HERBICIDES APPLICATION IN SPRING ROW CROPS

Maja Meseldžija, Milica Dudić, Olga Popović, Radovan Begović

University of Novi Sad, Faculty of Agriculture, Trg Dositeja Obradovića 8, Novi Sad, Serbia
e-mail: maja@polj.uns.ac.rs

Abstract
The level of weed infestation of maize and sunflower differs over locations and directly affects the intensity of the competitive relationships between crops and weeds, which results in lower or greater yield losses. The experiment with tested herbicides was placed at Lipar (Serbia) during 2017. Efficacy and phytotoxicity was evaluated according EPPO/OEPP standards. The dominant weeds were: *Ambrosia artemisiifolia* L., *Chenopodium album* L., *Chenopodium hybridum* L., *Amaranthus retroflexus* L., *Datura stramonium* L., *Cirsium arvense* (L.) Scop., *Sinapis arvensis* L., *Xanthium strumarium* L., *Convolvulus arvensis* L., *Setaria glauca* L., *Sorghum halerense* (L.) Pers., *Echinochloa crus-gali* L., *Agropyrum repens* L. In the maize presence of invasive weed species *Thladiantha dubia* L., was found. Isoxaflutole, herbicide for soil application had good efficacy on weeds in maize crop. Fluorochloridone, terbuthylazine and S-metolachlor had good efficacy on all weeds in sunflower, except for broad-leaf species *Convolvulus arvensis* L.

Introduction
At the present time, maize is the most important cereal crop in the world [1]. Weed control has a major effect on the success of maize growth because the competition ability of maize is relatively low at early growth stages [2]. Maize crop is often characterized by a complex of weed flora, which consists of broad-leaf and grass weeds [3]. Weed control in maize is carried out mainly by mechanical and chemical methods, but the use of herbicide is increasing, along with increases in growing areas and production costs [4]. Because of the negative effects of weeds on the crop of corn, for their suppression is used a number of herbicides [5], most commonly, a combination of 2, 3 or more active herbicide substances, due to proven greater efficacy [6]. Different types of pre and post-emergence herbicides are used to control weeds in maize in Europe. Among post-emergence herbicides in maize, foramsulfuron is a sulfonylurea that exerts its herbicidal activity by inhibiting acetolactate synthase also known as acetohydroxy acid synthase [2], and provides adequate control of many grasses and broad-leaf weeds. Foramsulfuron can be applied in mixture with other herbicides increasing the control of some important weeds, without the risks of carry-over problems also in rotational vegetable crops [2]. Isoxaflutole is a soil and post-emergence applied herbicide that inhibits p-hydroxyphenyl pyruvate dioxygenase (HPPD), an important enzyme involved in the biosynthesis of carotene pigments in plants [7]. Recently isoxaflutole was introduced in combination with a safener, cyprosulfamide, thus allowing pre and early post application through the of field corn. Tembotrione new active substance from the group triketone. After translocation, the active substance reaches the place of growth, which causes disruption in the synthesis of carotenoids. Tembotrione was used to control broadleaf and some grass weed species in maize. The compound is sold in various mixtures and formulations [8].
Sunflower (*Helianthus annuus* L.) is the most important oil crops in Serbia [9]. Seeds have a high content (38-50%) of high-quality oil, primarily used for human consumption. Additionally, sunflower oil can be used in a wide range of products in pharmaceutical, cosmetic and chemical industries, in floriculture, honey production and also for biodiesel production [10]. The sunflower is a thermophile plant and is usually sown in mid-spring, when a large number of weeds such as *Ambrosia artemisiifolia, Xanthium strumarium,*

Datura stramonium, *Amaranthus retroflexus*, have already emerged [11]. Application of appropriate selective herbicides on weeds in the early growth stage is a globally important aspect of growing sunflower, both from an economic as well as ecological and environmental aspect [12]. Rather than pre or post-emergence herbicide application alone, use of both pre and post–emergence herbicides sequentially along with cultural practices may be a viable option to control the weeds effectively right from the sowing to harvesting and to increase the productivity of sunflower [13]. Products based on flurochloridone, terbuthylazine, acetochlor, oxadiazon, oxyfluorfen, and other active ingredients have been applied in soil treatments for the suppression of some grass and annual broad-leaf weeds in sunflower [11]. Terbuthylazine, which belongs to the group of triazine herbicides, affected electron transport in photosystem II. S-metolachlor belongs to a chloroacetamide family of herbicides. The primary mode of action is not clear, but the most recent evidence suggests that it blocks the formation of very long chain fatty acids [14]. The efficacy of S-metolachlor is strongly influenced by soil moisture and delayed under dry conditions [1]. However, the success of the crop depends largely on effective weed control under weed management strategy. Chemical weed control is an alternative method that may be less expensive, but riskier because of weed becoming herbicide resistant and of concerns about an unwanted side effect of herbicides [15].
The aim of this work was to determine the efficacy of the herbicide and reduction of weed reproduction after the application of herbicides during pre-emergent and post-emergent application in maize and sunflower.

