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Research Article

The Effects Of Iron And Phosphorus Applications On The Yield and Yield Components In Chickpea (*Cicer arietinum* L.)

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Chickpea, phosphorus, iron, yield, yield components

Abstract
The research was conducted to determine effects of different levels of iron and phosphorus on the yield and some yield components in chickpea in 2017 in Van ecological conditions. The experiment was laid out in a factorial randomized block design with three replications. The doses were used phosphorus (0, 4 and 8 kg da^{-1}) and iron (0, 1 and 2 kg da^{-1}) in this study. In the study were investigated the plant height, first pod height, branch number per plant, pod, seed number and per plant, seed number per pod, biological yield, seed yield per unit, harvest index, 100-seed weight, protein ratio phosphorus content in seed, phosphorus content in seed and number of nodule. The results of the study indicated that iron and phosphorus applications increased significantly the seed yield and yield components. While the highest seed yield was obtained from 4 kg phosphorus /da + 1 kg iron /da application with 160.4 kg/da, the lowest seed yield was obtained from control parcels with 113.3 kg da^{-1}.

INTRODUCTION

Chickpea is an edible legume type that has been used in human and animal nutrition since ancient times, has high digestibility (21.5-23.9%) dry grain (76-88%), and is rich in essential amino acids and some mineral substances (Akçin, 1988). Chickpea is a plant suitable for planting rotations with cereals in fallow lands, due to its resistance to low temperatures (-8-10 ^{0}C) and its small vegetative component (Donder and Togay, 2021). Chickpea can benefit from the free nitrogen of the air since it is capable of living in symbiosis with rhizobium bacteria. Since the C/N ratio is very low in the root residues left in the soil after the harvest, the residues are broken down in a short time and turn into humus, thus leaving a more suitable soil for the next plants. This phenomenon, called symbiotic nitrogen fixation, occurs as a result of mutually beneficial interactions between *Rhizobium* spp bacteria and the host legume plant (Soysal and Erman, 2020). One of the most important cultural processes in increasing the unit area yield is fertilization. Nitrogen and phosphorus fertilizers are more common in fertilizer application in Turkey, and the habit of iron fertilization is almost absent or less. There has been a decrease in cultivation areas in our country in recent years. Increasing our cultivation areas will only be possible by purchasing products from fallow lands every year (Dinç and Togay, 2021). Phosphorus fertilizers are very important in increasing grain quality as well as increasing grain yield. The effect of phosphorus on plant root development is also important. Depending on the application of phosphorus, the contact surface of the root in the soil expands with the increasing root development, thus increasing the rate of utilization of other nutrients by the plants (Marschner, 1995). The lack of available phosphorus in the soil of the country and the resulting excessive phosphorus fertilization are emerging as important plant nutrition and fertilization problems. The properties of Turkish soils in terms of pH, lime and organic matter are such that they seriously limit the availability of phosphorus to our soils. In the Mediterranean and West Asian countries, including our country, the main nutritional problems that limit plant production is the low availability of phosphorus in the soil to plants (Cooper et al., 1987; Matar et al., 1992). It has been determined that phosphorus is insufficient in 58% of Turkey's soils (Eyüpoğlu, 1999). It has been determined in the studies that the soil where the experiment will be established is deficient in terms of Fe content (1.18 ppm) (Cimrin, 1996). Iron nutrition of plants grown in soils rich in lime and high pH is very often adversely affected. This problem is known as yellowing (chlorosis) caused by lime and there are signs of Fe deficiency in plants. The soils of Van province are quite rich in lime and the pH ratio is very high. The soils of the campus area where the research will be conducted are calcareous and the pH ratio is around 8.5. Iron activates various enzymes that have important physiological functions in plants and catalyze many biochemical reactions. These enzymes act as electron carriers in the respiratory chain and in energy metabolism, which is of paramount importance in oxidation reactions. In iron deficiency, the amounts of various pigments such as carotene and xanthine decrease in parallel with the amounts of chlorophyll a and b. A similar decrease is observed in the rate of photosynthesis in plants. This is explained by the inability of various enzymes, which have important functions in photosynthesis, to be sufficiently active in iron deficiency. In case of excess of plant nutrients such as P, Cu, Zn and Mo, the availability of iron decreases. Meanwhile, nitrogen fertilizers containing NH4+ or forming ammonium affect the availability of iron and manganese negatively compared to chemical fertilizers containing NO3- (Kacar and Katkat, 2007). This study was carried out to investigate the effect of phosphorus and iron fertilization in different doses applied to chickpea plant on some yield and yield components.

