Yield and quality of some sugar beet cultivars as responded to boron foliar application under sandy soil condition of Nubariya region

Abd-El Rahman, M. M. [1], **K. M, Agami.** [2] **and M. S. M, Aly.** [3]

1 - Department of Agricultural Physiology and Chemistry.

2- Department of Agricultural Practices.

3- Department of Agricultural Varieties Maintenance.

Agricultural Sugar Crops Research Institute, Agricultural Research Center (ARC), Giza 12619, Egypt

ABSTRACT

This investigation was carried out in a newly reclaimed sandy soil to study the effect of boron fertilizer where added at different rates as boric acid (H_3BO_3 17%) (0 – 0.5 – 0.75 – 1.0 kg B/fed) to three sugar beet cultivars (Gloria, Kawemira and Top) grown in sandy soil (1.14 dSm^{-1}) at West Nubariya region, Egypt during the two successive seasons, 2008/2009 and 2009/2010. In general, the three sugar beet cultivars were significantly different in root length and diameter (cm), root weight (g), root yield, top yield, sugar and recoverable sugar yields (ton/fed). Top cultivar showed more root yield, sucrose percentage, recoverable sucrose percentage, sugar and recoverable sugar yields than the other two cultivars, and the lowest values of Na, K and α amino N in their root juice. Application of boron rates from zero up to 0.75 Kg B /fed increased root length, diameter and root yield. The increase of root yield estimated by 6.38 and 9.68 ton/fed over the treatment received low or unfertilized by boron, respectively. However, increasing boron fertilizer up to 1.0 Kg/fed resulting in the highest sugar and recoverable sugar yields (1.84 and 1.61 ton/fed), respectively. Sucrose, recoverable sucrose and juice purity percentages were also increased by adding high level of boron rate. Such increases of sucrose, recoverable sucrose and juice purity percentages due to adding high level of boron might be attributed to decrease of Na and K uptake in root juice. Top cultivar showed the highest root weight, root and sugar yields when it received high level of boron rate (1.0 Kg/fed), while Kawemira cultivar was very affected by absence of boron application; hence it had the lowest values of these traits. On the other hand, Top cultivar was also significantly affected by high boron level; it had more sucrose and recoverable sucrose % and also the highest juice purity that due to the decrease of Na and K contents in their root juice at the same conditions of boron application.

INTRODUCTION

Sugar beet (*Beta vulgaris L.*) is considered the second sugar crop for sugar production in Egypt after sugarcane. Recently, sugar beet crop has an important position in Egyptian crop rotation as a winter crop not only in fertile soils, but also in poor, saline, alkaline and calcareous soils. It could be economically grown in newly reclaimed soils. Boron is by far the most important trace element needed for sugar beet productivity because, the deficiency of such element reflect the depression of yield and quality of roots **Cooke and Scott, (1993)**. Soil application, as well as, a foliar spray of boron is equally effective, hence the root fresh weight, sucrose %, root and top yields significantly increased by increasing boron levels **Jaszczolt, (1998)**.

Allen and Pilbeam (2006) stated that sugar beet crop has high requirements for boron. Boron is required for all plant growth stages. Adequate Boron nutrition is critical for high yields and quality of crops. **Kristek *et al.* (2006)** studied the effect of foliar fertilization with Fertina B element (1.0 kg B/ha) on sugar beet root yield and quality compared with the control variant, root yield is higher by 13.86 t/ha (19.4%), sugar concentration higher by 1.46% (relative 10.8%) and sugar yield higher by 3.15 t/ha (39.5%). Based upon these results, foliar fertilization with 1.0 kg B/ha is suggested for soils characterized by insufficient boron supply. It should be added through two top dressings, first prior leaves formation and second 10 -14 days later. **Ouda (2007)** studied the effect of chemical and bio-fertilizers of N and boron as well as their interactions on yield and quality of sugar beet. The results of interaction effects showed that significant interactions of application of nitrogen and serialine + boron, but most of them did not give additional information except root yield and sugar yield (ton/ fed). Therefore the objective is to investigate the effect of different boron rates as foliar spray on root yield and quality of some sugar beet cultivars grown under Nubaryia conditions in Egypt.

