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Some Agronomic Studies in Chickpea (*Cicer arietinum* L.) and Lentil (*Lens culinaris* Medik)

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Abstract

This study consisted of four different experiments in chickpea (*Cicer arietinum* L.) and lentil (*Lens culinaris* Medik): phosphorus fertilizer doses in chickpea and lentil, nitrogen fertilizer doses in chickpea and sowing rates in lentil. Studies were conducted at Diyarbakir in Southeast Anatolia of Turkey over two years (2010-2012). The experiment of phosphorus fertilizer doses in chickpea revealed that the effect of phosphorus on plant height and number of branches plant^{-1} and 100 seed weight was non-significant and with starter dose of 15 kg P ha^{-1} initially increased the yield and 30 kg P ha^{-1} application increased in chickpea. The effect of nitrogen fertilizer doses on plant height, number of branches, pods and seeds plant^{-1} and grain yield was significant, and the high grain yield was obtained from 20 kg N ha^{-1}. The effect of phosphorus doses on number of pods and seeds plant^{-1} was significant, but grain yield and harvest index was not significant in lentil. The effect of plant population densities on plant height, number of pods and seeds plant^{-1}, grain yield, biological yield and harvest index was significant. The highest grain yield was obtained in 200 seed m^{-2} sowing rates, (compared to low density seeding rate of 100 seed m^{-2}) but grain yield from 100 seed m^{-2} was low.

Key words: Chickpea**,** *Cicer arietinum* L., Lentil, *Lens culinaris* Medik., Nitrogen, Phosphorus, Sowing Rate

Nohut (*Cicer arietinum* L.) ve Mercimek (*Lens culinaris* Medik)'te Bazı Agronomik Çalışmalar

Özet

Bu çalışma, nohut (*Cicer arietinum* L.)'ta farklı fosfor ve azot dozları ile mercimekte (*Lens culinaris* Medik) farklı azot dozları ve bitki sıklığı denemesi olarak 4 farklı deneme sonucunu içermektedir. Araştırma, iki yıl süreyle (2010-2012) Diyarbakır'da yürütülmüştür. Araştırma sonuçlarına göre; nohutta farklı fosfor dozlarının bitki boyu, bitkide dal sayısı ve 100 tohum ağırlığına etkisi önemsiz bulunmuştur. İlk başlangıç dozu olan 15 kg P ha^{-1} ve 30 kg P ha^{-1} tane verimini arttırmıştır. Farklı azot dozlarının nohutta bitki boyu, bitkide dal, bakla ve tane sayısı ve tane verimine etkisi önemli bulunmuş, 20 kg ha^{-1} azot uygulaması nohut tane veriminde artış sağlamıştır. Mercimekte farklı fosfor dozlarının bitkide bakla ve tane sayısına etkisi önemli, tane verimi ve hasat indeksine etkisi önemsiz bulunmuştur. Mercimekte farklı bitki sıklıklarının bitki boyu, bitkide bakla ve tane sayısı, tane verimi, biyolojik verim ve hasat indeksine etkisi önemli olup, 200 tohum m^{-2} bitki sıkılığı en yüksek, 100 tohum m^{-2} bitki sıkılığı ise en düşük tane verimi vermiştir.

Anahtar Kelime: Nohut**,** *Cicer arietinum* L., Mercimek, *Lens culinaris* Medik., Azot, Fosfor, Ekim Sıklığı

Introduction

Chickpea (*Cicer arietinum* L.) crop performance is depended on cultivar performance and environmental conditions (Özer et al., 2010; Andeden et al., 2014). The most important factors limiting chickpea production in Southeast Anatolia of Turkey are low yield, anthracnose disease, inadequate moisture, late sown and poor soil nutrient availability. Production under dry land farming systems is limited by moisture deficiency and lack of plant available nutrients in the soil. Plant nutrient, suitable cultivars and correct fertilizers have significant effects on yield and yield component (Khan et al., 2008). All of them and correct consumption of fertilizers lead to optimum uses of soil and environmental factors to produce high yield (Falah, 2002; Sheikh and Siadat, 2003; Kamithi et al., 2009; Khourgamy and Farnia, 2009).

