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Application of herbicides on common winter wheat (*Triticum aestivum* L.) at different doses and their reflection on the structural elements of spike

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Abstract: *The aim of this investigation was to determine the effect of the application dose of herbicides on structural elements of spike in common winter wheat (Triticum aestivum L.). The investigations were carried out during 2015–2017 at Dobrudzha Agricultural Institute (DAI) – town of General Toshevo. The following herbicides were used: Derby super WG (33 g/ha; 66 g/ha; 132 g/ha), Secator OD (100 mL/ha; 200 mL/ha; 400 mL/ha), Ergon WG (50 g/ha; 100 g/ha; 200 g/ha), Granstar super 50SG (40 g/ha; 80 g/ha; 160 g/ha), Lintur 70WG (150 g/ha; 300 g/ha; 600 g/ha) and Mustang 306.25 CK (800 mL/ha; 1600 mL/ha; 3200 mL/ha) from the group of sulfunylureas with various mechanism of action. The preparations were applied at three doses – optimal, double and quadruple, at stage 29 of common winter wheat cultivar Dragana, Zlatitsa and Kalina. The herbicide effect was determined by the quantitative weight method and evaluated by the EWRS scale. These were the traced structural elements of the wheat spike: length of spike (cm), number of spikelets per spike, number of grains per spike, weight of grain per spike (g) and weight of 1000 grains (g). Four-factor dispersion analysis was applied. The factors year conditions, cultivar, herbicide and dose were traced. The factors with the highest strength of effect were the year conditions (10-95%) and the used cultivar (2-87%). Significantly lower was the effect of the factors applied herbicide (2-4%) and dose (1-2%) on the investigated structural elements of spike.*

Keywords: common winter wheat, cultivars, herbicides, weeds, application doses, structural elements of spike

Introduction

The main method for the control of weeds in cereal crops on the surface continues to be the use of herbicides. Plant height, length of spike and number of spikelets per spike are indicators for vegetative growth processes in wheat crops. It was reported that herbicides Puma super EV 69 (1250 mL/ha), Bristol EV69 (1235 mL/ha), Topic 15VP (247g/ha), Safener 15VP (247g/ha) and Tremor 24EK (247mL/ha) applied after sowing pre-emergence did not lead to a significant reduction in the length of the spike of wheat cultivar Punjab 2011 (Abbas et al., 2009).

Other authors indicated significant inhibitory effect of herbicides on the number of fertile spikes of the m^2 and the number of spikelets per spike (Cheema and Akhtar, 2005; Bibi et al., 2008). The number of grains per spike and weight of 1000 grains were important biometric indicators. Significantly greater number of grains per spike (55.7) was established after treatment with Puma super (1235 L/ha), followed by Bristol EV69 (1250 mL/ha), Topic 15VP (247g/ha), Safener 15VP (247g/ha). Minimum was the number of grains per spike (45.7) in the weeded control. The highest weight of 1000 grains was established under variant Safener 15VP (247g/ha) - 35.3g, and the lowest in variant with weeded control - 32.0g (Mehmood et al., 2014). Maximum mass of 1000 grains (39.8g) was detected after treatment with Isoproturon 50VP, followed by Eim 40DF (34.7g) used post emergemce of Pakistan winter wheat cultivar, a minimum one at weeded variant (22.3g) (Fahad al et., 2013).

After treatment wheat cultivar Pirsabak with herbicides applied post emergence with Buktril super 60EK (1.5L/ha) established a considerable number of grains per spike 104 grains, followed by Axial - 100 grains. The lowest number of grains per spike was in the weeded control – 42 number of grains (Hussain et al., 2013). A number of authors have reported an increase in the number of grains per spike after treatment with these herbicides post emergence compared with the weeded control (Arif et al., 2004; Cheema and Akhtar, 2005).

