ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

The Effects of Zinc Application on the Copper Contents of Some Peanut (Arachis Hypogaea) Varieties in the Çukurova Region of Turkey

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ABSTRACT

In this study, the effects of zinc application on copper contents of leaf and grain of two peanut varieties were investigated in the Çukurova Region in Turkey. Also correlation between copper content of soil and copper content of peanut plant were investigated in the study. The copper contents of soil samples collected from each experimental plot of NC-7 variety changed between 0.78 mg kg^{-1} and 0.96 mg kg^{-1} in 2006. The copper contents of soil samples of experimental plot of ÇOM variety ranged from 1.50 mg kg^{-1} and 1.86 mg kg^{-1}. While copper contents of soil samples of experimental plot of ÇOM variety were higher than 1.00 mg kg^{-1} which critical level for a lot of plants, the copper contents of soil samples of experimental plot of NC-7 variety were lower than 1.00 mg kg^{-1}. While the copper content of grain samples of NC-7 variety are changed between 8.00 mg kg^{-1} and 16.00 mg kg^{-1}, the copper content of grain samples of ÇOM variety are changed between 11.00 mg kg^{-1} and 18.00 mg kg^{-1} in 2006. While the copper contents of soil samples collected from each experimental plot of NC-7 variety changed between 1.10 mg kg^{-1} and 1.40 mg kg^{-1}, the copper contents of soil samples of ÇOM variety ranged from 0.90 mg kg^{-1} to 1.34 mg kg^{-1} in 2007. While there are positive correlation between copper content of soil and copper content of grain of NC-7 variety, there are negative correlation between copper content of soil and copper content of leaf in 2006 and 2007. Also, there is positive correlation between copper content of soil and copper content of leaf of ÇOM variety, there are negative correlation between copper content of soil and copper content of grain in each years. Also there is negative correlation between copper content of leaf of ÇOM variety and P contents of grain in 2007. This correlation was statistically significant ($P<0.01$). While there are positive correlation between dozes of Zn application and contents of leaf and grain of NC–7 variety, there negative correlation between Zn application and contents of leaf and grain of ÇOM variety in 2006. But this correlation was statistically insignificant. The negative correlation between dozes of Zn application and contents of leaf of ÇOM variety was statistically 0.05 level significant in 2007.

Keywords: Micro nutrient, zinc, copper, peanut.

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ISSN: 0975-8585

INTRODUCTION

It has been known that peanut (Arachis Hypogaea)is an important oil seed crop and food grain legume. It contains about 50 % oil, 25 % protein, 20% carbohydrate and 5 % fiber and ash which make a substantial contribution to human nutrition [1-3].

Previous some studies have shown that the importance role of micro nutrient element in human and plant nutrition. Insufficient content of micronutrient elements such as Zn, Fe in soil has negative effects on the development of crops and human health. Micro nutrient element deficiencies like zinc and iron bring out some serious health problems especially in children at developing age. In this respect, micronutrient elements exhibit a profound significance for the condition of human health as much as they do for a successful production of crops [4]

In this study, the effects of zinc application on copper contents of leaf and grain of two peanut varieties (ÇOM and NC–7) were investigated in the Çukurova Region in Turkey. Also the correlation between copper content of soil and copper content of peanut plant were investigated in the study.

MATERIAL AND METHODS

Material

The field experiments were carried out in Eastern Mediterranean Agricultural Research Institute, in Adana, Turkey. The Mediterranean climate is dominated in the region in which is mild and rainy in winter and hot and dry in summer. Total rainfall measured was 575, 5 mm in 2006, and 588.6 mm in 2007 [5, 6]. Soil temperature regime is thermic and moisture regime is Xeric [7]. Wheat, corn, cotton, soybean, peanut, sunflower, melon water and rapeseed are the cultivated field crops in the region.

Methods

The soil samples were taken from 0-30 cm depth from each of experiment plot, and dried, and passed through 2 mm sieve for chemical analyses. Soluble salt, $CaCO_3$, pH, organic matter, texture, available P_2O_5 and K_2O contents were performed by known methods [8-10]. Copper analysis of soil samples, leaf and grain were carried out according to DTPA method (Dietilentriaminpentaasetikasit) [11].

