ISSN 1392-3196 / e-ISSN 2335-8947
Zemdirbyste-Agriculture, vol. 102, No. 2 (2015), p. 147–152
DOI 10.13080/z-a.2015.102.019

Control of annual broadleaf weeds by combinations of herbicides in sugar beet

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Abstract

Sugar beet is a poor competitor to weeds. Weeds are a major constraint to sugar beet productivity. Field experiments were conducted at Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry (55º23′ N, 23º51′ E) during the period 2010–2012 on a loamy *Endocalcari-Epihypogleyic Cambisol* (*CMg-p-w-can*) to determine the influence of tank-mixed herbicides phenmedipham + desmedipham + ethofumesate (136.5 + 106.5 + 168 g ha^{-1} a.i.) with chloridazon (624 g ha^{-1} a.i.), metamitron (700 g ha^{-1} a.i.) and triflusulfuron (3.75 g ha^{-1} a.i.) on broad leaf weeds. Phenmedipham + desmedipham + ethofumesate was applied at three doses, 1/1, 2/3 and 1/2 of the recommended dose. Metamitron was applied at two doses, 1/1 and 1/2 of the recommended dose. All herbicide combinations acted similarly in reducing these weed species: *Chenopodium album*, *Thlaspi arvense*, *Tripleurospermum perforatum*, *Polygonum aviculare*, *Viola arvensis*, *Veronica arvensis*, *Lamium purpureum*, *Capsella bursa-pastoris* and *Euphorbia helioscopia*. The efficacy of phenmedipham + desmedipham + ethofumesate at full (1/1) dose was similar to that applied in a tank mix with chloridazon, metamitron and triflusulfuron at full dose. There were no significant differences in weed weight. Having reduced the dose of phenmedipham + desmedipham + ethofumesate by 33% and 50% in a tank mix, the dry weight of *C. album, T. perforatum* and *P. aviculare* increased not significantly. The addition of chloridazon, metamitron and triflusulfuron at full dose had a similar impact on weeds. The action of triflusulfuron was longer because the weight of dominant weeds (*C. album* and *T. perforatum*) decreased (6–37%) during all crop growing period. Reducing the dose of metamitron from 525 to 350 g ha^{-1} a.i. (33%) in a tank mix with phenmedipfam + desmedipham + ethofumesate at 1/2 dose, the dry weight of *C. album*, *T. perforatum*, *P. aviculare*, *V. arvensis* and *C. bursa-pastoris* increased not significantly. By reducing the dose of herbicides in a tank mix, the number of active ingredients (a.i.) should be increased.

Key words: annual weeds, *Beta vulgaris* subsp. *vulgaris*, herbicide combination, reduced doses.

Introduction

Sugar beet is an important crop in arable industry. Researchers are attempting to improve sustainability of beet growing and minimize any threat posed to the environment (Draycott, 2006). Sugar beet is very sensitive to weed competition from the early stages of growth (Paolini et al., 1999; Salehi et al., 2006). Therefore, effective control of weeds at early stages seems to be more important than at later development stages (Salehi et al., 2006). The length of weed-free period affected yield of sugar beet very markedly (Jursík et al., 2008). When sugar beet and weeds grow together 30 days after emergence of sugar beet, the root yield is decreased by up to 45% (Soroka, Gadzhieva, 2006). Understanding the emergence characteristics of weeds can be helpful in determining the optimum time to apply post-emergence herbicide (Jursík et al., 2008).

Weed control in crops is mainly based on the use of herbicides because they are efficient and easily applied (Lodovichi et al., 2013). Weed control is decisive and one of the most difficult agricultural arrangements in sugar beet growing is because of low crop interference with weeds (Jursík et al., 2008). The evaluated herbicidal control is a very effective strategy for weed control in sugar beet. After herbicide control the significant changes in weed flora were noted in terms of abundance and share of some weed species in the total weed community (Smatana et al., 2008; 2009). Herbicides for control of dicots can only be used until the crop starts to develop true leaves and their efficacy decreases as the weeds grow (Strandberg et al., 2005). Often sugar beets are treated with post-emergence herbicides two or more times (Dale et al., 2006; Deveikyte, Seibutis, 2008 a; Smatana et al., 2008; Panjehkeh, Alamshahi, 2011). Herbicides are applied at the cotyledon growth stage at 5 to 14 day intervals (Konstantinović, Meseldžija, 2006; Odero et al., 2008; Kucharski, 2009; Domaradzki, 2011).

