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EFFECTS OF IRRIGATION WATER QUALITY (DIFFERENT SALINITY LEVELS AND BORON CONCENTRATIONS) ON MORPHOLOGICAL CHARACTERISTICS OF GRAFTED AND NON-GRAFTED EGGPLANTS

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Abstract
High yield cultivars with quite high resistance against pests and diseases, irrigation water salinity and deficit irrigation conditions are significant in plant production activities. Researches have been conducted also to improve the resistance of available cultivars. Since 1990s, researchers have tried to use low quality irrigation waters just because of deficit water resources and current trends in global warming and climate change. The basic target in all these researches is to reduce production costs and to improve quality and yields. Availability of low quality irrigation waters is a basic component of sustainable agricultural production. The present study was conducted in 40 liter pots under greenhouse conditions. Grafted and non-grafted eggplant seedlings were planted into these pots. Then, plants were irrigated with irrigations waters with different salinity levels (0.25, 1, 1.5, 2, 4, 6, 10 and 15 dS/m) and boron concentrations (0, 1, 2, 4, 8, 16, 32 and 64 ppm). In this way, effects of different irrigation water qualities on plant morphological characteristics were investigated.

Keywords: Irrigation water quality, salinity, boron, eggplant

1. INTRODUCTION

Water quality deteriorations are among the greatest problems of industrialized countries of the world. Uncontrolled release of huge amount of wastes into environment negatively influences water quality and consequently distorts the aquatic life in in water bodies (Udosen, 2006; Danazumi and Bichi, 2010). Treated wastewaters are sometimes used as irrigation water in various parts of the world. However, heavy metals in wastewaters may create certain risks for plants and soils. Therefore, heavy metals should be removed from wastewaters before to use them in irrigations for sustainable environments. Heavy metals and trace elements may accumulate in soils ad plants and may ultimately reach to toxic levels for living organisms.

In arid and semiarid regions, soil salinity leads to reduced crop growth and yield. The most dominant influences on yield variability (other than climate) are the soil physical and chemical factors such as soil texture and salinity (Whelan and McBratney, 2003). Salinity limits the water uptake of plants by reducing the osmotic potential and thus the total soil water potential (Corwin and Lesch, 2003; Sheldon et al., 2004).

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Not only the irrigation method, irrigation scheduling and amount of irrigation, but also the quality of irrigation water is a significant issue in agricultural irrigations. Environmental pollution is getting a more serious concern along with the developments in agricultural activities and in other sectors. Especially the use of irrigation waters with more than 1 ppm boron concentration may result in serious problems both in plants and soils (Ayers and Westcot, 1989). Soil boron concentrations increase based on boron concentration of irrigation waters and duration of irrigations.

There are significant differences between boron tolerances of plants. Such differences result from different physiological and morphological responses of plants against boron toxicity (Paul et al., 1988; Huang and Graham, 1990; Nable, 1991; Taban and Erdal, 2000).

Sustainable irrigated farming will only be possible with a well soil and water management. Irrigation water quality constitutes a great component of water management. Irrigation water salinity has a vital significance for both plants and soils. Increasing salt concentrations in irrigation waters may create salt-damage on plants. Severity of salt damage varies based on type of salt, concentration of salt, applied quantities and application durations. The developments experienced in agricultural practices also altered the plant salt tolerance limits. According to Bresler et.al. (1982) and Grattan (2002), eggplant is quite sensitive to irrigation water salinity and the hazard threshold is 0.7 dS/m. However, Maas (1984; 1993) and Grieve et.al. (2012) indicated eggplant moderately sensitive to irrigation water salinity and reported the hazard threshold irrigation water salinity as 1.1 dS/m. There aren't any distinctive values for boron tolerance of eggplant. Currently available values belong to researches carried out 20 years ago for cultured cultivars. In recent years with new technologies and developments, salt-resistant cultivars have been developed and also high-yield cultivars have been grafted on salt-resistant ones to improve plant salt resistance levels.

The present study was conducted in 40 liter pots under greenhouse conditions. Grafted and non-grafted eggplant seedlings were planted into these pots. Then, plants were irrigated with irrigations waters with different salinity levels (0.25, 1, 1.5, 2, 4, 6, 10 and 15 dS/m) and boron concentrations (0, 1, 2, 4, 8, 16, 32 and 64 ppm). In this way, effects of different irrigation water qualities on plant morphological characteristics were investigated.

