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Full Length Research Paper

Effects of *rhizobium* inoculation, sulfur and phosphorus applications on yield, yield components and nutrient uptakes in chickpea (*Cicer arietinum* L.)

Necat Togay[1], Yesim Togay[1], Kerim Mesut Cimrin[2] and Metin Turan[3]

[1]Yüzüncü Yıl University, Faculty of Agriculture, Department of Field Crops, 65080, Van, Turkey.
[2]Yüzüncü Yıl University, Faculty of Agriculture, Department of Soil Science, 65080, Van, Turkey.
[3]Atatürk University, Faculty of Agriculture, Department of Soil Science, 25240, Erzurum, Turkey.

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This study was carried out to determine the effects of sulfur and phosphorus application and rhizobium inoculation for a chickpea variety, Aziziye-94, under Eastern Turkey conditions in 2004 and 2005. The trial was laid out in split-split block design with three replications. Chickpea variety was applied on three different sulfur levels (0, 50 and 100 kg ha^{-1}), phosphorus levels (0, 40 and 80 kg ha^{-1}) and inoculation (inoculated and uninoculated). Whereas the highest grain yield were obtained from 80 kg ha^{-1} P with 819 kg ha^{-1} from 100 kg ha^{-1} S with 758 and from inoculation with 723 kg ha^{-1}. In the first year, they were obtained from 80 kg ha^{-1} P with 879 kg ha^{-1} from 100 kg ha^{-1} S with 818 and from inoculation with 784 kg ha^{-1} in the second year. Nutrient uptake by grain of chickpea significantly increased due to sulfur doses, except for P uptake in grain at the year of 2004 and S uptake in grain at the year of 2005. Sulfur application significantly increased the uptake of Fe, Mn, Zn and Cu in grain in the both years. The effects of different doses of phosphorus application on nutrient uptakes by grain were found to be statistically significant in both years.

Key words: Chickpea, phosphorus, sulfur, yield, nutrient uptake.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the most important grain legumes of Turkey. As grown in 650 000 ha and a production of 610 000 tonnes, the mean yield is 938 kg ha^{-1} (Anonymous, 2005). Phosphorus (P) and sulfur (S) are major nutrient elements for grain legumes. Phosphorus has very positive effects on nodule formation and nitrogen fixation in legume crops (Sepetoğlu, 2002). Phosphorus in the soil has developmental activity in the plant's root growth. Depending on phosphorus applications, the contact area of the root expands with the growth of root which, in turn, gives rise to a flourishing in productivity, also making it easier for the plant to benefit from the other nutritional elements in higher proportions (Marschner, 1995).

Sulfur plays a vital role in plant metabolism. It constitutes the main element of amino acids such as cysteine and methionine, which are of essential nutrient value. In addition to these functions, ferro-sulfur proteins play an important role in nitrogen fixation and electron movement in photosynthesis (Kadıoğlu, 2004). Sulfur has positive effects on root growth in plants in general. This element positively affects nodulation in legume crops in particular (Kacar, 1984). With the conversion of soil pH into alkaline structures, the efficacy of some micro and macro nutritional elements are also impaired in different ways (Aktaş, 1994). Similarly all of the nutritional substances of the plant have close interaction lime; and it has long been known that lime in soil blocks or impairs nutritional intake, binding the nutritional substances of the plant. Thus, it would be much more tempting to conduct investigations into the effects of pH change while applying S in calcareous and alkaline soils in order to find out its efficacy in

*Corresponding author. E-mail: necattogay@hotmail.com. Tel: +90432-2251794. Fax: +904322251119.

nutritional elements of the plants, since this area of study is considered to be a crucial subject. Calcareous alkaline soils which are applied to increasing amounts of sulfur have also been found to enhance the efficacy of phosphorus (Kacar, 1984). The elemental sulfur applied to the soil through agricultural activities is converted into sulphate; therefore, it causes a reduction in soil reaction (Usta, 1995). This study was conducted in order to analyze the effect of different doses of phosphorus, sulfur applications and rhizobium inoculation on some yield components in chickpea plant grown in alkaline soils.

