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THE CRITICAL LEVELS OF BORON FOR GERMINATION AND SEEDLING GROWTH OF MELON

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Abstract: This study was conducted to determine the effects of boron levels on germination and seedling growth of melon cultivars with different fruit characteristics under laboratory conditions. The seeds of three melon cultivars (Hasanbey 1, Kırkağaç 589, and Toros Sarıbal) were germinated at different boron levels (0, 20, 40, 60, 80, and 100 mg L^{-1}) constituted by sodium borate ($Na_2B_8O_{13}.4H_2O$). Germination percentage, mean germination time, germination index, seedling growth parameters, and seedling dry matter were investigated. The optimum and toxicity levels of boron were calculated by regression analysis. Germination percentage, mean germination time, and germination index were not affected by increasing boron levels. A boron dose of 20 mg L^{-1} promoted root length, shoot length, and seedling fresh weight of melon; however, seedling growth of melon cultivars was inhibited at higher boron levels than 40 mg L^{-1}. Seedling dry weight and dry matter significantly enhanced when the boron levels were increased. Root length was more sensitive to boron than shoot length. Melon cultivars showed different responses to boron levels and the highest seedling growth parameters were obtained from Kırkağaç 589. The optimum boron level for shoot growth was calculated as 12.8 mg L^{-1}, while the inhibitory level of boron for root growth was 65.4 mg L^{-1}. The toxicity of boron on the germination performance was not detected and higher levels than 20 mg L^{-1} inhibited seedling growth of melon.

Keywords: *Cucumis melo* L., Genotype, Sodium borate, Germination, Seedling growth

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1. Introduction

Seed germination is adversely influenced by several biotic and abiotic stress factors. The major abiotic stresses in the seedbed are extreme temperatures, drought, flooding, salinity, and high heavy metal concentrations. Also, excessive or scarcity of plant nutrients may change the germination performance and subsequent seedling growth. Of these nutrients, boron (B) which is a micronutrient affecting adversely or positively plants, plays a key role in seed formation because healthy flowers cannot be produced, and no seeds develop in case of deficiency in B (Mozafar, 1993; Landi et al., 2019). However, the plants grown under increasing B concentration in the soil produce high B content in seeds, which negatively affected the germination ability (Rerkasem et al., 1997). B concentration in the arable soil changes from 1 to 467 mg kg^{-1}, but its concentration generally varies between 0.5 and 5 mg kg^{-1} (Gupta, 2016). In Türkiye, 46.2% of the agricultural soils suffer from B deficiencies, while 19.4% and 3.3% of the total area had excess and toxic concentrations of B, respectively (Kıllıoğlu, 2022). Increased B concentrations in soils resulted in an increase in uptake by plant tissues and transportation to the seeds. Recently, Kintl et al. (2023) showed a significant negative relationship between B concentration in black medic seeds and germination. Lower B levels have been used as priming agents for improvement in germination while higher levels of B had a toxic effect on seeds (Bonilla et al., 2004; Alamri et al., 2018; Kintl et al., 2023). Nevertheless, irrigation water contains B, which continuously causes the accumulation of B in the soils in arid and semi-arid conditions due to poor drainage; consequently, it can reach toxic levels (Reid, 2007; Tanaka and Fujiwara, 2008; Landi et al., 2019).

Melon (*Cucumis melo* L.) is a warm-season vegetable with juicy and sweet fruit, and it is cultivated under open fields and greenhouse conditions. There are a lot of melon cultivars with several fruit types (Vural et al., 2000) and they are grown on 63.000 hectares, with a fruit production of 1.6 million tons in Türkiye (Anonymous, 2023). Melons are classified as moderately boron-tolerant plants (Maas and Grattan, 1999); however, it depends on genotypic factors and plant growth stages. In the previous studies, the effects of B on plant growth, physiological parameters, and yield of melon were investigated, but germination and early seedling growth performance of melon under boron stress have not been reported (Goldberg et al., 2003; Shalaby and El-Messairy, 2018). This study aimed to determine the toxic and promoter levels of boron for seed germination and early seedling growth of melon cultivars.

2. Materials and Methods

A laboratory experiment was performed to determine the effect of boron levels on germination and seedling growth of melon cultivars at the Seed Science and Technology Laboratory, Eskişehir Osmangazi University in 2023. In the study, the seeds of melon cultivars with different fruits morphology (Hasanbey 1, Kırkağaç 589, and Toros Sarıbal) and sodium borate (20.9% $Na_2B_8O_{13}.4H_2O$) were used as materials. Some morphological characteristics of melon cultivars were given in Table 1.