MATERIALS AND METHODS

During the two successive seasons, 2008/2009 and 2009/2010 a field trials were carried out at West Nubariya region, in order to investigate the effect of different boron rates on root yield and quality of three sugar beet cultivars named Gloria, Kawemira and Top. Soil samples were randomly taken at a depth of 0 - 50 cm from different experimental sites, to determine physical and chemical properties of soil according to **Ankerman and Large (1974)**.

The sites of the two experiments were in the same locality of sandy soil containing distinctly low percent of organic matter (0.43 %), sand (83.57 %) and characterized by relatively low soluble cations (Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+} with values of 11.1, 13.87, 4.28 and 1.15 meq L^{-1}, respectively) and anions (CO_3^{-2}, HCO_3^{-}, CL^{-} and SO_4^{-2} with values of 0.02, 1.73, 12.11 and 0.93 meq L^{-1}, respectively). The soil had electrical conductivity of 1.14 dsm^{-1}, and pH 7.35. Also, it had 9.56 % $CaCO_3$, and relatively low N, P and K with values of 23.00, 3.14, 72.00 mg/kg and available boron 0.28 mg/kg, respectively.

The experimental design was split – plot in three replications, the three sugar beet cultivars (Kawemira, Top and Gloria) were arranged in the main plots, while, four boron rates as boric acid (H_3BO_3 17%) (0 – 0.5 – 0.75 – 1.0 kg B/fed) were randomly distributed in sub – plots where, solutions were prepared for use by dissolving appropriate amounts of H_3BO_3 in 400 L of deionizer water sprayed in two equal doses after 50 and 70 days from sowing. Phosphorous as calcium super phosphate (15.5% P_2O_5) and potassium as potassium sulphate (48% K_2O) fertilizers were added before sowing as recommended. Nitrogen fertilizer (ammonium nitrate, 33.5 % nitrogen) applied as three equal portions, the 1st at 35 days from sowing, the 2nd after 3 weeks and the 3rd after 3 weeks later.

The plot area was 10.5 m^2 (six ridges, 50 cm width with 3.5 m long /plot), where seeds were sown at hills 15 cm apart. The trial was planted at the first week of October for the two studied seasons; all agricultural practices for sugarbeet were done as recommended by Sugar Crops Research Institute (SCRI), for newly reclaimed region.

At harvest time (200 days from sowing) the two inner rows were guarded for each plot to determine the following measurements:

I. Yield and yield components:

- Root length (R.L, cm)
- Root diameter (R D, cm)
- Root fresh weight (F R W, g / plant)
- Leave fresh weight (F L W, g / plant)
- Root yield (R Y, ton/fed)
- Top yield (T Y, ton/fed)
- Sugar yield (S Y, ton/ fed)

II. Juice quality and impurities content :

Yield data were collected at harvest on 28th April 2011 and 30th April 2012 (with growing season about 200 days long for each). Sugar beet plants of each plot were up-rooted, topped, cleaned and weighed to determine root yield (ton /fed). Whereas, sugar yield per feddan was estimated after taking subsamples from each plot as fully cleaned roots and sent to Nile Sugar Company Lab to determine physiological and chemical characters as:

- Sucrose % (Pol %)
- Total soluble solids (T.S.S.) %
- Juice purity %
- Na , K and α amino N meq/100 g root

Which in turn recoverable sugar yield (ton/fed.) was deduced as described by **Mohamed (2002)**, applying the following formulae:

1- Recoverable sugar yield (ton/fed.) = roots yield (ton/fed.) × Rendement.

2- Rendement (recoverable sugar percent) was deduced according to **Harvey and Dutton (1993)** as it is = Pol % - [0.29 + 0.343 (K + Na) + α N (0.094), where, Pol %, K, Na, and α- amino- N were determined as meq/100 g beet.