MATERIAL AND METHODS

The field experiments were conducted in 2004 and 2005 on an alkaline soil, classified as entisols (Soil Survey, 1999) at Agriculture Faculty in Yüzüncü Yıl University, Van, Turkey. Average growing season rainfall at the site of the experiment was 125.3, with 100.3 mm falling in 2004 and 105 mm in 2005. Average growing season temperature was 15.2°C, being 16.3°C in 2004 and 19.3°C in 2005 (TSMS, 2005). The trial was conducted in a split-split block design with three replications. The trial sown on the 13th April in both years, three different sulfur (0, 50, 100 kg ha^{-1}), and phosphorus (0, 40, 80 kg ha^{-1}) applications and *rhizobium* inoculation were applied during the sowing and the characteristics of on plant height, first pod height, number of pod per plant, number of seed per plant, grain yield, biological yield, harvest index, and nutrient contents were recorded. Plots were 1.5 m wide and 5 m long. Elemental S was spread over the soil surface by hand before the sowing the crop, and was incorporated into the top 10 cm of soil using sand. Fertilizer P was applied in bands 3 cm below rows sown to chick pea. Chick pea seed (cv.Aziziye-94) was sown 5 cm deep by hand in 10 cm rows down each plot, with a row spacing of 30 cm. S, P and inoculation treatments were applied.

Soil analysis

In both years the soils were sampled to a depth of 0-30 cm of the soil, air-dried and sieved (2 mm) for soil analyses. Some physical and chemical properties of soils are given in Table 1. Particle size distribution was determined by Bouyoucus (1951) hidrometric method. Carbonate, phosphorus, potassium, pH and electric conductivity were determined by the methods described by Page et al. (1982), SO_4-Sulfur by the methods of Fox et al. (1964). pH 1:2.5 soil-water suspension (Jackson, 1958), organic matter by modified Walkley Black method (Walkey, 1947), available phosphorus by the methods of Olsen et al. (1954), sodium, potassium, calcium and magnesium in an extraction of neuter ammonium acetate (Thomas, 1982), available iron, copper, zinc, and manganese by mixing with DTPA (Lindsay and Norvell 1978). The extracted samples were analyzed by atomic absorption spectrophotometer.

Plant analysis

Methods and procedures used to measure grain yields and yield components were undertaken as outlined by Çiftçi and Şehirali (1984). On 20.07.2004 and 22.07.2005 10 mature plants were selected at random from near the center rows of each plot and the selected plants were cut at ground level. These were used to measure plant height (cm), first pod height (cm) pods per plant (number/plant) and grain yield (kg ha^{-1}). Plants were harvested by cutting the shoots from the soil surface and washed with de-ionized water. Plant grains and shoot were dried for 48 h at 70°C and were ground. Sub samples of the harvested grain and shoot were used to measure by the Kjeldahl method (Kacar, 1984). The P concentration in grain and shoot were measured by the vanado molibdo phosphoric acid yellow color procedure outlined by Kacar (1984). Plant samples were analyzed. K, Ca, Mg, Fe, Zn, Mn and Cu were determined after wet digestion in a H_2SO_4-salisilic acid mixture. K, Ca, Mg, Fe, Zn, Mn and Cu analysis was done by atomic absorption spectrometry (AOAC, 1990). Plant samples S analysis was determined as turbidimetrically (Kacar, 1984). Data on investigated characters were subjected to analysis of variance and means were separated according to Duncan Multiple Range Test (Düzgüneş et al., 1987).

Table 1. Some properties of the <2 mm fraction of the top 30 cm of soil used for each site.