The seeds were germinated at six boron levels (0, 20, 40, 60, 80, and 100 mg B L^{-1}) which were prepared from sodium borate (Etidot-67). Distilled water was used for control (0 mg L^{-1}). Four replicated fifty seeds from each melon cultivar were placed between three filter paper sheets with a dimension of 20 × 20 cm and each paper was watered with 7 mL for respective boron solutions. Just after the filter papers were rolled, they were put into a sealed plastic bag. The packages were incubated at 25 °C for 10 days under dark conditions. Two millimeters of radicle protrusion was considered as the germination criterion. Germination percentage (GP), mean germination time (MGT), and germination index (GI) were also calculated with the Equation 1, 2 and 3:

GP (%)= (Germinated seeds at final day / Total seeds) × 100, (ISTA, 2018) (1)

MGT (day)= ∑ Dn / ∑ n, (ISTA, 2018) (2)

where, n is the seed number germinated on day D, and D is the number of days from the beginning of the germination test.

GI= (Number of germinated seeds + Days of the first count) + …. + (Number of germinated seeds + Days of the final count), Salehzade et al. (2009) (3)

On the last day, randomly selected ten seedlings from each treatment were sampled to measure root length, shoot length, and seedling fresh and dry weight. The seedlings were dried in an air oven at 80 °C for 24 h.

2.1. Statistical Analysis

The experiment was set up in a two-factor factorial in a completely randomized design with four replicates. The data were analyzed by ANOVA and the differences were compared by the Least Significant Differences (LSD) test at a 5% level. The optimal boron levels for seedling growth were estimated by a quadratic regression equation. The independent variable (boron level) was attained on X-axis and the dependent variable (length) on the Y-axis. The peak value (-b/2a) from the regression equation ($y= -ax^2+bx+c$) in shoot length and the toxic dose of boron which is lead to a 50% reduction in root length was predicted from the linear regression ($y= -ax+b$) (Fallahi et al., 2017; Wang et al., 2020).

3. Results and Discussion

Analysis of variance revealed that there were no significant effects of boron levels on the germination parameters of melon cultivars (Table 2). However, there were statistically significant differences among melon cultivars for germination percentage, mean germination time, and germination index. Kırkağaç 589 possessed the highest germination percentage and germination index, while it had the shortest mean time for germination. Because there was no information on the germination performance of melon seeds under boron stress, the results of the studies conducted with other crops were considered. For instance, Rerkasem et al. (1997) reported no significant drop in the germination of soybean due to boron levels. The findings of Kaya et al. (2023) confirmed no significant changes in the germination percentage of sunflower, soybean, and poppy seeds and increased germination index up to 90 mg L^{-1}. Contrarily, Turhan and Kuşçu (2021) determined significant differences among B levels for germination percentage, index, energy, and mean germination time in watermelon, pepper, and eggplant, although they used lower doses (up to 16 mg L^{-1}) than in the present study. Furthermore, they reported a decrease in germination percentage and germination index, but an increase in mean germination time. This may be explained by using different plant species, or the germination criterion considered.

Boron levels significantly affected the seedling growth parameters of melon cultivars ($P<0.01$) and the interaction of cultivar × boron level was not significant only for seedling dry weight (Table 3). Kırkağaç 589 produced a higher shoot and root length, seedling fresh and dry weight, and dry matter than the other cultivars. An increase was observed in seedling growth at a boron level of 20 mg L^{-1}. They were decreased by increasing boron levels above 40 mg L^{-1}. This result showed a similarity with the findings of Mokhtari et al. (2022), who reported a significant increase in shoot and root length of sugar beet exposed to boron levels up to 1.6 ppm.

Table 1. Some fruit morphological characteristics of melon cultivars

Cultivars	Skin color	Flesh color	Fruit shape of longitudinal section
Hasanbey 1	Green	Greenish white	Round-oval
Kırkağaç 589	Green and black spots on yellow	White	Long elliptic
Toros Sarıbal	Yellow	Light yellow	Long elliptic

Table 2. Effects of boron levels on germination parameters of melon cultivars

Factor	Germination percentage (%)	Mean germination time (day)	Germination index
Cultivar (A)			
Hasanbey 1	87.8c	2.34a	20.1c†
Kırkağaç589	96.3a	2.02c	23.9a
Toros Sarıbal	91.7b	2.11b	22.2b
Boron level (B)			
0 mg L^{-1}	91.3	2.17	21.8
20 mg L^{-1}	91.0	2.15	21.8
40 mg L^{-1}	92.8	2.12	22.5
60 mg L^{-1}	92.2	2.15	22.1
80 mg L^{-1}	92.2	2.15	22.2
100 mg L^{-1}	92.2	2.21	21.9
Analysis of variance			
A	**	**	**
B	NS	NS	NS
A×B	NS	**	NS

