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THE INFLUENCE OF POST-EMERGENCE HERBICIDES COMBINATIONS ON BROAD-LEAVED WEEDS IN SUGAR BEET

Irena DEVEIKYTĖ, Vytautas SEIBUTIS

Lithuanian Institute of Agriculture
Instituto al. 1, Akademija, Kėdainiai distr., Lithuania
E-mail: irenad@lzi.lt, vytautas@lzi.lt

Abstract

The experiments with sugar beet (*Beta vulgaris* L.) cultivars were conducted at the Lithuanian Institute of Agriculture during 2006–2007. The goal of the investigation was to examine weed control efficacy and crop safety by applying post-emergence herbicides. Various combinations of phenmedipfam + desmedipham + ethofumesate (68, 91 and 114 + 53, 71 and 89 + 84, 112 and 140 g a. i. ha^{-1}) in mixture with metamitron (350 and 525 g a. i. ha^{-1}), chloridazon (650 g a. i. ha^{-1}) and triflusulfuron-methyl (5, 7.5 and 10 g a. i. ha^{-1}) were investigated. Herbicides were applied in three applications. The first application was done at the early cotyledon stage of weeds. Subsequent applications were done when the next weeds flush emerged or 10–17 days after the first flush.

Additions of metamitron and triflusulfuron-methyl to phenmedipfam + desmedipham + ethofumesate increased the weed spectrum controlled but reduced phenmedipfam + desmedipham + ethofumesate effectiveness by 20.8–66.0%. Increasing the doses of phenmedipfam + desmedipham + ethofumesate and metamitron gave more consistent control of *Chenopodium album* L., *Tripleurospermum perforatum* (Merat) M. Lainz*, Polygonum aviculare* L. and *Thlaspi arvense* L. All herbicide treatments produced similar sugar beet root and sugar yields to those in the manual weeding control. Non-sugars were not affected by the herbicide treatments.

Key words: weeds, herbicides, sugar beet.

Introduction

Weeds are known to cause crop yield losses, hamper harvest, reduce quality of the harvest product, and perhaps harbour insects and diseases that may harm the crop. Yield losses are of the greatest concern and have been predicted using early season assessments of the weed population such as weed seedling density, relative time of emergence, weed pressure, and relative leaf area /Schweizer, May, 1993; Dieleman, Mortensen, 1998/.

Sugar beet is a poor competitor with weeds in arable fields because it is slow growing early in the season and has a low canopy in its first year of a biennial life cycle /May, 2003/. Sugar beet is not competitive with emerging weeds until it has at least 8 true leaves. The total potential losses from weeds would be between 50 and 100% of the potential crop yield /May, 2001/. Weeds that emerge 8 weeks after sowing, and particularly after the sugar beet plants have eight or more leaves, are less likely to affect yield /Scott et al., 1979/. The most competitive are annual weeds, mostly broadleaved species that emerge with, or shortly after, the crop, grow taller than the crop and produce dense shade. These weeds often grow to a height two to three times that of sugar beet by midsummer /May, Wilson, 2006/.

Agrochemicals are the primary tools to manage weeds in industrialized countries. This is because the efficacy of herbicides is, overall, much higher than with other options, while causing no or little harm to the crop /Zoschke, Quadranti, 2002/. Weed control starts either pre-emergence or early post-emergence of the crop. A sequence of four to five sprays including preceding stubble treatments is typical. Therefore, post-emergence weed control uses a sequence of two or more applications /May, 2001/. Weeds in sugar beet can germinate over a long period, sequential applications at intervals of 8 to 14 days between two sprays are needed /Petersen, 2004/. For high efficacy of chemical method, the timing of application is very important. Weeds have to be small (cotyledon stage) to ensure successful weed control /Dale, Renner, 2005; Dale et al., 2005/.

Sugar beet herbicides seldom have a wide enough weed control spectrum or sufficient residual activity to control all weeds, and tank mixes and sequences of different herbicides are commonly used in order to provide a broad spectrum of weed control /May, Wilson, 2006/.