Phosphorus (P) is a key nutrient element required for high and sustained productivity of grain legumes such as chickpea. For instance, low soil phosphorus and poor utilization efficiency of phosphorus is a major constraint limiting the productivity of most grain legumes (Aulakh et al., 2003). Legume crops usually respond well to phosphorus fertilizers (Shukla, 1964) while the response of chickpea is variable (Saxena, 1980). Many studies found a positive yield response of chickpea to phosphorus fertilizer (Johansen and Sahrawat, 1991; Riley, 1994; Islam et al., 2011), however, Chen et al., (2006) reported that the rate of phosphorus required varies according to growth conditions. Johansen and Sahrawat (1991) noted that the optimal rate of phosphorus application for chickpea appears to be in the range of 15-30 kg P ha^{-1} but mostly in the vicinity of 20 kg P ha^{-1}.

In legumes, it generally has been found that nodulation decreases with an increasing nitrogen (N) supply, although small amounts of available nitrogen during early growth might benefit the symbiosis (Kanayama et al., 1990). In nitrogen deficient soils, application of nitrogen to the crops brings about considerable increase in productivity. In chickpea production, positive response to starter nitrogen dose of 15-20 kg ha^{-1} has been observed particularly in texturally poor soils, but such a response has not been found in soils with improved texture. Response to phosphorous up to 50-70 kg ha^{-1} has been observed in soils low in phosphorus availability while response to nitrogen was in general more on soils poor in nodulation. On calcareous soils, grain yield of chickpea was significantly increased by up to 40 kg P2O5 ha^{-1} while there was no response to an additional dose of nitrogen at a rate of 30 kg ha^{-1} (Kanwar, 1981).

Optimum plant population density in lentil is an important factor to realize the potential yields as it directly affects plant growth and development (Turk et al., 2003; Saleem et al., 2012). In our region, lentil producers are choice high plant populations since they suppose that high seed rates are high yield. However, sometimes high seed rates are resulted in diseases and lodging. Earlier studies show that lentil yields are remarkably stable over a wide range of population densities. The plants are able to fill available space by initiating lateral branches and, thus, can compensate for poor emergence and thin stands (Muehlbauer, 1973; Morrison and Muehlbauer, 1986; Salem et al., 2012). Salem et al., (2012), in southern Australia, reported that lentil yields improved by increasing sowing rates beyond those currently practiced (100-125 plants m^{-2}), and even higher sowing rates might be optimum where growing conditions are unfavorable and individual plant growth is limited. On the other hand, McDonald et al., (2007) reported that increasing the plant population densities of lentil is a more effective means of suppressing weed growth and increasing grain yield. The study was conducted to assess the effect of phosphorus in lentil and chickpea, nitrogen application in chickpea and sowing rates in lentil on seed yield and its components at Diyarbakir.

Materials and Methods

The experiment was conducted at the experimental farm of the Faculty of Agriculture. Dicle University, Diyarbakir, Southeastern Anatolia of Turkey, during 2010-2012. This study included on agronomic studies in lentil and chickpea varieties. Four different experiments were set up. i. phosphorus doses in chickpea: five phosphorus, triple superphosphate (P_2O_5), doses (0, 15, 30, 40 and 70 kg ha^{-1}) and two chickpea cultivars (Aziziye 94, Gökçe and a line (N540). ii. nitrogen doses in chickpea: four nitrogen (ammonium nitrate) doses (0, 20, 40 and 60 kg ha^{-1}) and two chickpea cultivars and two lines (Gökçe, Diyar 95, N275 and N218). iii. phosphorus doses in lentil: five phosphorus, triple superphosphate (P_2O_5), doses (0, 15, 30, 40 and 70 kg ha^{-1}) and two lentil cultivars (Fırat 87 and Şakar). iiii. sowing rates in lentil: five sowing rates (100, 150, 200, 250 and 300 seed m^{-2}) and two lentil cultivars (Fırat 87 and Şakar).

