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Full Length Research Paper

Effect of zinc fertilizer applications on yield and element contents of some registered chickpeas varieties

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In this study, the effect of zinc fertilizer applications on different chickpea varieties and the most suitable zinc application dose were investigated under the field conditions in May to September of 2003 and 2004. Three types of chickpeas (*Cicer arietinum* cv.Canitez-87, cv. ILC-482 and cv. Gokce) were studied under irrigated conditions. Zinc was applied to the soil at four doses 0, 0.5, 1.0 and 1.5 kg da^{-1} before sowing. During the experiment, leaf samples were regularly collected every week to determine the chlorophyll content of fresh leaf tissue. The changes in the total chlorophyll content were followed. Chickpea samples of each variety were harvested mainly taking into account maturation periods. Leaf chlorophyll concentration, grain phytic acid, zinc, nitrogen and phosphorus contents were determined in chickpea varieties. According to the results of the statistical analysis, the chlorophyll content in the leaves showed a significant difference among the varieties for both years ($P < 0.01$).The values of P, phytic acid and Zn contents in the seed and the Zn content in the leaf of ILC-482 variety were found to be higher when compared with other varieties. According to correlation test results, there were significant ($P < 0.05$) differences among the described criteria. Significant correlations were observed between phosphorus content in seed and grain yield (r= 0.75*); total chlorophyll content of leaves and grain yield (r= 0.78*); total chlorophyll content of leaves and phytic acid (r= 0.93); total chlorophyll content of leaves and phosphorus content in seed (r= 0.72*) particularly in ILC -482 variety. The application of zinc fertilizer did not provide a significant increase in the yield. However, significant increases were observed in phosphorus, phytic acid and zinc content in the seed and the chlorophyll concentration in the leaf through zinc fertilizer application at a dose of 1.0 kg da^{-1} ($P < 0.01$).**

Key words: *Cicer arietinum L.*, chlorophyll concentration, phytic acid, zinc, nitrogen, phosphorus.

INTRODUCTION

Chickpea (*Cicer arietinum*) is an important dry land pulse crop in many parts of the world. Productivity is often limited by periods of water deficit and in a number of regions, zinc deficiency occur. Osmotic potential was lower and turgor higher in the leaves of zinc-deficient plants, but the ability to adjust osmotically was reduced by zinc deficiency as stress developed. Zinc-deficiency reduced the efficiency with which the water was used for biomass production and compromised the plant's capacity to respond to water stress by osmotic adjustment (Khan et al., 2004). Zinc enzymes participate in a wide variety of metabolic processes including carbohydrate, lipid and protein synthesis or degradation. The metal is required for deoxyribonucleic and ribonucleic acid synthesis; it may also play a role in stabilizing plasma membranes (Shils et al., 1994). Zinc has been recognized as a co-factor of the superoxide dismutase enzyme, which is involved in protection against oxidative processes (Shils et al., 1994). The net delivery of Zn to an organism is a function of the total amount of this

Table 1. The soil analysis results of the chickpea-zinc trial field.

Trial year	pH (1:2.5)	$CaCO_3$ (%)	Organic matter (%)	DTPA- extractable micro elements (mg kg^{-1})				Texture			
				Fe	Zn	Mn	Cu	Sand (%)	Silt (%)	Clay (%)	Textural class
2003	8.21	31.03	1.61	0.99	0.29	1.23	0.45	21.51	38.85	39.64	Clay loam
2004	8.12	37.09	1.50	1.65	0.23	1.15	0.62	20.11	35.83	44.06	Clay loam

Table 2. Climate data of the trial area (Anonymous. 2004).

Year	Observation	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
2003	Precipitation	17.6	47.5	24.6	50.2	30.9	2.3	0	0	16.6
	Medium temprature	4.0	-1.7	1.8	9.5	17.2	21.2	23.6	23.6	18
2004	Precipitation	34.1	31.1	3.1	40.6	17.2	56.9	4.0	21.4	0
	Medium temprature	-1.2	2.0	6.2	10.4	15.2	19.8	22.3	23.1	18.6
Long-year averages (1993 to 2003)	Precipitation	26.6	19.58	29.72	38.86	43.41	23.91	7.56	8.57	14.76

Table 3. The effect of zinc administration on the element contents and the grain yield of different chickpea varieties.