The most popular active ingredients are phenmedipham, metamitron, ethofumesate, desmedipham, triflusulfuron-methyl, lenacil, clopyralid and chloridazon /May, 2001/. Herbicides are usually applied in tank mixes /Deveikyte, 2000; May, 2001; Wilson et al., 2005; Deveikyte, Seibutis, 2006/.

Phenmedipham + desmedipham control a number of broadleaf weeds in sugar beet by inhibiting photosystem II. This herbicide also decreases the photosynthetic activity of sugar beet /Prodoehl, Campbell, 1992/. Metamitron, a triazinone, is widely used for pre- or post-emergence broad-leaved weed control in sugar beet. Metamitron is systemic, xylem-translocated photosystem II (PSII) inhibitors. Metamitron is used for selective weed control in sugar beet because it is metabolized in this crop /Abbaspoor et al., 2005/. Triflusulfuron-methyl is selective low use rate sulfonylurea herbicide for the control of annual and perennial broad-leaved weeds and grasses in sugar beets /Wittenbach et al., 1994; Dietrich et al., 1995/. Similar to other sulfonylureas, the site of action of Triflusulfuron methyl is acetolactate synthase (ALS), an enzyme in branched-chain amino acid biosynthesis / Wittenbach et al., 1994/. Chloridazon is used extensively for broad-leaved weed control in sugar beet. Field observations indicate that *c.*30 days after application of a reduced dose of 1.3 kg ha^{-1} chloridazon, weed emergence recommences /Rouchaud et al., 1997/.

The objective of this study was to evaluate the efficacy of reduced dose rates of these herbicides for the control of annual broad-leaved weed.

Materials and Methods

The experiment was conducted for 2 years in Dotnuva, Lithuania on a light loamy *Endocalcari Endohypogleic Combisol* from 2006 to 2007. The main agochemical parameters of the arable soil layer: pH – 6.6–6.9, humus content – 2.1–2.3%, available P_2O_5 – 204–215 mg kg^{-1} and K_2O – 216–232 mg kg^{-1}. Sugar beet was planted after winter wheat, a row distance of 45 cm and population 130 000 plants ha^{-1}. Fertilisation was based on 120 kg N, 90–120 kg P_2O_5 and 120–160 K_2O per ha.

The field experiment included 7 treatments (Table 1). A randomized plot design with four replicates was used. Plot size – 8.1 m^2. The herbicides were applied three times. The first application was conducted at the cotyledon stage of weeds. Subsequent applications were done when the next weed flush had emerged or 10–17 days after the first flush. Water volume was 200 l ha^{-1}. Number and dry weight of weeds were determined in four weeks after the third treatments. Number of weeds and botanical composition was determined in 0.25 m^2 (0.20 m x 1.25 m) in 4 places of each plot.

Analysis of variance (ANOVA) was conducted on weeds, sugar beet quality parameters and yield data. Weed number data were transformed to $\sqrt{x+1}$ /Tarakanovas, Raudonius, 2003/.

Table 1. Treatments and doses

	Treatment	Dose g a. i. l^{-1} / Application		
		T_{1*}	T_{2*}	T_{3*}
1.	Cleaned manually (untreated)	–	–	–
2.	Phenmedipham + desmedipham + ethofumesate (Betanal Expert), 1029 g a. i. ha^{-1}	114+89+140	114+89+140	114+89+140
3.	Phenmedipham + desmedipham + ethofumesate + chloridazon (Pyramin Turbo), 2772 g a. i. ha^{-1}	91+71+112+ 650	91+71+112+ 650	91+71+112+ 650
4.	Phenmedipham + desmedipham + ethofumesate + metamitron (Goltix), 2397 g a. i. ha^{-1}	91+71+112+ 525	91+71+112+ 525	91+71+112+ 525
5.	Phenmedipham + desmedipham + ethofumesate + metamitron (1665 g a. i. ha^{-1})	68+53+84+350	68+53+84+350	68+53+84+350
6.	Phenmedipham + desmedipham + ethofumesate	91+71+112	–	–
	Phenmedipham + desmedipham + ethofumesate + triflusulfuron-methyl (Caribou)	–	91+71+112+5	–
	Phenmedipham + desmedipham + ethofumesate + triflusulfuron-methyl (837 g a. i. ha^{-1})	–	–	91+71+112+10
7.	Phenmedipham + desmedipham + ethofumesate	68+53+84	–	–
	Phenmedipham + desmedipham + ethofumesate + triflusulfuron-methyl (630 g a. i. ha^{-1})	–	68+53+84+7.5	68+53+84+7.5

* – T_1 – first application, T_2 – second application, T_3 – third application.