Soil properties	Soil 1, 2004	Soil 2, 2005
Texture	Sandy loam	Sandy loam
pH[A] 1:2.5	7.98	7.89
$CaCO_3$ (%)[B]	8.72	9.63
Organic matter (%)[C]	0.86	1.10
Olsen soil test P (mg/kg)[D]	7.33	8.40
Na (mg 100 g^{-1})	0.96	0.94
K (mg 100 g^{-1})	2.82	3.02
Ca (mg 100 g^{-1})	9.80	9.60
Mg mg (me 100 g^{-1})	1.92	1.92
Fe (mg 100 g^{-1})	5.28	12.96
Cu (mg 100 g^{-1})	0.40	0.40
Zn (mg 100 g^{-1})	0.95	0.95
Mn (mg 100 g^{-1})	3.90	3.80
SO_4-S (mg 100 g^{-1})	1.3	1.2

RESULTS AND DISCUSSION

Grain yield and yield components were significantly affected by *rhizobium* inoculation in both years except for harvest index and biological yield of first year. Plant height, first pod height, number of branches, pod number per plant, seed number per plant and grain yield increased with *rhizobium* inoculations.

The effects of different doses of sulfur and phosphorus applications on plant height and first pod height in chickpea were found to be statistically significant in both years. The highest plant height was obtained from 100 kg S ha^{-1} (37.0 and 37.2 cm) and 80 kg P ha^{-1} (36.9 and 37.9 cm) application. The lowest values of plant heights were found in control plots. The highest first pod height was obtained from100 kg S ha^{-1} (17.4 and 17.5 cm) and 80 kg P ha^{-1} (17.9 and 18.1 cm) application (Table 2). In a study conducted by Singh et al. (2003) and Shivakumar (2001) related with chickpeas, plant heights were reported to have been increased with the increasing doses of sulfur fertilization. These researchers noted that

Table 2. The effects of different sulfur, phosphorus levels and rhizobium inoculation on yield and yield components of chickpea (*Cicer arietinum* L.).

Treatment	Plant height (cm)			First pod height (cm)			Branches/plant (number/plant)			Pods /plant (number/plant)		
	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean
inoculated	35.7	36.6	36.15	17.2	17.3	17.25	2.6	2.3	2.45	12.3	12.4	12.35
uninoculated	34.8	35.1	34.95	15.9	16.1	16.00	2.3	2.4	2.35	11.4	11.6	11.50
LSD (p=0.05)	0.54	0.29		0.33	0.44		0.15	0.096		0.31	0.60	
S Doses kgha $^{-1}$												
0	33.5	34.2	33.85	15.6	15.7	15.65	2.3	2.3	2.3	11.1	11.3	11.2
50	35.3	36.3	35.8	16.7	16.9	16.8	2.4	2.4	2.4	11.9	12.0	11.95
100	37.0	37.2	37.1	17.4	17.5	17.45	2.6	2.6	2.6	12.6	12.7	12.65
LSD (p=0.05)	0.43	0.27		0.17	0.32		0.043	0.047		0.22	0.18	
P Doses kg ha $^{-1}$												
0	32.5	33.1	32.8	15.2	15.3	15.25	2.2	2.3	2.25	10.1	10.0	10.05
40	36.3	36.7	36.5	16.6	16.7	16.65	2.5	2.5	2.5	11.8	12.0	11.9
80	36.9	37.9	37.4	17.9	18.1	18.0	2.6	2.6	2.6	13.8	13.9	13.85
LSD(p=0.05)	0.34	0.30		0.18	0.19		0.032	0.078		0.17	0.13	
Treatment	**Seeds/plant (number/plant)**			**Grain yield (kg ha $^{-1}$)**			**Harvest index (%)**			**Biological yield (kg ha $^{-1}$)**		
inoculated	12.3	12.7	12.5	723.4	783.9	753.5	37.4	38.0	37.7	1927	2076	2001.5
uninoculated	11.5	11.9	11.7	691.3	721.7	706	37.4	37.6	37.5	1838	1894	1866
LSD (p=0.05)	0.05	0.63		19.2	13.8		NS	NS		NS	44.2	
S Doses kg ha $^{-1}$												
0	11.2	11.6	11.4	650.8	687.3	675.45	37.7	38.0	37.8	1755	1844	1799.5
50	11.9	12.4	12.15	712.8	752.2	732.5	37.7	38.2	37.9	1883	1974	1928.5
100	12.7	13.1	12.9	758.4	818.8	788	36.1	36.8	36.4	2010	2137	2073.5
LSD (p=0.05)	0.25	0.24		11.4	11.2		0.66	0.47		44.1	40.5	
P Doses kg ha $^{-1}$												
0	10.1	10.2	10.15	592.7	631.4	611.5	36.1	36.8	36.45	1639	1711	1675
40	11.9	12.3	12.1	710.2	748.1	729	37.7	38.1	37.9	1882	1965	1923.5
80	13.8	14.6	14.2	819.1	878.9	849	38.5	38.5	38.5	2127	2279	2203
LSD (p=0.05)	0.27	0.22		5.7	8.86		0.64	0.58		33.6	40.8	

