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The Effects on Germination and Growth of Bean and Chickpea of Boron Waste

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Abstract: In this study, the effects of two different boron concentrator wastes (A and B) on germination and growth of bean (***Phaseolus vulgaris*** L.) and chickpea (***Cicer arietinum*** L.) were investigated. For this purpose, the species seeds were shown in the petri dishes containing pure water (control) and the varied concentrations of two different wastes with three replications. The root and shoot lengths, fresh and dry weights of one week seedlings grown from the germinated seeds at the end of three days were measured. An inhibitor effect of boron waste on germination of species seeds was not determined. In addition, it was found out that 600 ppm and over concentrations of both boron wastes decreased the root and shoot lengths, fresh and dry weights of seedlings.

Key words: Boron concentrator waste, *Phaseolus vulgaris* L.(bean), *Cicer arietinum* L.(chickpea), germination, growth.

Bor Atığının Fasulye ve Nohutun Çimlenme ve Büyümesi Üzerine Etkileri

Özet: Bu araştırmada, fasulye (*Phaseolus vulgaris* L.) ve nohutun (*Cicer arietinum* L.) çimlenme ve büyümesi üzerine iki farklı bor konsantrator atığının (A ve B) etkisi araştırılmıştır. Bu amaçla, tür tohumları saf su (kontrol) ve bu iki farklı atığın farklı konsantrasyonlarını içeren petri kaplarına üç tekerrürlü olarak ekilmiştir. Üç gün sonunda çimlenen tohumlardan gelişen bir haftalık fidelerin kök ve gövde boyları ile taze ve kuru ağırlıkları ölçülmüştür. İlgili türlere ait tohumların çimlenmesi üzerine bor atığının bir inhibitor etkiye sahip olmadığı belirlenmiştir. Ayrıca, her iki bor atığının 600 ppm ve üstü konsantrasyonlarında fidanların kök ve gövde boyları ile taze ve kuru ağırlıklarını azalttığı ortaya çıkmıştır.

Anahtar kelimeler: Bor konsantrator atığı, *Phaseolus vulgaris* L.(fasulye), *Cicer arietinum* L.(nohut), çimlenme, büyüme.

1. Introduction

One of the reasons of not increasing agricultural production at the same rate in line with world population growth is the unplanned use of water resources. In this respect, the reuse of the refined wastewater plays a major role in the agricultural irrigation. In fact, World Health Organization (WHO) indicated that wastewater was rich in the nutrients required for plant growth and would be used for irrigation [1]. Some studies appeared that the use of boron plant waste in ceramic, brick and cement industries was suitable. Consequently, whether this waste can be used for agricultural activities must be supported by different scientific studies. Thus, both environmental pollution and wastage of energy would be prevented through the evaluation of wastes resulting from the different operations.

Boron is a micro nutrition for vascular plants, diatoms and some green algae taxa [2-3]. Excess and deficiency of boron can cause physiological and morphological variations in plants [4]. These variations were supported by different studies [5-7].

Bean (*Phaseolus vulgaris*), edible legume, consumed as dry and fresh and used in human food and forage industry due to high protein content, is an important cultivar [8]. Chickpea (*Cicer arietinum*), is the third most extensively planted grain legume. Besides being an important source of human food and provender the crop also plays an important role in the maintenance of soil fertility, particularly in arid regions [9].

On the other hand, although they were few, some important studies explaining the effects of different factors on the germination and growth of bean and chickpea were carried out. However, there wasn't any scientific study considering the effects of boron concentrator waste on the germination and morphological characteristics of bean and chickpea. In the sight of this view, in this study the effects of two different boron concentrator wastes on the germination and growth of bean and chickpea were investigated.