MATERIALS and METHOD

Morphological and grain characteristics of Diyar-95 chickpea cultivar used in the experiment: Plant Height: 50-75 cm, First Pod Length: 33-42 cm, Number of Plant Pods: 19-28, Number

of Grains per Pod: 1.7, Plant Growth Type: Upright, hundred grain weight: 40-45 g. Grain Color: Cream and Grain Type: Sheep head. The study was carried out in the experimental fields of the Faculty of Agriculture in the Y.Y.U Campus in 2015 as a summer residence. The province of Van, where the research was conducted, is located in the Eastern Anatolia Region, in a basin surrounded by mountains, with Lake Van to the west. The altitude of the province is 1725 m, and it is located at 380 25' north latitude and 430 21' east longitude. The location of the research is located in the north-east of the Lake part of Van and approximately 2-3 km from the lake shore. The climate data of the months covering the period of the study and the long-term average are given in Table 3.1. The average precipitation amount for the long years in the growing season of the area where the experiment was established is 301.6 mm, the average temperature is 17.0 °C, and the average relative humidity is 56.6%. The amount of precipitation falling in 2015 is 117.9 mm. Average temperature is 18.6 ^{0}C, average relative humidity is 52.8% (Table 1).

Table 1. Meteorological data for the growing seasons of 2015 and long-term averages in Van, Turkey

	Precipitation (mm)		Average tem (C^O)		Relative humidity (%)	
Months	2015	LTA	2015	LTA	2015	LTA
April	66.9	165.7	8.9	8.8	49.4	68.5
May	21.1	99.9	13.7	13.0	42.6	62.7
June	23.4	25.3	19.8	18.9	35.7	53.1
July	5.1	6.3	24	22.7	72.2	48.8
August	1.4	4.4	23.9	21.5	64.4	50.1
Total	117.9	301.6			52.8	
Average			18.6	17.0		56.6

According to the soil analysis, the soil samples taken from 0-20 cm of the research area are loamy textured, have strong alkaline reaction, low organic matter content, moderately calcareous in terms of lime content, unsalted, very low iron content, medium phosphorus content, potassium content. was found to be sufficient (Table 2).

Table 2. Some properties of the <2 mm fraction of the top 20 cm of soil used for site

Soil properties	2015
Texture	loam
pH[A]	8.88
Clay (%)[B]	40.8
$CaCO_3$ (%)[C]	6.6
Olsen soil test P (ppm)[D]	8,9
Fe (ppm)	0.2
Total Salt (%)[E]	0.01
Organic matter (%)[F]	1.89

[A] 1 : 2.5 soil : water, [B] Bouyoucos (1951), [C] lime by calcimetric methods, [D] Olsen et al. (1954), [E] Richard (1954), [F] Jackson (1962).

The experiment, consisting of 27 plots in total, was carried out according to the factorial experiment design in randomized blocks in 2015 and the number of replications was determined as 3. Each plot is 5 rows, the distance between the rows in the parcels is 30 cm. There is a 2 m gap between the parcel and the block. The parcel area is arranged as 1.5 meters x 5 meters = 7.5 square meters. The planting norm was adjusted according to Sepetoğlu (1996) to be 60 plants per square meter.