LSD (p = 0.05).

the highest plants within the context of this parameter about plant height were those to which the highest doses of sulfur were applied. The highest number of branches was obtained from 100 kg S ha $^{-1}$ and 80 kg P ha $^{-1}$ fertilization as 2.6 number/plant in both years. While the highest pod number per plant was obtained from 100 kg S ha $^{-1}$ (12.6 and 12.7 number/plant) and 80 kg P ha $^{-1}$ (13.8 and 13.9 number/plant) in 2004-05. Similarly the highest seed number per plant was obtained from 100 kg S ha $^{-1}$ (12.7 and 13.1 number/plant) and 80 kg P ha $^{-1}$ (13.8 and 14.6 number/plant) in both years. Singh et al. (2003) were reported that number of branches and pod number per plant increased with increasing doses in chickpea. Shivakumar (2001), in his study related with different doses of sulfur and phosphorus applications in chickpea, reported that the highest number of branches, pod number per plant and seed number per plant had been obtained from 80 kg ha $^{-1}$ and 40 kg ha ^{1} DAP application. The effects of different doses of sulfur and phosphorus applications on grain yield and biological yield in chickpea were found to be statistically significant in both years. In both years, the highest grain yield was obtained from 100 kg S ha $^{-1}$ (758 and 818 kg ha $^{-1}$) and 80 kg P ha $^{-1}$ (819 and 879 kg ha $^{-1}$) application. The highest biological yield was obtained from 100 kg S ha $^{-1}$ (2010 and 2137 kg ha $^{-1}$) and 80 kg P ha $^{-1}$ (2127and 2179 kg ha $^{-1}$) application. The lowest values of grain yield and biological yield were found in control plots (Table 2). Singh et al. (2003), reported that the highest yield in chickpea was obtained from 40 kg S ha $^{-1}$ application. This

Table 3. The effects of different sulfur, phosphorus levels and rhizobium inoculation on the grain nutrient uptake of chickpea (*Cicer arietinum* L.).

