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MICRONUTRIENT CONTENTS IN LEAVES OF SUNFLOWER CULTIVARS GROWN WITH DIFFERENT BORON DOSES

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SUMMARY

Although boron is essential for crop growth, the amount required differs among plant species. Sunflower (*Helianthus annuus* L.) requires greater quantities of boron to satisfy its metabolic needs than other cultivated species. The present work was undertaken to evaluate what effects five boron doses of 0, 2.5, 5.0, 7.5 and 10.0 kg B ha^{-1} (applied as a spray of boric acid, H_3BO_3) would have on micronutrient contents in leaves of four sunflower cultivars grown in B-deficient calcareous soils (0.19 B mg kg^{-1}) during the 2001 growing season. Boron (B), iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) concentrations were measured in sunflower leaves at the flowering stage. According to the results, the B concentration in the leaves was highly correlated with boron doses, that is, the leaf B content increased in accordance with increasing B doses applied to the soil. Fe, Mn, Cu, and Zn concentrations in the leaves were not changed by the different B levels. However, leaf Mn, B and Cu concentrations varied with the cultivars. Among the cultivars, TR-4098 had the highest Mn (90.74 mg kg^{-1}) and Cu contents (45.95 mg kg^{-1}), while AS-615 had the highest B (83.52 mg kg^{-1}) and Fe (202.55 mg kg^{-1}) concentrations.

Key words: **sunflower, *Helianthus annuus* L., boron, cultivar, micronutrients**

INTRODUCTION

Boron is a micronutrient element that plants require in trace amounts. The concentration range in which plants exhibit neither deficiency nor toxicity symptoms is narrower for B than for any other nutrient element. Plants can experience both B deficiency and B toxicity in a single growing season (Reisenauer *et al.*, 1973).

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Soils vary greatly in boron content. Some contain excessive amounts of boron and cause boron toxicity in many plants. Others contain insufficient boron to support normal plant growth. Boron deficiency, which develops frequently during drought periods, may occur under a wide range of soil conditions. Soil parent material and texture are considered to be the major soil factors associated with the occurrence of B deficiency (Shorrocks, 1997). In spite of their lesser prevalence compared to B-deficient soils, B-rich soils are also important, as they cause B toxicity in the field and decrease crop yields in different regions of the world. High concentrations of B may occur naturally in soils or in ground water, or they may enter soils from mining wastes, fertilizers, or irrigation water.

Boron toxicity has long been recognized as a common mineral nutritional problem, particularly in arid and semiarid regions, where B levels are frequently high in soils or in irrigation water, causing significant decreases in growth and yield as reported for many countries (Nable *et al.*, 1997). For example, the soils in Iraq, Syria, India, South Australia and Turkey have above-average B levels with some sites having toxic levels (Sillanpaa, 1982).

B toxicity has been reported as an important constraint to crop production in Turkey, particularly in Central Anatolia (Kalayci *et al.*, 1998). The soils in Central Anatolia are typical of those found in arid and semiarid regions. They have a low organic matter content, high free-lime content, high pH, and usually a fine texture. Gezgin *et al.* (2002) surveyed the B contents of 898 soil samples representing the Central Southern Anatolian soils. According to the survey, the concentration of extractable B with 0.01 M mannitol in soil samples ranged from 0.01 to 63.9 mg kg $^{-1}$ with a mean value of 2.48 mg kg $^{-1}$. Nearly 10% of the soils sampled in Central Anatolia contained more than 5 mg extractable B per kg soil, which is a widely accepted critical concentration for the occurrence of B toxicity in crop plants (Nable *et al.*, 1997).

Plant species differ in their boron requirements. Some plants are more susceptible to B deficiency and toxicity than others. Crops with higher boron requirements, such as lucerne, sunflowers, rapeseed, cauliflower and apples, are most likely to respond to boron (Dear and Weir, 2004). Sunflower has been found to be particularly sensitive to B deficiency and is used as an indicator crop for assessing available B in soils (Tisdale *et al.*, 1985). The critical concentration for B deficiency (associated with 90% maximum seed yield) in the youngest mature leaf at flowering has been reported as 34 mg kg^{-1} dry wt by Blamey *et al.* (1979), but Bergmann (1992) stated that B contents in the range of 31-140 mg kg^{-1} were adequate. Fertilizers containing B increase sunflower production in soils with a low B content, but problems exist in B uptake with low soil moisture or in applying B when symptoms only become evident during reproductive growth.

