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Investigation of the Morphological Characteristics of Chickpea (*Cicer arietinum* L.) Cultivars Cultivated under Irrigated and Non-Irrigated Conditions Sown in Winter and Early Spring

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A B S T R A C T

This research was carried out to determine the yield and physiological characteristics of İnci, Hasanbey, Seçkin and Aydın chickpea (*Cicer arietinum* L.) cultivars at different sowing times and under irrigated and non-irrigated conditions in Çukurova climate conditions. Experiments were carried out in a divided plot design with four replications for two years, in 2012 and 2013 growing years. In the study, two different planting times (winter-early spring) and two different water applications (irrigated and non-irrigated) were applied and some properties related to yield and morphology were examined. The trials were conducted at the Doğankent location in the Eastern Mediterranean Agricultural Research Institute research area. In the experiments, the main plots were arranged according to sowing time, and the sub-plots consisted of cultivars, and irrigated and non-irrigated plots. As a result of the research, it was determined that sowing time and water applications affected agronomic and morphological characteristics. These changes were observed according to planting times and varieties.

In terms of morphological characteristics, it was determined that there were decreases in summer plantings and non-irrigated conditions in which planting time and irrigation were significantly effective in all four cultivars. Increases were determined in winter plantings compared to summer plantings. Increases in yield and hundred-seed weights under irrigated conditions, increases in yield values, flowering and pod binding values were observed in winter plantings. In terms of two-year average values, a yield of 196.29 kg da^{-1} was obtained in irrigated conditions and 158.11 kg da^{-1} in non-irrigated conditions in winter plantings. In terms of two-year average values, 139.67 kg da^{-1} yield was obtained in irrigated conditions and 121.14 kg da^{-1} yield was obtained in summer plantings.

1. Introduction

Chickpea (*Cicer arietinum* L.) is a genus of Cicer, which has 2n=16 chromosomes, highly self-fertile, and is in the Leguminosae team, *Papilionacea* (butterfly-flowered) family, *Viceae* subfamily. Proteins are of great importance in human nutrition because they are highly digestible and close to animal-derived proteins in terms of amino acids they contain (Thudi et al., 2011). Edible legumes are an important food source for human nutrition with their cheap and high-quality vegetable protein content, mineral, vitamin and

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fiber ratio (Şehirali, 1988; Friedman, 1996). Chickpea is an important food source and contains high amounts of protein, fiber and carbohydrates. In terms of protein richness, it has an important position in human nutrition as a source of carbohydrates and is one of the basic nutrients. Chickpeas are rich in nutritional values and have positive contributions to the soil where they are grown. Chickpea is generally grown in arid and irrigated regions in our country. Chickpea is the second plant that is the second most resistant to heat and drought after the lentil plant, and suitable for cultivation in poor soils, it is an important plant in increasing the yield obtained from the unit area by entering the crop rotation in arid regions and narrowing our fallow areas (Eser, 1978). In Turkey, the cultivation area is 487,885 ha, the production is 475,000 tons, and the yield per unit area is 97 kg da^{-1} (TUIK, 2022). The fact that the chickpea plant can benefit from elemental nitrogen in the air through Rhizobium bacteria, which maintains a symbiosis in its roots, that it fixes the nitrogen in the air to the soil, that its cultivation is easy and that the vegetation period is short (Azkan 1989; Sepetoğlu 1994) increases the importance of the chickpea plant (Yorgancılar et al., 2008; Muehlbauer et al., 1987). Growing season can be postponed from winter to early spring to avoid anthracnose blight disease. However, in these regions, spring precipitation shows an insufficient and uneven distribution; The yield of chickpeas planted in summer is adversely affected by high temperature and drought stresses (Slim et al. 1993).

There are genetic and environmental variables that affect yield and yield elements in chickpea cultivation. It has been emphasized that the most important factor affecting the yield among the cultivation techniques applications is the sowing time, and that the flowering, pod filling and yield can vary depending on the climatic factors at different sowing times (Kayan et al., 2014). In previous studies, chickpea cultivars planted on different dates showed differences in terms of yield and yield components (Karasu et al., 1999; Partigöç et al., 2007; Ray et al., 2017), and late sowing dates affected yield and quality (Ali et al., 2018; Varoğlu and Abak, 2018). In addition, plant height and first pod height decrease (Akdağ, 1995; Erman and Tüfekçi, 2004), grain yield per decare decreased (Akdağ, 1995; Erman and Tüfekçi, 2004), 100 seed weight and alteration in protein content (Topalak and Ceyan, 2015).

