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THE EFFECT OF GENOTYPE AND ZINC ON SEEDLING GROWTH IN FOUR WHEAT CULTIVARS (*T. AESTIVIUM* L.)

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Abstract

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Effects of application of zinc (Zn) (0 and 10 mg kg^{-1} soil) and four genotypes (Bezostaja-I, Katea-I, Momtchill and Pehlivan) on accumulations in shoots and roots of winter wheat (*Triticum aestivum* L.) seedlings were investigated in a pot experiment. After starting emergence, five harvests were made on 6, 12, 17, 22 and 27 days after emergence and, shoot and root growth were observed for each harvest date. According to results of the research, the diffences among wheat cultivars were mostly significant for all characters. Among cultivars, Momtchill and Pehlivan were durable for drought, Bezostaja-I and Katea-I were susceptible for drought. Zinc application resulted in increase in shoot dry matter production while it resulted in decreases root-length, root dry weight, root/shoot ratio, root length density, and root growth rate. In the end of research, it was found that application of zinc (10 mg kg^{-1} soil) on these cultivars limited the root growth, encouraged the shoot growth and this may cause the deficiency of water and nutrients in dry conditions for these genotypes.

Key words: zinc, wheat, root and shoot development

Introduction

Micronutrient deficient soils are widespread; many millions hectares of arable land worldwide are deficient in one or more micronutrient elements (Welch et al., 1991). For example, Zn deficiency was reported for the soils of various characteristics: high and low pH, high and low organic matter, calcareous, sodic, sandy, wetland or ill drained and limed acid soils etc. (Takkar and Brennan, 1993). Zinc deficiency is probably the most widespread micronutrient deficiency in cereals (Graham et al., 1992), especially in wheat, limiting grain yield, for example in Australia, India (Takkar and Brennan, 1993) and Turkey (Cakmak et al., 1996). Zinc deficiency is a common nutritional problem for plants, particularly for cereals grown on calcareous soils of arid and semi arid regions, resulting in severe decreases in grain yield (Graham et al., 1992; Kalaycy et al., 1998; Sonmez and Kiral, 2004).

Millions of hectares of cultivated areas in Turkey are also deficient in Zn. About 50 % of arable soils in Turkey are reported to be Zn deficient (Kalfa et al., 1998). Zinc deficiency in Turkey is particularly pronounced in Central Anatolia which is the major wheat growing area (4.5 millions ha) of Turkey. Zinc deficiency is a common problem in soils in arid and semi arid region (Kalfa et al., 1998) and a great part of wheat farming (70 %) in Turkey has been cultivated in arid and semi arid. There are two major problems in dry lands such drought and Zn deficiency decreasing the grain yield. Correction of drought problem is not easy because irrigation is not possible everywhere while Zn deficiency is corrected by Zn fertilizer application. Therefore, the resistant genotypes to drought and proper cultivation techniques

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have to be used in drought regions in order to increase yield.

In wheat farming, using of zinc fertilizer have recently increased because of its importance, but on the other hand, unconsciously using of zinc fertilizer can bring unknown some risks. Where drought is a major problem and heavy winter conditions are, growing status of wheat seedlings in first stages has great importance point of view resistance to heavy winter and drought conditions and yield. Factors such genotype, climate, soil, nitrogen fertilization, seed size and seed reserve material affect the seedling vigour (Peacok and Hawkins, 1970; Das Gupta and Austenson, 1973; Bulisani and Warmer, 1980). Good developed roots in first stages strongly increase the resistance to the drought and winter. Two of the factors, which affect the seedling vigour, are Zn in seed and available Zn level in soil (Graham and Renegel, 1993; Dong et al., 1995; Rengel and Graham, 1995; Rengel and Wheal, 1997). In regions, which has drought, problem and irrigation is not possible, and mostly genotypes having good developed root are preferred in order to benefit water in the soil. In addition, Zn fertilization is suggested because Zn deficiency is a problem in arid and semi arid regions.

On the other hand, in done some studies (Çakmak et al., 1996; Erenoglu et al., 1999; Alam and Shereen, 2002; Zhao et al., 2005), it was found that Zn application in wheat negatively affected the root developing and increased shoot growing, and decreased root/shoot ratio in early growing stages. The result conflicts with the suggestion in wheat farming in arid and semi arid regions. Fast developing of shoot in early stages may cause consumption of limited water in the soil and water stress in heading and grain-filing period, which are the most critic periods for cereals, and winter damage in heavy winter conditions because the seedlings will have more vegetative material. In addition, in advanced periods of growing, genotypes may not sufficiently benefit from water and nutrients in the soil because of weak root growing. This shows that Zn fertilization on wheat in regions having heavy winter and drought has a risk if it is not used consciously.