Experimental

A field experiment was conducted at the Lipar (Serbia) during 2017, in order to determine the efficiency of applied herbicides on weed species in maize and sunflower. Herbicides efficiency trail was set up by random block system. Control plot, not treated with herbicides, was also included. The experiment was set up according to the EPPO/OEPP standards [16,17,18], in order to test the efficacy and phytotoxicity of the applied herbicides. The first treatment was applied after sowing and before the emergence of crop and weeds (preemergence - pre. em.), with preparations based on active ingredient isoxaflutole in the amount of 0.4 l/ha. The second treatment was applied when maize was in the 4-5 leaf phase with a preparation based on active substance tembotrione + isoxadifen-ethyl in an amount of 2 l/ha for the control of grass and broadleaf weeds and invasive weed species *Thlandiantha dubia* Bunge. The third treatment was applied when maize was in the 6-8 and *Sorghum halepense* in 4-5 leaf phase, with a preparation based on active substance foramsulfuron + isoxadifen-ethyl, in the amount of 2 l/ha and the active substance tembotrione + isoxadifen-ethyl in the low amount of 0.5 l/ha.The second experiment was set on a plot under the sunflower crop. Preemergence herbicides flurochloridone in the amount of 0.5 l/ha, postemergence herbicides terbuthylazine in the amount of 0.5 l/ha and S-metolachlor in the amount of 0.5 l/ha were applied. The second treatment was applied when *Sorghum halepense* (L.) Pers. was in 3-5 leaf phase, with a preparation based on active substance propaquizafop in the amount of 0.5 l/ha. Based on the obtained data, the coefficient of efficiency Ce (%) of herbicides is calculated by the formula Dodel loc. cit. Janjic (1985) and represents a relative ratio between the number of destroyed weeds compared to the weeds number in the control. Visual assessment of the phytotoxicity was performed according to the European Weed Research Council (EWRC) scale (1-9).

Results and discussion

At the investigated locality of Lipar the following weed species in maize and sunflower crop were identified: *Ambrosia artemisiifolia* L., *Chenopodium album* L., *Chenopodium hybridum* L., *Amaranthus retroflexus* L., *Datura stramonium* L., *Cirsium arvense* (L.) Scop., *Sinapis*

arvensis L., *Xanthium strumarium* L., *Convolvulus arvensis* L., *Setaria glauca* L., *Sorghum halerense* (L.) Pers., *Echinochloa crus-gali* L., *Agropyrum repens* L.

Application of the pre- and post-emergence herbicides in maize, isoxaflutole (0.4 l/ha), tembotrione + isoxadifen-ethyl (2 l/ha), foramsulfuron + isoxadifen-ethyl (2 l/ha) and the active substance tembotrione + isoxadifen-ethyl in low amount (0.5 l/ha) during the assessment of efficiency gave the following results presented in table 1.

Table 1. The presence of weeds in maize crop and the herbicide efficiency

	Weed species	No/m^2	Ce (%)	Control No/m^2
1	*Amaranthus retroflexus* L.	0	100%	2
2	*Ambrosia artemisiifolia* L.	0	100%	4
3	*Chenopodium album* L.	0	100%	2
4	*Convolvulus arvensis* L.	0	100%	3
5	*Datura stramonium* L.	0	100%	1
6	*Setaria glauca* L.	0	100%	2
7	*Sorghum halepense* (L.) Pers.	1	88%	9
8	*Thladiantha dubia* L.	1	95%	21
9	*Xantium strumarium* L.	0	100%	1
Total number of weeds		2		45
Total efficacy (%)		95.55		-
Phytotoxicity (EWRC scale 1-9)		1		-