The most important problem in chickpeas is anthracnose tolerance and suitability for mechanized agriculture. Since the production purpose is a high grain product, the development of varieties suitable for the region where chickpea will be grown is an important factor in increasing production and quality. This research was carried out to investigate and evaluate the yield and yield elements of chickpea plant, grown in irrigated and non-irrigated conditions in winter and summer plantings for the Çukurova region, and present it to the service of the farmer.

2. Materials and Methods

In this study, İnci, Hasanbey, Seçkin and Aydın chickpea cultivars were used. Experiments were carried out at Doğankent location in Çukurova region Agricultural Research Institute experimental area in 2012 and 2013 growing years, by planting in winter (December) and early spring (February) for two years. Sowing was done in 6 rows (13.5 m^2) of 5 m length with 45 cm row spacing and 8 cm row elevation. Before planting, fertilization was done with 3.0 kg N and 6 kg P_2O_5 per decare. Trials were 4 replications in split plots trial design in both years; It was made as 4 cultivars, 2 planting time and 2 applications (irrigated and non-irrigated).

2.1. Climatic characteristics of the experimental area

When Table 1 is examined, monthly precipitation, temperature and relative humidity rates in the production periods of chickpea are seen. Especially in 2012-2013, when precipitation did not show a balanced and regular distribution during the growing periods, heavy precipitation pressure and uneven precipitation compared to long years had a negative effect on the development of plants. It is seen that it receives low precipitation compared to the average of many years during the development periods. In both years, uneven precipitation distribution had a negative effect on the growth of plants.

Table 1. Climate data of Adana province for 2011-2012 and 2012-2013 growing years

Months	Precipitation (mm)			Average Temperature ℃			Relative humidity (%)		
	Long Year	2012-2013	2013-2014	Long Year	2012-2013	2013-2014	Long Year	2012-2013	2013-2014
November	67.2	187	1.0	15.3	17.4	17.7	63	52.3	57.5
December	118.1	154.4	12.2	11.1	11.4	10.4	66	73.7	42.7
January	111.7	25.9	28.2	9.7	9.5	11.5	66	66.8	69.6
February	92.8	49.0	18.5	10.4	12.1	10.8	66	73.9	56.9
March	67.9	70.1	56.1	13.3	13.9	15.1	66	61.1	65.6
April	51.4	43.2	18.6	17.5	18.1	17.7	69	72	66.9
May	46.7	57.4	22.4	21.7	22.7	21.3	67	72.3	70.4
June	22,4	0.3	50.0	25.6	25.3	24.0	66	65.7	68.2
July	5.4	0.0	0.3	27.7	28.2	28.2	68	65.2	72.6

3. Results and Discussion

Chickpea plant needs water like all plants, but the amount of water it needs is lower than for other crops. It is reported by many researchers that the yield components of this plant, which is generally fed with rain water, differ under different irrigation regimes (Özgun et al., 2004; Silim and Saxena, 1993; Toğay et al., 2005). In this context, agronomic parameters were examined in the prominent lines in the region where summer and winter cultivation were made under Mediterranean agro-ecological conditions, using irrigated and non-irrigated farming systems.

In 2012 and 2013, 50% flowering days, number of pod tying days, plant height, first pod height, hundred-seed weight and yield values in İnci, Hasanbey, Seçkin and Aydın chickpea cultivars in winter plantings with irrigation and without irrigation applied as four repetitions. analyzed and evaluated statistically (Table 2).

In 2012, the average number of days until flowering was 152.9 days, the number of days until pod tying 166.0 days, average plant height 64.5 cm, average first pod height 29.3 cm, average 100 seed weight 35.1 g and the average grain yield 183.7 kg da^{-1} was observed in irrigated plots sown in winter. In chickpea plots without irrigation, the average number of days until flowering was 152.3 days, the number of days until pod tying 165.31 days, average plant height 64.0 cm, average first pod height 27.9 cm, average 100 seed weight 35.9 g and the average grain yield 123.8 kg da^{-1} was observed (Table 2).

In 2013, the average number of days until flowering was 86.69 days, the number of days until pod tying 103.81 days, average plant height 70.0 cm, average first pod height 35.3 cm, average 100 seed weight 40,97 g and the average grain yield 208,9 kg da^{-1} was observed in irrigated plots sown in winter. In chickpea plots without irrigation, the average number of days until flowering was 88,50 days, the number of days until pod tying 102,4 days, average plant height 54,54 cm, average first pod height 28,74 cm, average 100 seed weight 40,5 g and the average grain yield 192,4 kg da^{-1} was observed (Table 2).

