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IMPROVING GROWTH, YIELD, AND ROOT QUALITY OF TABLE BEET PLANTS BY PHOSPHORUS FERTILIZATION AND BORAX FOLIAR APPLICATION UNDER NEW VALLEY CONDTIONS

Mohammed A. M. Ali[1*] and I.N. Nasef[2]

1. Hort. Dept., Fac. Agric., New Valley Univ., Egypt

2. Hort. Dept., Fac. Agric., Suez Canal Univ., Egypt

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ABSTRACT: Two field experiments were conducted during 2020/2021 and 2021/2022, at the Experimental Farm, Faculty of Agriculture, New Valley University, New Valley Governorate, Egypt with aim of investigation of phosphorus (P) as soil fertilization and borax as foliar application on growth, yield and chemical constituents of table beet. Four phosphorus levels, *i.e.*, 30, 45, 60 and 75 kg/Feddan in the form of calcium phosphate were applied as soil application and four borax levels, *i.e.*, 0, 2, 4 and 6 g/L were applied as foliar application in the recently reclaimed areas, especially governorate of New Valley as a promising area for agriculture expansion in Egypt. The results showed that application of P at 60 kg/feddan improved the vegetative growth and root parameters, total sugar, total carbohydrates, soluble solids content (SSC), phenolic, total betalains and mineral contents of table beet. In addition, foliar application of borax at 4 g/L improved the above-mentioned traits compared to other rates. In addition, the combination between P at 60 kg/feddan as soil application and borax at 4 g/L as foliar application was the more effective for enhancing yield and root quality of table beet.

Key words: Table beet, phenolic, phosphorus, boron, betalains, foliar application.

INTRODUCTION

Table beet (*Beta vulgaris* L.) is one of the most important fresh vegetables belonging to the *Chenopodiaceae* family. It is a winter crop cultivated in Egypt for its root. Beetroot is a good source of betalain pigments and exhibits antioxidant, chemo-preventive activities and anti-inflammatory **(Raish *et al.*, 2019)**. Several investigations confirmed that beetroot ameliorates multiple diseases such as atherosclerosis, type 2 diabetes, dementia and hypertension, and **(Winkler *et al.*, 2005)**. Betanin pigments is considered the primary molecules recognized having anticancer effects **(Ninfali and Angelino, 2013)** as it works to make an interruption in the metabolites exchange between tumor cell and surrounding tissues **(Reddy, 2005)** to hinder the tumor cells infiltration capacity. Moreover, it has antiproliferative effect on human chronic leukemia **(Sreekanth *et al.*, 2007).** Phosphorus is considered a primary nutrient for growth of plants **(Hinsinger, 2001)**. It is needed to optimum production and quality **(Zapata and Zaharah, 2002)**. Phosphorus is essential for reproduction, cell division, and plant metabolism; likewise, its role is related to the storage, acquisition and use of energy **(Epstein and Bloom 2004)**. Practically, phosphorus fertilizer resulted in maximized the root and sugar content of sugar beet **(Marinkovic *et al.*, 2008)**. Also, **Seadh (2012)** found that application of 30 kg P per feddan produced the highest values of vegetative growth, root and sugar yield of sugar beet plants.

Micronutrients are essential elements for normal growth and productivity of plant as they play important roles in the photosynthesis, chlorophyll formation, meristematic development and transpiration as well as development of phenolic compound **(Tripathi *et al.*, 2015)**. One of the

*** Corresponding author: Tel. :**+20100 643 8356
E-mail address: innasef@hotmail.com

most important microelements for plant growth and development of plant is boron (B). It has a vital role in the division of cell, elongation of root, metabolism of calcium, synthesis of auxin, metabolism of sugar and synthesis of protein **(Camacho-Cristóbal *et al.,* 2018)**. In addition, **Subba *et al.* (2016)** reported that boron enhanced the productivity and root quality of carrot. Furthermore, foliar application of boron improved root yield and its components, white and gross sugar percentages of sugar beet **(Mekdad, 2015)**.

The literature on the interaction between phosphorus and boron in table beet plant is limited. Therefore, the present study was to investigate the effects of phosphorus fertilizer as soil application and foliar application of boron as well as their interaction on vegetative growth, yield and chemical constituents of table beet.

MATERIALS AND METHODS

Plant Materials and Treatments

Tow field experiments were carried out at Agricultural Research Farm of the Faculty of Agriculture, New Valley University, New Valley Governorate, Egypt during two consecutive winter growing seasons 2020-2021 and 2021/ 2022 in order to study the effect of phosphorus as soil fertilization and borax as foliar application as well as their interaction on vegetative growth, yield, and chemical components of table beet (*Beta vulgaris* L.) "cv. Detroit dark red". P was applied as calcium super phosphate (15.5% P_2O_5) at level of 30, 45, 60, 75 kg P/fed. as soil application Borax was applied at 0, 2, 4, 6 g/L as foliar application. Phosphorus levels were applied during soil preparation. Borax with three drops of tween-twenty were sprayed 5 times. The first borax treatment was applied at age 20 days after germination with 7days intervals on the whole foliage in the morning (9-10 am). According to the stage of plant development, the sprayed solution volume ranged from 15 to 40 ml per plant each time by a manual pump. The control plants were sprayed with the same amount of distilled water plus ween-twenty.

Experimental Desgin

The experiment was arranged in a split plot in randomized complete block design with three replications. The experiment comprised of 16 treatment combinations of 4 rates of phosphorus and 4 levels of borax. Phosphorus rates contributed as the main plot while, Borax levels were in sub plot. Experimental plot had 4 rows each row was 4 m long and 70 cm width. The area of experimental unit (plot) was 11.2 m^2 and contained 4 rows, with 0.7 m in width and 4 m in length for each row. To protect against border effects, a guard rows were left without planting to separate the adjacent sub-plots.

Agricultural Practices

The experimental site was prepared by adding 20 m^3 of chicken manure. The soil was cleared, ploughed and harrowed, then divided into plots. Seeds of table beet were planted by hand on both sides of the row at a distance of 10 cm between plants under drip irrigation system. Table beet seeds were sown on 23^{th} and 25^{th} October in the 1^{st} and 2^{nd} seasons, respectively. The agricultural practices during season (*i.e.* irrigation and control of weed and pest) were performed for the production of red beet according to instructions of the Egyptian Ministry of Agriculture.

Samples of soil were randomly taken at depth of 0.0–40.0 cm before plantation and then collected together to measure the physicochemical and chemical properties of soil (**Jackson, 1973**). The soil analysis of the experimental site is illustrated in Table 1.

Measurements

Morphological and yield characters

Table beet plants were harvested after 80 days from germination and number of leaves per plant, leaf area per plant (cm^2),top fresh weight (g), top dry weight (g), root length (cm), root diameter(cm), root fresh weight (g), root dry matter (%) and total root yield(ton/fed.) were recorded.

Biochemical compounds

Total betalains was expressed as mg/100g of fresh weight content was measured spectrophotometrically at 536 nm and 476 nm, using a spectrophotometer, according to **Von Elbe (2001)**.

