YYÜ TAR BİL DERG
(YYU J AGR SCI)
2018, 28(özel sayı): 268-275

Geliş tarihi (Received): 10.03.2018
Kabul tarihi (Accepted): 18.12.2018

Araştırma Makalesi/*Research Article (Original Paper)*

Effects of Zinc Applications on Nutrient Contents of Up Ground Parts in Lentil (*Lens Culinaris*medic.) Varieties

Yeşim TOĞAY[1], Necat TOĞAY*[1], Füsun GÜLSER[2]

[1]Mugla Sitki Kocman University, Fethiye ASMK Vocational High School, Mugla, Turkey.
[2] Van Yüzüncü Yıl University, Faculty of Agriculture, Department of Soil Science, Van, Turkey.
*e-mail: necattogay@hotmail.com, Phone: +90 532 7346486; Fax:+90 252 2111317

Abstract: Lentil is one of the oldest domesticated crops grown and used mostly in human diets in Turkey. The experiment was carried out in factorial randomized complete block design with three replications. Sazak-91, Yerli Kırmızı and Kışlık Kırmızı-51 lentil variety were used as lentil varieties. Five different zinc levels (0, 5, 10, 15 and 20 kg ha^{-1}) were applied in two years. In the study, the effects of zinc doses on the N, P, K, Cu, Fe, Mn, Ca, Zn and Mg content of up ground parts were investigated in lentil varieties. Zinc applications increased N, K, Fe, Zn and Mn contents of up ground parts in lentil whereas P, Cu, Ca and Mg decreased.

Keywords: *Lens culinaris*, zinc fertilization, nutrient content, up ground parts

Introduction

Legumes are an important source of protein, vitamins, minerals and complex carbohydrates in diets of a large number of people, especially in developing countries. Among legumes lentil is the second leading grain legume crop after chickpea in Turkey. The lentil, a legume crop, fixes atmospheric nitrogen in the root-nodules in a symbiotic relationship with *Rhizobium* bacteria. It is an important crop because of its high protein content of seed and straw for human and animal nutrition. The current productivity trends of lentil are decreased on decades. Poor fertilization area is considered as an important factor effecting this decreasing. The plant needs some macro- and micronutrients for its normal growth. Lentil seeds have a quite high protein content (18-30 %) varied according to environmental conditions, varieties and agronomic process.

Zn is an essential nutrient in plants, animal and humans. In human's Zn deficiency causes severe health complications, including impairments of physical growth, immune system and learning capacity, DNA damage and cancer development (Levenson and Morris, 2011). It was reported that more than 30% of the world's populations is Zn deficient, with Zn deficiency being the 11th most important factor causing disease or death in the world (WHO Micronutrient Deficiencies, 2011).

Zinc contents of plants plays an important role in plant reproduction. Its deficiency inhibits floral development, male and female gametogenesis, fertilization and seed development. Pandey et al. (2006) reported that zinc deficiency reduces plant growth, pollen viability, flowering and grain production in plants.

Studies show that 30% of the arable areas in the world and 50% of the agricultural soils in Turkey suffer from zinc deficiency (Kenbeay and Sade, 1987). The Van region is among the areas most severely affected by zinc deficiency (Eyüboğlu et.al. 1998, Çamaş et al. 1998).

This study was carried out to investigate the effects of zinc applications on nutrient contents of up ground parts of lentil varieties in the Van region in eastern Turkey.

Materials and Methods

Sazak-91, Yerli Kırmızı and Kışlık Kırmızı-51 lentil cu1tivars were well adapted lentil in Van, Turkey ecological conditions. The two years' field experiments on clay loam soils were conducted during the winter seasons in the Zeve Campus of Agricultural Faculty of Van Yuzuncu Yil University (Long. 43°172 E2, Lat. 38°332 N2, and 1655 m above msl). Sowing of Sazak-91 Yerli Kırmızı and Kışlık Kırmızı-51 varieties were done by hand with 20 cm row spacing in late October in both years. Plot size was 1 m x 5 m = 5 m². Sazak-91, Yerli Kırmızı and Kışlık Kırmızı-51 lentil varieties were applied at five different zinc doses (0, 5, 10, 15 and 20 kg ha^{-1}) in two years. $ZnSO_4$ was used as Zn source. The seeding rate was 150 kg ha^{-1}. At sowing, 40 kg ha^{-1} P_2O_5 as a TSP and 20 kg ha^{-1} N as an ammonium sulfate were uniformly applied in the trial area as basic fertilization. Plots were hand-weeded twice each season. Plants were harvested in late June in both years. Some physical and chemical properties of research area soil are given in Table 1.