Two-year average for agronomic characters were 121,3 days until flowering, the 134,9 days until pod tying, 67,3 cm plant height, 32,3 first pod height, average 100 seed weight 38,1 g and the average grain yield was 196,3 kg da^{-1} in irrigated plots sown in winter. In chickpea plots without irrigation, the average number of days until flowering was 120,05 days, the number of days until pod tying 133,9 days, average plant height 59,28 cm, average first pod height 28,30 cm, average 100 seed weight 38,2 g and the average grain yield 158,1 kg da^{-1} was observed (Table 2).

All agronomic parameters varied between cultivars, years and irrigation practices, and the differences were found to be statistically significant. This difference stands out especially in yield and 100 grain weight parameters.

Togay et al. (2005) emphasized that the yield and agronomic characters in dry farming areas were lower than those in irrigated farming areas in their study using 2 cultivars in Van conditions. Özgun et al. (2004) in the result of a similar study carried out in Diyarbakır agro-ecological conditions, determined that 100 grain weight and yield per decare decreased in dry farming areas. In Adana conditions, 100 grain

weight was found to be higher in dry agriculture than in irrigated agriculture, while yield per unit of area was determined to be higher in irrigated agriculture. Uzun et al. (2012) emphasized that the number of pods per plant and the amount of yield per area showed a high positive correlation. Özgun et al. (2004) stated that the number of minor, major and pods per plant in chickpea cultivated without water is quite low. In our study, although the weight of 100 grains was low in non-irrigated agriculture, the reason why the yield per unit area was determined lower than in irrigated agriculture is thought occur due to the higher number of main branches and pods that highly affects the yield per plant.

Table 2. Agronomic Characteristics of Chickpea Varieties in Winter Sowing

Year	Application	Cultivars	Days Until Flowering (days)	Days Until Pod Tying (days)	Plant Height (cm)	First Pod Height (cm)	100 Seed Weight (g)	Yield (kg da^{-1})
2012	Irrigated	INCI	154a	166,0ab	63,9bc	29,4b-c	32,9 h	205,1 ab
		HASANBEY	152ab	165,8ab	64,4bc	30,3bc	39,0c-f	183,7 b-d
		SECKIN	153,3ab	166,8a	69,7ab	30,2bc	36,4fg	197,3 b
		AYDIN	152,5ab	165,5ab	60,1bcd	27,2c	32,2 h	148,8 c-e
	Average		152,9	166,0	64,5	29,3	35,1	183,7
	Non - Irrigated	INCI	153,3ab	167a	67,9ab	30,8bc	32,3 h	139,2 de
		HASANBEY	151,3b	163,5b	61,8bc	27,3c	37,7fg	114,7 e
		SECKIN	152,3ab	165,5ab	63,1bc	26,7c	37,9e-g	122,2 e
		AYDIN	152,5ab	165,3ab	63,3bc	26,6c	35,9g	119,2 e
	Average		152,3	165,3	64,0	27,9	35,9	123,8
2013	Irrigated	INCI	92,0c	106,5c	64,9bc	34,2ab	37,9 e-g	252,4 a
		HASANBEY	87,8de	102de	69,1ab	37,1a	42,9 ab	194,8bc
		SECKIN	89,8d	103de	69,6ab	36,2a	41,8 a-c	200,7 b
		AYDIN	89,3d	103,8d	76,5a	33,8ab	41,2 b-d	187,6 bc
	Average		89,7	103,8	70,0	35,3	40,9	208,8
	Non - Irrigated	INCI	89,8d	103,5de	56,3cd	29,2bc	37,9 e-g	214,37ab
		HASANBEY	87,0e	101e	56,2cd	27,9c	44,6 a	188,11 bc
		SECKIN	88,5de	102,5de	54,9cd	30,4bc	40,6b-e	195,11 bc
		AYDIN	88,8de	102,5de	50,8d	27,5c	38,7d-g	172,07 b-d
	Average		88,50	102,38	54,5	28,7	40,5	192,4
	LSD		2,06	2,67	10,3	5,2	2,8	47,49
2012 2013	Irrigated	INCI	123a	136,25a	64,4a-c	31,8ab	35,5de	228,8a
		HASANBEY	119,8cd	133,9bc	66,8ab	33,7a	41,0ab	189,2bc
		SECKIN	121,5b	134,9ab	69,6a	33,2a	39,1bc	198,9ab
		AYDIN	120,9bc	134,6ab	68,3ab	30,5a-c	36,7de	168,2b-d
	Average		121,3	134,9	67,3	32,3	38,1	196,3
	Non - Irrigated	INCI	121.5b	135,3ab	62,2b-d	30,0a-c	35,1e	176,7b-d
		HASANBEY	119,1d	132,3c	58,9cd	27,6c	41,1a	151,4d
		SECKIN	120,4b-d	134bc	58,9cd	28,5bc	39,3a-c	158,7cd
		AYDIN	120,6bc	133,9bc	57,0d	27,0c	37,3cd	145,6d
	Average		120,1	133,9	59,3	28,3	38,2	158,1
	LSD		1,5	1,9	7,3	3,7	2,0	33,6
	CV		1,2	1,4	11,5	12,0	5,2	18,8