Individual sugar beet herbicides seldom have a wide enough weed control spectrum or sufficient residual activity to control all weeds (Abdollahi, Ghardiri, 2004). The optimization of herbicide application in the sugar beet protection system can be achieved by using mixtures of appropriate components and their selected doses

(Strandberg et al., 2005; Domaradzki, 2009). Mixing of compatible herbicides has benefits such as consumption reduction, increase in weed control, reduced number of spray applications, releasing less chemicals to ecosystem with using their synergic effects, decrease in residue of herbicide in soil and crops in low concentrations and suppression of weed resistance against herbicides (Majidi et al., 2011). Weed control is often higher from tank-mixed herbicides than from a single herbicide (Deveikytė, Seibutis, 2008 b; Kucharski, 2009; Goleblowska, Domaradzki, 2010; Panjehkeh, Alamshahi, 2011; Najafi et al., 2013).

In older systems used for weed control in sugar beets, herbicides were applied at a high, single dose. Herbicides are often applied at rates higher than required for weed control under ideal conditions (Kucharski, 2009). The exploitation of competitiveness factors might favour the development of reduced herbicide use strategies for sugar beet (Paolini et al., 1999). Numerous research studies have indicated a few reasons for the potential successful use of reduced doses, including: 1) registered doses are set to ensure adequate control over a wide spectrum of weed species, weed densities, growth stages and environmental conditions, 2) maximum weed control is not always necessary for optimal crop yields, and 3) combining reduced doses of herbicides with other management practices, such as tillage or competitive crops, can markedly increase the odds of successful weed control (Blackshaw et al., 2006; Najafi et al., 2013). Several studies have demonstrated good weed control with reduced herbicide doses (Deveikyte, Seibutis, 2006; Domaradzki, 2009; Kucharski, 2009; Domaradzki, 2011; Najafi et al., 2013). For example, Goleblowska and Domaradzki (2010) reported that a 50% and 67% dose of Betanal Progress + Goltix + Safari and Betanal Progress + Venzar + Safari consistently produced 94–97% weed annihilation. The half dose of herbicides reduced weed biomass significantly (Najafi et al., 2013). The herbicide phenmedipham, desmedipham and ethofumesate are commonly tank-mixed with metamitron while chloridazon and triflusulfuron are used for broad-leaved weed control in sugar beet (Odero et al., 2008; Deveikytė, 2011; Domaradzki, 2011; Jursík et al., 2011; Majidi et al., 2011; Najafi et al., 2013).

A number of field trials on weed control in sugar beet have been carried out in Lithuania. Unfortunately, the focus has been placed on application of a high, single dose of herbicides and their combinations (Petkevičienė, 2011).

The objective of this study was to evaluate the efficacy of different herbicide mixtures used in recommended and reduced doses on broadleaf weeds in sugar beet: 1) to find out the most effective tank mixture of herbicides for the control of broadleaf weeds, 2) to evaluate the possibility of broadleaf weeds control with reduced rates of herbicides. It is expected that herbicide dose reduction in combination with the number of active ingredients increasing in a tank mixture, would not reduce the efficacy of herbicide.

Materials and methods

A field experiment was carried out during a three-year-period from 2010 until 2012 on arable fields located at Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry in Central Lithuania (55º23′ N, 23º51′ E) on a loamy *Endocalcari Epihypogleyic Cambisol* (*CMg-p-w-can*) (Buivydaitė et al., 2001). Soil texture was loam consisting of 14.5–17.7% clay, 34.8–39.9% silt and 44.7–49.4% sand. Humus content amounted to 2.2–2.4%, and pH – 6.1–6.9. The annual mean temperature and total amount of precipitation are 6.4ºC and 568.1 mm, respectively.

The experiment was laid out in a randomised complete block design with four replications. The treatments were a.i. (active ingredient) phenmedipham + desmedipham + ethofumesate at dose 136 + 106 + 168 g ha^{-1}, 2/3 (Betanal® Expert, 274 g l^{-1}), a.i. metamitron at dose 525 g ha^{-1} (Goltix® 700 SC, 700 g l^{-1}), a.i. chloridazon at 624 g ha^{-1} (Pyramin® Turbo, 520 g l^{-1}), a.i. triflusulfuron-methyl 3.75 g ha^{-1} (Caribou 50 WG, 500 g kg^{-1}). Phenmedipham + desmedipham + ethofumesate was applied at three doses, 1/1, 2/3 and 1/2 of the recommended dose. Metamitron was applied at two doses, 1/1 and 2/3 of the recommended dose (Table 1).

