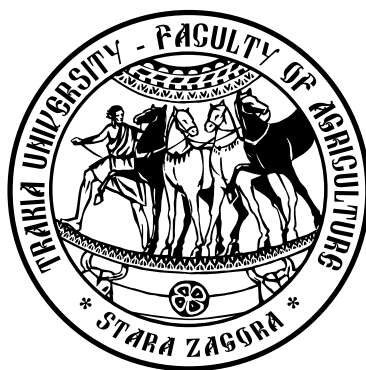


ISSN 1313 - 8820 (print)
ISSN 1314 - 412X (online)

Volume 11, Number 1
March 2019



AGRICULTURAL
SCIENCE AND TECHNOLOGY
2019

An International Journal Published by Faculty of Agriculture,
Trakia University, Stara Zagora, Bulgaria

Production Systems

Productivity and yield stability at late treatment of durum wheat (*Triticum durum* Desf.) with antibroadleaved herbicides. III. Influence at treatment during 3rd stem node stage

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(Manuscript received 5 July 2018; accepted for publication 1 February 2019)

Abstract. The aim of the study was to investigate the productivity and yield stability at durum wheat (*Triticum durum* Desf.) treated with antibroadleaved herbicides during 3rd stem node stage. The experiment was conducted during 2012-2014 on pellic vertisol soil type. Under investigation was Bulgarian durum wheat cultivar Victoria (*Triticum durum* var. *valenciae*). A total of 20 antibroadleaved herbicides were tested: Granstar 75 DF, Granstar super 50 SG, Ally max SG, Arat, Biathlon 4 D, Derby super WG, Mustang 306.25 SC, Weedmaster 646 CL, Sunsac, Secator OD, Logran 60 WG, Lintur 70 WG, Akurat 60 WG, Akurat extra WG, Eagle 75 DF, Herbaflex, Starane 250 EK, Sanafen, Dicotex 400 and Herby 675. All herbicides were treated in 3rd stem node stage of durum wheat. It was found that during 3rd stem node stage of durum wheat the antibroadleaved herbicides Arat, Biathlon, Derby super, Secator, Lintur, Akurat, Akurat extra and Starane can be used. These herbicides do not have a negative influence on grain yield. The most unstable yield is obtained after the treatment with herbicides Granstar, Granstar super, Ally max, Sunsac, Logran, Eagle, Herbaflex and Herby. Their selectivity to durum wheat is influenced most strongly by weather conditions during the vegetation period. From the viewpoint of technology for durum wheat growing, during 3rd stem node stage technologically the most valuable are herbicides Derby super, Arat, Biathlon, Secator, Akurat, Akurat extra and Lintur. After the treatment with them high grain yield with high stability with relation to different years is obtained. The herbicides Granstar, Granstar super, Ally max, Sunsac, Weedmaster, Logran, Eagle, Herbaflex, Sanafen, Dicotex and Herby cannot be used during 3rd stem node stage of durum wheat.

Keywords: durum wheat, herbicides, late treatment, grain yield, stability

Introduction

The creation of high-producing crops of durum wheat and obtaining high-quality grain requires efficacy weed control (Kieloch et al., 2008; Stashinskis, 2008; Delchev, 2018a, 2018b). In its evolutionary development weeds have gained mechanisms for adaptation to adverse conditions. This is why they are especially harmful in drought due to their great ecological plasticity and adaptability compared to the cultivated plants and that makes them more competitive (Heap, 1999). In creating an environment of ever stronger and more frequent drought serious problems emerge that must be solved (Labrada, 2000; Shehzad et al., 2012).

One of them is associated with the efficacy and selectivity, i.e. about the behaviour of foliar-applied and soil-applied herbicides under these conditions. We need to consider a number of factors that determine the effective application of these complex organic compounds. Pesticides will remain in the future agriculture an effective means of weed control as part of integrated control, which is why there is need for research for optimization of their use (Kudsk and Streibig, 2003; Adamczewski and Paradowski, 2004; Khan et al., 2006).

The purpose of this investigation was to establish the influence of treatment with 20 antibroadleaved herbicides in durum wheat applied during 3rd stem node stage on its grain yield and stability.