Wheat genotypes differently response to Zn fertilizer and in many studies, it was founded that there were genetic difference among cultivars when Zn applied on wheat. For that reason, to know the responses of the genotypes to Zn application in a drought region is very important. The effect of Zn fertilization on root growing in wheat must be known because the root developing and system significantly determine the yield and resistance to drought and winter of genotypes.

The aim of this study was to investigate the effect of zinc fertilizer on growth of shoot and root in four winter wheat cultivars, which are mostly preferred in this region.

Materials and Methods

Experiments in which four winter bread wheat cultivars (Bezostaja-I, Katea-I, Momtchill and Pehlivan) were used were planted on 22 December 2007 in Tokat, Turkey. In experiment, pots were kept in laboratory. These cultivars have generally preferred in the region. All seeds sown were derived from field-grown plants in the previous year. The mean 1000-grain weights and Zn contents of Bezostaja-I, Katea-I, Momtchill and Pehlivan cultivars were 38.5, 35.4, 44.2 and 48.1 g, and 26.4, 31.5, 29.2 and 27.1 ppm, respectively. Twenty seeds per pot of each application were planted at a constant depth (2 cm) in large plastic pots (19 cm tall and 18 cm diameter) conting 4 kg soil. Soil type was medium alkaline and clay-tan, and some physical and chemical properties of the study soil are given in Table 1.

Before sowing, as Zn fertilizer, Zn $SO_4.7H_2O$ was applied at 0 and 10 mg Zn kg^{-1}. N was applied at 150 mg N kg^{-1} as ammonium sulphate while P and K were applied at 100 mg P kg^{-1} as KH_2PO_4 (Kalfa et al., 1998; Torun et al., 1998). All fertilizers were melted in dis-

Table 1
Some physical and chemical properties of the study soil

Zn, ppm	Fe, ppm	Mn, ppm	Cu, ppm	pH	Organic matter, %	$CaCO_3$, %	Available P, mg kg^{-1}	K, me100g^{-1}	Clay, %	Silt, %	Sand, %
0.12	4.6	2.38	2.54	8.24	1.32	16.1	2.1	4.8	30	48	22

tilled water and applied to pots before sowing. In addition, half of N was applied before sowing; the other half was applied after emergence. After emergence, all pots were thinned to leave 15 healthy seedlings per pot. All pots were kept moist during the experiment by watering when the soil surface became dry. In the experiment, pots were arranged in a randomized complete block and there were four replicate blocks. Maximum and minimum temperatures in laboratory averaged 25 C day/15 C night.

After starting emergence, emergence dates for each pot were daily recorded. Five harvests were made on 6, 12, 17, 22 and 27 days after emergence and homogeny ten seedlings were harvested from each pot with their roots. Seedlings were carefully washed by distilled water on sieve and were loosened from soil. After washing, seedling length and root length on ten seedlings were measured and seedlings were separated to shoot and root (Gecit et al., 1987; Genctan et al., 1994). The root length density was determined for each pot (Newman, 1966). After separation, roots were counted by using a line intersect method (Newman, 1966) for each sample; those values were converted to root length (cm) and root length density (cm per volume) with Newman's equation R: (NA/2H)ð: where R is the total length of roots (cm), N is the number of intersections between the root and the straight lines. A is the area of the circle (cm^2), and H is total length of the straight lines that are intercepted by roots. After that, shoot and root dry weights were determined after drying for 48 hours at 90^0C (Lopez-Castaneda et al., 1995). The dried samples were weighed and individual shoot and root dry weights were determined. By using these values, root dry weight/shoot dry weight rates were calculated. In addition, growth rate (GR) and relative growth rate (RGR) were calculated for shoot and root (Hunt, 1982). GR was estimated as the ratio of difference between the dry weight at last harvest (on 27 day after emergence) and dry weight at first harvest (on 6 day after emergence) to growth to duration (21 days). RGR refers GR/dry weight at first harvest.

All data were analyzed with analysis of variance by using TARIST Soft Package (Anon, 1995). Differences among cultivars, harvest dates or Zn applications were determined by Student Newman Keuls multiple range test ($P<0.05$). Bartlett's test for homogeneity of variance was performed on plot variances.

Results

Average emergence durations of Bezostaja-I, Katea-I, Momtchill and Pehlivan cultivars which were studied through experiments were respectively 5.5, 8.6, 7.5, and 9.0 days; and no difference was observed between zinc-treated pots and others. The growth status of these cultivars after 6, 12, 17, 22 and 27 days are given in Table 2.