Total sugars were expressed as mg/100g of fresh weight and measured with phenol–sulfuric acid reagents by a spectrophotometer (UNICO UV/Visible 2100, USA) at 480 nm according to **Dubois *et al*. (1956)**.

Table 1. Physical and chemical characteristics of the experimental site in growing seasons

Soil characteristics	Season 2020/2021	Season 2021/2022
Silt (%)	12.76	12.53
Clay (%)	7.85	7.80
Sand (%)	79.39	79.67
Texture	Sandy	Sandy
PH	8.14	8.10
E.C dsm	1.03	1.01
Organic matter (%)	0.52	0.54
$CaCo_3$ (%)	5.02	5.05
Available N (mg/kg)	48.90	51.32
Available P (mg/kg)	5.17	5.21
Available K (mg/kg)	134.80	141.42
Soluble cations ((meq/100g)		
K^+	0.23	0.26
Ca^{++}	0.98	0.95
Mg^{++}	0.66	0.40
Na^+	3.14	3.21
Soluble anions (meq/100g)		
CO_3^{--}	-	-
HCO_3^-	1.12	1.10
Cl^-	2.96	2.84
SO_4^{--}	0.93	0.88

Total phenolic content was determined in roots by Folin-Ciocalteu method using a spectrophotometer (UNICO UV/Visible 2100, USA), according to **Sadasivam and Manickam (1991)**. The data were recorded as mg/100g of root fresh weight.

Total carbohydrates (%) were determined by method of **Mazumdar and Majumder (2003).**

Total sugars (%) of beet roots were determined by using the phenol-sulphuric acid method **(Dubois *et al.*, 1956)**.

Soluble solids content (SSC) (%) was measured by a hand refractometer.

Nitrogen, phosphorus, potassium and boron in leaves and roots

1- Total Nitrogen (mg/g dry weight) was estimated using semi-micro-kjeldahl method as described by **Ling (1963)**
2- Phosphorus (mg/g dry weight) was analyzed by chlorostannus reduced molybdophosphoric blue color method, in sulfuric acid system at 660 nm using a Spectro 22 spectrophotometer as described by **Jackson (1973)**.
3- Potassium concentrations (mg/g dry weight) were determined using a Perkin-elmer, Flame photometer (**Page, 1982**)
4- Boron (ppm) was measured according to **Dible *et al.* (1954)**.

Statistical Analysis

Statistical analysis of data was carried out using two-ways analysis of variance (ANOVA) as applied in program of Co-Stat Software. Means for phosphorus and borax treatments as well as their interactions were compared according to Duncan's multiple range test at a significance level α of 5%.

RESULTS

Vegetative Growth of Table Beet

The presented data in Table 2 show the effect of phosphorus and borax as well as their interaction on number, fresh weight, dry weight of leaves and leaf area during 2020/2021 and 2021/2022 seasons. These parameters were significantly enhanced by phosphorus treatment at 60 kg/fed as soil fertilization. Also, the results showed that borax at 4 g/L as foliar application resulted in a significant increase in these parameters compared with the other rates. The interaction between P at 60 kg/fed., With borax at 4 g/L gave the highest number of leaves/plant, leave fresh weight, leaves dry weight and leaf area/plant compare with other interactions treatment in both seasons.

Yield of Table Beet

The results in Table 3 show a significant difference between the treatments during the both seasons. Application of phosphorus as soil fertilization at 60 kg/fed. recorded the highest values of root diameter, root length, root fresh weight, root dry matter and root yield compared with the other rates during the both seasons. Regarding the main effect of borax, the significant highest diameter, length, fresh weight, dry matter and yield of root were observed with 4 g/L as foliar application. However, there are no significant differences between 4 g/L and 6 g/L for root length and root dry matter in the both seasons. The interaction effects between phosphorus and borax treatments are presented in Table 3. Table beet plants which were fertilized with 60 kg/fed., phosphorus and were sprayed with 4 g/L borax had the highest yield parameters and root yield compared with other combinations. The increasing percentage was approx. 41.34% and 41.23.1% for root diameter, 46.55% and 44.03% for root length, 51.70% and 52.08% for root fresh weight, 74.83% and 83.92% root dry weight and 55.74% and 56.51% root yield in the both seasons, respectively, when table beet plants received 60 kg/fed., P and treated with 4 g/L borax in comparison with 30 kg/fed P with 0 g/L borax.

Biochemical Compounds of Table Beet Roots

The main effects of phosphorus and borax treatments as well as their interaction on biochemical compounds such as SSC, total carbohydrates, total soluble sugars, total phenolics and betalains of table beet roots during 2020/021 and 2021/2022 seasons are presented in Table 4. With regard to the effect of phosphorus, the application of phosphorus at 60 kg/fed. as soil application gave the highest significant for all parameters under study. With respect to the effect of borax, spraying with 4 g/L of borax gave the highest content of biochemical compounds. Concerning the interaction effect, the results showed that the roots of table beet plants fertilized with phosphorus at a rate of 60 kg/fed., as soil application and spraying with 4 g/L borax gave the highest contents of biochemical compounds in comparison with the other interaction treatments.

Elements Content of Table Beet Leaves

The results shown in Table 5 indicated that nitrogen, phosphorus, potassium and boron concentration of table beet leaves were significantly affected by phosphorus and borax as well as their interaction during 2020/2021 and 2021/2022 seasons. The results illustrated that the highest nitrogen content of leaves was recorded with 60 kg/fad. P treatment but no significant difference was observed between 60 kg/fad., and 75 kg/fad., in the both seasons. Regarding to the effect of borax as foliar spray on nitrogen content of leaves, spraying with 4 g/L of borax gave the highest content of nitrogen, without significant differences with 6 g/L, while the control treatment gave the lowest content. Concerning the interaction effects on nitrogen content of leaves, sprayed plants with borax at a rate of 4 g/L and fertilized with

Table 2. Effect phosphorus, borax treatments and their interaction on leaves number, leaves fresh weight, leaves dry weight and leaf area during 2020-2021 and 2021-2022 seasons