In 2006 and 2007, a variety-dose experiment was established according to the split plot design that was splited in the randomized blocks. The main plot types were split plot applications and split plots which were planned to form doses. Zero, 10, 20 and 40 kg Zn ha^{-1} were applied in the form of $ZnSO_4$ before cultivation. In the leaf zinc application 0, 0.5, 1 and 1.5 kg ha^{-1} pure zinc doses were applied as $ZnSO_4$ solution. Nitrogen at a rate of 180 kg ha^{-1} and 80 kg ha^{-1} P_2O_5 were applied to each plot. Foliar applications were carried out three times following the flowering period with twenty day intervals. Leaf and grain samples were taken from each of experiment plots for copper analyses. Leaf samples were taken after the flowering period. Grain samples were taken after harvest. The data were evaluated according to the variance analysis in statistic program (Jump 5.0).

RESULTS AND DISCUSSION

Some Physical and Chemical Characteristics of Soils

Some physical and chemical characteristics of experiment plots' soils in 2006 were presented in Table 1. pH values ranged from 7.78 to 7.89. Soils were neutral and slightly alkaline (12). Total soluble salt contents of soil samples changed between 0.022 % and 0.02 7%. Lime content varied between 15.00 % to and 17.00%. Organic matter contents are low and ranged from 1.36 % to 1.55 %. Plant available P_2O_5 content ranged from 29.0 to 36.0 kg ha^{-1}. It is known that excessive phosphorus in soils interacts with extractable some microelements. Although the mechanism of this interaction hasn't been clearly explained, previous studies have shown that excessive phosphorus converts some microelements into non-active form within the plant [4, 13-16]

Table 1: Some physical and chemical characteristics of experiment plots in 2006

Mode of Application	Dose kg ha^{-1}	Soluble salt %	pH 1/1	$CaCO_3$ %	Organic matter %	Available P_2O_5 kg ha^{-1}	Available K_2O kg ha^{-1}	Sand %	Silt %	Clay %
Soil	0	0.027	7.80	17	1.36	36.0	860.0	27.4	42.0	30.6
	10	0.026	7.79	16	1.42	34.0	890.0	27.3	42.1	30.6
	20	0.022	7.89	16	1.36	32.0	920.0	29.0	40.4	30.6
	40	0.026	7.82	16	1.42	29.0	890.0	30.4	39.0	30.6
Foliar	0	0.022	7.78	16	1.36	29.0	890.0	26.9	40.8	32.3
	0.5	0.023	7.79	16	1.42	29.0	920.0	26.2	41.4	32.4
	1	0.024	7.82	15	1.55	34.0	890.0	26.2	41.0	32.8
	1.5	0.026	7.80	15	1.39	36.0	920.0	27.1	42.2	30.7

Plant available K_2O content was high and ranged from 860.0 kg ha^{-1} to 920.0 kg ha^{-1}. Soil textures were loamy and clayey loamy. Sand content changed between 26.2 % and 30.4 %, silt content changed between 39.0.0 % and 42.2 %, clay content changed between 30.6 % and 32.8 % in 2006 (Table 1).

Some physical and chemical characteristics of experiment plots' soils in 2007 were presented in Table 2. According to results of laboratory analysis total soluble salt contents of soil samples changed between 0.016 % and 0.029 %. pH values ranged from 7.86 to 8.02 in 2007. Lime content varied between 15.20 % to and 19.76 %. Organic matter contents are low and ranged from 0.75 % to 1.41%. Plant available P_2O_5 content ranged from 28.7 to 52.0 kg ha^{-1}. Plant available K_2O content was very high and ranged from 603.2 kg ha^{-1} to 892.7 kg ha^{-1}. Soil textures were loamy and clayey loamy (12). Sand content changed between 24.4 % and

32.9%, silt content changed between 38.0% and 41.5%, clay content changed between 28.6% and 33.9% in 2006 (Table 2).

Table 2: Some physical and chemical characteristics of experiment plots in 2007

Mode of Application	Dose kg ha^{-1}	Soluble Salt %	pH 1/1	$CaCO_3$ %	Organic matter %	Available P_2O_5 kg ha^{-1}	Available K_2O kg ha^{-1}	Sand %	Silt %	Clay %
Soil	0	0.016	7.96	18.43	1.09	28.7	603.2	31.8	38.0	30.2
	10	0.021	8.02	15.20	0.81	35.7	657.2	28.6	40.1	31.3
	20	0.021	7.91	19.76	0.84	39.6	630.0	30.3	39.0	30.7
	40	0.023	7.86	18.24	0.75	52.0	603.2	32.9	38.6	28.6
Foliar	0	0.023	7.99	17.48	1.00	34.9	713.1	29.6	38.1	32.3
	0.5	0.024	7.95	17.67	1.06	42.7	892.7	26.9	40.3	32.7
	1	0.023	8.00	17.29	0.97	34.2	713.1	27.7	39.0	33.3
	1.5	0.029	7.92	16.53	1.41	4.11	830.8	24.4	41.5	33.9