Genotypes

Due to delay in harvest time, significant growth in shoot lengths were observed as expected, and the differences among the cultivars were found significant during all harvest time (Table 2). At the first harvest, it was observed that Katea-I cultivar had shorter seedling length when compared to others and, Pehlivan and Momtchill cultivars were longer in seedling length and they sustained these characteristics during the last harvest as well.

As for dry shoot weight, the cultivars indicated a rapid growth and average 115.7 mg pot^{-1} plant dry shoot weight at first harvest reached up to 586.7 mg pot^{-1} plants at the last harvest (Table 2). There were also differences in average dry shoot weight of the cultivars and these differences were significant at all harvest times. Pehlivan cultivar, which showed a rapid growth in the beginning (138.3 mg pot^{-1} at first harvest), generally sustained this character at all periods and ranked first (Table 2).

Root lengths and dry root weights of the cultivars showed a significant increase as the harvest was delayed (Table 2). As for the mentioned characteristics, significant differences among the cultivars were also found (Table 2). In the measurements conducted 6 days after the emergence, it was observed that there was significant cultivar x zinc interaction. As seen in figure 1a, cultivars differently responded to zinc application, while root length in Bezostaja-I and Momtchill was negativelly affected by zinc, it was not affected in Katea-I and Pehlivan. On the other hand, Bezostaja-I and Momtchill cultivars had longer roots, but from the 12th day it was found that Katea-I cultivar showed a faster root growth

Table 2
Average shoot and root length, shoot and root dry weight, root/shoot dry weight rate, root- length density of four wheat cultivars grown with and without Zn fertilizer for 6, 12, 17, 22 and 27 days after emergence

	Shoot length, cm	Shoot-dry weight, mg pot^{-1}	Root length, cm	Root weight, mg pot^{-1}	Root/shoot dry weight, rate	Root density, mm cm^{-3}
			6 days after emergence			
Bezostaja-I	15.8 b*	111.0 b	21.6 a	52.3 a	0.48 a	0.54 a
Katea-I	13.5 c	94.7 c	17.0 b	35.9 c	0.38 b	0.37 b
Motchill	16.3 ab	118.6 b	20.5 a	48.4 a	0.42 b	0.48 a
Pehlivan	16.9 a	138.3 a	17.9 b	41.8 b	0.31 c	0.47 a
Zinc (mg Zn kg^{-1})						
0	15.6	115.8	20.1 a	46.8 a	0.42 a	0.48 a
10	15.6	115.5	18.7 b	42.4 b	0.38 b	0.46 b
CV %	9.6	12.5	8.9	10.0	10.6	13.5
			12 days after emergence			
Bezostaja-I	20.1 c	184.6 c	24.3 a	56.8 b	0.32 a	0.64 b
Katea-I	18.6 d	169.8 c	26.7 a	58.4 ab	0.36 a	0.63 b
Motchill	22.3 b	208.9 b	25.9 a	61.8 a	0.30 a	0.71 a
Pehlivan	24.2 a	285.9 a	19.9 b	52.1 c	19.0 b	0.61 b
Zinc (mg Zn kg^{-1})						
0	20.9	202.3 b	23.8	59.8 a	0.31 a	0.67 a
10	21.6	222.3 a	24.2	54.8 b	0.26 b	0.63 b
CV %	11.9	14.4	14.1	11.6	17.1	9.0
			17 days after emergence			
Bezostaja-I	26.2 b	237.5 c	25.2 b	67.0	0.29 a	0.70 b
Katea-I	23.9 c	259.0 bc	29.2 a	65.6	0.26 ab	0.83 a
Motchill	28.4 a	276.5 b	27.2 ab	66.4	0.24 b	0.72 b
Pehlivan	29.1 a	370.4 a	22.0 c	71.9	0.19 c	0.68 b
Zinc (mg Zn kg^{-1})						
0	26.5	271.1 b	27.2 a	69.0	0.26 a	0.77 a
10	27.3	300.6 a	24.7 b	66.4	0.23 b	0.70 b
CV %	8.6	11.0	15.8	14.6	10.1	8.2
			22 days after emergence			
Bezostaja-I	27.3 c	336.8 b	28.2 ab	74.3 b	0.23	1.11 b
Katea-I	26.7 c	338.9 b	31.3 a	85.0 a	0.25	1.16 ab
Motchill	29.6 b	390.5 ab	29.0 ab	83.9 a	0.22	1.14 ab
Pehlivan	32.5 a	444.3 a	24.5 b	89.8 a	0.21	1.29 a
Zinc (mg Zn kg^{-1})						
0	29.1	364.6	28.4	85.0	0.24 a	1.23 a
10	29.0	390.0	28.1	81.4	0.21 b	1.12 b
CV %	8.8	12.1	12.8	11.5	13.3	12.1
			27 days after emergence			
Bezostaja-I	32.6 b	574.8 b	31.4 a	97.9 b	0.18 b	1.69 c
Katea-I	32.6 b	520.3 c	33.8 a	127.4 a	0.25 a	2.02 b
Motchill	35.3 a	606.8 ab	31.2 a	120.0 a	0.20 b	2.31 a
Pehlivan	36.5 a	645.0 a	26.8 b	130.9 a	0.20 b	2.35 a
Zinc (mg Zn kg^{-1})						
0	33.9	566.4 b	32.2	129.0 a	0.24 a	2.15 a
10	34.6	607.0 a	29.4	109.1 b	0.18 b	2.04 b
CV %	7.9	11.9	11.7	13.6	14.4	13.7

