EFFECT OF BORON AND MOLYBDENUM ON CHEMICAL CONSTITUENTS AND QUALITY OF SOME SUGAR BEET VARIETIES

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Abstract

Two field experiments were conducted in Sakha Research Station, Kafr El-Sheikh, Agricultural Research Center during 2002/2003 and 2003/2004 seasons to investigate the effect of boron and molybdenum fertilizer levels on juice quality and chemical constituents of some sugar beet varieties. This study included 27 treatments which were the combination between three sugar beet varieties (Montebianco, Kawemira and Gloria), three boron fertilizer levels (zero, 0.50 and 1.00 kg B/fed) and three levels of molybdenum fertilizer (zero, 0.25 and 0.50 kg Mo/fed).

Treatments were arranged in a split plot design with three replications. Varieties were allocated in the main plots and the combination between levels of boron and molybdenum were assigned at random within sub-plots.

Montebianco variety recorded the highest values of total soluble solids percentage and potassium concentration in roots, petioles and blades, while, Gloria variety produced the highest values of sucrose, purity percentages and boron concentration roots, petioles and blades. Nitrogen percentages did not reach the level of significance, except in the first season for roots and petioles.

Increasing the supplied dose of boron negatively affected the values of total soluble solids percentage and it caused significant increases in sucrose and purity percentages. Application of 1.00 kg B/fed attained a significant increase in the molybdenum concentration in roots as well as Gloria and Kawemira gave the highest values of boron and nitrogen concentrations in blades, while application of 0.50 kg B/fed gave the highest insignificant concentration of molybdenum in the petiole and blade.

Increasing the supplied dose of molybdenum caused significant increases in sucrose and purity percentages and negatively affected the values of total soluble solids percentage, nitrogen concentration in roots, petioles and blades. Application of 0.50 kg Mo/fed attained a significant increases in the molybdenum concentration in roots, petioles and blades. Application of 0.50 kg Mo/fed or (0.50 kg B/fed + 0.50 kg Mo/fed) gave the lowest value of total soluble solids percentage.

INTRODUCTION

Sugar beet *(Beta vulagaris* L.) is the second important sugar crop in Egypt after sugar cane. Varieties are one of the most important factors directly affected the production of sugar beet root yield. The present work was conducted to find out the relative importance of two micro-elements (Boron and Molybdenum) to some sugar beet varieties in relation to chemical constituents and juice quality. Domska (1996) found that sugar beet cv. AJ Poly and PN Mono-1 were given of soil applications 0.6 kg boron gave the highest sugar content as well as high root N, Na, K, NH_2-N and B contents. Abd EL-Fatah (2000) studied the performance of six sugar beet (Alex, Universe, Kawemire, Pleno, Panther and Toro) under two harvesting dates (180 and 200 days after sowing). Panther variety recorded the highest contents of impurities (α-amino -N, K, and Na). The variety Kawemira had the highest percentage of recoverable sugar. Saif (2000) treated sugar beet variety Kawmera with four levels of boron (zero, 0.5, 1, and 1.5 kg B/fed). She found that the application of 0.5 kg B/fed was necessary to increase sucrose percentage in both seasons. In addition, the application of 0.5 kg. B/fed significantly increased juice purity percentage. El-Geddawy, *et al.* (2001) pointed out that sugar beet variety Lola attained the superiority over the other three studied varieties with respect to TSS%. However, this effect was insignificant with respect to sucrose percentage. Havashida, *et al.* (2001) demonstrated that sugar beet variety Abend is higher in sugar content and a little lower in Harmful non–sugar than Humming. Al-Labbody (2003) found significant differences among ten multigerm varietries (Toro, Lados, Vital, Gloria, Pamela, Del 937, Del 938, Del 939, kawemira and Athos poly) and five monogerm varieties (Marathon, Rhopsodie, Tellus, Vital and Helis) with respect to sucrose and purity% while TSS insignificantly differed in this respect. Osman, *et al.* (2003) found that variety Toro had the highest values of T.S.S%. They found that increasing the level of B up to 2 kg/fed increased sucrose and purity%. Shalaby (2003) studied the performance of 6 sugar beet varieties (Del 936, 937, 938, 939, Desperespoly and Demapoly). Del 938 surpassed the other varieties in TSS, Sucrose and Purity % and K% in sugar beet roots. Also, variety 939 surpassed the other varieties in α N and Na% in sugar beet roots. Nafei (2004) indicated that total soluble solids percentage was significantly increased as boron level was increased from zero to 0.500 kg sodium borate/fed, However, sucrose percentage was significantly increased up to 0.750 kg B/fed. Purity percentage was significantly influenced by B rates added to sugar beet plants in both seasons. Osman, *et al.* (2004) found that increasing the level of boron increased significantly sucrose % in the 1^{st} season. Ali (2005) studied the performance of three sugar beet varieties (KWS-9422, Pamela, Recolta-poly). KWS-9422 variety had the highest values of total soluble solids percentage, whereas the variety Pamela had the highest values of sucrose and purity percentages.

MATERIALS AND METHODS

Two field trials were carried out in Sakha Agricultural Research Station, Kafr EL-Sheikh Governorate on sugar beet crop in two successive seasons of 2002/2003 and 2003/2004. Each experiment included 27 treatments which were the combinations between three varieties of sugar beet (Montebianco, Gloria, Kawemira), three boron fertilizer levels (zero, 0.50 and 1.00 kg B/fed) which applied as sodium borate ($Na_2B_4O_7.10\ H_2O$) (11% B) and three molybdenum fertilizer levels (zero, 0.25 and 0.50 kg/fed) which applied as ammonium molybdate $(NH_4)_6\ Mo_7\ O_{24}.\ 4\ H_2O$ (54% Mo).

The experiments were laid out in a split plot design with three replications, where varieties were allocated in the main plots and the combinations between boron and molybdenum levels were distributed at random in the sub-plots. All micronutrients treatments were added singly or in combinations with each other and were mixed with an appropriate amount of sand and applied once as soil application with the second dose of nitrogen fertilizer (after 75 days from sowing).

Physical and mechanical analysis of the upper 30-cm of soil of the experimental site showed that the soil was silt (40.90 and 38.80%), clay (31.3 and 26.50%) and sand (26.75 and 33.50%). The chemical analyses of the experimental site are shown in Table (1).