The Correlation between Copper Contents of Soils and Copper Contents of Leaf and Grains

Copper contents of experiment plots' soils, leaves and grain samples in 2006 were presented in Table 3. The copper contents of soil samples taken from experiment plots of NC–7 variety in 2006 varied from 0.78 mg kg^{-1} to 0.96 mg kg^{-1}and 1.50 mg kg^{-1} and 1.86 mg kg^{-1}for COM variety. The copper content of soils in Çukurova Region was also reported as low by Irmak et al. [4].

The leaf copper contents of NC-7 variety in 2006 changed between 2.00 mg kg^{-1} and 9.00 mg kg^{-1}, the leaf copper contents of COM variety changed between 3.00 mg kg^{-1} and 9.00 mg kg^{-1}. The grain copper contents of NC-7 variety in 2006 ranged from 8.00 mg kg^{-1} to 16.00 mg kg^{-1} and for ÇOM variety grain copper contents varied from 12.00 mg kg^{-1} to 18.00 mg kg^{-1}. The grain P contents of NC-7 variety in 2006 changed between 0.40 % and 0.45 %, and for COM variety changed between 0.35 % and 0.40 %. The copper contents of soil samples were lower than deficiency critical level of 1.00 mg kg^{-1} for NC-7 variety.

While there are positive correlation between copper content of soil and copper content of grain of NC-7 variety, there is negative correlation between copper content of soil and copper content of leaf in 2006. Also, there is positive correlation between copper content of soil and copper content of leaf of ÇOM variety, there are negative correlation between copper content of soil and copper content of grain in each years. This correlation was statistically significant ($P<0.01$).

The copper contents of experiment plots' soils, leaves and grain samples in 2007 were presented in Table 4. The copper contents of soil samples taken from experiment plots of NC-7 variety in 2006 varied from 1.10 mg kg^{-1} to 1.40 mg kg^{-1}and 0.90 mg kg^{-1} and 1.34 mg kg^{-1} for COM variety. The copper content of the leaf samples from NC-7 variety changed between 2.40 mg kg^{-1} and 3.30 mg kg^{-1} and from COM variety changed between 2.90 mg kg^{-1} and 37.70 mg kg^{-1}(Table 4). While the copper content of grain samples of NC-7 variety changed between 14.00

mg kg^{-1} and 33.60 mg kg^{-1}, the copper content of grain samples of ÇOM variety changed between 15.06 mg kg^{-1} and 28.59 mg kg^{-1}. The grain P content from NC-7 variety in 2007 changed between 0.45 % and 0.58 %. The grain P content from COM variety in 2006 changed between 0.47 % ile 0.51 %. The results indicated that P contents of the grain were higher in 2007 for both species. While the copper content of grain samples of NC-7 variety changed between 14.00 mg kg^{-1} and 33.60 mg kg^{-1}, the copper content of grain samples of ÇOM variety changed between 15.06 mg kg^{-1} and 28.59 mg kg^{-1}.

While there are positive correlation between copper content of soil and copper content of grain of NC-7 variety, there is negative correlation between copper content of soil and copper content of leaf in 2007. Also, there is positive correlation between copper content of soil and copper content of leaf of ÇOM variety, there are negative correlation between copper content of soil and copper content of grain in each years. Also there is negative correlation between copper content of leaf of ÇOM variety and P contents of grain in 2007. This correlation was statistically significant ($P<0.01$).