Table 1. Time and doses of herbicide application

No.	Treatment	Dose l ha^{-1}	Dose g ha^{-1} a.i. / application 1st	2nd	3rd
1.	Phenmedipham + desmedipham + ethofumesate, 1/1 (control)	1.5 × 3	136 + 106 + 168	1364 + 106 + 168	136 + 106 + 168
2.	(Phenmedipham + desmedipham + ethofumesate, 2/3) + chloridazon, 1/1	1.0 + 1.2 × 3	(91 + 71 + 112) + 624	(91 + 71 + 112) + 624	(91 + 71 + 112) + 624
3.	(Phenmedipham + desmedipham + ethofumesate, 2/3) + metamitron, 1/1	1.0 + 0.75 × 3	(91 + 71 + 112) + 525	(91 + 71 + 112) + 525	(91 + 71 + 112) + 525
4.	(Phenmedipham + desmedipham + ethofumesate, 1/2) + metamitron, 2/3	0.5 + 0.5 × 3	(68 + 53 + 84) + 350	(68 + 53 + 84) + 350	(68 + 53 + 84) + 350
5.	Phenmedipham + desmedipham + ethofumesate;	1.0	91 + 71 + 112	–	–
	(Phenmedipham + desmedipham + ethofumesate) + triflusulfuron;	1.0 + 5	–	(91 + 71 + 112) + 5	–
	(Phenmedipham + desmedipham +ethofumesate, 2/3) + triflusulfuron, 1/1	1.0 + 10	–	–	(91 + 71 + 112) + 10
6.	Phenmedipham + desmedipham + ethofumesate;	0.75	68 + 53 + 84	–	–
	(Phenmedipham + desmedipham + ethofumesate, 1/2) + triflusulfuron, 1/1	0.75 + 15	–	(68 + 53 + 84) + 7.5	(68 + 53 + 84) + 7.5

The pre-crop (winter wheat) straw was chopped during harvesting and incorporated into the soil at 6–8 cm depth during stubble cultivation and ploughing. The field was fertilized with nitrogen, phosphorus and potassium at a ratio of 105:80:170 kg ha^{-1}. Mineral fertilizers were incorporated into the soil during cultivation. Sugar beet (*Beta vulgaris* subsp. *vulgaris*) cv. 'Firenze' was planted with a 45 cm row space, at a density of 148 thousand plants ha^{-1}. The fungicide Impact 25 SC (a.i. flutriafol 250 g l^{-1}) 0.25 l ha^{-1} and the insecticide Proteus OD (a.i. tiaklopiralid + deltametrin 100 + 10 g l^{-1}) 0.75 l ha^{-1} were applied. The herbicides were tank-mixed and applied three times. The first application was done at the early cotyledon stage of weeds. Subsequent applications were applied when the next weed flush emerged, or 10–17 days after the first and second flush. The plot size was 2.5 × 10 m. The herbicides in the experiment were broadcast-applied. The amount of water was 200 l ha^{-1}. Weed dry weight was measured twice: four weeks after last herbicide application and before harvest. At the time of assessment a quadrate of 0.20 × 1.25 m was randomly thrown in four places of each plot. The samples of weed were dried at 105°C for 24 h and weighed. Weed dry weight data were transformed to $\sqrt{x+1}$.

Meteorological conditions during the sugar beet growing season (April, October) are presented in Table 2. The spring of the year 2010 was late, wet and with contrasting temperatures (warm day and cool or cold night). The end of April and beginning of May were cool and dry. The conditions were unfavourable for sugar beet and weed germination. The summer was warm and wet and the weather conditions were favourable for sugar beet growing and development. The autumn was cold and dry. In the spring of 2011, dry and contrasting (warm day and cold night) weather prevailed. The summer was wet, except for the droughty period at the beginning of June; the average amount of precipitation was 24.2% higher than the long-term mean. The air temperature of the autumn was similar, but the amount of rain was higher (23%) as compared to long-term average. The spring of 2012 was early and it was dry at the beginning of May. The conditions were unfavourable for effective action of herbicides applied. Warm weather prevailed only at the end of April and May. The summer was warm and rainy. The weather conditions in the autumn were similar to long-term average. During the growing season the weather conditions were close to normal, except for the plant emergence period when recurring torrential rain aggravated plant emergence (soil crust).

***Table* 2.** Weather conditions during the sugar beet growing season

Month		1924–2012		2010		2011		2012	
		°C	mm	°C	mm	°C	mm	°C	mm
Spring	April	5.9	36.9	7.3	44.2	8.8	15.6	7.3	47.4
	May	12.3	52.1	13.7	94.2	13.0	46.8	13.3	42.1
Average	April–May	9.1	44.5	10.5	69.2	10.9	31.2	10.3	44.8
Σ	April–May	–	89.0	–	138.4	–	62.4	–	89.5
Summer	June	15.6	62.5	16.2	72.4	18.1	44.3	14.9	78.6
	July	17.7	75.2	21.7	142.0	19.7	115.0	18.9	120.3
	August	16.7	74.1	19.8	71.1	17.4	103.8	16.5	81.9
Average	June–August	16.7	70.6	19.2	95.1	18.4	87.7	16.8	93.6
Σ	June–August	–	211.8	–	285.5	–	263.1	–	280.8
Autumn	September	12.1	51.2	11.9	52.1	13.7	54.0	13.2	42.8
	October	6.8	49.9	5.0	38.0	7.6	23.9	7.2	61.6
Average	September–October	9.4	50.6	8.4	45.0	10.6	39.0	10.2	52.2
Σ	September–October	–	101.1	–	90.1	–	77.9	–	104.4

