SELECTIVITY AND EFFICACY OF THIFENSULFURON-METHYL WITH ADJUVANT AND WITHOUT IN CONTROL OF BROADLEAF WEEDS IN WINTER WHEAT

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Abstract

The research was conducted in 2020-2021, in 3 different locations (Constanța, Călărași and Teleorman) and aimed to evaluate the biological activity of the herbicide Thifensulfuron-methyl 75% WG with adjuvant and without in control of broadleaf weeds in winter wheat. The experiments were placed in randomized blocks, in 4 repetitions with a plot area of 100 m^2. The floristic composition of the winter wheat fields studied has been diversified, being present: *Amaranthus retroflexus, Capsella bursa – pastoris, Centaurea cyanus, Chenopodium album, Erigeron annuus, Fumaria officinalis, Galium aparine, Lamium* spp., *Papaver rhoeas*, *Polygonum convolvulus, Sinapis arvensis, Stellaria media, Veronica* spp., *Viola arvensis* etc. Herbicides were applied in post-emergence when weeds were in the early stages of growth and development. The herbicide Thifensulfuron-methyl 75% WG with adjuvant and without was applied at the doses of 20, 30 and 40 g/ha. The adjuvant (Trend 90 EC) was applied at 250 ml/ha. The assessments made at 10, 20 and 30 days after treatments focused the density of weeds, the percentage of soil cover, selectivity and the effectiveness compared to the untreated control. The results obtained showed that the efficacy depends on the dose applied, the type of weeds and their density on square meter. The Thifensulfuron-methyl 75% WG ensured a good efficacy in controlling of broadleaf weeds in winter wheat, the best results being obtained at the higher dose and when it was applied together with Trend 90 EC. Some weed species were insufficiently controlled at the dose of 20 g/ha: shepherd's purse, cleavers, black-bindweed, lamb's quarters etc.

Key words: wheat, control weeds, herbicides, *Triticum*

Wheat (*Triticum aestivum* L.) is the most important cereal and the plant that covers the largest areas in Romania. Here in it is one of the most important agricultural crops, with approximately 2 million ha sown each year. Thus, in 2020, the wheat area in our country was 2 146 thousand ha with a total yield of 6 410 thousand ha (National Institute of Statistics, 2021). Since wheat is sown in all areas of the country under different pedoclimatic conditions, the segetal flora that infests this crop is varied both in terms of species, in terms of the ratio between species, but especially in terms of the degree of weed infestation, being subject to permanent variations and adaptations, especially in the context of climate changes (Grădilă M. *et al*, 2018).

Whatever is the wheat growing area, even at plants emergence, during the lowering of the temperatures, autumn weeds infestation is occurring and their coexistence together with wheat plants is going on. However, during autumn, weeds are not a real problem as one of them can be destroyed by low temperatures. The spring period is the most critical for autumn wheat, because the degree of weed infestation in late spring creates the most obvious weed prejudices on the physiology and morphology of wheat plants (Berca M., Ciorlăuş A., 1994; Ionescu N., 2011; Ionescu N. *et al*, 2016). Overall, there are dicotyledonous weeds that predominate in wheat crops, with more than 40 species frequently found. The most common dicotyledonous weeds 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.,

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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 V., 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 case of clinging weeds (Șarpe N. *et al*, 1976; Şarpe N., Strejan Gh., 1981; Chirilă C., 2001; Berca M., 2004; Susana M. *et al*, 2017).

An effective weed control method is the chemical one, by using herbicides, as wheat is a completely mechanized crop. In order to avoid the concrete damage that weeds may cause to wheat, one can need to monitor and to map the segetal species and the degree of weed infestation, the rational application of the most appropriate herbicides, respecting the doses and the optimal moments of application. The best time to apply herbicides is when the wheat is in the end of tillering stage until beginning of stem elongation and the weeds are in the rosette stage (Șarpe N. *et al*, 1976). The range of herbicides for weed control in wheat crops is wide and recently there have been a lot of herbicides in granular forms characterized by high degree of effectiveness and selectivity, having a comprehensive spectrum of control and an increased flexibility of application, reducing the dangers for the environment being applied in small doses per unit area. In this regard, the work displays data on effectiveness and selectivity of thifensulfuron-methyl (750 g/l active ingredient) with adjuvant and without in control of broadleaf weeds in winter wheat.