2. Materials and Method

The boron concentrator wastes used in this study were taken from Boron Acid Fabric (Kütahya, Turkey). Boron concentrator wastes were dried in etuve at 68 °C for one week until reaching constant weight. Chemical contents of the wastes (A and B wastes) were given in Table 1. Growth mediums were prepared 20 different concentrations (20, 40, 60, 80, 100, 200, 400, 600, 800 and 1000 ppm) of wastes and distilled water (control treatment). Before have sown, seeds were sterilized. The experiment was arranged with three replicates of 20 seeds per Petri dish. This experiment regarding germination and seedling growth was done in a growth chamber at temperatures of 26/18 °C and for a 14/8 (day/night) h photoperiod.

Table 1. Chemical contents of A and B concentrator wastes

		Concentrator Wastes	
		A	B
B_2O_3	%	8.09	2.51
SiO_2	%	5.97	6.88
Fe_2O_3	%	0.41	0.40
Al_2O_3+TiO_2	%	0.62	1.44
CaO	%	23.06	26.01
MgO	%	2.89	2.45
SrO	%	2.18	1.89
Fe	%	0.29	0.28
As	Ppm	2975	1450
SO_4	%	40.54	44.67

The seed was considered as having germinated when the radicle protruded to a length of 3 mm. Germinating seeds were counted every other day starting three days from the beginning of the test. Measures of root and shoot length were done by a ruler and those of fresh and dry weight relating root and shoot were realized by a balance. Before dry weights of root and shoot were measured, these root and shoot samples were kept in etuve at temperatures of 68 ^{o}C for 72 h. Each treatment was represented 15 seedlings.

Differences among treatments were tested by using SPSS. Statistical variance analysis of the data was performed by using ANOVA and compared with Duncan test at the 5% level.

3. Results and Discussion

At the end of three days, most of the seeds belong to bean and chickpea were germinated. This result showed that boron wastes were not any inhibitor effect on the germination of the seeds of the studied species (Table 2-5). Moreover, the effects of different concentrations including A and B boron wastes on bean and chickpea germination were found significant at the 0.001 level.

Table 2. Statistics and Duncan test results of germination and growth characters belong to bean applied the different concentrations of A concentrator

Concentration (ppm)	G* (%)	RL (cm)	SL (cm)	RFW (g)	SFW (g)	RDW (g)	SDW (g)
0 (Control)	92.00b**	7.00bc	10.50d	55.00d	180.00e	6.50c	10.50d
20	98.00d	6.50b	11.00d	55.00d	190.00f	8.00d	12.50e
40	100.00e	7.00bc	11.00d	55.00d	180.00e	6.50c	10.50d
60	98.00d	6.70b	10.90d	55.00d	190.00f	8.00d	12.00e
80	96.00c	6.60b	11.20d	55.00d	195.00g	6.50c	12.20e
100	92.00b	6.50b	10.90d	55.00d	190.00f	6.30c	12.30e
200	93.00b	8.00c	11.50d	55.00d	200.00h	6.10c	10.50d
400	89.00a	3.10a	8.00c	25.00b	100.00d	4.00b	8.00c
600	90.00a	3.00a	6.40b	50.00c	80.00c	3.00ab	7.50c
800	100.00e	2.80a	6.00b	15.00a	70.00b	2.80a	6.00b
1000	98.00d	2.80a	3.90a	15.00a	55.00a	2.20a	4.50a
Mean	95.09±0.69	5.45±0.36	9.21±0.46	44.55±2.89	148.18±9.82	5.45±0.36	9.68±0.47
F	59.00	34.03	31.72	876.82	10174.09	34.98	81.98
P	0.000	0.000	0.000	0.000	0.000	0.000	0.000

* G: Germination, RL: Root Length, SL: Shoot Length, RFW: Root Fresh Weight, SFW: Shoot Fresh Weight, RDW: Root Dry Weight, SDW: Shoot Dry Weight ** Means within each column followed by the same letter (a–h) do not differ significantly at P < 0.001.