The soil properties of experiment area are a clay-loam, moderate in organic matter content (1.2%). pH:7.6 and low in phosphorus contents (16.15 kg P ha^{-1}). Normal phosphorus content of South East Anatolia of Turkey soils is insufficient for phosphorus by 65% (30-60 kg ha^{-1} to 60-90 kg ha^{-1}). Phosphorus fertilizer application is necessary in experimental land (16.15 kg P ha^{-1}) due to phosphorus deficiency in soil (Eyupoglu, 1999). Climatic conditions of growing period, from November to June, were given in Table 1. Total rainfall during growing season (March to June) was 303 mm during first year and 76 mm during second year of experiment. 2012 growing season had higher temperature and less rainfall than 2011 year. Winter of the 2012 year was prevailing more cold and snowy than 2011 (Table 1).

All experiments were arranged as a factorial, split-plot design, within a randomized complete-block design with three replicates over two years. Plots were 4 m length with 6 rows. In the chickpea experiments, crop was sown in the second week of March 2011 and 2012. Phosphorus and Nitrogen fertilizers applied at sown, and seed rate was 40 seeds m^{-2}. Plants were harvested in the second and first week of July of the 2011 and 2012 years. In the lentil experiments, crop was sown in the second week of November 2010 and 2011. Phosphorus fertilization applied at planting, and plants were harvested in the first week of June of the 2011 and 2012. Experimental data was separately evaluated. The data were statistically analyzed by using MSTATC computer package program.

Table 1. Climatic conditions in 2011-2012 crop seasons at Diyarbakir Turkey

Months	**Years**	**Temperature (°C)**			**Precipitation (mm)**	**Humidity (%)**
		Mean	**Max.**	**Min.**		
	2011	6.4	18.4	-7.1	73.0	58.5
November	2012	12	23.8	-0.2	83.2	77.4
	Long-term	9.5	22.9	-2.6	54.1	66.0
	2011	2.3	11.9	-8.1	40.2	73.9
December	2012	5.1	16.0	-4.7	160.8	85.4
	Long-term	4.1	15.2	-7.2	70.7	75.0
	2011	3.5	12.2	-7	40.0	73.1
January	2012	2.4	11.0	-8.6	78.3	85.0
	Long-term	1.7	12.1	-9.1	71.9	76.0
	2011	4.7	15.5	-7.5	49.9	69.1
February	2012	1.9	14.8	-8.4	74.4	68.0
	Long-term	3.6	15.4	-8.7	68.0	72.0
	2011	9.0	22.4	-4.5	46.6	56.1
March	2012	5.1	18.1	-5.8	44.0	59.0
	Long-term	8.2	21.5	-4.5	65.4	65.0
	2011	12.9	22.0	-0.5	209	75.6
April	2012	15.2	27.8	2.0	26.2	58.0
	Long-term	13.8	27.3	0.9	69.8	63.0
	2011	17.6	32.2	7.5	80.1	67.8
May	2012	19.6	33.0	8.6	41.0	58.0
	Long-term	19.2	33.2	5.8	41.8	55.0
	2011	25.4	38.9	11.7	13.6	38.3
June	2012	27.7	41.7	9.4	7.0	27.8
	Long-term	26.1	38.7	10.8	7.9	35.0

Results and Discussion

Phosphorus doses in chickpea: Mean values for the effect of phosphorus doses on agronomic traits in chickpea are given at Table 2. Analysis of variance revealed that the effect of phosphorus application on plant height was not significant, but cultivar, year and cultivar × phosphorus doses were significant. Maximum plant height (49.3 cm) was obtained from N540 × 70 kg P_2O_5 ha^{-1}. However, short plant height value was 42.8 cm in Gökçe × 70 kg P ha^{-1} (Table 2). Since phosphorus content of the soil of experimental area was deficient, crop response could be expected, but effects were inconsistent and small. However, Dahiya et al., (1993) reported that phosphorus applications increased plant height. Number of branches $plant^{-1}$ showed different response to phosphorus doses, although statistically was not significant, compared with control (0 kg P ha^{-1}). The effect of phosphorus fertilizer application on number of pods and seeds $plant^{-1}$ was significant. The highest number of pods and seeds were observed at 30 and 70 kg P ha^{-1} compared with to control and 15 kg P ha^{-1} in this study. The 100 seed weight was not affected by phosphorus doses. Maximum 100 seed weight was observed in Aziziye 94. Cultivar x doses interaction was significant. Gökçe had positive response to phosphorus doses for 100 seed weight, from 39.74 in 0 kg P ha^{-1} g to 42.06 g in 70 kg P ha^{-1} (Table 2). Khourgami and Farnia (2009) reported in Iran, grain yield, number of seeds pod plant^{-1} and 100 seed weight of chickpea were increased by phosphorus applications. Basir et al., (2008) showed that as compared to other phosphorus treatments 60 kg P ha^{-1} significantly improved agronomic traits.