Phosphorus (kg/ Feddan)	2020/2021 season					2021/2022 season				
	Borax (g/L)					Borax (g/L)				
	0	2	4	6	Mean	0	2	4	6	Mean
					No. of leaves/plant					
30	14.66 h	15.33 gh	15.66 fg	15.66 fg	15.33 D	14.66 i	15.66 gh	16.00 fg	16.00 fg	15.58 D
45	14.66 h	16.33 ef	17.00 de	16.33 ef	16.08 C	15.00 hi	16.66 ef	17.00 de	16.66 ef	16.33 C
60	15.33 gh	18.00 bc	19.00 a	18.66 ab	17.75 A	15.66 gh	18.33 bc	19.33 a	18.66 ab	18.00 A
75	15.00 gh	17.00 de	18.00 bc	17.33 cd	16.83 B	15.66 gh	17.66 cd	18.00 bc	17.66 cd	17.25 B
Mean	14.91 D	16.66 C	17.41 A	17.00 B		15.25 C	17.08 B	17.58 A	17.25 AB	
					Top fresh weight (g)					
30	30.20 j	34.48 hi	39.92 fg	36.63 gh	35.31 D	30.90 j	36.12 hi	40.93 fg	38.82 gh	36.69 D
45	31.42 ij	40.05 fg	43.41 ef	42.72 ef	39.40 C	32.53 ij	41.17 fg	46.95 de	43.80 ef	41.11 C
60	34.39 hi	51.46 bc	55.33 a	53.65 ab	48.71 A	35.68 hi	51.66 bc	56.29 a	55.45 ab	49.77 A
75	32.73 ij	46.35 de	50.16 bc	48.43 cd	44.41 B	32.87 ij	47.77 cd	51.63 bc	50.14 cd	45.60 B
Mean	32.18 D	43.08 C	47.20 A	45.36 B		32.99 D	44.18 C	48.95 A	47.05 B	
					Top dry weight (g)					
30	4.07 j	4.77 hi	5.34 fg	5.13 gh	4.83 C	4.14 j	4.81 hi	5.36 gh	5.31 gh	4.90 D
45	4.27 ij	5.61 fg	6.22 de	5.85 ef	5.49 B	4.29 ij	5.64 fg	6.27 de	5.97 ef	5.54 C
60	4.57 ij	7.11 bc	7.65 a	7.34 ab	6.66 A	4.63 ij	7.22 bc	7.77 a	7.39 ab	6.75 A
75	4.43 ij	6.58 cd	6.86 bc	6.64 cd	6.13 AB	4.50 ij	6.66 cd	6.91 bc	6.71 cd	6.19 B
Mean	4.33 C	6.02 B	6.52 A	6.24 B		4.39 C	6.08 B	6.58 A	6.34 AB	
					Leaf area/plant (cm^2)					
30	496.04 k	650.22 ij	774.45 gh	699.07 hi	654.94 D	509.73 k	740.74 hi	890.25 g	817.74 gh	739.61 D
45	518.22 k	815.68 fg	958.90 e	900.90 ef	798.42 C	550.97 jk	937.60 fg	1046.81 ef	952.46 fg	871.96 C
60	586.48 jk	1274.86 bc	1473.91 a	1315.16 b	1162.60 A	675.37 ij	1293.21 bc	1555.82 a	1422.57 b	1236.74 A
75	569.37 jk	1094.68 d	1226.86 bc	1193.11 c	1021.01 B	653.04 ij	1110.08 de	1237.64 cd	1205.05cd	1051.45 B
Mean	542.53 D	958.86 C	1108.53 A	1027.06 B		597.28 D	1020.41 C	1182.63 A	1099.45 B	

Means with the same letters are not significantly differed at 5% according to Duncan's multiple range test.

Table 3. Effect of phosphorus and borax treatments and their interaction on root diameter, root length, root fresh weight, root dry matter and root yield during 2020/2021 and 2021/2022 seasons

Phosphorus (kg/ Feddan)	2020/2021					2021/2022				
	Borax (g/L)					Borax (g/L)				
	0	2	4	6	Mean	0	2	4	6	Mean
Root diameter (cm)										
30	5.66 j	6.10 hi	6.50 fg	6.30 gh	6.14 D	5.70 j	6.40 gh	6.56 fg	6.46 gh	6.28 D
45	5.70 j	6.53 fg	6.80 ef	6.70 ef	6.43 C	5.90 ij	6.61 fg	6.99 de	6.86 ef	6.59 C
60	5.90 ij	7.50 bc	8.00 a	7.63 ab	7.25 A	6.10 hi	7.59 bc	8.05 a	7.71 ab	7.36 A
75	5.80 ij	7.00 de	7.23 cd	7.06 de	6.77 B	5.93 ij	7.06 de	7.33 cd	7.21 de	6.88 B
Mean	5.76 C	6.78 B	7.13 A	6.92 B		5.90 C	6.91 B	7.23 A	7.06 AB	
Root length (cm)										
30	6.23 k	6.93 hi	7.31 gh	7.28 gh	6.94 D	6.36 j	6.96 hi	7.36 gh	7.30 gh	7.00 D
45	6.30 k	7.50 fg	7.86 ef	7.66 fg	7.33 C	6.56 ij	7.53 fg	7.96 ef	7.83 ef	7.47 C
60	6.86 ij	8.56 bc	9.13 a	8.83 ab	8.35 A	6.93 hi	8.70 bc	9.16 a	8.96 ab	8.44 A
75	6.53 jk	8.06 de	8.36 cd	8.26 cd	7.80 B	6.60 ij	8.16 de	8.50 cd	8.43 cd	7.92 B
Mean	6.48 C	7.76 B	8.17 A	8.01 A		6.61 C	7.84 B	8.25 A	8.13 A	
Root fresh weight (g)										
30	102.06 k	112.76 ij	121.54 gh	116.86 hi	113.30 D	102.95 l	116.58 ij	124.89 gh	119.70 hi	116.03 D
45	05.50 jk	125.41 fg	131.36 ef	127.06 fg	122.33 C	105.90 kl	128.65 fg	135.45 ef	133.82 ef	125.95 C
60	110.55 ij	146.02 bc	154.82 a	150.93 ab	140.58 A	112.20 jk	147.76 bc	156.57 a	152.88 ab	142.35 A
75	06.37 jk	135.45 de	144.24 bc	140.08 cd	131.53 B	110.72 jk	137.17 de	146.83 bc	143.56 cd	134.57 B
Mean	06.12 D	129.91 C	137.99 A	133.73 B		107.94 D	132.54 C	140.94 A	137.49 B	
Root dry matter (%)										
30	14.46 h	17.18 fg	18.10 ef	17.45 ef	16.80 C	14.74 i	17.38 gh	18.39 fg	17.73 fg	17.06 D
45	14.99 gh	18.73 ef	19.70 de	19.26 ef	18.17 C	15.01 i	18.81 fg	20.94 de	19.65 ef	18.60 C
60	17.02 fg	23.08 bc	25.28 a	24.15 ab	22.38 A	17.14 gh	24.58 bc	27.11 a	25.66 ab	23.62 A
75	15.18 gh	21.43 cd	22.57 bc	21.81 cd	20.25 B	15.41 hi	21.74 de	23.00 cd	22.60 cd	20.69 B
Mean	15.41 C	20.10 B	21.41 A	20.67 AB		15.57 C	20.63 B	22.36 A	21.41 AB	
Root yield (ton/fed.)										
30	10.10 k	11.25 ij	12.11 gh	11.66 hi	11.28 D	10.14 l	11.53 ij	12.34 gh	11.83 hi	11.46 D
45	10.37 k	12.68 fg	13.34 ef	13.00 ef	12.35 C	10.68 kl	12.93 fg	13.50 ef	13.11 ef	12.56 C
60	11.11 ij	14.98 bc	15.73 a	15.30 ab	14.28 A	11.39 ij	15.02 bc	15.87 a	15.54 ab	14.45 A
75	10.80 jk	13.63 de	14.61 bc	14.30 cd	13.33 B	10.86 jk	13.76 de	14.86 bc	14.41 cd	13.47 B
Mean	10.60 D	13.14 C	13.95 A	13.56 B		10.77 D	13.31 C	14.14 A	13.72 B	

Means with the same letters are not significantly differed at 5% according to Duncan's multiple range test.

