J. Plant Production, Mansoura Univ., Vol. 8 (2):231- 238, 2017

Improving Growth, Top Root Yield and Betanin Pigment of Table Beet as a Result of Spraying with Magnesium, Copper and Boron under El-Arish Region

El-Tantawy, E. M.
Plant Production Department (Vegetables), Fac. Environ. Agric. Sci., Arish Univ., Egypt.

ABSTRACT

Growth of table beet plant *cv.* "Detroit Suprence", yield, betanin content and TSS in root top were studied due to application of Mg (0.75%, 1.5 %), Cu (15, 30 ppm), and B (30, 60 ppm) as foliar spray through two field experiments were carried out during the winter seasons of 2011-2012 and 2012-2013 at The Experimental Farm of Environ. Agric. Sci. Fac., Arish Univ., North Sinai. The results revealed that higher relative increment in leaf area was achieved by application of Mg at 1.5 % as foliar spray which increased by 90.6 % and 73.0 % in the 1^{st} and 2^{nd} seasons, respectively in comparison with control. Total fresh weight of plant was increased with application of B at 60 ppm in both seasons with relative increments of 47.55% and 43.65 % over the control treatment in 1^{st} and 2^{nd} seasons, respectively. Higher total dry weight per plant was recorded with foliar application of B at 30 ppm in the 1^{st} season, Cu at 15 ppm and B at 60 ppm in the 2^{nd} season. The relative increments in dry weight of plant were 43.45 %, 39.95 %, and 39.10 % over the control for spraying with B at 30 ppm in the 1^{st} season, Cu at 15 ppm and B at 60 ppm in the 2^{nd} season, respectively. Spraying with Cu at 15 ppm and Mg at both concentrations (0.75, 1.5%) achieved the highest contents of chl. a, b and chl. a+b compared to the control treatment. The highest relative yield/fed. was recorded with application of B at a concentration of 60 ppm where it was increased by 38.7 and 42.4% , in the 1^{st} and 2^{nd} seasons, respectively over the control. The content of betanin pigment in cortex increased as a result of spraying with Mg (1.5 %), B (30, 6. Ppm) and Cu (15 ppm), while it increased in core zone due to spray with Mg (0.75 %), Cu (15 ppm) and B(60 ppm) particularly in the 2^{nd} season. The concentration of the pigment in the core zone was lower than in the cortex zone.

Keywords: Table beet, Mg, Cu, B, top root yield, and betanin

INTRODUCTION

Table beet or beetroot (*Beta vulgaris* L.) is one of the popular crops of *Chenopodiaceae*. It is grown for food uses as pickles, salad, and juice further than sugar content which has high concentration of sucrose and low concentrations of glucose and fructose (Straus *et al.,* 2012). So, it is preferable for sports drinks (Wruss *et al.,* 2015; Bavec *et al.,* 2010; Murrary *et al.,* 1989). Beetroot contains high concentration of betalin pigment. Betanin equivalent to betacyanins and betxanthins (Gandia-Herrero, *et al.,* 2010). Rather the red colour is consumed as natural colorants in food industry; it has health benefits for human where it contains antioxidant against inflammatory activities, rich in vitamin B folate, which is essential for cellular processes from carbon to normal tissue growth and cognitive function (Zielinska-Przyjemska *et al.*, 2009; Georgiev *et al*., 2010; Neelwarne and Halagur, 2012). Farouk and Sharawy (2016) found a positive correlation between antioxidants activity and betanin values of red beet. In addition, it had a natural agent for prevention the hypertension of cardiovascular disease (Lundberg *et al.*, 2011), and it has a positive effect on redox homeostasis during hepatic ischemia-reperfusion (Vali *et al.*, 2007), but it must be careful when consume excessive amounts of beetroot products wherein lead to formation carcinogenic metabolites (Habermeyer *et al.*, 2015) or cause nephroliths (Holmes and Assimos, 2004; Salovaara *et al.,* 2002).

Table beet plant growth and its root quality were affected by the environmental conditions such as soil characters and mineral nutrition. Magnesium, boron and copper have vital roles in plant. Magnesium is a constituent of chlorophyll and required for several enzymes, and presence of Mg in plant in inadequate levels can inhibit CO_2 assimilation. Copper is involved in cation activated enzymes and has a role in synthesis, respiration and carbohydrate metabolism, and its deficiency decreases DNA levels in tissues and reducing sugars in young organs of plant. In addition, B plays a vital role in metabolism and translocation of carbohydrates and regulation of meristematic activity and then B deficit inhibits protein synthesis and accumulation of amino acids (Mengel and Kirkby, 2001; Reddy and Reddi, 2002; Srivastava and Gupta, 1996).The availability of these elements is decreased under sandy soil which has low CEC, high pH and calcareous soil. Magnesium deficiency occurs particularly in sandy soil which have been given heavy dressing of lime; Cu solubility decreases with increasing soil pH where it is precipitated as hydroxide and B deficiency under low CEC and it may be fixed with presence of $CaCO_3$ which reduce the availability of B as a result of B $(OH^-)_4$ genesis and the high rate of Ca/B, as well as root absorption was found proportionally through transpiration rate and consequently the uptake decrease in cold periods (Mengel and Kirkby, 2001; Srivastava and Gupta, 1996).