**= significant at 1%, NS= non-significant, †= Letter(s) connected with the means denote significance levels at P<0.05.

Table 3. Effects of boron levels on seedling growth parameters of melon cultivars

Factor	Shoot length (cm)	Root length (cm)	Seedling fresh weight (mg plant^{-1})	Seedling dry weight (mg plant^{-1})	Dry matter (%)
Cultivar (A)					
Hasanbey 1	6.35b	6.26b	208b	21.0c	11.1b†
Kırkağaç 589	7.34a	6.53a	255a	26.0a	10.9b
Toros Sarıbal	5.67c	6.17b	213b	24.4b	12.4a
Boron level (B)					
0 mg L^{-1}	7.77c	9.73b	272b	22.3c	8.19e
20 mg L^{-1}	9.05a	10.56a	298a	23.1bc	7.76e
40 mg L^{-1}	8.24b	8.13c	265b	23.8abc	9.06d
60 mg L^{-1}	6.13d	4.80d	211c	23.8abc	11.37c
80 mg L^{-1}	4.42e	2.91e	173d	25.0a	11.42b
100 mg L^{-1}	3.11f	1.78f	134e	24.0ab	17.92a
Analysis of variance					
A	**	**	**	**	**
B	**	**	**	**	**
A×B	**	**	**	NS	**

**= significant at 1%, NS= non-significant, †= Letter(s) connected with the means denote significance levels at P<0.05.

The interaction of cultivar × boron level on seedling growth parameters was shown in Figure 1. The shoot length of melon cultivars was changed by boron levels. Boron levels of 20 and 40 mg L^{-1} induced the shoot length, but higher levels inhibited it considerably (Figure 1A). Kırkağaç 589 gave the highest shoot length under all boron levels. At the highest boron level, the shoot length was reduced in Hasanbey 1 by 56%, in Kırkağaç 589 by 61%, and in Toros Sarıbal by 62%. Similar results were announced in sugar beet by Mokhtari et al. (2022) who reported an increase in seedling length in sugar beet exposed to boron levels up to 1.6 ppm. Habtamu et al. (2014) recorded a constant reduction in the shoot length of safflower at higher boron levels than 1 mg L^{-1}. The root length was depressed by boron levels except for 20 mg L^{-1} at which it was promoted (Figure 1B). Hasanbey 1 had the shortest length of root at boron levels of 60 and 80 mg L^{-1}, while no significant differences among cultivars were observed at 100 mg L^{-1}. The root growth was more sensitive to boron levels, and it declined by 81%. This result was confirmed by the findings of Habtamu et al. (2014) and Kaya et al. (2023) in safflower. Depending on shoot and root depletion, the seedling fresh weight was changed. Although Kırkağaç 589 had the highest fresh weight at all levels of boron, the minimum decrease was obtained from Toros Sarıbal by 48.8%, followed by Hasanbey 1 by 49.6% and Kırkağaç 589 by 50%. A boron level of 20 mg L^{-1} supported seedling fresh weight, but higher levels caused a significant decline (Figure 1C). Cıkılı et al. (2013) demonstrated a drastic diminish in shoot and root dry weight in cucumber because they grow the plants at maturity under increasing boron levels of 20 mg kg^{-1}. On the other hand, the dry matter of melon seedlings increased under increasing boron levels (Figure 1D). Dry matter indicates the ratio of dry weight to fresh weight, and it gives a more precise result than dry wights. In the study, a significant enhancement in dry matter was determined in Toros Sarıbal at 40 mg L^{-1} and higher boron levels caused an enhancement in dry matter.

The relationship between boron levels and shoot and root length was calculated by quadratic and linear regression equations, respectively. The peak value of shoot length was calculated at a boron level of 12.8 mg L^{-1} by means of the quadratic equation of $y=-0.0007x^2+0.0179x+8.2771$, with the significant determination coefficient $R^2=0.935^{**}$ (Figure 2). The shoot length gradually decreased at higher boron levels. However, the significant relationship between root length and boron levels was determined in linear regression, and the toxic dose of boron causing a 50% reduction in root growth was identified as 65.4 mg L^{-1} which was calculated by the equation of $y= -0.0943x+11.036$, $R^2= 0.924^{**}$ (Figure 3).