Treatment	N (kg ha^{-1})			P (kg ha^{-1})			K (kg ha^{-1})			Ca (kg ha^{-1})			Mg (kg ha^{-1})		
	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean
inoculated	22.53	24.59	23.56	2.60	2.29	2.45	11.72	11.70	11.71	2.58	2.80	2.69	3.63	4.05	3.84
uninoculated	22.23	21.17	21.70	2.64	2.42	2.53	11.26	10.91	11.08	2.58	2.68	2.63	3.87	4.05	3.96
LSD(p=0.05)	1.42	4.69		0.72	1.71		0.43	2.97		1.69	0.55		2.32	1.76	
S Dose kgha^{-1}															
0	21.27	20.45	20.86	2.48	2.14	2.31	10.51	10.36	10.44	2.32	2.58	2.45	3.41	3.66	3.54
50	22.07	23.73	22.90	2.65	2.27	2.46	11.71	11.37	11.54	2.66	2.79	2.73	3.83	4.08	3.95
100	23.79	24.46	24.13	2.72	2.65	2.68	12.26	12.17	12.22	2.77	2.86	2.82	4.02	4.41	4.22
LSD(p=0.05)	1.45	3.07		0.36	0.15		0.41	0.51		0.31	0.17		0.21	0.23	
P Doses kg ha^{-1}															
0	18.08	18.92	18.50	2.19	1.95	2.07	9.73	9.35	9.54	2.24	2.25	2.25	3.05	3.31	3.18
40	21.23	23.08	22.15	2.48	2.33	2.41	11.73	17.37	14.55	2.46	2.68	2.57	4.01	4.21	4.11
80	27.83	26.64	27.24	3.19	2.78	2.98	13.01	13.18	13.10	3.05	3.30	3.18	4.20	4.63	4.42
LSD(p=0.05)	2.51	3.93		0.55	0.27		0.32	0.50		0.56	0.31		0.65	0.54	
Treatment	**S (kg ha^{-1})**			**Fe (g ha^{-1})**			**Mn (g ha^{-1})**			**Zn (g ha^{-1})**			**Cu (g ha^{-1})**		
inoculated	3.51	3.68	3.60	22.57	27.02	24.80	16.16	17.68	16.92	26.75	32.75	29.75	8.38	11.83	10.07
uninoculated	2.85	3.24	3.05	20.97	26.65	23.81	15.37	17.58	16.48	27.60	31.99	29.80	8.14	11.70	9.92
LSD(p=0.05)	3.15	2.08		3.61	7.99		3.84	5.42		1.05	6.15		1.68	3.65	
S Dose kg ha^{-1}															
0	2.88	3.31	3.10	20.23	25.03	22.63	14.31	15.67	14.99	25.40	15.58	27.28	7.55	10.46	9.01
50	3.25	3.43	3.34	21.57	26.55	24.06	16.17	17.87	17.02	27.21	29.17	29.68	8.57	11.76	10.16
100	3.41	3.65	3.53	23.51	28.94	26.23	16.83	19.35	18.09	28.92	32.15	22.25	8.66	13.07	10.86
LSD(p=0.05)	0.27	0.38		1.37	1.56		1.33	1.15		1.38	1.19		0.81	0.79	
P Doses kg ha^{-1}															
0	2.66	2.76	2.71	18.57	21.98	20.28	13.42	14.76	14.09	23.15	28.01	25.58	7.07	9.65	8.36
40	3.27	3.66	3.46	21.51	26.36	23.94	16.37	17.08	16.73	26.98	31.93	29.46	8.24	12.06	10.15
80	3.62	3.97	3.79	25.24	32.17	28.71	17.52	21.05	19.28	31.39	37.38	34.38	9.48	13.59	11.54
LSD (p=0.05)	0.26	0.62		1.66	3.08		2.61	1.63		3.28	2.10		1.62	1.51	

LSD (p = 0.05).

investigation has been found coherent between the results of the study and those of the previous studies. Fertilizers containing sulfur decrease pH in calcareous and alkaline soils increase the intake of the other nutritional elements and thus facilitate the enhancement of productivity and yield. Whereas the highest harvest index were obtained 100 kg S ha^{-1} applications as 36.1 and 36.8 %, the difference between this application and the based on 0 and 40 kg ha^{-1}were found to be statistically insignificant.