Table 3. Statistics and Duncan test results of germination and growth characters belong to bean applied the different concentrations of B concentrator

Concentration (ppm)	G* (%)	RL (cm)	SL (cm)	RFW (g)	SFW (g)	RDW (g)	SDW (g)
0 (Control)	98.00e**	7.20g	10.20c	65.00f	110.00f	7.00	11.00c
20	98.00e	6.40f	10.20c	50.00c	100.00d	6.80	10.50c
40	97.00de	7.10g	10.00c	60.00e	105.00e	7.00	12.50d
60	96.00cd	6.40f	6.40a	55.00d	110.00f	6.00	11.00c
80	96.00cd	6.50f	10.20c	50.00c	100.00d	7.00	11.00c
100	95.00bc	5.90d	10.30c	65.00f	120.00h	6.90	10.60c
200	96.00cd	5.60c	9.80c	50.00c	110.00f	6.00	10.70c

400	95.00bc	6.20e	10.00c	50.00c	115.00g	5.80	10.00bc
600	96.00cd	4.90b	8.20b	40.00b	85.00b	6.00	9.00ab
800	90.00a	3.80a	8.00b	30.00a	90.00c	5.70	8.50a
1000	94.00b	3.90a	7.90b	30.00a	80.00a	5.70	8.40a
Mean	95.55±0.40	5.81±0.20	9.20±0.24	49.55±2.05	102.27±2.15	6.35±0.14	10.29±0.23
F	14.62	404.67	19.09	441.82	485.46	1.79	9.93
P	0.000	0.000	0.000	0.000	0.000	0.122	0.000

* Abbreviations of variable are given in Table 1. ** Means within each column followed by the same letter (a–h) do not differ significantly at P < 0.001.

Table 4. Statistics and Duncan test results of germination and growth characters belong to chickpea applied the different concentrations of A concentrator.

Concentration (ppm)	G* (%)	RL (cm)	SL (cm)	RFW (g)	SFW (g)	RDW (g)	SDW (g)
0 (Control)	91.00de**	9.60g	10.00d	210.00g	280.00g	6.40d	9.00c
20	80.00a	6.10d	9.20cd	205.00e	270.00e	5.00bc	8.00c
40	92.00e	8.10ef	9.50cd	205.00e	275.00f	5.00bc	7.90c
60	85.00c	8.50f	9.40cd	210.00f	280.00g	5.50cd	8.10c
80	83.00b	6.30d	8.70c	205.00e	275.00f	5.00bc	7.90c
100	91.00de	7.80e	9.00c	210.00f	275.00f	5.40cd	9.00c
200	92.00e	7.60e	8.80c	215.00f	280.00g	6.10cd	9.00c
400	90.00d	5.20c	7.60b	110.00d	150.00d	4.00b	6.50b
600	90.00d	4.00b	7.00b	80.00c	110.00c	2.50a	5.00a
800	86.00c	2.80a	4.30a	70.00b	80.00b	2.60a	4.10a
1000	85.00c	2.70a	4.20a	55.00a	70.00a	2.50a	4.00a
Mean	87.73±0.71	6.25±0.40	7.97±0.35	161.36±11.26	213.18±15.17	4.55±0.26	7.14±0.34
F	50.46	163.88	44.00	13381.36	24289.09	16.68	20.34
P	0.000	0.000	0.000	0.000	0.000	0.000	0.000

* Abbreviations of variable are given in Table 1. ** Means within each column followed by the same letter (a–g) do not differ significantly at P < 0.001.

Table 5. Statistics and Duncan test results of germination and growth characters belong to chickpea applied the different concentrations of B concentrator