Interactions among B and other micronutrients have been described in several plants. Interrelationships were generally synergistic, *i.e.* B deficiency was associated with low Mn and Zn contents in cotton leaves and B fertilization enhanced Zn, Mn and Cu contents in several species. Toxic B levels in soil solution seemed to reduce micronutrient contents (Gomez Rodriguez *et al.*, 1981). These findings were obtained with plants in the vegetative stage of development and the described effects were attributed to a direct influence of B on micronutrient uptake. However, this effect could result from the change in growth caused by B levels, which would change the nutrient demands.

The objective of the present study was to determine what effect different boron doses will have on micronutrient contents in the leaves of some sunflower cultivars currently grown in Turkey when these are grown on B-deficient calcareous soils.

MATERIALS AND METHODS

The research was carried out during the 2001 growing season at the Research Institute of Rural Affairs, Konya, Turkey. The field experiment was conducted on a soil that contains 0.19 mg kg^{-1} extractable boron using a 0.01 M mannitol+0.01 M $CaCl_2$ solution before reading on ICP-AES (Varian-Vista Model). Four sunflower cultivars currently grown in Turkey (AS-615, S-288, Coban and TR-4098) were used as plant material. The soil in the experimental area, a calcareous loam with 68.1% silt, 26.7% sand, 5.2% clay, is poor in organic matter and has a pH of 7.6 and a B content of 0.19 mg kg^{-1}. Extractable B levels of the experimental soil were low according to the critical levels indicated by Reisenauer *et al.* (1973) and Keren and Bingham (1985) for many crops.

The experimental design was a randomized complete block in a split-plot arrangement with three replications. Cultivars were used as the main plots and B treatments as the sub-plots. Boron treatments were 0 (B0), 2.5 (B1), 5.0 (B2), 7.5 (B3) and 10.0 (B4) kg B ha^{-1}. Boron was sprayed on the soil surface using 0.86% H_3BO_3 solution, followed by incorporation into the soil at a depth of 10-15 cm prior to sowing. The experimental plots were sown in 5 rows 3 m long and 70 cm apart on 11 April. The plants within the rows were spaced 30 cm apart by thinning at the 7-8 leaf stage. Before sowing, phosphorus and nitrogen were applied in the form of diammonium phosphate (550 kg ha^{-1}) (18% N; 46% P_2O_5). The plots were irrigated five times using sprinkler irrigation.

Three rows in the middle of each plot were harvested by hand on 22 July. During the flowering stage, the five youngest mature leaves in each plot were picked and washed with water. The leaf samples were then dried at 70°C for 48 h and dry weights of the leaves were recorded. The dried leaf samples were finely ground and 0.5 g plant material was digested with concentrated HNO_3 in a microwave system (CEM, Mars 5). The extracts were analyzed for B and other micronutrient contents by ICP-AES (Varian-Vista Model) (Nyomora *et al.*, 1997). The data were subjected to standard analysis of variance (ANOVA) using MSTAT-C programme. The least significant difference (LSD) test was used to compare the treatment means (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The results of the present study are summarized in Table 1. As can be seen from Table 1, the leaf B content showed a significant positive relationship with soil-applied boron doses. However, the application of B did not have any significant effects on Fe, Mn, Zn and Cu concentrations in the leaves. On the contrary, the cultivars showed significantly varying responses to B treatments with regard to Mn, B and Cu contents of the leaves.

Table 1: Mean leaf micronutrient concentrations in four sunflower cultivars and in different boron doses

Cultivars	Micronutrient concentration of leaf (mg kg^{-1})				
	B	Fe	Mn	Zn	Cu
AS-615	83.52a	202.55	73.77b	20.34	35.18b
S-288	76.23b	181.41	76.79b	17.64	27.71c
Coban	80.36a	195.56	76.07b	19.66	38.24b
TR-4098	72.91b	193.88	90.74a	17.95	45.95a
			Boron doses		
B0	69.23e	197.18	83.72	20.36	38.51
B1	73.46d	193.64	76.70	18.62	36.46
B2	78.74c	197.03	77.61	19.10	36.83
B3	82.49b	194.37	80.54	18.41	36.45
B4	87.36a	184.51	78.14	17.99	35.60

Mean in the same column for each micronutrient followed by the same letter are not significant at P<0.05 based on LSD test.

