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The Effects of the Boron Application on Indole-3-Acetic Acid Levels in *Triticum durum* Desf. cv. Gediz Seedlings

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Abstract: In this research work, the effects of varying boron concentrations on IAA levels of seedlings of *Triticum durum* Desf. cv. Gediz plants were investigated. Experiments were conducted using one week-old wheat seedlings grown in slop culture under greenhouse conditions. Seedlings were supplied with Hoagland solutions containing different concentrations of boron. At the end of four weeks of growth, seedlings were harvested and the amount of endogenous IAA was determined. According to the obtained results, increasing level of boron application to the culture media gave rise to a correlative linear decrease in the IAA level of the seedlings.

Key words: Boron, Indole-3-acetic acid (IAA), *Triticum durum*.

Triticum durum Desf. cv. Gediz Fidelerinde Bor Uygulamasının İndol-3-Asetik Asit Düzeyi Üzerine Etkileri

Özet: Bu çalışmada, *Triticum durum* Desf. cv. Gediz bitkisi fidelerinde IAA düzeyi üzerine değişik bor elementi kosantrasyonlarının etkileri incelenmiştir. Denemeler, sera koşullarında kum kültüründe yetiştirilen 1 haftalık buğday fideleri kullanılarak yürütülmüştür. Bu amaçla, yetiştirilen fideler farklı konsantrasyonlarda bor içeren Hoagland besin çözeltisi ile sulanmıştır. Dört haftalık deneme süreci sonunda hasat edilen bitkilerde içsel IAA miktarları belirlenmiştir. Elde edilen sonuçlara göre, kültür ortamındaki bor konsantrasyonu artışıyla ilişkili olarak, fidelerdeki IAA düzeyinin doğrusal biçimde azaldığı belirlenmiştir.

Anahtar sözcükler: Bor, İndol-3-asetik asit (IAA), *Triticum durum*.

Introduction

Boron toxicity is one of the most important micronutrient problems affecting plant growth in Turkey. Especially, in Central Anatolia, where cultivation of wheat is very common, bor toxicity is well-documented [1,2].

In many places in the world, even natural waters contain small amounts of boron (100 ppb or less). But it should be kept in mind that this level also varies from location to location. This fact may be examplified by stating that the tap water in the city of Los Angeles contains 0.50-1.5 ppm boron [3]. On the other hand, the boron content in the soil changes between 2-100 ppm [4]. Boron content in the soil is considered to be 30 ppm in average. Depending on the main rock, boron content in the soil exhibits a large variation. Consequently plants need trace amounts of boron but it becomes toxic at 2 ppm or greater for most plants [5].

Plants have developed several adaptation mechanisms againts boron toxicity. Among the well-described such mechanisms is inhibition of boron uptake by roots and its transport into shoots [6].

Several physiological impairments are known to be caused by boron deficiency such as inhibitions of mitosis and cell elongation, along with of cell differentiation and development, and suppression of respiration, and photosynthesis, an increase in auxin content [7]. According to Dugger [8], boron deficiency plays an important role in auxin biosynthesis in the meristem of the plant. For example, a decrease in the level of free auxin, an increase in the level of bound auxin, and also a reduction of IAA-oxidase activity have been observed in case of boron deficiency [7]. In addition, it has been known that, depending on a reduction of IAA-oxidase activity, an increase is observed in the IAA level of the plant [6, 7, 8, 9].

Furthermore it has been shown that sunflowers with boron deficiency contained more IAA than control group, that IAA-oxidase was inhibited due to high level of phenolic acid [7]. On the other hand, Robertson and Loughman [10] showed that boron has an effect on the transport metabolism and activity of auxins. The results of the above-mentioned research work suggests that boron controls the level of IAA in plants.

Boron-deficient sunflower plants contained more IAA than controls, and also decreased IAA-oxidase activity, presumably because of high levels of phenolic compounds [7].

Bohnsack and Albert [11] showed a severe inhibition in root growth of squash and increase in IAA oxidation by boron deficiency. Resupply of boron to boron-deficient squash plants rapidly stimulated root growth and reduced IAA oxidation.

To our knowledge, the relationship between boron nutritional status of plants and IAA metabolism has been studied only under boron deficiency, but not boron toxicity conditions. Therefore, in the present research work, we have attempted to study the influence of adequate, inadequate and excessive levels of boron on IAA levels in wheat seedlings grown in nutrient solutions with varying boron concentrations.