Therefore, addition of the previous elements as foliar spray under inappropriate conditions is very important to avoid their fixing. In addition, the most of attempts were done to improve the nutritive values and human health benefits of table beet top roots, but few efforts were done to study the effect of mineral nutrition as Mg, B and Cu on growth and quality of table beet under both sandy soil and high water salinity which was the principal aim of this work.

MATERIALS AND METHODS

Two field experiments were carried out during the winter seasons of 2011/2012and 2012/2013 at The

Experimental Farm of Environ. Agric. Sci. Fac., Arish Univ., North Sinai. The main object of this work was to study the effect of spraying with magnesium, copper, and boron on growth, yield, and content of betanin pigment in root of table beet (*Beta vulgaris* L) *cv.* Detroit Suprence. The soil used was loamy sand in texture; pH 7.8, 8.0; organic matter contents 0.15, 0.18%; EC 1.05, 1.09 dSm^{-1}; available N 12.11, 13.44 ppm; available P 12.10, 12.43 ppm; available K 71.92, 67.15 ppm; in the first and second seasons, respectively. pH and EC for irrigation water were 7.02, 7.11 and 3648, 3840 ppm in the 1st and 2nd seasons, respectively.

This experiment included 7 treatments as follows:

1- Control treatment (spraying with tap water),
2- Spraying with copper at 7.5 ppm,
3- Spraying with copper at 15 ppm,
4- Spraying with magnesium at 0.75 %,
5- Spraying with magnesium at 1.5 %,
6- Spraying with boron 30 ppm, and
7- Spraying with boron at 60 ppm

Treatments were arranged randomly in a randomized complete block design (RCBD) in three replicates. The sources of elements were magnesium chelae (EDETA) 12% for Mg, $CuSO_4$. 5 H_2O for Cu, and Explore Borpak (8.9 % B) for B. The experimental plot area was 10 m^2 (10 m in length and 1 m in width). Transplants were transplanted on October 19th and 22th in the 1st and 2nd seasons, respectively at 30 cm distance between plants, and the seedlings were transplanted around the both sides of the dripper lines. Plants were sprayed with the nutrients three times beginning after 20 days from transplanting at15days intervals. Plants were harvested at 105 days after transplanting.

Data Recorded:

Samples of 9 plants from each experimental unit were randomly taken at 80 days after transplanting to determine the following data:

1. Vegetative growth: Plant height, number of leaves/plant, and leaves area /plant
2. Fresh weight/plant (gm): Fresh weight of roots, leaves, top root and total fresh weight of plant (fresh weight of roots+ leaves+ top root).
3. Dry weight/plant (gm): All plant parts were dried at 70˚ C till constant weight, then dry weight of roots, leaves, top root and total dry weight of plant (dry weight of roots+ leaves+ top root) were determined.
4. Photosynthetic pigments: Chlorophyll a, chlorophyll b and Carotenoids were determined in middle fully expanded leaf according to Wettstein (1957).
5. Yield and root shape: Yield of every experimental unit was weighed and divided into number of plants to determine yield /plant and yield per feddan was estimated. Root length (L), root diameter (D), and root circularity (L/D) were calculated.
6. Betanin content (mg/g F.W.) was determined in top root cortex and core, betanin pigment was determined according to a modified method described by Pucher *et al*. (1937).
7. TSS (%) were measured by using a hand refractometer.

Statistical Analysis: The obtained data were subjected to statistical analysis of variance according to Snedecor and Cochran (1980). Duncan's multiple range tests (1955) was used for comparison among means.

RESULTS AND DISCUSSION

1. Vegetative growth

Data in Table 1 show significant effects for spraying table beet plants with Cu, Mg and B on all studied vegetative growth parameters. The highest plant height was recorded with spraying Cu at 7.5 ppm without significant difference with Mg at concentration of 7.5% in both seasons. The highest number of leaves was recorded with application of Mg at 1.5% in both seasons without significant differences with foliage application of Cu at both concentrations (7.5, 15 ppm), Mg (0.75 %) and B (60 ppm) in the second season. Concerning leaf area per plant, the same data illustrate that the highest leaf area was obtained with spraying by Mg at 1.5 % in both seasons without significant differences with spraying with Mg at a concentration of 7.5 % or Cu at 15 ppm. Therefore, it could be noticed that spraying table beet plants with Cu, Mg and B at both concentrations of each element increased the vegetative growth of plant compared to control treatment. Higher relative increment in leaf area was achieved by application of Mg at 1.5 % as foliar spray which causes increases up to 90.6 % and 73.0 % in the 1st and 2nd seasons, respectively in comparison with control as shown in Fig. 1.