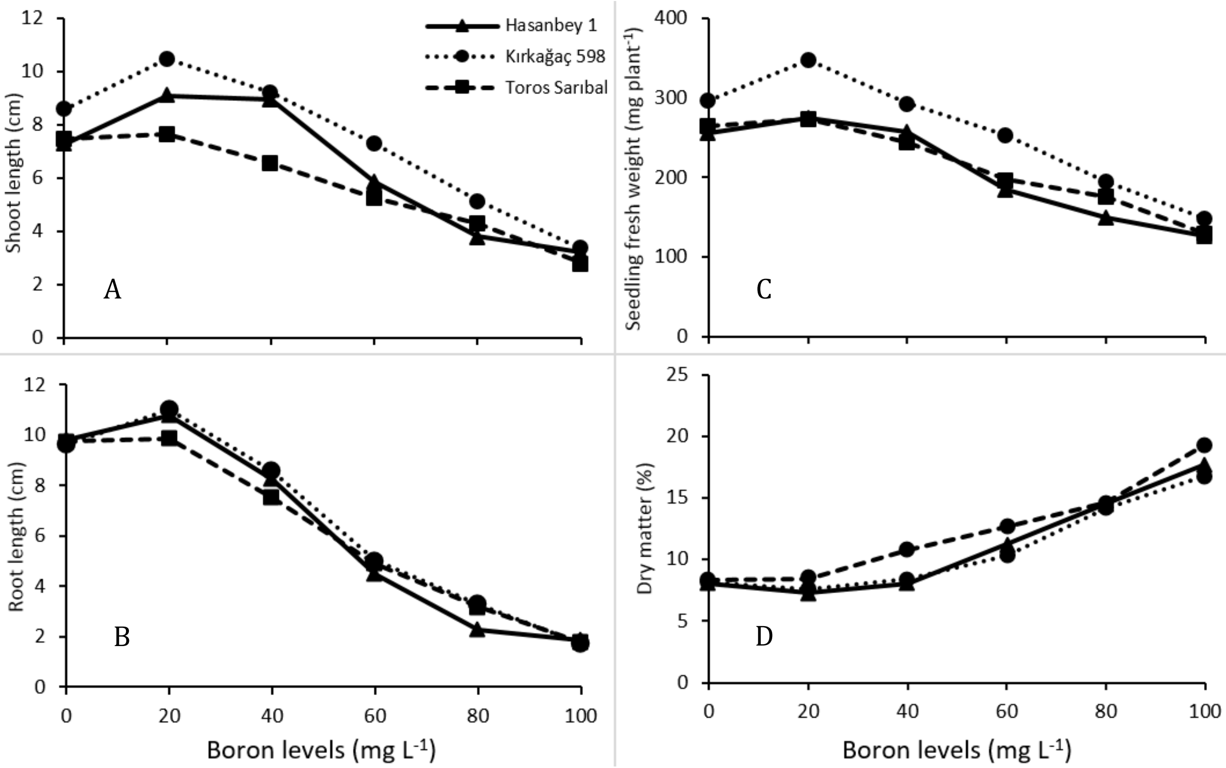

Figure 1. Changes in shoot length (A), root length (B), seedling fresh weight (C), and dry matter (D) of melon cultivars under different boron levels.