It is indicated that in terms of the indicator number of spikelets per spike, the treated with Strech (1.5 g/da), Derby super VG (3.3 g/da), Puma super 7.5 EV (100 mL/da), Topic EC 080 (50 mL/da), Derby super VG (3.3 g/da) + Puma super 7.5 EV (100 mL/da) have the highest values, respectively, 9.9, 13.2, 17.1, 12.5 and 21.7 at stage tillering (Delibaltova et al., 2009). According to authors minor is the difference between the number of spikelets per spike for variant Boxer 80 EC (0.25 kg/da) 18.0 and for weeded control 15.1 at stage of tillering (Khan et al., 2003). After treatment with herbicide mixture Bromotril 24EK + MCPA (185 mL/da) at stage tillering 43.2 grains/spike are established. A smaller number is observed in the weeded control - 40.3. (Mahmood et al., 2012). Some authors found that after treatment with Boxer 80 EC (0.3 kg/da) there were 56.3 grains/spike and in the weeded control - 13 grains/spike (Qureshi et al., 2002; Khan et al., 2003). After treatment with Topic EC080 (0.045 kg/da) at stage tillering the following indicators have been established: number of grains per spike (47.28) and weight of 1000 grains (49.38 g) (Shehzad et al., 2012). According to Mushtaq et al. (2004), Noor et al. (2007) and Abbas et al. (2010) the use of effective herbicides significantly increases the weight of 1000 grains in wheat. Results state that 55.9g is the weight of 1000 grains after treatment with Mustang (0.05 L/da) at stage tillering, against 53.3g for weeded control (Pacanoski, 2007). Weight of 1000 grains (40.8 and 37.5g) was established in Logran extra 64VG (0.016 kg/da) and Buktril M 40EK (0.05 kg/da). Lower scores (28.5g) were established in weeded control (Khan et al., 2003). High scores for this indicator

* e-mail:

(43.3g) were observed after treatment at stage tillering with Bromotril 24EK + Agrokson (185 mL/da) and Starane M (74.1 mL/da) - 42.3g (Cheema and Akhtar, 2005; Mahmood et al., 2012). Results indicate that the weight of 1000 grains 41.0g was detected after treatment at stage tillering with Izor 500 SK (0.2 kg/da) Buktril + Super 60 EC (75 mL/da), and with Izor 500 SK (0.2 kg/da) + Buktril super 60 EC (50 mL/da) - 40.0g. Low score was observed in the weeded control - 30.0g (Sangi et al., 2012).

The aim of this investigation was to determine the effect of the application dose of herbicides on structural elements of spike in common winter wheat (*Triticum aestivum* L.).

Material and methods

The investigations were carried out during 2015–2017 at Dobrudzha Agricultural Institute (DAI) – town of General Toshevo. The field trial was designed according to the block method in three replications, the size of the trial area being 10.5 m^2. Two check variants were involved: K_1 – weed - free variant manually cleaned till stage heading of wheat, and K_2 – check variant infested with weeds till the end of the crops' vegetation period. The following herbicides were used:

- Derby super WG (florasulam+aminopyrali-potassium) – 33 g/ha, 66 g/ha, 132 g/ha;
- Secator OD (amidosulfuron+iodosulfuron) - 100 mL/ha, 200 mL/ha, 400 mL/ha;
- Ergon WG (metsulfuron-metil+tifensulfuron-metil) - 50 g/ha, 100 g/ha, 200 g/ha;
- Granstar super 50SG (tifensulfuron-metil+tribenuron-metil) – 40 g/ha, 80 g/ha, 160 g/ha;
- Lintur 70WG (triasulfuron+dicamba) – 150 g/ha, 300 g/ha, 600 g/ha;
- Mustang 306.25 CK (florasulam+2.4-D ester) – 800 mL/ha, 1600 mL/ha, 3200 mL/ha.

The preparations were applied at stage “end of tillering” and at “stage 29” according to Zadoks et al. (1974) at three doses – optimal, double and quadruple of three common winter wheat cultivars Dragana, Zlatitsa and Kalina.