Table 2. The effect of phosphorus doses on agronomic traits in for chickpea

Factors	PH (cm)	NBP (number)	NPP (number)	NSP (number)	NHSW (g)	GY (kg ha^{-1})
			Phosphorus doses kg ha^{-1}			
Control	46.0	2.59	14.0	13.8	41.07	1152
15	45.6	2.42	12.9	13.5	40.89	1256
30	46.5	2.72	15.6	16.4	41.8	1339
40	46.0	2.41	14.1	14.2	41.49	1283
70	46.0	2.43	15.6	15.6	41.79	1178
LSD	-	-	*0.98***	*0.7***	-	*72***
			Cultivars			
Gökçe	44.0	2.38	14.5	14.7	41.09	1475
N540	47.7	3.12	13.5	13.6	36.61	927.8
Aziziye 94	46.3	2.18	15.4	15.6	46.52	1321
LSD	*0.79***	*0.16***	*0.37***	*1.2***	*0.78**	*64***
			Cultivar × dose interactions			
Control	44.2	2.61	13.4	13	39.74	1376
Gökçe ×15	44.1	2.11	12.7	12.5	40.44	1455
Gökçe ×30	44.2	2.38	17.4	18.9	40.5	1633
Gökçe ×40	45.0	2.31	13.6	14	42.71	1540
Gökçe ×70	42.8	2.31	15.3	15.1	42.06	1373
Control	47.6	2.96	13.5	13	36.97	849
N540 ×15	48.0	2.95	10.5	10.9	36.31	948
N540 ×30	47.5	3.51	14.4	14.5	36.47	946
N540 ×40	46.1	3.00	14.3	14.2	35.33	1089
N540 ×70	49.3	2.66	14.7	15.4	37.99	805
Control	46.1	2.2	15.1	15.3	46.52	1230
Aziziye 94 ×15	44.6	2.2	15.8	16.6	45.93	1365
Aziziye 94 ×30	47.8	2.26	15.2	15.7	48.42	1437
Aziziye 94 ×40	46.8	1.91	14.4	14.1	46.44	1219
Aziziye 94 ×70	46.0	2.31	16.9	16.3	45.3	1355
LSD	*1.86***	-	*1.01***	*1.37***	-	*133***
			Years			
1	52.3**	2.51	17.46**	18.07**	43.44**	1267.1*
2	39.7	2.52	11.51	11.26	39.37	1215.6

**:0.01.*: 0.05 significant levels, PH (cm): Plant height, NBP (number): Number of branches plant, NPP (number): Number of pods plant, NSP (number): Number of seeds plant, NHSW (g): 100 Seed weight, GY (kg ha^{-1}): Grain yield

Grain yield was increase up to 16 and 12% with the application of 30 and 40 kg P ha^{-1}, respectively, when compared to control dose. Chickpea cultivars showed low response to phosphorus application (Table 2). The low response may be result of spring sown and under rainfed condition. Johansen and Sahrawat (1991) reported that chickpea is usually grown under rainfed conditions therefore reduced available water in soil profile could be the reason for less response of chickpea plants to phosphorus application. Also, Riley (1994) found that, in the clay soil of Australia, application of 100 kg P ha^{-1} had no effect on yield. In our study, the grain yield of chickpea showed a positive response to phosphorus fertilizers from control to 40 kg P ha^{-1} (Table 2).