In 2012 and 2013, the number of 50% flowering days, number of pod tying days, plant height, first pod height, hundred-seed weight and yield values in İnci, Hasanbey, Seçkin and Aydın chickpea cultivars in summer plantings with irrigation and non – irrigated areas applied as four repetitions analyzed and evaluated statistically (Table 3).

Table 3. Agronomic Characteristics of Chickpea Varieties in Summer Planting

Year	Application	Cultivars	Days Until Flowering (days)	Days Until Pod Tying (days)	Plant Height (cm)	First pod Height (cm)	100 Seed weight (g)	Yield (kg da^{-1})
2012	Irrigated	İNCİ	62,56a	72,90a	55,95b-d	24,74fg	31,07ıj	113,68bc
		HASANBEY	61,25a-c	70,25b	54,16 b-e	27,58c-g	37,67b-d	132,78bc
		SEÇKİN	60,0cd	70,50b	46,08f	26,58e-g	35,16d-g	120bc
		AYDIN	61,75ab	71,50ab	60,41b	28,41b-g	31,75h-j	102,89c
	Average		61,4	71,3	54,2	26,8	33,9	117,3
	Non - Irrigated	İNCİ	61,50a-c	71,25ab	56,50b-d	27,33d-g	29,92j	123,37bc
		HASANBEY	60,25b-d	71,0b	55,66b-e	25,58fg	34,67d-h	118,22bc
		SEÇKİN	59,50d	69,75b	51,17c-f	23,74g	33,33f-ı	124,96bc
		AYDIN	60,75b-d	71,25ab	68,08a	33,07ab	32,41g-j	110,44c
	Average		60,5	70,81	57,85	27,43	32,58	119,25
2013	Irrigated	İNCİ	48,75e	66,50c	57,48bc	33,70a	32,95f-j	148,74b
		HASANBEY	43,0h	65,25cd	56,65b-d	34,58a	37,30b-e	189,70a
		SEÇKİN	46,25g	62,00e	54,55 b-e	32,08a-d	38,63bc	189,59a
		AYDIN	47,75e-g	66,50c	57,45bc	32,45a-c	33,63f-ı	120bc
	Average		46,44	65,06	56,53	33,20	35,63	162,01
	Non - Irrigated	İNCİ	49,0e	64,75cd	51,13c-f	31,80a-d	33,98e-ı	128,74bc
		HASANBEY	42,75h	65,50c	49,87d-f	30,75a-e	42,48a	123,11bc
		SEÇKİN	46,50fg	63,50de	48,73ef	28,70b-f	39,80ab	125,26bc
		AYDIN	48,0ef	65,25cd	52,38 c-f	31,23a-e	36,15c-f	114,96bc
	Average		46,56	64,75	50,53	30,62	38,10	123,02
	LSD		1,63	1,90	7,08	4,93	3,44	25,95
2012 2013	Irrigated	İNCİ	55,63a	69,70a	56,71ab	29,22a-c	32,01c	131,21bc
		HASANBEY	52,13cd	67,75bc	55,41ab	31,08ab	37,48a	161,24a
		SEÇKİN	53,13c	66,25d	50,32c	29,33a-c	36,89a	154,80ab
		AYDIN	54,75ab	69,00ab	58,93a	30,43ab	32,69c	111,44c
	Average		53,91	68,18	55,34	30,02	34,77	139,67
	Non - Irrigated	İNCİ	55,25ab	68,00b	53,81bc	29,57a-c	31,95c	126,06c
		HASANBEY	51,50d	68,25b	52,77bc	28,17bc	38,57a	120,67c
		SEÇKİN	53,0c	66,63cd	49,95c	26,22c	36,57ab	125,11c
		AYDIN	54,38b	68,25b	60,23a	32,15a	34,28bc	112,70c
	Average		53,53	67,78	54,19	29,03	35,34	121,14
	LSD		1,14	1,34	4,99	3,47	2,42	25,95
	CV		2,11	1,95	9,01	11,62	6,83	19,63

