RESEARCH ARTICLE Legume Research- An International Journal, Volume 43 Issue 1: 117-121 (February 2020)

The effects of weed density and different weed control applications on yield and yield components of chickpea cultivars

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10.18805/LR-480

ABSTRACT

This study was conducted to determine the effects of weed density and different weed control treatments on chickpea yield and yield components. The experiment was carried out in split plot design with 3 replications in experimental fields of Kirsehir Ahi Evran University during 2016 and 2017 crop seasons. Total nine treatments (no weed control, permanent weed control, one-time hoeing, two-time hoeing, three-time hoeing, herbicide application after emergence, one-time hoeing with herbicide application, two-time hoeing with herbicide application and three-time hoeing with herbicide application) were compared to know the most effective weed control method. *Vaccaria pyramidata* Medik., *Sinapis arvensis* L., *Acroptilon repens* L. weed species were found to be the most intense in the experimental area. All weed control applications had significant effect on chickpea yield and yield components compared to weedy plots. Three-time hoeing with herbicide application increased the yield by 361.55-478.50% compared to weedy plots. Likewise, three-time hoeing application even increased the yield by 348.50-357.09% compared to weedy plots. The results revealed that three-time hoeing with herbicide and three-time hoeing applications stood out in weed management to obtain a good yield in chickpea cultivation at Kirsehir province.

Key words: Chickpea, Herbicide, Hoeing, Weed, Yield components.

INTRODUCTION

Many biotic and abiotic stresses are known to limit chickpea productivity in Turkey which is otherwise possible to realize (Chaithra *et al.,* 2019; Yılmaz and Kulaz, 2019). Weeds cause yield losses by competing with crops in terms of light, water and nutrients along with allelopathy (Kong *et al.,* 2007; Joshi and Joshi, 2016). Therefore, weeds are one of the most important problems, chickpea production and harvest difficult.

Weeds, in addition to competition with water and nutrients, complicate mechanical harvesting and adversely affect the quality by mixing with crop. Chickpea is poor competitor to weeds at early growth stages (Sanli *et al.,* 2009) due to low initial growth vigor. Farmers often do not use any weed control methods in chickpea crop that leads to low productivity.

Most widespread annual broad-leaved weeds such as *Chenepodium album* and *Asphodelus tenouifolius* have been reported to affect chickpea cultivation under irrigated and rainfed conditions adversely (Ahlawat *et al.,* 1981) and reported to cause huge losses in grain yields. The studies conducted showed that weeds even at low density caused 20-40% yield loss in chickpea (ICARDA, 1987). Yield losses in chickpea due to weed competition vary depending on the weed density and species in the agricultural area (Sanli *et al.,* 2009). The weeds reduce the yield in chickpea due to the competition and result in a significant reduction in grain quality. Therfore consequently creates, they storage problems and negatively affects the market value (Khan *et al.,* 2012; Saxena, 1980). The farmers of Central Anatolia Region in Turkey are sometimes using herbicides to prevent yield losses resulting from weeds. The aims of this study were to investigate the effects of weeds on yield and yield components of chickpea and determine the most appropriate weed control method under Kirsehir ecological conditions.

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How to cite this article: Yilar, M., Sozen, O. and Karadavut, U. (2020). The effects of weed density and different weed control applications on yield and yield components of chickpea cultivars. Legume Research. 43(1): 117-121.

Submitted: 12-02-2019 **Accepted:** 25-06-2019 **Published:** 04-10-2019

MATERIALS AND METHODS

Climate and soil characteristics of the research area

This research was carried out during two crop year (2016, 2017) on the experimental fields of Ahi Evran University in Kirsehir province where 6% of chickpea production of Turkey takes place. The climate data for 2016 and 2017 and long-term averages were collected to characterize growing environments (Table 1).

Soils were found slightly alkaline, low in organic matter content and sufficient in available potassium concentration. Soils are high in available phosphorus concentration, non-saline and high in calcium carbonate content (Table 2).

Table 1: Climate data for Kirsehir Province.*

Months	Average temperature (°C)			Total rainfall (mm)			Average relative humidity (%)		
	2016	2017	Long Years	2016	2017	Long Years	2016	2017	Long Years
March	7.1	7.3	5.5	44.8	41.5	37.4	60.7	60.8	68.2
April	13.8	10.7	10.6	24.0	29.0	45.6	47.4	52.4	64.3
May	14.9	15.2	15.3	98.2	49.9	43.9	63.7	59.4	61.4
June	21.0	20.7	19.4	18.5	18.4	36.9	53	54.3	55.1
July	24.2	26.0	23.0	5.8	0.4	9.6	42.5	36.0	48.7
Average	16.2	15.9	14.8				53.5	52.6	59.5
Total				191.3	139.2	173.4			

*Kirsehir provincial meteorology directorate.