Material and methods

The research was conducted during 2012 - 2014 with Bulgarian durum wheat cultivar Victoria (*Triticum durum* Desf. var. *valenciae*). A field experiment was carried out as a block method in 4 repetitions, on a 20m² harvesting area, on pellic vertisol soil type, after sunflower predecessor. For exploration the possibilities to fight with secondary weed infestation with broadleaved weeds in durum wheat fields for processing and for seed production 20 antibroadleaved herbicides were investigated: Granstar 75 DF, Granstar super 50 SG, Ally max SG, Arat, Biathlon 4 D, Derby super WG, Mustang 306.25 SC, Weedmaster 646 CL, Sunsac, Secator OD, Logran 60 WG, Lintur 70 WG, Akurat 60 WG, Akurat extra WG, Eagle 75 DF, Herbaflex, Starane 250 EK, Sanafen, Dicotex 400 and Herby 675. The active substances and doses of the investigated herbicides are given in Table 1. The weak adhesion of herbicides Granstar, Granstar super and Ally max required their application with adjuvant Trend 90-0.1%. The weak adhesion of herbicides Arat and Biathlon required their application with adjuvant Dash HC - 500 ml/ha.

All herbicides were treated during 3rd stem node stage of durum wheat. All variants were applied with working solution consumption 200 l/ha. To examine only the influence of herbicides and eliminate the negative influence of weeds they were removed by hand weeding during the growing period.

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The selectivity of herbicides has been established by their influence on grain yield. The math processing of the data was done according to the method of analysis of variance (Shanin 1977; Barov, 1982; Lidanski, 1988). The stability of grain yield

depending on the applied herbicides and years was estimated using the stability variances σ_i^2 and S_i^2 of Shukla (1972), the ecovalence W_i of Wricke (1962) and the stability criterion YS_i of Kang (1993).

Table 1. Investigated variants of herbicides

No	Herbicide	Active substance	Doses
1	Check	-	-
2	Granstar 75 DF	tribenuron-methyl	25 g/ha
3	Granstar super 50 SG	tribenuron-methyl + tifensulfuron-methyl	40 g/ha
4	Ally max SG	metsulfuron-methyl + tribenuron-methyl	35 g/ha
5	Arat	tritosulfuron + dicamba	200 g/ha
6	Biathlon 4 D	tritosulfuron + florasulam	55 g/ha
7	Derby super WG	florasulam + aminopyralid	33 g/da
8	Mustang 306.25 SC	florasulam + 2.4-D	800 ml/ha
9	Weedmaster 646 CL	2.4-D + dicamba	1 l/ha
10	Sunsac	metosulam + 2.4-D	1 l/ha
11	Secator OD	iodosulfuron + amydosulfuron	100 ml/ha
12	Logran 60 WG	triasulfuron	37.5 g/ha
13	Lintur 70 WG	triasulfuron + dicamba	150 g/ha
14	Akurat 60 WG	metsulfuron-methyl	10 g/ha
15	Akurat extra WG	metsulfuron-methyl + tifensulfuron-methyl	50 g/ha
16	Eagle 75 DF	chlorsulfuron	15 g/ha
17	Herbaflex	beflubutamid + isoproturon	2 l/ha
18	Starane 250 EK	fluroxypyr	1 l/ha
19	Sanafen	2.4-D	2 l/ha
20	Dicotex 400	2M-4X	4 l/ha
21	Herby 675	2.4-D + 2M-4X	1.4 l/ha

Results and discussion

The data about the influence of the investigated antibroad-leaved herbicides on grain yield showed that herbicides Arat, Biathlon, Derby super, Secator, Lintur, Akurat, Akurat extra and Starane, applied during 3rd stem node stage of durum wheat did not cause a statistically significant reduction on grain yield (Table 2).

With herbicides Granstar, Granstar super, Ally max, Mustang, Weedmaster and Sunsac the same trend was preserved - an increase of phytotoxicity and a decrease of grain yield from 592 kg/ha to 663 kg/ha or from 11.3% to 12.7%. The decrease of grain yield by treatment with herbicides Granstar, Weedmaster and Sunsac during 3rd stem node stage is proven during each year, regardless of weather conditions. With herbicides Granstar super, Ally max and Mustang statistically significant decrease of the yield is reported only during certain years.

Hormone-similar herbicides Sanafen, Dicotex and Herby as well as Logran, Eagle and Herbaflex also have phytotoxicity on durum wheat. The biggest is the negative effect with the herbicide Logran where the decrease of grain yield in relation to the control is up to 1911 kg/ha during 2012 or 36.9%.

3rd stem node stage is the first stage during which herbicides Mustang, Dicotex and Herby show phytotoxicity to du-

rum wheat. During 1st and 2nd stem node stages these three herbicides show good selectivity to durum wheat.

Weather conditions during the three years included in the investigation, were significantly different. Significant differences between years were very favourable for evaluation of the investigated antibroadleaved herbicides.

