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EFFECTS OF DIFFERENT HERBICIDES ON WEED DENSITY AND PRODUCTIVITY OF WINTER WHEAT (*TRITICUM AESTIVUM* L.)

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Abstract

The experiment was carried out during 2016 – 2019 on the agricultural lands of the town of Kubrat, Bulgaria. The aim of the study was to establish the effect of some herbicides and herbicide combinations on weed density, as well as on the productivity and yield of winter wheat (Avenue cultivar). The experiment included 8 treatments: 1. Control - untreated; 2. Control (economic) - untreated, weed free; 3. Trimur (750 g/kg tribenuron-methyl) – 0.020 kg ha^{-1}; 4. Sekator (25 g/l jodosulfuron + 100 g/l amidosulfuron) – 1.00 l ha^{-1}; 5. Puma Super (69 g/l fenoksaprop-P-ethyl) - 1.00 l ha^{-1}; 6. Axial (50 g/l pinoxaden) – 0.90 l ha^{-1}; 7. Sekator - 1.00 l ha^{-1} + Puma Super – 1.00 ml ha^{-1}; 8. Trimur – 0.020 kg ha^{-1} + Puma Super – 1.0 l ha^{-1}.

All studied herbicides showed good control against the weeds and reduced their density. The structural elements of the yield after the herbicide application, except for the herbicide combination Trimur + Puma Super were higher than those of the untreated control. The herbicide combination Sekator + Puma Super controlled 90.0% of the broadleaf and 100% of the grass weeds and the highest grain yield of 6.550 t ha-1 average for the period was obtained. It is recommendable to use this herbicide mixture in wheat fields with mixed weed infestation. The lowest yield was obtained after the application of Trimur + Puma Super. This was probably due to phytotoxic damage caused by the incompatibility of these two herbicides.

Keywords: wheat, weeds, herbicides, grain yield.

INTRODUCTION

Winter wheat (*Triticum aestivum* L.) is main grain crop in Bulgaria. The total harvested area for 2017 are 1 144 519 ha with average yields of 5.358 t ha-1 (MZH, 2017). The weeds are main competitors of winter wheat for light, space, nutrients, water, etc. The weeds also cause indirect damage, as many of the species are hosts of diseases and pests (Kalinova et al., 2012). The high infestation with weeds can cause yield decrease with up to 70% (Atanasova & Zarkov, 2005).

Weed control in wheat fields is one of the most important and responsible practices in wheat-growing technology. It is impossible to obtain high yields without effectively destroying the weeds. According to a study of Sabev (2000), the grain yield can be decreased by 10-20% at an average degree of weed infestation and in the case of heavy infestation losses exceeded 60-70%.

Chemical products are mainly used for weed control during wheat vegetation. Herbicides are and will remain the most effective and easy means of weed control (Tonev et al., 2011).

Studies by some researchers in the country and abroad (Abouziena et al., 2008; Chaudhary et al., 2011; Hossain et al., 2009; Mitkov et al.,2017) showed that the grain yield of common wheat in herbicide-treated areas was 10 to 41% higher and according to Khan et al. (2004) – by 64.3% higher than in the untreated areas.

The choice of herbicides suitable for application in wheat fields is determined by the diversity and density of the weed species. However, most herbicides control only a specific group of weeds and herbicide combinations are recommended to provide broader spectrum of weed control (Bostrom and Fogeilors, 2002; Mitkov et al., 2018; Walia et al., 2000).

According to Chaudhry et al. (2008),

when combining herbicides against grassy and broadleaf weeds, the density of both weed types decreased significantly (by 96.3% and 97.6%, respectively), and the grain yield was increased up to 15% compared to the separate application of the herbicides.

The aim of the present study was to establish the effect of some herbicides and herbicide combinations on weed density, as well as on the productivity and yield of common winter wheat.

MATERIALS AND METHODS

The experiment was carried out on leached chernozem soil type (Valcheva and Todorova, 2013) in the period 2016 – 2019, in the territory of the town of Kubrat, Northeast Bulgaria. The experiment included 8 variants: 1. Control - untreated; 2. Control (economic) - untreated, weed free; 3. Trimur (750 g/kg tribenuron-methyl) – 0.020 kg ha^{-1}; 4. Sekator (25 g/l jodosulfuron + 100 g/l amidosulfuron) – 1.00 l ha^{-1}; 5. Puma Super (69 g/l fenoksaprop-P-ethyl) - 1.00 l ha^{-1}; 6. Axial (50 g/l pinoxaden) – 0.90 l ha^{-1}; 7. Sekator - 1.00 l ha^{-1} + Puma Super – 1.00 l ha^{-1}; 8. Trimur – 0.20 kg ha^{-1} + Puma Super – 1.00 l ha^{-1}. The method of complete Block design in four replications was used. The size of the experimental plot was 15 m^2.