2. MATERIALS AND METHODS

Experiments were conducted in greenhouses of Agricultural Structures and Irrigation Department of Ankara University Agricultural Faculty. Physical and chemical characteristics of soil used in experiments are provided in table 1. Soils were placed into 40-liter pots and grafted and non-grafted seedlings were transplanted into these pots. Irrigation waters with eight different salt concentration (0.25, 1, 1.5, 2, 4, 6, 10 and 15 dS/m) and eight different boron conditions (0, 1, 2, 4, 8, 16, 32 and 64 ppm) were used in irrigation. Salinity levels were so adjusted as to have irrigation water SAR value of below 3. In this way, potential sodium and chlorine hazard was prevented.

Class A pan was placed into the greenhouse to determine the amount of irrigation water to be applied in each irrigation. All pots were brought to field capacity before the implementation of experimental traits. While applying irrigation waters with different salt and boron contents, additional 20% leaching water was also applied with irrigation water.

Irrigations were performed in frequent intervals as not to create a water stress on plants. Excess water was drained from the pot under free drainage conditions.

Data were statistically analyzed to determine the analysis of variance (ANOVA) and significant differences between the means were compared by LSD Multiple Range Test using Jump computer program.

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Table 1. Soil characteristics

Parameter	Unit	Value
EC	(µs/cm)	436.5
pH		7.98
OM	%	5.3
Texture	%	Clay loam
Lime	%	5.73
N	%	0.092
P	%	19.28
K	%	0.047
Ca	ppm	2566
Mg	ppm	137.19
Cu	ppm	1.09
Fe	ppm	6.36
Zn	ppm	0.72
Mn	ppm	7.46
B	ppm	3.487

3. RESULTS AND DISCUSSIONS

3.1 Effect of Salinity

3.1.1 Plant Height

Plant heights were directly influenced by irrigation water salinity levels. Plants exhibited different responses to changes in irrigation water salinity. The differences in plant heights of salinity treatments were found to be significant at 1% level and resultant LSD groups were provided in Table 2. Both grafted and non-grafted eggplant seedlings had similar responds against salinity levels (Figure 1). With regard to plant height, grafted seedlings were found to be more resistant to salinity.

Table 2. Effects of Irrigation Water Salinity on plant morphological characteristics

Salinity Levels (dS/m)	Plant Height (cm)		Stem Diameter (mm)	
	Grafted	Non-Grafted	Grafted	Non-Grafted
0.25	104.25 a	82.50 bcd	12.08 bcd	11.95 a
1	98.75 a	99.25 a	12.25 abc	11.95 a
1.5	101.00 a	87.50 bc	12.40 a	12.10 a
2	98.50 a	92.00 ab	12.48 a	12.28 a
4	99.25 a	89.50 ab	12.35 a	12.05 a
6	90.00 b	78.25 cd	12.03 cd	11.93 a
10	81.00 c	72.75 d	11.90 d	11.53 b
15	74.25 d	58.50 e	11.90 d	9.70 c

Note: Means with the same letter are not significantly different

Growth recessed in non-grafted seedlings after a threshold value of 1.1 dS/m. Such a recess was observed in grafted seedlings after 4dS/m. In other words, grafted seedlings had quite higher resistance than non-grafted seedlings to salinity. There was about 4 folds difference between grafted and non-grafted seedlings with regard to their resistance to salinity. While the plant height was around 100 cm in grafted seedlings irrigated with 4 dS/m irrigation water, the value was about 89 cm in non-grafted seedlings. The plant height of non-grafted seedlings at 1 dS/m irrigation water was about 100 cm.