Table 2: Physical and chemical properties of soils in trial areas.*

Soil Properties	0-30 cm	30-60 cm
Power of Hydrogen (pH)	7.59	7.63
Total Salt (%)	0.02	0.02
Calcium Carbonate (%)	27.90	28.39
Saturation	55.00	55.00
Organic Matter (%)	1.81	1.64
Phosphorus	2.14	2.29
Potassium Oxide	66.62	51.47

Field trials

Two chickpea varieties (Aksu and Azkan) were used materials for experimentation study. The experiment was carried out in split plot design with 3 replications during crop seasons of 2016 and 2017 under rainfed conditions. The chickpea varieties (Table 3) were placed in the main plots and weed control applications in sub-plots. The chickpea seeds were sown on March 25th in 2016 and March 24th in 2017 keeping 1.2 x 4 m area per treatment per replication, respectively. Standard agronomic practices were followed to raise crop successfully. Total of 9 weed applications (no weed control, permanent weed control, one-time hoeing, two-time hoeing, three-time hoeing, herbicide application after emergence, one-time hoeing with herbicide application, two-time hoeing with herbicide application and three-time hoeing with herbicide application) were evaluated in the study with the aim to identify most appropriate weed control method for the Central Anatolia Region (Kirsehir).

The plants located on each side of a plot and within 50 cm of row heads were excluded from the observation. All observations and saplings were performed over a 0.6 m x 4 m = 2.4 m^2 area. The first hoeing was carried out to prevent early competition in 3-leaf period of chickpea plants, the second hoeing was in the budding period of flowers and the third hoeing was in the period of flowering and podding periods. The necessary precautions were taken to ensure having no weeds in the continuous no weed plots. The post-emergence herbicide application was carried out at the specified dose and period with the commercial herbicide containing the active substance of Aclonifen (600 g/l). Using 10 plants randomly selected for agronomic characters *viz*., plant height (cm), first pod height (cm), number of pods per plant (number/plant), number of seeds per plant (number/plant), 100-seed weight (g), yield per plant (g/plant), yield (kg ha^{-1}), biological yield (g/plant), number of branches per plant (number/plant) and harvest index (%) were collected from each plot in both years of the experiment. The density of the weeds in the parcels was determined using a frame (1 meter square).

Data analysis

The analysis of the obtained data was made on the average of two years. The ANOVA was performed to assess effects of treatments on characteristics evaluated. Duncan multiple comparison test (P>0.05) was used to group the characteristics affected by the treatments determined by the ANOVA test (Duzgunes *et al.,* 1987). All statistical computations and processes were performed in the MINITAB 14 V statistical package program.

RESULTS AND DISCUSSION

The densities of weed and weed species in the trial are presented in Table 4. A total of 15 weed species belonging to 10 different families were determined in the trial area. It has been noticed that plants such as *Vaccaria pyramidata* Medik., *Sinapis arvensis* L., *Acroptilon repens* (L.) DC. form more density in terms of weed. *Amaranthus albus, Polygonum bellardii*, *Lactuca seriola*, *Vicia cracca*, *Cichorium intybus*, *Hordeum spp*., *Anagallis arvensis* were most densily presentin a study conducted in Celanpinar and Diyarbakir (Demir *et al.,* 2005). *Amaranthus albus* L., *Chenopodium album* L., *Convolvulus* arvensis L., *Acroptilon repens* (L) D.C., *Raphanus raphanistrum* plants were intensively identified in a similar study conducted in Isparta province (Sanli *et al.,* 2009).

The weed species at different locations may differ due to climatic differences, the agricultural activities, product pattern and soil characteristics of the experimental site (Topcu and Cangi, 2017; Arslan, 2018). The ecological factors of the experimental sites have significantly effected on differences observed in weed species.

Weeds and different weed control applications had statistically significant effect (P<0.05) on yield parameters such as the plant height (cm), the first pod height (cm), the number of pods per plant (number/plant), the number of seeds per plant (number/plant), 100-seed weight (g), yield

Table 3: Some features of chickpea varieties included in the study.

Cultivar Name	Characteristic Features	Registrant Institution
Azkan	It has erect growth, irregular rounded-brain shaped grain type and beige seed colored.	Transitional Zone Agricultural Research Institute/Turkey
Aksu	It has semi erect growth, irregular rounded-brain shaped grain type and beige seed colored.	East Mediterranean Transitional Zone Agricultural Research of Institute/Turkey

Table 4: Weeds including a dense population in trial area.