The winter wheat cultivar grown in the study was “Avenue”. The predecessor was sunflower. The performed soil tillage before the wheat sowing was deep ploughing followed by disking and cultivation. Fertilization with 300 kg ha^{-1} with NPK 15:15:15 applied before sowing and spring dressing with 300 kg ha^{-1} NH_4NO_3 was done. The herbicides were applied in phenophase tillering – beginning of spindling of the wheat (BBCH 29-31).

In the weed free control the weeds were removed once in the first half of April. Weed species and their density were reported before and 30 days after treatment.

The following characteristics of the winter wheat were evaluated: productive tillering (pcs. per m^2), plant height (cm), spike length (cm), number of spikelets, number of grains, grain weight per spike (g) and grain yield (t ha^{-1}).

The data obtained were statistically processed using the methods of dispersion and correlation analysis, and the differences between the variants were established by Duncan's multiple range test.

The years of study differed in terms of weather conditions, which influenced plant growth and development. The economic year 2018 – 2019 was characterized as not very favorable for wheat. During the period from sowing till emergence, rainfall was 386 mm vs 440 mm over a multi-year period, with an uneven distribution. Drought during sowing led to a delay in emergence (in January) and the heavy rainfall during wheat ripening delayed harvesting, which adversely affected the productive capacity of the plants. In 2016 – 2017, the precipitation during the period October – July was 625 mm. Rainfall was evenly distributed and, in combination with average monthly temperatures close to the values reported over a multi-year period, completely satisfied the requirements of the crop for moisture and temperature during vegetation. During the production year 2017 – 2018, the amount of rainfall reached values close to those reported over a multi-year period, relatively well-distributed, which had a positive effect on the wheat development. The most favorable for plant growth and development was the season 2016 – 2017, followed by 2017 – 2018 and the third season of the experiment (2018 – 2019) was unfavorable affecting the elements of the productivity and yields of winter wheat “Avenue” cv.

RESULTS AND DISCUSSION

The obtained results showed that the weed species found on the experimental field were from different biological groups and in different associations (Table 1). The total number of weeds was 14 - 11 annual and 3 perennial. The study showed that among the annual species there were both mono- and dicotyledonous species.

The monocotyledonous weed species were represented by Wild oat, Black-grass, Annual ryegrass and Rough bluegrass, while the dicotyledonous weeds were represented by ephemeral, winter-spring, early-spring and late-spring weeds. Perennial species found were Creeping thistle, Field bindweed and Dandelion.

The degree of weed infestation on average for the study period is presented on Figure 1. The results showed that the annual broadleaf weeds dominated in the field. Their density varied from 22 to 36 pcs/m^2 between the treatments.

Table1. Weed observed on the trial area

Weed species and number
Annual: Monocotyledonous - 4
Wild oat (*Avena fatua* L.)
Black-grass (*Alopecurus myosuroides* Huds.)
Annual ryegrass (*Lolium rigidum* Gaud.)
Rough bluegrass (*Poa trivialis* L.)
Annual: Dicotyledonous - 7
Cleavers (*Galium aparine* L.)
Ivy-leaved speedwell (*Veronica hederifolia* L.)
Fat-hen (*Chenopodium album* L.)
Wild mustard (*Sinapis arvensis* L.)
Black bindweed (*Fallopia convolvulus* L.)
Shepherd's purse (*Capsella bursa-pastoris* L.(Medik.))
Chamomile (*Matricaria chamomilla* L.)
Perennial: Dicotyledonous - 3
Creeping thistle (*Cirsium arvense* L. (Scop.))
Field bindweed (*Convolvulus arvensis* L.)
Dandelion (*Taraxacum officinale* L. (Weber ex F.H. Wigg.))
Total weed number - 14

That group of weeds represented 63.7% of the weeds in the experimental area. The density of the annual grass and perennial weeds was from 6 to 13 pcs/m² and 5 to 9 pcs/m², respectively, or 20.9% and 15.4% of the total weed infestation.