Some physical and chemical soil properties of the field were determined in soil sample taken from 0 – 20 cm depth as follows: particle size distribution by Bouyocous hydrometer method (Bauyocous, 1951); lime content by Scheibler Calcimeter, soil reaction (pH) in 1:1 (w:v) soil:water suspension by pH meter and soil salinity by EC meter in the same suspension (Black, 1965); organic matter content by Walkley-Black method, exchangeable cations by ammonium acetate extraction; available phosphorus by Olsen's method; total nitrogen by the Kjeldahl method (Kacar,1994) and DTPA extractable heavy metals (Fe, Mn, Zn, Cu) according to Lindsay and Norvel (1978).

Table 1. Some physical and chemical properties of the soil

Sand, %	19.90	NH_4OAc Extractable	
Silt,%	17.50	K, g kg^{-1}	0.29
Clay,%	62.60	Ca, g kg^{-1}	2.65
$EC_{25°C}$,mmhos cm^{-1}	0.77	Mg, g kg^{-1}	0.24
pH	8.54	DTPA Extractable	
Organic matter,%	0.44	Fe, mg kg^{-1}	6.80
$CaCO_3$,%	3.68	Cu, mg kg-1	1.20
Total N, g kg^{-1}	1.10	Zn, mg kg-1	0.37
Olsen P, mg kg^{-1}	31.20	Mn, mg kg-1	11.40

Some physical and chemical soil properties of the field were determined in soil sample taken from 0 – 20 cm depth in the experimental field are given in Table 1. The results can be summarized as; the textural class of soil is sandy loam, sufficient in a phosphorus and potassium contents, slightly alkaline in pH, low in organic matter, very slightly saline according to EC values. DTPA- extractable Zn concentration in soil was lower than the widely accepted critical Zn concentration of 0.5 mg kg^{-1}.

The nutrient contents of the harvested plant samples were analyzed in dried and grinded plant samples according to following methods reported by Kacar (1984). The N content was determined by the Kjeldahl method, the P level was analyzed by the spectrophotometric method, and K, Ca, Mg, Fe, Mn, Zn, and Cu levels were determined by using an atomic absorption spectrophotometer (Themo ICE 3000 series).

Statistical analyses were done using SAS package programs to show difference among the mean values of nutrient contents from the different applications.

Results and Discussion

The data on the effects of different zinc applications on nutrient contents of up ground parts in lentil varieties are given in Table 2 and Figure 1, 2, 3, 4, 5.

Table 2. Effects of Zn applications on nutrient contents of up ground parts in lentil varieties

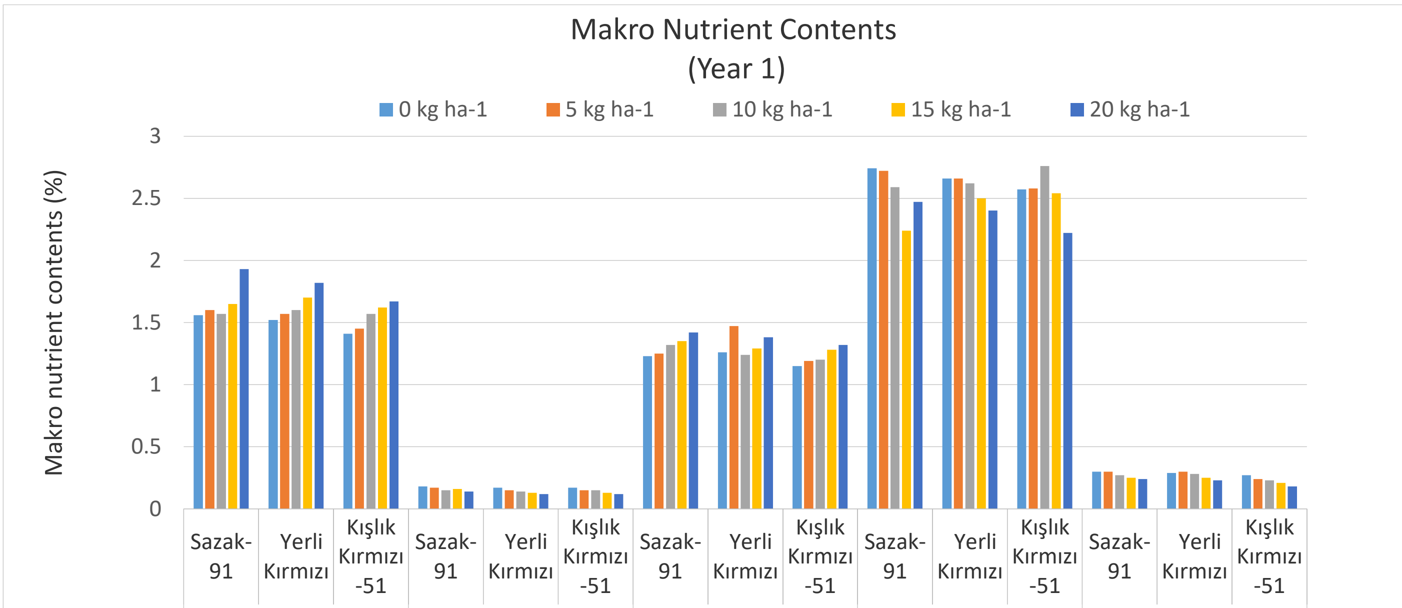
		N (%)				**P (%)**			
	Zinc levels (kg ha^{-1})	Sazak-91	Yerli Kırmızı	Kışlık Kırmızı-51	**Mean**	Sazak-91	Yerli Kırmızı	Kışlık Kırmızı-51	**Mean**
First year	0	1.56 gh	1.52 h	1.41 I	1.50 E	0.18	0.17	0.17	0.17 A
	5	1.60 e-g	1.57 fg	1.45 i	1.54 D	0.17	0.15	0.15	0.16 B
	10	1.57 g-h	1.60 e-g	1.57 fg	1.58 C	0.15	0.14	0.15	0.15 C
	15	1.65 cd	1.70 c	1.62 ef	1,.65 B	0.16	0.13	0.13	0.14 C
	20	1.93 a	1.82 b	1.67 cd	1.80 A	0.14	0.12	0.12	0.13 D
	Mean	1.66 A	1.64 B	1.54 C		0.16 A	0.14 B	0.14 B	
	0	1.63 g	1.60 gh	1.57 h	1.60 E	0.19	0.18	0.17	0.18 A
	5	1.71 ef	1.61 gh	1.60 gh	1.64 D	0.18	0.17	0.16	0.17 AB