The analysis of variance for grain yield (Table 3) shows that the investigated variants have proven influence on grain yield – 96.5%. The years have the highest influence on grain yield – 36.9% of the variants. It is determined by unequal response of variants to changes in environmental conditions. The reason is the large differences in the meteorological conditions during the three years of investigation. The strength of influence of the investigated herbicides is 35.0%. The influence of years and preparations is well proven at $p \leq 0.1$. There is an interaction between treatment with herbicides and meteorological conditions of years (AxB) – 24.6%. It is well proven at $p \leq 0.1$. That means that some of the herbicides Granstar, Granstar super, Ally max, Arat, Biathlon, Derby super, Mustang, Weedmaster, Sunsac, Secator, Logran, Lintur, Akurat, Akurat extra, Eagle, Herbaflex, Starane, Sanafen, Dicotex and Herby, applied during the 3rd stem node stage of durum wheat, have negative influence on grain yield which depends on different weather conditions in the particular years.

Table 2. Grain yield of durum wheat at treatment during 3rd stem node stage (2012 - 2014)

Herbicides	2012		2013		2014		Mean	
	kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
Check	5184	100	5199	100	5299	100	5227	100
Granstar	4636	89.5	4767	91.7	4500	84.9	4635	88.7
Granstar super	4666	90.0	4767	91.7	4504	85.0	4647	88.9
Ally max	4636	89.5	4783	92.0	4504	85.0	4642	88.8
Arat	4879	94.1	5100	98.1	4981	94.0	4987	95.4
Biathlon	4868	93.9	4933	94.9	5034	95.0	4945	94.6
Derby super	4909	94.7	4933	94.9	5167	97.5	5003	95.7
Mustang	4879	94.1	4833	92.9	5034	95.0	4913	94.0
Weedmaster	4758	91.8	4500	86.5	4433	83.6	4564	87.3
Sunsac	4758	91.8	4833	92.9	4300	81.1	4630	88.6
Secator	4879	94.1	5100	98.1	4967	93.7	4982	95.3
Logran	3273	63.1	4400	84.6	3433	64.8	3702	70.8
Lintur	4879	94.1	4903	94.3	5029	94.6	4929	94.3
Akurat	4868	93.9	4835	93.0	5045	95.2	4913	94.0
Akurat extra	4900	94.5	4835	93.0	4981	94.0	4903	93.8
Eagle	4727	91.2	4500	86.5	4833	91.2	4687	89.6
Herbaflex	4818	93.0	4350	83.6	4567	86.2	4578	87.6
Starane	4849	93.6	4907	94.4	5067	95.6	4941	94.5
Sanafen	4666	90.0	4600	88.5	4767	90.0	4798	89.5
Dicotex	4879	94.1	4800	92.3	4700	88.7	4793	91.7
Herby	4818	93.0	4733	91.0	4900	92.4	4817	92.1
LSD 5%	350	6.7	339	6.6	374	7.0		
LSD 1 %	466	9.1	432	8.2	487	9.1		
LSD 0.1%	603	11.6	565	10.8	598	11.1		

Based on proven herbicides treatment x year interaction stability parameters for each variant for grain yield of durum wheat with relation to years were evaluated (Table 4). The stability variances σ_i^2 and S_i^2 of Shukla, the ecovalence W_i of Wricke and the stability criterion YS_i of Kang were calculated.

Stability variances (σ_i^2 и S_i^2) of Shukla, which recorded linear and nonlinear interactions, respectively, unidirectionally evaluate the stability of the variants. The variants which showed lower values are considered to be more stable because they interact less with the environmental conditions.

Negative values of the indicators σ_i^2 and S_i^2 are considered 0. At high values of either of the two parameters - σ_i^2 and S_i^2 , the variant is regarded as unstable. At the ecovalence W_i of Wricke, the higher the values of the index, the more unstable the variant.

On this basis, using the first three parameters of stability, it is found that during 3rd stem node stage of durum wheat the most unstable yield is obtained after treatment with herbicides Granstar, Granstar super, Ally max, Sunsac, Logran, Eagle, Herbaflex and Herby, followed by Mustang, Sanafen

Table 3. Analysis of variance for grain yield

Source of variation	Degrees of freedom	Sum of squares	Influence of factor, %	Mean squares
Total	188	138088	100	-
Tract of land	2	40999	1.6	13966.1***
Variants	62	398970	96.5	31572.0***
Factor A - Years	2	198201	36.9	29364.2***
Factor B - Herbicides	20	176862	35.0	31323.3***
A x B	40	163290	24.6	27756.6**
Pooled error	124	51601	1.9	303.2

* $p \leq 5\%$; ** $p \leq 1\%$; *** $p \leq 0.1\%$

Table 4. Stability parameters of herbicides for grain yield with relation to years at treatment during 3rd stem node stage

