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EFFECT OF HERBICIDES APPLIED IN DIFFERENT GROWTH STAGES ON HECTOLITER WEIGHT OF BARLEY

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SUMMARY

Three barley varieties (Rex, NS 293 and Egej), treated with six herbicides (2,4-D, MCPP+dicamba, triasulfuron+dicamba, 2,4-D+florasulam, amidosulfuron+ iodosulfuron and florasulam+flumetsulam) were included in this experiment. Herbicides were applied during the three different growth stages tillering (BBCH 24-27), first node (BBCH 31) and second node (BBCH 32). The aim of this experiment was to consider the influence of herbicides (applied in different growth stages) on barley hectoliter weight. In first and third experimental years herbicides did not significantly influence barley seed hectoliter weight. In second experimental year at Rex variety in first and second node stage MCPP+dicamba significantly increase barley hectoliter weight compared with weed free control. In second node stages 2,4-D and florasulam+flumetsulam also increase barley hectoliter weight compared with weed free control. At NS 293 in tillering stage MCPP+dicamba significantly decrease barley hectoliter weight compared with weed free control. Also at Egej variety triasulfuron+dicamba at first node stage was also significantly decrease barley hectoliter weight compared with weed free control. Differences between growth stages during the herbicide applications in all three years of testing were very small, so they have no impact on barley hectoliter weight. If conditions do not allow herbicides to be used in the optimal period, it can be used until second node stage, without having a negative impact on the barley hectoliter weight.
Key words: barley, growth stages, hectoliter weigh, herbicides, varieties

UTJECAJ HERBICIDA PRIMIJENJENIH U RAZLIČITIM FAZAMA RAZVOJA NA HEKTOLITARSKU MASU JEČMA

SAŽETAK

Cilj istraživanja bio je utvrditi utjecaj herbicida primijenjenih u tri različite razvojne faze na hektolitarsku masu ječma. Istraživano je šest herbicidnih tretmana (2,4-D, MCPP+dikamba, triasulfuron+dikamba, 2,4-D+florasulam,

amidosulfuron+jodosulfuron i florasulam+flumetsulam), koji su aplicirani u tri različite razvojne faze (BBCH 24-27, BBCH 31, BBCH 32) ječma. Istraživane sorte ječma bile su Rex, NS 293 i Egej. U prvoj i trećoj godini istraživanja herbicidi nisu imali statistički značajan utjecaj na hektolitarsku masu ječma. U drugoj godini istraživanja tretman MCPP+dikamba primijenjen u fazama BBCH 31 i BBCH 32 statisički je značajno utjecao na povećanje hektolitarske mase ječma u usporedbi s kontrolom. Jednako je utvrđeno i nakon primjene 2,4-D i florasulam+flumetsulam u fazi BBCH 32. Kod sorte NS 293 u fazi busanja, MCPP+dicamba statistički su značajno utjecali na smanjenje hektolitarske mase ječma. Isto tako, kod sorte Egej statistički značajno smanjene hektolitarske mase utvrđeno je nakon primjene triasulfuron+dikamba u fazi BBCH 31. Istraživanjem nisu utvrđene razlike u hektolitarskoj masi ovisno o razvojnoj fazi ječma. Ukoliko uvjeti ne dopuštaju da se herbicidi u ječmu primjene u optimalnom roku, istraživanje ukazuje na to da se bez negativnog uticaja na hektolitarsku masu ječma mogu primijenjivati sve do faze BBCH 32.
Ključne riječi: ječam, faze razvoja, hektolitarska masa, herbicidi, sorte

INTRODUCTION

Barley (*Hordeum sativum Jessen*) in the Republic of Macedonia is grown on about 47 500 ha with average yield of 3 440 kg/ha (Anonymous, 2009). It is the second cultivated crop right after the wheat. Very often barley production is disturbed by weed infestation. In barley, losses due to competitive effects of weeds estimated at 15-25% of potential production. Contemporary, chemical weed control in barley and wheat begins after Second World War. Various herbicides have various influence on barley, dependent on barley varieties and the growing stages during the application. Tottman (1976) emphasizes that the knowing of growth stages during the herbicides application is of the high importance. Since then over 50 a. i. are synthesized for selective weed control in barley and wheat. Most of the herbicides which are used in barley and wheat are foliar and tillering is the optimum growth stage for application. By using the herbicides in advance growth stages barley and wheat sensitivity can be increased and yield elements can be reduced (Allien, 1966; Markovic, 1978; Rinella et al., 2001). According Folley (1985), barley is more sensitive to herbicides than wheat.