English Name of Plant*	Latin name of the plant	The Family of the Plant	Density (%)
Canada thistle	*Cirsium arvense* L.	Asteraceae	8
Cow soapwort	*Vaccaria pyramidata* Medik.	Caryophyllaceae	10
Field bindweed	*Convolvulus arvensis* L.	Convolvulaceae	3
Prostrate knotweed	*Polygonum aviculare* L.	Polygonaceae	2
Wild mustard	*Sinapis arvensis* L.	Brassicaceae	15
Hardheads	*Acroptilon repens* (L.) DC	Asteraceae	9
Prickly lettuce	*Lactuca serriola* L.	Asteraceae	1
Shepherd's purse	*Capsella bursa-pastoris* (L.) Medik.	Brassicaceae	1
Lambs quarters	*Chenopodium album* L.	Chenopodiaceae	3
Wild wheat	*Triticum sp.*	Poaceae	3
Common fumitory	*Fumaria officinalis* L.	Papaveraceae	1
Russian thistle	*Salsola kali* L.	Chenopodiaceae	6
Wild oat	*Avena fatua* L.	Poaceae	2
Purple deadnettle	*Lamium purpureum* L.	Lamiaceae	1
Redroot amaranth	*Amaranthus retroflexus* L.	Amaranthaceae	5

*Anonymous, 2019

per plant (g/plant), yield (kg ha^{-1}), biological yield (g/plant) number of main branches (number/plant) and harvest index (%) of the chickpea plants in present study. Statistically significant differences were found for various traits like number of seeds per plant, harvest index and yield of Aksu and Azkan varieties. The difference is resulted from the characteristics of the varieties and the difference between their response to weeds and weed control methods. The number of main branches in the Aksu variety was at the highest value in the non-weed plot. The highest number of main branches were found from three-time hoeing with herbicide application with an average of 2.44 branches per plant. The biological yield (12.33 g/plant), plant height (39.52 cm), the number of seeds per plant (14.04 number/plant), yield per plant (5.65 g/plant), harvest index (47.41%), 100-seed weight (41.77 g) and yield per hectare (1100.9 kg ha^{-1}) values of Aksu variety were obtained from three-time hoeing application. However, the first pod height (23.96 cm) and the number of pods per plant (19.04 number/plant) for the Aksu variety were obtained in the three-time hoeing application (Table 5 and 6).

The highest number of branches per plant (2.78 number/plant), biological yield (14.35 g/plant), plant height (40.33 cm), the first pod height (23.44 cm), the number of seeds per plant (17.30 number/plant), yield per plant (6.57 g), 100-seed weight (38.36 g) and yield per hectare (1004.8 kg ha^{-1}) were obtained in three-time hoeing with herbicide application (Table 5 and 6). The results obtained in the experiment indicated that proper weed control in chickpea under Kirsehir conditions resulted in approximately 478.50% yield increase in Aksu variety and 407.48% increase in Azkan variety (Table 6). Effective weed control in chickpea was earlier reported to increase yield by 17-105% (ICARDA-FSP, 1980). Similarly, the weed control in chickpea increased the yield by 107% and reported that weed competition was higher in the 4th and 6th week of the emergence (Ahlawat, 1981). Weed competition in chickpea is much higher after 60 days of the emergence (Sexana *et al.,* 1976). Rathod *et al.* (2017) explored that in the chickpea plant, the effect of 12 different applications in which the Imazethapyr herbicide was used was investigated. As a result, the highest grain yield was obtained from a weed plucking 25-30 days after the outlet.

This result indicated the importance of weed management in chickpea after 60 days of emergence to increase yield. Demir *et al.* (2005) evaluated the efficiency of herbicide application before sowing, before emergence and after emergence and hoeing on chickpea yield and reported that the most successful treatment in terms of chickpea yield was hoeing application. These results are in conformity with the earlier report of Sanli *et al.* (2009). Pooniya *et al.* (2009) reported that in a study conducted in India, importance of weed management for obtaining higher yield and harvest index has been reported. The result of the study investigated the efficacy of different weed control applications on chickpea yield and yield components revealed that all the treatments had a positive effect on yield

Table 5: The effect on chickpea yield of weed control methods.