Herbicides	$\bar{x}$	σ_i^2	S_i^2	Wi	Ysi
Check	5227	203.7	5.8	402.6	22+
Granstar	4635	573.0**	1150.0**	1086.5	-10
Granstar super	4647	563.0***	35.9***	1058.7	-5
Ally max	4642	560.7***	12.6***	1063.8	-6
Arat	4987	200.7	100.5	497.3	17+
Biathlon	4945	400.3	85.7	744.0	16+
Derby super	5003	230.3	21.8	452.1	19+
Mustang	4913	213.8*	443.9	421.4	5
Weedmaster	4564	718.4	-0.8	444.6	-5
Sunsac	4630	118.2**	239.4**	244.4	-9
Secator	4982	72.1	82.8	104.4	14+
Logran	3702	573.0**	1150.0**	1086.5	-10
Lintur	4929	151.9	106.6	395.7	10+
Akurat	4913	120.0	49.9	210.4	14+
Akurat extra	4903	111.9	70.8	234.0	12+
Eagle	4687	146.2***	86.2***	381.3	-5
Herbaflex	4578	118.2**	239.4**	244.4	-9
Starane	4941	91.9	36.6	195.7	4
Sanafen	4798	307.8*	630.5	595.5	-3
Dicotex	4793	328.2*	65.3	633.2	0
Herby	4817	336.3**	81.2**	648.8	-1

and Dicotex. After the treatment with herbicides Granstar, Granstar super, Ally max, Sunsac, Logran, Eagle, Herbaflex and Herby values of stability variance σ_i^2 and S_i^2 of Shukla and ecovalence Wi of Wricke are the highest and mathematically proven. Instability is of linear and nonlinear type - proven values of σ_i^2 and S_i^2 . After the treatment with herbicides Mustang, Sanafen and Dicotex instability of grain yield is of linear type - proven values of σ_i^2 , the values of S_i^2 are not proven. The reason for this high instability is greater variation in grain yields during the experimental years as weather conditions affect those most. The treatment with the other nine herbicides Arat, Biathlon, Derby super, Weedmaster, Secator, Lintur, Akurat, Akurat extra and Starane exhibit high stability because they interact poorly with the conditions of years. In treatment with herbicide Weedmaster, however, high stability has always been connected with the low grain yields during this stage.

To evaluate the complete efficacy of each herbicide both its effect on grain yield of durum wheat and its stability - the reaction of wheat to this variant during the years should be considered. Valuable information about the technological value of the variant gives the stability criterion YSi of Kang for simultaneous assessment of yield and stability, based on the reliability of the differences in yield and variance of interaction with the environment. The value of this criterion is experienced that by using nonparametric methods and warranted statistical differences we get a summary assessment aligning variants in descending order according to their economic value.

Generalized stability criterion YSi of Kang, taking into account both the stability and value of yields gives a negative

assessment of herbicides Granstar, Granstar super, Ally max, Sunsac, Weedmaster, Logran, Herbaflex, Eagle, Sanafen and Herby due to the fact that after treatment with them the lowest and unstable yields are obtained. These ten herbicides receive low estimates due to their high phytotoxicity to durum wheat during application in 3rd stem node stage of durum wheat. Herbicide Dicotex received estimate 0.

According to this criterion, during treatment in 3rd stem node stage of durum wheat, technologically the most valuable appear to be herbicides Derby super, Arat, Biathlon, Secator, Akurat, Akurat extra and Lintur. The treatment with these herbicides combines high levels of grain yield and high stability of this index during the years. From the viewpoint of technology for durum wheat growing, during 3rd stem node stage positive estimates have also the herbicides Mustang and Starane. The treatment with these herbicides combine good levels of grain yield and comparatively good stability of this index during the years.

Conclusion

During 3rd stem node stage of durum wheat the anti-broadleaved herbicides Arat, Biathlon, Derby super, Secator, Lintur, Akurat, Akurat extra and Starane can be used. These herbicides do not have a negative influence on grain yield. The most unstable yield is obtained after treatment with herbicides Granstar, Granstar super, Ally max, Sunsac, Logran, Eagle, Herbaflex and Herby. Their selectivity to durum wheat is influenced most strongly by weather conditions during the vegetation period. From the viewpoint of technology for durum wheat growing, during 3rd stem node stage techno-

logically the most valuable are herbicides Derby super, Arat, Biathlon, Secator, Akurat, Akurat extra and Lintur. After treatment with them high grain yield with high stability during different years is obtained. Herbicides Granstar, Granstar super, Ally max, Sunsac, Weedmaster, Logran, Eagle, Herbaflex, Sanafen, Dicotex and Herby cannot be used during 3rd stem node stage of durum wheat.

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