Before sowing, seeds were inoculated into each plot using Rhizobium culture prepared at a density of 10^6 cells g^{-1} (Vincent, 1970). Bacterial culture was obtained from Ankara Soil Research Institute. Sugar water was used to ensure that the bacterial culture adhered to the seeds in inoculation (Akdağ and Şehirali, 1994). In the experiment, 3 iron doses (0, 1 and 2 kg da^{-1}) and 3 phosphorus doses (0, 4 and 8 kg da^{-1}) were used as fertilizer. Fertilizer was used as ammonium sulphate with 4 kg da^{-1} of pure nitrogen on the bottom. The trial was established on 05.04.2015. At harvest, the first and fifth rows in the plots, one row on each side, and the plants within fifty cm from the plot heads were excluded as edge effects (Ceylan and Sepetoğlu, 1979). Measurements and weighing's were made over an area of 0.9 meters' x 4 meters = 3.6 square meters. Sowing, harvesting and threshing were done by hand. Weed control in the study area was carried out by hand plucking and hoeing twice, before and after flowering. The trial was harvested on 15.08.2015. Measuring, counting and threshing processes of harvested plants were made and average values were taken. Grain yields per unit area were also found by threshing with the condition that the plants were dried and crushed. Since the experiment was conducted in dry conditions, irrigation was not done.

RESULTS and DISCUSSION

In the determination of the difference between different phosphorus and iron doses in the chickpea tested in the study in terms of yield and yield components, factorial trial design variance analysis method was used in random blocks, and in the determination of different groups, the Multiple Comparison Test (Düzgüneş et al., 1987) used.

Plant heights

In table 3 the average plant height in chickpea of phosphorus fertilization applied at different doses is between 29.7-38.2 cm. The maximum plant height of 38.2 cm was obtained from phosphorus fertilization of 4 kg da^{-1}, and the minimum plant height of 29.7 cm was obtained from the plots that did not apply phosphorus with 0 kg da^{-1} (control). According to their studies, some researchers have reported that phosphorus doses cause an increase in plant height (Sharma et al., 1989; Rathore and Patel, 1991; Pingoliya et al., 2014a).

Table 3. Plant height averages of iron and phosphorus dose applications in chickpea and Duncan groups formed (cm)*

		Iron Doses			
		0 kg da^{-1}	1 kg da^{-1}	2 kg da^{-1}	Mean
Phosphorus Doses	0 kg da^{-1}	28.3 f	30.5 de	30.4 de	29.7 c
	4 kg da^{-1}	32.0 cd	47.0 a	35.6 b	38.2 a
	8 kg da^{-1}	33.3 c	37.0 b	30.0 e	33.4 b
	Mean	31.2 b	38.2 a	32.0 b	

*Values belonging to the same letter group are not different according to Duncan 5%.

When the plant height in chickpea was examined in terms of iron doses, the highest plant height was obtained from the application of 32.0 cm and 2 kg ha^{-1}, while the lowest plant height was obtained from the control application (31.2 cm) (Table 3). Pingoliya et al. (2014 a) reported that with increasing doses of iron fertilization in chickpea, plant height also increased. The findings obtained as a result of this study confirm the findings of the researchers. Iron x phosphorus interaction was found to be statistically significant in terms of plant height. The maximum value was determined as 47.0 cm at 4 kg da^{-1} phosphorus dose and 1 kg/da iron dose. The lowest value in terms of plant height was determined as 28.3 cm in the control plot without iron and phosphorus.

Number of pods per plant

Considering the effect of phosphorus doses on the number of pods in chickpea, the highest number of pods was obtained from the phosphorus dose of 18.6 with 4 kg da^{-1}, and the least number of pods in the plant was taken from the control applications with 12.1 units. Rathore and Patel (1991), Sarawgi and Singh (1989) report that phosphorus fertilization increases the total number of pods. When the effect of iron doses on the number of pods in the plant was examined, it was determined that the highest number of pods in the plant was 17.9 with 1 kg da^{-1} of iron dose and the least number of pods in the plant was 14.2 in the control plot, while the difference between two kg da^{-1} of iron application was insignificant. Khan et al. (2014) reported that iron doses increased the number of pods in the plant compared to the control in their study on chickpea. The findings of this study are in harmony with the findings of the researchers. The iron x phosphorus interaction was found to be statistically significant in terms of the number of pods in the plant. The most obtained data was determined as 22.3 at 4 kg da^{-1} phosphorus dose and 1 kg da^{-1} iron dose. The least value in terms of the number of pods per plant was found to be 10.1 in the control plots (Table 4).