Results and Discussion

Weed distribution in the experiment ranged from 84.2 to 124.5 plants m^{-2} while annual dicotyledonous weeds predominated (98.9–100.0%). The less number of weeds was determined in 2007 (84.2–102.5 weeds per m^2). Before herbicide application 10–14 species of weeds were registered, while only a few of them were prevailing: *Chenopodium album* L., *Viola arvensis* Murray, *Veronica* arvensis L., *Lamium purpureum* L., *Tripleurospermum perforatum* (Merat.) M. Lainz., *Galium aparine* L. and *Fallopia convolvulus* (L.) Löve.

Table 2. Prevailing weed species 1 month after the third application, 2006–2007, weeds per m^2

Treatment	Weed number per m^2							
	CHEAL	THLAR	GALAP	MATIN	POLAV	EPHHE	Other	Total
P+D+E (1029 g^x), standard	4.9	0.9	0.2	1.6	0.2	0.2	2.6	10.6
P+D+E+CH (2772 g^x)	4.6	0.4	1.4	0.8	0.0	1.1	3.7	12.0
P+D+E+M (2397 g^x)	0.9**	0.2	0.4	0.1**	0.0	0.1	1.9	3.6**
P+D+E+M (1665 g^x)	4.0	0.6	2.0*	0.6*	0.1	0.6	2.7	10.6
P+D+E+T (837 g^x)	4.0	0.6	1.5*	0.6*	0.0	0.0	1.7	8.4
P+D+E+T (630 g^x)	11.1**	0.2	2.0*	1.0	0.0	0.4	5.5	20.2**

Note. P – phenmedipham, D – desmedipham, E – ethofumesate, M – Metamitron, CH – chloridazon, T – triflusulfuron-methyl; g^x – g a. i. ha^{-1}*;* CHEAL – *Chenopodium album,* THLAR – *Thlaspi arvense,* GALAP – *Galium aparine,* MATIN – *Tripleurospermum perforatum,* POLAV – *Polygonum aviculare,* EPHHE – *Euphorbia helioscopia;* ** – difference significant at 99% probability level.

The post-emergence trials showed that commercial mixture of phenmedipham + desmedipham + ethofumesate (1029 g ha^{-1} – full dose) applied alone controlled *G. aparine* more effectively than other herbicide mixtures (Table 2). When the dose of phenmedipham + desmedipham + ethofumesate in a herbicide mixture was reduced by 20% but addition of chloridazon was used the effectiveness of phenmedipham + desmedipham + ethofumesate did not reduce. This mixture effectively reduced the number of *T. perforatum* and *Thlaspi arvense* L. than the application of phenmedipham + desmedipham + ethofumesate. Substituting chloridazon with metamitron also centrolled most weed species, particularly *T. perforatum*, *C. album, Euphorbia helioscopia* L. According to literature /Fisher et al., 1995, Deveikyte, 2005/, metamitron showed the high efficacy (93–100%) in controlling the *T. perforatum.* Weed control from herbicide mixtures of phenmedipham + desmedipham + ethofumesate + metamitron (2397 g ha^{-1}) was the highest. The herbicide mixtures greatly increased the spectrum controlled, giving an acceptable control of most species. This combination significantly reduced weed number. Additions of metamitron and triflusulfuron-methyl to phenmedipfam + desmedipham + ethofumesate reduced phenmedipfam + desmedipham + ethofumesate efficacy by 20.8–66.0% when phenmedipham + desmedipham + ethofumesate were used at average doses (91 + 71 + 112 g a. i. ha^{-1}). When the dose of phenmedipfam + desmedipham + ethofumesate in this herbicide mixture was reduced by a third, the number of *C. album*, *G. aparine* and *T. perforatum* increased.