The efficacy assessment of herbicide application in maize was total (Ce=100%) for the following weed species: *Ambrosia artemisiifolia* L., *Chenopodium album* L., *Amaranthus retroflexus* L., *Setaria glauca* L., *Datura stramonium* L., *Xanthium strumarium* L., *Convolvulus arvensis* L. Good efficacy (Ce= 95%) of applied herbicides was on weed that are poor in our region, *Thladiantha dubia* L., and has the status of an invasive weed species. Assessment of the efficacy of the applied herbicides of 88% in maize crop was established in weed species *Sorghum halepense* (L.) Pers. Gatzweiler et al. (2012) [8] showed that composition tembotrione+isoxadifen-ethyl at the exaggerated rate of 300+150 g a.i./ha achieves a complete crop tolerance in the vast majority of the common maize varieties.According to Radivojevic et al. (2014) [19] mesotrione has shown high efficacy in the control of the following species: *Amaranthus retroflexus* L., *Chenopodium album* L., *Chenopodium hybridum* L., *Solanum nigrum* L., *Xantium strumarium* L., *Cirsium arvense* (L.) Scop., *Datura stramonium* L.,. For *Abutilon theophrasti*, *Ambrosia artemisiifolia* L., *Bilderdykia convolvulus*, *Polygonum aviculare* high efficacy was confirmed only in higher quantities of application (1.2 L/ha). According to Onc Jovanovic et al. (2010) [20] application of compounds of different mechanisms of action and spectrum give good results in the control of annual broadleaf weeds in maize.

Application of the pre- and post-emergence herbicides flurochloridone (0.5 l/ha), terbuthylazine (0.5l/ha), S-metolachlor (0.5l/ha) and propaquizafop (0.5l/ha) in sunflower, during the assessment of efficiency gave the following results presented in table 2.

Table 2. The presence of weed species and the efficacy of tested herbicides in sunflower crop

	Weed species	No/m^2	Ce (%)	Control No/m^2
1	*Agropyrum repens* L.	0	100%	3
2	*Ambrosia artemisiifolia* L.	0	100%	12
3	*Chenopodium album* L.	1	90%	11
4	*Chenopodium hybridum* L.	1	100%	17
5	*Cirsium arvense* (L.) Scop.	0	100%	2
6	*Convolvulus arvensis* L.	2	0%	2
7	*Datura stramonium* L.	0	100%	7
8	*Echinochloa crus-galli* L.	1	50%	2
9	*Sinapis arvensis* L.	0	100%	1
10	*Solanum nigrum* L.	0	100%	3
11	*Sorghum halepense* (L.) Pers.	0	100%	5
Total number of weeds		5		75
Total efficacy (%)		93.33		-
Phytotoxicity (EWRC scale 1-9)		1		-

Total efficacy Ce (100%) of applied herbicides in sunflower was on: *Chenopodium hybridum* L., *Ambrosia artemisiifolia* L., *Sinapis arvensis* L., *Datura stramonium* L., *Cirsium arvense* (L.) Scop., *Sorghum halepense* (L.) Pers., *Solanum nigrum* L., *Agropyrum repens* L. (tab. 2). Tested herbicides had low efficacy (50%) on *Echinochloa crus-galli* L., while applied herbicides did not have effect on *Convolvulus arvensis* L.In a study performed by Jursik et al. (2015) [21] efficacy of flurochloridone on *E. crus-galli, M. annua*, and *S. physalifolium* was not satisfactory, especially with treatments without irrigation, while S-metolachlor only controlled *A. retroflexus* and *E. crus-galli* (efficacy 93–100%). Simić et al. (2011) [11] showed that applied herbicides flurochloridone + s-metolachlor reduced the number of annual broad-leaf species *S. nigrum*, *D. stramonium*, *A. retroflexus*, *Ch. album* and *Ch. hybridum*, while the effect of the herbicides on the most dominant species, *A. artemisiifolia* and *X. strumarium*, was unsatisfactory.

Conclusion

Based on the results of research during 2017, can be made the following conclusions: 9 weed species were determined in maize, while 11 weed species were determined in the sunflower crop. The presence of invasive weed species *Thladiantha dubia* L., was found in corn. Herbicide for soil application isoxaflutole had good efficacy on weeds in maize crop. Application of herbicides fluorochloridone, terbuthylazine and S-metolachlor in sunflower had good efficacy on all weed species, except for broad-leaved species *Convolvulus arvensis* L. Using the tested herbicides in maize and sunflower crops, uninterrupted growth and development has been ensured.

References

[1] J. Andr, V. Hejnák, M. Jursík, V.Fendrychová (2014). Effects of application terms of three soil active herbicides on herbicide efficacy and reproductive ability for weeds in maize. Plant, Soil and Environment, 60(10), 452-458.