Second Year	10	1.83 c	1.73 ef	1.71 f	1.76 C	0.18	0.17	0.15	0.16 B
	15	1.93 b	1.80 cd	1.76 de	1.83 B	0.17	0.15	0.13	0.15 C
	20	1.98 a	1.90 b	1.79 cd	1.89 A	0.15	0.13	0.12	0.13 D
	Mean	1.81 A	1.73 B	1.68 C		0.17 A	0.16 B	0.14 C	
		K (%)					**Ca (ppm)**		
	0	1.23	1.26	1.15	1.21 C	2.74	2.66	2.57	2.65 A
	5	1.25	1.47	1.19	1.25 BC	2.72	2.66	2.58	2.65 A
First year	10	1.32	1.24	1.20	1.30 AB	2.59	2.62	2.76	2.66 A
	15	1.35	1.29	1.28	1.30 AB	2.24	2.50	2.54	2.43 B
	20	1.42	1.38	1.32	1.37 A	2.47	2.40	2.22	2.36 B
	Mean	1.31 A	1.33 A	1.22 B		2.55	2.57	2.53	
	0	1.23 f	1.27 ef	1.26 ef	1.25 C	2.74 a	2.68 c-e	2.69 cd	2.70 A
	5	1.24 f	1.28 d-f	1.26 ef	1.26 C	2.76 a	2.65 de	2.65 e	2.69 A
Second Year	10	1.29 c-f	1.32 b-e	1.28 ef	1.29 B	2.73 ab	2.61 f	2.57 g	2.63 B
	15	1.34 bc	1.34 b-d	1.29 c-f	1.32 B	2.70 bc	2.56 g	2.50 h	2.62 B
	20	1.46 a	1.37 b	1.25 f	1.36 A	2.68 c-e	2.70 bc	2.47 i	2.59 C
	Mean	1.31 A	1.31 A	1.27 B		2.72 A	2.64 B	2.59 C	
		Mg (%)					**Fe (ppm)**		
	0	0.30	0.29	0.27	0.28 A	116.00 e	151.33 c-e	212.33ab	159.88 BC
	5	0.30	0.30	0.24	0.28 A	214.00 ab	149.00 c-e	178.66 b-e	180.55 AB
First year	10	0.27	0.28	0.23	0.26 B	184.00 b-d	205.33a-c	174.33b-e	187.88 AB
	15	0.25	0.25	0.21	0.24 C	192.66a-c	174.00b-e	248.33a	205.A
	20	0.24	0.23	0.18	0.21 D	167.33 b-e	149.00ce	129.33de	148.55 C
	Mean	0.27 A	0.27 A	0.23 B		174.76	165.73	188.59	
	0	0.29	0.27	0.27	0.28 A	151.4 de	150.1 e	152.2 c-e	151.2 C
	5	0.28	0.25	0.25	0.26 B	155.5 cd	150.7 e	150.1 c-e	152.1 C
Second Year	10	0.25	0.24	0.23	0.24 C	160.0 b	152.4 c-e	151.0 e	154.5 B
	15	0.24	0.21	0.19	0.21 D	164.7 a	156.2 bc	152.2c-e	157.7 A
	20	0.22	0.17	0.17	0.18 E	164.1 a	160.1b	151.9 c-e	158.7 A
	Mean	0.25 A	0.23 B	0.22 B		159.2 A	153.9 B	151.5 C	
		Cu (ppm)					**Zn (ppm)**		
	0	45.0b-d	68.6 a	68.3 a	60.6 A	5.66 hi	5.00 i	4.66 i	5.11 E
	5	49.3 b-d	42.0 d	52.6 a-d	48.0 B	6.66 gh	5.66 hi	5.00 I	5.77 D
First year	10	41.0 d	62.0ab	48.6 b-d	50.5 B	11.33 d	8.00 f	7.00 fg	8.77 C
	15	53.0 a-d	48.6 b-d	60.6 a-c	54.1 AB	14.66 b	11.66 d	9.33e	11.88 B
	20	56.0 a-d	43.3 cd	43.0cd	47.4 B	16.66 a	13.33 c	12.33 cd	14.11 A
	Mean	48.8 B	52.9A	54.6A		11.00 A	8.73 B	7.66 C	
	0	71.4 a	69.2 a-c	65.9 cd	68.8 A	5.98	5.62	5.36	5.66 D
	5	70.8 a	64.5 de	63.2 de	66.2 B	6.33	5.80	5.63	5.92 D
Second Year	10	69.5 ab	62.1 ef	57.6 g	63.1 C	7.36	7.00	7.03	7.13 C
	15	66.5 b-d	58.9 fg	53.4 h	59.6 D	10.30	8.40	8.70	9.13 B
	20	59.7 fg	56.3 gh	48.6 I	54.9 E	15.63	13.26	12.66	13.85 A
	Mean	67.7 A	62.2 B	57.7 C		9.12 A	8.01 B	7.88 B	