Variety	P in the seed (mg kg^{-1})	Phytic acid (mg 100 g^{-1})	N in the seed (%)	Zn in the leaves (mg kg^{-1})	Zn in the seed (mg kg^{-1})	Grain yield (kg da^{-1})	Medium chlorophyll content (mg g^{-1} fresh leaf weight)
1st year							
CANITEZ-87	5289 [c]	1145.3 [b]	2.73	116.09	121.69	267.61	1.841 [a]
ILC-482	6093 [a]	1297.1 [a]	2.67	146.19	126.06	203.56	1.719 [b]
GOKCE	5818 [b]	1263.8 [a]	2.47	127.57	123.57	248.79	1.863 [a]
LSD value P < 0.01	63.48	49.22	ns	ns	ns	ns	0.0899
2nd year							
CANITEZ-87	4757 [b]	1113.6	2.92	-	46.53	190.95	2.133 [a]
ILC-482	4826 [b]	1151.7	2.85	-	42.48	174.51	2.026 [b]
GOKCE	5142 [a]	1161.5	2.87	-	44.82	149.66	2.121 [a]
LSD value P < 0.01	82.47	ns	ns	-	ns	ns	0.0901

element in foods and its bioavailability. The recommended daily intake for adults is 12 to 15 mg (National Research Council, 1989); certain groups of people can be at risk with regard to Zn nutrition.

The Zn content in 60% of the agricultural soils located in the Central Anatolia Region of Turkey is below 0.5 mg kg^{-1}, which is accepted as the sufficient limit (Eyüpoglu et al., 1995). There are certain differences among the cultivated plant types in terms of their response to Zn deficiency (Graham and Rengel, 1993). Zn deficiency is commonly observed in a number of areas where chickpea is cultivated (Khan et al., 2000). There are difficulties encountered during the development period of the plant due to Zn deficiency and insufficiency of water required for irrigation in a great number of countries where chickpea production is significant (Khan et al., 2003). Zn deficiency impedes the root development of the chickpea plant by decreasing the uptake capacity of the plant in using the humidity reserve of the soil (Khan et al., 1998).

There are very few studies in our country conducted to determine the differences among the types of chickpea cultivated on Zn-deficient soils in terms of Zn efficiency. In a study conducted by Meyveci et al. (1998) under the conditions of Eskisehir province, low yield was obtained with Zn fertilization in approximately 30% of the advanced lines and populations of chickpea varieties adapted to the region and it was found that, these varieties were sensitive to Zn. It was reported that, the leaf chlorophyll content was related to the photosynthesis potential and production of the plant (Gitelson et al., 2003) and the low concentration of Zn (25 μM) addition induced chlorophyll content and high doses of Zn reduced the chlorophyll synthesis (Sharma et al., 2009).

The aim of the present study is to determine the response of chickpea varieties to different Zn applications, to find out the appropriate dose of zinc for the varieties and to determine the changes in the leaf chlorophyll content, phytic acid, zinc, nitrogen and phosphorus contents of grain.

MATERIALS AND METHODS

The experiment was conducted on the trial fields of the Bahri Dagdas International Agricultural Research Institute located in the Central Anatolia of Turkey. The results of the physical and chemical analysis performed on the soil samples taken from depths of 0 to 20 cm before the sowing process, are presented in Table 1.

The trial soils are highly calcareous, poor in Zn and show a clay loam character. The climate data and the long-year averages of the region where the experiment was conducted are presented in Table 2. When the table is examined, it can be seen that, 2003 was more arid when compared with long-year averages and 2004. Taking this state into consideration, during the experiments, three irrigations were implemented particularly in 2003 and one irrigation was implemented in 2004.

Seeds of ILC-482, Gokce-448 and Canitez-87 varieties used in the experiments were obtained from Ankara Field Crops and Eskisehir Agricultural Research Institutes. The study, the experiments of which consisted of four repetitions (0, 0.5, 1.0 and 1.5 kg Zn da^{-1}), was conducted according to the randomized complete block design with a split-plot design in which the four Zn application doses formed the blocks. In the first week of May before the experiment was set up, 100 kg of diammonium phosphate (DAP) per hectare was applied to all the plots and mixed with soil.

