BIOLOGICAL EFFICACY AND SELECTIVITY OF FLUROXYPYR AND FLORASULAM IN CONTROL OF BROADLEAF WEEDS IN WINTER BARLEY

Raluca-Monica Cristea*, Valentin-Marius Ciontu, Daniel Jalobă, Marga Grădilă

Research – Development Institute for Plant Protection, 8 Ion Ionescu de la Brad Blvd, 013813, Bucharest, Romania

Abstract

During 2021-2022 two fields trial with the winter barley variety "Lucian" was conducted. The studys was conducted in 2 different locations (Constanța and Călărași) and aimed to evaluate the biological activity of two herbicides based Fluroxypyr and Florasulam in control of broadleaf weeds in winter barley crops. The experiments were placed in randomized blocks, in 4 repetitions with a plot area of 100 m^2. Efficacy and selectivity of the herbicides Flurostar Super SE (100 g/l fluroxypyr +1 g/l florasulam) and Tomigan XL 102.5 SE (100 g/l fluroxypyr + 2.5 g/l florasulam), applied at registered and higher rates, was evaluated. The herbicide application was done at the phenophase of the crop – 1st – 2nd stem node (BBCH 30-32). The efficacy of the products by the 10 score scale of EWRS was recorded. The results were compared with untreated controls. The herbicide selectivity for the winter barley by the 9 score scale for phytotoxicity of EWRS was reported. The results obtained showed that the efficacy depends on the dose applied, the type of weeds and their density on square meter. The herbicide based floroxypyr and florasulam ensured a good efficacy in controlling of broadleaf weeds in winter barley, the best results being obtained at the higher dose. For both herbicides (Flurostar Super and Tomigan XL) at all evaluated rates signs of phytotoxicity for the crop were not observed.

Keywords: *winter barley, weeds, herbicides, selectivity, efficacy*

1. INTRODUCTION

The use of herbicides for the control of weeds in cereal crops in modern agriculture in the context of the application of an integrated management of control is of particular importance. Obtaining quantitatively and qualitatively high productions is unthinkable without the use of herbicides, in accordance with good agricultural practices. Barley (*Hordeum vulgare* L.) is an important cereal crop for Romania with multiple uses: as feed, in the manufacture of beer, in food, etc. In our country, winter barley is the 2nd most cultivated grain cereal after wheat, with a harvested area of 455 thousand hectares and total grain production of 1.9 million tonnes (Boanta et al. 2020; FAO 2020)**.** Barley is one of the staple crops for crop rotation because it clears the field early, helps reduce weeds, allows seeding of successive crops and is a good precursor to most spring crops.

Like wheat, barley is grown in all areas of the country under different pedoclimatic conditions and as a result the segetal flora that infests this crop is varied both in terms of species, but especially of the relationship between species, being subject to permanent variations and adaptations, especially in the context of climate changes (Grădilă et al. 2018, 2022). In the barley crops, dicotyledons prevail, being the most common are: *Agrostemma githago* (L.), *Amaranthus* spp. (L.), *Brassica nigra* (L.) Koch., *Capsella bursa - pastoris* (L.) Medicus., *Centaurea cyanus* (L.), *Cirsium arvense* (L.) Scop., *Chenopodium album* (L.), *Convolvulus arvensis* (L.), *Delphinium consolida* (L.), *Fumaria officinalis* (L.), *Galium aparine* (L.), *Lamium purpureum* (L.), *Matricaria inodora* (L.), *Papaver rhoeas* (L.), *Polygonum convolvulus* (L.) sin. *Fallopia convolvulus* (L.) A. Löve, *Raphanus raphanistrum* (L.), *Stellaria media* (L.) Vill., *Sinapis arvensis* (L.), *Sonchus arvensis* (L.) and among the monocots: *Avena fatua* (L.), *Apera spica-venti* (L.) Pal. Beauv., etc.