		Mn (ppm)			
	0	108.66a-d	112.00a-c	90.33d-f	103.66
	5	107.66a-d	101.00b-f	89.00d-f	99.22
First year	10	86.00ef	84.66ef	97.66b-f	89.44
	15	114.66ab	91.66c-f	97.33b-f	101.22
	20	123.66a	81.66f	104.00a-e	103.11
	Mean	108.13 A	94.20 B	95.66 B	
	0	90.6 b-e	88.8 de	88.1 b-d	89.2 D
	5	90.9 b-d	88.9 de	89.1 e	89.6 D
Second Year	10	92.7 a-c	90.0 c-e	89.3 de	90.7 C
	15	94.7 a	90.5 b-e	90.1 de	91.7 B
	20	95.1 a	91.0 b-d	91.1 b-d	92.4 A
	Mean	92.8 A	89.8 B	89.5 B	

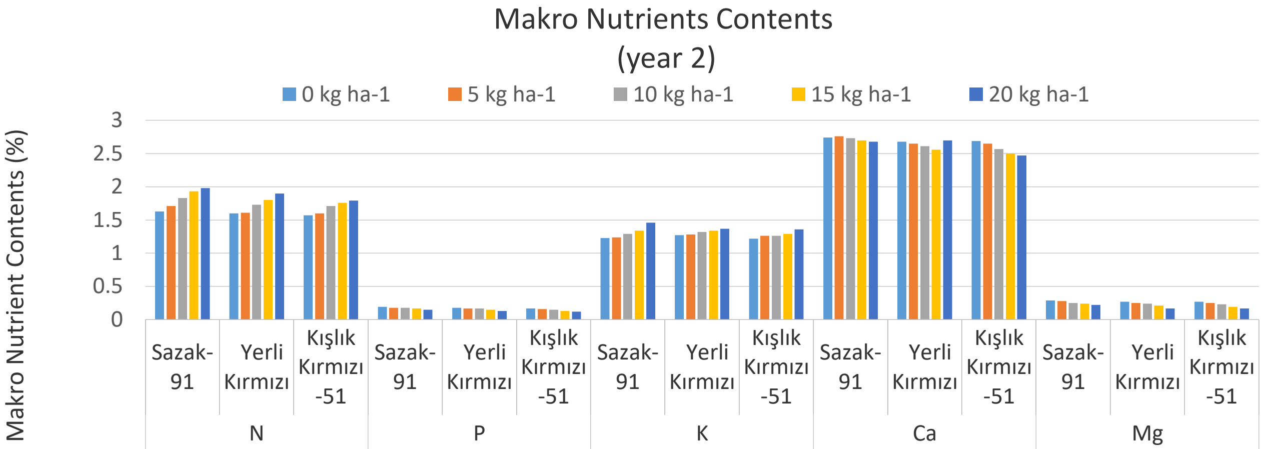
*There is no significant difference between the same letters in each column statistically at 5 % level.