The efficacy of the studied herbicides and herbicide combinations on the weed density was different in the separate variants (Figure 2). High weed infestation was reported in the variants treated with Puma Super – 1.00 l ha^{-1} and Axial 0.90 l ha^{-1}. The reason is that both herbicides (Puma Super and Axial) control grass weeds only, while the crop was predominantly infested by dicotyledonous weeds.

The efficacy against the grass weeds was 100% after treatment with Axial and 50% after applying Puma Super. Those data confirmed the studies of Chaudhary et al. (2011) who reported that Axial has higher efficacy than the herbicide product Puma Super and it is recommended for the control of monocotyledonous weeds in winter wheat fields.

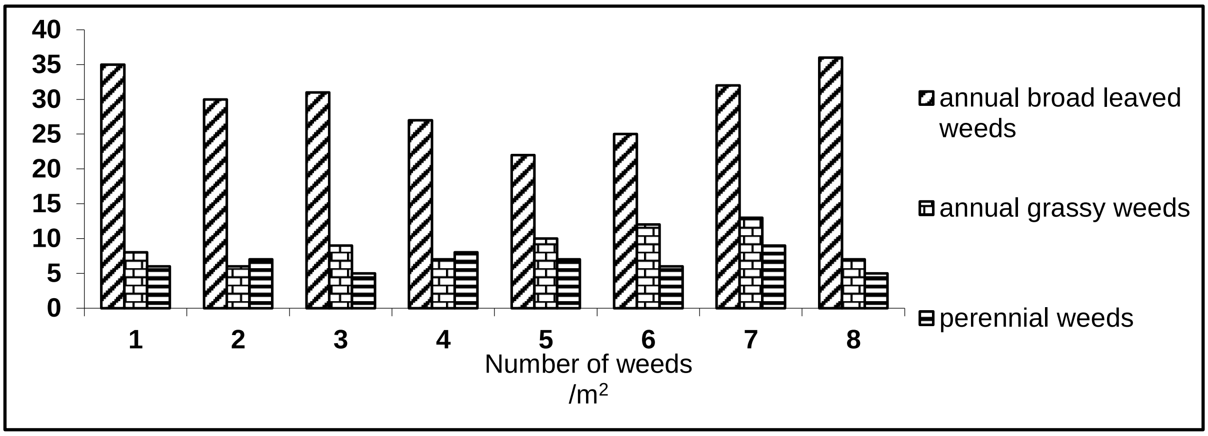

Figure 1. Weed density before herbicide application (number/m²)

The highest efficacy was found after the application of the herbicide combination Sekator (1.00 l ha^{-1}) + Puma Super (1.00 l ha^{-1}), which controlled 96.8% of the annual broadleaf weeds, 100% of the grass species and 66.8% of the perennial. The results correspond with findings from our previous studies where the combined application of Sekator + Puma Super showed excellent herbicide efficacy against the weeds (Mitkov et al., 2017).

The efficiency of Trimur applied alone (0.020 kg ha^{-1}), was 74% and that of Sekator (1.00 ml ha^{-1}) – 92%. Those herbicides did not control grass weeds because their mode of action is against broadleaf species only. The efficacy of the herbicide combination Trimur (0.020 kg ha^{-1}) + Puma Super (1.00 l ha^{-1}) was 77.4%.

