THE WEEDS IN SOYBEAN AND THE EFFICACY OF THEIR CONTROL BY FLUMIOXAZIN 510 g/kg WG

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Abstract

Soybean is one of the most important agricultural crops and one of the leading problems in the soybean production is the presence of the weeds. The weed species are, for the most part, controlled by herbicides. The use of soil herbicides, as well as the subsequent application of the corrective foliar herbicides, reduces the amount of the potential weeds on the field. During the vegetative period in 2023, the number of the weed species was monitored at four localities in the Republic of Serbia (Stara Pazova, Kać, Despotovo and Čurug), after which the efficacy of different application rates of flumioxazine 510 g/kg WG was compared. At the application rates of 0.12 and 0.16 kg/ha, the studied herbicide had high level of efficacy in the control of: *A. retroflexus*, *D. stramonium*, *C. hybridum*, *H. trionum*, *S. glauca*, *S. arvensis* and *S. nigrum*, satisfactory efficacy in case of *C. album* and *B. convolvulus*, poor to satisfactory efficacy in case of *S. halepense* and low efficacy in the control of *A. theophrasti*, *A. artemisiifolia*, *C. arvense*, *C. arvensis* and *X. strumarium*. The standard showed the same results as the tested herbicide. The phytotoxicity was not observed.

Introduction

Soybean, scientifically known as *Glycine max* (L.) Merrill, is one of the oldest cultivated plants, with roots tracing back to the Far East around 3000 BC. Renowned for its high protein and oil content, along with essential minerals and vitamins, soybean is a crucial agricultural resource for both human and animal nutrition, as well as various industrial applications. Despite its nutritional importance, soybean has not always received the recognition it deserves in agricultural production. Originating in China, the plant later spread to southern China, Korea and Japan, which are considered the secondary centers of its development. The soybean gained wider awareness in the West during the 18th century due to advancements in maritime transport, leading to its introduction in European and American botanical gardens. Benjamin Franklin is credited with bringing soybean to America. By the 19th century, soybean began to proliferate globally, solidifying its role in modern agriculture [1]. For successful soybean production, it is essential to adhere to all recommended agronomic practices, with weed control playing a critical role. Soybean, like the other field crops, is particularly vulnerable to competition with the weeds during the early growth stages, when the greatest struggle occurs for available space, sunlight, water and nutrients [2]. In soybean, as in the other row crops, a wide range of different weed species can be encountered. Some of the most prevalent broadleaf weeds in soybean are: *Abutilon theophrasti* Medik., *Amaranthus retroflexus* L., *Ambrosia artemisiifolia* L., *Chenopodium album* L., *Cirsium arvense* (L.) Scop., *Convolvulus arvensis* L., *Datura stramonium* L., *Hibiscus trionum* L., *Polygonum convolvulus* L., *Sinapis arvensis* L., *Solanum nigrum* L., *Xanthium strumarium* L., etc., while the important grass weeds which can occur are: *Agropyrum repens* L., *Digitaria sanguinalis* (L.) Scop., *Echinochloa crus-galli* (L.) P.Beauv., *Panicum* sp., *Setaria* sp. and *Sorghum halepense* L. [3]. The objective of the research was to identify and monitor weed vegetation in soybean crops at four studied localities under the

conditions of chemical control. The aim of the study was to determine and evaluate the efficacy of the tested herbicide for the weed control in soybean.