Before planting of wheat, artificial background of weed infestation was created using the most widespread weeds in the region of DAI – General Toshevo: the annual broad-leaf weeds ivy-leaved speedwell - *Veronica hederifolia* (L.), wild mustard - *Sinapis arvensis* (L.), cleavers - *Galium tricorne* Stok, the *German chamomile* - *Matricaria chamomila* (L.), field chamomile - *Anthemis arvensis* (L.), Royal knight's spur - *Consolida orientalis* J. Gay; and the perennial broad-leaf weeds creeping thistle - *Cirsium arvense* (L.) Scop and field bindweed - *Convolvulus arvensis* (L.). Weed density was measured quantitatively per unit area by species using ¼ frame in four replications prior to introduction of herbicides.

The herbicide efficiency was estimated 25-30 days after the use of the preparations according to species, by amount and weight, using ¼ frame in four replications, measuring the weight of the weeds in fresh and dry condition. The effect was evaluated according to the 9-degree scale of EWRS for reading the herbicide activity and selectivity, 1 corresponding to 100% efficiency of the preparation, without symptoms of phytotoxicity on the cultural plants; and 9 corresponding to 29.9% - 0% effect of the preparation and complete perishing of the plants.

Cultivar Dragana is characterized with 85-90cm stem height, high resistance to lodging and spike which is awned, with high number of grains and complete resistance to lodging. The cultivar is medium early, with high cold and winter resistance and high drought tolerance. This cultivar belongs to B quality group – medium strong wheat with increased strength; the recommended sowing norm is 600 germinating seeds/m^2.

Cultivar Zlatitsa has stem height 90-95cm and possesses excellent resistance to lodging and high number of productive tillers. The cultivar is awnless and completely resistant to shedding. It is medium early, with high cold and winter resistance and high drought tolerance. This cultivar, too, belongs to quality group B of medium strength; the recommended sowing norm is also 600 germinating seeds/m^2.

Cultivar Kalina is 80-90cm high, with high resistance to lodging and good number of productive tillers. The spike is awned and highly resistant to shedding. The cultivar is also early maturing and tolerant to drought. It belongs to quality group B of medium strength; the recommendable sowing norm is 600 germinating seeds/m^2.

These were the traced structural elements of the wheat spike: length of spike (cm), number of spikelets per spike, number of grains per spike, weight of grain per spike (g) and weight of 1000 grains (g).

The main meteorological elements, especially rainfalls, during all three years of the investigation considerably varied in comparison to the mean values of the long-term period 1960-2010 (Figure 1). Year 2015 and the period of development of wheat by sowing to the end of tillering, was characterized by the highest amount of rainfalls (372.8mm). This year was considerably moist compared with the same period of the development of wheat in the 60-year period of meteorological observations in the region. The period from April to July 2015 was characterized as the most hacking (117.7mm), compared to the same period of the investigation for the remaining years, including the long-term period (1960-2010). This affects the critical stages of the development of wheat in May and June. For the period from sowing to harvest of wheat, 2016 and 2017 were characterised as humid years compared to the period 1960-2010.

On average for the three years of investigation the highest average monthly temperature (6.5°C) was established during the period from sowing to the end of tillering of wheat in 2016. Significant differences in the values of the meteorological element compared to the three years of investigation, including the long-term period (1960-2010) were not observed.

Four-factor dispersion analysis was applied. The factors year conditions, cultivar, herbicide and dose of application were traced. The data were analysed by statistic program SPSS 13.0.

Results and discussion

The analysis of the variances for structural elements of spike revealed strongly expressed correlations of the values of the index with the independent and combined effect of the factors tested in the experiment (Table 1).

The indicator length of spike is genetically embedded (Figure 2). The action of herbicides has no significant impact on that parameter. They vary within narrow limits in the three cultivars and the dose of application. The strongest effect on this indicator is exercised by the factors weather conditions of the year (62%), followed by the factor tested cultivar (32%).