Table 1. Mechanical and chemical analysis of soil of the experimental site (2002/2003 and 2003/2004 seasons)

Season	2002/2003	2003/2004
Soil depth (cm)	0-30	0-30
Mechanical soil distribution		
Sand %	26.75	33.50
Silt %	40.90	38.80
Clay %	31.30	26.50
Chemical analysis in soil extraction		
a) Cations mg/L		
Ca^{++}	0.18	0.16
Na^{+}	0.22	0.42
K^{+}	0.08	0.16
b) Anions mg/L		
Cl^{-}	0.15	0.18
SO_4^{--}	0.10	0.13
$CaCO_3$	0.15	0.21
HCo_3^{-}	1.25	1.18
Available B ppm	0.41	0.45
Available Mo ppm	9.55	10.00
Available N ppm	38.20	39.40
Available P ppm	18.20	19.80
Available K ppm	395.2	385.40
pH	8.00	8.20
E.C ds m	2.18	2.25

Soil physical and chemical properties were determined according to Jackson (1956).

Nitrogen fertilizer was applied at the rate of 80 kg N/fed as Urea (46% N), in two equal doses, the first one after thinning (45 days from sowing) and the second one month later. Phosphorus fertilizer at the rate of 30 kg P_2O_5/fed as calcium super phosphate (15 % P_2O_5) and potassium fertilizer at the rate of 48 kg K_2O/fed as potassium sulphate (48% K_2O) were applied in both seasons. Phosphorus fertilizer was applied at seedbed preparation, whereas potassium fertilizer was applied once with the first dose of nitrogen.

Plot area was 17.5 m^2 (5 ridges which were 7 meter in length, 50 cm in width and 20 cm between hills). Sowing date was on the 5^{th} of October in both seasons and harvesting date was after 7 months. The preceding crop was rice in both seasons. Other agricultural practices were done as recommended by Sugar Crops Research Institute (SCRI).

The Recorded data:

At harvest (210 days from sowing), samples of five plants were taken at random from each sub plot to determine the following:

I. Juice quality:

1. Total soluble solids percentage, (TSS %) was determined by using hand refractometer (A.O.A.C.,1995).
2. Sucrose percentage was determined by using Saccharimeter according to the method described by Le Docte (1927).
3. Purity percentage was calculated according to Carruthers *et al.* (1961) as follows:

   Purity = (sucrose % x 100) / TSS %.

II. Chemical constituents:

4. Nitrogen percentage in roots, petioles and blades were determined using micro Kjldahl apparatus according to Pergl (1945).
5. Potassium and sodium percentages in roots, petioles and blades were determined in the digested solution using flame photometer according to Brown and Lilliland (1964).
6. Boron and molybdenum (ppm) dry matter in roots, petioles and blades were determined as described in Flame Method, Manual for Atomic Absorption, and Model 22Brooklyn AVE at 213 nm as given by the (A.O.A.C., 1995).

Statistical analysis:

The expermintal data of both seasons were subjected to proper statistical analysis of variance according to Sendecor and Cochran (1967). The heterogeneity of error variances across seasons indicated that error terms were homogeneous. The combined analysis was conducted for the data of the two seasons according to Gomez and Gomez (1984). For comparison between means, Duncan's multiple range test was used (Duncan, 1955).

RESULTS AND DISCUSSION

1. Varietal performance:

a. Juice quality:

Data in Table (2) showed that varieties were significantly differed in total soluble solids, sucrose and purity percentages in both seasons and their combined. Montebianco attained the highest value of total soluble solids percentage in the two seasons and the combined data. These results coincide with those obtained by Shalaby (2003) and Ali (2005).

Table 2. Varietal performance with relation to juice quality percentage of some sugar beet roots at harvest {2002/03, 2003/04 seasons and their combined data}

Variety (V)	Total soluble solids %			Sucrose %			Purity %		
	2002/03	2003/04	combined	2002/03	2003/04	combined	2002/03	2003/04	combined
Montebianco	24.63 a	23.98 a	24.31 a	14.97 c	15.00 c	14.98 c	60.83 c	62.61 c	61.72 c
Kawemira	24.21 b	23.71 b	23.96 b	17.06 b	17.01 b	17.04 b	70.75 b	71.85 b	71.21 b
Gloria	23.87 c	23.36 c	23.61 c	19.44 a	19.42 a	19.43 a	81.59 a	83.27 a	82.43 a
F.test (V X S)			NS			NS			NS

NS : not significant

However, the same variety recorded the lowest values of sucrose and purity percentage as compared with the other two varieties. Meanwhile, Gloria produced the highest values of sucrose and purity percentages in the two seasons and the combined data. These results coincide with those obtained by EL-Geddawy (2001), AL-Labbody (2003) and Ali (2005).

Variety Kawemira attained a medium values between Montebianco and Gloria in respect to juice quality parameters.

b. Chemical constituents:

Results in Table (3) elucidated that boron content of leaf petiole and blade were significantly varied by the studied genotypes. On the contrary, boron root content was insignificantly affected by the examined varieties. It could be remarked that sugar beet variety Gloria recorded the highest boron concentration in root, petiole and blade comparing with the other two varieties in the combined data.

Table 3. Varietal performance with relation to boron concentration (ppm) in the different plant organs of some sugar beet varieties at harvest {2002/03, 2003/04 seasons and their combined data}

Variety (V)	Boron (ppm) in root			Boron (ppm) in petiole			Boron (ppm) in blade		
	2002/03	2003/04	combined	2002/03	2003/04	combined	2002/03	2003/04	combined
Montebianco	12.58 a	12.26 a	12.42 a	28.10 c	27.37 c	27.73 c	28.56 c	28.43 b	28.50 c
Kawemira	12.88 a	12.46 a	12.67 a	29.48 b	28.96 b	29.22 b	29.97 b	30.08 a	30.02 b
Gloria	12.83 a	12.82 a	12.82 a	31.15 a	30.06 a	30.60 a	31.45 a	31.21 a	31.33 a
F.test (V X S)			NS			NS			NS

NS : not significant

Once more, the results given in Table (4) clear that the studied varieties did not differ significantly in molybdenum concentration in the various parts of sugar beet plants roots, petioles and blades these finding were completely true in the two seasons and the combined data.