ANOVA was applied for statistical processing of the data. The Duncan's multiple range test, set at 0.05, was used to determine the significance of the difference between the treatment means.

Results and discussion

The weed spectrum differed between years. In 2010, *Chenopodium album* L., *Veronica arvensis* L., *Thlaspi arvense* L., *Viola arvensis* Murray and *Euphorbia helioscopia* L. dominated the weed flora, in 2011, *C. album* and *Tripleurospermum perforatum* (Merat.) M. Lainz. were the most prevalent weed species and in 2012 *C. album* and *T. perforatum*, *Polygonum aviculare* L., *Lamium purpureum* L. and *Capsella bursa-pastoris* (L.) Medik. were the most frequently found species.

All tank mixtures of phenmedipham + desmedipham + ethofumesate with chloridazon, metamitron and triflusulfuron similarly reduced dry weight of *T. arvense*, *T. perforatum*, *V. arvensis*, *P. aviculare*, *L. purpureum*, *C. bursa-pastoris* and *E. helioscopia* compared with alone phenmedipham + desmedipham + ethofumesate (Table 3). The higher dry weight of *C. album* and *V. arvensis* was after application of 50% (1/2) dose phenmedipham + desmedipham + ethofumesate with triflusulfuron. Similar results were reported by Odero et al. (2008), where applications of phenmedipham + ethofumesate with triflusulfuron at low doses were less effective on *C. album* than higher doses.

Total weed dry weight different among the years (Table 4). The higher weed dry weight was in the third experimental year when meteorological conditions were unfavourable (dry at the beginning of May) for efficacy of herbicides.

The efficacy of phenmedipham + desmedipham + ethofumesate at the 50% (1/2) dose with triflusulfuron was significantly lower than that of other herbicide combinations in 2010 and 2011. No significant differences between treatments were registered in 2012. Averaged data suggest that the weight of weeds increased 20% in the treatment where sugar beet had been applied at lower doses of herbicides. However, there were no statistically significant differences.

Table 3. Weed dry weight four weeks after last treatment, g m^{-2}

Weeds	P + D + E, 1/1*	(P + D + E, 2/3) + CH, 1/1	(P + D + E, 2/3) + M, 1/1	(P + D + E, 1/2) + M, 2/3	(P + D + E, 2/3) + T, 1/1	(P + D + E, 1/2) + T, 1/1
Chenopodium album	10.59 abc	5.94 a	3.04 a	9.64 abc	3.68 a	18.08 c
Thlaspi arvense	0.25 ab	0.05 ab	0.02 ab	0.07 ab	0.30 b	0.17 ab
Tripleurospermum perforatum	49.48 ab	44.79 ab	44.35 ab	51.54 ab	45.91 ab	54.49 b
Viola arvensis	0.08 ab	0.17 ab	0.11 ab	0.39 b	0.03 ab	0.20 ab
Veronica arvensis	0.02 abc	0.01 a	0.01 abc	0.12 abc	0.08 abc	0.19 c
Polygonum aviculare	9.93 ab	2.78 ab	5.36 ab	23.27 b	13.97 ab	8.58 ab
Lamium purpureum	0.01 ab	0.00 ab	0.24 ab	0.16 ab	0.54 ab	2.32 b
Capsella bursa-pastoris	0.37 b	0.07 ab	0.00 ab	0.00 ab	0.00 ab	0.06 ab
Euphorbia helioscopia	0.04 ab	0.04 b	0.00 ab	0.03 ab	0.00 ab	0.02 ab

Notes. P – phenmedipham, D – desmedipham, E – ethofumesate, M – metamitron, CH – chloridazon, T – triflusulfuron-methyl; * – doses: 1/1 – full, 2/3 – reducing the dose by 33%, 1/2 – reducing the dose by 50%. The means followed by the same letter within a line are not significantly different at $P < 0.05$ according to the Duncan's multiple range test.