Table 4. Effect of phosphorus, borax treatments and their interaction on chemical constituents of table beet roots during 2020/2021 and 2021/2022 seasons

Phosphorus (kg/ Feddan)	2020/2021					2021/2022				
	Borax (g/L)					Borax (g/L)				
	0	2	4	6	Mean	0	2	4	6	Mean
Total betalains (mg/100g)										
30	282.65 l	293.17 ij	298.51 gh	295.08 hi	292.35 D	284.35 l	294.68 ij	300.84 gh	297.45 hi	294.33 D
45	284.26 kl	300.59 fg	305.66 ef	303.43 fg	298.49 C	286.59 kl	301.58 gh	307.59 ef	305.57 fg	300.33 C
60	290.17 ij	316.39 bc	322.27 a	318.85 ab	311.92 A	291.51 jk	317.49 bc	322.61 a	319.90 ab	312.88 A
75	288.19 jk	308.76 de	314.23 bc	311.52 cd	305.67 B	289.38 kl	310.67 de	314.85 cd	312.11 de	306.75 B
Mean	286.32 D	304.73 C	310.17 A	307.22 B		287.96 D	306.10 C	311.47 A	308.76 B	
Total phenols (mg/100g)										
30	121.20 l	128.76 ij	132.44 gh	130.47 hi	128.21 D	122.77 k	130.43 hi	133.05 gh	131.99 gh	129.56 D
45	123.76 kl	133.24 gh	136.92 ef	134.90 fg	132.20 C	124.84 jk	134.46 fg	138.85 de	136.88 ef	133.76 C
60	127.33 ij	144.24 bc	148.05 a	145.80 ab	141.35 A	127.94 ij	145.58 bc	149.95 a	148.49 ab	142.99 A
75	125.85 jk	139.32 de	143.18 bc	141.25 cd	137.40 B	126.34 jk	140.39 de	144.92 bc	141.97 cd	138.41 B
Mean	124.53 D	136.39 C	140.15 A	138.10 B		125.47 D	137.71 C	141.69 A	139.83 B	
Total carbohydrate (mg/g)										
30	84.4 k	95.2 hi	98.3 gh	96.5 hi	93.6 D	87.2 k	99.5 hi	103.7 gh	100.3 hi	97.7 D
45	88.2 jk	102.6 fg	106.4 ef	104.3 ef	100.4 C	91.4 jk	107.3 fg	110.9 ef	108.6 fg	104.6 C
60	92.6 ij	117.3 bc	123.7 a	120.3 ab	113.5 A	96.2 ij	121.6 bc	127.3 a	125.5 ab	117.6 A
75	89.6 jk	109.4 de	114.5 cd	112.4 cd	106.4 B	92.3 jk	114.6 de	118.5 cd	116.7 cd	110.5 B
Mean	88.7 C	106.1 B	110.7 A	108.3 AB		91.8 C	110.8 B	115.1 A	112.8 AB	
Total sugars (mg/g)										
30	56.3k	62.4hi	65.9fg	64.8gh	62.3D	56.4k	62.8hi	66.0gh	65.6gh	62.7D
45	57.6jk	66.9fg	70.4de	68.9ef	65.9C	57.9jk	67.3fg	70.6ef	69.0fg	66.2C
60	60.8ij	74.9bc	80.1a	77.5ab	73.3A	61.0ij	76.2bc	81.3a	79.0ab	74.3A
75	60.1ij	70.5de	74.4bc	73.4cd	69.6B	60.5ij	72.7de	75.5cd	74.5cd	70.8B
Mean	58.7C	68.7B	72.7A	71.1A		59.0C	69.7B	73.3A	72.0A	
Soluble solids content (%)										
30	6.32 k	7.00 hi	7.25 gh	7.10 hi	6.92 D	6.34 l	7.06 ij	7.44 gh	7.25 hi	7.02 D
45	6.50 jk	7.49 fg	7.70 ef	7.63 ef	7.33 C	6.56 kl	7.60 fg	7.94 ef	7.64 fg	7.43 C
60	6.85 ij	8.39 bc	8.79 a	8.52 ab	8.14 A	6.91 ij	8.57 bc	8.95 a	8.77 ab	8.30 A
75	6.61 jk	7.92 de	8.31 bc	8.07 cd	7.73 B	6.72 jk	8.09 de	8.40 cd	8.30 cd	7.88 B
Mean	6.57 C	7.70 B	8.01 A	7.83 B		6.63 C	7.83 B	8.18 A	7.99 B	

Means with the same letters are not significantly differed at 5% according to Duncan's multiple range test.

Table 5. Effect of phosphorus, borax treatments and their interaction on N, P, K and B contents of table beet leaves during 2020/2021 and 2021/2022 seasons

Phosphorus (kg/ Feddan)	2020/2021 season					2021/2022 season				
	Borax (g/L)					Borax (g/L)				
	0	2	4	6	Mean	0	2	4	6	Mean
					N (mg/g DW)					
30	21.00i	22.67gh	23.67fg	23.37fg	22.68C	21.10i	22.73gh	23.77fg	23.67fg	22.82C
45	21.33hi	24.40ef	25.37de	25.33de	24.11B	21.63hi	24.47ef	25.57de	25.43de	24.28B
60	22.23ghi	27.13bc	29.00a	28.00ab	26.59A	22.60gh	27.17bc	29.07a	28.13ab	26.74A
75	22.87g	26.30cd	27.83ab	27.23bc	26.06A	23.07g	26.20cd	27.73b	27.13bc	26.03A
Mean	21.86C	25.13B	26.47A	25.98A		22.10C	25.14B	26.53A	26.09A	
					P (mg/g DW)					
30	2.73 k	3.05 hi	3.17 gh	3.12 gh	3.02 D	2.80 k	3.07 hi	3.24 fg	3.17 gh	3.07 D
45	2.82 jk	3.24 fg	3.42 de	3.33 ef	3.20 C	2.86 jk	3.27 fg	3.44 de	3.35 ef	3.23 C
60	2.92 ij	3.45 de	3.53 cd	3.50 cd	3.35 B	2.98 ij	3.51 cd	3.63 bc	3.58 cd	3.42 B
75	2.94 ij	3.59 bc	4.01 a	3.70 b	3.56 A	3.03 hi	3.63 bc	4.09 a	3.77 b	3.63 A
Mean	2.85 D	3.33 C	3.53 A	3.41 B		2.92 D	3.37 C	3.60 A	3.47 B	
					K (mg/g DW)					
30	35.3 m	40.0 ij	41.2 hi	40.3 hi	39.2 D	35.9 n	40.1 jk	41.7 hi	40.9 ij	39.6 D
45	36.6 lm	41.9 gh	44.2 ef	42.9 fg	41.4 C	37.2 mn	42.6 gh	44.5 ef	43.4 fg	41.9 C
60	38.6 jk	47.3 bc	49.8 a	48.1 b	45.9 A	39.0 kl	47.8 bc	49.9 a	48.4 b	46.3 A
75	37.2 kl	44.6 ef	46.4 cd	45.6 de	43.4 B	38.0 lm	45.4 de	46.8 cd	46.0 de	44.0 B
Mean	36.9 C	43.4 B	45.4 A	44.2 B		37.5 C	44.0 B	45.7 A	44.7 B	
					B (ppm)					
30	4.91 k	5.86 hi	6.84 ef	7.81 bc	6.35 D	4.96 k	5.93 hi	6.86 ef	7.78 bc	6.38 C
45	5.17 jk	6.15 gh	7.05 de	7.97 bc	6.58 C	5.23 jk	6.24 gh	7.11 de	8.03 bc	6.65 B
60	5.56 ij	6.54 fg	7.51 cd	8.70 a	7.08 A	5.59 ij	6.59 fg	7.56 cd	8.83 a	7.14 A
75	5.45 ij	6.31 gh	7.20 de	8.23 b	6.80 B	5.48 ij	6.35 gh	7.24 de	8.24 b	6.82 B
Mean	5.27 D	6.21 C	7.15 B	8.18 A		5.31 D	6.28 C	7.19 B	8.22 A	