Table 4. Varietal performance with relation to molybdenum concentration (ppm) in the different plant organs of some sugar beet varieties at harvest {2002/03, 2003/04 seasons and their combined data}

Variety (V)	Molybdenum (ppm) in root			Molybdenum (ppm) in petiole			Molybdenum (ppm) in blade		
	2002/03	2003/04	combined	2002/03	2003/04	combined	2002/03	2003/04	combined
Montebianco	4.51 a	4.20 a	4.35 a	4.72 a	4.93 a	4.83 a	5.21 a	5.25 a	5.23 a
Kawemira	4.32 a	4.26 a	4.29 a	4.81 a	5.32 a	5.06 a	5.13 a	5.31 a	5.22 a
Gloria	4.45 a	4.44 a	4.44 a	4.70 a	4.97 a	4.84 a	4.93 a	5.29 a	5.11 a
F.test (V X S)			NS			NS			NS

NS : not significant

Data in Table (5) showed that the tested sugar beet varieties differed significantly in N% in roots and petioles in the 1st season as well as in roots in the combined data. However, N% in roots (in the 2nd season), in petioles (in the 2nd season and the combined data) and in leaf blades (in both seasons and their combined data) were insignificantly different. These results coincide with that obtained by Shalaby (2003).

Table 5. Varietal performance with relation to nitrogen percentages in the different plant organs of some sugar beet varieties at harvest {2002/03, 2003/04 seasons and their combined data}

Variety (V)	Nitrogen % in root			Nitrogen % in petiole			Nitrogen % in blade		
	2002/03	2003/04	combined	2002/03	2003/04	combined	2002/03	2003/04	combined
Montebianco	1.66 a	1.32 a	1.49 a	2.29 b	2.45 a	2.37 a	3.54 a	3.59 a	3.56 a
Kawemira	1.65 a	1.34 a	1.49 a	2.37 a	2.43 a	2.40 a	3.39 a	3.50 a	3.44 a
Gloria	1.38 b	1.36 a	1.37 b	2.62 a	2.33 a	2.48 a	3.50 a	3.57 a	3.53 a
F.test (V X S)			S			S			NS

S : significant , NS : not significant

Data in Table (6) revealed that differences between varieties with respect to potassium leaf's, petiole contents were significant in the first season and the combined data. Also, insignificant differences between varieties were obtained for potassium concentrations in leaf blade. Montebianco almost recorded the highest values of potassium percentage for the various parts of the plant followed by Kawemira, while Gloria variety gave the lowest ones. These results coincide with that obtained by Shalaby (2003).

Table 6. Varietal performance with relation to potassium percentages in the different plant organs of some sugar beet varieties at harvest {2002/03, 2003/04 seasons and their combined data}

Variety (V)	Potassium % in root			Potassium % in petiole			Potassium % in blade		
	2002/03	2003/04	combined	2002/03	2003/04	combined	2002/03	2003/04	combined
Montebianco	2.02 a	1.84 a	1.93 a	3.24 a	2.94 a	3.09 a	3.39 a	3.40 a	3.39 a
Kawemira	1.80 ab	1.41 b	1.60 b	3.18 a	2.92 a	3.05 a	3.42 a	3.36 a	3.39 a
Gloria	1.40 b	1.36 b	1.38 b	2.79 b	2.68 a	2.74 b	2.99 a	3.19 a	3.09 a
F.test (V X S)			NS			NS			NS

NS : not significant

Results in Table (7) revealed that the studied varieties differed significantly in sodium concentration of their roots in the first season and in the combined data. These results coincide with that obtained by Shalaby (2003).

Table 7. Varietal performance with relation to sodium percentages in the different plant organs of some sugar beet varieties at harvest {2002/03, 2003/04 seasons and their combined data}

Variety (V)	Sodium % in root			Sodium % in petiole			Sodium % in blade		
	2002/03	2003/04	combined	2002/03	2003/04	combined	2002/03	2003/04	combined
Montebianco	2.23 a	2.31 a	2.27 a	4.07 a	4.14 a	4.11 a	4.12 a	4.29 a	4.20 a
Kawemira	2.29 a	2.21 a	2.25 a	3.85 a	3.86 b	3.85 a	4.01 a	4.42 a	4.21 a
Gloria	1.86 b	2.27 a	2.07 b	3.90 a	3.95 b	3.93 a	4.05 a	4.37 a	4.21 a
F.test (V X S)			S			NS			NS

S : significant , NS : not significant

2. Effect of boron fertilizer levels on:

a. Juice quality:

Data in Table (8) showed that total soluble solids percentage was statistically affected by the applied levels of boron fertilizer, increasing the supplied dose of boron negatively affected the values of TSS %. Also, it is well known the direct role of boron element in sucrose translocation between plant organs, it well be not enough to depend upon the values of total soluble solids percentage only with respect to juice quality.

Table 8. Effect of boron fertilizer levels on juice quality percentages of sugar beet roots at harvest {2002/03, 2003/04 seasons and their combined data}

Boron levels (kg B/fed)	Total soluble solids %			Sucrose %			Purity %		
	2002/03	2003/04	combined	2002/03	2003/04	combined	2002/03	2003/04	combined
zero	24.62 a	24.09 a	24.35 a	16.79 b	16.83 b	16.81 b	68.39 c	69.99 b	69.19 c
0.50	24.14 b	23.48 b	23.81 b	17.13ab	17.11ab	17.12 b	71.16 b	73.07 a	72.11 a
1.00	23.95 b	23.49 b	23.72 b	17.54 a	17.50 a	17.52 a	73.44 a	74.67 a	74.06 a
F.test (B X S)			NS			NS			NS

NS : not significant

It could be noted that the response of both measurements to the additional application of boron fertilizer was inverse to the response of TSS%.

This result assured the important and real of role micro-elements such as boron in sucrose translocation.

Applying 1.00 kg B/fed gave the highest values of sucrose and purity percentages followed by 0.50 kg B/fed and control. The same trends were reported by Saif (2000), Osman *et al.* (2003) and Nafei (2004).

b. Chemical constituents:

Results in Table (9) elucidated that boron contents in root, leaf petiole and blade were significantly increased as the applied dose of boron fertilizer increased from zero to 0.50 and up to 1.00 kg B/fed. This finding was true in both seasons and their combined data. Similar results were obtained by Domska (1996).