Table 4. Total weed dry weight four weeks after last treatments, g m^{-2}

No.	Treatments	2010	2011	2012	Average
1.	Phenmedipham + desmedipham + ethofumesate, 1/1 (control)	6.2 a	6.0 a	200.5 ab	70.9 ab
2.	(Phenmedipham + desmedipham + ethofumesate, 2/3) + chloridazon, 1/1	4.1 a	3.4 a	155.2 ab	54.2 ab
3.	(Phenmedipham + desmedipham + ethofumesate, 2/3) + metamitron, 1/1	0.9 a	0.7 a	160.0 ab	53.8 ab
4.	(Phenmedipham + desmedipham + ethofumesate, 1/2) + metamitron, 2/3	6.4 a	4.0 a	250.6 b	87.0 b
5.	Phenmedipham + desmedipham + ethofumesate; (Phenmedipham + desmedipham + ethofumesate) + triflusulfuron; (Phenmedipham + desmedipham + ethofumesate, 2/3) + triflusulfuron, 1/1	6.1 a	3.4 a	188.1 ab	65.8 ab
6.	Phenmedipham + desmedipham + ethofumesate; (Phenmedipham + desmedipham + ethofumesate, 1/2) + triflusulfuron, 1/1	18.0 b	20.7 b	216.7 ab	85.1 ab

Notes. 1/1 – full, 2/3 – reducing the dose by 33%, 1/2 – reducing the dose by 50%. The means followed by the same letter within a column are not significantly different at $P < 0.05$ according to the Duncan's multiple range test.

In the herbicide-applied treatments, before sugar beet harvesting the following weeds dominated in the stand – *T. perforatum* (41–69%), *C. album* (10–34%) and *P. aviculare* (14–35%). Smatana et al. (2009) and Domaradzki (2011) also found that after herbicide application *C. album*, *P. aviculare* and *T. perforatum* remained the dominant weed species in sugar beet. It should be noticed that the herbicide combination insufficiently controlled these weeds (Table 5). The full dose (1/1) of phenmedipham + desmedipham + ethofumesate 2.3–5.7 times more effectively controlled *C. album* than a mixture of this herbicide at 2/3 and 1/2 doses with metamitron, chloridazon and triflusulfuron. The efficacy of the commercial mixture of phenmedipham + desmedipham + ethofumesate at the full dose and of mixture of this herbicide at 2/3 and 1/2 doses with triflusulfuron was higher as compared with other treatments. However, a similar reduction of dry weight of weeds was recorded for all herbicide combinations. These results are in conformity with Najafi et al. (2013) who reported that the efficacy of tank-mixed phenmedipham + desmedipham + ethofumesate with chloridazon and triflusulfuron was similar.

Table 5. Weed dry weight before harvest, g m^{-2}

Weeds	P + D + E, 1/1 *	(P + D + E, 2/3) + CH, 1/1	(P + D + E, 2/3) + M, 1/1	(P + D + E, 1/2) + M, 2/3	(P + D + E, 2/3) + T, 1/1	(P + D + E, 1/2) + T, 1/1
Chenopodium album	4.29 ab	24.40 b	10.82 ab	14.43 ab	10.00 ab	16.69 ab
Thlaspi arvense	0.25 ab	0.07 ab	0.36 ab	0.00 ab	0.54 ab	1.37 b
Tripleurospermum perforatum	23.25 ab	32.41 ab	31.91 ab	33.47 ab	43.34 ab	34.17 ab
Viola arvensis	0.10 ab	0.40 ab	0.83 b	0.05 ab	0.03 ab	0.38 ab
Veronica arvensis	1.54 b	0.14 ab	0.02 ab	0.09 ab	0.00 ab	0.00 ab
Polygonum aviculare	8.49 ab	13.32 ab	13.69 ab	29.18 b	8.75 ab	9.03 ab
Lamium purpureum	0.01 ab	0.00 ab	0.01 ab	0.00 ab	0.00 ab	0.04 b
Capsella bursa-pastoris	0.79 ab	0.23 ab	0.00 ab	1.23 b	0.01 ab	0.06 ab
Euphorbia helioscopia	0.03 ab	0.07 b	0.01 ab	0.00 ab	0.07 ab	0.00 ab

Notes. P – phenmedipham, D – desmedipham, E – ethofumesate, M – metamitron, CH – chloridazon, T – triflusulfuron-methyl; * – doses: 1/1 – full, 2/3 – reducing the dose by 33%, 1/2 – reducing the dose by 50%. The means followed by the same letter within a line are not significantly different at $P < 0.05$ according to Duncan's multiple range test.