The level of yield losses caused by weeds in grass cereals ranges between 10 and 70% (Ion 2010). Weeds strongly compete with crop plants, affecting their growth and development, they cause economic damage by consuming an important part of the applied fertilizers, they reduce the tillering capacity, resistance to frost, to drought, they negatively influence the vegetative growth of plants, the productivity of the ear, they cause the appearance and intensification of the process of shrivelling of kernels and falling of plants in the case of clinging weeds (Șarpe et al. 1976; Șarpe & Strejan 1981; Chirilă 2001; Berca 1995, 2004).

The large number of registered herbicides for cereal crops requires efficacy and selectivity studies to offer the most effective chemical control solutions to farmers under certain pedoclimatic conditions and especially under the influence of applying their own technologies. On the other hand, taking into account the emergence of herbicide resistance phenomena in recent years, herbicides based on 2-3 active substances with different modes of action have been developed precisely to prevent the emergence and development of cross-resistance phenomena. For example, it was found that in Romania, the repeated use of herbicides based on 2,4 D and MCPA on crops cereals, determined major changes in the spectrum of weeds, with infestations with "resistant" species increasingly present: *Galium*, *Papaver*, *Matricaria, Anthemis*, *Stellaria*, *Polygonum* (not controlled by the two herbicides). The subsequent research carried at National Agricultural Research and Development Institute Fundulea highlighted the fact that by applying the first "combinations" of herbicides (2,4 D + dicamba, MCPA + bromoxynil), a simple herbicides - bromoxynil, chlorsulfuron, as well as the most recent combinations of herbicides, such as: metosulam + 2,4 D, triasulfuron + dicamba, fluroxypir + 2,4 D, florasulam + 2,4 D, flumetsulam + florasulam, bentazon + dicamba, tritosulfuron + dicamba, amidosulfuron + iodosulfuron + safener, had a superior effectiveness in combating dicotyledonous, annual and perennial weeds (over 90%), being destroyed and dicotyledonous species "resistant" to herbicides based on 2,4 D and MCPA, registering significant increases in production (Șarpe et al. 1983; Șarpe 1987; Popescu et al. 1994, 1995; Popescu 2007).

Such herbicides that are the subject of the research presented in the paper is Tomigan XL 102.5 (100 g/l Fluroxipir +2,5 g/l Florasulam) and Flurostar Super (100g/l Fluroxipir + 1g/l Florasulam) SE formulated as a suspension emulsion. The purpose of the research was to evaluate the efficacy of Fluroxypyr and Florasulam in weed control in different pedoclimatic zones and different technologies, in winter barley.

2. MATERIALS AND METHODS

The research was conducted in 2020-2021 in two experimental fields with winter barley, in 2 different locations, on 2 different types of chernozem soils at Dâlga (Călărași county) and under irrigation conditions at Agigea (Constanța county). The winter barley crops in which the assessments were performed, were cultivated by private farmers according to their own technologies (Table 1).

Table 1. Agronomic practices in the field experiments

Location	Soil	Preceding crop	Cultivar	Fertilis. data	Sowing date	Density (pl/m^2)	Treat. data	BBCH* (Scale)
Agigea N: 44°458'352" E: 28°374'610"	Vermi-calcic chernozem	Maize	Lucian	NPK 190 Kg/ha 16.10.2022	18.10.2020	300	26.04.2021	Maj: 31-32 Min: 29 Max: 33
Dâlga N: 44°281'158" E: 27°322'610"	Cambic chernozem	Sunflower	Lucian	NPK 220 Kg/ha 28.09.2020	20.10.2020	720	05.04.2021	Maj: 28-30 Min: 26 Max: 32

*Legend: 26 - 6 tillers detectable; 28 - 8 tillers detectable; 29 - End of tillering. Maximum no. of tillers detectable;

30 - Beginning of stem elongation; 31 - First node at least 1 cm above tillering node;

32 - Node 2 at least 2 cm above node 1; 33 - Node 3 at least 2 cm above node 2.