Table 9. Effect of boron fertilizer levels on boron concentrations (ppm) in the different plant organs of sugar beet at harvest {2002/03, 2003/04 seasons and their combined data}

Boron levels	Boron (ppm) in root			Boron (ppm) in petiole			Boron (ppm) in blade		
(kg B/fed)	2002/03	2003/04	combined	2002/03	2003/04	combined	2002/03	2003/04	combined
zero	11.32 c	11.32 b	11.32 c	28.64 c	28.23 b	28.43 c	29.35 b	29.44 b	29.40 b
0.50	12.82 b	13.17 a	13.00 b	29.55 b	29.08 a	29.32 b	29.64 b	29.70 b	29.67 b
1.00	14.15 a	13.05 a	13.60 a	30.53 a	29.08 a	29.80 a	30.99 a	30.57 a	30.78 a
F.test (B X S)			S			S			NS

S : significant , NS : not significant

Data in Table (10) cleared that the application of 1.00 kg B/fed produced the highest concentration of molybdenum in root, petiole and blade of sugar beet leaves. Moreover, it could be noted that this influence was statistically significant only in the first season and the combined of the two seasons with respect to molybdenum concentration in petiole tissue, meanwhile differences between boron levels and their influence on molybdenum concentrations were not great enough to reach the level of significance in blade.

Table 10. Effect of boron fertilizer levels on molybdenum concentrations (ppm) in the different plant organs of sugar beet at harvest {2002/03, 2003/04 seasons and their combined data}

Boron levels	Molybdenum (ppm) in root			Molybdenum (ppm) in petiole			Molybdenum (ppm) in blade		
(kg B/fed)	2002/03	2003/04	combined	2002/03	2003/04	combined	2002/03	2003/04	combined
zero	3.99 c	3.73 b	3.86 c	4.69 b	5.03 a	4.86 b	5.02 a	5.33 a	5.17 a
0.50	4.33 b	4.58 a	4.46 b	4.99 a	5.10 a	5.05 a	5.19 a	5.31 a	5.25 a
1.00	4.96 a	4.60 a	4.78 a	4.55 b	5.08 a	4.82 b	5.06 a	5.22 a	5.14 a
F.test (B X S)			S			S			NS

S : significant , NS : not significant

Results in Table (11) revealed that nitrogen concentrations in root, petiole and blade were insignificant affected in the two seasons. Similar results were obtained by Domska (1996).

Table 11. Effect of boron fertilizer levels on nitrogen percentages in the different plant organs of sugar beet at harvest {2002/03, 2003/04 seasons and their combined data}

Boron levels	Nitrogen % in root			Nitrogen % in petiole			Nitrogen % in blade		
(kg B/fed)	2002/03	2003/04	combined	2002/03	2003/04	combined	2002/03	2003/04	combined
zero	1.60 a	1.30 a	1.45 a	2.40 a	2.41 a	2.40 a	3.44 a	3.52 a	3.48 b
0.50	1.54 a	1.33 a	1.43 a	2.48 a	2.36 a	2.42 a	3.46 a	3.52 a	3.49 b
1.00	1.55 a	1.40 a	1.47 a	2.40 a	2.44 a	2.42 a	3.51 a	3.62 a	3.57 a
F.test (B X S)			NS			NS			NS

NS : not significant

Potassium percentage in root and sodium percentage in blade responded significantly to the applied boron fertilizer levels in the second season (Tables, 12 and 13). Similar result was obtained by Domska (1996).

Table 12. Effect of boron fertilizer levels on potassium percentages in the different plant organs of sugar beet at harvest {2002/03, 2003/04 seasons and their combined data}

Boron levels	Potassium % in root			Potassium % in petiole			Potassium % in blade		
(kg B/fed)	2002/03	2003/04	combined	2002/03	2003/04	combined	2002/03	2003/04	combined
zero	1.75 a	1.43 a	1.59 a	3.09 a	2.74 a	2.92 a	3.20 a	3.17 a	3.18 a
0.50	1.77 a	1.53 ab	1.65 a	3.07 a	2.85 a	2.96 a	3.30 a	3.34 a	3.32 a
1.00	1.70 a	1.65 a	1.67 a	3.04 a	2.95 a	3.00 a	3.30 a	3.44 a	3.37 a
F.test (B X S)			S			NS			NS

S : significant , NS : not significant

Table 13. Effect of boron fertilizer levels on sodium percentages in the different plant organs of sugar beet at harvest {2002/03, 2003/04 seasons and their combined data}

Boron levels	Sodium % in root			Sodium % in petiole			Sodium % in blade		
(kg B/fed)	2002/03	2003/04	combined	2002/03	2003/04	combined	2002/03	2003/04	combined
zero	2.25 a	2.32 a	2.28 a	3.87 a	3.92 a	3.89 a	4.44 a	4.68 a	4.56 a
0.50	2.20 a	2.36 a	2.28 a	4.06 a	4.02 a	4.04 a	4.14 b	4.40 b	4.27 b
1.00	1.93 b	2.11 a	2.02 b	3.90 a	4.01 a	3.96 a	3.60 c	3.99 c	3.80 c
F.test (B X S)			NS			NS			NS

NS : not significant

3. Effect of molybdenum fertilizer levels on:

a. Juice quality:

Results given in Table (14) showed that juice quality was significantly affected by molybdenum fertilizer levels. Increasing molybdenum fertilizer decreased the values of total soluble solids percentage.

On the contrary the response of sucrose and purity percentages to the additional increase of molybdenum was positive, applying 0.25 kg Mo/fed raised the values of sucrose percentage over that of the control by 5.82 %, 4.93 % and 5.37 %. Corresponding by 7.06 %, 6.71 % and 6.87 % for juice purity percentage in the two seasons and the combined data, respectively.

Raising the applied dose of molybdenum to 0.50 kg Mo/fed attained additional increase over check treatment reached to 9.74 %, 8.53 % and 9.10 % for sucrose percentage corresponding to 13.81 %, 12.44 % and 13.12 % for purity percentage in the two growing seasons and their combined successively.