MATERIAL AND METHOD

The research was conducted in 2020-2021, in 3 different locations, on 3 different types of chernozem soils and under irrigation conditions at Agigea, Constanța. Four experimental fields were carried out, one in Agigea (Constanța county), one in Dâlga (Călărași) and two in Fântânele (Teleorman). The winter wheat 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	Agigea Constanța	Dâlga Călărași	Fântânele 1 Teleorman	Fântânele 2 Teleorman
GPS for experimental field	N: 44°564'102" E: 28°334'828"	N: 44°290'03" E: 27°029'48"	N: 43°411'528" E: 25°121'521"	N:43°421'18" E: 25°151'63"
Soil	Vermi - calcic chernozem	Cambic chernozem	Argic chernozem	
Preceding crop	Maize	Rapeseed	Sunflower	Soybean
Cultivar	PG 101	Glosa	Rubisko	Genius
Sowing date	01.10.2020	12.10.2020	10.10.2020	10.10.2020
Density (plants m^2)	400	650	350	700
Emergence date	11.10.2020	23.10.2020	22.10.2020	22.10.2020
Insecticides	Faster Delta 0.3 l/ha - 28.04.22	Sumi Alpha 5 EC 0.2 l/ha- 30.04.2021	Faster Gold 50 EC 0.10 l/ha - 05.04.2021 Lamdex Extra WG 0.3 Kgha - 21.04.2021	-
Fungicides	Priaxor EC 0.75 l/ha - 07.04.22 Delaro 325 SC 1.0 l/ha - 28.04.22	Mystic Top 0.5 l/ha-25.04.2022 Mirage 45 EC 1.0 l/ha-21.04.2021	Leander 750 EC 0.75 l/ha - 05.04.2021 Mirage 45 EC 1.0 l/ha - 21.04.2021	-
Water Irrigation	16.10.2020 - 600 m^3/ha	-	-	
Treatments herbicide	28.03.2021	6.04.2021	10.04.2021	30.03.2021
Stage Majority (BBCH)	23*	23*	34 - 35*	34 - 35*
Stage Minimum (BBCH)	21*	21*	33*	33*
Stage Maximum (BBCH)	24*	24*	36*	36*

Legend – The BBCH-scale is used to identify the phenological development stages of plants:
*21 - beginning of tillering: first tiller detectable;
*23 - 3 tillers detectable;
*24 - 4 tillers detectable;
*33 - node 3 at least 2 cm above node 2;
*34 - node 4 at least 2 cm above node 3;
*35 - node 5 at least 2 cm above node 4;
*36 - node 6 at least 2 cm above node 5.

The experiments were placed in randomized blocks, in 4 repetitions with a plot area of 100 m^2. Herbicides 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 (*table 1*).

The herbicide Thifensulfuron-methyl 75% WG with adjuvant and without was applied at the doses of 20, 30 and 40 g/ha. The adjuvant Trend 90 EC (ethoxylated isodecyl alcohol) was applied at 250 ml/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 C., 2001). 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).

RESULTS AND DISCUSSIONS

In experimental field in spring at Agigea, dicotyledonous weeds species prevailed and we noted: *C. album*, *P. rhoeas*, *P. convolvulus*, *S. arvensis* and *Veronica* spp. There were found other species, too, but in a lower number with a density <5 plante/m^2: *Thlaspi arvense* (L.), *Echinochloa crus-galli* (L.) Pal. Beauv., *M. inodora*, *C. arvense*, *Setaria pumila* (Poir.) Roem. & Schult., *C. bursa - pastoris*, *G. aparine* and *S. media*.

The distribution of weed species according to the percentage of soil coverage at 30 days after treatments application in the control sample is shown in (*figure 1*), where *Plantaginaceae* was the dominant weed family (25.5%).

In such conditions of weeds infestation, the post-emergence applied Thifensulfuron-methyl 75% WG with adjuvant and without was very effective in controlling annual broadleaf weeds in winter wheat at Agigea, the best results being obtained at the rate of 30 and 40 g/ha and when it was applied together with Trend 90 EC.

At the dose of 20 g/ha some weeds species are insufficiently controlled, such as *C. album* 72.8%, *P. convolvulus* 69.3% and *Veronica* sp. 67.9% (*table 2*). It is noted that species of the genus *Veronica* predominated, being present *V. hederifolia* (L.), *V. agrestis* (L.) and *V. persica* Poiret.