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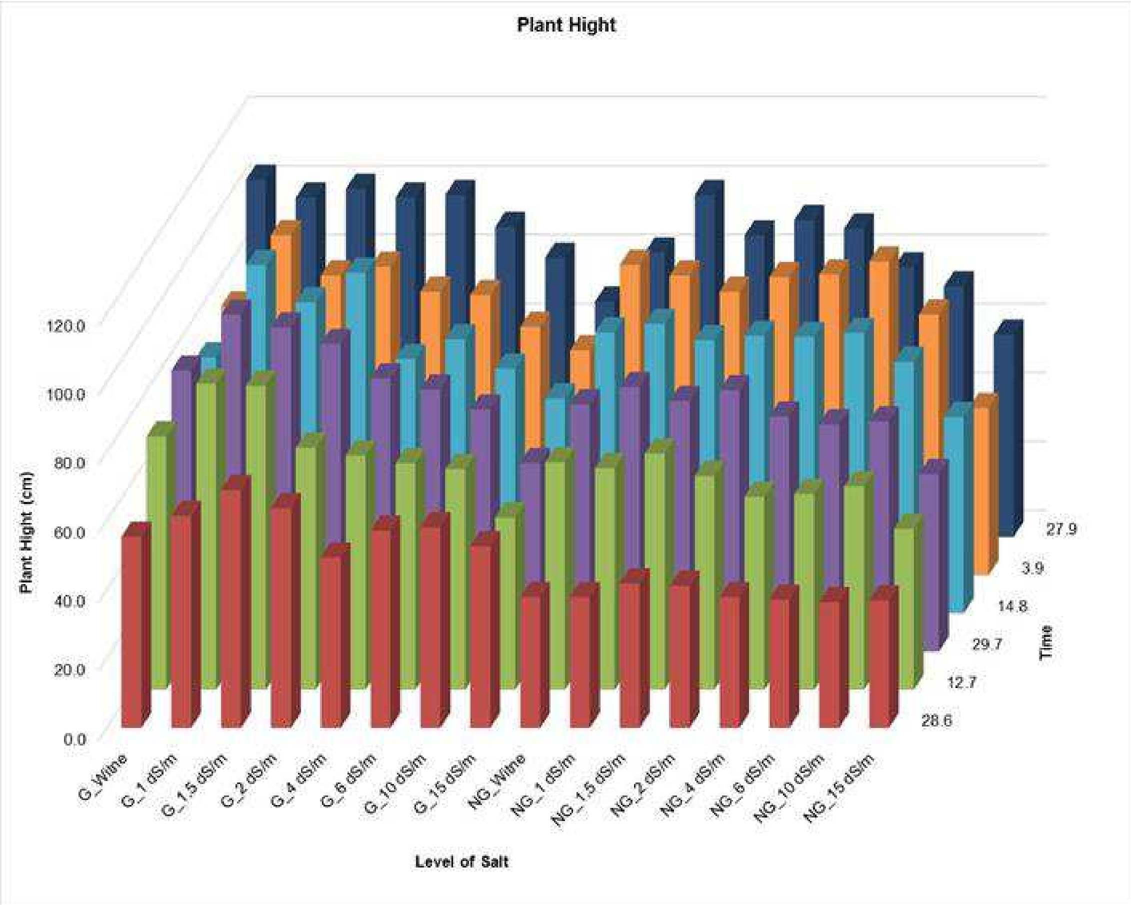

Figure 1. Changes in plant heights with salinity levels.

3.1.2 Stem Diameter

As it was in plant heights, stems diameters were also influenced by irrigation water salinity levels. Both grafted and non-grafted seedlings exhibited different responses to irrigation water salinity levels. The differences in stem diameters of salinity treatments were found to be significant at 1% level and LSD groups are provided in Table 2.

Increasing irrigation water salinity had significant effects on stem diameter. The most distinctive toxic effect of increasing salinity levels was observed at 6 dS/m in non-grafted seedlings and at 15 dS/m in grafted seedlings. Stem diameter developed faster in non-grafted seedlings starting from the planting since nothing was performed over non-grafted seedlings. There is a need for some time in grafted seedlings to have a full union, development and adaptation of the stem. Then, adapted seedling exhibits faster growth and form thicker and stronger stem. As it was in plant height, grafted seedlings were found to be better in stem diameter. Stem thickening result in a strong stem and then plant will be more resistant to plant and fruit weight.