Hectoliter weight of barley seeds is very important for storing, animal food production and quality brewing and milling industry. However high hectolitre barley samples indicate sound grain which performs well in the malting process (Verma et al., 2008).

Growing stages during the herbicides application have various influence on hectoliter weight. According Spasic (1972) investigated herbicides in wheat have increase hectoliter weight compared with weedy plots and decrease hectoliter weight compared with weed free plots. Hectoliter weight due to

herbicides was decrease in Kavkaz, aurora and Bezostaja varieties and increase in Zlatna dolina and libelula varieties (Spasic et al., 1975). Martin et al. (1989) emphases that herbicides 2,4-D, MCPA and dicamba applied in three growth stages did not affect wheat hectoliter weight either experimental year.

The aim of the experiment was to evaluate the influence of herbicides applied in three growth stages on hectoliter weight at some barley varieties.

MATERIAL AND METHODS

Field trial was conducted at the Agriculture institute in Skopje. The experimental design was randomized complete block with four replicates, and harvest plot size of 16 m^2. The trial was three factorial (factor 1-herbicides, factor 2–varieties and factor 3-barley growth stages during herbicides application) The studies were carried out with three barley varieties Rex, NS 293 and Egej which were seeded with seeding rate of 300 kg/ha on October 19th (1st year), November 4th(2nd year) and November 13th (3rd year). The harvest was carried out with plot combine Wintersteiger on June 22th (1st year), July 3th (2nd year) and July 18th (3rd year) (Table 1).

Table 1 Variants of the trial
Tablica 1. Tretmani u istraživanju

Variants – active ingredient (a.i.)	Rate	Time of aplication
Weed free control	/	/
2,4-D	1 L/ha	I, II, III*
MCPP+dicamba	4 L/ha	I, II, III*
Triasulfuron+dicamba	100	I, II, III*
2,4-D+florasulam	0.5 L/ha	I, II, III*
Amidosulfuron+iodosulfuron	0.25	I, II, III*
Florasulam+flumetsulam	60	I, II, III*

*I-tillering, II- first node, III- second node

The weed population in three experimental year was consisted of annual winter and spring weeds (*Papaver rhoeas* L., *Delphinium consolida* L., *Capsella bursa pastoris* (L.) Medic*., Raphanus raphanistrum* L., *Lamium amplexicaule* L, *Galium tricorne* (Stokes), *Bifora radians* Bieb, *Matricaria chamomila* L., *Polygonum aviculare* L. etc).

All herbicides were applied with CO^2-pressurized backpack sprayer with 300 L/ha water.

Hectoliter weight was measured according to ISTA methods. The data were subjected to statistical analysis applying LSD-test.

RESULTS AND DISCUSSION

In the 1st experimental year (Table 2) barley hectoliter weight was ranged from 66.9 kg/hL at NS 293 variety treated with florasulam+flumetsulam at second node stage to 69.1 kg/hL at Rex variety treated with MCPP+dicamba at second node stage. The investigated herbicides did not significantly influence the barley hectoliter weight.