Material and Methods

Our study was conducted with seedlings of *Triticum durum* Desf. cv. Gediz grown with a slop culture method in the greenhouse conditions. *Triticum durum* Desf. cv. Gediz seeds were germinated in quartz sand taken from a stream bed. When the seedlings emerging from them reached to a height of 2.5-3 cm, they were selected for uniformity and divided into four groups. The plants in these groups were either irrigated with standard Hoagland solution (control) [12], or Hoagland minus boron, or Hoagland with 5 (2.3 ppm) or 10 times (4.6 ppm) stronger in boron content. During experimental period, seedlings were irrigated once with 100 ml solution that supplied needed amount of boron for each experimental group. The following irrigations against dessication were done with distilled water. This experiment was lasted for four weeks and at the end of the 4^{th} week, the plants were harvested in four groups, and 5 g leaves from each group were taken for analysis.

In order to determine hormonal level of the leaves at the time of harvest, the extraction process of Scott and Jacobs [13] method was modified, and for separation, thin-layer chromatography was used (Nitsch and Nitsch method [14]. In determining the amount of auxin (IAA), spectrophotometric method of Yürekli et al. [15] was used.

Qualitative determination of IAA, which was extracted from the plant material, was conducted with wheat coleoptile straigth-growth biological test [16]. Reliability of the tests was analysed with Tukey test [17].

Results and Discussion

When spectrophotometric IAA results of *Triticum durum* Desf. cv. Gediz grown in slop culture were examined, relatively high endogen IAA content was determined in seedlings of *Triticum durum* Desf. cv. Gediz seedlings which were grown in Hoagland solution not containing boron, in comparison with control group at 224 nm (Figure 1).

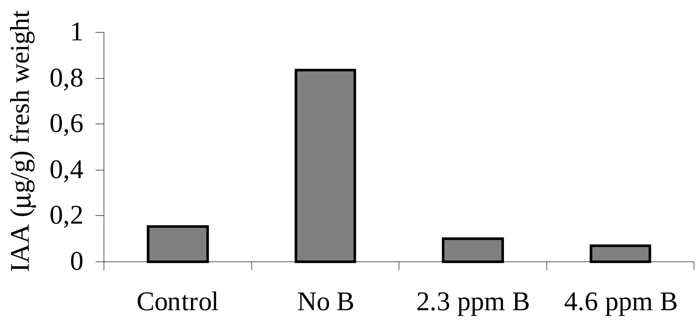

Figure 1. The spectrophotometric analysis depicting IAA contents of *Triticum durum* cv. Gediz seedlings grown in different media containing varying boron levels, B, boron.

According to obtained data (Fig. 1), a 5.4 times increase in IAA content of seedlings that were grown in Hoagland solution without boron was observed. In contrast there appeared a decrease of 65% in IAA content in the seedlings grown with 2.3 ppm boron in Hoagland solution. Finally a decrease in IAA level was also observed, more drastically than the former group in the seedlings grown in the 4.6 ppm boron containing medium.

Since acid hydrolysis method was used when IAA was extracted from the material during experiments, total amount of IAA in plant was obtained. Furthermore, our results of biological test seems to support spectrophotometrical analysis results (Figure 2).