Where: Pol = Sucrose %

Statistical Analysis:

The obtained data were subjected to the appropriate statistical analysis according to procedure outlined by **Sendecor and Cochran (1980)**. Combined analyses between the two seasons were deduced according to **Mc Intosh (1983)**.The significant difference (L.S.D) **(Waller and Duncan, 1969)** at 5% level of significant was done to compare means.

RESULTS AND DISCUSSIONS

1. Yield and yield components

I-1: Effect of cultivars

Sugar beet cultivars showed a significant difference in root characters and top (Table 1). Top cultivar had more root length, root weight, than the other two cultivars; however, the lowest one recorded with Gloria cultivar. At the same time, the differences between Kawemira and Top cultivars were not significant in these traits. The data also cleared that there were significant difference between three cultivars used in root, top yields, and sugar yield. These results are in agreement with those obtained by **Shehata *et al* (2000)**, while, such results are in contrast with those obtained by **Ismail (2002)**, he reported that root length and diameter found to be not significant between sugar beet cultivars, whereas, root and top yields were significant.

Table 1: Effect of cultivars on yield and yield components of sugar beet by combined analysis in two seasons (2008/ 2009 and 2009/ 2010)

Cultivars	R.L cm	R.D cm	R.F.W kg/ plant	L.F.W kg/ plant	R. Y Ton/fed	T.Y Ton/fed	S.Y ton/fed
Gloria	37.32	14.19	0.74	0.26	16.28	5.72	2.75
Kawemira	37.53	14.08	1.02	0.43	22.44	9.46	3.85
Top	37.74	14.17	1.23	0.56	27.06	12.32	5.02
LSD,5%	0.381	0.51	0.048	0.12	0.368	0.633	0.263

Key: Root Length (R.L), Root Diameter (R.D), Root Fresh weight (R.F.W), Leaf Fresh weight (L.F.W), Root Yield (R.Y), Top Yield (T.Y) and Sugar yield (S.Y)

I-2: Effect of boron fertilizers

The data obtained from Table (2) showed that application of boron at different rates result a significant increase in root, top yields and sugar yield attributes especially when sugar beet plants grown under sandy soil. It is well known that sandy soil is poor. Boron is by far considered one of the most important trace element needed for sugar beet because, without an adequate supply, the yield and quality of roots is very depressed, for this reason, boron application is important for sugar beet plants grown in sandy soils. The presence of boron is essential to facilitate sugar transport within plant. Data in (Table 2) indicated that root length, diameter, root weight and yield were significantly increased due to increasing boron rates. **El – Hawary (1999)** supported this finding, however, adding boron fertilizer at a rate of 1.0 kg/fed resulting a significant decrease in root length, diameter root weight, root and top yields were also significantly affected by boron application, the highest root and top yields were obtained by adding 0.75 kg B/fed. The increase in root yield estimated by 9.68 ton/fed. Compared with control ones. Increasing of boron rates from zero to 0.50 and 0.75 kg B/fed showed a gradually increase in top yield estimated by 7.0 ton/fed in compared with to untreated plants. **Gobarah and Thalooth (2001)** reported that foliar spraying with different micronutrients significantly increased root length and diameter, fresh root weight, root, and top yield. On the other hand, **El – Geddawy *et al*.(2000)** indicated that application of boron at a rate of zero to 1.0 Kg B/fed showed no significant effect in root length and diameter, root, top and sugar yields, whereas, **Gezgin *et al*.(2001)** found that root and sugar yields increased by increasing boron fertilizer.