The total dry weight of weeds ranged from 0 to 246.6 g m^{-2} (Table 6). The least efficacy of herbicide combinations was in 2012, but the highest in 2011. In 2010, the highest reduction in weed weight was achieved when phenmedipham + desmedipham + ethofumesate at 2/3 and 1/2 doses was tank-mixed with metamitron at full (1/1) and 2/3 doses, respectively. There were significant differences compared with phenmedipham + desmedipham + ethofumesate at full dose and tank mix of phenmedipham + desmedipham + ethofumesate at 1/2 dose with triflusulfuron. In 2011, all herbicide combinations did not result in significant differences in weed weight. The highest weed dry weight was in 2012 when the meteorological conditions were unfavourable (dry) for herbicide action. The full dose of phenmedipham + desmedipham + ethofumesate significantly reduced weed weight compared with a tank mix of this herbicide at the lower (1/2) dose with metamitron at 2/3 dose. However, it did not significantly differ from other herbicide combinations. The effect on weeds by adding of chloridazon was shorter than that for triflusulfuron because of the dry weight of weeds was found to increase at the second assessment after chloridazon application. In general, the efficacy of commercial mix phenmedipham + desmedipham + ethofumesate (1/1) was similar to that of this herbicide application at the 2/3 and 1/2 doses with chloridazon, metamitron and triflusulfuron. Other studies have also reported no significant reduction of weeds with application of phenmedipham + desmedipham + ethofumesate or in combination with triflusulfuron and metamitron (Domaradzki, 2009; Goleblowska, Domaradzki, 2010).

Table 6. Total weed dry weight before harvest, g m^{-2}

No.	Treatment	2010	2011	2012	Average
1.	Phenmedipham + desmedipham + ethofumesate, 1/1 (control)	12.3 bcd	0.3 ab	116.5 a	43.0 ab
2.	(Phenmedipham + desmedipham + ethofumesate, 2/3) + chloridazon, 1/1	3.0 ab	1.4 ab	213.2 bc	72.5 ab
3.	(Phenmedipham + desmedipham + ethofumesate, 2/3) + metamitron, 1/1	0.9 a	0.2 ab	241.6 bc	81.3 ab
4.	(Phenmedipham + desmedipham + ethofumesate, 1/2) + metamitron, 2/3	2.0 a	0.0 ab	246.6 c	82.5 b
5.	Phenmedipham + desmedipham + ethofumesate; (Phenmedipham + desmedipham + ethofumesate) + triflusulfuron; (Phenmedipham + desmedipham + ethofumesate, 2/3) + triflusulfuron, 1/1	2.3 ab	0.6 ab	185.4 abc	62.8 ab
6.	Phenmedipham + desmedipham + ethofumesate; (Phenmedipham + desmedipham + ethofumesate, 1/2) + triflusulfuron, 1/1	18.9 d	1.9 b	175.8 abc	65.6 ab

Note. 1/1 – full, 2/3 – reducing the dose by 33%, 1/2 – reducing the dose by 50%. The means followed by the same letter within a column are not significantly different at $P < 0.05$ according to Duncan's multiple range test.

Conclusions

1. All herbicide combinations acted similarly in reducing these weed species: *Chenopodium album*, *Thlaspi arvense*, *Tripleurospermum perforatum*, *Polygonum aviculare*, *Viola arvensis*, *Veronica arvensis*, *Lamium purpureum*, *Capsella bursa-pastoris* and *Euphorbia helioscopia*.

2. The efficacy of phenmedipham + desmedipham + ethofumesate at full (1/1) dose was similar to that as applied in a tank mix with chloridazon, metamitron and triflusulfuron at full dose. There were no significant differences in weed weight.

3. Reducing the dose of penmedipham + desmedipham + ethofumesate by 33% and 50% in a tank mix, the dry weight of *C. album*, *T. perforatum* and *P. aviculare* increased not significantly.

4. The addition of chloridazon, metamitron and triflusulfuron at full dose had a similar effect on weeds. The action of triflusulfuron was longer because the weight of dominant weeds (*C. album* and *T. perforatum*) decreased (6–37%) during all crop growing season.

5. With a reduction of the dose of metamitron from 525 to 350 g ha^{-1} a.i. (33%) in a tank mix with phenmedipfam + desmedipham + ethofumesate at 1/2 dose, the dry weight of *C. album*, *T. perforatum*, *P. aviculare*, *V. arvensis* and *C. bursa-pastoris* increased not significantly.

Acknowledgements

The study was supported by the UAB "Nordic Sugar Kėdainiai".

