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Reaction of the new grain sorghum variety Maxibel to soil herbicides

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Abstract

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During 2014 and 2015, a field experiment was carried out on the experimental fields of Agricultural Institute – Shumen with the new grain sorghum variety Maxibel. The biological influence of the herbicides Gezaprim 90 WG, Dual Gold 960 EK and Stomp 330 EK was studied. Dual Gold and Stomp showed low efficiency in relation to *Amaranthus retroflexus*, as well as Gezaprim towards *Solanum nigrum*. High efficiency towards *Solanum nigrum* was shown by Dual Gold, and the same herbicide together with Stomp gave excellent control of *Datura stramonium.*

During both years of testing, most unsatisfactory performance was manifested by Stomp towards *Amaranthus retroflexus.* The effect of the studied herbicides on the development and yield of the grain sorghum variety Maxibel was positive. The studied herbicides do not exhibit phytotoxicity to the grain sorghum.

Keywords: Sudan grass; herbicides; efficiency; weeds

Introduction

Grain sorghum is the fifth most important cereal-grain crop, spread around the world. It is grown in a large climate zone and is characterized with excellent resistance to drought (Kaschieva & Koleva, 2014; Slanev, 2019). Appropriate selection of varieties and agro technologies produce stable yields in extreme droughts. Due to this fact, sorghum is becoming increasingly widely used crop in Bulgaria (Enchev, 2013). It is used for various purposes - human food, feed for animals, biofuel production, building materials and raw materials for the light industry (Rooney & Waniska, 2000; Kikindonov & Slanev, 2008).

In modern grain production, herbicides are an effective means for of controlling weeds in grain sorghum. When used in practice, it is necessary to know not only the sensitivity of the weeds to them, but also their specific effect on the crop plants, as well as the effect on every other culture following sorghum in the crop rotation.

Despite of its valuable biological and economic qualities, sorghum is characterized by slow germination and development in the early stages, which is why it is highly vulnerable to the competitive impact of weeds. The reduction in yield of grain sorghum as a result of competition with weeds is higher compared to other cereals crops, and reaches 50% (Feltner et al., 1969; Trostle & Bean, 2014; Kaczmarek, 2017).

Weed control of this crop is challenging due to the limited number of herbicides available to producers. Experiments have been carried out with various herbicides under various soil and climatic conditions that determine the impact of atrazine, dimethenamid, pyrasulfotole, bromoxynil, pendimethalin and 2,4-dichlorophenoxyacetic acid (Knowles & Ottman, 1997; Grichar et al., 2004; Rodrigues & Almeida 2011; Fromme et al., 2012; Galon et al., 2016).

It is well known that application of the same herbicides against certain weeds causes the formation of compensatory processes and the formation of resistant forms. Therefore, when applying new herbicides, it is necessary to investigate and establish both their weed efficiency and their crop selectivity (Angelova & Lambev, 2010).

The purpose of the study was to determine the effectiveness of herbicides Gezaprim 90 WG, Dual Gold 960 EC and Stomps 330 EC in weeds and in harvesting grain sorghum, variety Maxibel.

Materials and Methods

The experimental work was carried out in 2014 and 2015 in the experimental fields of Agricultural Institute – Shumen on carbonate chernozem soil, under non-irrigated conditions. The upper layer contains 50% physical clay and 5% carbonate on average, humus-3.3%, $CaCO_3$-6.5%, pH (H_2O) -7.8, PH (KCl) -7.4, Nitrogen-35 mg/kg, P_2O_5-4.7 mg/100 g, K_2O-34 mg/kg, B-1.2 mg/kg, Zn-0.1 mg/kg, Mo-0.1 mg/kg. The experiment was arranged according to block method in four repetitions with 10^2 experimental ploт, after a beet precursor.