Experimental

During the growing season in 2023 (in May and June) the study conducted on the weed flora in soybean crops at four localities in the Republic of Serbia (Stara Pazova, Kać, Despotovo and Čurug) was carried out. The assessment of the weed species in soybean fields involved counting the weeds in randomly chosen 1 m² quadrants within each 25 m² plot. This method allowed for a systematic evaluation of weed diversity in the crop. The identification of the weed species was done according to the literature sources [4,5]. The experiment was conducted using a randomized block design with four replicates, which included a standard treatment (the herbicide with the same formulation and equivalent amount of active ingredient as the one being tested) and a control group (untreated plots), following EPPO guidelines [6,7]. Weather conditions throughout the experiment were optimal for the effective performance of the herbicides under investigation. The results were compiled and analyzed at the University of Novi Sad, Faculty of Agriculture, Department of Environmental and Plant Protection, using MS Excel and Statistica 10. This analysis was based on the average values from four plots for each treatment, including the control. The efficacy of the studied herbicide was assessed using the following categories: poor efficacy (less than 75%), satisfactory efficacy (75-90%) and high efficacy (greater than 90%). Phytotoxicity was visually assessed on a scale from 0 to 100% during the efficacy evaluation, where 0% indicates no visible signs of phytotoxicity and 100% signifies complete plant degradation. Flumioxazin 510 g/kg WG was applied at two application rates: 0.12 and 0.16 kg/ha, while the standard was applied at the rate 0.16 kg/ha. Table 1 provides the details of the field sites and the experiment.

Table 1. The overall information about the field sites and the experiment

Locality	**Stara Pazova**	**Kać**	**Despotovo**	**Čurug**
Coordinates	44°58’59’’N 20°11’19’’E	45°20’18’’N 19°52’23’’E	45°27’52’’N 19°34’13’’E	45°31’33’’N 20°01’45’’E
Crop variety	Dukat	Rubin	Wendy	Rubin
Sowing time	20.04.2023.	30.04.2023.	30.04.2023.	01.05.2023.
Date of application	22.04.2023.	04.05.2023.	05.05.2023.	04.05.2023.
Temperature atmoa* [C°]	15.87	15.60	17.09	15.53
Humidity atmoa [%]	42.85	76.06	84.66	77.36
Amount of water used [l/ha]	300	300	300	300
First assessment	06.05.2023.	22.05.2023.	22.05.2023.	22.05.2023.
Second assessment	13.05.2023.	05.06.2023.	29.05.2023.	05.06.2023.

*atmoa – at the moment of application

Results and discussion

Flumioxazin is a selective, contact (foliar) herbicide from the chemical group of N-phenylphthalimides. Flumioxazin is used for post-emergence control of annual broadleaf weeds. Its mode of action affects the chlorophyll biosynthesis and inhibits the PPO (protoporphyrinogen oxidase) activity, leading to the irreversible damage to the function and structure of the lipid membranes [8].

Efficacy of flumioxazin 510 g/kg WG at Stara Pazova locality. The results of flumioxazin 510 g/kg WG efficacy at Stara Pazova locality are shown in Table 2.

Table 2. The efficacy of flumioxazin 510 g/kg WG at Stara Pazova locality.

Weed species	Control	Flumioxazin 510 g/kg WG 0.12 kg/ha		Flumioxazin 510 g/kg WG 0.16 kg/ha		Standard 510 g/kg WG 0.16 kg/ha	
	No./m^{2*}	No./m^2	Eff.*	No./m^2	Eff.	No./m^2	Eff.
			First assessment				
Abutilon theophrasti	3.25	1.25	61.54	1.00	69.23	1.00	69.23
Ambrosia artemisiifolia	4.00	1.50	62.50	1.25	68.75	1.25	68.75
Chenopodium album	4.75	1.00	78.95	0.75	84.21	0.50	89.47
Cirsium arvense	4.75	2.00	57.89	1.25	73.68	1.50	68.42
Datura stramonium	4.00	0.25	93.75	0.00	100.00	0.25	93.75
Solanum nigrum	3.50	0.00	100.00	0.00	100.00	0.00	100.00
			Second assessment				
Abutilon theophrasti	4.50	1.75	61.11	1.50	66.67	1.25	72.22
Ambrosia artemisiifolia	6.00	3.00	50.00	2.00	66.67	2.25	62.50
Chenopodium album	6.25	1.50	76.00	1.00	84.00	0.75	88.00
Cirsium arvense	6.00	2.75	54.17	2.00	66.67	2.25	62.50
Datura stramonium	6.50	0.50	92.31	0.00	100.00	0.25	96.15
Solanum nigrum	5.50	0.25	95.45	0.00	100.00	0.00	100.00

