTOŠOVÁ M., PUŠKÁROVÁ V. (1996): Weed control for organic vegetable farming. *Rostl. Vyr.*, **42**: 463–466.

Received for publication July 22, 1999

Accepted for publication September 15, 1999

Súhrn

RIFAI M. N., LACKO-BARTOŠOVÁ M., SOMR R. (1999): **Regulácia zaburinenosti v sadoch horúcou parou a plameňom**. *Pl. Protect. Sci.*, **35**: 147–152.

Na základe experimentu sme stanovili efektívnosť termickej metódy, použitia horúcej pary a mulčovania na reguláciu zaburinenosti v jablňovom sade. Poľné experimenty sa uskutočnili v rokoch 1997 a 1998 na dvoch farmách v Morrístowne, Nové Škótsko. Dávky plynu boli regulované pojazdovou rýchlosťou (2, 3 a 4 km/h) a predstavovali 80, 54 a 40 kg/ha pri jednej aplikácii. Na Mountain Crest Farm bola použitá postemergentná aplikácia plameňom v 5–7-dňových intervaloch (celkovo štyrikrát) pri dvoch pojazdových rýchlostiach (2 a 3 km/h) – varianty T₁, T₂, T₃ a T₄, pri celkovej dávke plynu 320 a 216 kg/ha. Na Apple Lane Farm bola postemergentná aplikácia v 5–7-dňových intervaloch trikrát pri pojazdových rýchlostiach 2, 3 a 4 km/h (varianty T₁, T₂, T₃ a celkové dávky plynu 240, 162 a 120 kg/ha). Pri experimente II bola post-emergentná aplikácia horúcej pary realizovaná systémom Easy Kleen pri tlaku 1 MPa a teplote 150 °C, doba expozície 2, 6 a 9 minút v 6-dňových intervaloch. V pokusoch sme hodnotili efektívnosť z hľadiska spotreby plynu, účinkov na buriny a rezistentné druhy burín. Pri použití mulčovania bolo cieľom predĺžiť účinky aplikovaných herbicidov a tak znížiť počty ošetrov. Ako mulčovací materiál boli použité piliny, kôra a seno. Efektívnosť ošetrovania plameňom závisela najmä od burinného druhu a vývojovej fázy burín. Na Mountain Crest Farm boli z trváčich burín prevládajúce *Taraxacum officinalis* a *Malva neglecta*, z jednoročných *Amaranthus* ssp. (tab. 1). Bola dosiahnutá pomerne nízka celková redukcia burín (76 a 74,6 %), ovplyvnená najmä vysokou rezistenciou *Malva neglecta*, ktorá nebola poškodená ani celkovou dávkou plynu 320 kg/ha. Na 96–78% redukciu *Taraxacum officinalis* v 2 až 4 ošetrovaniach (v závislosti od vývojového štádia) sa spotrebovalo 160–216 kg plynu/ha. Tiež redukcia *Amaranthus* ssp. závisela od jeho vývojového štádia, pri spotrebe 54–320 kg/ha. Lepšie výsledky sa dosiahli na Apple Lane Farm, kde prevládajúce druhy burín boli jednoročné (tab. 2). Viac ako 95% redukcia burín sa dosiahla pri pojazdovej rýchlosti 2 a 3 km/h a celkových dávkach plynu 240 a 162 kg/ha. Dominantným druhom bol *Chenopodium album*. Účinnosť jedného ošetrovania pri rôznych vývojových fázach burín a pojazdových rýchlostiach vyjadruje tab. 3. Stopercentná redukcia *Chenopodium album* sa dosiahla pri dávke plynu 80 kg/ha a vývojovej fáze 4–6 pravých listov. Čím bola burina vzrastenejšia a dávka plynu nižšia, tým bolo nižšie percento regulácie. Vo fáze >8 pravých listov a dávke plynu 40 kg/ha, *Chenopodium album* nebola regulovaná vôbec. Post-emergentná aplikácia horúcej pary nebola v uvedenom experimente efektívna metóda regulácie zaburinenosti (tab. 4). Ani doba expozície 9 minút nepostačovala na reguláciu burín. Mulčovanie sa ukázalo ako vhodná alternatíva na redukcii celkových dávok herbicidov (tab. 5) bez ohľadu na použitý mulčovací materiál. Využitie termických plečiek je efektívne najmä pri jednoročných plodinách a predstavuje významnú pomoc pre ekologických farmárov. Efektívnosť v trvalých kultúrach bude závisieť od druhového zástupenia burín, výskytu rezistentných trváčich burín, schopnosti regenerácie burín a vývojového štádia burín. Regulácia jednoročných burín vo fáze > 6 pravých listov si bude vyžadovať viacnásobné ošetrovanie.

Kľúčové slová: ekologické hospodárenie; jablňové sady; horúca para; plameň; zaburinenosť; mulčovanie

Corresponding author:

Doc. Ing. MAGDALÉNA LACKO-BARTOŠOVÁ, CSc., Slovenská poľnohospodárska univerzita, Katedra poľnohospodárskych sústav, Tr. A. Hlinku 2, 949 76 Nitra, Slovenská republika, tel.: + 421 87 60 12 05, fax: + 421 87 41 14 51, e-mail: bartosova@afnet.uniag.sk.