Table 4. Average number of pods per plant in chickpea and Duncan groups formed (number plant^{-1})*

		Iron Doses			
		0 kg da^{-1}	1 kg da^{-1}	2 kg da^{-1}	Mean
Phosphorus Doses	0 kg da^{-1}	10.1 g	11.8 f	14.4 e	12.1 c
	4 kg da^{-1}	15.6 de	22.3 a	17.7 c	18.6 a
	8 kg da^{-1}	16.7 cd	19.4 b	11.4 f	15.9 b
	Mean	14.2 b	17.9 a	14.5 b	

*Values belonging to the same letter group are not different according to Duncan 5%.

Number of grains per plant

When the effect of phosphorus applied at different doses on the number of grains per plant in chickpea was examined, the highest value was found at a phosphorus dose of 29.1 pieces/plant and 4 kg da^{-1}, and the minimum number of grains per plant was found at 18.1 pieces/plant in the parcels without phosphorus (Table 4). Vadavia et al. (1991), Sarawgi and Singh (1989) also state that phosphorus fertilization increases the number of grains in the plant. The number of grains in the plant; It is affected by factors such as the type of sowing, the frequency of sowing, the type of fertilizer used, the application time of the used fertilizer, especially the variety. Considering the effect of iron fertilizer doses on the number of grains in the plant, the highest value was found in the plot with 28.0 pieces plant^{-1} and 1 kg da^{-1} of iron dose, while the lowest number of grains in the plant was obtained from the plot with 21.7 pieces plant^{-1} in which no iron was applied, while 2 kg da^{-1} of iron was applied in the plot. was included in the same group as the parcel. Khan et al. (2014) reported that they obtained similar results. The results obtained from this study confirm each other with the measurements made by the researchers in question. The iron x phosphorus interaction was found to be statistically significant in terms of the number of grains in the plant. The highest value was determined as 35.6 units at 4 kg da^{-1} phosphorus dose and 1 kg da^{-1} iron dose. While the lowest value in terms of the number of grains in the plant was found as 13.7 in the control plots, it was 16.0 in the same group with the application of 2 kg da^{-1} iron and control phosphorus dose (Table 5).

Table 5. Average number of grains per plant in chickpea and Duncan groups formed (number plant^{-1})*

		Iron Doses			
		0 kg da^{-1}	1 kg da^{-1}	2 kg da^{-1}	Mean
Phosphorus Doses	0 kg da^{-1}	13.7 f	17.4 e	23.1 d	18.1 c
	4 kg da^{-1}	24.5 cd	35.6 a	27.2 c	29.1 a
	8 kg da^{-1}	26.8 c	31.1 b	16.0 ef	24.7 b
	Mean	21.7 b	28.0 a	22.1 b	

*Values belonging to the same letter group are not different according to Duncan 5%.

Grain yield per unit area

In Table 6, the maximum value in the average grain yield per area of different phosphorus fertilizations was found in phosphorus application with 139.0 kg da^{-1} and 8 kg da^{-1}, while the lowest value was obtained from 123.4 kg da^{-1} and 0 kg da^{-1} phosphorus application. It has been determined by many researchers that phosphorus fertilization increases the grain yield per unit area (Thakur and Jadhav, 1990; Mishra 1995). When the effect of different iron dosage applications on grain yield per unit area was examined, the highest value was found at 1 kg da^{-1} iron dose as 140.7 kg da^{-1}, while the lowest value was observed with 126.4 kg da^{-1} and zero kg/da iron application. Kumar et al. (2009), Khan et al. (2014), Pingoliya (2014) reported that iron fertilization caused significant increases in yield. It was found that the grain yield values per unit area of iron x phosphorus interaction varied between 113.3-160.3 kg da^{-1}. The highest yield per decare was obtained from 4 kg da^{-1} of phosphorus and 1 kg da^{-1} of iron application as 160.3 kg da^{-1}. The least value was obtained from 0 kg da^{-1} phosphorus and 0 kg da^{-1} iron (Control) application with 113.3 kg da^{-1}.