Relationship between Zinc Application and Copper Contents of Leaf and Grain Samples

Relationship between zinc application and copper contents of leaf and grain samples in 2006 were presented in Table 3. The doses of Zn applications on soil and foliar and copper contents of the leaf samples had an inverse relation. While the copper content of leaf samples in control of NC-7 variety for Zn application on soil was 8.00 mg kg^{-1}, the copper content of leaf samples applied with second dose Zn of 10 kg ha^{-1} realized as 5.00 mg kg^{-1}. The copper content of leaf samples was 7.00 mg kg^{-1} in third dose of 20 kg ha^{-1} as well as 9.00 mg kg^{-1} in fourth dose of 40 kg ha^{-1}. Similarly while the copper content of leaf samples of control plot of COM variety for Zn application on soil was 6.00 mg kg^{-1}, the copper content of leaf samples applied with the second dose Zn of 10 kg ha^{-1} realized as 5.00 mg kg^{-1}. The copper contents of the leaf samples increased as applied Zn doses decreased and the copper content of leaf samples was 3.00 mg kg^{-1} in third dose of 20 kg Zn ha^{-1} as well as 5.00 mg kg^{-1} in the fourth dose of 40 kg Zn ha^{-1}. Statistically significant ($P<0.05$) negative relationship was occurred between Zn application on soil and copper contents of leaf samples for both species.

Table 3: Copper Contents of Soil, Leaf and Grain Samples in 2006.

Mode of Application	Dose kg ha^{-1}	Cu content of soil mg kg^{-1}		Cu content of leaf mg kg^{-1}		Cu content of grain mg kg^{-1}		P content of grain %	
		NC-7 variety	ÇOM variety	NC-7 variety	ÇOM variety	NC-7 variety	ÇOM variety	NC-7 variety	ÇOM variety
Soil	0	0.94	1.70	8.00	6.00	15.00	18.00	0.43	0.35
	10	0.78	1.60	5.00	5.00	16.00	15.00	0.42	0.40
	20	0.90	1.60	7.00	3.00	15.00	15.00	0.42	0.38
	40	0.86	1.50	9.00	5.00	14.00	13.00	0.41	0.36
Foliar	0	0.86	1.72	-	9.00	8.00	12.00	0.41	0.38
	0.5	0.96	1.76	3.00	5.00	12.00	11.00	0.40	0.35
	1	0.92	1.86	2.00	5.00	12.00	14.00	0.45	0.36
	1.5	0.78	1.74	6.00	4.00	8.00	15.00	0.42	0.39

Table 4: Copper Contents of Soil, Leaf and Grain Samples in 2007.

Mode of Application	Dose kg ha^{-1}	Cu content of soil mg kg^{-1}		Cu content of leaf mg kg^{-1}		Cu content of grain mg kg^{-1}		P content of grain %	
		NC-7 Variety	ÇOM variety	NC-7 Variety	ÇOM variety	NC-7 variety	ÇOM variety	NC-7 variety	ÇOM variety
Soil	0	1.10	0.96	3.10	2.60	27.92	28.59	0.53	0.47
	10	1.32	0.90	3.10	2.90	30.38	24.14	0.52	0.49
	20	1.28	0.92	2.40	3.40	14.00	22.63	0.58	0.48
	40	1.38	0.96	3.20	3.10	32.89	15.06	0.51	0.51
Foliar	0	1.40	1.10	2.10	7.50	33.37	26.15	0.49	0.47
	0.5	1.24	1.06	3.20	4.10	22.74	26.35	0.47	0.48
	1	1.38	1.18	3.30	3.60	33.60	24.26	0.48	0.49
	1.5	1.38	1.34	3.10	2.90	22.02	26.93	0.45	0.49

The grain copper content of control plot for NC-7 variety in soil Zn application was 15.00 mg kg^{-1}, the copper content of grain samples applied with the second dose kg Zn ha^{-1} realized as 16.00 mg kg^{-1}. The copper content of grain samples was 15.00 mg kg^{-1} in the third dose of 20 kg Zn ha^{-1} as well as 14.00 mg kg^{-1} in the fourth dose of 40 kg Zn ha^{-1}. The grain copper contents decreased as Zn doses increased for NC-7 variety. But, the correlation between soil Zn application and grain copper contents was not statistically significant. Similarly the grain copper contents of COM variety decreased as applied Zn doses increased in 2006. While the copper content of grain samples in control plot of COM variety for soil Zn application was 18.00 mg kg^{-1}, the grain copper content applied with the second dose 10 kg Zn ha^{-1} realized as 15.00 mg kg^{-1}. The grain copper content applied with the third dose 20 kg Zn ha^{-1} realized as 15.00 mg kg^{-1} and the fourth dose of 40 kg Zn ha^{-1}realized as 13.00 mg kg^{-1}.