Nutrient uptake by grain and shoot of chickpea plants are summarized in Tables 3 and 4. The single effects of inoculation were non significant except for uptake K in grain and S in shoot in 2004. Nutrient uptake by grain of chickpea was significantly increased due to sulfur doses, except for P uptake in grain in 2004 and S uptake in grain of chickpea in 2005. Total N uptake ranged from 21.27 to 23.79 kg ha^{-1} in the first year (2004), and ranged from 20.45 to 24.46 kg ha^{-1} in the second year (2005). The highest N uptake by grain of chickpea in the both years was observed in 100 S kg ha^{-1} treatment (Table 3). While N uptake in shoot was not significant with S doses in the second year, it was significantly affected with S doses in the first year, but increasing rates of applied S doses increased N uptake in shoot of chickpeas at the both years (Table 4). Uptake of P by grain of chickpea in 2005 was significantly increased by increasing S level. Total P uptake ranged from 2.48 to 2.72 kg ha^{-1} in the first year (2004), ranged from 2.14 to 2.65 kg ha^{-1} in the second year (2005). The highest P uptakes by grain of chickpeas were observed in 100 S kg ha^{-1} treatment, which was statistically different to 50 S kg ha^{-1} and 100 S kg ha^{-1} in the second year but similar to all of treatment in the first year (Table 3). While Phosphorus uptake in shoot was

Table 4. The effects of different sulfur, phosphorus levels and rhizobium inoculation on the shoot nutrient uptake of chickpea (*Cicer arietinum* L.).

Treatment	N (kg ha^{-1})			P (kg ha^{-1})			K (kg ha^{-1})			Ca (kg ha^{-1})			Mg (kg ha^{-1})		
	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean	2004	2005	Mean
inoculated	12.78	10.37	11.58	2.23	2.49	2.36	3.94	4.24	8.18	1.79	1.77	1.78	3.18	4.48	3.83
uninoculated	12.32	10.11	11.22	2.16	2.17	2.16	2.94	3.28	3.11	1.65	1.79	1.72	3.16	4.10	3.63
LSD(P=0.05)	6.55	4.08		0.92	1.68		1.82	1.42		0.68	0.36		0.57	0.72	
S Doses kg ha^{-1}															
0	11.55	9.77	10.66	2.07	2.21	2.14	3.25	3.43	3.34	1.69	1.61	1.65	2.95	4.03	3.49
50	12.74	10.14	11.44	2.18	2.31	2.25	3.52	3.77	3.65	1.73	1.81	1.77	3.20	4.32	3.76
100	13.35	10.80	12.08	2.34	2.47	2.41	3.54	4.08	3.81	1.75	1.93	1.84	3.35	4.52	3.94
LSD(P=0.05)	0.98	0.77		0.17	0.28		0.46	0.41		0.22	0.15		0.27	0.17	
P Doses kg ha^{-1}															
0	10.70	9.11	9.91	1.97	2.04	2.01	2.94	3.28	3.11	1.47	1.55	1.51	2.69	3.78	3.24
40	12.72	10.31	11.52	2.11	2.22	2.16	3.31	3.63	3.47	1.70	1.86	1.78	3.29	4.21	3.75
80	14.22	11.30	12.76	2.51	2.74	2.63	4.06	4.36	4.21	1.99	1.93	1.96	3.52	4.87	4.19
LSD(P=0.05)	2.48	1.33		0.28	0.50		0.82	0.36		0.25	0.18		0.27	0.24	
Treatment	**S (kg ha^{-1})**			**Fe (g ha^{-1})**			**Mn (g ha^{-1})**			**Zn (g ha^{-1})**			**Cu (g ha^{-1})**		
inoculated	2.85	3.95	3.40	15.64	17.77	16.71	10.36	14.70	12.53	18.80	13.80	16.30	7.22	7.53	7.37
uninoculated	2.70	3.36	3.03	17.02	18.08	17.55	8.21	15.07	11.64	18.61	12.88	15.75	6.67	8.73	7.70
LSD(P=0.05)	0.14	1.85		1.95	2.78		2.85	10.60		6.92	8.81		2.78	2.73	
S Doses kg ha^{-1}															
0	2.67	3.44	3.06	15.37	16.50	15.94	7.88	14.14	11.01	17.67	12.51	15.09	6.76	7.35	7.06
50	2.74	3.56	3.15	16.44	18.24	17.34	10.30	14.15	12.23	18.46	13.10	15.78	6.95	8.08	7.52
100	2.92	3.97	3.45	17.16	19.04	18.10	9.68	16.37	13.03	19.97	14.47	17.22	7.13	8.95	8.04
LSD(P=0.05)	0.17	0.19		2.34	2.29		1.96	1.85		1.18	1.32		0.84	1.00	
P Doses kg ha^{-1}															
0	2.48	3.16	2.82	14.16	16.38	15.27	8.32	12.73	10.53	16.72	11.36	14.04	6.47	6.92	6.69
40	2.72	3.60	3.16	16.53	17.16	16.85	9.25	13.38	11.32	18.47	13.63	16.05	6.70	8.20	7.45
80	3.12	4.21	3.66	18.28	20.24	19.26	10.30	18.54	14.42	20.92	15.07	18.31	7.67	9.27	8.47
LSD (P=0.05)	0.20	0.28		2.32	1.86		3.96	3.26		3.12	1.96		1.17	1.27	