* $p<0.05$

and surpassed the other cultivars. In the order made according to the last harvest, it was observed that Katea-I, Bezostaja-I and Momtchill cultivars came out in the first three ranks (Table 2) and they had close values. When a general evaluation is made, it was significant that Katea-I and Momtchill exhibited a more stable growth in terms of root length; and Pehlivan cultivar, which had the longest seedling length, came out in the last rank in terms of root length (Figure 1).

As for resistance to adverse conditions, dry root weight is among the important characteristics. Except third harvest time, significant differences among the cultivars were found in terms of these characteristics (Table 2). At first harvest period, like in root length, Bezostaja-I and Momtchill cultivars ranked first in dry root weight and Katea-I cultivar ranked last. In second harvest period, for root dry weight, important cultivar x zinc interaction was found (Figure 1b). As seen Figure 1b, zinc treatment sharply decreased root dry weight in Momtchill and Pehlivan while it did not affect root dry weight in Bezostaja-I and Katea-I. There was no significant interaction in other harvests and cultivars gave similar responses. On the other hand, differences in root growth rates were observed until the last harvest and the order of the cultivars changed at the last harvest period. For example, Bezostaja-I cultivar, which had longer root length and higher dry root weight at first, had the lowest value with 97.9 mg pot^{-1} at the last harvest (Table 2). Pehlivan, Katea-I and Momtchill showed a fast growth especially after the third harvest and at the last harvest, no statistically significant difference was found among them (Table 2). On the other hand, despite having a shorter root length when compared to others, it was interesting that Pehlivan cultivar ranked first in dry root weight.

As it is given in Table 2, root/shoot ratio had significantly changed when compared to harvest time and root/shoot ratio decreased when the harvest was delayed. This is due to slower growth of root than aboveground organs. The differences among the cultivars in terms of root/shoot ratio were found significant in all harvests except for fourth harvest. At the last harvest period, root/shoot ratio of Katea-I cultivar was found to be significantly higher than root/shoot ratio of other cultivars. This situation is respectively related to improvement in dry shoot weight of Katea-I cultivar.

As it is seen in Table 2, parallel to delay in harvest, there were significant differences in root length density of the cultivars and the differences among cultivars were more significant in all harvest times. For example, the highest value of root length density was derived from Momtchill at second harvest, from Katea-I at third harvest, from Pehlivan at fourth harvest and from Pehlivan again at the last harvest. At the last harvest, it was determined that there was not a significant different between Momtchill and Pehlivan cultivars and these cultivars were significantly superior to other cultivars.

There were significant differences between the cultivars in terms of shoot and root GR (Table 3). Shoot GR which means the daily dry material amount that accu-