Similar results were obtained for the foliar Zn application in 2006. While the leaf copper contents in zero dose of NC-7 variety for foliar Zn application was 5.00 mg kg^{-1}, the leaf copper content applied with the second dose 0.5 kg Zn ha^{-1} realized also as 3.00 mg kg^{-1}. However, the leaf copper content of NC-7 variety was lowered to 2.00 mg kg^{-1} with 1 kg Zn ha^{-1} application. The copper content of leaf samples was increased to 6.00 mg kg^{-1} with 1.5 kg Zn ha^{-1}. Similar results were obtained for the foliar Zn application for COM variety. The leaf copper contents of COM variety in zero dose of foliar Zn application was 9.00 mg kg^{-1}, the leaf copper contents applied with the second dose 0.5 kg Zn ha^{-1} realized as 5.00 mg kg^{-1}. The leaf copper contents of COM variety is 5.00 mg kg^{-1} for 1 kg Zn ha^{-1} dose of foliar Zn application and is 4.00 mg kg^{-1} for doze 1.5 kg Zn ha^{-1}.

The grain copper content of in zero dose of NC-7 variety for foliar Zn application was 8.00 mg kg^{-1}; the copper content of grain samples applied with the second dose 0.5 kg Zn ha^{-1} realized also as12.00 mg kg^{-1}. The grain copper contents applied with the third dose 1 kg Zn ha^{-1} realized as 12.00 mg kg^{-1} and with the fourth doze 1.5 kg Zn ha^{-1} realized as 8.00 mg kg^{-1}. Similar results were obtained for the foliar Zn application for COM variety. The grain copper content of COM variety in zero dose of foliar Zn application was 12.00 mg kg^{-1}, the grain copper content applied with the second dose 0.5 kg Zn ha^{-1} realized as 11.00 mg kg^{-1}. The grain copper content of COM variety was14.00 mgkg^{-1} for 1 kg Zn ha^{-1} dose of Zn application foliar and was 15.00 mg kg^{-1} for 1.5 kg Zn ha^{-1} application dose (Table 3).

Relationship between zinc application and copper contents of leaf and grain samples in 2007 were presented in Table 4. While the copper content of leaf samples in control of NC-7 variety for Zn application on soil was 3.10 mg kg^{-1}, the copper content of leaf samples applied with second dose Zn of 10 kg ha^{-1} realized as 3.10 mg kg^{-1}. The copper content of leaf samples was 2.40 mg kg^{-1} in third dose of 20 kg ha^{-1} as well as 3.20 mg kg^{-1} in fourth dose of 40 kg ha^{-1}. Similarly while the copper content of leaf samples of control plot of COM variety for Zn application on soil was 2.60 mg kg^{-1}, the copper content of leaf samples applied with the second dose Zn of 10 kg ha^{-1} realized as 2.90 mg kg^{-1}. The copper contents of the leaf samples increased as applied Zn doses increased and the copper content of leaf samples was 3.40 mg kg^{-1} in third dose of 20 kg Zn ha^{-1} as well as 3.10 mg kg^{-1} in the fourth dose of 40 kg Zn ha^{-1}. Statistically significant ($P<0.05$) negative relationship was occurred between Zn application on soil and copper contents of leaf samples for both species.

The leaf copper content of NC-7 variety in zero dose of foliar Zn application was 2.10 mg kg^{-1}, the leaf copper content applied with the second dose 0.5 kg Zn ha^{-1} realized as 3.20 mg kg^{-1} by presenting an increase in 2007. However, the leaf copper content of NC-7 variety was 3.30 mg kg^{-1} with 1 kg Zn ha^{-1} dose and was 3.10 mg kg^{-1} with 1.5 kg Zn ha^{-1} dose. Similar results were obtained for the foliar Zn application for COM variety. The leaf copper content of COM variety in zero dose of foliar Zn application was 7.50 mg kg^{-1}, the leaf copper content applied with the second dose 0.5 kg Zn ha^{-1} realized as 4.10 mg kg^{-1} by presenting a decrease. The leaf copper content of COM variety was 3.60 mg kg^{-1} for 1 kg Zn ha^{-1} dose of foliar Zn application and was 2.90 mg kg^{-1} for doze 1.5 kg Zn ha^{-1}. The negative correlation between dozes of Zn application and contents of leaf of ÇOM variety was statistically 0.05 level significant in 2007.