The common winter barley variety that was an object in the present research is Lucian. It is a typical autumn barley variety (with six rows of grains in the ear), semi-early, with o good twinning capacity, hows good resistance to wintering and foliar diseases (medium resistant to brown reticular spotting of barley leaves *Pyrenophora teres* f. teres).

In the experimental lot from Agigea, 2 irrigations were applied each with 600 m^3 of water/ha (an irrigation in autumn to help the uniform germination of barley and one in spring because the precipitation was extremely low). The experiments were placed in randomized blocks, in 4 repetitions with a plot area of 100 m^2. Herbicides (Tomigan XL and Flurostar Super) were applied in post-emergence in spring during the tillering stage until the flag leaf visible stage, when weeds were in the early stages of growth and development. Tomigan XL was applied at the rates of 1.0, 1.25 and 1.50 l/ha and Flurostar Super at 1.25 and 1.50 l/ha. Assessments were focused on the determination of weed species found in the experimental fields, weed density, selectivity and control effectiveness. Weeds density was assessed as percentage of soil coverage and in number of plants per square meter. Determination of segetal flora was performed on one square meter using a metric frame (Chirilă 1988). The percentage of weeds ground cover was expressed visually, depending on the species, density and phenological features of each weed (germination, emergence, leaves unfolding, tillering, flowering, fruiting, ripening, seed dispersal, height, etc.). The herbicide efficacy was recorded on the 10, 20 and 30 days after treatments according EWRS (European Weed Research Society) and the effectiveness was calculated in % control compared to untreated plots. In each trial, herbicide phytotoxicity was rated visually at each date of the efficacy assessments on a 0 -10 scale (0: no visible injury; 10: dead plant). Statistical data - processing of the assessments was based on the analysis of ARM-9 software (P= .05, Student-Newman-Keuls).

3. RESULTS AND DISCUSSION

In experimental field in spring at Dâlga, dicotyledonous weeds species prevailed and we noted: *G. aparine*, *S. arvensis*, *F. officinalis*, *Cannabis ruderalis* Janisch. and *Vicia villosa* Roth. There were found other species, too, but in a lower number with a density<5 plante/m^2: *S. media*, *Erigeron annuus* (L.) Pers., *Viola arvensis* Murray, *V. persica*, *C. arvensis*, *Setaria* spp., *Cardaria draba* (L.) and *C. arvense*. The distribution of weed species at Dâlga according to the percentage of soil coverage at 30 days after treatments in the untreated is shown in figure 1, where *Rubiaceae* was the dominant weed family (35.5%).

In experimental field at Agigea, there were annual weeds: *Veronica* spp., *P. rhoeas* and *Daucus carota* subsp. sativus. There were found other species, too, but in a lower number with a density<5 plante/m^2: *P. convolvulus*, *C. album*, *E. crus-galli*, *C. arvense*, *S. pumila*, *C. bursa-pastoris* and *G. aparine.* The distribution of weed species at Agigea according to the percentage of soil coverage at 30 days after treatments in the untreated is shown in figure 2, where the species of genus *Veronica* was the dominant (60.5%).