Concentration (ppm)	G* (%)	RL (cm)	SL (cm)	RFW (g)	SFW (g)	RDW (g)	SDW (g)
0 (Control)	98.00g**	9.00e	9.80e	45.00f	80.00d	5.80b	8.50cd
20	98.00g	6.90bc	8.30bc	45.00f	85.00e	5.70b	8.40c
40	97.00fg	8.10d	8.50cd	45.00f	80.00d	5.80b	8.50cd
60	96.00ef	8.00d	9.00d	45.00f	88.00f	5.70b	8.30bc
80	96.00ef	7.40cd	8.90d	45.00f	90.00g	5.60b	8.50cd
100	84.00a	7.40cd	8.70cd	40.00e	65.00c	6.00b	9.00d
200	90.00c	7.70d	8.60cd	35.00d	65.00c	4.00a	7.80ab
400	87.00b	6.20ab	7.90ab	30.00c	60.00b	5.00ab	7.80ab
600	93.00d	6.10a	7.80ab	25.00b	55.00a	4.00a	7.60a
800	95.00e	5.90a	7.70a	25.00b	55.00a	4.00a	7.60a
1000	93.00d	5.70a	7.60a	20.00a	55.00a	4.00a	7.50a
Mean	93.36±0.79	7.13±0.19	8.44±0.12	36.36±1.65	70.73±2.37	5.05±0.18	8.14±0.9
F	63.76	17.69	13.34	286.36	590.46	4.14	7.34
P	0.000	0.000	0.000	0.000	0.000	0.000	0.000

* Abbreviations of variable are given in Table 1. ** Means within each column followed by the same letter (a–g) do not differ significantly at P < 0.001.

According to variance analysis results, the difference among concentrations was significant at the 0.001 level for the measured characteristics of both bean and chickpea seedlings. The effects of different concentrations of A and B boron wastes on seedling characteristics of species were presented in Table 2-5. In general sense, the measured seedling characteristics had higher values in the control treatment (without waste). Moreover, it was detected that they decreased in especially 600 ppm and over concentrations of A and B wastes.

The root and shoot lengths, the fresh root and shoot weights, the dry root and shoot weights of bean seedlings applied A concentrate decreased up to 60%, 63%, 73%, 69%, 66%, and 57% and compared to control treatment, respectively. When B concentrate applied they reduced up to 60%, 63%, 73%, 69%, 66%, and 57% compared to control treatment, respectively (Table 2-3).

The root length, shoot length and the fresh weight of root and shoot and the dry weight of root and shoot of chickpea seedlings applied A concentrate decreased by up to 72%, 58%, 74%, 75%, 61%, and 56%, respectively compared to the control treatment. When B concentrate applied they decreased by up to 37%, 22%, 56%, 31%, and 12%, respectively compared to the control treatment (Table 4-5). Based on these data, it was understood that the difference between different concentrates of B waste and control treatment were lower than A waste.

The mean values obtained from the measures of bean and chickpea seedlings applied B waste was higher than those applied A waste. Accordingly the mean root and shoot lengths, the fresh root and shoot weights, the dry root and shoot weights of bean seedlings were found 5.81 cm, 9.20 cm, 49.55 g, 102.27 g, 6.35 g and 10.29 g, respectively. On the other hand, the mean root and shoot lengths, the fresh root and shoot weights, the dry root and shoot weights of chickpea seedlings were found 7.13 cm, 8.44 cm, 36.36 g, 70.73 g, 5.05 g and 8.14 g, respectively.

Boron amount had a significant effect on the first pod height, boron content of grain, germination rate, 1000-seed weight and grain yield [8]. Either boron lacking or excess boron in the medium did not affect germination rate of sunflower. In addition, it was reported that boron deficiency caused an increase in the root length and IAA content but, a decrease in the shoot length and pigment content; while the excess boron caused a decrease in root length and IAA content but, an increase in the shoot length and pigment content, at the end of four week [10]. Boron had no significant effect on shoot and root growth of sunflower but caused a decrease in root fresh weight [11].

The excess boron led to a decrease in the growth of wheat [12]. Nevertheless, it was conducted that boron caused a decrease in dry weight of Bolal-2973 and Gerek-79 varieties but an increase in dry weight of Çakmak-79 ve Kızıltan-91 varieties. The excess boron decreased the root and shoot length of barley and wheat [13-14]. However, the excess boron decreased the root and shoot fresh weights of corn [15]. The common way of these studies was to arise a decrease in seedling characteristics depending on boron increasing. In other words, these results confirmed those of the present study. The effects of boron on plants varied with plant species and boron concentrations applied [10].