Table 14. Effect of molybdenum fertilizer levels on juice quality percentages of sugar {2002/03, 2003/04 seasons and their combined data}

Molybdenum levels (kgMo/fed)	Total soluble solids %			Sucrose %			Purity %		
	2002/03	2003/04	combined	2002/03	2003/04	combined	2002/03	2003/04	combined
zero	24.61 a	24.08 a	24.34 a	16.31 c	16.41 c	16.36 c	66.38 c	68.22 c	67.30 c
0.25	24.33 b	23.71 b	24.02 b	17.26 b	17.22 b	17.24 b	71.07 b	72.80 b	71.93 b
0.50	23.77 c	23.27 c	23.52 c	17.90 a	17.81 a	17.85 a	75.55 a	76.71 a	76.13 a
F.test(MoXS)			NS			NS			NS

NS : not significant

b. Chemical constituents:

Data presented in Table (15) showed that boron contents in the various organs of sugar beet plants in roots, petioles and blades were significantly increased as molybdenum fertilizer levels increased from zero to 0.50 kg Mo/fed. These results were true in the two seasons and their combined except the combined data over the two seasons of the boron content in the petioles where the difference did not reach the level of significance. Application of 0.50 kg Mo/fed gave the highest value of boron contents in root, petiole and blade.

Table 15. Effect of molybdenum fertilizer levels on boron concentrations (ppm) in the different plant organs of sugar beet at harvest {2002/03, 2003/04 seasons and their combined data}

Molybdenum levels (kgMo/fed)	Boron (ppm) in root			Boron (ppm) in petiole			Boron (ppm) in blade		
	2002/03	2003/04	combined	2002/03	2003/04	combined	2002/03	2003/04	combined
zero	12.14 b	11.69 c	11.92 c	29.41 b	28.55 b	28.98 a	29.13 c	29.82 b	29.48 b
0.25	12.75ab	12.49 b	12.62 b	29.49 b	28.91 a	29.20 a	29.88 b	29.82 b	29.73 b
0.50	13.39 a	13.36 a	13.38 a	29.83 a	28.92 a	29.37 a	30.96 a	30.32 a	30.64 a
F.test(MoXS)			NS			NS			S

S : significant , NS : not significant

This observation may be indicating to the relative important of molybdenum fertilizer application to sugar beet plants especially that this element appeared an effective role in juice quality.

The results in Table (16) obtained throw some lights on the inverse relationship between molybdenum application and nitrogen contents in sugar beet plants. Based on the results obtained, increasing the applied dose of molybdenum decreased nitrogen percentage. This phenomenon is considered a good result because it well know that the highest, the nitrogen content in sugar beet roots and the lowest the juice quality.

Table 16. Effect of molybdenum fertilizer levels on nitrogen percentages in the different plant organs of sugar beet at harvest {2002/03, 2003/04 seasons and their combined data}

Molybdenum levels (kgMo/fed)	Nitrogen % in root			Nitrogen % in petiole			Nitrogen % in blade		
	2002/03	2003/04	combined	2002/03	2003/04	combined	2002/03	2003/04	combined
zero	1.75 a	1.47 a	1.61 a	2.61 a	2.58 a	2.59 a	3.66 a	3.70 a	3.68 a
0.25	1.54 b	1.32 b	1.43 b	2.42 b	2.42 b	2.42 b	3.46 b	3.55 b	3.50 b
0.50	1.39 c	1.22 c	1.31 c	2.25 c	2.21 c	2.23 c	3.30 c	3.41 c	3.35 c
F.test(MoXS)			NS			NS			NS

NS : not significant

Results given in Tables (17 and 18) showed that potassium and sodium percentages were negatively significantly affected by the applied doses of molybdenum fertilizer. And regardless the significance, it could be noted that both of potassium and sodium contents in sugar beet roots had an inverse relationship with the applied dose of molybdenum, and in general increasing molybdenum application tended to lower the values of potassium and sodium percentages in petioles and leaf blade of sugar beet plants.

Table 17. Effect of molybdenum fertilizer levels on potassium percentages in the different plant organs of sugar beet at harvest { 2002/03, 2003/04 seasons and their combined data }

Molybdenum levels (kgMo/fed)	Potassium % in root			Potassium % in petiole			Potassium % in blade		
	2002/03	2003/04	combined	2002/03	2003/04	combined	2002/03	2003/04	combined
zero	1.93 a	1.76 a	1.84 a	3.33 a	2.84 a	3.09 a	3.46 a	3.44 a	3.45 a
0.25	1.77 b	1.51 b	1.64 b	3.09 b	3.07 a	3.08 a	3.26 ab	3.23 a	3.24 a
0.50	1.52 c	1.34 c	1.43 c	2.79 c	2.63 a	2.71 b	3.09 b	3.28 a	3.18 b
F.test(MoXS)			NS			NS			NS

NS : not significant

Table 18. Effect of molybdenum fertilizer levels on sodium percentages in the different plant organs of sugar beet at harvest {2002/03, 2003/04 seasons and their combined data}

Molybdenum levels (kgMo/fed)	Sodium % in root			Sodium % in petiole			Sodium % in blade		
	2002/03	2003/04	combined	2002/03	2003/04	combined	2002/03	2003/04	combined
zero	2.25 a	2.32 a	2.28 a	3.87 a	3.92 a	3.89 a	4.44 a	4.68 a	4.56 a
0.25	2.20 a	2.36 a	2.28 a	4.06 a	4.02 a	4.04 a	4.14 b	4.40 b	4.27 b
0.50	1.93 b	2.11 a	2.02 b	3.90 a	4.01 a	3.96 a	3.60 c	3.99 c	3.80 c
F.test(MoXS)			NS			NS			NS

NS : not significant

Once more, the irreversible effects of the applied doses of molybdenum fertilizer on the root content from nitrogen, potassium and sodium, may be considered very important results for sugar manufacture, because, it is will known that there is an inverse relationship between the concentration of such elements (impurities) and the extracted sugar. Based on these results, it could be recommended by molybdenum application to decrease the impurities (nitrogen, potassium and sodium) consequently increased sugar extraction.

4. Effect of the interaction between varieties and boron fertilizer levels:

The combined data in Table (19) showed that B concentration (ppm) in blades was significantly affected by the interactions between boron fertilizer levels and sugar beet varieties. Gloria variety produced 3.23, 2.45 and 2.81 ppm B higher than that recorded by Montebianco under the control, 0.50 and 1.00 kg B/fed, respectively, i.e. the difference between the two varieties in this trait was more distinguished under the control compared with the other two B levels.