The crop density is 25 000 plants per hectare. We have tested the effect of soil herbicides on weeds with the newest variety of Bulgarian grain sorghum Maxibel. The following soil herbicides were obtained:

- Control, grain sorghum – untreated, without weed control
- Gezaprim 90 WG (900 g/kg atrazine) – 120 g/da
- Dual Gold 960 EC (960 g/l s- metolachlor) – 150 ml/da
- Stomps 330 EC (330 g/l pendimethalin) – 450 ml/da

The application of herbicides was carried out with a backpack sprayer at a flow rate of 40 l/da in the early spring before the vegetation of sorghum and weeds. The weed infestation was reported through implementation of permanent metrics in each variation and repetition of the experiment. We have tracked the weed infestation index and species composition of weeds. The influence of herbicides on productivity and structural elements of yield in the tested sorghum variety was measured by biometric investigations: plant height (cm), weight (g), broom length (cm), broom weight (g) obtained as a result of averaging the results obtained from 20 plants for each variant. The influence of soil herbicides on the grain yield parameter was established by measuring the yield in kg/da. The data were processed by dispersion analysis.

Result and Discussion

The meteorological conditions (rainfall and temperatures) are presented in Table 1. The data for 2014 show almost twice the normal rainfall rate, with a four-fold excess in the volume and duration of rainfall in May and September.

The spring of 2015 was characterized as continuous and cold which postponed the sorghum sowing. Drought occurred after the sowing, with rainfall falling by mid-August. The amount of rainfall during the treatment period and 1-2 months after that was insufficient to show the effect of the used soil herbicides. The stable weather at the end of the vegetation period allowed the harvesting delay until the end of September, which largely compensated for the unfavorable meteorological factors.

Table 1. Meteorological conditions at Agricultural institute-Shumen during 2014-2015

Years	Month	Rainfalls mm					Temperature°C
		Decades			Amount	Norm	Average
		I	II	III			
2014	IV	–	33.8	10.6	44.4	41.0	11.5
	V	26.0	52.9	147.6	226.5	64.0	15.1
	VI	37.0	19.9	14.6	71.5	75.0	19.3
	VII	2.2	4.4	63.9	70.5	60.0	21.9
	VIII	29.0	37.3	4.0	70.3	42.0	22.5
	IX	54.3	0.2	–	54.5	28.0	17.5
	X	4.5	3.0	48.3	55.8	53.0	11.6
Total for the period					593.5		
2015	IV	32.6	10.5	10.0	53.1	41.0	14.6
	V	6.3	3.2	6.3	15.8	64.0	20.8
	VI	2.5	18.6	3.0	24.1	75.0	23.6
	VII	2.3	6.6	–	8.9	60.0	27.1
	VIII	0.6	8.8	15.2	24.6	42.0	28.4
	IX	1.1	40.2	–	41.3	28.0	22.8
	X	14.9	12.7	26.0	53.6	53.0	15.2
Total for the period					221.4		

Table 2. Herbicide efficiency on weeds/1 m^2, 2014-2015

Herbicide	Species weeds	2014			2015			Average efficiency, %
		Before treatment	After treatment	Efficiency, %	Before treatment	After treatment	Efficiency, %	
Gezaprim 90 WG, 120 g/da	*Chenopodium album*	5	2	60	5	3	40	50
	Solanum nigrum	27	14	48	24	14	42	45
	Amaranthus retroflexus	4	1	75	4	3	25	46
	Datura stramonium	3	1	67	2	1	50	59
Dual gold 960 EC, 150 ml/da	*Chenopodium album*	6	2	67	9	5	44	56
	Solanum nigrum	40	4	90	40	23	43	67
	Amaranthus retroflexus	4	3	25	7	4	43	47
	Datura stramonium	1	0	100	3	1	67	84
Stomp 330 EC, 450 ml/da	*Chenopodium album*	6	0	100	7	4	43	72
	Solanum nigrum	34	9	74	38	19	50	62
	Amaranthus retroflexus	5	4	20	3	3	0	10
	Datura stramonium	1	0	100	1	0	100	100

When monitoring the level of weed infestation of sorghum, it was found that the tested soil herbicides showed different efficacy over the years of testing and in relation to weed species. For 2014, Dual Gold 960 EC and Stomp 330 EC had poor performance with *Amaranthus retroflexus,* and Gezaprim with *Solanum nigrum*. Dual Gold had a very good performance against *Solanum nigrum* and together with Stomp 330 EC showed excellent efficiency towards *Datura stramonium.*

The extreme droughts during the spring of 2015 led to lower efficiency of the used herbicides. With the most unsatisfactory performance were Gezaprim and Stomp 330 EC towards *Amaranthus retroflexus*, 25% and 0% efficiency, respectively.