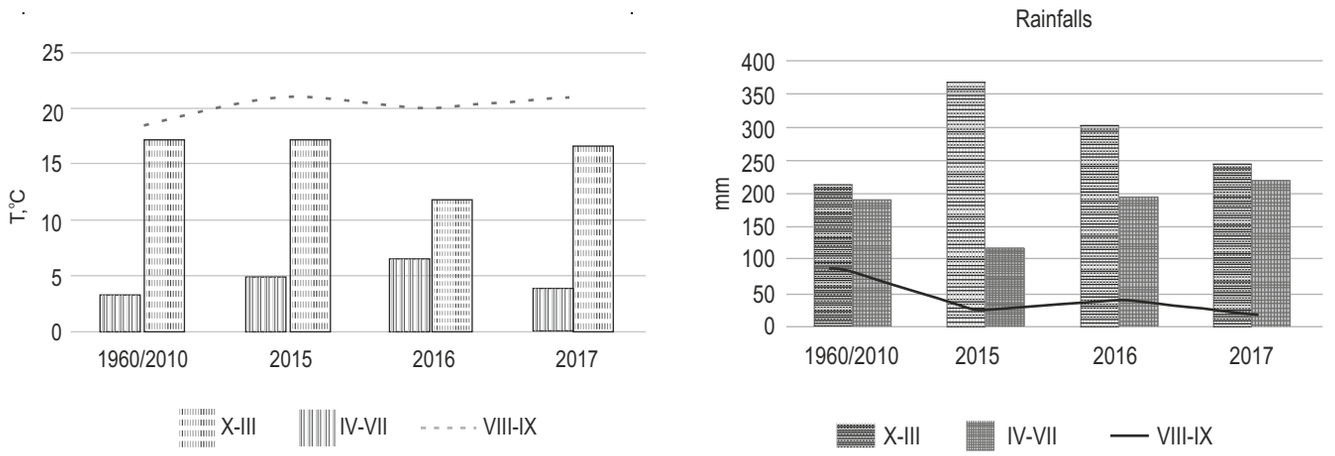

Figure 1. Air temperatures and rainfalls during the period 1960-2017

Table 1. Structural elements of spike-analysis of variances (p – 0.05)

Source	df	Length of spike		Number of spikelets per spike		Number of grains per spike		Weight of grain per spike		Weight of 1000 grains	
		F	Effect,%	F	Effect,%	F	Effect,%	F	Effect,%	F	Effect,%
Years	2	276.085	26	319.046	32	50.479	8	271.743	46	3153.212	75
Cultivar	2	143.824	13	25.337	3	433.471	64	155.445	26	71.380	2
Herbicide	5	16.689	2	15.405	2	8.32	1	10.844	2	91.031	2
Dose	2	9.133	1	606	0	3.501	1	5.450	1	9.556	0
YxC	4	553.086	52	525.038	53	115.01	17	79.696	14	652.512	16
YxH	10	6.614	1	10.857	1	4.192	1	10.474	2	43.921	1
CxH	10	7.786	1	10.334	1	3.789	1	8.807	1	38.397	1
YxCxH	20	10.158	1	12.632	1	7.202	1	10.156	2	21.654	1
YxD	4	5.523	1	7.484	1	2.515	0	4.918	1	9.875	0
CxD	4	6.188	1	13.375	1	5.336	1	2.412	0	8.355	0
YxCxD	8	1.948	0	4.771	0	3.827	1	2.381	2	9.778	0
HxD	10	13.401	1	15.094	2	12.067	2	8.786	0	28.050	1
YxHxD	20	11.233	1	15.347	2	9.158	1	7.960	1	15.606	0
CxHxD	20	6.456	1	6.38	1	5.992	1	5.096	1	18.702	0
YxCxHxD	40	4.224	0	8.019	1	7.509	1	5.327	1	16.475	0