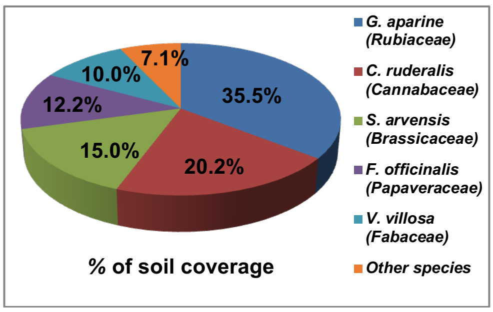

Figure 1. Weed species at Dâlga

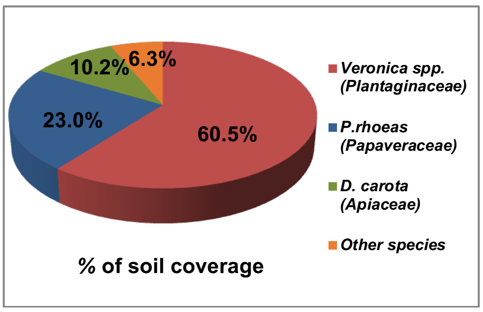

Figure 2. Weed species at Agigea

The dominant weed at Dâlga was the cleavers weed which at 30 days after treatment had a percentage of ground coverage>35% in the untreated control. Cleavers is a problematic broadleaved weed in winter crops in Eurasia and North America (Defelice 2002; Mennan & Zandstra 2005; Johnson et al. 2018; Zargar et al. 2020). This weed is highly adapted to the environment due to its inherent characteristics such as flexibility in the timing of seed germination, variable growth forms, multiple annual lifecycles, freezing tolerance, high dispersal ability and high genetic diversity (Hubner et al. 2003; Mennan et al. 2011). It is an annual or perennial seminiferous plant, hibernating, climbing, rough to the touch and sticky, which causes direct damage to barley production through the consumption of water and nutrients, but also indirect damage because it makes harvesting difficult and is a host plant for nematodes, insects and pathogens (Ştef et al. 2020). It is a hard to control weed as over the last decades the research carried out has clearly shown that this species is resistant to 2,4-D and MCPA, herbicides frequently used to control weeds in wheat crops (Glazunova et al. 2015; Zargar et al. 2020). Cases of high levels of resistance to herbicides that inhibit ALS (chlorsulfuron and tribenuron) have also been reported, as well as situations of additional cross-resistance to florasulam + 2,4-D (Papapanagiotou et al. 2019). Combinations of postemergence herbicides are recommended to sustain season long-term control of cleavers. In this context, the herbicides based Florasulam + Fluroxypyr had a good effectiveness in controlling the *G. aparine* the best results being obtained at higher doses (Tables 2 and 3). Thus, at the rate of 1.5 l/ha the effectiveness of Tomigan XL from cleavers was: 96.1% at 20 days after treatment and 88.8% at 30 days after treatment. The effectiveness of Flurostar Super at the rate of 1.5 l/ha from cleavers was: 90.5% at 20 days after treatment and 88.7% at 30 days after treatment. Overal, in such conditions of weeds infestation, the post-emergence applied Florasulam + Fluroxypyr at Dâlga was very effective in controlling annual broadleaved weeds with the exception of the perennial species *C. ruderalis*, a late spring weed and is mainly seen in spring field crops and orchards (Small et al. 2003). This weed species has above-ground biomass that reaches 2-3 m in height, as well as a strong and deep root system, being a very aggressive weed that produces great economic damage (Duary & Mukherjee 2013). Reisinger et al. (2005) reported that wild hemp is significantly more competitive compared to culture. This leads to inefficient use of the available soil moisture and available nutrients. Its presence in high density in the fields makes the production difficult and sharply decreases yields (Osman et al. 2014). For the wild hemp control different methods are applied. Many authors recommend the biological control by using mycoherbicides (Dochev et al. 2016).

The information about the chemical control of the wild hemp at cereals as well as at the other crops is still limited. Pandey (1989) established that the infestation with wild hemp at maize is controlled by usage of metribuzin at dose of 0.5 kg/ha, pendimethalin at dose of 1.0 kg/ha and two times earthing up on the 25th and on the 45th day. For wild hemp the effectiveness of Tomigan XL at the rate of 1.50 l/ha was: 57.6% at 20 days after treatment and 52.4% at 30 days after treatment. The effectiveness of Flurostar Super for wild hemp at the rate of 1.50 l/ha was: 55.0% at 20 days after treatment and 49.8% at 30 days after treatment, the herbicidal effect being similar to the herbicide Tomigan XL.

Similarly, an unsatisfactory control was also observed in the case of *V. villosa* species at 20 days after treatment 65.0% at rates of 1.25 l/ha for both herbicides and 55.2% at rates of 1.50 l/ha for Tomigan XL and 52.6 for Flurostar Super at 30 days after treatment (Tables 2 and 3). The most unsatisfactory efficacy was observed when the herbicides based on Florasulam + Fluroxypyr were applied at 1.0 l/ha, especially in the case of hard-to-control aggressive perennial species.