Table 19. Effect of the interaction between varieties and boron fertilizer on boron concentration (ppm) in blade of some sugar beet varieties at harvest {2002/03, 2003/04 seasons and their combined data}

Variety (V)	2002/03			2003/04			combined		
	Boron level (kg B/fed)			Boron level (kg B/fed)			Boron level (kg B/fed)		
	zero	0.50	1.00	Zero	0.50	1.00	zero	0.50	1.00
Montebianco	27.81 e	28.32 e	29.55 cd	27.98 e	28.27de	29.04 cd	27.90 e	28.29 e	29.30 d
Kawemira	29.13 d	29.92 c	30.86 b	29.18 c	30.04 b	31.00 a	29.16 d	29.98 c	30.93 b
Gloria	31.10 b	30.68 b	32.56 a	31.17 a	30.80ab	31.67 a	31.13 b	30.74 b	32.11 a
F.test(VXBXS)		-			-			NS	

NS : not significant

The combined data in Table (20) showed that Mo (ppm) in petioles was significantly affected by the interactions between boron fertilizer levels and sugar beet varieties. The difference between Kawemira and Gloria varieties was insignificant under 0.50 kg B/fed, while, the difference between the two varieties in this trait was significant under the control or 1.00 kg B/fed.

Table 20. Effect of the interaction between varieties and boron fertilizer on molybdenum concentration (ppm) in petiole of some sugar beet varieties {2002/03, 2003/04 seasons and their combined data}

Variety (V)	2002/03			2003/04			combined		
	Boron level (kg B/fed)			Boron level (kg B/fed)			Boron level (kg B/fed)		
	zero	0.50	1.00	Zero	0.50	1.00	zero	0.50	1.00
Montebianco	4.49 de	5.01 ab	4.68 cd	5.07abcd	4.84 cd	4.89 bcd	4.78 bc	4.92 ab	4.78 bc
Kawemira	4.94 abc	4.84 bc	4.65 cd	5.37 a	5.33 ab	5.26 abc	5.15 a	5.08 a	4.95 ab
Gloria	4.65 cd	5.13 a	4.33 e	4.66 d	5.14 abc	5.10 abcd	4.65 c	5.14 a	4.71 bc
F.test(VXBXS)	-			-			NS		

NS : not significant

The combined data in Table (21) showed that Mo concentration (ppm) in blades was significantly affected by the interactions between boron fertilizer levels and sugar beet varieties. Gloria variety produced 0.4 and 0.13 ppm Mo lower than that recorded by Montebianco under the control and 0.50 kg B/fed, respectively.

Table 21. Effect of the interaction between varieties and boron fertilizer on molybdenum concentration in blade (ppm) of some sugar beet varieties {2002/03, 2003/04 seasons and their combined data}

Variety (V)	2002/03			2003/04			combined		
	Boron level (kg B/fed)			Boron level (kg B/fed)			Boron level (kg B/fed)		
	zero	0.50	1.00	zero	0.50	1.00	zero	0.50	1.00
Montebianco	5.32 a	5.23 a	5.08 a	5.43 ab	5.20 ab	5.12 ab	5.37 ab	5.22abcd	5.10 bcd
Kawemira	5.03 a	5.32 a	5.03 a	5.31 ab	5.57 a	5.06 b	5.17abcd	5.44 a	5.05 cd
Gloria	4.70 b	5.02 a	5.07 a	5.24 ab	5.16 ab	5.47 ab	4.97 d	5.09 cd	5.27 abc
F.test(VXBXS)							NS		

S : significant , NS : not significant

The combined data in Table (22) showed that N% in petioles was significantly affected by the interactions between boron fertilizer levels and sugar beet varieties. The difference between M & K varieties was insignificant under zero or 1.0 kg B/fed. However, the difference between the two varieties in this trait was significant under 0.5 kg B/fed. In addition, the difference between Montebianco and Gloria varieties was insignificant under 0.50 kg B/fed and significant under the control and 1.0 kg B/fed.

Table 22. Effect of the interaction between varieties and boron fertilizer on nitrogen percentage in petiole of some sugar beet varieties at harvest {2002/03, 2003/04 seasons and their combined data}

Variety (V)	2002/03			2003/04			combined		
	Boron level (kg B/fed)			Boron level (kg B/fed)			Boron level (kg B/fed)		
	zero	0.50	1.00	zero	0.50	1.00	zero	0.50	1.00
Montebianco	2.23 c	2.37 bc	2.26 c	2.52 ab	2.38abc	2.44 ab	2.38 b	2.37 b	2.35 b
Kawemira	2.30 bc	2.47 ab	2.35 bc	2.43 ab	2.53 ab	2.33 abc	2.36 b	2.50 ab	2.34 b
Gloria	2.66 a	2.60 a	2.61 a	2.29 bc	2.16 c	2.55 a	2.47 ab	2.38 b	2.58 a
F.test(VXBXS)	-			-			NS		

NS : not significant

The combined data in Table (23) showed that N% in blades was significantly affected by the interactions between boron fertilizer levels and sugar beet varieties. The difference between M & G varieties was insignificant under zero or 0.5 kg B/fed. However, the difference between the two varieties in this trait was significant under 1.0 kg B/fed.

Table 23. Effect of the interaction between varieties and boron fertilizer on nitrogen percentage in blade of some sugar beet varieties at harvest {2002/03, 2003/04 seasons and their combined data}

Variety (V)	2002/03			2003/04			combined		
	Boron level (kg B/fed)			Boron level (kg B/fed)			Boron level (kg B/fed)		
	zero	0.50	1.00	zero	0.50	1.00	zero	0.50	1.00
Montebianco	3.40 bc	3.66 a	3.55 ab	3.62 ab	3.46 b	3.96 a	3.51 ab	3.56 a	3.62 a
Kawemira	3.38 bc	3.25 c	3.53 ab	3.43 b	3.46 b	3.62 ab	3.41 bc	3.35 c	3.57 a
Gloria	3.55 ab	3.48 ab	3.46 b	3.15 ab	3.63 ab	3.56 ab	3.53 ab	3.56 a	3.51 ab
F.test(VXBXS)	-			-			S		

S : significant

5. Effect of the interaction between varieties and molybdenum fertilizer levels:

The combined data in Table (24) showed that total soluble solid % was significantly affected by the interactions between molybdenum fertilizer levels and sugar beet varieties. Gloria variety produced 0.45 and 0.67 % lower than that recorded by Montebianco under the control and 0.25 kg Mo/fed, respectively, while it increased by 0.96 % under the 0.5 kg Mo/fed.