Means with the same letters are not significantly differed at 5% according to Duncan's multiple range test.

phosphorus at a rate of 60 kg/fed gave the highest nitrogen content compared the other combinations. With respect to the effect of phosphorus treatments on phosphorus content of leaves, the results showed that phosphorus content increased gradually by increasing the phosphorus level from 30 up to 75 kg/fed as soil application. Concerning borax effect, foliar application of borax at 4 g/L recorded the maximum content of phosphorus in table beet leaves compared with the other rates. The interaction between 75 kg/L phosphorus as soil application and 4 g/L borax as foliar application gave the highest phosphorus content of leaves compared to the other combinations.

Concerning, potassium content of leaves, the effect of phosphorus treatments revealed that the plants received 60 kg/fad., recorded the maximum potassium content of leaves, and sprayed with 4 g/L borax gave the highest potassium content of leaves. The combination of P at 60 kg/fed with borax at 4 g/L recorded the highest potassium content of leaves in the both seasons. Regarding the boron content in leaves, plants fertilized with 60 kg/fed of P recorded the highest concentration of boron, and spraying with boron at 6 g/L gave the highest value of B in leaves in the both seasons. With respect to the interaction treatment, fertilized plants with 60 kg/fed of P and sprayed with 6 g/L increased boron content in leaves in the both seasons.

Elements Content of Table Beet Roots

Nitrogen, phosphorus, potassium and boron content of table beet roots were significantly affected by phosphorus and boron as well as their interaction during 2020/2021 and 2021/ 2022 seasons (Table 6). Concerning the main effect of phosphorus treatments, the highest N, K and B content in roots were recorded by the plants which fertilized with 60 kg/fad., of phosphorus, while the highest P content of roots was recorded in plants which fertilized with 75 kg/fad., in the both seasons. With respect to the effect of borax treatments, the highest N, P and K content of roots were found in the plants which sprayed with 4 g/L while B in roots increased gradually with increasing the borax levels from 0 up to 6 g/L as foliar application in the both seasons. Concerning the interaction between phosphorus and borax treatments, the highest N and K content of roots were recorded with the interaction between P at 60 kg/fed and borax at 4 g/L in the both seasons, while the highest P content was found in the roots of plants which fertilized with 75 kg/fad., of P and sprayed with 4 g/L of borax. The interaction between P at 60 kg/fad., as soil application and borax at 6 g/L as foliar application achieved the highest B content of roots.

DISCUSSION

Plants need essential macro and micro-elements for normal growth,development and formation of fruits and seeds.Phosphorus is an essential macro-element plays a vital role in the physiological processes of plants such as nucleic acid synthesis, energy generation, photosynthesis, carbohydrate metabolism, respiration, glycolysis and nitrogen fixation **(Kabir *et al.*, 2013)**. Boron is an essential micronutrient, plays a role in the metabolism and function of membrane and involved in the reactions of enzymes as well as ions transport, hormones and metabolites, so the deficiency of boron affects the capacity of photosynthetic and photosynthetic products transport. Also, boron deficiency inhibits root elongation by cell division cessation in the apical meristem **(Brdar-Jokanovic, 2020)**. Also, **Ahmad *et al.* (2009)** reviewed that B deficiency impairs cell wall structure and synthesis, membrane integrity, carbohydrate metabolism, sugar transport, respiration, phenol metabolism, indole acetic acid metabolism, and RNA metabolism. In our study, the significant effects of P and borax application were observed regarding number of leaves, leaves fresh weight, leaves dry weight, leaf area and yield of table beet. The application of phosphorus at a rate 60 kg/fed as soil fertilization enhanced the vegetative growth parameters and improved the yield. These results are agreement with **Silva *et al.* (2019)**, who found that the fertilization of phosphorus promoted the growth and yield of four table beet cultivars. The increase in vegetative growth by P might be due to enhance the rate of photosynthetic **(Irfan *et al.*, 2019)**. The results revealed that the concentration of 4 g/L of boraxwas more effective in improving the vegetative growth and yield of table beet. In the same context, borax foliar application improved

Table 6. Effect of phosphorus, borax treatments and their interaction on N, P, K and B contents of table beet roots during 2020/2021 and 2021/2022 seasons