Table 3. The effect of nitrogen doses on agronomic traits in chickpea

Factors	PH (cm)	NBP (number)	NPP (number)	NSP (number)	NHSW (g)	GY (kg ha^{-1})
			Nitrogen doses (kg ha^{-1})			
Control	45.29	2.38	18.17	16.73	39.07	1299
20	44.33	2.47	19.83	19.24	39.6	1345
40	44.79	2.83	13.35	14.06	39.15	1194
60	42.5	3.04	16.32	15.62	39.27	1104
LSD	*1.93***	*0.35***	*1.47***	*1.49***	-	*9.05***
			Cultivars			
N275	43.79	2.64	15.92	15.32	40.05	1324
N218	46.71	2.52	16.78	15.74	35.75	1233
Diyar 95	44.63	2.86	16.75	16.1	39.76	1013
Gökçe	41.79	2.69	18.23	18.49	41.52	1373
LSD	*2.97***	-	*1.31***	*1.38***	*1.69***	*8.31***
			Cultivar × nitrogen interactions			
Control	42.67	2.75	18.08	16.6	40.18	1353
N275×20	44.17	2.48	17.48	15.37	40.39	1380
N275×40	44.33	2.73	17.4	16.22	39.98	1226
N275×60	44	2.61	19.73	18.75	39.67	1336
Control	49	2.26	16.08	15.18	36.07	1301
N218×20	46.17	2.25	20.03	19.65	34.69	1312
N218×40	47.17	2.65	19.93	19.2	35.83	1293
N218×60	44.5	2.95	23.25	22.93	36.41	1027
Control	45	2.36	13.03	13.03	38.74	1068
Diyar 95×20	46.83	2.71	14.48	14.58	40.42	1217
Diyar 95×40	46.33	3.38	14.2	14.82	39.7	968
Diyar 95×60	40.33	3	11.7	13.8	40.17	796
Control	44.5	2.16	16.47	16.48	41.28	1473
Gökçe×20	40.17	2.43	15.12	13.35	42.9	1472
Gökçe×40	41.33	2.58	15.45	14.18	41.1	1288
Gökçe×60	41.17	3.6	18.25	18.47	40.82	1257
LSD	*3.85***	*0.70***	*2.94***	*2.77***	-	*18.11***
			Years			
1	49.71**	2.45	19.87**	19.71**	40.41**	1254
2	38.96	2.91**	13.96	13.16	38.13	1218

**:0.01.*: 0.05 significant levels, PH (cm): Plant height, NBP (number): Number of branches plant, NPP (number): Number of pods plant, NSP (number): Number of seeds plant, NHSW (g): 100 Seed weight, GY (kg ha^{-1}): Grain yield

Differences among years were significant. This result may be due to different climatic conditions. There are many researchers reported that grain yield was affected by years or locations under phosphorus fertilization (Chen et al., 2006). According to this experiment results, chickpea cultivars showed low response to phosphorus application, since the chickpea experiment exposed to drought stress due to late sown. Also phosphorus fertilization completely could not be effective since late sown caused short growing season. Early sown and supply irrigation can be advisable for more effectiveness phosphorus intake in this region.

Table 4. The effect of phosphorus doses on agronomic traits in lentil

Factors	PH (cm)	NBP (number)	NPP (number)	NSP (number)	GY (kg ha-1)	BY (kg ha-1)	HI (%)
				Phosphorus doses			
Control	29.75	2	15.57	21.19	2105	6162	0.37
15	32.67	1.9	20.35	24.95	2155	6095	0.37
30	31.83	2.1	20.92	26.06	2200	6367	0.37
45	33.17	1.9	21.39	28.48	2222	6720	0.37
75	34.58	2.2	18.95	27.03	2065	6389	0.37
LSD	*2.82**		*2.47***	*3.94***	-	*45.5***	-
				Cultivars			
Şakar	29.46	1.8	19.54	25.9	21957	5851	0.38
Fırat 87	35.33	2.3	19.32	25.18	21028	6843	0.36
LSD	**	**	**	**	**	**	
				Cultivar × dose interactions			
Control	27.83	1.6	15.03	17.42	2095	5627	0.36
Şakar ×15	28.17	1.6	20.23	27.8	2229	5728	0.4
Şakar × 30	29.67	1.8	23.5	27.4	2247	5729	0.39
Şakar × 45	30.67	1.9	20.72	28.23	2228	6053	0.39
Şakar × 75	31	2.1	18.25	28.68	2180	6117	0.39
Control	31.67	2.3	16.1	24.97	2115	6698	0.37
Fırat 87× 15	37.17	2.3	20.47	22.1	2081	6463	0.35
Fırat 87× 30	34	2.4	18.33	24.72	2152	7005	0.35
Fırat 87× 45	35.67	2.1	22.07	28.73	2216	7388	0.36
Fırat 87× 75	38.17	2.3	19.65	25.38	1949	6662	0.36
LSD	*3.99*	*0.32*	*3.5***	*5.57***	*13.94***	*64.42***	
				Years			
1	35.66**	35.66**	25.44**	34.68**	24374**	6356	0.38
2	29.13	29.13	13.42	16.4	18611	6341	0.36