Table 1. Effect of spraying with Cu, Mg, and B on vegetative growth of table beet plants at 80 days after transplanting during 2011-2012 and 2012-2013 seasons

Parameters	Vegetative growth					
Treatments	Plant height (cm)	No. of leaves /plant	Leaf area/plant (cm^2)	Plant height (cm)	No. of leaves /plant	Leaf area/plant (cm^2)
	2011-2012 season			2012-2013 season		
Control (Tap water)	38.33d	21.67c	272.82d	39.00c	18.66c	264.63e
Cu at 7.5 ppm	56.67a	27.67b	397.40c	53.00a	21.33ab	395.66bc
Cu at 15ppm	44.00bcd	26.00bc	408.38bc	42.67b	20.66abc	407.91abc
Mg at 0.75%	57.33a	28.00b	436.33ab	52.67a	20.00abc	440.28ab
Mg at 1.5%	50.00ab	34.00a	520.01a	43.33b	25.24a	457.81a
B at 30 ppm	43.33cd	25.00bc	412.80bc	41.33bc	19.67bc	326.41d
B at 60 ppm	45.33abc	24.33bc	392.04bc	44.67b	23.16ab	392.35c

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test

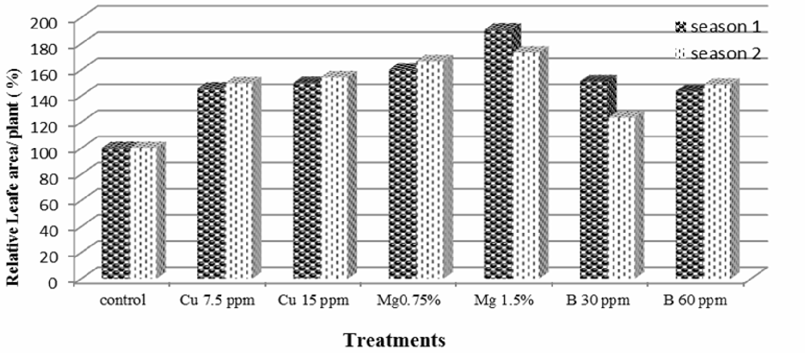

Fig. 1 : Effect of foliar spray wth Cu, Mg, and B on relative leaf area / plant (%) of table beet plant in 2011-2012 and 2012-2013 seasons.

2. **Fresh weight**

Data in Table 2 show significant effects for Cu, Mg, and B nutrients on fresh weight of table beet in both seasons. Application of Cu at a concentration of 15 ppm recorded the highest root fresh weight/plant in both seasons, while the highest leaves fresh weight was accomplished by application of Mg as foliar spray at a rate of 1.5% in both seasons associated with application of B at 60 ppm in the 2nd season. The same data reveal that spraying with Mg (0.75%), B (30, 60 ppm in the 1st season) as well as Mg (0.75%) and Cu (15 ppm) engaged the increment in leaves fresh weight in the 1st and 2nd seasons, respectively.Concerning top root portion, the same results illustrate that spraying with B at 60 ppm recorded the highest values in 1st season and spraying with B at both of concentrations (30, 60 ppm) and Cu at 15 ppm in the 2nd one. The highest total fresh weight of leaves/plant was recorded by spraying with B at 60 ppm in both seasons (with relative increments by 47.55% and 43.65 % over the control treatment in 1st and 2nd seasons, respectively) without significant differences with the other treatments, except control treatment or Cu at 7.5 ppm in both seasons.

Table 2. Effect of spraying with Cu, Mg, and B on fresh weight of table beet plant at 80 days after transplanting during 2011-2012 and 2012-2013 seasons

Parameters	Fresh weight /plant (g)							
Treatments	Roots	Leaves	Top root	Total fresh weight	Roots	Leaves	Top root	Total fresh weight
	2011-2012 season				2012-2013 season			
Control (Tap water)	6.16d	219.67d	230.00c	455.83c	8.33b	199.33d	263.47b	471.13c
Cu at 7.5 ppm	9.50bc	289.00c	256.97bc	555.47b	10.00ab	277.50bc	286.80b	574.30b
Cu at 15ppm	15.33a	297.00bc	305.49ab	617.82ab	12.00a	286.07abc	322.12a	620.19ab
Mg at 0.75%	9.83bc	317.33ab	319.00ab	646.16ab	9.33b	297.33ab	270.79b	577.45ab
Mg at 1.5%	12.00b	337.67a	269.64bc	619.31ab	9.00b	309.17a	277.19b	595.36ab
B at 30 ppm	10.11bc	321.66ab	317.55ab	649.32ab	8.58b	245.87c	338.2a	592.65ab
B at 60 ppm	8.92c	315.67abc	348.00a	672.59a	8.81b	305.73a	342.23a	676.78a

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test

The highest relative increment of total fresh weight / plant was attained by application of B at concentration of 60 ppm which was increased by 47.55% and 43.65% in the 1st and 2nd seasons, respectively over the control treatment.