Table 2. The efficacy of herbicides in winter barley after 20 days of treatment

Treatment name	Rate l/ha	Dâlga (Călărași)					Agigea (Constanța)		
		Efficacy (% control compared with the untreated plots)							
		Weeds stage majority (BBCH)							
		34-40	36-40	34-40	34-40	35-40	36-51	40-44	36-40
		GALAP	**SINAR**	**FUMOF**	**CNIRU**	**VICVI**	**VERSS**	**PAPRH**	**DAUCA**
Untreated		0.0d	0.0c	0.0c	0.0d	0.0d	0.0b	0.0c	0.0c
Tomigan XL	1.0	63.0c	68.2b	70.2b	34.9c	55.0c	52.6a	57.6b	73.2b
	1.25	76.2bc	78.9b	80.5ab	44.0b	65.0b	68.6a	83.0a	75.9ab
	1.50	96.1a	93.3a	88.8a	57.6a	75.1a	80.5a	67.0ab	92.5a
Flurostar Super	1.25	78.3bc	72.8b	86.4ab	43.2b	65.0b	55.2a	65.4ab	81.2ab
	1.50	90.5ab	90.5a	89.6a	55.0a	75.1a	71.1a	79.2ab	86.0ab
LSD P=Various		**12-19**	**10-14**	**11-13**	**5.9-6.1**	**3.4-3.8**	**22-23**	**16-17**	**12-14**
Standard Deviation		**8.5t**	**6.5t**	**6.3t**	**2.3t**	**1.4t**	**9.4t**	**7.1t**	**6.8t**

Legend: 34 - 4 visibly extended internode; 35 - 5 visibly extended internode; 36 - 6 visibly extended internode;

40 - Vegetative reproductive organs begin to develop (rhizomes, stolons, tubers, runners, bulbs);

51 - Inflorescence or flower buds visible.

At Agigea, it is noted that species of the genus *Veronica* predominated, being present *V. hederifolia* (L.), *V. agrestis* (L.) and *V. persica* Poiret. Its germination period coincides with that of rapeseed and cereals causes significant yield losses, especially on soils well supplied with nitrogen (Chirilă et al. 2001). *V. persica* has been reported as a weed for 27 crops in 45 countries (Holm et al. 1997) being a major weed in 10 countries and one of the four most common broadleaf weeds (Whitehead & Wright 1989). For serious infestations, controlling *Veronica* calls for a combination of good cultural practices and the use of herbicides. Pre-emergence products should be applied around the time you expect seeds to germinate and use post-emergent herbicides in spring and fall when the plants are actively growing (Jackie 2021).

Table 3. The efficacy of herbicides in winter barley after 30 days of treatment

Treatment name	Dose l/ha	Dâlga (Călărași)					Agigea (Constanța)		
		Efficacy (% control compared with the untreated plots)							
		Weeds stage majority (BBCH)							
		46-50	44-48	44-48	46-50	50-54	46-50	51	48-50
		GALAP	**SINAR**	**FUMOF**	**CNIRU**	**VICVI**	**VERSS**	**PAPHR**	**DAUCA**
Untreated		0.0c	0.0c	0.0d	0.0d	0.0c	0.0b	0.0b	0.0b
Tomigan XL	1.0	55.1b	63.0b	62.2c	26.3c	29.5b	38.5a	52.6a	68.0a
	1.25	64.2b	73.7b	75.8bc	36,9b	39.7b	50.0a	65.3a	80.4a
	1.50	88.8a	88.8a	88.8a	52.4a	55.2a	58.9a	78.7a	94.7a
Flurostar Super	1.25	64.3b	72.0b	75.9bc	39.5ab	39.7b	39.5a	55.0a	88.8a
	1.50	88.7a	87.9a	85.0ab	49.8ab	52.6a	55.5a	78.3a	90.3a