**:0.01, *: 0.05 significant levels PH (cm): Plant height, NBP (number): Number of branches plant, NPP (number): Number of pods plant, NSP (number): Number of seeds plant, NHSW (g): 100 Seed weight, GY (kg ha^{-1}): Grain yield, BY (kg ha^{-1}): Biological Yield, HI (%): Harvest index

Nitrogen doses in chickpea: Mean values for the effect of nitrogen doses on agronomic traits in chickpea are given in Table 3. Analysis of variance revealed that the effect of nitrogen application on plant height, number of branches, pods and seeds plant^{-1} and grain yield was significant. Cultivar × nitrogen doses interaction was significant for all traits, except 100 seed weight (Table 3).

Although the effect of nitrogen fertilization on plant height was significant and negative, the effect was small. Control dose had maximum plant height (45.29 cm), but the lowest value (42.5 cm) was obtained from 60 kg N ha^{-1} (Table 3). Earlier researcher reported that the effect of urea treatment on plant height was notable (Aliloo et al., 2012), and that application of 100 kg urea ha^{-1} increased plant height by 30.9%, compared to control (Namvar et al., 2011a). Cultivar × N dose interaction was important; while line N218 only had the high value in control dose (0 kg N ha-^{1}) other cultivars had taller plant height in high N doses. Differences among years for plant height were significant, low rainfall (in 2012 year) shortened plant height. Nitrogen fertilizer had a significant effect on number of branches and the highest dose (60 kg N ha^{-1}) produced higher branch (3.04) than other treatments. In high nitrogen dose, plant height was decreased, but number of branches increased. Cultivar × nitrogen dose interaction was significant (Table 3). Namvar et al., (2011b) reported that increasing of nitrogen fertilizer from 0 to 100 kg urea ha^{-1} enhanced the number of branches per plant by 26.61 and 50.05%, respectively. Number of pods and seeds $plant^{-1}$ was affected by nitrogen doses. 20 kg N ha^{-1} was produced more pods and seeds compared with control and other doses. Maximum N fertilizer dose (60 kg N ha^{-1}) had less pods and seeds, and nitrogen dose increased had negative effects for these traits. While N218 × 60 kg N ha^{-1} produced more pods and seeds, other cultivars produced less pods and seeds in the same dose. Gökçe had more pods and seeds than other cultivars (Table3). Namvar et al., (2011a) reported that the highest number of total pods per plant was recorded in 100 kg urea ha^{-1} application that showed no significant difference with those in 75 kg urea ha^{-1}. In Table 3, year effect was significant, and second experiment year had low value. This result can be due to climatic conditions, which second year had higher temperature and less rainfall than first year (Table 1). The high grain yield was obtained from 20 kg N ha^{-1}. N dose increased was decreased the yield. Cultivar × N dose interaction was significant. Gökçe had high grain yield and it was showed high response to nitrogen doses (Table 3). Kamithi et al., (2009) reported that nitrogen fertilizer application also had significant effects on chickpea grain yield. The highest grain yield production by desi chickpea under 20 and 40 kg N ha^{-1}, respectively, in the long rain seasons. During the short rain season, increasing nitrogen application rates also increased grain yield. Kanvwar, (1981) reported that response to phosphorous up to 50-70 kg ha^{-1} has been observed in soils low in phosphorus availability while response to nitrogen was in general more on soils poor in nodulation. Kamithi et al., (2009) said that chickpea yield increased with increase in the fertilizer rates. Nitrogen fertilizer application beyond 35 kg N ha^{-1} caused a declined in the grain yield. Results indicated that application of 20 kg ha^{-1} N fertilizer as starter can be beneficial to improve yield components and final yield.