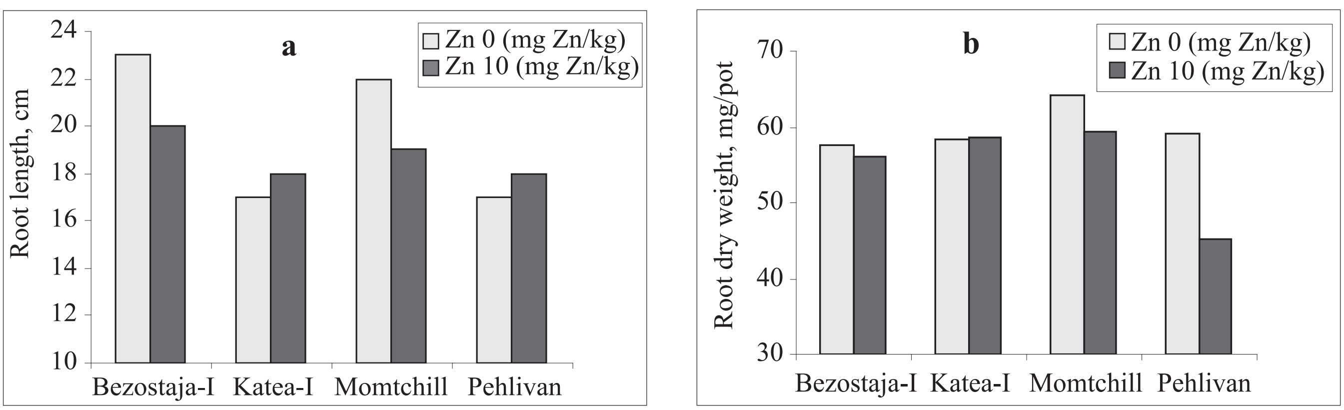

Fig. 1. Cultivar x zinc interaction on root length on 6 days after emergence (a), on root dry weight on 12 days after emergence (b)

Table 3
Average shoot and root GR, relative shoot and root GR of four wheat cultivars grown with and without Zn fertilizer for 27 days

Cultivars	Shoot GR, mg day^{-1}	Root GR, mg day^{-1}	Relative shoot GR, mg $mg^{-1}day^{-1}$	Relative root GR, mg $mg^{-1}day^{-1}$
Bezostaja-I	22.09 ab*	2.18 b	0.200	0.042 c
Katea-I	20.28 b	4.35 a	0.213	0.122 a
Momtchill	23.24 a	3.41 a	0.200	0.072 b
Pehlivan	24.11 a	4.21 a	0.175	0.102 a
Zinc, mg Zn kg^{-1}				
0	21.50 b	3.91 a	0.194	0.090
10	23.40 a	3.17 b	0.200	0.079
CV %	13.2	11.1	18.0	14.6

* $p<0.05$

mulates in the shoot and it was observed that Pehlivan and Momtchill cultivars were significantly superior to Katea-I, but not to Bezosataja (Table 3). Based on daily accumulated dry matter amount in root, it was found that Katea-I, Momtchill and Pehlivan cultivars were similar and Bezostaja-I cultivar accumulated less dry material when compared to these three cultivars (Table 3).

When the RGR, which means daily dry material accumulation amount compared to initial dry weight, was studied, it was found that the cultivars used in this study were same in terms of relative shoot growth and different in terms of relative root growth (Table 3). It was found that Katea-I and Pehlivan cultivars had higher PGR in terms of the mentioned characteristic.

Zinc Application

As it is seen in related tables, zinc treatment did not have a significant effect on shoot length in five harvest periods (Table 2). While zinc had no effect on dry shoot weight 6 days after emergence, the effect of zinc was observed in the following harvest periods and dry shoot weights of all cultivars significantly increased (Table 2).

In contrast to shoot length, root length was adversely affected by zinc-treatment in general, however only the effects in first and third harvests were significant (Table 2). In zinc-treated pots, dry root weight also decreased during harvest periods, but the decreases in third and fourth harvests were not significant (Table 2).

Root/shoot ratio decreased in delayed harvest (Table 2). On the other hand, the effect of zinc-treatment on root/shoot ratio was significant during all harvests and root/shoot ratio significantly decreased with zinc-treatment (Table 2). This stems from positive effect of zinc on seedling length and dry shoot weight and adverse effect of zinc on root length and dry root weight.

Similar to root length and dry root weight, zinc-treatment had a significant effect on root length density and zinc decreased root length density in all harvest periods (Table 2). Parallel to zinc-treatment, the decrease rate in root length density increased as the harvest was delayed.

Zinc-treatment had a significant effect on daily dry material accumulation on the shoot, but the positive effect was not observed in root dry material accumulation, in contrast, the daily dry material accumulation in the roots of the cultivars were significantly reduced (Table 3). On the other hand, as for shoot and root relative growth ratio, it was observed that zinc had no significant effect (Table 3).

Discussion and Conclusion

In the study, it was found that in terms of shoot and root growth, the cultivars that were observed for 21 days from the time of emergence, was significantly different. According to the last harvest, it was observed that Pehlivan and Momtchill cultivars were better in terms of above-surface organs and shoot growth ratio of these cultivars with long seedling length was higher. In their studies, Lafond and Baker (1997), Genctan et al. (1994), Sonmez (2000), Sonmez (2001) found that there were significant differences among the cultivars for dry shoot weight.