*No./m^2 – number per m^2; Eff. – efficacy

Flumioxazin 510 g/kg WG applied at the rates 0.12 and 0.16 kg/ha at Stara Pazova locality had high efficacy in the control of *D. stramonium* and *S. nigrum*, satisfactory efficacy in case of *C. album* and poor efficacy for the remaining three weed species.

Efficacy of flumioxazin 510 g/kg WG at Kać locality. The results of flumioxazin 510 g/kg WG efficacy at Kać locality are shown in Table 3.

Table 3. The efficacy of flumioxazin 510 g/kg WG at Kać locality.

Weed species	Control	Flumioxazin 510 g/kg WG 0.12 kg/ha		Flumioxazin 510 g/kg WG 0.16 kg/ha		Standard 510 g/kg WG 0.16 kg/ha	
	No./m^{2*}	No./m^2	Eff.*	No./m^2	Eff.	No./m^2	Eff.
			First assessment				
Ambrosia artemisiifolia	4.75	1.75	63.16	1.25	73.68	1.25	73.68
Chenopodium album	4.25	0.00	100.00	0.00	100.00	0.00	100.00
Sinapis arvensis	4.00	0.00	100.00	0.00	100.00	0.00	100.00
Solanum nigrum	3.75	0.25	93.33	0.00	100.00	0.00	100.00
Xanthium strumarium	5.00	2.00	60.00	1.75	65.00	1.50	70.00
			Second assessment				
Ambrosia artemisiifolia	7.25	3.00	58.62	2.25	68.97	2.00	72.41
Chenopodium album	5.00	0.25	95.00	0.00	100.00	0.00	100.00
Sinapis arvensis	6.25	0.50	92.00	0.25	96.00	0.00	100.00
Solanum nigrum	5.50	0.50	90.91	0.00	100.00	0.25	95.45
Xanthium strumarium	6.75	2.50	62.96	2.00	70.37	2.25	66.67

*No./m^2 – number per m^2; Eff. – efficacy

Flumioxazin 510 g/kg WG applied at the rates 0.12 and 0.16 kg/ha at Kać locality had poor efficacy in the control of *A. artemisiifolia* and *X. strumarium*, as well as the high efficacy in case of the remaining three weed species.

Efficacy of flumioxazin 510 g/kg WG at Despotovo locality. The results of flumioxazin 510 g/kg WG efficacy at Despotovo locality are shown in Table 4.

Table 4. The efficacy of flumioxazin 510 g/kg WG at Despotovo locality.

Weed species	Control	Flumioxazin 510 g/kg WG 0.12 kg/ha		Flumioxazin 510 g/kg WG 0.16 kg/ha		Standard 510 g/kg WG 0.16 kg/ha	
	No./m²*	No./m²	Eff.*	No./m²	Eff.	No./m²	Eff.
First assessment							
Ambrosia artemisiifolia	4.25	2.25	47.06	2.00	52.94	1.75	58.82
Chenopodium album	3.75	0.75	80.00	0.50	86.67	0.50	86.67
Convolvulus arvensis	4.25	2.00	52.94	1.75	58.82	1.50	64.71
Setaria glauca	3.50	0.25	92.86	0.00	100.00	0.00	100.00
Sorghum halepense	4.25	2.00	52.94	1.50	64.71	1.25	70.59
Xanthium strumarium	3.00	1.50	50.00	1.00	66.67	1.00	66.67
Second assessment							
Ambrosia artemisiifolia	5.75	3.50	39.13	2.75	52.17	2.50	56.52
Chenopodium album	4.75	1.00	78.95	0.75	84.21	0.75	84.21
Convolvulus arvensis	6.50	3.25	50.00	2.75	57.69	2.50	61.54
Setaria glauca	4.25	0.25	94.12	0.00	100.00	0.00	100.00
Sorghum halepense	6.50	3.50	46.15	2.50	61.54	2.00	69.23
Xanthium strumarium	5.50	2.75	50.00	2.00	63.64	2.25	59.09