In 2012, the average number of days until flowering was 61.4 days, the number of days until pod tying 71.3 days, average plant height 54.2 cm, average first pod height 26.8 cm, average 100 seed weight 33.90 g and the average grain yield 117.3 kg da^{-1} was observed in irrigated plots sown in early spring. In chickpea plots without irrigation, the average number of days until flowering was 60.5 days, the number of days until pod tying 70.81 days, average plant height 57.85 cm, average first pod height 27.43 cm, average 100 seed weight 32.58 g and the average grain yield 119.25 kg da^{-1} was observed (Table: 3).

In 2013, the average number of days until flowering was 46.44 days, the number of days until pod tying 65.06 days, average plant height 56.53 cm, average first pod height 33.2 cm, average 100 seed weight 35.63 gr and the average grain yield 162.01 kg da^{-1} was observed in irrigated plots sown in early spring. In chickpea plots without irrigation, the average number of days until flowering was 46.56 days, the number of days until pod tying 64.75 days, average plant height 50.53 cm, average

first pod height 30.62 cm, average 100 seed weight 38.1 gr and the average grain yield 123.02 kg da^{-1} was observed (Table 3).

Two-year average for agronomic characters were 53.91 days until flowering, the 68.18 days until pod tying, 55.34 cm plant height, 30.02cm first pod height, average 100 seed weight 34.77 g and the average grain yield was 139.67 kg da^{-1} in irrigated plots sown in early spring. In chickpea plots without irrigation, the average number of days until flowering was 53.53 days, the number of days until pod tying 67.78 days, average plant height 54.19 cm, average first pod height 29.03 cm, average 100 seed weight 29.03 g and the average grain yield 121.14 kg da^{-1} was observed (Table 3).