Phosphorus doses in lentil: Mean values for the effect of phosphorus doses on agronomic traits in lentil were given at Table 4.

Analysis of variance revealed that the effect of phosphorus application on plant height significant. Plant height results different but small, it ranged from 29.75 cm in control group to 34.58 cm in 70 kg P_2O_5 ha-1. Number of branches $plant^{-1}$ was statistically did not significant. Cultivar × phosphorus interaction was significant. Maximum number of branches (2.4) Fırat 87 × 30 kg P ha^{-1} had compared to Şakar × 30 kg P ha^{-1} (1.8). The effect of phosphorus on number of pods and seeds $plant^{-1}$ was significant. Number of pods and seeds $plant^{-1}$ increased with the increasing of phosphorus application rate. Response to phosphorus was positive for these traits. When minimum number of pods and seeds was observed in control (15.57 and 21.19, respectively), maximum number of pods and seeds $plant^{-1}$ (21.39 and 28.48, respectively) was observed in 45 kg P ha^{-1} (Table 4). Although grain yield and harvest index was no affected by phosphorus fertilization, response to doses was positive but erratic. Grain yield increased with the increasing of phosphorus doses (from control to 45 kg P ha^{-1}), however the least grain yield was obtained from maximum dose (2065 kg ha^{-1}). Cultivar × dose interaction was significant for grain yield. While Şakar × 30 kg P ha^{-1} had high grain yield (2247 kg ha^{-1}), Fırat × 45 kg P ha^{-1} had high grain yield (1949 kg ha^{-1}). Biological yield increased with the increasing of P doses. The highest value (6720 kg ha^{-1}) was recorded in 45 kg P ha^{-1} doses. Control and start dose, 15 kg P ha^{-1}, had minimum values (6162, 6095 kg ha^{-1}, respectively). Cultivar x dose interaction was significant for biological yield. While Şakar showed almost same response to all doses, Fırat 87 showed increasingly positive response. Fırat 87 × 45 kg P ha^{-1} dose had maximum value (7388 kg ha^{-1}).

Sowing rates in lentil: mean values for the effect of sowing rates on agronomic traits in lentil were given at Table 5. The effect of population densities on plant height, number of pods and seeds $plant^{-1}$, grain yield, biological yield and harvest index was significant. Plant height values in different sowing rates was different, erratic and small, and plant height in 200 and 300 seed m^{-2} in sowing rates were a little taller (33.33 cm and 33.75 cm, respectively) than other ones. Number of pods and seeds $plant^{-1}$ was affected by sowing rates. Number of pods and seeds $plant^{-1}$ were tending to decrease with increasing plant density. The decrease in pods $plant^{-1}$ at 250 and 300 seed m^{-2} was attributed to increased competition among plant and environment factors, also this may cause reduced the number of effective branches. 100 seed m^{-2} was produced more pods (20.04) and seeds (26.95) compared with high sowing rates. Maximum sowing rates (300 seed m^{-2}) had less pods (14.96 pods) and seeds (18.58 seeds). Cultivar × plant population interaction was significant for these traits. The effect of sowing rates on grain yield and biological yield was significant. The highest grain yield (2100 kg ha^{-1}) was obtained in 200 seed m^{-2} sowing rates. 100 seed m^{-2} of grain yield was low. Sowing rates more than 200 seed m^{-2} caused low grain yield.

Generally, grain yield was tending to decreasing with increasing sowing rates. High sowing rates lead to severe competition between plants. The high yield resulted from higher number of pods and seed per unit area produced. However, the higher sowing rate causes higher inter-plant competition and results in poor individual plant. The highest grain yield (2106 kg ha^{-1}) was obtained from 200 seed m^{-2} sowing rates (Table 5). Kantar et al., (1994) reported that although increasing sowing density resulted in high yields, seed yield increased only marginally after 85 kg seed ha^{-1} seeding rate. Selim, (1999) reported that high plant density may lead to competition among plants and increase risk of disease and lodging of the crop, resulting in reduced grain yield. On the other hand, low and scattered plant populations are unable to utilize the resources efficiently and often produce low yields (Salem et al., 2012).