Methods	Number of Branches per Plant (number/plant)		Biological Yield (g/plant)		Plant Height (cm)		The First Pod Height (cm)		Number of Pods per Plant (number/plant)	
	Aksu	Azkan	Aksu	Azkan	Aksu	Azkan	Aksu	Azkan	Aksu	Azkan
no weed control	1.87 c	1.88 c	6.36 c	6.41 c	33.12 b	32.53 b	19.96 a	19.13 b	8.60 c	8.55 c
permanent weed control	2.79 a	2.17 ab	13.38 a	10.81 ab	38.17 a	37.91 a	20.50 a	21.65 ab	15.64 b	14.96 ab
one-time hoeing	2.13 b	1.91 bc	8.21 bc	7.98 bc	38.84 a	39.26 a	21.28 a	19.74 ab	10.74 bc	11.68 bc
two-time hoeing	2.40 ab	2.05 b	11.00 ab	8.33 bc	36.96 ab	37.50 ab	22.46 a	21.27 ab	15.08 c	12.55 bc
three-time hoeing	2.46 ab	2.65 a	11.57 ab	13.56 a	39.39 a	38.96 a	23.96 a	22.13 ab	19.04 a	20.26 a
herbicide application after emergence	2.04 b	2.04 b	9.06 b	7.88 b	35.46 ab	37.52 a	20.33 a	19.14 b	12.67 abc	10.78 bc
one-time hoeing with herbicide application	2.21 bc	2.42 ab	9.44 b	11.54 ab	35.68 ab	39.33 a	20.37 a	19.30 b	12.84 abc	15.58 abc
two-time hoeing with herbicide application	2.32 ab	2.48 ab	9.98 b	12.03 ab	37.48 a	40.04 a	21.00 a	20.29 ab	14.05 bc	17.62 ab
three-time hoeing with herbicide application	2.44 ab	2.78 a	12.33 a	14.35 a	39.52 a	40.33 a	21.64 a	23.44 a	16.22 ab	18.44 ab
Average	2.30 A	2.27 A	10.15 A	10.32 A	38.79 A	38.17 A	21.28 A	20.68 A	13.88 A	14.49 A

Table 6: The effect on chickpea yield of weed control methods.

Methods	Number of Seeds per Plant (number/plant)		Yield per Plant (g/plant)		Harvest Index (%)		100-Seed Weight (g)		Yield (kg da^{-1})	
	Aksu	Azkan	Aksu	Azkan	Aksu	Azkan	Aksu	Azkan	Aksu	Azkan
no weed control	7.48 c	8.19 bc	2.83 bc	2.95 c	37.46 c	43.65 c	36.15 b	32.23 b	19.03 f	21.77 e
permanent weed control	15.38 a	13.78 ab	6.14 a	5.18 ab	45.42 ab	48.19 b	40.00 ab	38.21 a	92.94 bc	70.82 c
one-time hoeing	8.91 bc	10.46 b	3.26 b	3.74 bc	39.34 bc	44.36 c	35.84 b	34.47 ab	81.76 c	47.47 d
two-time hoeing	12.23 ab	11.18 b	4.65 ab	3.93 b	41.94 b	47.58 b	36.54 b	35.54 ab	82.93 c	65.81 c
three-time hoeing	13.16 ab	17.26 a	5.04 ab	6.39 a	43.95 ab	56.40 a	36.64 b	37.68 a	85.35 c	99.51 a
herbicide application after emergence	10.92 ab	9.91 b	4.37 ab	3.69 bc	41.57 b	44.71 bc	36.17 b	35.89 ab	56.46 e	69.94 c
one-time hoeing with herbicide application	11.21 ab	14.50 ab	4.04 ab	5.23 ab	44.42 ab	45.34 bc	37.49 ab	36.37 ab	71.19 d	83.62 b
two-time hoeing with herbicide application	12.00 ab	15.86 ab	4.47 ab	5.95 ab	45.18 ab	45.88 bc	38.58 ab	37.43 ab	97.89 b	99.37 a
three-time hoeing with herbicide application	14.04 a	17.30 a	5.65 a	6.57 a	47.41 a	48.79 b	41.77 a	38.36 a	110.09 a	100.48 a
Average	11.70 B	13.16 A	4.93 A	4.85 A	42.97 B	47.21 A	37.69 A	36.24 A	77.52 A	73.20 B

compared to the control group. The results of the two-year study showed that three-time hoeing after the herbicide application leads to better results on chickpea yield. The hoeing without herbicide application may be sufficient for a good yield in chickpea in the periods when competition is high. However, herbicide application (yield increase was up to 196-221% compared to weedy plots) may be sufficient after weed control in areas where labor is limited.

CONCLUSION

The results revealed that weed management significantly increases the chickpea yield depending on the management strategy. The weeds in chickpea cultivation fields have always been a serious problem needed to be overcome. However, ecological management is also important to ensure weed control causes the least harm to both nature and people. The results showed that three-hoeing without herbicide application can be sufficient for successful chickpea cultivation. Considering the damage of herbicide caused to economic value and nature and the economic value of hoeing, it would be more appropriate to prefer hoeing for successful chickpea production. Weed control wil be largely influenced by eccentrics factors in open areas. For this reason, it is recommended that the application in large areas carried out taking into account the ecological characteristics and differences of the region.

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