LSD P=Various	**11-14**	**11-13**	**9.5-11**	**10-11**	**8.9-9.4**	**17-17**	**10-20**	**17-21**
Standard Deviation	**5.8t**	**50.t**	**5.0t**	**4.2t**	**3.8t**	**6.7t**	**8.1t**	**10.2t**

Since the scientific literature presents data on the different sensitivity of *Veronica* sp. to the action of herbicides, farmers must be very careful how they identify the species, because in the herbicide labels they are often grouped as *Veronica* spp., accompanied by the popular name of a single species, and the data clearly show that *V. hederifolia* is more resistant to the action of herbicides compared to other species of *Veronica*. The knowledge regarding the sensitivity and resistance of weeds to the action of herbicides helps farmers to choose the most appropriate strategies for controlling them. Due to the irrigation in the experimental lot from Agigea, the *Veronica* species considered ephemerals developed and multiplied a lot like a vegetal carpet, being identified young plants that had just emerged and plants that were already in flower.

No symptoms of phytotoxicity were revealed in the experimental plots. No symptoms of chlorosis, browning, necrosis, leaf deformations or flowering delays were observed in the experimental wheat lots treated with Florasulam + Fluroxypyr (OEPP/EPPO Standards Bulletin 2014).

Florasulam is an active substance belonging to a chemical group (1,5 triazolo-pyrimidine-sulfon-anilides) known to inhibit the enzyme acetolactate synthase (ALS). Fluroxypyr belongs to a chemical group of herbicides (pyridine carboxylic acids) known to disrupt the growth of plant cells in newly formed stems and leaves. This affects protein synthesis and normal cell division, leading to the development of malformations and tumors in affected weeds. In the experimental field, the first symptoms were observed after 1-2 weeks of application, meristematic tissues being the first affected by symptoms of chlorosis and necrosis, followed by chlorosis and total necrosis of the leaves. At lower doses some weeds species are insufficiently controlled, such as *G. aparine* 55.1%, *S. arvensis* 63.0%, *F. officinalis* 62.2%, *Veronica* species 38.5%, *P. rhoeas* 52.6% and *D. carota* 68.0% at the rate of 1.0 l/ha.

4. CONCLUSIONS

The appearance of the phenomena of resistance to herbicides required the development of herbicides with 2 or 3 active substances with different modes of action. The purpose of the research was to evaluate the efficacy of Fluroxypyr and Florasulam in weed control in different pedoclimatic zones and different technological sequences, in winter barley. In the experimental fields with winter barley studied, annual dicotyledonous weeds predominated. The herbicide Fluroxypyr and Florasulam provided a good efficacy on broadleaved weeds, the best results were obtained at the higher dose.

Some weed species were insufficiently controlled at the lower doses: cleavers, wild mustard, fumitory, veronica, poppy, wild carrot, etc. The herbicidal effect was manifested much faster in 7-10 days after application by the total drying of the weeds sensitive to Agigea in the irrigation conditions and much slower within 30 days at Dâlga in drought conditions.

ACKNOWLEDGMENTS

We respectfully and gratefully thank to farmers from trials locations who made this study possible.

REFERENCES

1. Berca, M 1995, “Combaterea buruienilor din culturile agricole”, *Ed. Fermierul Român*, București, pp. 155-158.
2. Berca, M 2004, “Weed Integrated Management”, *Ceres Publishing House*, pp. 534.