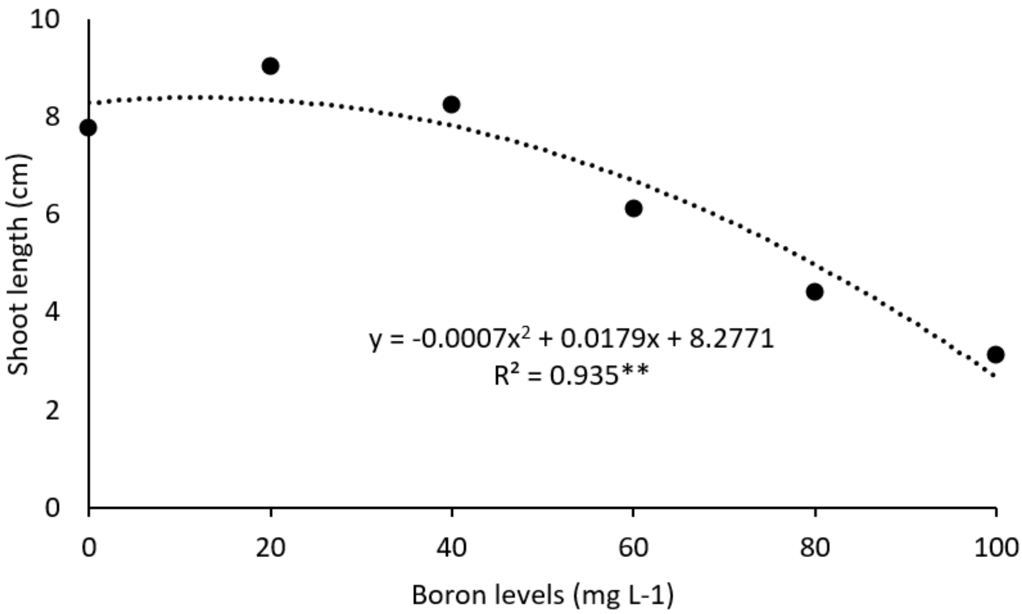

Figure 2. The quadratic regression between boron levels and mean shoot length of melon cultivars.

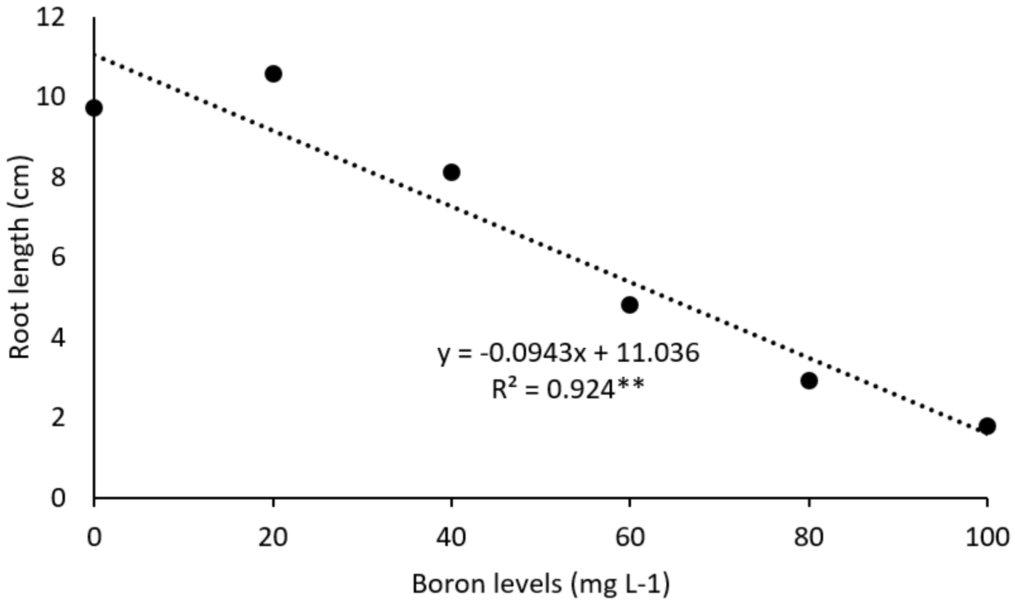

Figure 3. The linear regression between boron levels and mean root length of melon cultivars.

4. Conclusion

The study demonstrated that the germination characteristics of melon cultivars were not adversely influenced by boron levels up to 100 mg L^{-1}. However, increased boron levels depressed the seedling growth, and the inhibitory effects on shoot length were identified at 40 mg L^{-1}. The sensitivity of seedling parts of melon was different and root growth was much more affected by boron levels than shoot growth. It was concluded that the positive effect of boron on seedling growth was up to 12.8 mg L^{-1}, but the detrimental impact was at 65.4 mg L^{-1} during the early seedling development of melon.

Author Contributions

The percentage of the author contributions is presented below. The author reviewed and approved the final version of the manuscript.

	G.K.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100
PM	100
FA	100

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The author declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because there was no study on animals or humans.

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References

Alamri SA, Siddiqui MH, Al-Khaishani MY, Hayssam MA. 2018. Boron induces seed germination and seedling growth of Hordeum vulgare L. under NaCl stress. J Adv Agri, 8(1): 1224-1234.

Anonymous. 2023. Turkish Statistical Institute, URL: https://biruni.tuik.gov.tr/medas/?kn=92&locale=tr (accessed date: February 10, 2023).

Bonilla I, El-Hamdaoui A, Bolaños L. 2004. Boron and calcium increase Pisum sativum seed germination and seedling development under salt stress. Plant Soil, 267: 97-107.