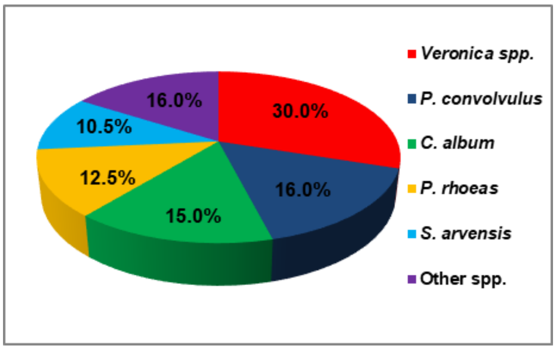

Figure 1 **Weed species at Agigea**

In Romania, new invasive plant species have been reported in the last years, especially in segetal and ruderal habitats (Dihoru G., 2004). Such an invasive plant is the species *V. persica*, frequently found in winter rapeseed and winter cereals crops. In Romania, this species is found in the steppe area, up to the beech wood level (Chirilă C. *et al*, 2002). Furthermore, *Veronica* species were found in all 4 experimental fields. 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*.

Also, at Agigea we noted the presence of Wild buckwheat, an annual summer weed, frequently found in wheat crops, a competitive weed that can cause yield losses of up to 66%. Apart from competing for nutrients, water and solar energy, climbing buckwheat entangles and climbs host plants, making harvesting operations very difficult (Pandian B.A. *et al*, 2020).

In addition, the chemical control against *P. convolvulus* is challenging in cereal crops because some herbicides (e.g. 2.4-dichlorophenoxyacetic acid (2.4-D) and 2-methyl-4-chlorophenoxyacetic acid (MCPA), widely used to control broadleaf weeds in wheat crops are not effective against this species (McCurdy E.V., Molberg E.S., 1974).

Therefore, control of *P. convolvulus* (wild buckwheat) in cereal crops is highly extent dependent on the use of herbicides that inhibit acetolactate synthase (ALS) such as Thifensulfuron-methyl (methyl 3-[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl) aminocarbonyl] aminosulfonyl]-2- thiophenecarboxylate), a sulfonylureic herbicide, which after application within an hour, inhibits the ALS enzyme resulting in the fast cessation of cell division and plant growth. 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.

Table 2

The efficacy of Thifensulfuron 75% WG with adjuvant and without in control of broadleaf weeds in winter wheat (Agigea, Constanța 2021)

Weeds	Thifensulfuron 75% WG (g/ha)			LSD P= .05	S.D.	Thifensulfuron 75% WG + Trend 90 EC- 250 ml/ha			LSD P= .05	S.D.
	20	30	40			20	30	40		
C. album	72.8c	81.0bc	94.7a	9.98-13.49	6.30t	88.4b	95.4ab	99.3a	3.97-12.79	5.17t
P. rhoeas	79.3b	96.8a	99.6a	5.87-15.52	6.75t	88.4b	97.43a	100.0a	6.92-18.49	7.53t
P. convolvulus	69.3b	81.0ab	94.1a	12.1-15.95	7.19t	78.9c	93.7b	99.3a	6.98-17.17	7.58t
S. arvensis	84.4b	92.5ab	99.3a	2.93-15.14	6.54t	88.4b	96.8ab	99.3a	3.08-12.15	4.90t
Veronica sp.	67.9b	83.8ab	93.5a	15.0-18.88	4.41t	74.3b	96.8a	97.4a	4.98-12.25	4.86t

In experimental field at Dâlga village, Călărași county, there were annual weeds: *C. bursa - pastoris, S. media, L. purpureum, F. officinalis, Erigeron annuus* (L.) Pers., *Viola arvensis* Murrray and *V. persica* (*figure 2*). The dominant weed was the shepherd's purse weed which at 30 days after the treatment, had a percentage of ground coverage >30% in the untreated control. The triumph of the shepherd's purse species is ensured by the fact that it can survive the winter, being a very competitive biennial species with resistant roots, unpretentious to the soil (it also lives on dry soils) and due to the fact that the seeds germinate staggered throughout the year. It is a prolific seed producer, a single *C. bursa - pastoris* plant being able to produce several thousand seeds (Karimi H., 2001). At Dâlga, the Thifensulfuron-methyl 75% WG with adjuvant and without had a good effectiveness in controlling weeds with the exception of the species *C. bursa - pastoris* where 30 days after the treatments application at a dose of 20 g/ha the effectiveness was 51.2% when Thifensulfuron-methyl 75% WG was applied without adjuvant and 65% when it was applied together with Trend 90 EC (*table 3*). Similarly, an unsatisfactory control (around 65%) was also observed in the case of *S. media* and *V. arvensis* species at the dose of 20 g/ha, especially when Thifensulfuron-methyl was applied without adjuvant.

