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STUDY OF THE EFFECT OF DIFFERENT HERBICIDES AND HERBICIDAL COMBINATIONS ON WEED FLORA AND CHICKPEA YIELD

Sofia Petrova*, Stanislav Stamatov, Blagoy Andonov

Institute of Plant Genetic Resources "Konstantin Malkov"- Sadovo

***E-mail: soniapetrova123@abv.bg**

Abstract

Chickpea (*Cicer arietinum* L.) is the third most important grain legume crop in the world and the first important legume in the South and West Asia. For Bulgaria the chickpea is an old traditional crop used mainly for human consumption and to a lesser extent for feed.

One of the most important yield limiting factors in the chickpea seed production is the poor weed management. The establishment of the most appropriate herbicide or herbicide combination for the effective control especially of the weed flora is a priority task of the chickpea cultivation. The aim of this study was to investigate the effect of different herbicides and herbicidal combinations on weed flora and on the chickpea yield. The herbicides and herbicidal combinations were tested in nine treatments plus one weedy check control. All herbicides were used in pre-emergence applications at different doses. During the study the predominated weeds were *Amaranthus retroflexus* L. (redroot pigweed) and *Convolvulus arvensis* L. (field bindweed). Generally, all tested herbicidal combinations showed good control on the mixed weed flora and the grain yield was high. Three herbicidal combinations had the best effect on weed numbers and grain yield compared to the weed check: Clomazone -15 ml/da + S-metolachlor - 120 ml/da; Clomazone - 30 ml/da + S-metolachlor - 60 ml/da and Clomazone - 15 ml/da + Pendimethalin - 500 ml/da. Most of the studied herbicides and herbicidal combinations were tolerant, non-suppressive and showed a high positive effect on the chickpea yield.

Keywords: chickpea, weeds, herbicides, herbicidal combinations, selectivity

INTRODUCTION

Chickpea (*Cicer arietinum* L) has a strategic position as a protein crop in the structure of the world agricultural production, especially in regions with warm, temperate, semi-arid and dry climates. According to statistics, 92% of the area and 75.4% of the seed production are concentrated in areas with moisture deficiency (FAOSTAT 2008).

Chickpea is an old traditional crop in Bulgaria mentioned as main food in the old chronicles of St. Ivan Rilski (876-946) (e.g. Koinov, 1968). In the recent decades there is an increased interest in chickpea and its role in the healthy diet. The grains are rich in protein, carbohydrates, fats, minerals and vitamins (e.g. Petrova 2015).

An important step for the successful growing of this crop and the obtaining of a high yield is the effective control of the weed flora. If weeds are not properly controlled within the critical growth periods, the yield loses may reach up to 88%. Annual broad-leaved weeds have a similar growth pattern to that of chickpea and are more competitive to this crop (e.g. Bhalla et al., 1998).

For this reason, it is very important to select the most appropriate herbicides or herbicidal combinations to control the number of weeds at suitable costs. Numbers of herbicides have been reported from India: Pendimethalin before emergence at 1.0 kg ha^{-1} (e.g. Tewari et al., 2003; Vaishya et al., 1995);

Imazethapyr after emergence at 0.1 kg ha^{-1} (e.g. Singh et al., 2003), Clodinafop-propargyl after emergence at 0.03 kg ha^{-1} (Marwat et al., 2004) and Oxyfluorfen (600 g ha^{-1}) (e.g. Yousefi et al., 2007). According to Abbas et. al., 2016 and Khan et al., 2018 the most effective pre-emergence herbicides influenced on grain yield and also on yield parameters were Pendimethalin 330 EC @ 3750 ml ha^{-1} and Top Max 96% (Metachlor 83%+ Pendimethalin 13%) @ 3350 ml ha^{-1}.

The aim of this study was to investigate the effect of different herbicides and herbicidal combinations on the weed flora and on the chickpea yield.

MATERIALS AND METHODS

The experiment was conducted on the experimental field of the Institute of Plant Genetic Resources (IRGR) - Sadovo in 2018-2019. It was designed as a randomized block with three replicates. There were ten treatments of herbicides and herbicidal combinations including one control variant - weedy check (Table 1).

The plot size of each treatment was 10 m^2 and had six rows: three central rows for measurements and three border rows on the perimeter of each plot to reduce potential border effects. The working solution of the herbicides and herbicidal combinations was 400 ml per plot, applied pre-emergence.

Ten normally developed chickpea plants per plot were assessed based on the following descriptors: plant height (cm), height to first pod (cm), number of main branches, number of pods and number of grains per plant, number of grains per pod and mass of the grains per plant (g). The chickpea yield was expressed by the mass of grains per plant. The effect of herbicides on the weeds was recorded twice during the experiment. The type of the weeds as well as the total number of weeds by treatment was counted.