Received 28 01 2014
Accepted 11 05 2015

References

Abdollahi F., Ghardiri H. 2004. Effect of separate and combined applications of herbicides on weed control and yield of sugar beet. Weed Technology, 18 (4): 968–976 http://dx.doi.org/10.1614/WT-03-142R2

Blackshaw R. E., O'Donovan J. T., Harker K. N., Clayton G. W., Stougaard R. T. 2006. Reduced herbicide doses in field crops: a review. Weed Biology and Management, 6 (1): 10–17 http://dx.doi.org/10.1111/j.1445-6664.2006.00190.x

Buivydaitė V. V., Vaičys M., Juodis J., Motuzas A. 2001. Classification of the soils of Lithuania, book No. 34. Vilnius, 139 p. (in Lithuanian)

Dale T. M., Renner K. A., Kravchenko A. N. 2006. Effect of herbicides on weed control and sugar beet (*Beta vulgaris*) yield and quality. Weed Technology, 20 (1): 150–156 http://dx.doi.org/10.1614/WT-04-278R1.1

Deveikytė I. 2011. Weediness reduction possibilities by chemical means in sugar-beets stand. Žemės ūkio mokslai, 18 (2): 59–63 (in Lithuanian)

Deveikyte I., Seibutis V. 2006. Broadleaf weeds and sugar beet response to phenmedipham, desmadipham, etofumesate and triflusulfuron-methyl. Agronomy Research, 4: 159–162

Deveikyte I., Seibutis V. 2008 (a). Effects of the phenmedipham, desmedipham, ethofumesate, metamitron and triflusulfuron-methyl on weeds and sugar beet. Universitatea de Stiinte Agricole si Medicina Veterinara lasi, Lucrari Stiintifice, seria Agronomie, 51: 278–286

Deveikytė I., Seibutis V. 2008 (b). The influence of post-emergence herbicides combinations on broad-leaved weeds in sugar beet. Zemdirbyste-Agriculture, 95 (3): 43–49

Domaradzki K. 2009. Organiczenie nakładów na odchwaszczanie buraka cukrowego poprzez optymalizację dawkowania herbicydów w zabiegach systemowych. Progress in Plant Protection, 49 (4): 1790–1797 (in Polish)

Domaradzki K. 2011. Skuteczność mikrodawek herbicydów w systemach chemicznej ochrony buraka cukrowego. Progress in Plant Protection, 51 (4): 1683–1689 (in Polish)

Draycott A. P. 2006. Introduction. Draycott A. P. (ed.) Sugar beet. Oxford, UK, p. 1–8

Goleblowska H., Domaradzki K. 2010. Chemical systems of weed control in field crops of sustainable agriculture aspect. Fragmenta Agronomica, 27 (1): 32–43 (in Polish)

Jursík M., Holec J., Soukup J., Venclová V. 2008. Competitive relationships between sugar beet and weeds in dependence on time of weed control. Plant, Soil and Environment, 54 (3): 108–116

Jursík M., Soukup J., Venclová V., Holec J. 2011. POST herbicide combinations for velvetleaf (*Abutilon theophrasti*) control in sugarbeet. Weed Technology, 25 (1): 14–18 http://dx.doi.org/10.1614/WT-D-10-00059.1

Konstantinović B. I., Meseldžija M. U. 2006. Occurrence, spread and possibilities of invasive weeds control in sugar beet. Proceedings for Natural Sciences, 110: 173–178

Kucharski M. 2009. Changes in application system – influence on herbicides residue in soil and sugar beet roots. Journal of Plant Protection Research, 49 (4): 421–425 http://dx.doi.org/10.2478/v10045-009-0067-4

Lodovichi M. V., Blanco A. M., Chantre G. R., Bandoni J. A., Sabbatini M. R., Vigna M., López R., Gigón R. 2013. Operational planning of herbicide-based weed management. Agricultural Systems, 121 (2): 117–129 http://dx.doi.org/10.1016/j.agsy.2013.07.006

Majidi M. M., Heidari G., Mohammadi K. 2011. Management of broad leaved weeds by combination of herbicides in sugar beet production. Advances in Environmental Biology, 5 (10): 3302–3306

Najafi H., Bazoubandi M., Jafarzadeh N. 2013. Effectiveness of repeated reduced rates of selective broadleaf herbicides for post emergence weed control in sugar beet (*Beta vulgaris*). World Journal of Agricultural Research, 1 (2): 25–29

Odero D. C., Meshab A. O., Miller S. D. 2008. Economics of weed management systems in sugarbeet. Economics of Weed Management, 45 (1–2): 49–63 http://dx.doi.org/10.5274/jsbr.45.1.49

Panjehkeh N., Alamshahi L. 2011. Influence of separate and tank-mixted application of some broadleaf herbicides on sugarbeet weeds and their effects on crop productivity. Australian Journal of Basic and Applied Sciences, 5 (7): 332–335