The main plots of the trial were 1.5x10 m. $ZnSO_4$ was applied to the soil as Zn fertilizer through a pulverize and then chickpea seeds were sown with a 30 cm distance between the rows and 10 cm distance within the rows (3 rows of each variety). The varieties that were ready to harvest were harvested by hand until the end of August to the middle of September, by taking the maturity of the plant into consideration. In order to determine the most favorable sampling time for assessing the leaf chlorophyll content, leaf samples were taken from the plants and chlorophyll measurements were performed (mg g^{-1} fresh leaf weight) every week throughout the experiment. Grain yield was determined after harvesting and then the seed and leaf samples taken from the plants were dried at 65°C and ground. Dried plant samples were digested using a H_2SO_4 and H_2O_2 mixture (Bayrakli, 1986). The amount of Zn existing in the solutions was measured by using ICP-AES (Varian Vista model) device, phosphorous was measured through an UV-160 spectrophotometer with Barton solution and nitrogen was measured by using a Kjhdahl distillation device (Soltanpour and Workman, 1981). The data obtained through the measurements were statistically analyzed using Minitab and Mstat software (Yurtsever, 1984).

RESULTS

The results of the experiment that was conducted in order to determine the effect of Zn fertilizer administration at different doses on the P, N, Zn and phytic acid content and the yield of chickpea varieties are presented in Tables 3 and 4. From Table 3, it can be seen that according to the variance analysis, there was no significant difference among the chickpea varieties regarding the N and Zn content in the seed, Zn content in the leaves and the grain yield values in the first year of the experiment. However, a significant difference was observed at the level of $P < 0.01$ among both varieties and the Zn administration doses regarding the P and phytic acid content in the seed. In a similar manner, the chlorophyll content in the leaves showed difference among the varieties for both years ($P < 0.01$). The values of P, phytic acid, N and Zn content in the seed and the Zn content in the leaf of ILC-482 variety was found to be higher when compared with other varieties. Grain yield was found to be higher in the Canitez-87 variety when compared with the other varieties of chickpea (267.61 kg da^{-1}) in the first year of the experiment. Similar to the findings of the first trial, the variance analysis did not show any significant differences among the chickpea varieties and the Zn doses regarding the phytic acid, N and Zn content in the seed and the yield values in the second year of the experiment. However, there were statistically significant differences among both the varieties and the Zn administration doses regarding only the P content in the seed ($P <0.01$).

Table 4 . The effect of different zinc administration on the element contents and the grain yield.

Zinc doses	Phosphorus in the seed (mg kg^{-1})	Phytic acid (mg100 g^{-1})	Nitrogen in the seed (%)	Zn in the leaves (mg kg^{-1})	Zn in the seed (mg kg^{-1})	Grain yield (kg da^{-1})	Medium chlorophyll content (mg g^{-1} fresh leaf weight)
1st year							
Zn_0	4733 ^{d}	1141.7 ^{c}	2.70	114.67 ^{ab}	117.42	280.46	1.841
Zn_1	5749 ^{b}	1267.4 ^{b}	2.59	162.24 ^{a}	124.71	222.23	1.777
Zn_2	7059 ^{a}	1372.4 ^{a}	2.66	109.34 ^{b}	128.58	240.05	1.778
Zn_3	5392 ^{c}	1160.3 ^{a}	2.55	133.58 ^{ab}	124.37	217.21	1.836
LSD value P < 0.01	63.48	60.28	ns	48.30	ns	ns	ns
2nd year							
Zn_0	4276 ^{d}	1078.9 ^{b}	2.91	-	45.38	178.44	2.076 ^{b}
Zn_1	5155 ^{b}	1233.2 ^{a}	2.78	-	43.50	178.99	2.035 ^{b}
Zn_2	5461 ^{a}	1194.2 ^{a}	2.93	-	46.78	183.63	2.196 ^{a}
Zn_3	4740 ^{c}	1062.7 ^{b}	2.91	-	42.78	145.77	2.065 ^{b}
LSD value P < 0.01	95.23	81.04	ns	ns	ns	ns	0.1047

When the two years of the experiment are compared, it can be seen that the grain yield in 2003 was found to be higher when compared with 2004. It is considered that this difference was caused by the additional irrigation that was performed due to inadequate precipitation. Furthermore, it was observed that the application of water decreased the grain Zn uptake (Table 4).

DISCUSSION

The effect of Zn application to different varieties of chickpea on grain yield was found to be statistically not significant. Comparing the values obtained in both years, it can be seen that grain yield varied on average between145.77 to 280.46 kg da^{-1} (Table 4). Zn application did not provide an increase in grain yield. It was found out that an increase in yield was maintained in Akcin and ILC varieties with the application of 10 kg Zn under the field conditions of Eskisehir (Meyveci et al., 1998). In a study conducted by Khan et al. (1998) on 13 chickpea varieties, it was reported that, the Zn application created different effects on the varieties regarding the dry matter production of the aerial parts. It was stated that the dry matter production maintained an increase in some varieties, whereas it did not cause a significant change in certain others at the end of the growing period.