The lowest nutrient contents were obtained in Kışlık Kırmızı-51 variety. It was reported that nutrient absorption by plants show differences among plant varieties (Aydemir and İnce, 1988). The nutrient contents of varieties did not show differences among years except Cu, Zn and Mg contents. Nitrogen, K, Fe, Mn and Zn contents significantly ($p<0.05$) increased by increasing Zn doses while P, Cu, Ca and Mg contents decreased both years.



	N			P			K			Ca			Mg		
	Sazak-91	Yerli Kırmızı	Kışlık Kırmızı-51	Sazak-91	Yerli Kırmızı	Kışlık Kırmızı-51	Sazak-91	Yerli Kırmızı	Kışlık Kırmızı-51	Sazak-91	Yerli Kırmızı	Kışlık Kırmızı-51	Sazak-91	Yerli Kırmızı	Kışlık Kırmızı-51
0 kg ha-1	1.56	1.52	1.41	0.18	0.17	0.17	1.23	1.26	1.15	2.74	2.66	2.57	0.3	0.29	0.27
5 kg ha-1	1.6	1.57	1.45	0.17	0.15	0.15	1.25	1.47	1.19	2.72	2.66	2.58	0.3	0.3	0.24
10 kg ha-1	1.57	1.6	1.57	0.15	0.14	0.15	1.32	1.24	1.2	2.59	2.62	2.76	0.27	0.28	0.23
15 kg ha-1	1.65	1.7	1.62	0.16	0.13	0.13	1.35	1.29	1.28	2.24	2.5	2.54	0.25	0.25	0.21
20 kg ha-1	1.93	1.82	1.67	0.14	0.12	0.12	1.42	1.38	1.32	2.47	2.4	2.22	0.24	0.23	0.18

Figure1. Makro nutrients contents of different lentil varieties Lentil (First year)