LSD (P=0.05).

significant with S doses in the first year, it was not significantly affected with S doses in the second year. The K uptake by grain of chickpea was significantly increased with increasing rates of applied S doses. The highest K uptakes by grain of chickpeas were observed in 100 S kg ha^{-1} treatment in both years. In both year,100 S kg ha^{-1} treatment (12.26 kgha^{-1} in the first year, 12.17 kg ha^{-1} in the second year) was statistically different from 0, 50 and 100 S kg ha^{-1} treatments (Table 3). The K uptake by shoot of chickpea was not significant in the both years, but the K uptakes of shoot were increased with the rates of applied S doses. The highest K uptakes by shoot of chickpeas were observed in 100 S kg ha^{-1} treatments (3.54 kg ha^{-1} in the first year, 4.08 kg ha^{-1} in the second year) (Table 4). Uptake of Ca by grain of chickpea was significantly increased with increasing S level. Total Ca uptake ranged from 2.32 to 2.77 kg ha-1 in the first year and from 2.58 to 2.86 kg ha^{-1} in the second year. The highest Ca uptakes by grain of chickpeas were observed in 100 S kg ha^{-1} treatments in both years (Table 3). The Ca uptake by shoot of chickpea was not significant in the both years but the Ca uptakes of shoot were increased with the rates of applied S doses. The highest Ca uptakes by shoot of chickpeas were observed in 100 S kg ha^{-1} treatments which 1.75 kg ha^{-1} in the first year, 1.93 kg ha^{-1} in the second year (Table 4). Uptake of Mg by grain of chickpea was significantly increased with S levels. The highest Mg uptakes by grain of chickpeas were observed in S_{100} treatments, which were statistically different to S_0, treatments in the first year, 0, 50 and 100 S kg ha^{-1} treatments in the second year. The highest Mg uptakes by shoot of chickpeas were observed in 100 S kg ha^{-1} treatments which was 4.02 kg ha^{-1} in the first year, 4.41 kg ha^{-1} in the second year (Table 3). The Mg uptake by shoot of chickpea was significantly increased with rates of applied S doses in the first year (2004) but not significant, the highest Mg uptake was found 100 S kg ha^{-1} treatment (3.35 kg ha^{-1} in 2004 and 4.52 in 2005 kg ha^{-1}). The Mg uptakes of shoot were significantly increased with the rates of applied S doses in the both years. Similar result was reported by Singh et al. (2004), that nutrient uptake by chickpea plant increased with increasing levels of sulfur. While S uptake in grain and shoot was significant with S doses in the first year, was not significantly affected with S doses in the second year, but increasing rates of applied S doses increased S uptake of grain and shoot of chickpeas in the both years (Table 3, 4). The S uptake in grain of chickpea ranged from 2.88 to 3.41 kg ha^{-1}, the S uptake in shoot of chickpea from 2.67 to 2.92 kg ha^{-1} in 2004. The S uptake in grain of chickpea ranged from 3.31 to 3.65 kg ha^{-1}, the S uptake in shoot of chickpea from 3.44 to 3.97 kg ha^{-1} in the year of 2005 (Table 3, 4). Sulfur application significantly increased the uptake of Fe, Mn, Zn and Cu in grain of chickpea in the both years (Table 3). Sulfur application were not significantly effected the uptake of Fe, Mn, Zn and Cu in shoot of chickpea in the both years except only Mn and Zn uptake by shoot of chickpea in the first years (Table 4). The highest the uptakes of Fe, Mn, Zn and Cu in grain and shoot of chickpea were observed in the highest sulphur applications in the both years. The Fe uptake by grain of chickpea ranged from 20.23 to 23.51 g ha^{-1} in the first year, and ranged from 25.03 to 28.94 g ha^{-1} in the second year. The Mn uptake by grain of chickpea ranged from 14.31 to 16.83 g ha^{-1} in the first year, and ranged from 15.67 to 19.35 g ha^{-1} in the second year (Table 3). The Mn uptake by shoot of chickpea ranged from 7.88 to 10.30 g ha^{-1} in the first year, and ranged from 14.14 to 16.37 g ha^{-1} in the second year (Table 4). The Zn uptake by grain of chickpea ranged from 25.40 to 28.92 g ha^{-1} in the first year, and ranged from 15.58 to 32.15 g ha^{-1} in the second year (Table 3). The Zn uptake by shoot of chickpea ranged from 17.67 to 19.97 g ha^{-1} in the first year, and ranged from 12.51 to 14.47 g ha^{-1} in the second year (Table 4). The Cu uptake by grain of chickpea ranged from 7.55 to 8.66 g ha^{-1} in the first year, and ranged from 10.46 to 13.07 g ha^{-1} in the second year (Table 3). Manchanda et al. (1993) reported that the uptake of Fe, Mn, Zn and Cu in lentil plant increased significantly over control at all S level. The increased availability of these micronutrients, owing to a decline in soil pH caused by the applied S (Lindsay, 1972), seems to be responsible for their increased uptake in the lentil plants. Also rhizosphere pH is important after elemental S application. But in the present experiment the soil pH and rhizosphere pH has not been measured. Since the soils are used in this experiment have high pH it is very hard to find a significant pH change in a short term in the soil.