*No./m² – number per m²; Eff. – efficacy

Flumioxazin 510 g/kg WG applied at the rates 0.12 and 0.16 kg/ha at Despotovo locality had high efficacy in the control of *S. glauca*, satisfactory efficacy in case of *C. album* and poor efficacy for the remaining four weed species.

Efficacy of flumioxazin 510 g/kg WG at Čurug locality. The results of flumioxazin 510 g/kg WG efficacy at Čurug locality are shown in Table 5.

Table 5. The efficacy of flumioxazin 510 g/kg WG at Čurug locality.

Weed species	Control	Flumioxazin 510 g/kg WG 0.12 kg/ha		Flumioxazin 510 g/kg WG 0.16 kg/ha		Standard 510 g/kg WG 0.16 kg/ha	
	No./m²*	No./m²	Eff.*	No./m²	Eff.	No./m²	Eff.
First assessment							
Amaranthus retroflexus	5.00	0.25	95.00	0.00	100.00	0.00	100.00
Ambrosia artemisiifolia	3.50	1.25	64.29	1.00	71.43	1.00	71.43
Bilderdykia convolvulus	4.25	0.75	82.35	0.50	88.24	0.50	88.24
Datura stramonium	4.00	0.25	93.75	0.00	100.00	0.25	93.75
Hibiscus trionum	3.50	0.25	92.86	0.00	100.00	0.00	100.00
Sorghum halepense	4.75	1.00	78.95	0.75	84.21	0.50	89.47
Second assessment							
Amaranthus retroflexus	6.50	0.50	92.31	0.00	100.00	0.00	100.00
Ambrosia artemisiifolia	5.50	2.00	63.64	1.50	72.73	1.75	68.18
Bilderdykia convolvulus	5.75	1.00	82.61	0.75	86.96	1.00	82.61
Datura stramonium	6.00	0.50	91.67	0.25	95.83	0.50	91.67
Hibiscus trionum	5.50	0.50	90.91	0.00	100.00	0.25	95.45
Sorghum halepense	6.25	1.50	76.00	1.00	84.00	0.75	88.00

*No./m² – number per m²; Eff. – efficacy

Flumioxazin 510 g/kg WG applied at the rates 0.12 and 0.16 kg/ha at Čurug locality had poor efficacy in the control of *A. artemisiifolia*, satisfactory efficacy in case of *B. convolvulus* and *S. halepense*, as well as the high efficacy for the remaining three weed species.
The results obtained in this study are similar to those from the research published by [9], in which flumioxazin had high efficacy in the control of the majority of the broadleaf weeds, such as *A. retroflexus* and *H. trionum*, even in case of *A. theophrasti* and *C. album* for which, in our study, the efficacy was poor or satisfactory.

Conclusion

According to the obtained results it can be concluded that the flumioxazin 510 g/kg WG at the application rates of 0.12 and 0.16 kg/ha had high level of efficacy in the control of: *A. retroflexus*, *D. stramonium*, *C. hybridum*, *H. trionum*, *S. glauca*, *S. arvensis* and *S. nigrum*, satisfactory efficacy in case of *C. album* and *B. convolvulus*, poor to satisfactory efficacy in case of *S. halepense* and low efficacy in the control of *A. theophrasti*, *A. artemisiifolia*, *C. arvense*, *C. arvensis* and *X. strumarium*. The standard showed the same results as the tested herbicide. The phytotoxicity was not observed.

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