Phosphorus (kg/ Feddan)	2020/2021 season					2021/2022 season				
										Mean
	0	2	4	6	Mean	0	2	4	6	Mean
					N (mg/g DW)					
30	15.3 k	17.8 hi	19.0 gh	18.6 gh	17.7 D	15.5 l	18.1 ij	19.2 hi	18.8 hi	17.9 D
45	15.9 jk	19.8 fg	21.1 de	20.6 ef	19.4 C	16.2 kl	19.9 gh	21.2 ef	20.7 fg	19.5 C
60	17.0 ij	23.4 bc	25.0 a	24.3 ab	22.4 A	17.4 jk	23.8 bc	25.2 a	24.6 ab	22.7 A
75	16.6 ij	21.6 de	23.1 bc	222 cd	20.9 B	16.7 kl	21.9 ef	23.2 cd	22.3 de	21.0 B
Mean	16.2 D	20.6 C	22.1 A	21.4 B		16.4 D	20.9 C	22.2 A	21.6 B	
					P (mg/g DW)					
30	2.01 k	2.41 hi	2.58 gh	2.54 gh	2.38 D	2.09 k	2.43 hi	2.62 fg	2.55 gh	2.42 D
45	2.11 jk	2.65 fg	2.81 ef	2.70 fg	2.57 C	2.14 jk	2.71 fg	2.89 de	2.78 ef	2.63 C
60	2.19 jk	2.94 de	3.09 cd	3.03 cd	2.81 B	2.23 jk	2.95 de	3.13 bc	3.05 cd	2.84 B
75	2.26 ij	3.18 bc	3.47 a	3.28 b	3.05 A	2.29 ij	3.23 bc	3.49 a	3.31 b	3.08 A
Mean	2.14 D	2.79 C	2.99 A	2.89 B		2.19 D	2.83 C	3.03 A	2.92 B	
					K (mg/g DW)					
30	27.0 l	31.5 ij	33.9 gh	33.1 hi	31.4 D	27.6 k	32.2 hi	34.1 gh	33.2 hi	31.8 D
45	28.6 kl	35.1 gh	37.5 ef	36.0 fg	34.3 C	28.8 jk	35.7 fg	37.6 ef	36.4 fg	34.6 C
60	29.8 jk	42.6 bc	45.4 a	43.1 b	40.2 A	31.0 ij	42.7 bc	45.7 a	43.3 b	40.7 A
75	29.1 kl	39.0 de	41.5 bc	40.5 cd	37.5 B	29.6 jk	39.2 de	41.7 bc	40.8 cd	37.8 B
Mean	28.6 C	37.0 B	39.5 A	38.2 B		29.2 C	37.5 B	39.8 A	38.4 B	
					B (ppm)					
30	3.53 l	4.33 ij	5.23 fg	6.03 cd	4.78 C	3.65 j	4.35 hi	5.27 ef	6.04 cd	4.83 C
45	3.65 kl	4.54 ij	5.52 ef	6.30 bc	5.00 BC	3.68 j	4.67 gh	5.57 de	6.40 bc	5.08 BC
60	4.08 jk	5.03 gh	5.82 de	6.97 a	5.47 A	4.09 ij	5.07 fg	5.95 cd	6.99 a	5.52 A
75	3.84 kl	4.74 hi	5.72 de	6.51 b	5.20 B	3.87 ij	4.77 gh	5.73 de	6.52 b	5.22 B
Mean	3.77 D	4.66 C	5.57 B	6.45 A		3.82 D	4.72 C	5.63 B	6.49 A	

Means with the same letters are not significantly differed at 5% according to Duncan's multiple range test.

the sugar beet yield **(Armin and Asgharipour, 2012).** This could be attributed to the role of boron in cell division and elongation thereby encouraging the vegetative growth and root yield **(Camacho-Cristóbal *et al.,* 2015)**.The interactions between phosphorus and borax had a significant effect on vegetative growth and roots yield. Interestingly, in the previous studies, the combination of P and B enhanced the metabolic function of plants **(Muhlbachova *et al.,* 2017)**, and a synergistic relationship between P and B was found **(Irfan *et al.,* 2019)**. The current study suggested that 60 kg/fed., of phosphorus and 4 g/L of borax is the best combination for improving the vegetative growth and root yield parameters.

Red beet root is a natural source for biochemical compounds such as betalain pigments, which is permitted as a food ingredient **(Kujala *et al.,* 2002)**. Red beet consumption improving and maintaining the human health and helping in the treatment and prevention of leukaemia, malignancies and the consequences of radiation exposure as well as the regulation of blood pressure, cholesterol and triglycerides **(Bobek *et al.,* 2000)**. One of the goals of our study is improvement of the biochemical contents of red beet, the total carbohydrate and total soluble sugar content of roots were enhanced by phosphorus fertilization. This result may be attributed to the role of phosphorus in the bioactivities inside the plants such as energy transformation, where it is a key constituent of adenosine triphosphate (ATP) **(Kabir *et al.,* 2013)**. Another factor helps in increasing total carbohydrates and total soluble sugars content of red beet root is boron element, it has a positive role in carbohydrates transportation from source to sink **(Rashid *et al.,* 2004)**. Related the interaction between phosphorus and borax on sugars content, the results indicated that the combination of 60 kg/fed P and 4 g/L borax was more effectiveness in increasing the sugar contents in table beet root. Concerning SSC, in the present study, SSC of table beet root was improved, this attributed to increase the total sugars by phosphorus and borax treatments.

Phenolic compounds had a vital role in human health, such as anti-inflammatory, anti-aging, anti-proliferative and antioxidant activities **(Lin *et al.,* 2016)**. In our study, total phenolic increased in beetroot by phosphorus application. This may be attributed to the appropriate conditions for growing table beet. In addition, phosphorus is involved in regulating the phenolic compounds synthesis, although its mechanism is not completely clear, study suggests that phosphorus is a part of the structure of nucleic acid and thus playing an important role in the balancing of synthesis of plant hormones **(Attarzadeh *et al.,* 2020)**. In contrast, **Pontigo *et al.* (2018)** found that phenolic increased under P deficiency. This may be due to the difference plant species or growth conditions. Borax treatments enhanced the total phenolic compounds of table beet, this result indicated that boron have a role in phenolic metabolism, where B induced the activity of phenylalanine ammonia-tyase (PAL), and also phenolics are complexed with B, thereby unavailable for oxidation **(Ruiz *et al.,* 1998)**. In dependent on the above, the interaction between phosphorus and boraximproved the phenolics content in table beet root by the good synergistic effect between phosphorus and boron.

Increasing phosphorus levels resulted in significant increase in betalains content of table beet roots.This increase could be attributed to the photosynthesis process activity **(Silva *et al.,* 2019)**. Betalain pigments are maximized by borax treatments, this result may be due to the role of boron in the physiological processes such as sugars transport and stimulation or inhibition of specific metabolism pathways **(Ahmad *et al.,* 2009)**.

Phosphorus and borax treatments resulted in increasing N P K and B content of table beet. This study shows that phosphorus fertilization improved status of nutrient, which can explain the higher effect on table beet growth. This may be attributed to the role of phosphorus fertilization in encouraging the plants to take up more nutrients (e.g., N, P, K and B) from the soil **(Graciano *et al.,* 2006)**. Borax treatments as foliar application resulted in improving N, P, K and B contents in table beet. These results are in agreement with **Lopez-Lefebre *et al.* (2002)** who found that boron fertilization enhanced the N and K contents of tobacco leaves. Also, the application of boron doses caused an increase in N P K and B content of tomato **(Gundes and Sonmez, 2021)**. The interaction between P and borax treatments had a positive effect on N, P, K and B content of table beet plants. These results are in harmony with those reported by**Sinha *et al.* (2003) and Gundes and Sonmez (2021)**.

In general, Synergism was observed between phosphorus and boron when several characteristics were measured. These results are supported by many reports which demonstrated that the reduction in DNA and RNA concentration under phosphorus deficiency became more marked when both phosphorus and boron were deficient together. This may be due to phosphorus is a part of nucleotides, while boron is required for the synthesis of some component of nucleotides **(Bould 1983)**. Nucleic acids reduction under phosphorus and boron deficiency probably produces a chain reaction. RNA depression causes a depression in protein which leads to impairs growth and reduces dry weight **(Chatterjee *et al.*, 1990).** In addition, **Long and Peng (2023),** reviewed that the absorption of B by *Brassica napus* plants was promoted by an appropriate phosphorus amount, perhaps because phosphorus can improve absorption of water by plants and boost their transpiration and growth, thereby enhance absorption of boron by improving these physiological processes. Also, phosphorus can influence the biochemical properties of plant rhizosphere, and hence enhance boron availability in soil.