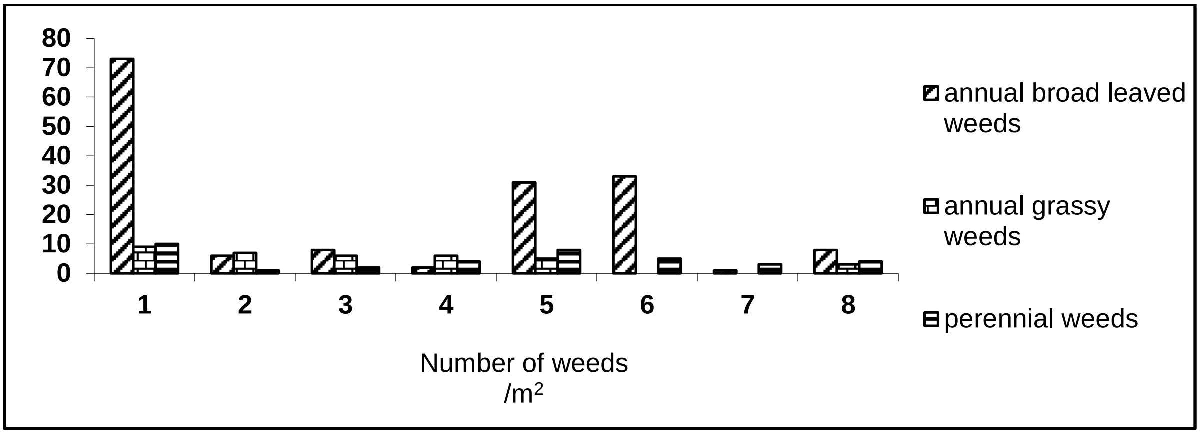

Figure 2. Weed density after herbicide application (number/m^2)

The studied herbicides and herbicide combinations showed some effect on the structural elements of the winter wheat grain yield (Table 2). The highest values of those indicators in the variant with Sekator (1.00 l ha^{-1}) + Puma Super (1.00 l ha^{-1}) and the lowest – in the variant with Trimur (0.020 kg ha^{-1}) + Puma Super (1.00 l ha^{-1}) were reported.

Table 2. Influence of the herbicides and their combinations on the elements of the productivity (average for 2016-2019).

Variants	Productive tillering/m^2	Plant height, cm	Spike length, cm	Number of spikelets	Number of grains per spike	Grain weight per spike, g
Control - untreated	552 ^{b}	75.0 ^{b}	11.0 ^{b}	16.0 ^{b}	35.0 ^{b}	1.60 ^{b}
Control - weed free	606 ^{c}	94.3 ^{d}	12.3 ^{c}	19.6 ^{d}	42.0 ^{d}	1.86 ^{f}
Trimur - 0.020 kg ha^{-1}	615 ^{d}	82.0 ^{c}	12.0 ^{c}	18.5 ^{c}	40.8 ^{c}	1.75 ^{d}
Sekator -1.00 l ha^{-1}	618 ^{d}	84.0 ^{c}	12.2 ^{c}	19.0 ^{d}	42.0 ^{d}	1.80 ^{e}
Puma super -1.00 l ha^{-1}	600 ^{c}	77.0 ^{b}	12.1 ^{c}	18.0 ^{c}	39.5 ^{c}	1.67 ^{c}
Axial - 0.90 l ha^{-1}	610 ^{c}	81.0 ^{c}	12.0 ^{c}	18.3 ^{c}	40.0 ^{c}	1.70 ^{c}
Sekator -1.00 l ha^{-1} + Puma super -1.00 l ha^{-1}	630 ^{e}	90.5 ^{d}	12.8 ^{d}	20.2 ^{e}	43.1 ^{e}	1.90 ^{f}
Trimur - 0.020 kg ha^{-1} + Puma super -1.00 l ha^{-1}	536 ^{a}	71.5 ^{a}	10.1 ^{a}	15.0 ^{a}	31.7 ^{a}	1.40 ^{a}

As a result of the antagonistic action of the two products (Trimur + Puma Super) applied in the tank mixture, invisible phytotoxic effects were found and the main productive characteristics were adversely affected, showing lower values of all studied parameters - productive tillering, plant height, spike length, number of spikelets, number of grains and grain weight per spike.

The number of spike-bearing stems per m^2 in the variants treated with Trimur (20 g/ha), Sekator (1.00 l ha^{-1}), Puma Super (1.00 l ha^{-1}), Axial (0.90 l ha^{-1}) and Sekator (1.00 l ha^{-1}) + Puma Super (1.00 l ha^{-1}) ranged from 536 to 630 pcs/m^2, and in the untreated control - 552 pcs/m^2. The application of the tank mixture of Trimur (0.20 kg ha^{-1}) + Puma Super (1.00 l ha^{-1}) resulted in reduced values of the indicator by 16 and 70 pcs/m^2, in the untreated and weed free controls respectively.

All herbicides applied alone, and the herbicide combination of Sekator (1.00 l ha^{-1}) + Puma Super (1.00 l ha^{-1}) contributed to an increase of plant height by 15.5 cm compared to the untreated and weed free controls. The effect of the herbicide combination Trimur (0.020 kg ha^{-1}) + Puma Super (1.00 l ha^{-1}) resulted in a decrease in the stem height by 4.9% compared to the untreated and non-weeded variant.

That confirmed the results obtained by Tonev (1990) and Drozd (1998) who established that some herbicides reduced plant height by up to 15%.