The results of the correlation analysis revealed significant relationships between Zn content in the leaves and total chlorophyll concentration (3rd week) (r= 0.85*), Zn content in the seed and total chlorophyll concentration (9th week) (r= 0.77*), grain yield and total chlorophyll concentration (8th week) (r= 0.84**) in Canitez variety in the first year of the experiment; in the second year of the experiment, again in Canitez variety, significant relationships were found between grain yield and phosphorus content in the seed (r= 0.94**) and crop yield and zinc content in the seed (r= 0.75*). Leaf chlorophyll content is an important factor in determining the photosynthesis rate and dry matter production (Ghosh et al., 2004). Similarly, statistically significant relationships were observed through the correlation analysis performed on the data obtained in the experiment at the level of P < 0.05 between phytic acid and phosphorus content in the seed, between zinc and phytic acid in the

Table 5. The results of the correlation analysis among the element contents. yield and weekly chlorophyll concentrations of chickpea varieties following the zinc application (1st year trial) (*: P < 0.05; **: P < 0.01).

Varieties	**CANITEZ -87**						**ILC-482**						**GOKCE**					
1st year	**P (mg kg^{-1})**	**Phytic acid (mg 100g^{-1})**	**N (%)**	**Zn in leaf (mg kg^{-1})**	**Zn in seed (mg kg^{-1})**	**Grain Yield (kg da^{-1})**	**P (mg kg^{-1})**	**Phytic acid (mg 100 g^{-1})**	**N (%)**	**Zn in leaf(mg kg^{-1})**	**Zn in seed(mg kg^{-1})**	**Grain Yield(kg da^{-1})**	**P (mg kg^{-1})**	**Phytic acid(mg 100 g^{-1})**	**N (%)**	**Zn in leaf(mg kg^{-1})**	**Zn in seed(mg kg^{-1})**	**Grain Yield (kg da^{-1})**
Phytic acid	0.08						0.87*						0.98**					
N	-0.40	0.40					-0.34	-0.38					0.09	0.24				
Zn in leaf	0.17	0.29	-0.01				0.01	0.09	-0.30				-0.22	-0.17	0.17			
Zn in seed	0.48	0.73*	0.07	0.19			0.28	0.49	-0.23	-0.19			0.18	0.28	0.55	0.001		
Yield	0.14	0.28	-0.25	-0.20	0.10		-0.74*	-0.38	-0.12	0.06	0.29		-0.41	-0.38	-0.05	0.00	-0.42	
Chlo. 1st week	0.17	0.76*	-0.08	-0.10	0.72*	0.47	-0.29	0.10	-0.22	0.28	0.51	0.72*	-0.29	-0.17	0.71*	-0.23	0.51	0.34
Chlo. 2nd week	-0.59	-0.44	-0.11	-0.17	-0.68	0.24	0.48	0.41	0.58	0.02	-0.17	-0.38	-0.23	-0.26	-0.56	0.27	-0.78*	0.54
Chlo. 3rd week	-0.12	0.32	0.39	0.85*	0.04	-0.33	-0.25	-0.44	0.27	-0.37	-0.02	0.04	0.38	0.50	0.31	-0.05	0.72*	-0.13
Chlo. 4th week	-0.14	-0.54	-0.21	-0.43	-0.33	0.43	-0.28	-0.34	0.22	-0.32	0.50	0.23	0.29	0.23	-0.45	-0.22	-0.78*	0.36
Chlo.5th week	-0.14	0.02	0.15	0.64	-0.23	-0.66	-0.51	-0.72*	-0.09	-0.06	-0.72*	0.11	0.20	0.29	0.45	-0.26	0.72*	0.18
Chlo.6th week	-0.15	0.58	-0.11	0.15	0.52	0.44	-0.30	0.02	0.02	0.69	-0.29	0.36	0.37	0.38	-0.13	0.28	0.38	-0.39

seed and between the leaf chlorophyll content sampled every week and zinc, grain yield and phytic acid in the seed and nitrogen in the seed, also in other chickpea varieties (Tables 5 to 6). The correlation relationships were observed to be higher during the 5th sampling period (the beginning of flowering) as the time of chlorophyll sampling. Therefore, it could be suggested that the determination of the chlorophyll content should be performed in the flowering period.