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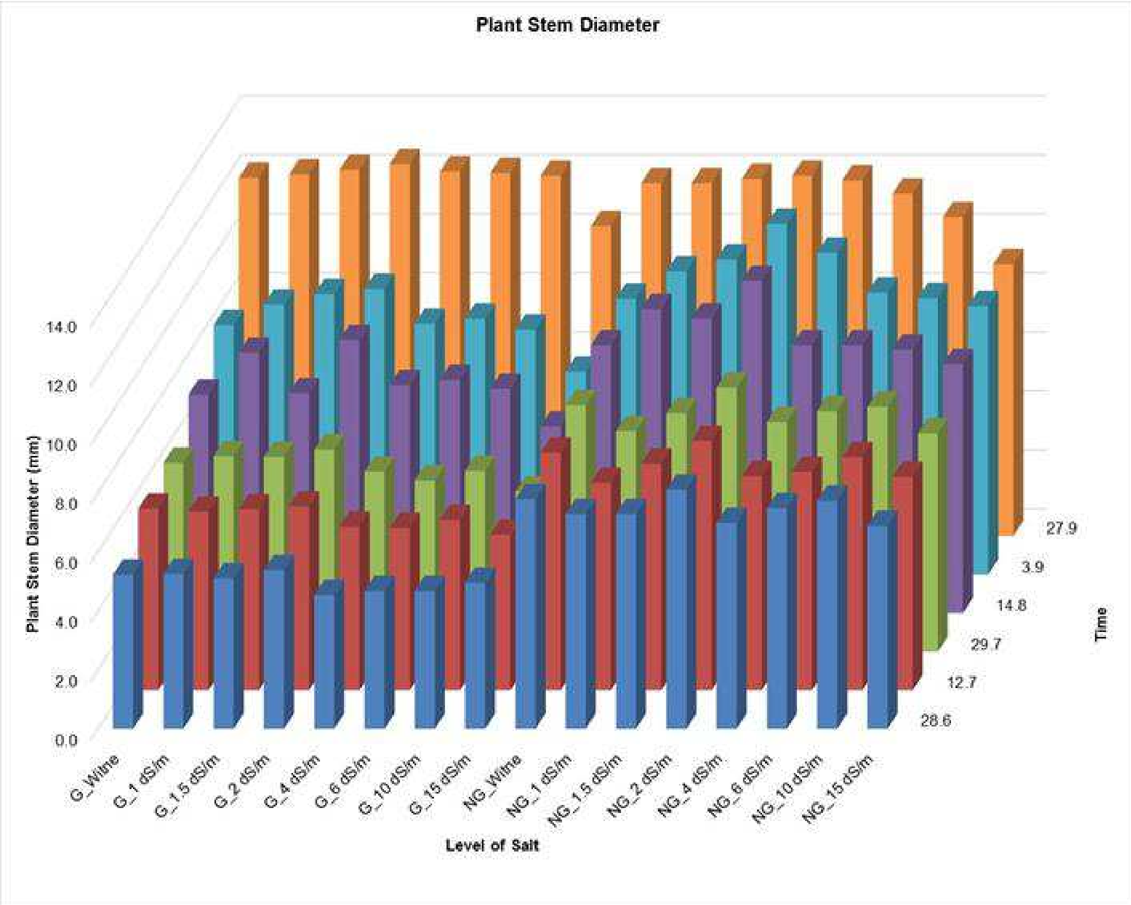

Figure 2. Changes in plant stem diameters with salinity levels

3.2 Effect of Boron

3.2.1 Plant Height

Boron is also an essential micro nutrient for plants. World-wide, boron deficiency is more extensive than deficiency of any other plant micro nutrient (Gupta, 1979; Reisenauer et al., 1973).

Increasing irrigation water boron concentrations influenced plant heights. The differences in plant heights of non-grafted seedling of boron treatments were found to be significant at 1% level and resultant LSD groups are provided in Table 3. The differences in plant height of grafted seedlings were not found to be significant. Increasing boron concentrations acted as a fertilizer in grafted seedlings.

Table 3. Effects of boron concentrations on plant morphological characteristics

Boron Levels (ppm)	**Plant Height (cm)**		**Stem Diameter (mm)**	
	Grafted	**Non-Grafted**	**Grafted**	**Non-Grafted**
0	104.25	82.50 b	11.95 a	12.08 a
1	103.00	92.50 ab	9.10 c	8.60 cd
2	103.25	101.75 a	9.20 c	8.88 cd
4	101.75	92.50 ab	9.23 c	8.88 cd
8	102.00	91.50 ab	9.40 c	8.93 cd
16	105.00	97.25 a	10.48 b	9.93 b
32	105.50	97.75 a	9.90 b c	9.18 b
64	100.25	97.25 a	9.48 b c	8.08 d

Note: Means with the same letter are not significantly different

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Irrigation waters with different boron concentrations were applied to grafted and ungrafted seedlings in this study. Increasing boron concentrations had positive impacts on plant height of grafted seedlings. Fertilizer effect was observed until 32 ppm concentration. Damage was observed following 64 ppm concentration. The 32 ppm concentration was above the threshold toxic value of 2 ppm for eggplant. In non-grafted seedlings, toxicity was observed after the threshold toxic value of 2 ppm. The concentration until 2 ppm had fertilizer effects on plants.