The chickpea yield reduction due to weed flora not destroyed from herbicide has been reported by one-factor dispersion analysis. The effect of weed, herbicide and interaction weed x herbicide on the chickpea yield was explained by a two-factor dispersion analysis (Cattel, 1965). The correlation analysis was used to show whether a single weed from the weed flora had a suppressing effect on the chickpea yield or whether the harmful effect was expressed by the total number of weeds. The analyses were conducted using the SPSS 19 statistical processing program.

Table 1. Experimental treatments of herbicides and herbicidal combinations

	Trade name/ **Tested dose**	**Active sustance - g/l**
1	Weedy check	-
2	Beflex - **50 ml/da**	500 g/l beflubutamide
3	Korum - **100 ml/da**	480 g/l bentazone + 22.4 g/l imazamox
4	Bismarck –**200 ml/da**	clomazone 55 g/l + pendimethalin 275 g/l
5	Bismarck –**100 ml/da**	clomazone 55 g/l + 275 g/l pendimethalin
6	Beflex - **50 ml/da**+ Dual Gold – **120 ml/da**	500 g/l beflubutamide + 960 g/l S-metolachlor
7	Sirtaki - **30 ml/da**+ Dual Gold – **60 ml/da**	360 g/l clomazone +960 g/l S-metolachlor
8	Sirtaki - **15 ml/da**+ Dual Gold – **120 ml/da**	360 g/l clomazone +960 g/l S-metolachlor
9	Sirtaki - **30 ml/da**+ Stomp Nov 330ЕК - **250 ml/da**	360 g/l clomazone +330 g/l pendimethalin
10	Sirtaki - **15 ml/da**+ Stomp Nov 330 ЕК - **500 ml/da**	360 g/l clomazone +330 g/l pendimethalin

RESULTS AND DISCUSSION

Amaranthus retroflexus L. (redroot pigweed) and *Convolvulus arvensis* L. (field bindweed) were the most spread weeds on chickpea during the reporting period (Table 2). *Amaranthus retroflexus* L. was the dominated one.

Table 2. Number and species composition of weeds per 1 m^2 plot of chickpea

№	Treatment	*Amaranthus retroflexus* L.	*Atriplex sp.* L.	*Convolvulus arvensis* L.	Total number of weeds
1	Weedy check	53	4	21	78
2	Beflubutamide - 50 ml/dka	19	2	17	38
3	Bentazone + imazamox - 100 ml/dka	15	0	19	34
4	Clomazone + pendimethalin – 200 ml/dka	33	1	5	39
5	Clomazone + pendimethalin – 100 ml/da	35	3	15	53
6	Beflubutamide - 50ml + S-metolachlor – 120ml/ dka	16	2	9	27
7	Clomazone - 30 ml/dka + S-metolachlor – 60 ml/dka	17	3	2	22
8	Clomazone - 15 ml/dka + S-metolachlor – 120 ml/dka	13	6	0	19
9	Clomazone - 30 ml/dka + pendimethalin – 250 ml/dka	31	2	0	33
10	Clomazone - 15 ml/dka + pendimethalin – 500 ml/dka	8	0	11	19

All of the tested herbicidal combinations (treatments - 6, 7, 8, 9 and 10) had good control over the total numbers of weed plants which ranged between 22 numbers/m^2 to 36 numbers/m^2, compared to the control (53 numbers/m^2). The herbicidal combinations (Beflubutamide - 50ml/da + S-metolachlor - 120ml/da) and (Clomazone - 30ml/da + S-metolachlor - 60ml/da) had good control over *Amaranthus retroflexus* L. and *Atriplex sp.* but no so good on *Convolvulus arvensis* L. The herbicidal combination (Clomazone - 15ml/da + S-metolachlor - 120ml/da) was the most effective against *Convolvulus arvensis* and gave good results also on *Amaranthus retroflexus*. Good results were obtained also by two herbicidal combinations (Clomazone - 30ml/da + S-metolachlor - 60 ml/da) and (Clomazone - 15ml/da + Pendimethalin - 500 ml/da) as the numbers of weed plants were much lower than those in the weed control. The herbicidal combination (Clomazone - 30 ml/da + Pendimethalin - 250 ml/da) was more effective over *Atriplex sp.* L. and *Convolvulus arvensis* L. compare to *Amaranthus retroflexus* L. The results about the application of Pendimethalin before emergence were in agreement with Vaishya et al. 1995 and Tewari et al., 2003. Singh et al., 2018 also reported that the pre-emergence herbicides have varied effects over broad-leaved and narrow-leaved weeds - in agreement with our results.