The increment in total fresh weight of table beet plant due to application of B at 60 ppm may be due to the increments in fresh weight of leaves and mainly in top root of plant. The increments in plant growth and consequently fresh weight due to application of Mg, Cu and B at the previous concentrations may be owe to the vital roles of these elements in plant metabolism. Beside the discerned function of magnesium in chlorophyll, it is required in other physiological processes. It is one of the major factor in almost activating phosphorylation, as a constituent of various enzymes as cytochrome, and catalase. The increments in plant growth and leaf area due to application of Mg may also attribute to its role for activation enzyme ribulose diphosphate carboxylase (RUDP carboxylase) and hence photosynthesis. Also, switches off RUGP carboxylase during the night and switches on in day may be induced by the changes in Mg levels in stroma, and inadequate levels of Mg can inhibit CO_2 assimilation. On the other side, Cu can increase plant growth through its role in plant. Copper is involved in cation activated enzymes; it has a role in synthesis, respiration, protein and carbohydrate metabolism and its possible effect on DNA and RNA synthesis (Mengel and Kirkby, 2001; Srivastava and Gupta, 1996; Reddy and Reddi, 2002).

It was reported that B is important for synthesis N-bases such as uracil which required for RNA and ribosomes to synthesis protein which affect meristematic growth of plants and the deficiency of B inhibits protein synthesis and accumulation of amino acids; low formation of uracil affects negatively uridin diphosphate glucose (UDPG) which is an essential coenzyme in the formation of sucrose (Srivastava and Gupta, 1996) and translocation of carbohydrates to the meristematic growth and consequently increase the vegetative growth. Hussein *et al.* (2011) found that plant height and numbers of leaves of fodder beet plant were not significantly affected by application of B at concentrations of 75, 150 ppm of boric acid and control treatments while, leaf area of plant was increased with increasing boric acid up to the highest concentration (150 ppm). In this connection Talukder *et al*., (2009) found that plant height and number of shoots of potato were not significantly affected by application of Mg at different rates (0 10, 15, 20 kg ha^{-1}). The same results were found by Bari *et al*.,(2001) on potato plant. Anwar *et al*. (2011) found that spraying artichoke plants with Mg at concentrations of 1% or 2% increased the vegetative growth expressed in plant height, number of shots/plant and fresh weight of shoots/plant.

3. Dry weight

Data in Table 3 illustrate that spraying table beet plant with Cu, Mg and B resulted in significant effect on all studied traits of plant dry weight in both seasons. The highest root dry weight per plant was recorded by spraying plants with Mg at 1.5% , and B at 60 ppm in the 1st season and with Cu at 15 ppm in 2nd one without significant differences with all other traits of Cu, Mg, and B in the 1st season, wherein there were slight differences among the treatments; and Cu at 7.5 ppm and Mg at 0.75% in the 2nd season. Regarding leaves dry weight, the highest values were observed with application of Mg at 0.75% and B at 30 ppm in the 1st season and Cu at 15ppm in the 2nd one, without significant differences with Cu at 15 ppm, and Mg at 1.5% in the 1st season; and Cu at 7.5ppm, Mg at 0.75% and B at 60 ppm in the 2nd season. Concerning top root dry weight per plant, the highest values were recorded with B at both concentrations (30, 60 ppm) in both seasons. Finally, total dry weight per plant was recorded with foliar application of B at 30 ppm in the 1st season, Cu at 15 ppm and B at 60 ppm in the 2nd season. The relative increment in dry weight of plant were 43.45 %, 39.95 %, and 39.10 % over the control for spraying with B at 30 ppm in the 1st season, Cu at 15 ppm and B at 60 ppm in the 2nd season, respectively. The increment in total dry weight /plant due to application of B at both concentrations may owe to the increments in dry weight of top root fresh weight which was induced by the increase in fresh weight of top root, and total fresh weight of plant as shown in Table 2. In this connection Hussein *et al.* (2011) found an increase in dry weight of fodder beet plant received 75 ppm of boric acid compared to 150 ppm and control treatments. On the other side, Anwar *et al.* (2011) found that spraying artichoke plants with Mg at concentrations of 1% or 2% increased shoots dry weight of artichoke plants.