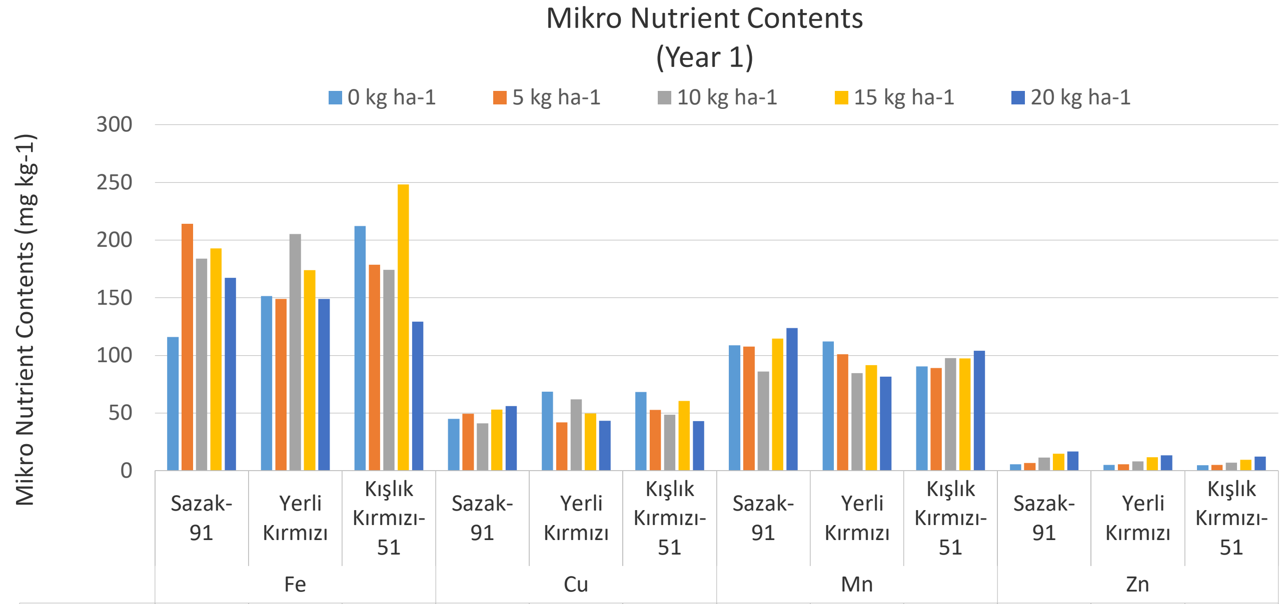


	N			P			K			Ca			Mg		
	Sazak-91	Yerli Kırmızı	Kışlık Kırmızı -51	Sazak-91	Yerli Kırmızı	Kışlık Kırmızı -51	Sazak-91	Yerli Kırmızı	Kışlık Kırmızı -51	Sazak-91	Yerli Kırmızı	Kışlık Kırmızı -51	Sazak-91	Yerli Kırmızı	Kışlık Kırmızı -51
0 kg ha-1	1.63	1.6	1.57	0.19	0.18	0.17	1.23	1.27	1.22	2.74	2.68	2.69	0.29	0.27	0.27
5 kg ha-1	1.71	1.61	1.6	0.18	0.17	0.16	1.24	1.28	1.26	2.76	2.65	2.65	0.28	0.25	0.25
10 kg ha-1	1.83	1.73	1.71	0.18	0.17	0.15	1.29	1.32	1.26	2.73	2.61	2.57	0.25	0.24	0.23
15 kg ha-1	1.93	1.8	1.76	0.17	0.15	0.13	1.34	1.34	1.29	2.7	2.56	2.5	0.24	0.21	0.19
20 kg ha-1	1.98	1.9	1.79	0.15	0.13	0.12	1.46	1.37	1.36	2.68	2.7	2.47	0.22	0.17	0.17

Figure 2. Makro nutrients contents of different lentil varieties Lentil (Second year)

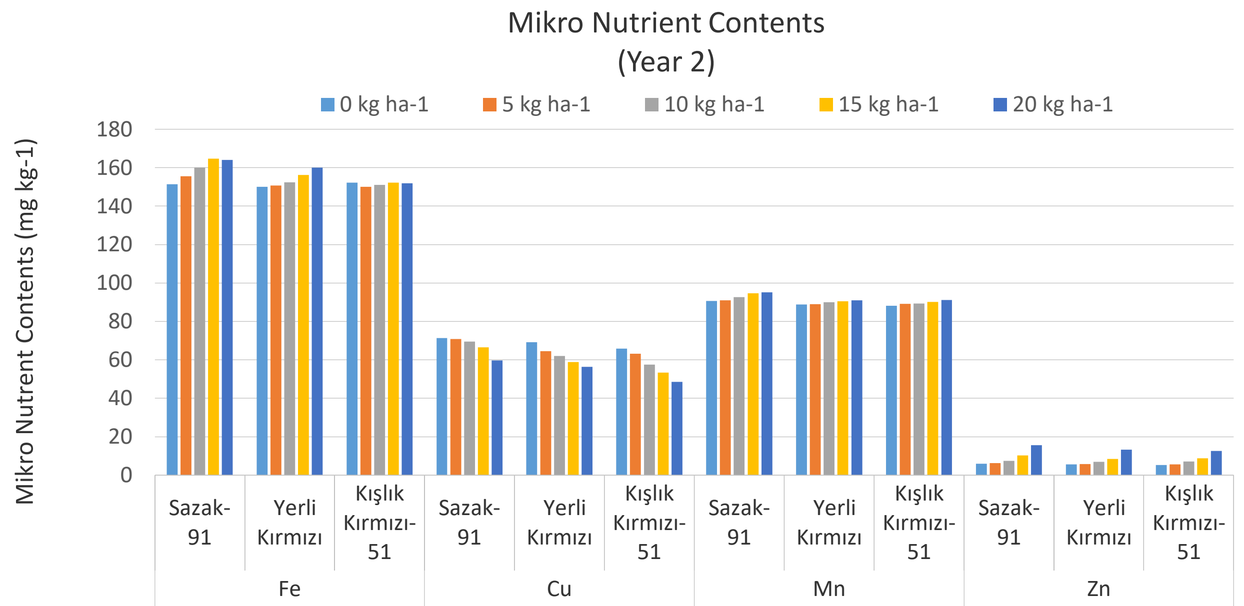
The lowest N, K and Zn contents were obtained as 1.41%, 1.15% and 5.11% mg kg^{-1} by 0 kg ha^{-1} Zinc application in Kışlık Kırmızı- 51 variety. The highest N, K and Zn contents were 1.98 %, 1.46% and 16.66 mg kg^{-1} in Sazak-91 variety with 0 kg ha^{-1} Zinc dose. There are many researchs about zinc fertilization in crop plants. But number of researchs related with effects of zinc fertilization on nutrient uptake in leguminosea are fewer and limited.