In conclusion, the application of zinc fertilizer did not provide a significant increase in the yield of chickpea varieties that are used in the present study and widely cultivated in Konya. The only increase was observed in the P and phytic acid content in the seed through the application of 1.0 kg Zn da^{-1}.

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Table 5. Contd.

Chlo. 7th week	-0.02	-0.17	-0.06	-0.63	-0.14	-0.28	0.01	-0.26	-0.18	0.66	-0.55	-0.30	-0.07	-0.10	0.50	0.06	0.02	-0.21
Chlo.8th week	-0.10	0.20	0.15	-0.17	-0.24	0.84**	-0.17	-0.14	0.50	-0.01	-0.37	-0.23	0.44	0.42	0.35	0.03	-0.01	0.01
Chlo.9th week	0.49	0.67	0.19	0.48	0.77*	-0.18	-0.27	0.10	-0.32	0.34	0.33	0.59	-0.21	-0.17	0.40	-0.57	-0.15	0.44
Chlo.10th week	0.34	-0.22	-0.21	0.28	0.28	-0.74*	-0.57	-0.52	0.39	-0.40	-0.41	0.35	-0.49	-0.54	-0.80*	-0.05	-0.43	0.43

Table 6. The results of the correlation analysis among the element contents. yield and weekly chlorophyll concentrations of chickpea varieties following the zinc application (2nd year trial)(*: P < 0.05; **: P < 0.01).

Varieties	**CANITEZ -87**					**ILC-482**					**GOKCE**				
2nd years	**P (mg kg-1)**	**Phytic acid (mg 100 g-1)**	**N (%)**	**Zn in seed (mg kg-1)**	**Grain yield (kg da-1)**	**P (mg kg-1)**	**Phytic acid (mg100 g-1)**	**N (%)**	**Zn in seed (mg kg-1)**	**Grain yield (kg da-1)**	**P (mg kg-1)**	**Phytic acid (mg 100 g-1)**	**N (%)**	**Zn in seed (mg kg-1)**	**Grain yield (kg da-1)**
Phytic acid	0.94**					0.81					0.49				
N	0.33	0.53				-0.12	0.02				0.02	-0.14			
Zn in seed	-0.11	-0.18	-0.27			-0.04	-0.10	0.18			0.22	-0.01	0.51		
Yield	-0.01	0.01	-0.14	-0.75*		0.75*	0.67	-0.01	0.24		-0.43	0.01	-0.33	0.22	
Chlo.1st week	-0.50	-0.66	-0.51	0.10	0.13	0.82	0.93**	-0.14	-0.11	0.78*	0.40	0.08	-0.27	0.43	-0.06
Chlo. 2nd week	0.39	0.42	0.06	-0.15	-0.30	0.02	0.14	-0.64	-0.81	-0.25	-0.03	-0.32	-0.56	-0.24	0.04
Chlo. 3rd week	0.50	0.45	0.36	0.32	-0.48	0.59	0.77*	-0.16	0.03	0.35	0.62	0.07	-0.22	-0.08	-0.58
Chlo. 4th week	0.20	0.17	0.09	-0.31	0.60	-0.28	-0.49	-0.21	0.64	0.17	-0.27	-0.06	-0.47	-0.47	-0.01
Chlo. 5th week	0.48	0.55	0.34	-0.43	0.44	0.72*	0.88**	-0.11	-0.22	0.65	0.34	0.00	0.35	-0.09	-0.39
Chlo. 6th week	0.28	0.11	-0.25	0.43	0.03	-0.33	-0.65	-0.37	0.14	0.02	0.34	0.70*	0.56	0.46	-0.10
Chlo.7th week	-0.06	0.00	-0.08	-0.72*	0.95	-0.16	-0.30	-0.39	0.21	0.24	0.03	-0.67	-0.01	0.47	0.16
Chlo.8th week	0.36	0.21	0.00	-0.58	0.46	-0.37	-0.54	-0.27	0.44	-0.05	-0.05	0.56	0.18	0.17	0.52
Chlo.9th week	-0.08	-0.22	-0.12	0.21	-0.35	-0.65	-0.82*	-0.21	-0.37	-0.53	0.22	0.40	0.40	0.05	0.00

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