As expected, the B concentration in the leaves was highly correlated with boron doses, that is, the leaf B content increased in accordance with increasing B doses applied to the soil (Table 1). The leaf B concentrations were in the 69.23-87.35 mg kg^{-1} range, with the lowest being found in the control plots having no boron at all. The highest B content was measured in plants treated with the highest B dose of 10.0 kg ha^{-1} (B4), with a 26.2% increase over the control. Similar findings indicating that B content in sunflower increases with increasing B in nutrient solution have also been reported by Asad *et al.* (2001). The interaction between boron doses and the cultivars was found to be significant, and the highest B value (94.17 mg kg^{-1}) was obtained in the AS-615 cultivar with a B level of 10.0 kg ha^{-1} (Figure 1).

Among the cultivars, the leaf B content of the AS-615 variety was significantly greater than those of the other cultivars. Boron concentration in the leaves of sunflower cultivars ranged from 121.99 mg kg^{-1} in the Coban cultivar to 176.10 mg kg^{-1} in the AS-615 cultivar. Dear and Weir (2004) reported that boron deficiency occurred when the B content of younger leaves decreased below 15-20 mg kg^{-1} and the B content of leaves of plants growing normally ranged from 35 to 200 mg kg^{-1}. According to this finding, the leaf B values (69.23-87.35 mg kg^{-1}) obtained in our study were within the normal range.

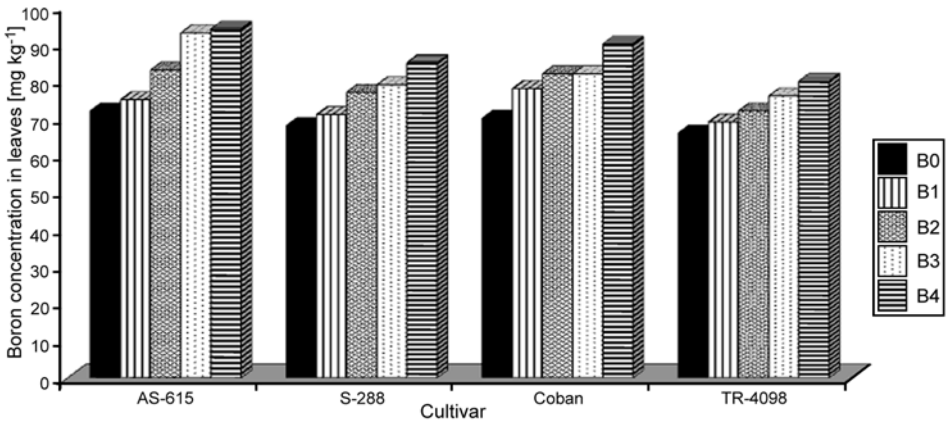

Figure 1: Effects of different boron doses on the boron concentration in sunflower cultivars leaves.

Boron does not easily move around the plant. Therefore, a deficiency is most likely to be seen in the younger tissues first. Because of this poor mobility, boron must be continuously taken up by plants throughout the growing season, and this is one reason why deficiency symptoms can develop suddenly. According to the literature (Oertli and Richardson, 1970), the leaves are the main plant organ for B accumulation, and the amount of B accumulated in the leaves cannot be redistributed to other organs under any conditions. The youngest leaves are the first to show symptoms. Sunflower, one of the crops most sensitive to B deficiency, has poor vegetative growth and seed set in soils with limited B supply, and deficiency symptoms first become evident on the younger leaves (Asad *et al.*, 2001).

The micronutrients iron, copper, manganese and zinc are considered essential elements with specific functions in normal plant growth. However, the benefits of these micronutrients may be completely reversed if they are present in excess amounts. In the present study, the leaf Fe and Zn levels were typically within the ranges considered adequate for normal plant growth. There were no significant differences in the leaf Fe and Zn concentrations among either the cultivars or the boron doses. The leaf Mn concentrations ranged from 73.77 mg kg^{-1} in AS-615 to 90.94 mg kg^{-1} in TR-4098. The cultivars differed significantly in their leaf Cu content, with TR-4098 having the highest Cu content of 45.95 mg kg^{-1}.

In conclusion, the results of the present study revealed that B concentration in sunflower leaves increased with increasing B levels in the soil. Increasing soil-applied boron doses, however, did not have any significant effects on Fe, Mn, Zn and Cu concentrations in sunflower leaves.

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