The effects of different doses of phosphorus applications on nutrient uptakes (N, P, K, Ca, Mg, S, Fe, Mn, Zn and Cu) by grain of chickpea were found to be statistically significant in both years (Table 3). While the lowest values of nutrient uptakes were found in control applications, the highest values of nutrient uptakes were found in 80 kg P ha^{-1} applications. Phosphorus application significantly increased the uptake of N, P, K, Ca, Mg, S, Fe and Zn in shoot of chickpea in the first year (Table 4). Phosphorus applications were not significant as statistical the uptake of all in nutrient but the nutrients uptakes of shoot were increased with the rates of applied phosphorus doses in the both years (Table 4). This region soils and experiment soils which have poorer phosphorus content would bring good results of phosphorus fertilization nutrient uptake by grain and shoot of chickpea.

Conclusion

Various studies have shown that sulfur fertilization in calcareous and alkaline soils reduces pH and improves soil property. In calcareous soils the intake of nutritional elements are impaired by the plant, and thus, some productivity and yield components become disrupted, thereby leading to lower criteria in these components. Also, the plants do not efficiently benefit from the fertilizers applied to the soil. In this study, sulfur fertilization was found to improve soil property and enhance the intake of phosphorus fertilizer applied together. In the final course of the study, it was concluded that in the soils of this region, which have poorer phosphorus content and are highly alkaline, 100 kg ha^{-1} sulfur and 80 kg ha^{-1} phosphorus fertilization would bring good results and thus could be beneficial in order to have adequate chickpea farming.

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