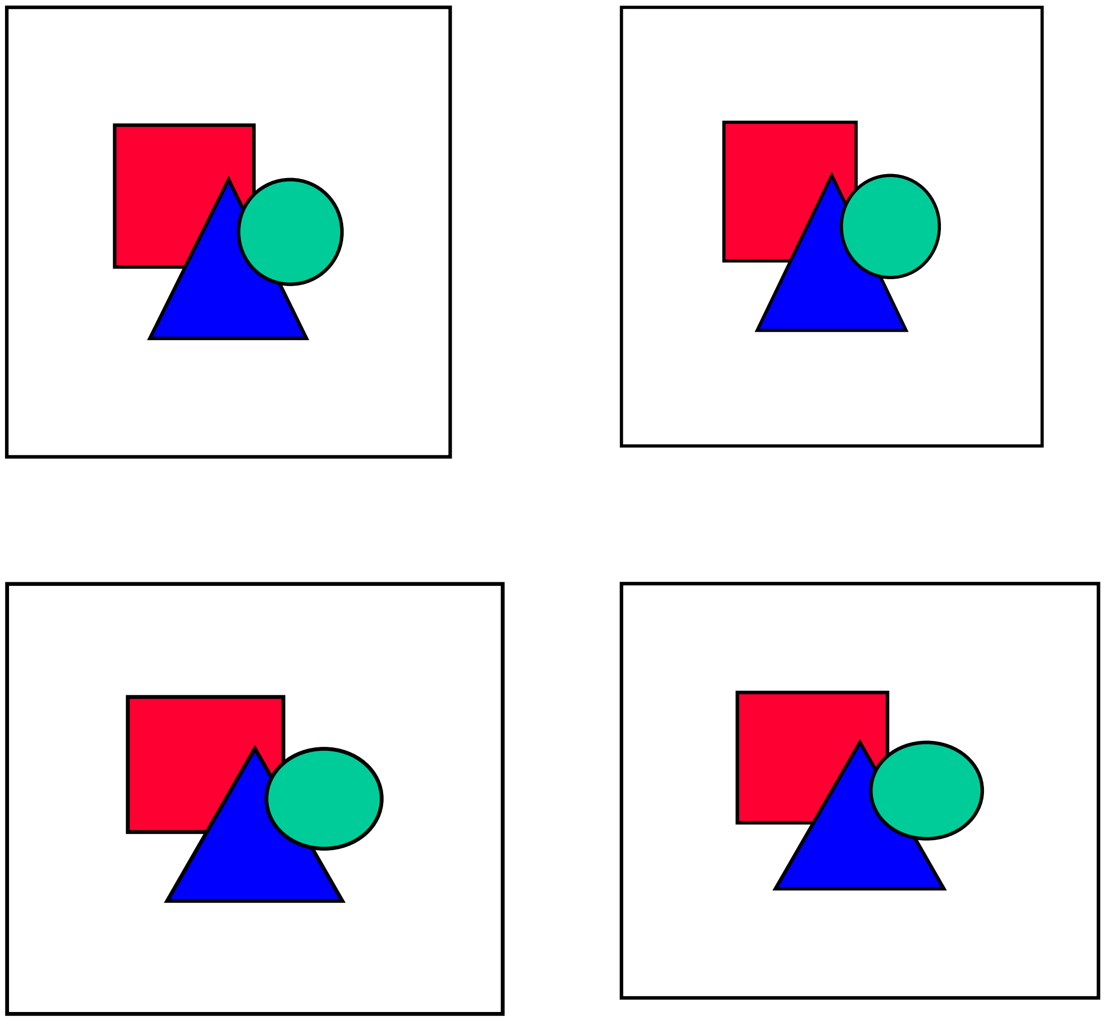

Figure 2. The wheat coleoptile straight-growth biological test results for *Triticum durum* cv. Gediz leaves for IAA. **a,** Control; **b,** No boron; **c,** 2.3 ppm boron; **d,** 4.6 ppm boron. The areas beyond the dotted lines depict the statistically significant differences. Bar is presented SE of the mean.

The results of our work in which we used *Triticum durum* cv. Gediz seedlings implies that high concentration of boron, which may be present in the soil and irrigation water in natural conditions, seems to have a suppressive effect on the growth of the plants.

This problem is more important in boron-rich soils than boron-poor soils. A number of methods can be used to improve the quality the soils containing high levels

of boron. In this framework, determining the boron toxicity can be limited neither by noticable symptoms nor by analysis of tissue. For this reason, it has been recommended recently that more research to be done on growing crop in soils containing high level of boron [18]. In this scope, to grow crop and get maximum efficiency in soils containing high level of boron, it is obvious that detailed physiological studies have been done in order to determine genotypes with tolerance to boron [19, 20].

It has been observed by many researchers that IAA level in plants are controlled by boron [7, 10]. Rajaratnam and Lowry [21] reported that IAA content in palm trees increased in the presence of boron deficiency. Furthermore, Shkolnik [22] could explain the physiological role of boron with the fact that auxin and phenolic compounds exhibit accumulation at the absence of boron. Also that the auxin level in plant rises with boron deficiency was noted by some other researchers [23, 24]. Our results hence comply with those of the above stated workers.

As Dugger [8] stated, boron deficiency causes a decrease in the level of free auxin and an increase in that of bound auxin [7] But although total level of auxin, instead of the level of free auxin, was determined in our study, our results seem to agree with most of the data in literature. There are results indicate that nonperoxidative IAA-oxidase might play a major role in the regulation of indole-3-acetic acid content in pea seedlings [8]. Indole-3-acetic acid was oxidized by horseradish peroxidase [7]. They also reported the presence of excessive IAA in boron-deficient oil palm [21]. For this reason, the results we obtained seem to support the findings of other researchers that have obtained high levels of IAA in plants grown in boron-deficient media. The fact that IAA level we have determined in our material grown in high boron concentration has been found to be lower than the control group, is completely coherent with those described above.

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