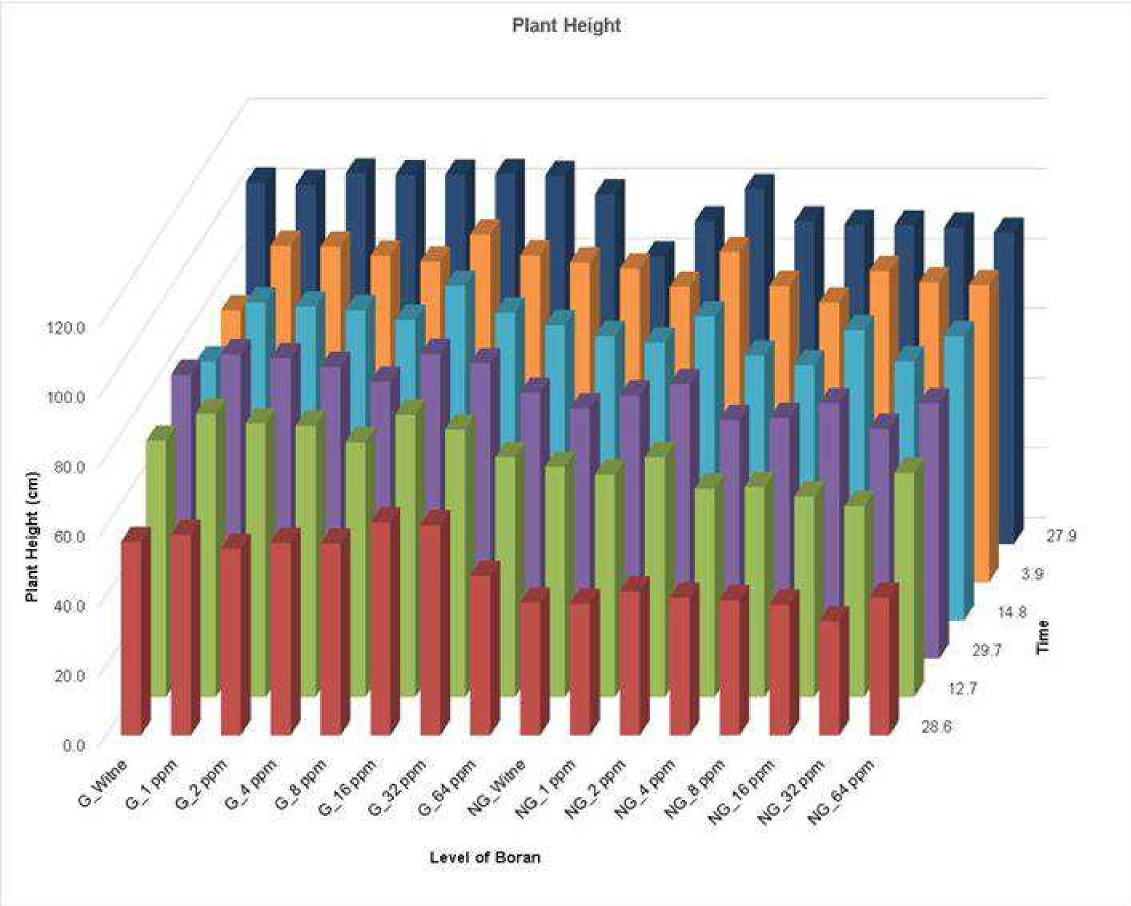

Figure 3. Changes in plant heights with boron concentrations

3.2.1 Stem Diameter

The differences in stem diameters of both grafted and non-grafted seedlings of different boron treatments were found to be significant at 1% level. Statistical analysis results and LSD groups are provided in Table 3.

With regard to stem diameter, boron concentrations had fertilizer effect until 32 ppm in grafted seedlings. However, toxicity started after the threshold value of 2 ppm in ungrafted seedlings. Plant growth recessed with increasing boron concentrations. The least growth and development was observed at 64 ppm concentration.