Cıkılı Y, Samet H, Dursun S. 2013. Effects of potassium treatment on alleviation of boron toxicity in cucumber plant (Cucumis sativus L.). Soil-Water J, 2(2): 719-726.

Fallahi HR, Aghhavani-Shajarib M, Mohammadic M, Kadkhodaei-Barkookd R, Zareeid E. 2017. Predicting of flixweed (Descurainia sophia (L.) Webb ex Prantl) germination response to temperature using regression models. J Appl Res Medic Aromat Plants, 6: 131-134.

Goldberg S, Shouse PJ, Lesch SM, Grieve CM, Poss JA, Forster HS, Suarez DL. 2003. Effect of high boron application on boron content and growth of melons. Plant Soil, 256: 403-411.

Gupta UC. 2016. Boron. In: Barker AV, Pilbeam DJ, editors. Handbook of Plant Nutrition, CRC press, New York, US, pp: 257-294.

Habtamu A, Ibrahim AH, Urgecha F, Ermias E. 2014. Boron toxicity on seed germination and seedling growth of safflower (Carthamus tinctorius L.). Herald J Agric Food Sci Res, 3(1): 1-6.

ISTA 2018. International rules for seed testing. International Seed Testing Association. URL: https://www.seedtest.org/ (accessed date: February 10, 2023).

Kaya MD, Ergin N, Harmancı P. 2023. Effects of boron forms and doses on germination in sunflower, soybean, and opium poppy seeds. J Agri Product, 4(1): 1-6.

Kıllıoğlu M. 2022. Effect of boron (B) application on development and some quality properties of corn plant. MSc thesis, Çukurova University, Institute of Natural and Applied Sciences, Adana, Türkiye, pp: 71.

Kintl A, Huňady I, Ondrisková V, Hammerschmiedt T, Brtnický M, Vejražka K, Kubíková Z, Elbl J. 2023. Influence of boron and drought simulation on germinability and hardseededness of black medick seeds (Medicago lupulina L.). J Plant Growth Regul, 42: 1704-1719.

Landi M, Margaritopoulou T, Papadakis IE, Araniti F. 2019. Boron toxicity in higher plants: an update. Planta, 250: 1011-1032.

Maas EV, Grattan SR. 1999. Crop yields as affected by salinity. In: Skaggs RW, van Schilfgaarde J, editors. Agricultural Drainage. Agronomy Monograph No: 38, ASA, Madison, US, pp: 55-108.

Mokhtari NEP, Asan NT, Kızılgeçi F. 2022. Investigation of the effects of boron application on germination and early seedling development of sugar beet. Toprak Bil Bitki Besleme Derg, 10(1): 29-33.

Mozafar A. 1993. Role of boron in seed production. In: Gupta UC, editor. Boron and its role in crop production. CRC Press, New York, US, pp: 186-206.

Reid R. 2007. Update on boron toxicity and tolerance in plants. In: Xu F, Goldbach HE, Brown PH, Bell RW, Fujiwara T, Hunt CD, Goldberg S, Shi L, editors. Advances in plant and animal boron nutrition, Springer, Berlin, Germany, pp: 83-90.

Rerkasem B, Bell RW, Lodkaew S, Loneragan JF. 1997. Relationship of seed boron concentration to germination and growth of soybean (Glycine max). Nutrient Cycling Agroecosyst, 48: 217-223.

Salehzade H, Shishvan MI, Ghiyasi M, Forouzin F, Siyahjani AA. 2009. Effect of seed priming on germination and seedling growth of wheat (Triticum aestivum L.). Res J Bioll Sci, 4: 629-631.

Shalaby OS, El-Messairy MM. 2018. Humic acid and boron treatment to mitigate salt stress on the melon plant. Acta Agri Slovenica, 111(2): 349-356.

Tanaka M, Fujiwara T. 2008. Physiological roles and transport mechanisms of boron: Perspectives from plants. European J Physiol, 456: 671-677

Turhan A, Kuşçu H. 2021. The effect of boron stress on germination properties of pepper, eggplant and watermelon seeds subjected to salicylic acid pre-application. Anadolu J Agr Sci, 36(2): 179-188.

Vural H, Eşiyok D, Duman İ. 2000. Kavun. In: Kültür Sebzeleri (Sebze Yetiştirme). Ege Üniversitesi Basımevi, İzmir, Türkiye, pp: 364-377.

Wang GS, Lynch AL, Cruz VMV, Heinitz CC, Dierig DA. 2020. Temperature requirements for guayule seed germination. Indust Crops Products, 157: 112934.