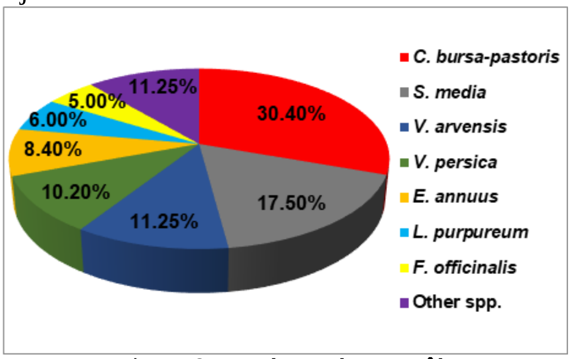

Figure 2 **Weed species at Dâlga**

Table 3

The efficacy of Thifensulfuron 75% WG with adjuvant and without in control of broadleaf weeds in winter wheat (Dâlga, Călărași 2021)

Weeds	Thifensulfuron 75% WG (g/ha)			LSD P= .05	S.D.	Thifensulfuron 75% WG + Trend 90 EC- 250 ml/ha			LSD P= .05	S.D.
	20	30	40			20	30	40		
C.b.- pastoris	51.2b	58.9ab	66.7a	8.96-9.19	7.94t	65.0b	76.3b	86.5a	8.35-11.51	4.73t
S. media	65.5b	80.7ab	86.4a	16.2-18.2	5.00t	67.5b	77.9b	86.6a	12.31-14.2	6.12t
L. purpureum	80.5cd	96.3b	100.0a	2.24-12.6	5.71t	92.5b	100.0a	100.0a	3.53-9.84	7.18t
F. officinalis	82.1b	96.1a	98.1a	4.67-9.15	4.62t	94.7b	97.4ab	100.0a	3.26-12.8	6.90t
E. annuus	70.6bc	83.2b	96.1a	6.35-12.0	4.86t	86.5c	97.4b	100.0a	1.29-7.84	4.34t
V. arvensis	68.9b	74.0b	84.4a	7.76-9.11	3.85t	87.5a	96.1a	98.1a	8.43-10.9	7.21t
V. persica	71.4b	85.8ab	93.3a	12.4-16.6	7.88t	81.0c	94.1b	99.3a	5.01-13.7	6.07t

At Dâlga we identified the presence of the invasive species *E. annuus*, native to North America, which is at present one of the major weed in crop fields (Kim C.S. *et al*, 2008).

In Romania eastern daisy fleabane is the most frequent invasive plant which is found both in semi-natural and artificial habitats (Anastasiu P., Negrean G., 2005).

In experimental field of Fântânele 1, Teleorman county there were found the following weed species: *G. aparine*, *Amaranthus retroflexus* (L.), *C. bursa - pastoris, S. media, Veronica* spp., *Lamium* spp. and *C. cyanus* (*figure 3*).

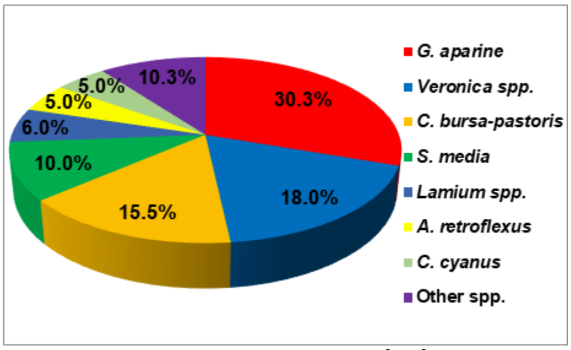

Figure 3 **Weed species at Fântânele 1**

At Fântânele 2, the following weeds were met amongst the annual dicotyledonous: *G. aparine*, *Veronica* spp., *P. rhoeas*, *T. arvense*, *C. album*, *P. convolvulus* and the perennial dicotyledonous *C. arvense* (*figure 4*). The dominant species *G. aparine* causes direct damage to wheat production through the consumption of water and nutrients but also indirect damage because it makes harvesting difficult. It is a hard weed to control 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 (Zargar M. *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 A. P. *et al*, 2019).

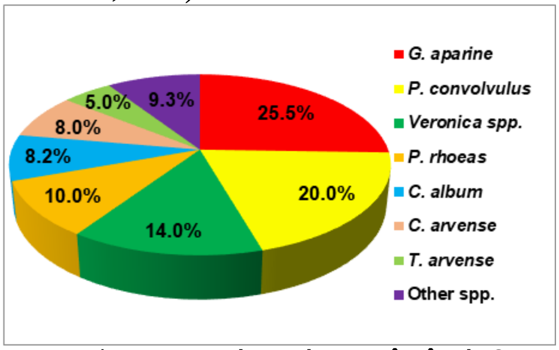

Figure 4 **Weed species at Fântânele 2**

The herbicide Thifensulfuron-methyl 75% WG with adjuvant and without had a good effectiveness in controlling weeds in the experimental field from Fântânele 1 with the exception of the species of *G. aparine*, *C. bursa-pastoris* and *C. cyanus* at a dose of 20 g/ha, especially when the herbicide Thifensulfuron-methyl 75% WG was applied without adjuvant. (*table 4*).