In conclusion, an inhibitor effect of two boron wastes on bean and chickpea germination wasn't found. On the contrary, 600 ppm and over concentrations of both wastes led to a reduction in the measured characteristics of seedlings. It was considered that these reductions would be derived from the excess boron or synergistic effects of many mineral elements within waste.

References

[1] Kozan E., Kırcalı Sevimli F., Köse M., Eser M., Çiçek H., 2007. Examination of Helminth Contaminated Wastewaters Used for Agricultural Purposes in Afyonkarahisar. *Türkiye Parazitoloji Dergisi*, 31 (3): 197-200.

[2] Marschner H., 1997. Mineral Nutrition of Higher Plants, *Academic Press*, UK, p. 313.

[3] Brown P.H., Bellaloui N., Wimmer M.A., Basil E.S., Ruiz J., Hu H., Pfeffer H., Dannel Römheld V., 2002. Boron in plant biology, *Plant Biology*, 4: 205-223.

[4] Kastori R.R., Maksimovial I.V., Kraljevia M.M., Kobiljski B.D., 2008. Physiological and Genetic Basis of Plant Tolerance to Excess Boron. *Proceedings for Natural Sciences, Matica Srpska Novi Sad*, No. 114: 41-51.

[5] Lovatt C.J., 1985. Evolution of Xylem Results in a Requirement for Boron in the Apical Meristems of Vascular Plants, *New Phytology*, 99: 509-522.

[6] Shelp B.J., 1993. Physiology and Biochemistry of Boron in Plants, In: Boron and Its Role in Crop Protection (Ed. U.C. Gupta), *CRC Press*, Boca Raton FL, p. 53-85.

[7] Mahboobi H., Yücel M., Öktem H.A., 2000. Changes in Total Protein Profiles of Barley Cultivars in Response to Toxic Boron Concentration, *Journal of Plant Nutrition*, 23(3): 391-399.

[8] Gülümser A., Odabaş M.S., Özturan Y., 2005. The Effect of Soil and Foliar Applied Boron at Different Rates on Yield and Yield Components of Common Bean (*Phaseolus vulgaris* L.). *Akdeniz University, Journal of Agricultural Faculty*, 18(2): 163-168.

[9] Al-Mutawa M.M., 2003. Effect of Salinity on Germination and Seedling Growth of Chickpea (*Cicer arietinum* L.) Genotypes, *International Journal of Agriculture&Biology*, 05(3): 226–229.

[10] Akçam-Oluk E., Demiray H., 2004. The Effects of Boron on the Growth of sambro no.3 Sunflower (*Helianthus annuus* L.), *Ege University, Journal of Agriculture Faculty*, 41(1): 181-190.

[11] Ortaca Ş., 2005. The effects of boron on vegetative growing, pigment, protein quantity and protein prophile in Sunflower plant. MSc thesis, Graduate School of Natural and Applied Sciences Dumlupınar University, Kütahya, 42 p.

[12] Rerkasem B., Jamjod S., 2004. Boron deficiency in wheat: a review. *Field Crops Research*, 89(2-3): 173-186.

[13] Taban S., Erdal İ., 2000. Effects of Boron on Growth of Various Wheat Varieties and Distribution of Boron in Aerial Part. *Turkish Journal of Agricultural Forestry*, 24: 255–262.

[14] Ayvaz M., 2002. Effects of boron on growth and development of some barley cultivars. MSc thesis, Institute of Science and Technology, Ege University, İzmir, 45 p.

[15] Güneş A., Alpaslan M., Özcan H., Çıkılı Y., 2000. Tolerance to Boron Toxicity of Maize (*Zea mays* L.) Cultivars Widely Cultivated in Turkey, *Turkish Journal of Agricultural Forestry,* 24: 277-282.

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