The grain copper content of NC–7 variety in zero doses for soil Zn application was 27.92 mg kg^{-1}, the grain copper content applied with the second dose of 10 kg Zn ha^{-1} realized as 30.38 mg kg^{-1} by presenting an increase in 2007. The grain copper content was 14.00 mg kg^{-1} in the third dose of 20 kg Zn ha^{-1} and realized as 32.89 mg kg^{-1} in the fourth dose of 40 kg Zn ha^{-1}. Similarly the grain copper content of COM variety zero dose of for soil Zn application was 28.59 mg kg^{-1}, the grain copper content applied with the second dose of 10 Zn ha^{-1} realized as 24.14 mgkg^{-1}. The grain copper contents decreased as applied Zn doses increased and the grain copper content was 22.63 mg kg^{-1} in the third dose of 20 kg Zn ha^{-1} realized as 15.06 mg kg^{-1} in the fourth dose of 40 kg Zn ha^{-1}.

The grain copper content of NC–7 variety in zero dose of foliar Zn application was 33.37 mg kg^{-1}, the grain copper content applied with the second dose 0.5 kg Zn ha^{-1} realized as 22.74 mg kg^{-1} by presenting a decrease. The grain copper content applied with the third dose 1 kg Zn ha^{-1} realized as 33.60 mg kg^{-1} and with the fourth doze 1.5 kg Zn ha^{-1} realized as22.02 mg kg^{-1}. Similarly the grain copper content of COM variety in zero dose of foliar Zn application was 26.15 mg kg^{-1}, the grain copper content applied with the second dose 0.5 kg Zn ha^{-1} realized as

26.35 mg kg^{-1}. The grain copper content of COM variety was 24.26 mg kg^{-1} for 1 kg Zn ha^{-1} dose of Zn application foliar and was 26.93 mg kg^{-1} for doze 1.5 kg Zn ha^{-1}.

CONCLUSION

While there are positive correlation between copper content of soil and copper content of grain of NC-7 variety, there are negative correlation between copper content of soil and copper content of leaf in 2006 and 2007. Also, there is positive correlation between copper content of soil and copper content of leaf of ÇOM variety, there are negative correlation between copper content of soil and copper content of grain in each years. Also there is negative correlation between copper content of leaf of ÇOM variety and P contents of grain in 2007. This correlation was statistically significant ($P<0.01$). While there are positive correlation between dozes of Zn application and contents of leaf and grain of NC–7 variety, there negative correlation between Zn application and contents of leaf and grain of ÇOM variety in 2006. But this correlation was statistically insignificant. The negative correlation between dozes of Zn application and contents of leaf of ÇOM variety was statistically 0.05 level significant in 2007.

REFERENCES

[1] Fageria NK, Baligar VC and Jones C. Growth and Mineral Nutrition of Field Crops 2nd Ed Marcel Dekker Inc New York 1001 k 1997; 494.
[2] Arıoğlu H, Çalışkan S, Söğüt T, Güllüoğlu L, Zaimoğlu B, Türkiye I. Yağlı Tohumlar Bitkisel Yağlar ve Teknolojileri Sempozyumu 2003, İstanbul.
[3] FAO 200. Statical Department Online Web site http://www.fao.org
[4] Irmak S, Sürücü AK and Aydin S. Int J Soil Sci 2008; 3:109-118.
[5] Climatic Data Cukurova Agricultural Research Institude Meteorology Center 2006; Adana Turkey.
[6] Climatic Data Cukurova Agricultural Research Institude Meteorology Center 2007; Adana Turkey.
[7] Soil Survey Staff USDA 19 th Ed. USA 2006; 341.
[8] Black CA. Part 2 Am Soc Agron No 9 Madison WI 1965; 1572.
[9] McKeague JA. Canada Soc Soil Science Ottawa Canada edn 2, 1978.
[10] Nelson DW and Sommers LE. Part 3 Am Soc Agron Madison WI 1996; 961-1010.
[11] Lindsay WL and WA. Norvell Soil Sci Soci Ame Journ 1978; 42:421-428.
[12] U S Salinity Lab Staff Agr Handbook 60 USDA Washington D 1954; 83-147.
[13] Brown JC and Tiffin LO. Soil Sci 1960; 89:8-15.
[14] Cakmak İ, Torun B, Erenoğlu B, Öztürk L, Marschner H, Kalaycı M, Ekiz H and Yılmaz A. Euphytica 1998; 100:349-357.
[15] Erdal İ, Bozkurt MA and Mesut K. Tarım Bılımlerı Dergısı 2000; 3:91–96.
[16] Cakmak İ, Pfeiffer WH and McClafferty B. Cereal Chem 2010; 87:10–20.