Kumar et al. (2016) determined that combined effect of biofertilizers and micronutrients (Fe+Zn) was significantly improved yield, yield parameters and nutrient uptake. Singh et al. (2017) reported that application of sulphur 40 kg ha^{-1} and zinc 20-30 kg ha^{-1} increased yield, quality and sulphur and zinc uptake in soybean. Abdul-Raziq et al. (2016) found that the highest zinc uptake obtained in 10 kg Zn ha^{-1} along with HA application and the lowest mean occured in control plants. Similarly they reported that alone zinc applications and zinc applications with humic acid increased yield and quality of french bean in zinc defficient soils.



	Fe: Sazak-91	Fe: Yerli Kırmızı	Fe: Kışlık Kırmızı-51	Cu: Sazak-91	Cu: Yerli Kırmızı	Cu: Kışlık Kırmızı-51	Mn: Sazak-91	Mn: Yerli Kırmızı	Mn: Kışlık Kırmızı-51	Zn: Sazak-91	Zn: Yerli Kırmızı	Zn: Kışlık Kırmızı-51
0 kg ha-1	116	151.33	212.33	45	68.6	68.3	108.66	112	90.33	5.66	5	4.66
5 kg ha-1	214	149	178.66	49.3	42	52.6	107.666	101	89	6.6	5.66	5
10 kg ha-1	184	205.33	174.33	41	62	48.6	86	84.66	97.66	11.33	8	7
15 kg ha-1	192.66	174	248.33	53	49.6	60.6	114.66	91.66	97.33	14.66	11.66	9.33
20 kg ha-1	167.33	149	129.33	56	43.3	43	123.66	81.66	104	16.6	13.33	12.33

Figure 3. Mikro nutrients contents of different lentil varieties (First year)



	Fe: Sazak-91	Fe: Yerli Kırmızı	Fe: Kışlık Kırmızı-51	Cu: Sazak-91	Cu: Yerli Kırmızı	Cu: Kışlık Kırmızı-51	Mn: Sazak-91	Mn: Yerli Kırmızı	Mn: Kışlık Kırmızı-51	Zn: Sazak-91	Zn: Yerli Kırmızı	Zn: Kışlık Kırmızı-51
0 kg ha-1	151.4	150.1	152.2	71.4	69.2	65.9	90.6	88.8	88.1	5.98	5.62	5.36
5 kg ha-1	155.5	150.7	150.1	70.8	64.5	63.2	90.9	88.9	89.1	6.33	5.8	5.63
10 kg ha-1	160	152.4	151	69.5	62.1	57.6	92.7	90	89.3	7.36	7	7.03
15 kg ha-1	164.7	156.2	152.2	66.5	58.9	53.4	94.7	90.5	90.1	10.3	8.4	8.7
20 kg ha-1	164.1	160.1	151.9	59.7	56.3	48.6	95.1	91	91.1	15.6	13.26	12.66

Figure 4. Mikro nutrients contents of different lentil varieties (Second year)

Iron and Mn contents also significantly ($p<0.05$) increased by zinc applications in only second year.

Access to these, the lowest P contents were obtained as 0.12% and 0.13% by 20 kg ha-1 Zn applications in all varieties and first year. Similarly, the lowest Cu, Ca and Mg contents were also in 10 kg ha-1 Zn applications in the first year. It was thought that the decreases of P, Ca, Mg and Cu contents in high zinc doses caused by interactions between Zn and P, Ca, Mg and Cu (Marschner,1995). Tather (2008) reported that among the various levels of zinc, application of 40 kg ha-1 gave highest pod yield and application of 20 kg ha-1 significantly increased uptake of N, P, K, Ca and Mg exhibiting synergistic effect of lower level and antagonistic effects at higher level. Awlad et al. (2003) investigated that effects of increasing zinc doses (0-2.5-5.0-10.0 and 20.0 kg Zn ha-1) and sulphur doses on nodulation, dry matter yield and nutrient content of soy bean. They determined that the highest zinc content was obtained in S30Zn20 application. Application of different levels of Zn accelerated nodulation, dry matter yield and nutrient content of soybean. Our results were corresponding with results of referred researches.

In this study, Zn applications increased N, K, Fe, Zn and Mn contents of up ground parts in lentil whereas P, Cu, Ca and Mg decreased.

Conclusion

Zinc applications increased the N, K, Fe, Zn, Mn contents of lentil up ground parts. As a result, in the soils of this region, which have poor zinc content and are highly alkaline, 20 kg ha^{-1} zinc fertilization would be beneficial and thus could be suggested in order to have efficient lentil farming. It was thought that investigations of effects of higher doses than 20 kg ha^{-1} zinc dose on nutrient contents can be useful for amelioration of crop amount and quality in lentil.