Paolini R., Principi M., Froud-Wiiiams R. J., Del Puglia S., Biancardi E. 1999. Competition between sugar beet and *Sinapis arvensis* and *Chenopodium album*, as affected by timing of nitrogen fertilization. Weed Research, 39 (6): 425–440 http://dx.doi.org/10.1046/j.1365-3180.1999.00156.x

Petkevičienė B. 2011. Sugar-beet research in Lithuania: 1910–2010. Žemės ūkio mokslai, 18 (2): 72–82 (in Lithuanian)

Salehi F., Esfandiari H., Mashhadi H. R. 2006. Critical period of weed control in sugar beet in Shahrekord region. Iranian Journal of Weed Science, 2 (2): 1–12

Smatana J., Macák M., Demjanová E., Dalović I. 2008. Herbicide weed control in sugar beet. Acta Herbologica, 17 (2): 131–135

Smatana J., Macák M., Demjanová E., Djalović I. 2009. Weed control in canopy of sugar beet. Research Journal of Agricultural Science, 41 (1): 299–302

Soroka S. V., Gadzhieva G. J. 2006. State of weed infestation and features of sugar beet protection in Belarus. Proceedings for Natural Sciences, 110: 165–172

Strandberg B., Pedersen M. B., Elmegaard N. 2005. Weed and arthropod populations in conventional and genetically modified herbicide tolerant fodder beet fields. Agriculture, Ecosystems and Environment, 105 (2): 243–253 http://dx.doi.org/10.1016/j.agee.2004.03.005

ISSN 1392-3196 / e-ISSN 2335-8947
Zemdirbyste-Agriculture, vol. 102, No. 2 (2015), p. 147–152
DOI 10.13080/z-a.2015.102.019

Vienamečių dviskilčių piktžolių naikinimas cukrinių runkelių pasėliuose herbicidų deriniais

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Santrauka

Cukriniai runkeliai silpnai konkuruoja su piktžolėmis. Piktžolės yra vienas pagrindinių veiksnių, lemiančių cukrinių runkelių produktyvumą. 2010–2012 m. Lietuvos agrarinių ir miškų mokslų centro Žemdirbystės institute giliau karbonatiniame sekliai glėjiškame priemolio rudžemyje (RDg8-k2) atlikti tyrimai, siekiant įvertinti fenmedifamo + desmedifamo + etofumezato (136,5 + 106,5 + 168 g ha^{-1} v. m.) mišinių su chloridazonu (624 g ha^{-1} v. m.), metamitronu (700 g ha^{-1} v. m.) ir triflusulfuronu (3,75 g ha^{-1} v. m.) veiksmingumą. Fenmedifamas + desmedifamas + etofumezatas purkštas trimis normomis – 1/1, 2/3 ir 1/2 rekomenduojamos normos. Metamitronas purkštas 1/1 ir 2/3 rekomenduojamos normos. Herbicido fenmedifamo + desmedifamo + etofumezato mišinių su cloridazonu, metamitronu ir triflusulfuronu veiksmingumas buvo panašus. Jie vienodai mažino *Chenopodium album*, *Thlaspi arvense*, *Tripleurospermum perforatum*, *Polygonum aviculare*, *Viola arvensis*, *Veronica arvensis*, *Lamium purpureum*, *Capsella bursa-pastoris* ir *Euphorbia helioscopia* sausąją masę. Visa norma fenmedifamo + desmedifamo + etofumezato piktžoles veikė panašiai kaip ir jo mišiniai su chloridazonu, metamitronu ir trisulfuronu. Fenmedifamo + desmedifamo + etofumezato normų sumažinimas 33 ir 50 % mišiniuose su chloridazonu, metamitronu ir trisulfuronu neturėjo esminės įtakos *C. album*, *T. perforatum* ir *P. aviculare* sausųjų medžiagų masei. Neišryškėjo skirtumai tarp chloridazono, metamitrono ir triflusulfurono (1/1 norma) veiksmingumo. Tik triflusulfurono poveikis buvo ilgesnis, nes jį panaudojus vyraujančių piktžolių (*C. album* ir *T. perforatum*) sausųjų medžiagų masė mažėjo visą vegetacijos laikotarpį. Metamitrono sumažinta nuo 525 iki 350 g ha^{-1} v. m. (33 %) norma mišinyje su puse normos (50 %) fenmedifamo + desmedifamo + etofumezato neturėjo esminės įtakos *C. album*, *T. perforatum*, *P. aviculare*, *V. arvensis* ir *C. bursa-pastoris* sausajai masei. Mišinyje mažinant herbicidų normą jame būtina didinti veikliųjų medžiagų kiekį.

Reikšminiai žodžiai: cukriniai runkeliai, herbicidų mišiniai, normų mažinimas, vienametės piktžolės.