Table 3. Effect of spraying with Cu, Mg, and B on dry weight of table beet plant at 80 days after transplanting during 2011-2012 and 2012-2013 seasons

Parameters	Dry weight /plant (g)							
Treatments	Roots	Leaves	Top root	Total dry weight	Roots	Leaves	Top root	Total dry weight
	2011-2012 season				2012-2013 season			
Control (Tap water)	5.66b	29.33c	36.80c	71.80d	5.16b	27.67c	39.30c	72.13d
Cu at 7.5 ppm	7.66ab	34.33bc	41.12bc	83.12c	8.00a	40.33ab	43.06bc	91.39b
Cu at 15ppm	7.66ab	41.33ab	48.88ab	97.88b	8.16a	43.67a	49.12ab	100.95a
Mg at 0.75%	6.90ab	46.33a	47.85ab	101.08ab	7.00ab	42.33ab	38.52c	87.85bc
Mg at 1.5%	8.13a	38.33ab	40.45bc	86.91c	6.10b	38.67b	40.32c	85.10c
B at 30 ppm	7.67ab	42.10a	54.11a	103.88a	5.95b	38.17b	51.08a	95.20ab
B at 60 ppm	7.99a	37.28b	55.68a	100.95ab	6.07b	41.55ab	52.70a	100.33a

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test

4. Photosynthetic pigments

Data in Table 4 illustrate significant differences among treating table beet plants with Cu, Mg, and B compared to control treatment in both seasons. Chlorophyll a in both seasons as well as chl. a + b were increased with application of Cu at a concentration of 15 ppm and both concentrations of Mg. Regarding the content of chl. b the same data reveal that application of Mg as foliar spray at concentrations of 0.75% and 1.5% were the superior treatments in the 1st and 2nd seasons, respectively. Carotenoids were increased significantly with application of Cu at 7.5 ppm in the 1st season without significant differences with Mg at 7.5% or 1.5% and B at 60 ppm. Slight differences were obtained among the treatments in the 2nd season wherein chl. b was increased with all treatments, except application of B at 30 ppm and control treatments. The highest percentages of Chl. a, Chl. b, carotenoids and total chlorophyll were obtained by spraying 75 ppm boric acid compared to spraying with 150 ppm of boric acid or control plants (Hussein *et al.*,2011). Generally, it could be concluded that spraying with Cu at 15 ppm and Mg at both concentrations (0.75, 1.5%) achieved the highest contents of chl. a, b and chl. a + b compared to the control treatment.

Table 4. Effect of spraying with Cu, Mg, and B on photosynthetic pigments of table beet plant at 80 days after transplanting during 2011-2012 and 2012-2013 seasons

Parameters	Photosynthetic pigments (mg/g fresh weight)							
Treatments	Chl. a	Chl. b	Total Chl. a+b	Carotenoids	Chl. a	Chl. b	Total Chl. a+b	Carotenoids
	2011-2012 season				2012-2013 season			
Control (Tap water)	2.09d	1.23c	3.22c	1.95d	2.23c	1.13b	3.36c	1.65b
Cu at 7.5 ppm	2.95b	1.44b	4.39b	2.70a	2.97ab	1.61b	4.58b	2.65a
Cu at 15ppm	3.33a	1.77b	5.10a	2.21bc	3.43a	1.95ab	5.38ab	2.48a
Mg at 0.75%	3.13ab	2.47a	5.60a	2.55ab	3.38a	2.20ab	5.58ab	2.60a
Mg at 1.5%	3.22a	1.43b	4.65ab	2.62ab	3.35a	2.40a	5.75a	2.72a
B at 30 ppm	2.72bc	1.56b	4.28b	1.84cd	2.83b	1.97ab	4.80b	2.19ab
B at 60 ppm	2.66c	1.34b	4.00b	2.54ab	2.81b	1.55b	4.36b	2.78a

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test, Chl.: chlorophyll

The increase in photosynthetic pigments due to application of Cu or Mg as foliar spray may be due to the roles of both elements in photosynthesis or chlorophyll molecule structure. Copper is a constituent of plastocyanin protein which presents in chloroplast and helps in translocation of é from photo-system II to photo-system I (Reddy and Reddi, 2002). Copper plays a role in stability of chlorophyll and other pigments where it is required for antioxidant enzymes as superoxide dismutase enzyme where by enables organisms to survive in the presence of high free radicals and high concentration of O_2 (Mengel and Kirkby, 2001) and, consequently delays the senescence of leaves. Moreover, Mg is very important for photosynthetic pigments because it is found in chlorophyll molecule as a central atom (Marschner, 1995). Barker and pilbeam (2006) reported that Mg has functions in protein synthesis that can affect the size, structure, and function of chloroplast. The requirement of Mg in protein synthesis is apparent in chloroplast, where Mg is essential for synthesis and maintenance of protein in thylakoids of chloroplasts.