Collectively all these results indicated that phosphorus at rate of 60 kg/fed as top-dressing and borax at rate of 4 g/L as foliar application promoted the vegetative growth, enhanced root yield and improved the biochemical compound and minerals contents of table beet plants.

REFERENCES

Ahmad, W., A. Niaz, S. Kanwal, R. Rahmatullah and M.K. Rasheed (2009). Role of boron in plant growth: A review. J. Agric. Res., 47(3): 329-338.

Armin, M. and M. Asgharipour (2012). Effect of Time and Concentration of Boron Foliar Application on Yield and Quality of Sugar Beet. Ame.-Euras. J. Agric. And Environ. Sci., 12 (4): 444-448.

Attarzadeh, M., H. Balouchi, M. Rajaie, M. M. Dehnavi and A. Salehi (2020). Improving growth and phenolic compounds of *Echinacea purpurea* root by integrating biological and chemical resources of phosphorus under water deficit stress. Ind. Crops and Prod., 154 (2020) 112763. https:// doi.org/10.1016/j.indcrop.2020.112763

Bobek, P., S. Galbavy and M. Mariassyova (2000). The effect of red beet (*Beta vulgaris* var. rubra) fiber on alimentary hypercholesterolemia and chemically induced colon carcinogenesis in rats. Nahrung., 44(3):184-187.

Bould, C. (1983). Methods of diagnosing nutrient disorders in plants. Pages 111 136 in J.B.D. Robinson, ed. Diagnosis of mineral disorders in plants, Vol. I. Principles H.M.S.O. London, U.K.

Brdar-Jokanovic, M. (2020). Boron Toxicity and Deficiency in Agricultural Plants. Int. J. Mol. Sci. 21, 1424; doi:10.3390/ijms21041424

Camacho-Cristóbal, J.J., M.T. Navarro-Gochicoa, J. Rexach, A. González-Fontes and M.B. Herrera-Rodríguez (2018). Plant Response to Boron Deficiency and Boron Use Efficiency in Crop Plants. Plant Micronutrient Use Efficiency, 109-121.

Camacho-Cristóbal, J.J., E.M. Martín-Rejano, M.B. Herrera-Rodríguez, M.T. Navarro-Gochicoa, J. Rexach and A. González-Fontes (2015). Boron deficiency inhibits root cell elongation via an ethylene/auxin/ROS-dependent pathway in Arabidopsis seedlings. J. Exp. Bot., 66 (13): 3831-3840.

Chatterjee, C., P. Sinha and S.C. Acarwala (1990). Interactive effect of boron and phosphorus on growth and metabolism of maize grown in refined sand. Can. J. Plant Sci., 70: 455-460.

Dible, W.T., E. Truog and K.C. Berger (1954). Boron Determination in Soils and Plants. Anal. Chem., 26(2): 418-421.

Dubois, M.K.A., J.K. Hamilton, P.A. Rebers and F. Smith (1956). Colorimetric method for determination of sugars and related substances, Anal. Chem., 28: 350-356.

Epstein, E. and A.J. Bloom (2004). Mineral nutrition of plants: Principles and perspectives (2nd Ed.). Sunderland, MA: Sinauer Associates, Inc. 402.

Graciano, C., J.F. Goya, J.L. Frangi and J.J. Guiamet (2006). Fertilization with phosphorus increases soil nitrogen absorption in young plants of Eucalyptus grandis. Forest Ecolo. and Manag., 236: 202-210.

Gundes, F.A. and I. Sonmez (2021). Effect of phosphorus on the alleviation of boron toxicity in the tomato plant. J. Elem., 26(4): 1053-1063. DOI: 10.5601/jelem.2021.26.3. 2146.

Hinsinger, P. (2001). Bioavailability of soil inorganic P in the rhizosphere as affected by root-induced chemical changes: a review. Plant and Soil, 237(2):173-195.

Irfan, M., M. Abbas, J.A. Shah, N. Depar, M.Y. Memon and N.A. Sial (2019). Interactive effect of phosphorus and boron on plant growth, nutrient accumulation and grain yield of wheat grown on calcareous soil. Euras. J. Soil Sci., 8 (1): 17-26. DOI: 10. 18393/ejss.484654

Jackson, M.L. (1973). Soil Chemical Analysis. Prentice-Hall of India Private Limited New Delhi, 141.

Kabir, R., S. Yeasmin, A.K.M.M. Islam and M. D.A.R. Sarkar (2013). Effect of Phosphorus, Calcium and Boron on the Growth and Yield of Groundnut (*Arachis hypogea* L.) Int. J. Bio-Sci. and Bio-Technol., 5 (3): 51-59.

Kujala, T.S., M.S. Vienola, K.D. Klika, J.M. Loponen and K. Pihlaja (2002). Betalain and phenolic compositions of four beetroot (*Beta vulgaris*) cultivars. Eur. Food Res. Technol. 214: 505–510. DOI 10.1007/s00217-001-0478-6

Lin, D.,M. Mengshi Xiao, J. Zhao, Z. Li, B. Xing, X. Li, M. Kong, L. Li, Q. Zhang, Y. Liu, W. Chen Qin, H. Wu. and S. Chen (2016). An Overview of Plant Phenolic Compounds and Their Importance in Human Nutrition and Management of Type 2 Diabetes. 21, 1374; doi:10.3390/molecules 21101374

Ling, E.R. (1963). Determination of total nitrogen by semimicrokjeldahl method. Dairy Chem., 11: 23-84.

Long, Y. and J. Peng (2023). Interaction between Boron and Other Elements in Plants. Genes 14, 130. https://doi.org/10.3390/ genes 14010130

Lopez-Lefebre, L.R., R.M. Rivero, P.C. Garcia, E. Sanchez, J.M. Ruiz and L. Romero (2002). Boron effect on mineral nutrients of tobacco. J. Plant Nutr., 25(3): 509-522. DOI: 10.1081/PLN- -120003379

Marinkovic, B., J. Crnobarac, G. Jaćimovic, D. Marinkovic, D.V. Mircov and M. Rajici (2008). Importance of increasing amounts of NPK nutrients on sugar beet yield. Res. J. Agric. Res., 40 (2): 99-104.

Mazumdar, B.C. and K. Majumder (2003). Methods on Physico-Chemical Analysis of Fruits. Daya Publishing House, Delhi-110035, 162-163.

Mekdad, A.A.A. (2015). Sugar beet productivity as affected by nitrogen fertilizer and foliar spraying with boron. J. Curr. Microbiol. App. Sci., 4 (4): 181-196.

Muhlbachova, G., P. Cermak, R. Vavera, M. Kas, M. Pechova, K. Markova, H. Kusa, P. Ruzek, J. Hlusek and T. Losak, (2017). Boron availability and uptake under increasing phosphorus rates in a pot experiment. Plant, Soil and Environ., 63 (11): 483-490.