The spike length in the variant treated with Trimur (0.020 kg ha^{-1}) + Puma Super (1.00 l ha^{-1}) decreased by 8.9% and in the other treated variants increased by 9.0 to 16.4% compared to the untreated control. The manual weed removal contributed to an increase of the spike length by 11.8% compared to the untreated control.

In the treatments with Trimur (0.020 kg ha^{-1}), Sekator (1.00 l ha^{-1}), Puma Super (1.00 l ha^{-1}), Axial (0.90 l ha^{-1}) and Sekator (1.00 l ha^{-1}) + Puma Super (1.00 l ha^{-1}), the number of spikelets per spike was higher in value by 15.6%, 18.7%, 12.5%, 14.3 and 25.0% respectively, compared to the untreated control. However, when comparing the variants with the weed free control, the number of spikelets was with 3.1% higher only after the application of the herbicide combination Sekator (1.00 l ha^{-1}) + Puma Super (1.00 l ha^{-1}).

The number of grains per spike varied from 31.7 pcs in the variant treated with Trimur (0.20 kg ha^{-1}) + Puma Super (1.00 l/ha^{-1}) to 43.1 pcs in the variant with Sekator (1.00 l ha^{-1}) + Puma Super (1.00 l ha^{-1}). Compared to the untreated control, the values of that indicator were higher by 12.9% to 16.7% in the variants with alone application of the herbicides and by 23.1% in the variant with Sekator (1.00 l ha^{-1}) + Puma Super (1.00 l ha^{-1}).

Table 3. Influence of herbicides and their combinations on the grain yield, t ha^{-1}

Variants	Year			Average		
	2016/ 2017	2017/ 2018	2018/ 2019	t ha^{-1}	% - C_1	% - C_2
Control - untreated	6.160 ^{b}	5.900 ^{b}	3.980 ^{b}	5.347	100.0	83.0
Control - weed free	7.400 ^{e}	7.230 ^{d}	4.600 ^{e}	6.440	120.0	100.0
Trimur - 0.020 kg ha^{-1}	7.500 ^{f}	7.180 ^{d}	4.300 ^{d}	6.327	118.3	98.2
Sekator -1.00 l ha^{-1}	7.620 ^{g}	7.310 ^{e}	4.380 ^{d}	6.437	120.4	99.0
Puma super -1.00 l ha^{-1}	6.530 ^{c}	6.140 ^{c}	4.120 ^{c}	5.630	105.3	87.4
Axial - 0.90 l ha^{-1}	6.600 ^{d}	6.170 ^{c}	4.200 ^{c}	5.656	105.8	87.8
Sekator -1.00 l ha^{-1} + Puma super -1.00 l ha^{-1}	7.760 ^{h}	7.400 ^{f}	4.500 ^{f}	6.550	122.5	101.7
Trimur - 0.20 kg ha^{-1} + Puma super -1.00 l ha^{-1}	5.400 ^{a}	5.100 ^{a}	3.600 ^{a}	4.700	87.9	73.0

*Means within columns with different letters are significantly different according to the LSD test ($P<0.05$)

The studied herbicides Trimur (0.020 kg ha^{-1}), Sekator (1.00 l ha^{-1}), Puma Super (1.00 l ha^{-1}), Axial (0.90 l ha^{-1}) and Sekator (1.00 l ha^{-1}) + Puma Super (1.00 l ha^{-1}) had a positive effect on the grain weight per spike. The herbicide application contributed to the increase of the values of the indicator from 4.4 to 18.7% compared to the untreated control.

The activity of the herbicide combination Trimur (0.020 kg ha^{-1}) + Puma Super (1.00 l ha^{-1}) resulted in a reduction of the grain weight compared to the zero and the economic control by 14.3% and 32.8% respectively.

According to Bekelle (2004) the high weed density in wheat can decrease the yield up to 70%.

The grain yield obtained after the application of this herbicide combination during the next two years (2017/2018 and 2018/2019) was by 1.500 kg ha^{-1} and 0.610 kg ha^{-1} higher than the untreated control. Lower values by 0.760, 0.800 and 0.380 t ha^{-1} compared to untreated control were reported after the treatment with Trimur (0.20 kg ha^{-1}) + Puma Super (0.10 l ha^{-1}). With the exception of that variant on average for the study period, all the treated variants had by 5.3% to 22.5% higher yield compared to the untreated control. For the weed free tretment, the values of that indicator increased by 1.093 t ha^{-1} compared to the untreated control. The obtained results were statistically significant. Compared to the weed free control, higher yield was obtained by 1.7% only in the treatment with Sekator (0.10 l ha^{-1}) + Puma Super (0.10 l ha^{-1}). That herbicide combination resulted in the highest yield obtained, exceeding the untreated control by 1.203 t ha^{-1}. Differences were statistically proved.