The obtained chickpea yield data (Table 3) supported the observed effect of the herbicidal combinations on the numbers of weed plants. A higher yield was proved in all combinations compared to the control treatment. In all other variants, the weed suppressing effect was clearly expressed and reflected negatively on the chickpea yield. The herbicidal combinations of the clomazone + S-metolachlor at the two doses (30 ml/da + 60 ml/da; 15 ml/da + 120 ml/da) as well as clomazone - 15 ml/da + pendimethalin - 500 ml/da had a clear synergistic effect. These herbicidal combinations had the highest proven mean difference (4.160, 5.910 and 3.890).

The effectiveness of herbicides and herbicidal combinations in weed control and their selectivity to chickpea plants were studied by two-factor analysis of variance. The reduction of chickpea yield was entirely due to the weeds; phytotoxity was not observed. Most of the studied herbicides and herbicidal combinations were tolerant, non-suppressive and showed an indirect positive effect on the chickpea yield. Those of them with little control over the total number of weeds had a proven negative effect on the chickpea yield. The interaction herbicide x weed had a weak effect

on the chickpea yield (Table 4). Singh and Singh, 1992 and Chaudhary et al., 2005 also reported a reduction in the yield of chickpea (40-45% and 75%, respectively) due to a serious competition of the chickpea crop with weeds.

Table 3. Effect of herbicides and herbicidal combinations on the chickpea yield

Herbicide/Dose	Mean Difference	Std. Error	Sig.	95% Confidence Interval	
				Lower Bound	Upper Bound
Beflubutamide - 50 ml/dka	0.670	1.135	0.556	1.580	2.920
Bentazone + imazamox - 100 ml/dka	2.070	1.135	0.071	4.320	0.180
Clomazone + pendimethalin - 200 ml/dka	1.930	1.135	0.092	4.180	0.320
Clomazone + pendimethalin - 100 ml/dka	0.770	1.135	0.499	3.020	1.480
Beflubutamide - 50ml + S-metolachlor - 120ml/ dka	**2.800***	1.135	0.015	5.050	-0.550
Clomazone - 30 ml/dka + S-metolachlor - 60 ml/dka	**4.160***	1.135	0.0004	6.410	1.910
Clomazone - 15 ml/dka + S-metolachlor - 120 ml/dka	**5.910***	1.135	0.000001	8.160	3.660
Clomazone 30 ml/dka + pendimethalin - 250 ml/dka	**3.280***	1.135	0.005	5.530	1.030
Clomazone - 15 ml/dka + pendimethalin - 500 ml/dka	**3.890***	1.135	0.001	6.140	1.640

Table 4. Interaction of weed, herbicide and herbicide x weed with the chickpea yield

Source	Sum of Squares	DF	Mean Square	F	Significant
Corrected Model	478.219	23	20.792	3.336	0.000
Intercept	2704.651	1	2704.651	433.930	0.000
Herbicide	380.632	11	34.603	5.552	**0.000**
Weed	46.004	1	46.004	7.381	**0.008**
Herbicide xWeed	51.583	11	4.689	0.752	0.686
Error	598.360	96	6.233		
Total	3781.230	120			
Corrected Total	1076.579	119			

The total number of weed plants had a depressive effect on the chickpea yield (r = -0.602) during the period of evaluation (Table 5). Two main weed species (*Amaranthus retroflexus* L. and *Convolvulus arvensis* L.) formed the total weeding (r =0.913 and r =0.669 respectively) and decreased the chickpea yield significantly (r =-0.444 and r =-0.737 respectively).

Table 5. Correlation dependencies between the number and species composition of weeds and chickpea yield

	Amaranthus retroflexus L.	*Atriplex sp.*L.	*Convolvulus arvensis* L.	Total number of weeds	Mass of grains per plant, g
Amaranthus caudatus L.	1.000	0.149	0.334	0**.913***	-0.444
Atriplex sp. L.		1.000	-0.267	0.057	0.174
Convolvulus arvensis L.			1.000	**0.669***	-0.737
Total number of weeds				1.000	**-0.602***
Mass of grains per plant, g					1.000

*correlation significant at 0.05% P – level

CONCLUSION

The effect of several new herbicides and herbicidal combinations over the weed flora and the chickpea yield has been evaluated. Generally all tested four herbicidal combinations had good control over the dominated weed species leading to a proven higher yield from chickpea. The best herbicidal combinations were Clomazone - 15 ml/da + S-metolachlor - 120 ml/da; Clomazone - 30 ml/da + S-metolachlor - 60 ml/da; Clomazone - 15 ml/da + pendimethalin - 500 ml/da. Under these treatments it was observed a low number of main weed plants and a higher chickpea yield compared to the weedy check. The total number of weed plants had a depressive effect on the chickpea yield during the studied period. Two main weed species (*Amaranthus retroflexus* L. and *Convolvulus arvensis* L.) formed the total weeding and decreased the chickpea yield significantly.

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