5. Yield and root characters

Data in Table 5 show significant effects on yield /plant and per fed. due to spray with Cu, Mg, and B. The highest yield/plant was attained with B at 60 ppm in both seasons without significant differences with Cu at 7.5 ppm in the 1st season. In addition, spraying with B at 60, 30 ppm, respectively, Cu at 15 ppm and Mg at 0.75% resulted in the increase of total yield /fed. in the 1st season, while, spraying with B (30, 60ppm) and Cu (7.5, 15 ppm) were the superior treatments in the 2nd season compared to control and Mg treatments. So, it could be said that spraying table beet plants with B at concentrations of 60, and 30 ppm, respectively or application of Cu at 15 ppm were the best treatments in both seasons for total yield, while the lowest yield was actualized with Mg at the highest concentration (1.5 %). The highest relative yield/fed. were recorded with B at 30ppm and 60 ppm which increased by 30.36, 38.26 and 38.7 and 42.4 % , in the 1st and 2nd seasons over the control; Mg at 0.75% in the 1st season by35.31% and Cu at both concentrations (7.5 and 15 ppm) in both seasons which increased by 25.0, 33.70 and 35.31, 39.16 in the 1st and 2nd seasons, respectively as shown in Fig.2. Regarding root characters, the same data show that root length and its circularity in the 1st season and root diameter in the 2nd season were not significantly affected, while, root diameter in the 1st season and both of root length and its circularity in the 2nd season had slight differences among the treatments wherein application of B at 60 ppm recorded the highest values of the previous traits (root diameter in the 1st season and both of length and root circularity in the second one).

Table 5. Effect of spraying with Cu, Mg, and B on yield and top root characters of table beet at 80 days after transplanting during 2011-2012 and 2012-2013 seasons

Parameters	Yield		Root characters			Yield		Root characters		
Treatments	g/plant	Ton/ fed.	Length (L) (cm)	Diameter (D) (cm)	Circularity (L/D)	g/plant	Ton/ fed.	Length (L) (cm)	Diameter (D) (cm)	Circularity (L/D)
	2011-2012 season					2012-2013 season				
Control (Tap water)	236.7c	7.08d	5.50a	6.33b	0.868a	480.6e	7.71b	6.10b	7.70a	0.792ab
Cu at 7.5 ppm	415.0ab	8.85bc	6.00a	7.00ab	0.908a	605.2d	10.31a	5.03b	7.50a	0.671b
Cu at 15ppm	330.0b	9.58a	6.16a	7.50ab	0.823a	654.1bcd	10.73a	8.00ab	7.93a	1.008ab
Mg at 0.75%	393.3b	9.58a	5.50a	6.33b	0.890a	674.2bc	8.57b	6.17b	8.53a	0.723ab
Mg at 1.5%	351.7b	8.33c	6.33a	7.00ab	0.901a	707.9b	8.44b	7.33ab	8.33a	0.880ab
B at 30 ppm	402.0b	9.23ab	6.20a	7.23ab	0.858a	615.8cd	10.66a	7.67ab	8.13a	0.951ab
B at 60 ppm	493.6a	9.82a	6.63a	7.73a	0.857a	798.6a	10.98a	10.67a	9.17a	1.164a

Values having the same alphabetical letter (s) did not significantly differ at 0.05 level of significance according to Duncan's multiple range test

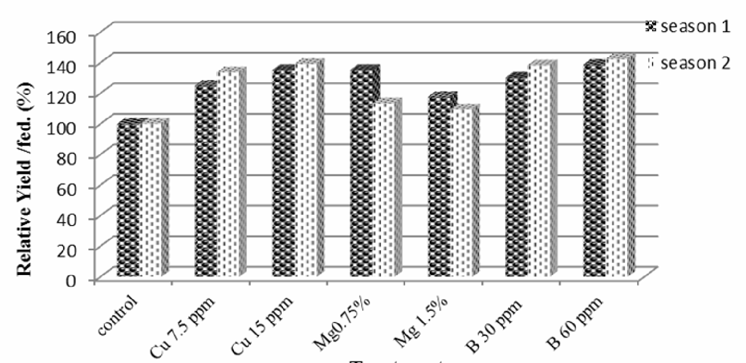

Fig 2. : Effect of foliar spray wth Cu, Mg, and B on relative relative yield/ fed.(%) of table beet in 2011- 2012 and 2012-2013 seasons.