When the herbicides Trimur (20 g/ha) and Sekator (100 ml/ha) were applied separately, the grain yield increased by 18.3% and 20.0%, respectively, compared to the untreated control.

The dispersion analysis made on the effect of the herbicide treatment (Factor A) and the year of the study (Factor B) and their interaction (AB) on the grain yield is presented in Table 4.

Table 4. Analysis of variance ANOVA

Source of Variation	Sum of Square	Df	Mean Square	F	P-value	F crit
Variant (A)*	36434595.83	7	5204942.0	310.4854	0.00	2.139656
Year (B)**	135979408.33	2	67989704.0	4055.724	0.00	3.123907
Interactions (AB)*	5768991.667	14	412070.8	24.58086	0.00	1.831607
Within	1207000	72	16763.89			

* F-test significant at P<0.05; ** F-test significant at P<0.01; ns non-significant

Table 5. Values of the coefficient of correlation

	Grain yield	Productive tillering	Plant height	Spike length,	Number of spikelets	Number of grains per spike	Grain weight per spike	annual broadleaf weeds	annual grass weeds	perennial weeds
Grain yield	1.000									
Productive tillering	0.898307*	1.000								
Plant height	0.818975*	0.842318*	1.000							
Spike length	0.918029**	0.967009**	0.867922*	1.000						
Number of spikelets	0.935916**	0.961692**	0.900225**	0.97166**	1.000					
Number of grains per spike	0.856287*	0.839886*	0.67606	0.755293*	0.777603*	1.000				
Grain weight per spike	0.969357**	0.904842**	0.878099*	0.953424**	0.968908**	0.771432*	1.000			
annual broadleaf weeds	-0.48751	-0.48307	-0.24039	-0.37611	-0.49438	-0.4246	-0.380	1.000		
annual grassy weeds	0.009667	-0.30901	-0.08197	-0.18475	-0.2409	-0.0043	-0.079	0.371915	1.000	
perennial weed	-0.5503	-0.47365	-0.4052	-0.35203	-0.53701	-0.55045	-0.459	0.878666*	0.269086	1.000

The data show the strongest impact of Factor B – the year with a dominant effect and statistical significance of $P<0.01$ on the changes in that characteristic. Second comes Factor A with a significance of $P<0.05$. The correlation between the factors in the studied characteristic (grain yield) was statistically significant. Those data correspond to the results of the study of Stoyanova et al. (2015). The authors established that the weather conditions of the year had the greatest effect on the grain yield, while the effect of the herbicides was lower and less pronounced.

As a result of the correlation analysis between the structural elements, grain yield and weeds (Table 5), a very strong correlation ($r > 0.9$) was found between the following indicators: grain yield and spike length; grain yield and weight per spike; number of spikelets and grain yield; productive tillering and spike length; productive tillering and grain weight per spike; number of spikelets and productive tillering; plant height and number of spikelets; spike length and number of spikelets; spike length and grain weight per spike; grain weight per spike and number of spikelets.

High positive values of r ($r > 0.8$ and $r > 0.7$) were reported for grain yield and productive tillering; grain yield and plant height; number of grains and grain yield; productive tillering and number of grains; productive tillering and plant height; grain weight per spike and plant height; spike length and number of grains; number of spikelets and number of grains; number of grains and grain weight per spike; annual broadleaf weeds and predominant weeds.

CONCLUSIONS

The studied herbicides – Trimur, Sekator, Puma Super, Axial, Sekator + Axial and Trimur + Puma Super, showed good efficacy in the broadleaf and grassy weeds control as significantly reduce their density in the experimental field .

The values of the structural elements of the yield after the application of the herbicides, except for the herbicide combination Trimur + Puma Super were higher than those in the non-weeded control.

The herbicide combination Sekator + Axial controlled 90.0% of the broadleaf and 100% of the grassy weeds and the highest grain yield (6.550 t ha-1) average obtained was recorded.