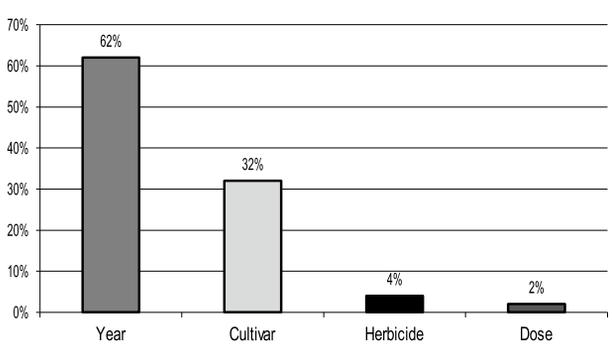

Figure 2. Strength of the factors´ effect on length of spike

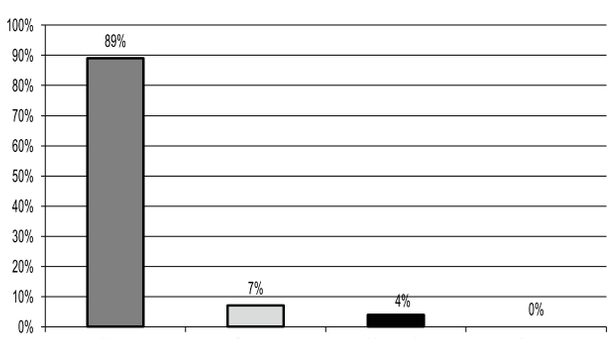

Figure 3. Strength of the factors´ effect on number of spikelets per spike

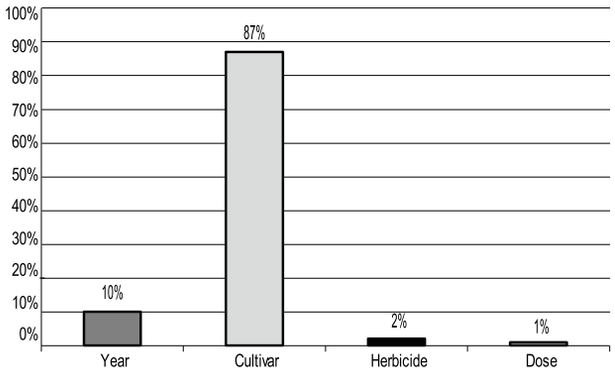

Figure 4. Strength of the factors´ effect on number of grains per spike

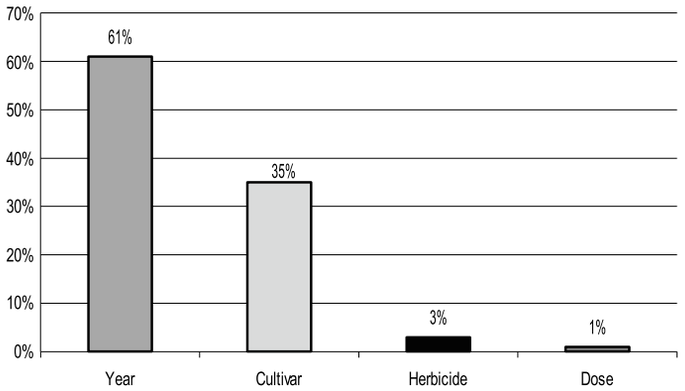

Figure 5. Strength of the factors´ effect on weight of grain per spike

Indicator number of spikelets per spike is also genetically embedded (Figure 3). The action of herbicides has no significant impact on that parameter. They vary within narrow limits in the three cultivars and the dose of application. Factor conditions of the year is characterized by the greatest strengh of influence (89%) on this indicator. Significantly weaker effect have the factors cultivar and herbicide. The dose of application of the tested herbicides has no effect on the number of spikelets per spike.