Table 6. Grain yield per area averages of iron and phosphorus dose applications in chickpea and Duncan groups formed (kg/da)*

		Iron Doses			
		0 kg da^{-1}	1 kg da^{-1}	2 kg da^{-1}	Mean
Phosphorus Doses	0 kg da^{-1}	113.3 e	122.5 d	134.4 c	123.4 c
	4 kg da^{-1}	123.6 d	160.3 a	133.0 c	134.2 b
	8 kg da^{-1}	142.4 b	139.3 b	121.1 d	139.0 a
	Mean	126.4 c	140.7 a	129.4 b	

*Values belonging to the same letter group are not different according to Duncan 5%.

100 Seed Weight

In Table 7, the average weight of 100 grains from different phosphorus doses varied between 40.7-42.7 g. Akçin and Işık (1995) reported that the effect of fertilizer applications on hundred grain weight was insignificant. The average weight of 100 grains of different iron doses varied between 40.8-42.1 g. While the maximum 100 grain weight was found to be 42.1 g and 2 kg da^{-1} iron application, the lowest value was found to be 40.8 g 0 kg da^{-1} iron application. Similar results were reported by Pingoliya (2014) and Khan et al. (2014) reported that they reached it.

Table 7. Average 100 grain weight of chickpea and Duncan groups formed (g)*

		Iron Doses			
		0 kg da^{-1}	1 kg da^{-1}	2 kg da^{-1}	Mean
Phosphorus Doses	0 kg da^{-1}	37.9	39.6	44.8	40.7
	4 kg da^{-1}	42.4	43.5	42.2	42.7
	8 kg da^{-1}	42.3	42.1	39.4	41.2
	Mean	40.8	41.7	42.1	

*Values belonging to the same letter group are not different according to Duncan 5%.

Protein ratio in seed

It was determined that different groups were formed between phosphorus doses in terms of protein ratio in the grain. The highest protein ratio in grain was obtained as 23.2% from 4 kg da^{-1} phosphorus application. The protein ratio in the least grain was found to be 21.9% from 0 kg da^{-1} phosphorus application. (Brar and Lal (1991) and Khan et al. (2014) in their study investigating the effects of phosphorus and iron applications on yield and yield components of chickpea reported that the protein content of the grain increased as the phosphorus doses increased. The protein content of the grain of different iron doses varied between 22.0 and 23.3%. The highest protein content in 1 kg/da iron application was 23.3%, and the lowest grain protein content was obtained as 22.0% from the parcels without iron application (Table 8). It is thought that the highest protein ratios are obtained in the second doses, as iron and phosphorus enter into competition.

Table 8. Protein ratio in seed of chickpea and Duncan groups formed (%)*

		Iron Doses			
		0 kg da^{-1}	1 kg da^{-1}	2 kg da^{-1}	Mean
Phosphorus Doses	0 kg da^{-1}	20.7	21.7	23.3	21.9 b
	4 kg da^{-1}	22.4	24.5	22.6	23.2 a
	8 kg da^{-1}	22.8	23.5	22.3	22.9 a
	Mean	22.0 c	23.3 a	22.7 b	

*Values belonging to the same letter group are not different according to Duncan 5%.

CONCLUSION

The maximum grain yield per decare was obtained as 160.3 kg da^{-1} from the application of four kg da^{-1} of phosphorus and one kg da^{-1} of iron. The least value was obtained from zero kg da^{-1} phosphorus and zero kg da^{-1} iron (Control) application with 113.3 kg da^{-1}. Growth characters such as plant height, number of pods of the plant, number of grains of the plant, grain yield, and quality factors such as protein ratio in grain were affected differently by phosphorus and iron doses, and especially increasing phosphorus and iron doses had a positive effect on these characters up to a certain point. Phosphorus and iron showed antagonistic effects in the applications where the iron and phosphorus doses were the highest. As a result of the study, it was determined that the application of phosphorus and iron fertilizers in the region where the annual precipitation is low and the monthly distribution is irregular, provides significant increases in the yield and the characters closely related to the yield. As a result, it can be recommended to apply a dose of 4 kg da^{-1} phosphorus + 1 kg iron da^{-1} in chickpea in Van and its surroundings.

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