In this concern, the lowest yield /plant and per fed. due to spraying with high rate of Mg may be due to high increment in vegetative growth expressed in plant height, number of leaves/plant as well as fresh weight of leaves (Tables1, 2) which retarded the filling of root. On the other hand, the increment in yield per fed. due to spraying of Cu or B may be owed directly to the increment in yield/plant as a result of homeostasis plant growth expressed in both of fresh and dry weight of plant. Furthermore, copper participates in carbohydrate metabolism where it is important in enzyme synthesis. Moreover, the increment in yield resulted by spraying of B belike owe to its effect of root anatomy which increased phelloderm and cortex thickness as well as the average distance between growth rings resulted in increasing the area of paranchematous cell which enhanced the capacity of storability (El-Tantawy and Eisa, 2009). Additionally, B helps in sugar translocation through complexion with hydroxyl compounds including alcohols and sugars as sugar borate complex which is more easily pass through the cellular membranes than highly polar sugar molecular alone (Srivastava and Gupta, 1996; Mengel and Kirkby, 2001).

6. Betanin pigment

Data in Figs. 3 and 4 show the effect of spraying table beet plants with Cu, Mg and B on betanin contents in cortex and core of top root. It is obvious from the Figs. that most of nutrients applied increased the contents of betanin in both cortex and core zones. Betanin content in cortex was increased with application of Cu as foliar spray at a concentration of 15 ppm (13.33, 17.53 mg/g F.W.), Mg at1.5% (12.67, 20.63 mg/g F.W.) in the 1st and 2nd seasons, respectively, and with B at 60 ppm (12.81 mg/g F.W.) and 30 ppm (19.45 mg/g F.W.) in the 1st and 2nd seasons, respectively. On the other hand, the content of betanin in core was increased by spraying with Cu at 15 ppm (8.43, 10.53 mg/g F.W.) and B at 60 ppm (8.32, 10.55) in the 1st and 2nd seasons, respectively and spraying with Mg at 7.5 % (10.60 mg/g F.W.), and 1.5% (8.80 mg/g F.W.) in the 2nd and 1st seasons, respectively. In this connection Akita *et al.* (2002) found that betacyanin decreased when B was removed from the medium and consequently B was essential for betacyanin production. We can note from Figs. 1and 2 that the concentration of the pigment in the core zone is lower than in the cortex zone. This is probably due to the large zone occupied by the transportation vessels and the reservoir zone is lower at the core zone than the cortex zone.

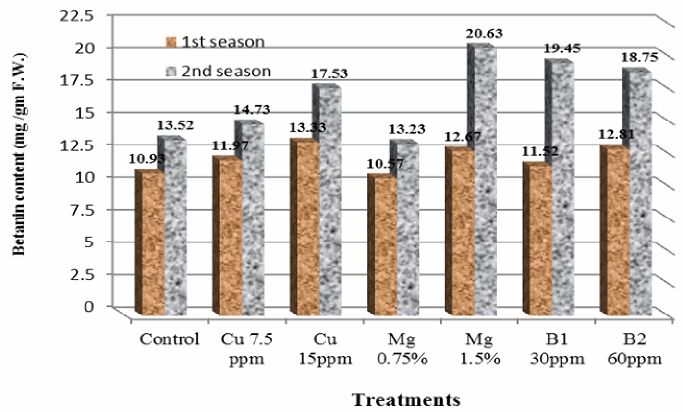

Fig. 3: Effect of spraying with Cu, Mg and B on betanin content in cortex of table beet top root in 2011-2012 and 2012-2013 seasons.

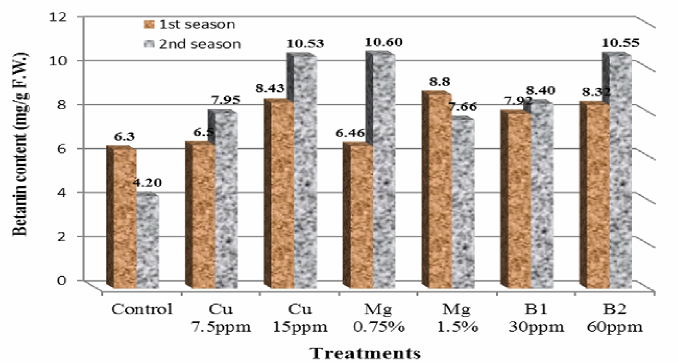

Fig. 4 : Effect of spraying with Cu, Mg, and B on betanin content in core of table beet topr root in 2011-2012 and 2012-2013 seasons.