Table 24. Effect of the interaction between varieties and molybdenum fertilizer on total soluble solids percentage of some sugar beet varieties at harvest {2002/03, 2003/04 seasons and their combined data}

Variety (V)	2002/03			2003/04			combined		
	Molybdenum level (kg Mo/fed)			Molybdenum level (kg Mo/fed)			Molybdenum level (kg Mo/fed)		
	zero	0.25	0.50	zero	0.25	0.50	zero	0.25	0.50
Montebianco	24.95 a	24.62ab	24.31 bc	24.24 a	24.01ab	23.71 b	24.59 a	24.32 b	24.01 c
Kawemira	24.56 b	24.30bc	23.79 d	24.05ab	23.86 b	23.22 c	24.30 b	24.08 bc	23.50 d
Gloria	24.32bc	24.06cd	23.22 e	23.95ab	23.25 c	22.88 d	24.14 bc	23.65 d	23.05 e
F.test(VXBXS)	-			-			NS		

NS : not significant

The combined data in Table (25) showed that potassium % in root was significantly affected by the interactions between molybdenum fertilizer levels and sugar beet varieties. Gloria variety produced 0.72, 0.61 and 0.31 % lower than that recorded by Montebianco under the control, 0.25 and 0.50 kg Mo/fed, respectively.

Table 25. Effect of the interaction between varieties and molybdenum fertilizer on potassium percentage in root of some sugar beet varieties at harvest {2002/03, 2003/04 seasons and their combined data}

Variety (V)	2002/03			2003/04			combined		
	Molybdenum level (kg Mo/fed)			Molybdenum level (kg Mo/fed)			Molybdenum level (kg Mo/fed)		
	zero	0.25	0.50	Zero	0.25	0.50	zero	0.25	0.50
Montebianco	2.31 a	2.12 ab	1.62 de	2.19 a	1.85 b	1.49 c	2.25 a	1.98 b	1.55 d
Kawemira	1.93 bc	1.81 cd	1.65 de	1.56 c	1.32 cd	1.33 cd	1.75 c	1.57 d	1.49 de
Gloria	1.55 ef	1.38 fg	1.28 g	1.51 c	1.36 cd	1.20 d	1.53 de	1.37 ef	1.24 f
F.test(VXBXS)	-			-			NS		

NS : not significant

The combined data in Table (26) showed that sodium % was significantly affected by the interactions between molybdenum fertilizer levels and sugar beet varieties. Gloria variety produced 0.53 and 0.13 % lower than that recorded by Montebianco under the control and 0.25 kg Mo/fed, respectively, while it increased by 0.05 % under 0.50 kg Mo/fed.

Table 26. Effect of the interaction between varieties and molybdenum fertilizer on sodium percentage in root of some sugar beet varieties at harvest {2002/03, 2003/04 seasons and their combined data}

Variety (V)	2002/03			2003/04			combined		
	Molybdenum level (kg Mo/fed)			Molybdenum level (kg Mo/fed)			Molybdenum level (kg Mo/fed)		
	zero	0.25	0.50	zero	0.25	0.50	zero	0.25	0.50
Montebianco	2.39 a	2.28 ab	2.03 bc	2.58 a	2.31abc	2.03 abc	2.48 a	2.30 abc	2.03 cd
Kawemira	2.43 a	2.52 a	1.91 c	2.41abc	2.22abc	2.01 bc	2.42 a	2.37 ab	1.96 d
Gloria	1.94 bc	1.79 c	1.87 c	1.97 c	2.56 ab	2.30 abc	1.95 d	2.17abcd	2.08 bcd
F.test(VXBXS)	-			-			NS		

NS : not significant

6. Effect of the interaction between boron and molybdenum fertilizers:

The combined data in Table (27) showed that total soluble solids % was significantly affected by the interactions between boron and molybdenum fertilizer levels. Applying 0.50 or 1.0 kg B/fed in combination with 0.5 kg Mo/fed was insignificant, while, both fertilizer levels had a significant effect at using it in combination with control and 0.25 kg Mo/fed

Table 27. Effect of the interaction between boron and molybdenum fertilizers on total soluble solids percentage of sugar beet roots at harvest {2002/03, 2003/04 seasons and their combined data}

Boron levels (kg B/fed)	2002/03			2003/04			combined		
	Molybdenum level (kg Mo/fed)			Molybdenum level (kg Mo/fed)			Molybdenum level (kg Mo/fed)		
	zero	0.25	0.50	zero	0.25	0.50	zero	0.25	0.50
zero	24.90 a	24.64ab	24.31 bc	24.38 a	24.00 b	23.86 bc	24.64 a	24.32 b	24.08 bc
0.50	24.55ab	24.34 b	23.51 d	23.95 b	23.53 d	22.93 e	24.25 b	23.94 cd	23.22 e
1.00	24.37 b	23.98 c	23.49 d	23.89bc	23.57cd	23.00 e	24.13 bc	23.78 d	23.24 e
F.test (BX MoXS)	-			-			NS		

NS : not significant

The results in Table (28) indicate that sodium percentage in blade was significantly influenced by the applied boron and molybdenum fertilizer levels. The lowest percentage was obtained by applied 0.50 kg B/fed with 0.50 kg Mo/fed in the combined as well as in the first season, but it gave the highest percentage by unfertilized.

Table 28. Effect of the interaction between boron and molybdenum fertilizers on sodium percentage in blade of sugar beet at harvest {2002/03, 2003/04 seasons and their combined data}

Boron levels (kg B/fed)	2002/03			2003/04			combined		
	Molybdenum level (kg Mo/fed)			Molybdenum level (kg Mo/fed)			Molybdenum level (kg Mo/fed)		
	zero	0.25	0.50	zero	0.25	0.50	zero	0.25	0.50
zero	4.53 a	4.28 ab	3.91 c	2.20 cd	2.30 bc	2.06 de	4.58 a	4.31 bc	4.04 de
0.50	4.40 ab	4.06 bc	3.35 d	2.28 bc	2.23 cd	2.37 abc	4.56 a	4.23 cd	3.55 f
1.00	4.38 ab	4.06 bc	3.54 d	2.47 ab	2.56 a	1.91 e	4.53 ab	4.26 cd	3.81 e
F.test (BX MoXS)	-			-			NS		

NS : not significant

7. Effect of the interaction between varieties, boron and molybdenum:

The results presented in Table (29) revealed that the values of total soluble solids percentage was statistically affected by the second order interaction However, it could be noted that increasing the applied levels for any of the two micro-elements decreased the values of total soluble solids percentage. These finding were completely true under the different varieties in this study. The highest values of total soluble solids percentage were recorded for the unfertilized treatment.