[2] Pannacci, E. (2016). Optimization of foramsulfuron doses for post-emergence weed control in maize (*Zea mays* L.). Spanish Journal of Agricultural Research, 14(3), p.e1005.

[3] Pannacci, E., Onofri, A. (2016). Alternatives to terbuthylazine for chemical weed control in maize. Communications in Biometry and Crop Science, 11, 51–63.
[4] Kir, K., Dogan, M.N. (2009). Weed control in maize (*Zea mays* L.) with effective minimum rates of foramsulfuron. Turkish Journal of Agriculture and Forestry, 33(6), 601-610.
[5] Nestorović, M.(2009). Efikasnost herbicida u suzbijanju korova u usevu kukuruza. Savremena poljoprivreda, vol. 58, 3-4, 87-93.
[6] Golijan, J., Elezović, I. (2015). Ispitivanje fitotoksičnosti i efikasnosti acetohlora sa dihlormidom u kukuruzu. Zaštita bilja 66 (1): 38-44.
[7] Robinson, D.E., Soltani, N., Shropshire, C., Sikkema, P.H. (2013). Cyprosulfamide safens isoxaflutole in sweet corn (Zea mays L.). Hortscience 48: 1262-1265.
[8] Gatzweiler, E., Krähmer, H., Hacker, E., Hills, M., Trabold, K., Bonfig-Picard, G. (2012). Weed spectrum and selectivity of tembotrione under varying environmental conditions. In: Proceedings of the 25th German Conference on Weed Biology and Weed Control. Braunschweig, Germany, 385–391.
[9] Marković, M. (2003). Zaštita ratarskih kultura, Agroteka, Beograd.
[10] Castro, C., Leite, R. (2018). Main aspects of sunflower production in Brazil. OCL, 25(1) p.D104.
[11] Simić, M., Dragićević, V., Knežević, S., Radosavljević, M., Dolijanović, Z., Filipović, M. (2011). Effects of applied herbicides on crop productivity and on weed infestation in different growth stages of sunflower (Helianthus annuus L.). Helia, 34(54), 27-37.
[12] Smatana, J., Macák, M.,Ernst, D. (2014). Weed control in sunflower (*Helianthus annuus* L.) on the interface of agro-climatic conditions of maize and sugar beet growing region. Acta fytotechnica et zootechnica, 17(04), 115-121.
[13] Sujith, G.M., Geetha, K.N., Shadakshari, Y.G. (2017). Effect of different herbicides and cultural practices on weed dynamics and productivity of sunflower (*Helianthus annuus* L.) Grown on alfisols of eastern dry zone of Karnataka. International Journal of Advanced Biological Research, 7 (3), 595-599.
[14] Reddy, S., Stahlman, P., Geier, P., Thompson, C. (2012). Weed Control and Crop Safety with Premixed S-Metolachlor and Sulfentrazone in Sunflower. American Journal of Plant Sciences, 03(11),1625-1631.
[15] Tadavi, A.G., Chorey, A.B., Gaikwad, G.S., Sawadhkar, S.M. (2017). Integrated Weed Management in Sunflower. Int.J.Curr.Microbiol.App.Sci. 6(9), 1080-1088.
[16] EPPO/OEPP Standards. (2009). Guidelines for the efficacy evaluation of plant protection products. Phytotoxicity assessment, 31-37.
[17] EPPO/OEPP Standards. (2009). Guidelines for the efficacy evaluation of plant protection products. Weed in sunflower, 30-34.
[18] EPPO/OEPP Standards. (2009). Guidelines for the efficacy evaluation of plant protection products. Weed in maize, 6-10.
[19] Radivojević, Lj., Gajić Umiljendić, J., Marisavljević, D., Anđelković, A., Pavlović, D. (2014). Primena mezotriona u kombinaciji sa terbutilazinom, nikosulfuronom i s-metolahlorom u kukuruzu. Zaštita bilja, 65 (4), 290, 155-162.
[20] Onć Jovanović, E., Marković, S., Gavrilović, Z., Dakić, P. (2010). The broadleaf weeds in corn of crop on area southwestern Banat and their control, Banat's Journal of Biotechnology. 1(1), 52–55.
[21] Jursík, M., Soukup, J., Holec, J., Andr, J., Hamouzová, K. (2015). Efficacy and selectivity of pre-emergent sunflower herbicides under different soil moisture conditions. Plant Protection Science, 51(4), 214-222.