The data for the effect of soil herbicides on the grain yield parameter are shown in Table 2. The effect of the tested herbicides on the yield of the variety Maxibel was different. As a result of the more favorable climatic conditions in the first year were obtained higher grain yields. The results show that the yields of sorghum treated with the Stomp 330 EC and Dual Gold herbicides are similar, respectively 1286 kg/da and 1250 kg/da. Their excess over the control variant is statistically proven.

The extreme droughts during 2015 led to a combination of bad performance of soil herbicides, a small number of removed weeds and accordingly a negative effect for sorghum development, which reflects on the grain yield. Under water deficit conditions, the effects of different herbicides treatments resulted in yields ranging from 540-600 kg/da. This was best expressed for Stomp-599 kg/da with a proven excess over the yield of the respective control variant.

The average values of variation for some biometric traits are presented in Table 3. The average results for the two years of testing show that there were very significant variations between the tested variants. The plant height ranged from 91.5 cm in the control to 105.6 cm in the Stomp Herbicide variant; weight of one plant - 41.7 g in control variant -59.7 g with Stomp; broom length - 16.6 cm (control) -20.1 cm (Stomp); weight of a broom-15.7 g-31.7 g. In all variants the trait variation is very broad.

Table 3. Grain yield with 14% moisture in dependence on the herbicides used

Variant	2014		2015		Mean	
	kg/da	Rel. %	kg/da	Rel. %	kg/da	Rel. %
Untreated control	920.0	100	315	100.0	617.5	100.0
Gezaprim 90 WG	1170.0	127.1	562	178.4	866.0	140.2
Dual gold 960 EC	1250.0	135.8	540	171.4	895.0	144.9
Stomp 330 EC	1286.0	139.7	599	190.0	942.5	152.0
GD1%	168	14.1	163	14.0		
P%	5.56		5.51			

Table 4. Mean values of variation of the researched biometrical indexes of grain sorghum variety Maxibel in dependence of the used herbicide (average for 2014-2015)

Variant		Height of plant, cm	Plant weight, g	Panicle length, cm	Panicle weight, g
Untreated control	X	91.5	41.7	16.6	15.66
	± Sx	3.04	5.04	0.77	3.08
	P %	3.32	12.10	4.66	19.68
	C %	12.8	46.8	18.04	76.16
Gezaprim 90 WG	X	95.1	43.33	16.8	22.2
	± Sx	5.64	7.25	1.11	3.53
	P %	5.93	16.74	6.63	15.94
	C %	22.97	64.78	25.67	61.69
Dual gold 960 EC	X	100.33	57.0	17.93	24.66
	± Sx	5.81	10.70	1.14	3.50
	P %	5.79	18.78	6.40	14.20
	C %	22.44	72.69	24.80	54.96
Stomp 330 EC	X	105.6	59.66	20.1	31.7
	± Sx	4.78	7.31	1.41	4.72
	P %	4.52	12.26	7.02	14.92
	C %	17.53	47.45	27.19	57.75

The variety of effects when using different herbicides is demonstrated with proven differences between them on the basis of weight of the plant, length of the broom and weight of one broom. The coefficient of variation is from about 47.0% (control and Stomp) to 72.7% (Dual Gold) for the weight of the plant trait and from 18.0% (control) to 27.2% (Stamp) for length of the broom.

The weight of the broom is largely determined by the conditions of the environment which vary widely. This is evident through the variation coefficient, which ranges from 54.96% (Dual Gold) to 76.16% (control variant).

Conclusions

Dual Gold 960 EC and Stomp 330 EC herbicides show poor performance against *Amaranthus retroflexus*, also bad is the effect of Gezaprim treatment towards *Solanum nigrum*. Dual Gold 960 EC has a very good performance towards *Solanum nigrum* and together with Stomp - excellent to *Datura stramonium*.

During the two years of testing, Stomp 330 EC treatment was most unsatisfactory against *Amaranthus retroflexus*.

Grain yields from variants of the tested herbicides have been shown to be higher than the herbicide-free variant.

The effects of using various herbicides is demonstrated with proven differences between them by the traits weight of one plant, length of the broom and weight of panicle.

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