Table 2 Influence of herbicides on barley hectoliter weight (1st year)
Tablica 2. Utjecaj herbicida na hektolitarsku masu ječma (1. godina)

Variants	Varieties											
	Rex			NS 293			Egej					
	Tillering	First node	Second node	Tillering	First node	Second node	Tillering	First node	Second node	Tillering	First node	Second node
	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL
Weed free control	67.9	67.9	67.9	67.5	67.5	67.5	68.5	68.5	68.5	1.1	1.4	1.4
2,4-D	67.3	68.4	68.1	67.7	68.2	67.1	68.8	68.7	68.0	1.5	1.9	1.9
MCPP+dicamba	67.9	68.4	69.1	67.7	67.5	67.6	67.5	68.1	68.6			
Triasulfuron +dicamba	67.7	68.2	68.5	68.4	68.6	68.5	68.1	68.0	67.8			
2,4-D+florasulam	67.2	67.7	67.8	68.1	68.0	67.7	67.4	67.9	67.3			
Amidosulfuron+ iodosulfuron	67.8	67.0	68.2	67.7	67.2	68.3	67.4	67.8	68.5			
Florasulam+flumetsulam	67.2	67.7	68.3	67.5	67.5	66.9	67.7	68.2	68.2			
LSD 0.05												
LSD 0.01												

In 2nd year (Table 3) the highest barley hectoliter weight (66.9 kg/hL) was measured at NS 293 variety treated with 2,4-D+florasulam at first node stage. Lowest barley hectoliter weight (63.6 kg/hL) was measured at Egej variety treated with triasulfuron+dicamba also at first node stage. Significantly increase of barley hectoliter weight ($p<0.05$) compared with weed free control was found at Rex variety treated with MCPP+dicamba at first and second node stage also treated with 2,4-D and florasulam+flumetsulam at second node stage. Significantly decrease of barley hectoliter weight ($p<0.05$) compared with weed free control was found at NS 293 treated with MCPP+dicamba at tillering stage also at Egej variety treated with triasulfuron +dicamba at first node stage.

Table 3 Influence of herbicides on barley hectoliter weight (2nd year)

Tablica 3. Utjecaj herbicida na hektolitarsku masu ječma (2. godina)

Variants	Varieties											
	Rex				NS 293				Egej			
	Tillering	First node	Second node		Tillering	First node	Second node		Tillering	First node	Second node	
	kg/hL	kg/hL	kg/hL		kg/hL	kg/hL	kg/hL		kg/hL	kg/hL	kg/hL	
Weed free control	64.7	64.7	64.7		66.8	66.8	66.8		65.7	65.7	65.7	
2,4-D	66.1	65.8	66.2*		65.4	65.5	66.4		66.6	65.6	66.1	
MCPP+dicamba	66.1	66.6*	66.0*		64.5*	64.5	66.5		66.6	65.8	64.8	
Triasulfuron +dicamba	65.3	65.5	65.0		65.5	65.6	65.4		64.8	63.6*	65.8	
2,4-D+florasulam	66.0	65.1	64.5		66.3	66.9*	65.6		66.0	65.9	65.4	
Amidosulfuron+ iodosulfuron	65.3	64.7	63.7		65.9	65.7	66.1		65.6	65.1	64.8	
Florasulam+flumetsulam	65.9	65.2	65.9*		65.7	64.9	65.7		65.3	64.7	65.3	
LSD 0.05	1.4	1.5	1.1		2.0	2.3	1.8		2.1	1.6	1.8	
LSD 0.01	1.9	2.1	1.5		2.7	3.1	2.4		2.8	2.2	2.4	

In 3 rd year (Table 4) the highest barley hectoliter weight (70.1 kg/hL) was mesaured at Rex variety treated with MCPP+dicamba at first node stage and triasulfuron+dicamba at second node stage also at NS 293 variety treated with MCPP+dicamba at second node stage. Lowest barley hectoliter weight (67.8 kg/hL) was measured at Egej variety treated with 2,4-D+florasulam treated at tillering stages. The investigated herbicides did not significantly influence the barley hectoliter weight.