The herbicides Sekator and Axial applied separately, resulted in lower yield – 6.437 and 5.656 t ha-1 respectively. The lowest yield (4.700 t ha-1) was found in the variant with Trimur + Puma Super. When applying that herbicide combination, the grain yield was reduced by 13.7% and 37.0% respectively, compared to the zero and the economic control.

The studied herbicides and the combination Sekator + Axial increased the grain yield by 22.3% compared to the non-weeded and untreated control.

Based on the conducted research, it is recommended to use the herbicide mixture Sekator + Axial in wheat fields of mixed weed infestation and in cases of infestation with dicotyledonous weeds - Sekator alone.

REFERENCES

Abouziena, H., A. Sharara, R. Eldesoki, 2008. Efficacy of Cultivar Selectivity and Weed Control Treatments on Wheat Yield and Associated Weeds in Sandy Soils. World Journal of Agricultural Sciences, 4 (3), 384-389.

Adamczewski, K., K. Miclaszewska, 2001. Evaluation of iodosulfuron and amidosulfuron mixture to control broad-leaved weeds in winter and spring cereals. Journal of Plant Protection Research 41 (2), 101-108.

Atanasova, D., B. Zarkov, 2005. Weed infestation of barley and wheat grown as monoculture. Field Crop Studies, 2(1), 93-97.

Bekelle, A., 2004. Assessment and management of weeds in wheat in Debark woreda, North Gonder. Haramaya-Ethiopia. Master thesis.

Bostrom, U., H. Fogelfors, 2002. Response of weeds and crop yield to herbicide dose decision support guidelines. Journal Weed Science, 50, (2), 186 – 195. DOI:https://doi.org/10.1614/00431745(2002)050[0186:ROWACY]2.0.CO;2

Chaudhary, S., M. Hussain, J. Iqbal, 2011. Chemical weed control in wheat under irrigated conditions. Journal of Agricultural Research (03681157), 49 (3).

Chaudhry, S., M. Hussain, M. Anjum, J. Iqbal, 2008. Efficacy and economics of mixing of narrow and broad leaved herbicides for weed control in wheat. Journal Agricultural Research, 46 (4), 355 – 360.

Hossain, M., N. Barma, A. Rafiqulislam, M. Uddin, M. Rahman, 2009. Effect of newly developed herbicides on the growth and yield of wheat. International Journal of Sustain Crop Production, 4, (1), 1-4.

Jarwar, A., M. Arain, L. Rajput, 2005. Chemical weed control in wheat. Pakistan Journal of weed science research, 11 (1-2), 11-15.

Kalinova Sht., I. Zhalnov, G. Dochev, 2012. Overview of indirect weed harm as hosts of diseases and pests on crop plants. Scientific Works of the Agricultural University of Plovdiv. LVI, 291-294.

Khan, M., G. Hassan, I. Ahmad, I. Khan, 2004. Studies on chemical weed control wheat (*Triticum aestivum*). Pakistan Journal of weed science research, 10 (3-4), 113-118.

Mitkov, A., N. Neshev, M. Yanev, T. Tonev, 2018. Control of broadleaf weeds in winter wheat (Triticum aestivum L.). Proceedings of the 53rd Croatian & 13th International Symposium on Agriculture. February 18 - 23, 2018, Vodice, Croatia, 328-332.

Mitkov, A., M. Yanev, N. Neshev, T. Tonev, 2017. Opportunities for Single and Combine Application of Herbicides at Winter Wheat. Scientific Papers-Series A, Agronomy, 60, 314-319.

MZH, 2017. MZH – Ministry of Agriculture and Foods, Bulgaria. Retrieved from http://www.mzh.government.bg/media/filer_public/2018/09/03/ra343publicationcrops2017.pdf

Sabev, G., 2000. Now is the time to give a serious resistance to the weeds in the cereal crops. Plant protection, 2, 20-21.

Tonev, T., M. Tityanov, A. Vasilev, 2011. Guide to integrated weed management and proficiency of agriculture. Publisher "Biblioteka Zemedelsko Obrazovanie", Plovdiv, 108.

Valcheva, V., S. Todorova, 2013. Model for Investigation, Amelioration and Organization of Terrains with Complex Topology for Planting of Vineyards. Scientific Papers-Series A, Agronomy, 56, 160-166.

Walia, U., S. Kakhwinder, L. Brar, L. Kaur, 2000. Control of broad leaved weeds in wheat with sulfonylurea herbicides. Journal Agricultural Research, 37 (3-4), 176-180.