Indicator number of grains per spike is the most variable magnitude (Figure 4). In this investigation herbicides are applied at stage end of tillering of cultivars Dragana, Zlatitsa and Kalina. This is the main reason why there are no signs of phytotoxicity (for example: anthocyanin coloration of the leaves and spikes, which later leads to partial and full sterility of spikes). The range of herbicides in the survey and increase of the dose of their application (double and quadruple) does not lead to the presence of phytotoxic events on the tested cultivars. The studied cultivars is a factor having the most profound effect on the indicator number of grains per spike (87%). The conditions of the year are characterized by significantly weaker impact (10%).

The indicator weight of grain per spike is also the most variable magnitude (Figure 5). Due to the standard application of herbicides in practice (end of stage of tillering of wheat) this indicator did not change significantly, regardless of the type and dose of the herbicide. The factors conditions of the year and tested cultivars are characterized by the greatest effect of the impact on this indicator (61 and 35%, respectively).

For cultivars Dragana, Zlatitsa and Kalina the mass of 1000 grains varies within narrow limits (Figure 6). The values of the physics parameter are not affected by the set of herbicides and the dose of their application. The weather of the year has the greatest power of influence on this indicator (95%).

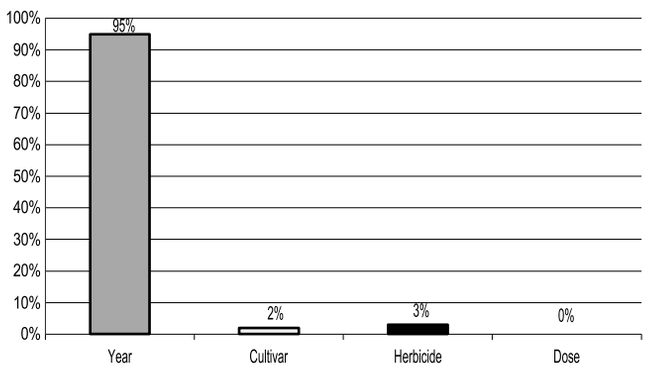

Figure 6. Strength of the factors´ effect on weight of 1000 grains

Conclusion

Visible symptoms of phytotoxicity of the spike of cultivars Dragana, Zlatitsa and Kalina were not observed after treatment with optimal, double and quadruple dose with the set of herbicides from the group of sulfunylureas. The factors with the highest strength of effect were the year conditions (10-95%) and the used cultivar (2-87%). Significantly lower was the effect of the factors applied herbicide (2-4%) and dose (1-2%) on the investigated elements.

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The introduction must answer the following questions: What is known and what is new on the studied issue? What necessitated the research problem, described in the paper? What is your hypothesis and goal ?

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Simm G, Lewis RM, Grundy B and Dingwall WS, 2002. Responses to selection for lean growth in sheep. Animal Science, 74, 39-50

Books: Author(s) surname and initials, year. Title. Edition, name of publisher, place of publication. Example:

Oldenbroek JK, 1999. Genebanks and the conservation of farm animal genetic resources, Second edition. DLO Institute for Animal Science and Health, Netherlands.

Book chapter or conference proceedings: Author(s) surname and initials, year. Title. In: Title of the book or of the proceedings followed by the editor(s), volume, pages. Name of publisher, place of publication. Example:

Mauff G, Pulverer G, Operkuch W, Hummel K and Hidden C, 1995. C3-variants and diverse phenotypes of unconverted and converted C3. In: Provides of the Biological Fluids (ed. H. Peters), vol. 22, 143-165, Pergamon Press. Oxford, UK.

Todorov N and Mitev J, 1995. Effect of level of feeding during dry period, and body condition score on reproductive performance in dairy cows,IXth International Conference on Production Diseases in Farm Animals, September 11–14, Berlin, Germany.

Thesis:

Hristova D, 2013. Investigation on genetic diversity in local sheep breeds using DNA markers. Thesis for PhD, Trakia University, Stara Zagora, Bulgaria, (Bg).

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Animal welfare

Studies performed on experimental animals should be carried out according to internationally recognized guidelines for animal welfare. That should be clearly described in the respective section “Material and methods”.

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