It was found that Bezostaja-I, Katea-I, and Momtchill cultivars had a better performance in terms of root length, Katea-I, Momtchill ve Pehlivan cultivars has a better performance in terms of dry root weight and root growth ratio, Katea-I cultivar had a better performance in terms of root/shoot ratio, Katea-I and Momtchill cultivars had a better performance in terms of relative root growth. It was interesting that, despite having a weaker root in the beginning, Katea-I cultivar had a rapid growth due to its high root growth and relative root growth ratio and kept up with other cultivars and surpassed them. In studies of Pinthus and Eshel (1963), Kahari and Elonen (1970), Sidorov (1984), Gecit et al. (1987), Genctan et al. (1994), it was noted that there were differences between the cultivars in terms of dry root weight, root length and root/shoot ratio; the cultivars with higher root length and root/shoot ratio were more resistant to drought and yield potential of these cultivars were higher. In our study, in general, during growth period, significant increases were observed in root and aboveground organs in terms of dry material, however dry material increase in the root was lower than dry material increase in the shoot. Lu and Barber (1985) also reported similar findings.

For having an idea about root system that the plants develop, studying of root length, dry root weight and root/shoot ratio are not sufficient, they just supply general information. For benefiting from water in the soil in areas where water is deficient, rather than having thick and heavy root structure, it is wished that plants had long root system with a surface that have a larger contact with the soil that grows deeper in the ground. Long roots that grow deeper make better use of the water and nutrition elements in the soil. For this reason, while deciding on cultivars, total root length in per unit volume should be taken into account. Since it is difficult to detect this feature, in many studies, only dry root weight, root length and root/shoot ratio were determined. In this study, root length densities of the cultivars, which mean root length in per unit volume, were also studied. It was found that Momtchill and Pehlivan cultivars had a better root length density value. Despite being in a good state in terms of root length, dry root weight, root/shoot ratio and daily root growth ratio, Katea-I cultivar could not show the same performance in terms of root length density. This results indicates that Katea-I cultivar had a heavier and thicker root structure and its total root length was shorter, thus its possibility of making use of mineral matters and water in the soil could be lower.

Early-stage growth status of wheat seedlings is of great importance in areas where winter conditions are heavy and drought is an important problem. Because, at early stages of growth, root lengths and weights of cultivars that consume more nutrition for root growth are higher and as a result they have a better resistance to adverse conditions (Gecit et al., 1987). Therefore, in arid regions, genotypes whose roots grow better are necessary. When this situation is taken into account, it can be stated that Momtchill and Pehlivan cultivars had a better potential when compared to others.

Zinc-treatment had significant effects on seedling growth. Zinc-treatment along with cultivation promoted shoot growth and significantly increased dry material accumulation in shoot. In the studies conducted in similar subjects, Cakmak et al. (1996), Erenoglu et al. (1999), Alam and Shereen (2002) found that zinc-treatment promoted shoot growth and increased dry shoot material production of cultivars; Zhao et al. (2005) found that zinc-treatment reduced these processes. In this study, unlike shoot growth, root growth was adversely effected by zinc-treatment and dry root weight, root length, root/shoot ratio; root length density and root growth ratio was significantly reduced in zinc-treated plants. The effect of zinc on root growth was studied by many researches, and different results were obtained. In their studies on various cereals; Çakmak et al. (1996), Erenoðlu et al. (1999), Alam and Shereen (2002), Zhao et al. (2005) stated that root length and dry weight was reduced by zinc; on the other hand Gene et al. (2000), Grifferty and Barrrington (2000), Alam et al. (2001) stated that zinc promoted dry root weight and root length. The difference in results may result from differences in research conditions and the selected cultivars. Also, Graham and Rengel (1993), Dong et al. (1995), Rengel and Graham (1995), Rengel and Wheal (1997), Torun and Cakmak (2004) reported that there were genotypic differences against the treated zinc.

The fact that zinc promotes aboveground organs may be an advantage for yield in areas with irrigation potential (Condon and et al., 1987; Cooper et al., 1987; Gregory et al., 1992). However, in arid regions, rapid shoot growth in early stages may result in consumption of already insufficient water in early stages and water stress in flowering period, causing reduction in yield. On the other hand, the fact that 10 mg zinc-treatment under these conditions decreased root growth of cultivars seems like another disadvantage. The dry material amount that the cultivars use for root growth that provides water and nutrition material was daily 3.91 mg pot^{-1} under zincless conditions; 3.17 mg pot^{-1} under zinc conditions; dry material amount that is used for above-ground organs which is related to consumed water amount was higher than root, It was daily 21.50 mg pot^{-1}, under zincless conditions, and 23.40 mg pot^{-1} under zinc conditions. While conducting zinc-treatment especially under conditions where arid conditions prevail and irrigation is impossible, this effect of zinc on root growth should be taken into account.