3. Boanta, EA, Muntean, L, Russu, F, Porumb, I, Parlici, RM & Ona, AD 2020, "Variability of yield traits in a germplasm of barley cultivars, studied at Turda Agricultural Research and Development Station, Cluj County, Romania", *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, 20(1), pp. 95-100.
4. Chirilă, C 1988, "Cartarea - componentă a sistemului integrat de prevenire şi combatere a buruienilor", *Simpozionul Național de Herbologie*, București, 6, pp. 19-24.
5. Chirilă, C 2001, "Biologia buruienilor", *Ed. Ceres*, Bucureşti, pp. 304.
6. Duary, B, Mukherjee, A 2013, "Distribution pattern of predominant weeds in wet season and their management in West Bengal, India'. The role of weed science in supporting food security by 2020", Proceedings of the 24th Asian-Pacific Weed Science Society Conference, Bandung, Indonesia, October 22-25, Bandung: *Weed Science Society of Indonesia*, 2013, pp. 191-199.
7. Defelice, MS 2002, "Catchweed bedstraw or cleavers, *Galium aparine* L. a very "sticky" subject", *Weed Technol*., 16, pp. 467– 472.
8. Dochev, C, Mitkov, A, Yanev, M, Neshev, N & Tonev, T 2016, "Herbicide control of wild hemp (*Cannabis sativa* L.) at sunflower grown by Express Sun technology", In VII International Scientific Agriculture Symposium, *"Agrosym 2016*", 6-9 October 2016, Jahorina, Bosnia and Herzegovina, Proceedings, pp. 1339-1344.
9. FAO - Food and Agriculture Organization of the United Nations 2020, "Faostat", http://www.fao.org/faostat/en/
10. Glazunova, JA, Bezgina, DV, Ustymov, LV, Maznitsyna, OV 2015, "Modern herbicides in winter wheat crops and their influence on crop yield ", *Agriculture and Crop Production*, 9, pp. 29–31.
11. Grădilă, M, Jalobă, D, Vasile, N 2018, "Researches regarding weed control in winter wheat in the context of climate changes", Lucrări științifice, seria Agronomie, Iași, 61(2), pp. 175-180.
12. Grădilă, M, Jalobă, D, Ciontu, M, Cristea, R, Petcu, V 2022, "Selectivity and efficacy of thifensulfuron-methyl with adjuvant and without in control of broadleaf weeds in winter wheat", *Lucrări Ştiinţifice* – vol. 65(2), seria Agronomie, Universitatea Pentru Ştiinţele Vieții" Ion Ionescu de la Brad" Iaşi, ISSN 1454-7414, pp. 125-130.
13. Holm, L, Doll, J, Holm, E Pancho, J Herberger, J 1997, "World Weeds: *Natural Histories and Distribution*", John Wiley and Sons, New York, USA.
14. Hubner, T, Fykse, H, Hurle, K, Klemsdal, SS 2003, "Morphological differences, molecular characterization, and herbicide sensitivity of Catchweed bedstraw (*Galium aparine*) populations", *Weed Sciences*. 51, pp. 214-225.
15. Ion, V 2010, "Fitotehnie. Curs Universitar", Fac. Horticultură București, www. horticultura-bucuresti. ro/images/pdf/Fitotehnie. Pdf.
16. Jackie, C 2021, "Speedwell Control: How To Get Rid Of Speedwell Lawn", Weedshttps://www.gardeningknowhow.com/plant-problems/weeds/speedwell-lawn-weeds.htm
17. Johnson, EN, Wang, Z, Geddes, CM, Coles, K, Hamman, B, Beres, BL 2018, "Pyroxasulfone is effective for management of Bromus spp. in winter wheat in Western Canada", *Weed Technol*., 32, pp. 739-748. doi:10.1017/wet.2018.70.
18. Mennan, H, Zandstra, BH 2005, "Effect of wheat (*Triticum aestivum*) cultivars and seeding rate on yield loss from *Galium aparine* (Cleavers)", *Crop Protec*., 24, pp. 1061–1067.
19. Mennan, H, Streibigb, JC, Ngouajioc, M, Cankaya S 2011, "Response of two catchweed bedstraw (*Galium aparine*) populations to post-emergence herbicides in winter wheat", *Int J Pest Manage.* 54, pp. 347–356. doi:10.1080/ 09670874.2011.622085.