Ninfali, P. and D. Angelino (2013). Nutritional and Functional Potential of Beta vulgariscicla and Rubra. Fitoterapia, 89: 188-199.https:// doi.org/10.1016/j.fitote.2013.06.004

Page, A.L. (1982). Methods of soil analysis. 2^{nd} Ed. Part 1, Soil Sci. Soc. Amer. Madison Wisc. USA.

Pontigo, S., M. Ulloa, K. Godoy, N. Nikolic, M. Nikolic, M.L. Mora and P. Cartes (2018). Phosphorus efficiency modulates phenol metabolism in wheat genotypes. J. Soil Sci. and Plant Nutr., 18 (3): 904-920.

Raish, M., A. Ahmad, M.A. Ansari, K.M. Alkharfy, A. Ahad, A. Khan, N. Ali, M.A. Ganaie and M.A.A. Hamidaddin (2019). Beetroot juice alleviates isoproterenol-induced myocardial damage by reducing oxidative stress, inflammation, and apoptosis in rats. 3 Biotech. 2019 Apr., 9 (4):147. doi: 10.1007/s13205-019-1677-9. Epub 2019 Mar 23. PMID: 30944794; PMCID: PMC6430824.

Rashid, A., M. Yasin, M. Ashraf and R.A. Mann (2004). Boron deficiency in calcareous soil reduces rice yield and impairs grain quality. Int. Rice Res. Notes, 29: 58-60.

Reddy, M.K., R.L. Alexander-Lindo and M.G. Nair (2005). Relative Inhibition of Lipid Peroxidation, Cyclooxygenase Enzymes, and Human Tumor Cell Proliferation by Natural Food Colors. J. Agric. Food Chem., 53 (23): 9268–9273.

Ruiz, J.M., G. Bretones, M. Baghour, L. Ragala, A. Belakbir and L. Romero (1998). Relationship between boron and phenolic metabolism in tobacco leaves. Phytochem., 48 (2): 269-272.

Sadasivam, S. and A. Manickam (1991). Biochemical Methods for Agricultural Sciences. Wiley.

Seadh, S.E. (2012). Maximizing sugar beet yield with decreasing mineral fertilization pollution. Int. J. Agric. Sci., 4 (7): 293-298.

Silva, G.A., L.C. Grangeiro, V.F.L. Sousa, L.R. R. Silva, P.M.M. Jesus and J.L.A. Silva (2019). Agronomic performance of beet cultivars as a function of phosphorus fertilization. R. Bras. Eng. Agríc. Ambiental, 23 (7): 518-523. DOI: http://dx.doi.org/10.1590/1807-1929/agriambi.v23n7p518-523

Sinha, P., B.K. Dube and C. Chatterjee (2003). Phosphorus stress alters boron metabolism of mustard, Comm. Soil Sci. Plant Anal, 34(3-4): 315-326. DOI: 10.1081/CSS-120017823

Sreekanth, D., M.K. Arunasree, K.R. Roy, T.C. Reddy, G. V. Reddy and P. Reddanna (2007) Betanin a betacyanin pigment purified from fruits of Opuntia ficus-indica induces apoptosis in human chronic myeloid leukemia Cell line-K562,Phytomedicine, 14 (11): 739-746. https://doi.org/10.1016/j. phymed. 2007.03. 017.

Subba, S.K., R.K. Yambem, R.K. Asha, A. Das, S.B. Chattopadhyay and P. Choudhuri (2016). Effect of potassium and boron on quality parameters of carrot (*Dacus carota* L.). Int. Quality J. Environ. Sci. Special Issue, IX: 487-490

Tripathi, D.K., S. Singh, S. Singh, S. Mishra, D.K. Chauhan and N.K. Dubey (2015). Micronutrients and their diverse role in agricultural crops: advances and future prospective. Acta physiol. Plant, 37(7): 139.

Von Elbe, J.H. (2001). Betalains. Spectorophotometric determination of betacyanins and betaxanthins. Current Protocols in Food Analytical Chemistry F3.1.1-F3.1.7, New York: Wiley.

Winkler, B.W.C., K. Schroecksnadel, H. Schennach and D. Fuchs (2005). In vitro effects of beet root juice on stimulated and unstimulated peripheral blood mononuclear cells. Ame. J. Biochem. Biotechnol., 1:180-185. doi: 10.3844/ajbbsp.2005.180.185.

Zapata, F. and A.R. Zaharah (2002). Phosphate availability from phosphate rock and sewage sludge as influenced by addition of water soluble phosphate fertilizers. 2002. Nutrient Cycling in Agroecosystems, 1 (63):43-48.

تحسين نمو ومحصول وجودة جذور نباتات بنجر المائدة بالتسميد الفوسفاتي والرش الورقي بالبوراكس تحت ظروف الوادى الجديد

محمد علي [1] - إبراهيم ناصف [2]

1- قسم البساتين - كلية الزراعة - جامعة الوادي الجديد- مصر

2- قسم البساتين - كلية الزراعة - جامعة قناة السويس - مصر

أجريت تجربتين حقليتين خلال موسمي 2021/2020 و 2022/2021م فى مزرعة كلية الزراعة جامعة الوادى الجديد بمحافظة الوادى الجديد جمهورية مصر العربية؛ بهدف بحث التسميد الفوسفاتى والرش الورقي بالبوراكس على النمو والمحصول والمكونات الكيميائية والعناصر المعدنية فى بنجر المائدة. تم تطبيق أربعة مستويات من الفوسفور: 30 و 45 و60 و 75 كجم/الفدان كتسميد أرضي و كذلك أربعة مستويات من البوراكس: 0 و 2 و 4 و6 جرام/لتر رش ورقي وذلك فى المساحات المستصلحة حديثاً، وبالأخص محافظة الوادى الجديد كمساحات واعدة فى توسع الزراعة فى مصر. بينت النتائج أن تطبيق الفوسفور بمعدل 60 كجم/الفدان حسن النمو الخضري وصفات الجذر ومحتوى السكريات والمواد الصلبة الذائبة والفينولات وصبغات البيتالينات والعناصر المعدنية فى بنجر المائدة. أيضاً، كشفت الدراسة أن الرش الورقي بالبوراكس بمعدل 4 جرام/ لتر حسن النمو الخضري والمحصول والمركبات البيوكيميائية مقارنة بالتركيزات الأخرى. إضافة إلى ذلك، التفاعل بين الفوسفور بمعدل 60 كجم/فدان والبوراكس بمعدل 4 جم/لتر كان أكثر تأثيراً على بنجر المائدة عن باقى التوليفات ، وكان تأثره معنوياً على النمو والمحصول وجودة بنجر المائدة.

المحكمـــــون:

1- أ.د. الســـــيد أبو الخيـــــر أستاذ بمعهد بحوث البساتين - مركز البحوث الزراعية - الجيزة.

2- أ.د. عبد الله برديسي أحمد أستاذ الخضر المتفرغ - كلية الزراعة - جامعة الزقازيق