The results obtained through this study indicates that Momthcill and Pehlivan cultivars had a better root structure thus had a potential of using water and beneficial nutritious elements in the soil. In addition, it was observed that these cultivars were also in good condition in terms of shoot growth and shoot growth was promoted by zinc-treatment. Therefore, it is thought that 10 mg Zn kg^{-1} dose zinc to be treated on these cultivars will promote their early-stage growth, and in arid regions, this may result in reduction of limited water and nutrition elements in early stages of growth. Therefore, fast and excessive growth of aboveground organs in these cultivars may cause water stress in flowering and post-flowering, which are most critical periods of cereals. In addition, the decrease observed in root growth after zinc-treatment may cause another adverse effect in terms of water and nutrition uptake.

In order to obtain more reliable results, different doses of zinc should be treated and the responses of cultivars in terms of aboveground and root organs growth in early growth period should be studied. In addition, the possible benefits of using this feature of zinc in some plants such as silage corn, forage plants and green area plants, which are cultivated for green organs, should be studied.

References

Alam, S. M, A. Khan, M. Ali and R. Ansari, 2001. Effect of different levels of zinc and phosphorus on seedling growth, Chlorophyll and Peroxidase contents of rice. *Journal of Biology Science,* **1**(2): 49-51.

Alam, S. and A. Shereen, 2002. Effect of different levels of zinc and phosphorus on seedling growth of wheat. *Asian Plant Journal of Science,* **1**(4): 364-366.

Anonymous, 1995.Tarist Packet Sofware. Ege University, Agric. Fac. İzmir, Turkey.

Bulisani, E. A. and R. L. Warner, 1980. Seed protein and nitrogen effects upon vigor in wheat. *Agronomy Journal,* **72**: 657-661.

Condon, A. G., R. A. Richards, and G. D. Farquhar, 1987. Carbon isotope discrimination is positively correlated with grain yield and dry matter production in field-grown wheat. *Crop Science,* **27:** 996-1001.

Cooper, P .J., P. J. Gregory, H. Keatinge and S. C. Brown, 1987. Effects of fertilizer, variety and location on barley production under rainfed condition in Northern Syria. II. Soil water dynamics and crop water use. *Field Crops Researches,* **16**: 67-84.

Gregory, P. J., D. Tennant and R. K. Belford, 1992. Root and shoot growth and water and light use effienciency of Barley and wheat crops grown on a shallow duplex soil in a mediterranean type environment. *Australian Journal Agriculture Research,* **43**: 555-573.

Cakmak, I., N. Sari, H. Marschner, M. Kalayci, A. Yilmaz, S. Eker and K. Y. Gulut, 1996. Dry matter production and distribution of zinc in bread and durum wheat genotypes differing in zinc efficiency. *Plant and Soil,* **180:** 173-181.

Das Gupta, P. R. and H. M. Austenson, 1973. Analysis of interrelationships among seedling vigor, field emergence and yield in wheat. *Agronomy Journal,* **65**: 417-422.

Dong, B., Z. Rengel and R. D. Graham, 1995. Root morphology of wheat genotypes differing in zinc efficiency. *Journal of Plant Nutrition,* **18**: 2761-2773.

Erenoglu, B., I. Cakmak, V. Römheld, R. Derici and Z. Rengel, 1999. Uptake of zinc by rye, bread wheat and durum wheat cultivars differing in zinc efficiency. *Plant and Soil,* **209**: 245-252.

Gecit, H. H., H.Y. Emeklier, C. Y. Ciftci, S. Unver and S. Senay, 1987. The status of the root and shoots of the bread wheat in the first development stage. Turkey Ceral Symposium Simpozyumu, pp. 91-99, Bursa.

Genctan, T., I. Baser and E. Baharozu, 1994. The studies on development of root and shoot at seedling stage of bread wheat. *Journal of Tekirdag Agriculture Faculty,* **3**(1-2): 131-138.

Gene, Y., G. K. Donald and R. D. Graham, 2000. Effect of seed zinc content on early growth of barley (*Hordeum* *vulgare* L.) under low and adequate soil zinc supply. *Australian Journal of Agriculture Research,* **51**: 37-45.

Graham, R. D., J. S. Ascher and S. C. Hynes, 1992. Selecting zinc efficient cereal genotypes for soils of low zinc status. *Plant and Soil,* **146**: 241-250.

Graham, R. D. and Z. Rengel, 1993. Genotypic Variation in Zinc Uptake And Utilization in Plants, in "Zinc in soils and plants" ed. A.D. Robson. Proceedings of International Symposium on "Zinc in soil and plants". The university of Western Australia. *Kluwer Academic Publishers*, The Nedherlands.