Table 29. Effect of the interaction between varieties, boron and molybdenum fertilizers on total soluble solids percentage of sugar beet roots at harvest{2002/03, 2003/04 seasons and their combined data}

Varieties (V)	Boron levels (kg B/fed	2002/03			2003/04			combined		
		Molybdenum levels (kg Mo/fed)			Molybdenum levels (kg Mo/fed)			Molybdenum levels (kg Mo/fed)		
		zero	0.25	0.50	zero	0.25	0.50	zero	0.25	0.50
Montebianco	zero	25.13 a	25.02 ab	24.76 abcd	24.77 a	24.35 ab	23.91 bc	24.95 a	24.68 ab	24.34 bcde
	0.50	24.78 abcd	24.63 abcde	24.18 Defg	24.12 bc	23.81 bc	23.73 bc	24.45 bcd	24.22 cde	23.96 efg
	1.00	24.93 abc	24.20 defg	23.99 efghi	23.80 bc	23.86 bc	23.46 cd	24.36 bcde	24.03 defg	23.72 fgh
Kawemira	zero	24.91 abc	24.33 bcdef	24.64 abcde	24.36 ab	23.83 bc	23.92 bc	24.63 abc	24.08 defg	24.28 bcde
	0.50	24.47 abcdef	24.38 bcdef	23.33 ij	23.79 bc	23.83 bc	22.92 de	24.13 def	24.11 def	23.12 jk
	1.00	24.28 cdef	24.17 defg	23.38 hij	23.99 bc	23.91 bc	22.81 e	24.14 def	24.04 defg	23.09 jk
Gloria	zero	24.65 abcde	24.57 abcdef	23.51 ghij	24.02 bc	23.82 bc	23.77 bc	24.34 bcde	24.20 cdef	23.64 ghi
	0.50	24.41 bcdef	24.02 efgh	23.02 j	23.95 bc	22.96 de	22.15 f	24.18 cdef	23.49 hij	22.59 L
	1.00	23.90 fghi	23.58 ghij	23.10 j	22.87 bc	22.95 de	22.72 e	23.89 efgh	23.27 ijk	22.91 kL
F.test(VXBXMoXS)		-			-			NS		

NS : not significant

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تأثير البورون والموليبدنيوم علي الصفات الكيماوية و الجودة لبعض أصناف بنجر السكر

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أقيمت تجربتان حقليتان بمحافظة كفر الشيخ لدراسة تأثير مستويات التسميد بكلا من البورون والموليبدنيوم علي الصفات الكيماوية والجودة لبعض أصناف بنجر السكر خلال موسمى الزراعه ٢٠٠٣/٢٠٠٢ و ٢٠٠٤/٢٠٠٣ – وقد اشتملت الدراسة علي ٢٧ معاملة هي عبارة عن التوافيق بين ٣ أصناف من بنجر السكر (مونت بيانكو، كاوميرا و جلوريا) ، ٣ مستويات من البورون (صفر، ٠,٥٠، ١,٠٠ كجم بورون/فدان) و ٣ مستويات من الموليبدنيوم (صفر، ٠,٢٥، ٠,٥٠ كجم موليبدنيوم/فدان) وذلك باستخدام تصميم القطع المنشقة مرة واحدة ذو ثلاث مكررات حيث وضعت الأصناف في القطع الرئيسية بينما وضعت مستويات البورون والموليبدنيوم في القطع الشقية.

حقق الصنف مونت بيانكو أعلي نسبة مئوية للمواد الصلبة الذائبة الكلية وأعلي تركيز للبوتاسيوم في الجذر وعنق ونصل الأوراق بينما حقق الصنف جلوريا أعلي نسبة من السكروز والنقاوة وأعلي تركيز لعنصر البورون في الجذر في حين وجد أعلي تركيز للبورون في عنق ونصل الأوراق وأقل تركيز للبوتاسيوم في الجذر والعنق والنصل في كلا الموسمين والتحليل التجميعي لهما ، كما وجدت فروق معنوية بين الأصناف في نسبة النيتروجين في الجذر والعنق في الموسم الأول بينما اختلف تركيز الصوديوم بالجذر معنويا في الموسم الأول والتحليل التجميعي.

أثرت المستويات الأعلي (٠,٥٠ و ١,٠٠ كجم/ف) من البورون سلبيا علي نسبة المواد الصلبة الذائبة الكلية ولكنها أدت إلي زيادة معنوية في نسبة السكروز والنقاوة وأدت إضافة ١,٠٠ كجم بورون/فدان إلي زيادة معنوية في تركيز الموليبدنيوم في الجذر وإضافة ٠,٥٠ كجم بورون/فدان إلي تحقيق أعلي تركيز في عنق ونصل الأوراق والذي لم يصل إلي حد المعنوية كما أعطيا صنفي جلوريا وكاوميرا أعلي قيمة لمحتوي النصل من البورون والنيتروجين وذلك باضافة ١,٠٠ كجم بورون/فدان علي الترتيب.

ازدادت نسبتي السكروز والنقاوة معنويا بزيادة مستويات التسميد بالموليبدنيوم بينما كان لها تأثير سلبي علي نسبة المواد الصلبة الذائبة الكلية ونسبة النيتروجين في الجذر وعنق ونصل الأوراق وتأثر تركيز الصوديوم في الجذر والنصل فقط ، وأدت إضافة ٠,٥٠ كجم موليبدنيوم/فدان إلي تأثير معنوي علي محتوي الجذر وعنق ونصل الأوراق من الموليبدنيوم وتحققت أقل نسبة مئوية للمواد الصلبة الذائبة الكلية بإضافة ٠,٥٠ كجم موليبدنيوم/فدان أو إضافة (٠,٥٠ كجم بورون/فدان + ٠,٥٠ كجم موليبدنيوم/فدان).