Table 5. The effect of sowing rates on agronomic traits in lentil

Factors	PH (cm)	NBP (number)	NPP (number)	NSP (number)	GY (kg ha^{-1})	BY (kg ha^{-1})	HI (%)
			Sowing rates (seed m^{-2})				
100	31.6	1.95	20.04	26.95	1805	5384	33
150	31.1	2	18.72	23.72	1919	5760	33
200	33.3	1.81	16.71	20.25	2106	5894	35
250	32.9	1.79	18.93	20.26	2006	5745	34
300	33.7	1.74	14.96	18.58	1928	5937	32
LSD	*2.21***	-	*2.92***	*3.71***	*8.87***	*40.82***	*0.03**
			Cultivars				
Şakar	29.83	1.74	18.3	23.74	2011	5512	0.36**
Fırat 87	35.23	1.97	17.44	20.15	1893	5976	0.31
LSD	**	**		**	**	**	
			Cultivar × sowing rate interactions				
Şakar × 100	29	1.883	21.52	29.15	1750	4944	0.35
Şakar ×150	28.5	1.75	16.18	23.4	1960	5248	0.36
Şakar × 200	30.5	1.667	17.4	21.98	2157	5515	0.39
Şakar × 250	30.5	1.883	21.52	24.58	2253	6011	0.37
Şakar × 300	30.6	1.533	14.9	19.62	1932	5843	0.32
Fırat 87× 100	34.2	2.017	18.57	24.75	1853	5824	0.31
Fırat 87× 150	33.6	2.25	21.25	24.03	1879	6273	0.29
Fırat 87× 200	36.1	1.967	16.02	18.52	2054	6272	0.32
Fırat 87× 250	35.3	1.7	16.35	15.93	1759	5479	0.32
Fırat 87× 300	36.8	1.95	15.02	17.55	1924	6032	0.31
LSD	*3.12***	*0.42**	*4.13***	*5.33***	*12.55***	*57.3***	*0.05*
			Years				
1	36.20**	1.73**	22.72**	29.23**	2173**	5607*	0.38**
2	28.86	1.98	13.01	14.67	1733	5881	0.29

**:0.01, *: 0.05 significant levels PH (cm): Plant height, NBP (number): Number of branches plant, NPP (number): Number of pods plant, NSP (number): Number of seeds plant, NHSW (g): 100 Seed weight, GY (kg ha^{-1}): Grain yield, BY (kg ha^{-1}): Biological Yield, HI (%): Harvest index

Generally, biological yield was positively related to sowing rates, tending to increasing with increasing plant density. High biological yield was obtained both 200 and 300 seed m^{-2} sowing rates (Table 5). The effect of sowing rates on biological yield was significant and erratic. Biological yield was tending to increasing with increasing sowing rates. Harvest index had positive response to increased sowing rates. Maximum harvest index was obtained from 200 seed m^{-2} and 250 seed m^{-2}, 300 seed m^{-2} had minimum harvest index (32%). Harvest index was affected by sowing rates, but values were similar between high rates (32%) in 200 seed m^{-2} sowing rates and low ones (33%) in

300 seed m^{-2} ones (Table 5). In our region, lentil producers wished high plant populations since they suppose that high seed rates are high yield. However, sometimes high seed rates are resulted in diseases and lodging. Kantar et al., (1994) reported that higher harvest index compensated yield disadvantages at lower plant densities.

Conclusion

Grain yield was increase up to 16 and 12% with the phosphorus application of 30 and 40 kg P ha^{-1}, respectively, when compared with control dose. Nitrogen application of 20 kg ha^{-1} as starter can be beneficial to improve yield components and final yield. Grain yield was tending to decreasing with increasing sowing rates. High sowing rates lead to severe competition between plants. The highest grain yield (2106 kg ha^{-1}) was obtained from 200 seed m^{-2} sowing rates for lentil.

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