Grifferty, A. and S. Barrington, 2000. Zn uptake by young wheat plant under two transpiration regions. *Environmental Quality,* **29**/2: 443-446.

Hunt, R., 1982. Plant growth Curves. Edward Arnold Ltd., London.

Kahari, J. and P. Elonen, 1970. Effect of placement of fertilezer and sprinkler irrigation on the development of the spring cereals on the basis of root investigations. *Field Crop Abstracts,* **23:** 430.

Kalayci, M., M. Aydin, V. Ozbek, C. Cekic and I. Cakmak, 1998. Field Experiments concerning zinc deficiency problem in wheat in Eskisehir region. I. National Zinc Congress, Turkey, pp. 107-113.

Kalfa, H., K. Y. Gulut, M. Atlı, S. Eker, H. Barut and I. Cakmak, 1998. Effect of increaing phosporus supply on physiological availability of zinc in wheat leaves. I. National Zinc Congress, Turkey, pp. 453-460.

Lafond, G. P. and R. J. Baker, 1986. Effect of genotype and seed size on speed of emergence and seedling vigor in nine spring wheat cultivars. *Crop Science,* **26:** 341-345.

Lopez-Castaneda, C., R. A. Richards and G. D. Farquar, 1995. Variation in early vigor between wheat and barley. *Crop Science,* **35**: 472-479.

Lu, N. and S. A. Barber, 1985. Phosphorus uptake rate and growth characterristics of wheat roots. *Field Crops Abstracts,* **39**: 368.

Newman, E., 1966. A method of estimating the total length of root im a sample. *Journal of. Applied Ecololgy,* **3**: 139-145.

Peacok, H. and S. Hawkins, 1970. Effect of seed source on seedling vigor yield and lint characteristics of upland cotton (*Gossypium hirsutum* L.). *Crop Science,* **10**: 667-670.

Pinthus, M. J. and Y. Eshel, 1963. Observation on the development of root system of some wheat varieties. *Israel Journal of Agricultural Researches*, **12**: 13-20.

Rengel, Z. and R. D. Graham, 1995. Wheat genotypes differ in zinc efficiency when grown in the chelate buffered nutrient solution. *Journal of Experimental Botany,* **47:** 217-226.

Rengel, Z. and M. S. Wheal, 1997. Herbicide chlorsulfuron decreases growth of fine roots and micronutrient uptake in wheat genotypes. *Journal of Experimental Botany,* **48**: 927-934.

Sidorov, A. V., 1984. The posibility of increasing the number of seminal roots in spring wheat. *Field Crops Abstracts,* **39**: 1043.

Sonmez, F., 2000. The effect of seed size and nitrogen on root and shoots in first development stage of barley. *Turkish Journal of Agriculture and Forestry,* **24**: 669-675.

Sonmez, F., 2001. The status of the root and shoots in the first development stage of Tir wheat lines. IV. Türkiye Tarla Bitkileri Kongresi, 17-21 Eylül 2001, Tekirdağ, Türkiye, pp. 297-302.

Sonmez, F. and A. S. Kiral, 2004. Effect of zinc application on yield and some yield components of two bread wheat (*Triticum aestivum* L.) cultivars. Turkiye Ulusal 3. Çinko Kongresi, 11-13 Ekim, Tokat, Turkiye, pp. 535-544.

Takkar, P. N. and C. D. Brennan, 1993. The distribution and corrction of zinc deficiency.In Zinc in Soils and Plants. Ed. A. D. Robson, pp 151-156. *Kluwer Academic Publishers.* Dordrecht, the Netherlands.

Torun, B., S. Eker, A. Aklan, F. Işler and I. Cakmak, 1998. The sensitivity of different bread wheat genotypes to Zn deficiency. I. Ulusal Çinko Kongresi, Türkiye, pp. 897-900.

Torun, B. and I. Cakmak, 2004. Zinc deficiency in middle Anatolia region. Turkiye Ulusal 3. Çinko Kongresi. 11-13 Ekim, Tokat, Türkiye, pp. 521-534.

Welch, R. M., W. H. Allaway, W. A. House and J. Kubota, 1991. Georaphic distribution of trace element problems. In Micronutrioents in Agriculture, Ed. Eds Mortwedt, J. J., F. R. Cox, L. M. Shuman, And R. M. Welch. Soil Sci. Soc. Am. Madison, WI., pp. 31-57.

Zhao, Z. Q., Y. G. Zhu,S. E., Smith and F. A. Smith, 2005. Cadmium uptake by winter wheat seedlings in response to interactions between phosphorus and zinc supply in soils. *Journal of Plant Nutrition*, **28** (9): 1569-1580.

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