The least efficacy was registered for phenmedipham + desmedipham + ethofumesate + triflusulruron-methyl (630 g ha^{-1}). In this mixture the doses of phenmedipham + desmedipham + ethofumesate were the lowest. By reducing the doses of phenmedipham + desmedipham + ethofumesate by 20% their effectiveness reduced 2.4 times. Increasing the doses of phenmedipfam + desmedipham + ethofumesate and metamitron gave more consistent control of *C. album*, *T. perforatum, Polygonum aviculare* L. and *T. arvense*.

Crop yield was not significantly different between herbicide treatments (Table 3). All herbicide treatments produced lower sugar beet yields than the hand weeded check, except the treatments where phenmedipham + desmedipham + ethofumesate with chloridazon and low doses of metamitron have been used. Similar results were reported elsewhere /Alford et al., 2003; Abdollahi, Ghadiri, 2004/.

Table 3. Sugar beet yield and quality, 2006–2007

Treatment	Root yield t ha^{-1}	Sugar content %	α – amino N mmol 100 g^{-1}	K mmol 100 g^{-1}	Na mmol 100 g^{-1}	Sugar yield t ha^{-1}
Cleaned manually (untreated)	72.20	17.49	0.79	3.97	0.24	11.32
P+D+E (1029 g a.i. ha^{-1})	70.30	17.56	0.84	4.03	0.24	11.06
P+D+E+CH (2772 g a.i. ha^{-1})	72.40	17.44	0.84	3.95	0.22	11.34
P+D+E+M (2397 g a.i. ha^{-1})	70.62	17.61	0.86	3.96	0.21	11.17
P+D+E+M (1665 g a.i. ha^{-1})	72.41	17.62	0.80	4.00	0.23	11.44
P+D+E+T (837 g a.i. ha^{-1})	70.59	17.64	0.89	3.96	0.25	11.17
P+D+E+T (630 g a.i. ha^{-1})	70.00	17.52	0.81	3.95	0.23	11.00
LSD_{05}	3.342	0.316	0.098	0.167	0.037	0.572

Note. P – phenmedipham, D – desmedipham, E – ethofumesate, M – metamitron, CH – chloridazon, T – triflusulfuron-methyl.

Sugar and non sugar content were not affected by the herbicide treatments. Sugar yield data followed the root yield data, because the herbicides did not have any influence on the amount on sugar beet root quality parameters. In the trials published by Dale et al (2006), white sucrose per hectare did not differ among post herbicide treatments.

Conclusions

1. Phenmedipham + desmedipham + ethofumesate were less effective against *Chenopodium album, Thlaspi arvense* and *Tripleurospermum perforatum* when applied in a mixture with metamitron than their mixture with chloridazon and triflusulfuron-methyl.

2. Weed number was significantly higher when reducing the dose of phenmedipham + desmedipham + ethofumesate in mixture with triflusulfuron-methyl by 40% compared with the standard.

3. None of these herbicide mixtures showed significant effect on sugar beet yield and quality.

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REFERENCES

1. Abbaspoor M., Teicher H. B., Streibig J. C. The effect of root-absorbed PSII inhibitors on Kautsky curve parameters in sugar beet // Weed Research. – 2008, vol. 46, No. 3, p. 226–235

2. Abdollahi F., Ghadiri H. Effect of separate and combined applications of herbicides on weed control and yield of sugar beet // Weed technology. – 2004, vol. 18, iss. 4, p. 968–976

3. Alford C. M., Nelson K. K., Miller S. D. Plant population, row spacing and herbicide effects on weeds and yield in sugar beets // International sugar journal. – 2003, vol. 105, No. 1254, p. 283–285

4. Dale T. M., McGrath J. M., Renner K. A. Response of sugar beet varieties and populations to post emergence herbicides // Journal of Sugar Beet Research. – 2005, vol. 42, p. 119–126

5. Dale T. M., Renner K. A., Kravchenko A. N. Effect of herbicides on weed control and sugar beet (*Beta vulgaris*) yield and quality // Weed Technology. – 2006, vol. 20, iss. 1, p. 150–156

6. Dale T. M., Renner K. A. Timing of post emergence micro-rate applications based on growing degree days in sugar beet // Journal of Sugar Beet Research. – 2005, vol. 42, p. 87–102