Table 4 Influence of herbicides on barley hectoliter weight (3rd year)

Tablica 4. Utjecaj herbicida na hektolitarsku masu ječma (3. godina)

Variants	Varieties											
	Rex			NS 293			Egej					
	Tillering	First node	Second node	Tillering	First node	Second node	Tillering	First node	Second node	Tillering	First node	Second node
	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL
Weed free control	68.7	68.7	68.7	69.5	69.5	69.5	68.9	68.9	68.9	68.9	68.9	68.9
2,4-D	69.5	68.8	68.9	70.0	69.5	68.6	68.3	70.0	68.8			
MCPP+dicamba	69.5	70.1	69.6	69.5	69.3	70.1	69.3	69.4	69.8			
Triasulfuron +dicamba	69.8	69.2	70.1	69.2	69.1	69.4	68.9	69.0	69.4			
2,4-D+florasulam	69.0	69.1	69.5	68.8	69.2	68.7	67.8	68.7	69.1			
Amidosulfuron+ iodosulfuron	69.1	69.4	69.8	68.0	68.8	69.7	68.9	68.0	68.7			
Florasulam+flumetsulam	69.0	69.0	68.0	69.6	70.0	69.2	68.1	68.6	69.3			
LSD 0.05	1.5	1.8	1.6	1.6	1.3	1.5	1.2	1.7	1.5			
LSD 0.01	2.0	2.4	2.1	2.2	1.7	2.0	1.7	2.4	2.0			

Lallukka (1976) emphases that the investigated herbicides including MCPA and dicamba significantly decreased hectoliter weight only in barley variety

Pirkka and only by the later treatments. Associations of iodosulfuron-methyl + fenoxaprop-p-ethyl (6.5 + 82.5; 6.5 + 110 and 6.5 + 165 g/ha), as well as of iodosulfuron-methyl + fenoxaprop-pethyl + 2.4-D (6.5 + 110 + 335 g/ ha) were selective for BRS Campeiro and BRS Gralha azul wheat cultivars and did not feature symptoms of intoxication and significant losses in grain yield and hectoliter weight, when compared to the treatment with no application. For BRS Brau barley cultivar, only iodosulfuron-methyl + fenoxaprop-pethyl associations, in doses of 6.5 + 82.5 and 6.5 + 110 g/ha were feasible for selectivity (Karpinski, et al., 2018). According (Sareta, 2016) mesosulfron methyl+Idosulfuron methyl sodium (liquid) 1 L/ha a.i., Pyroxsulam (liquid) 0.5 L/ha was not significant for plant height, spike length and hectoliter weight. Hectolitre weights of winter wheat, winter and spring barley was not affected by herbicide rate of Ally + Duplosan, Cameo + Duplosan, Starane, Cougar and Duplosan alone (Mitchell, 1998). According (Mellado et al., 2005) from the stage of semihard grain and on, herbicides 2,4-D, glyphosate, glyphosate + MCPA, and paraquat can be applied, without affecting grain yield and germination, as well as hectoliter weight. (Marinkovic, 1997) found out that the application of MCPP and 2,4-D+MCPA in the 1st year of study, as well as application of MCPP+3,6-D and 2,4-D+MCPA in the 2nd year, caused high significant increase of hectoliter mass of wheat comparing to control. Double amount of MCPP+3,6-D applied in the 1st investigation year caused high significant decrease of hectoliter mass, in relation to the application of recommended quantities. Influence of application time of herbicides on hectoliter mass was not established.

In our experiment differences between growth stages during the herbicide applications in all three years of testing (Table 5) were very small, so they have no impact on barley hectoliter weight.

Table 5 Influence of growth stages on barley hectoliter weight

Tablica 5. Utjecaj razvojne faze na hektolitarski masu ječma

Growth stage	Average of all herbicides								
	1st year			2nd year			3rd year		
	Rex	NS 293	Egej	Rex	NS 293	Egej	Rex	NS 293	Egej
	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL	kg/hL
Tillering	67.5	67.8	67.8	65.8	65.5	65.9	69.3	69.2	68.5
First node	67.9	67.8	68.1	65.5	65.5	65.1	69.3	69.3	68.9
Second node	68.3	67.7	68.0	65.2	65.9	65.3	69.3	69.3	69.2

CONCLUSION

Based of the obtained results it can be concluded that the influence of herbicides on barley hectoliter weight is not dependent on the growth stages.

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