Table 4

The efficacy of Thifensulfuron 75% WG with adjuvant and without in control of broadleaf weeds in winter wheat (Făntânele 1, Teleorman 2021)

Weeds	Thifensulfuron 75% WG (g/ha)			LSD P= .05	S.D.	Thifensulfuron 75% WG + Trend 90 EC - 250ml/ha			LSD P= .05	S.D.
	20	30	40			20	30	40		
G. aparine	48.7c	58.8b	80.5a	6.97-8.54	3.18t	52.5b	62.6b	82.5a	9.93-12.1	4.58t
A. retroflexus	85.3b	96.8a	99.3a	3.66-10.97	4.89t	90.5bc	97.4b	100.0a	2.33-9.83	6.10t
C.b. - pastoris	58.8b	68.1ab	82.4a	16.76-18.4	7.43t	67.0b	79.0ab	86.8a	10.15-12.0	5.09t
Veronica sp.	69.3b	75.7ab	85.6ab	12.12-13.9	6.14t	75.1b	81.7ab	88.5a	7.87-9.07	4.21t
S. media	71.9c	90.5b	97.4a	5.58-11.12	4.89t	84.2b	96.8a	99.3a	3.47-8.16	4.71t
Lamium spp.	79.3c	94.2c	99.3a	3.53-9.94	4.77t	86.5a	99.3a	100.a	2.23-9.23	5.70t
C. cyanus	68.8b	83.0ab	90.0a	15.35-18.6	8.59t	78.3b	91.7a	97.5a	5.89-12.24	5.19t

Table 5

The efficacy of Thifensulfuron 75% WG with adjuvant and without in control of broadleaf weeds in winter wheat (Fântânele 2, Teleorman 2021)

Weeds	Thifensulfuron 75% WG (g/ha)			LSD P= .05	S.D.	Thifensulfuron 75% WG + Trend 90 EC- 250 ml/ha			LSD P= .05	S.D.
	20	30	40			20	30	40		
G. aparine	52.5c	61.4b	77.5a	5.45-71.5	2.68t	58.8b	68.1ab	82.4a	16.76-18.4	7.43t
C. arvense	61.3b	67.7ab	85.5a	15.2-17.31	7.09t	66.5b	74.6ab	83.7ab	14.72-17.4	7.62t
Veronica sp.	67.9b	76.0ab	87.7a	12.31-14.3	6.24	71.4b	85.0ab	94.1a	12.76-16.3	7.71t
P. rhoeas	50.0b	60.4b	83.6a	17.0-19.69	7.53t	52.5b	61.4b	80.2a	11.9-14.16	5.38t
T. arvense	70.2c	85.3b	97.4a	4.76-10.15	4.30t	78.3b	96.1a	99.3a	4.3-12.16	5.48t
C. album	61.3b	67.7ab	85.5a	5.2-17.3	7.09t	66.5b	74.6a	82.7ab	14.93-17.6	7.71t
P. convolvulus	53.8c	70.5b	80.6a	7.28-9.59	3.61t	62.9b	74.8b	88.8a	1.10-14.55	5.96t

It was surprising for us that the poppy populations from Fântânele 2 proved more resistant to the action of the herbicide Thifensulfuron-methyl compared to the populations assessed in the experimental field from Agigea. At Fântânele 2 the situation was similar for *G. aparine*, but in the case of the *C. arvense* species, there were no significant differences between the sample with and without the adjuvant, the results being similar (*table 5*).

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 Thifensulfuron-methyl 75% WG with adjuvant and without it (OEPP/EPPO Standards Bulletin, 2014).

CONCLUSIONS

The herbicide Thifensulfuron-methyl 75% WG provided a good efficacy on broadleaf weeds, the best results were achieved at the higher dose and when it was applied together with Trend 90 EC. Some weed species were insufficiently controlled at the dose of 20 g/ha: shepherd's purse, cleavers, black-bindweed, lamb's quarters etc.

The best results are achieved when Thifensulfuron-methyl is applied to young, actively growing weeds and that the effectiveness depends on the dose used, the sensitivity and the development stage of the weeds as well as the environmental conditions before and after application. The wet conditions due to irrigation had the effect of increasing the activity of the Thifensulfuron-methyl herbicide, performing very good results.

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.

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