20. Osman, A, El-Habieb, R, Elkhawad, M 2014, "Herbicidal efficasy of oxyfluorfen (Sharoxy 24 EC) for pre-emergence weed control in sunflower", *Persian Gulf Crop protection* 3 (4) Dezful: Islamic Azad University, Plant Protection Department, pp. 37-44.
21. OEPP/EPPO Standards Bulletin 2014, PP1/135 (4) "Phytotoxicity assessment, Efficacy evaluation of plant protection products Evaluation biologique des produits phytosanitaires", vol. 44, no. 3, pp. 265-273, <https://onlinelibrary.wiley.com/doi/epdf/10.1111/epp.12134
22. Pandey, J 1989, "Effect of *Cannabis sativa* infestation on yield of rabi maize", *Indian Journal of Agronomy* 34(1), pp. 109-110.
23. Papapanagiotou, AP, Damalas, CA, Bosmali, I, Madesis, P, Menexes, GC, Eleftherohorinos, IG 2019, "*Galium spurium* and *G. aparine* resistance to ALS-inhibiting herbicides in northern Greece", *Planta Daninha*, 37: e019207288. DOI: 10.1590/s0100-83582019370100106.
24. Popescu, A, Vlăduţu, I, Bârlea, V, Popa, F, Beraru, C, Ciobanu, C, Nagy. C, Pogăceanu, M, Chiriță, N, Vilău, N, Ionescu, Fl, Păunescu, G 1994, "Eficacitatea aplicării noilor sortimente de erbicide în combaterea buruienilor dicotiledonate din cultura grâului", *Simpozionul Proplant, Călimănesti*: pp. 140-154.
25. Popescu, A, Ciobanu, C, Bârlea, V, Păunescu, G, Bodescu, Fl, Vilău, N, 1995, "Various herbicides efficacy in controlling the on annual and perennial dicotyledons weeds in winter wheat under Romanian conditions", *Proceedings of the 9th EWRS Symposium*, Hungary, 10-12 July 1995.
26. Popescu, A 2007, "Rezultate experimentale privind combaterea chimică a buruienilor din culturile de câmp", An INCDA Fundulea, vol. LXXV, vol. jubiliar, pp. 343-356.
27. Reisinger, P, Lehoczky, É, Komives T 2005, "Competitiveness and precision management of the noxious weed *Cannabis sativa* L. in winter wheat", *Communications in Soil Science and Plant Analysis* 36 (4/6) Washington: Taylor & Francis, pp. 629-634.
28. Small, E, Pocock, T, Cavers, P 2003, "The biology of Canadian weeds. 119. *Cannabis sativa* L", *Canadian Journal of Plant Science* 83(1) Ottawa: Agricultural Institute of Canada, pp. 217- 237.
29. Șarpe, N, Ciorlăuş, A, Ghinea, L, Vladuţu I 1976, "Erbicidele", *Editura Ceres,* Bucureşti, pp. 360.
30. Șarpe, N, Strejan, GH 1981, "Combaterea chimică a buruienilor din culturile de câmp". *Ed. Ceres*, București, pp. 554.
31. Șarpe, N, Dinu, C, Popescu, A, Penescu, A 1983, "Opinii, concepţii şi rezultate privind combaterea integrală a buruienilor din culturile de câmp", *Probleme de agrofitotehnie teoretică şi aplicată*, 5(4), pp. 333-358.
32. Șarpe, N 1987, "Integrated Control of Weeds in Agricultural Crops", *Ceres Publishing House*, Bucharest, pp. 485.
33. Ştef, R, Cărăbet, A, Grozea, I, Manea, D, Vîrteiu, AM, Ienciu, A, Chifan R 2020, "The sensitivity of the *Galium aparine* L. species to sulfonylurea herbicides", *Research Journal of Agricultural Science*, 52(2), pp. 188-197.
34. Whitehead, R, Wright, HC 1989, "The incidence of weeds in winter cereals in Great Britain", In: *Proceedings 1989 Brighton Crop Protection Conference* – Weeds, pp. 107-112. Farnham: British Crop Protection Council.
35. Zargar, M, Bayat, M, Romanova, E & Izadi-Darbandi, E 2020, "Post herbicide programs utilizing tribenuron for cleavers (*Galium aparine* L.) control in winter wheat cultivars", *Archives of Agronomy and Soil Science*, 66(9), pp. 1235-1243.