7. Deveikytė I. Biological effectiveness the mixture of herbicides for sugar beet // Development of environmentally friendly plant protection in the Baltic region. – 2000, p. 28–30

8. Deveikytė I. Sensitivity of *Tripleurospermum perforatum* and *Chenopodium album* on low rates of phenmedipham, desmedipham, etofumesate, Metamitron and chloridazon // Lucrari stiintifice Universitatea de stipinte agricole si medicina veterinara Ion Ionescu de la Brad. Seria Agronomy. – Romania, Iasi, 2005, vol. 48, p. 386–204

9. Deveikytė I., Seibutis V. Broadleaf weeds and sugar beet response to phenmedipham, desmedipham, ethofumesate and Triflusulfuron-methyl // Agronomy Research. – 2006, vol. 4, p. 159–162

10. Dieleman J. A., Mortensen D. A. Influence of Weed Biology and Ecology on Development of Reduced Dose Strategies for Integrated Weed Management Systems // Integrated weed and soil management / eds. J. L. Hatfield, D. D. Buhler, B. A. Stewart. – ANN Arbor Press, 1998, p. 333–362

11. Dietrich R. F., Reiser R. W., Stieglitz B. Identification of Microbial and Rat Metabolites of Triflusulfuron Methyl, a new Sugar Beet Herbicide // Journal of Agricultural Food and Chemistry. – 1995, vol. 43, No. 2, p. 531–536

12. Fisher S. J., May M. J., Dickinson G. Post-emergence broad-leaved weed control in sugar beet with triflusulfuron in the UK 1993–1994 // Weeds: Proceedings Brighton Crop Protection Conference. – Brigiton, 1995, vol. 3, p. 853–858

13. May M. Crop protection in sugar beet. Pesticide Outlook. – 2001, vol. 12, iss. 5, p. 188–191

14. May M. J. Economic consequences for UK farmers of growing GM herbicide tolerant sugar beet // Annals of Applied Biology. – 2003, vol. 142, p. 41–48

15. May M. J., Wilson R. G. Weeds and weed control // Sugar beet / eds. A. P. Drycott. – Blackwell Publishing Ltd, 2006, p. 359–386

16. Petersen J. A review on weed control in sugar beet // Weed Biology and Management / ed. Inderjit. – Dordrecht (The Netherlands), 2004, p. 467–515

17. Prodoehl K. A., Campbell L. G. Phenmedipham + desmedipham effects on sugar beet // Agronomy Journal. – 1992, vol. 84, No. 6, p. 1002–1005

18. Rouchaud J., Neus O., Hermann O. Influence of application rate and manure amendment on chloridazon dissipation in the soil // Weed research. – 1997, vol. 37, p. 121–127

19. Schweizer E. E., May M. J. Weeds and weed control // The sugar beet crop / ed. D. A. Cooke, R. K. Scott. – Chapman and Hall, 1993, p. 485–519

20. Scott R. K., Wilcockson S. J., Moisey F. R. The effects of time of weed removal on growth and yield of sugar beet // Journal of Agricultural Science. – 1979, vol. 93, p. 693–709

21. Tarakanovas P., Raudonius S. Agronominių tyrimų duomenų statistinė analizė taikant kompiuterines programas ANOVA, STAT, STAT-PILOT iš paketo SELEKCIJAI IRRISTAT. – Akademija, 2003. – 60 p.

22. Wilson R. G., Smith J. A., Yonts C. D. Repeated reduced rates of broadleaf herbicides combination with methylated seed oil for post emergence weed control in sugar beet (*Beta vulgaris*)[1] // Weed Technology. – 2005, vol. 19, iss. 4, p. 855–860

23. Wittenbach V. A., Koeppe M. K., Lichtner F. T. et al. Basis of selectivity of Triflusulfuron methyl in sugar beet (*Beta vulgaris*) // Pesticide biochemistry and physiology. – 1994, vol. 49, No. 1, p. 72–81

24. Zoschke A., Quadranti M. Integrated weed management: Quo vadis? // Weed Biology and Management. – 2002, vol. 2, p. 1–10