References

Awlad, H.M., Chowdhury, M.A.H., Talukder, N.M., 2003. Effect of Sulphur and Zinc on Nodulation Dry Matter Yield and Nutrient Content of Soybean. Pakistan Journal of Biological Sciences. 6(5):461-466.

Aydemir, O., Ince, F., 1988. Bitki Besleme. Dicle Univ. Faculty of Education Publications. No:2.

Bouyoucos, GS 1951. Recalibration of the hydrometer methods for making mechanical analysis of soil. Agron. J. 43: 434-438.

Camas, H., A. Bildik and F. Gülser, 1998. Determination of zinc levels in soils, plant and sheep. In: Proceeding of the 1st National Zinc Congress, 12-16 May 1998, Anatolian Agricultural Research Institute, Eskişehir, Turkey. (In Turkish), pp: 637-641.

Eyüboğlu, F., N. Kurucu and S. Talaz, 1998. Concentration of plant available zinc in Turkish soils. In: Proceeding of the 1st National Zinc Congress, 12-16 May 1998, Anatolian Agricultural Research Institute, Eskişehir, Turkey. (In Turkish), pp: 99-106.

Jackson M 1958. Soil Chemical Analysis. Prentice Hall, Inc. New Jersey, USA.

Kacar, B., 1984. Plant Nutrition Application Manual. A.Ü, A.F., Yay. No:900, Practice Manual: 214, Ankara, 104.

Kacar, B., 1994. Chemical Analysis of Plant and Soil: III Soil analysis. A.Ü., A.F., Education Research and Development Foundation Publications No: 3, Ankara, 705.

Kenbeay, B. and B. Sade, 1998. The determination of response of barley varieties (Hordeum vulgare L.) to zinc doses in Konya under rained conditions. In: Proceeding of the 1st National Zinc Congress, 12-16 May 1998, Anatolian Agricultural Research Institute, Eskisehir, Turkey. (In Turkish), pp: 339-348.

Kumar, R. P., Singh, O. N., Singh, Y., Dwivedi, S., Singh, J. P., 2009. Effect of Integrated Nutrient Management on Growth, Yield, Nutrient uptake and Economics of French bean (Phaseolus vulgaris). Indian Journal of Agricultural Sciences. 79 (2):122-128.

Levenson, C. W., Morris, D., 2011. Zinc and neurogenesis: making new neurons from development to adulthood. Advances in Nutrition, 2, 96–100.

Marschner, H., 1995. Mineral nutrition of higher plants. 2nd Ed. P. 1-889. Academic Press, San Diego. USA.

Olsen SR, Cole CV, Watanabe FS, Dean LA (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Circ. US. Dep. Agric., p. 939.

Pandey, N., Pathak, G. C., Sharma, C. P., 2006. Zinc is critically required for pollen function and fertilization in lentil. Journal of Trace Element and Medical Biology, 20, 80–96.

Raziq, A., Gurmani, A. R., Khan, S. U., Malik, A.A., Rubab, T., Khan, S.M, Shah, I., 2016. Influence of Zinc and Humic Acid on Yield, Nutritional Quality, Uptakes and Economic Returns of French Bean (Phaseolus vulgaris L.) (Paulista) under Field Conditions. Sci. Int. (Lahore), 28(2): 1237-1242.

Richard LA (1954). Diagnosis and improvement of saline and alkaline soils. Handbook 60, U.S. Department of Agriculture.

SAS. (1998). Statistical Analysis Software. Version 6.12. SAS Institute, Cary, NC, USA.
Singh, S., Singh, V., Layek, S.,2017. Influence of Sulphur and Zinc Levels on Growth Yield and Quality of Soybean (Glycine max. L). International Journal of Plant & Soil Science. 18(2):1-7.
Soil Survey Staff, 1999. Soil Taxonomy: A Basic system of soil classification for making and interpreting soil surveys. USDA-NRCS, Agriculture Handbook No: 436. U.S. Government Printing Office, p. 870.
Walkey A 1947. A Critical Examination of a Rapid Method for Determining Organic Carbon in Soils: Effect of Variations in Digestion Conditions and Inorganic Soil Constituents. Soil Sci. 63: 251-263.
Tathe, A.S., 2008. Responce of Different Levels of Sulphur and Zinc Fertilization on Yield and Uptake of Nutrients by Groundnut. An. Asian Journal of Soil Science. 3(1):133-136.
WHO. Micronutrient Deficiencies, Iron Deficiency Anemia., 2011. Retrieved 12.04.2018.