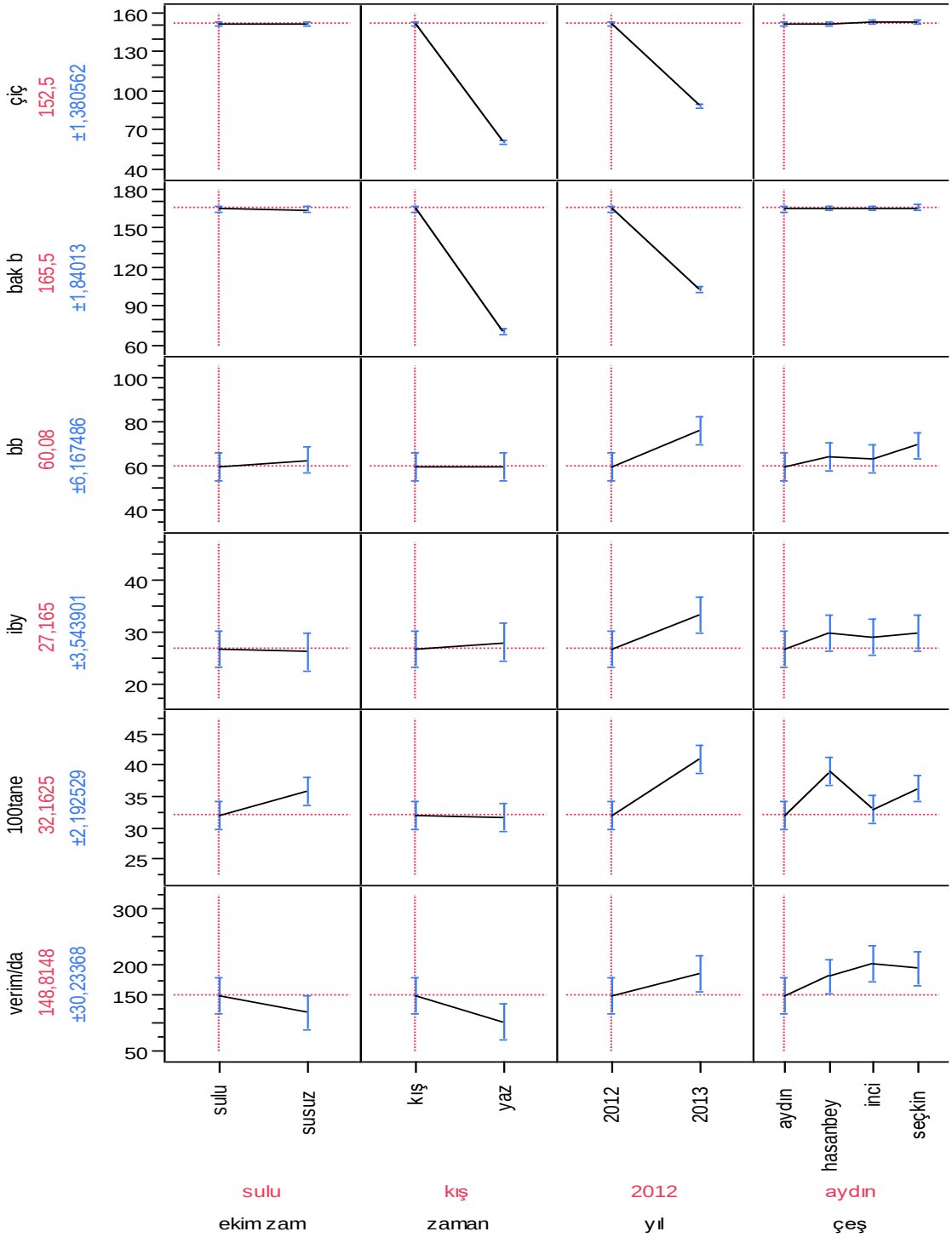

Figure 1. Agronomic characteristics in irrigated and non-irrigated conditions of chickpea cultivars in winter, summer sowing

While 4 chickpea cultivars subjected to different irrigation regimes in 2012 and 2013 in summer planting did not show any significant difference in terms of agronomic characters according to years and irrigation systems, it was determined as a result of statistical analysis that the observed differences were caused by cultivars. Silim and Saxena (1993) found in their study that the parameters most affected by the irrigation regime are yield and biomass. It has been determined that some agronomic characters of İnci, Aydın, Seçkin and Hasanbey cultivars are not significantly affected in irrigated and non-irrigated agriculture, but it has been determined that yield elements are affected more by the irrigation regime than other parameters, and at the same time, the degree of impact of the irrigation regime varies depending on the cultivar (Table 2 – 3; Figure 1). In addition, Şanlı and Kaya (2008) reported in their study that the amount of yield per unit area from the areas where summer planting is made is quite low compared to winter planting. Karadavut and Sözen (2020) emphasized that with the delay of sowing time, there is a decrease in the quality of the agronomic characters of the chickpea plant. The difference between chickpeas cultivated in winter and summer is supported by the literature.

When the agronomic characteristics of the cultivars were evaluated regardless of irrigated and non-irrigated agriculture, the highest yield was observed in İnci cultivar, while the highest 100 grain weight was observed in Hasanbey cultivar (Figure 1).

Mart et al. (2021), in their study, determined that the yield elements of İnci, Seçkin, Hasanbey cultivars were the highest under Adana Agro – ecological conditions.

The number of flowering days and pod-fixing days are vegetation characteristics and are highly affected by planting time and ecological conditions (Gregersen et al., 2013). The number of flowering days and pod-fixing days were observed to differ between years and depending on the planting time, which is thought to be related to ecological and planting time.

4. Conclusion

The importance of irrigated and non-irrigated agriculture in winter chickpea planting in 2012-2013 and 2013-2014 was investigated and evaluated in terms of different agronomic characters. At the same time, the response of standard cultivars to irrigated and non-irrigated farming in the region was studied. As a result of the study, agronomic characters differed depending on irrigation, variety and year. It has been determined that the yield per decare in the irrigated areas is high, and the 100-grain weight is higher in non - irrigated agriculture.

In the same years, the effects of summer chickpea planting on the development and yield of cultivars in irrigated and non-irrigated agriculture were investigated, and it was determined that the yield elements were 50% higher in irrigated agriculture compared to non-irrigated agriculture in summer planting conditions. Winter sowing is recommended to obtain high yields; at the same time, if the conditions are suitable, it is appropriate to make irrigated farming irrigated farming with tolerant cultivars.

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