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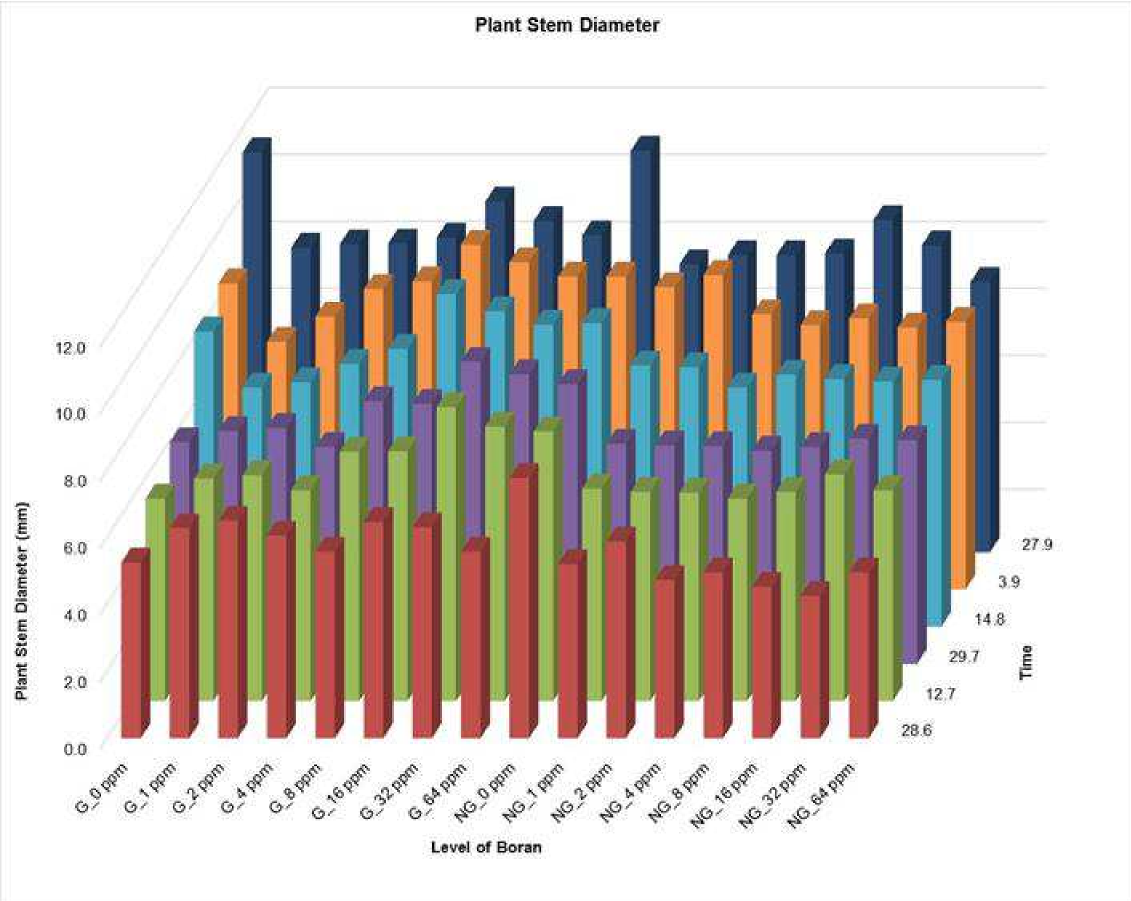

Figure 4. Changes in plant stem diameters with boron concentrations

4. CONCLUSIONS

At higher irrigation water salinity levels, the seedlings grafted on resistant rootstocks should be used in production activities. Grafting will allow both production of economically valuable plants and use of waters with quite high salt concentrations as irrigation water. Similar cases are valid also for boron concentrations. The plants and rootstocks resistance to high salinity and boron levels should be used for sustainable plant growth. Leaching water may also provide significant contributions for sustainability of agricultural activities.

Boron plays significant roles in plants. It is required for protein synthesis, cell wall development, sugar translocation, carbohydrate metabolism, hormone regulation, pollen grain germination and pollen tube growth, fruit set and seed development. It is mobile element and can leach through soils. Therefore, regular supplementations in small quantities are necessary for many plants.

Among the dissolved salts in irrigation water, the most harmful one is sodium and chlorine salts. Therefore, sodium absorption ratio of irrigation water should also be considered. With the use of a proper irrigation program, highly saline water can be used in irrigations.

Rootstocks play great roles in salt and boron tolerance of grafted seedlings. In this study, eggplant seedlings grafted on tomato rootstocks were sued. Additional leaching water (20%) played also significant role in prevention of salt hazards in plants. Therefore, hazard was observed at quite higher toxic levels than the levels in specified in previous literature.

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