7. Total soluble solids (TSS%)

Effect of application of Cu, Mg and B on TSS % in table beet root is illustrated in Fig. 3. The data show that spraying table beet plants with Mg or B with both concentrations used increased the contents of TSS % in roots. The increment in TSS % due to application of B may be due to the hypothesis for the role of B in plant metabolism. The hypothesis is based on the property of boric acid complexion with polyhydroxyl compounds including alcohols and sugars, and sugar borate complex which make it more easily to pass through cellular membranes than the highly polar sugar molecules alone (Mengel and Kirkby, 2001)

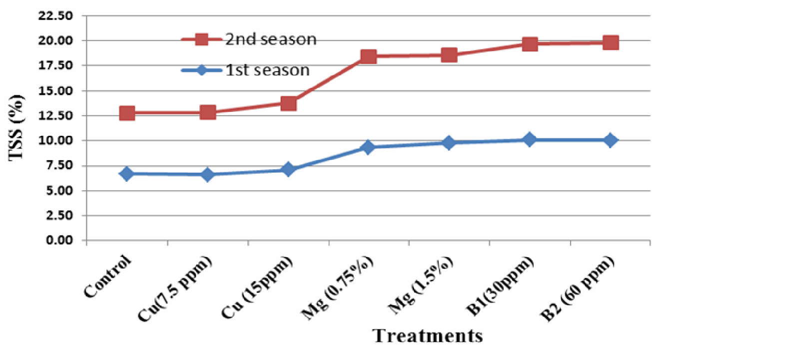

Fig. 5 : Effect ofspraying with Cu, Mg, and B TSS % of table beet topr oot in 2011-2012 and 2012-2013 seasons.

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تحسين النمو، والمحصول، والمحتوى من صبغة البيتانين لنبات بنجر المائدة بالرش بالماغنيسيوم، والنحاس، والبورون تحت ظروف منطقة العريش

السيد محمد الطنطاوي
قسم الإنتاج النباتي (خضر)- كلية العلوم الزراعية البيئية- جامعة العريش- مصر

أجريت تجربتان حقليتان بالمزرعة التجريبية بكلية العلوم الزراعية البيئية بالعريش- جامعة العريش – شمال سيناء خلال الموسمين الشتويين ٢٠١١-٢٠١٢، ٢٠١٢-٢٠١٣ لدراسة تأثير الرش الماغنسيوم بتركيز ٠.٧٥%، و ١.٥ %، والنحاس بتركيز ١٥، و٣٠ جزء فى المليون، والبورون بتركيز ٣٠، و٦٠ جزء في المليون على النمو، والمحصول، والمحتوى من صبغة البيتانين والمواد الصلبة الذائبة الكلية لنبات بنجر المائدة صنف ديترويت سوبرنس. أظهرت النتائج أعلى زيادة نسبية في المساحة الورقية نتيجة الرش بالماغنيسيوم بتركيز ١.٥%حيث زادت بنسبة ٩٠.٦% و ٧٣.٠% في الموسمين الأول والثاني على التوالي مقارنة بمعاملة الكنترول. حققت معاملة الرش بالبورون بتركيز ٦٠ جزء فى المليون زيادة في الوزن الغض الكلى بنسبة ٤٧.٥٥%، و ٤٣.٦٦% فى كلا الموسمين الأول والثاني على التوالي مقارنة بمعاملة الكنترول. أدى الرش بالبورون بتركيز ٣٠ جزء في المليون في الموسم الأول، والرش بكل من النحاس بتركيز ١٥ جزء في المليون، والبورون بتركيز ٦٠ جزء فى المليون فى الموسم الثاني إلى زيادة الوزن الجاف للنبات حيث زاد الوزن الجاف الكلى للنبات بنسبة ٤٣.٤٥%، و٣٩.٩٥%، و٣٩.١٠% عن الكنترول نتيجة الرش بالبورون بتركيز ٣٠ جزء في المليون في الموسم الأول، والرش بكل من النحاس بتركيز ١٥ جزء في المليون، والبورون بتركيز ٦٠ جزء في المليون في الموسم الثاني على التوالي. زاد المحتوى من كلوروفيل أ، ب، وكلوروفيل أ+ ب نتيجة الرش بالنحاس بتركيز ١٥ جزء فى المليون والرش بالماغنيسيوم بكلا التركيزين مقارنة بمعاملة الكنترول. تم الحصول على أعلى محصول نسبى نتيجة الرش بالبورون بتركيز ٦٠ جزء فى المليون حيث زاد بنسبة ٣٨.٧%، و٤٢.٤٠% في الموسمين الأول والثاني على التوالي مقارنة بمعاملة الكنترول. زاد محتوى الجذر من صبغة البيتانين في منطقة القشرة بوضوح بالرش بالماغنيسيوم بتركيز ١.٥%، والبورون بتركيز ٣٠،و٦٠ جزء في المليون ثم النحاس بتركيز ١٥ جزء في المليون في الموسم الثاني، بينما زاد المحتوى من الصبغة في منطقة القلب للجذر بالرش بالماغنيسيوم بتركيز ٠.٧٥%، وبالنحاس بتركيز ١٥ جزء فى المليون وكذلك الرش بالبورون بتركيز ٦٠ جزء في المليون على التوالي في الموسم الثاني. أظهرت النتائج أن تركيز صبغة البيتانين كان أقل في منطقة القلب عنه في منطقة القشرة.