Table 2: Effect of boron rates on yield and yield components of sugar beet by combined analysis in two seasons of (2008/ 2009 and 2009/ 2010)

Boron rates kg B	R.L cm	R.D cm	R.F.W kg/ plant	L.F.W kg/ plant	R. Y ton/fed	T.Y ton/fed	S.Y ton/fed
0	32.42	13.12	0.82	0.273	18.04	6.00	3.07
0.5	33.45	14.22	0.97	0.423	21.34	9.30	3.65
0.75	37.13	15.17	1.26	0.591	27.72	13.00	4.88
1.0	36.96	14.11	1.22	0.541	26.84	11.90	4.91
LSD 5%	0.38	0.46	0.03	0.43	0.58	0.74	0.215

Key: Boric aced (B), Root Length (R.L), Root Diameter (R.D), Root Fresh weight (R.F.W), Leaf Fresh weight (L.F.W), Root Yield (R.Y), Top Yield (T.Y) and Sugar yield (S.Y)

I-3: Effect of interaction

It is well established that sugar beet crop characterized by its suitability to grown well in sandy soils. Moreover, yield of sugar beet and its technological properties is highly affected by micronutrients, especially boron fertilizer **Gobarah and Thalooth (2001)**. Data in (Table 3) indicated that sugar beet cultivars were very affected by boron application at different rates. Root length and diameter, as well as, root weight were higher when

Top cultivar was treated by 0.75 kg B/fed, whereas Gloria cultivar had the lowest values of these traits. Data also indicated that root and top yields were significantly affected by the interaction between sugar beet cultivars x boron rates. Moreover, application of boron fertilizer (0.75 kg B/fed) to Gloria, Kawemira and Top cultivars at a rate of (0.75 kg B/fed) resulting in the higher root yield (26.62, 28.60 and 29.04 ton/fed) respectively and the lowest (18.04 ton/fed) was recorded when Kawemira cultivar had no boron fertilizer. Top yield (ton/fed) was also increased with increasing level of boron up take (0.75 kg B/fed). There was a significant difference between three cultivars in sugar yield, generally, Top cultivar showed the highest sugar yield than the other cultivars. **El-Gharabawy *et al.* (1994)** and **Khalifa and header (1995)** had confirmed the importance of micronutrients to root yield.

Table 3: Interaction between sugar beet cultivars and boron rates on yield and yield components by combined analysis in two seasons (2008/2009 and 2009/2010)

Cultivars	Boron rates kg B	R.L cm	R.D cm	R.F.W kg/ plant	L.F.W kg/ plant	R. Y Ton/ fed	T.Y Ton/ fed	S.Y ton/ fed
Gloria	0	33.32	12.19	0.96	0.314	21.12	6.90	3.59
	0.5	35.53	13.18	1.13	0.398	24.86	8.75	4.25
	0.75	36.54	13.99	1.21	0.422	26.62	9.28	4.84
	1.0	35.98	14.75	1.23	0.413	27.06	9.08	4.85
Kawemira	0	31.34	11.22	0.82	0.311	18.04	6.84	3.06
	0.5	34.71	12.16	0.92	0.329	20.24	7.23	3.49
	0.75	35.38	15.65	1.30	0.438	28.60	9.63	5.32
	1.0	35.12	14.89	1.24	0.432	27.28	9.50	5.00
Top	0	34.63	12.23	0.98	0.381	21.56	8.38	3.69
	0.5	37.21	13.81	1.19	0.403	26.18	8.86	4.54
	0.75	38.75	15.19	1.32	0.466	29.04	10.25	5.39
	1.0	35.13	13.64	1.20	0.414	26.40	9.10	4.77
LSD 5%		0.381	0.56	0.039	0.055	0.542	0.71	0.247

Key: Boric aced (B), Root Length (R.L), Root Diameter (R.D), Root Fresh weight(R.F.W), Leaf Fresh weight(L.F.W), Root Yield (R.Y), Top Yield (T.Y) and Sugar yield (S.Y)

2. Juice quality and impurities content

2 -1: Effect of cultivars

Recoverable sugar yield was significantly differed between the three cultivars used.Top cultivar showed more sugar and recoverable sugar yields than Gloria or Kawemira cultivars. Root quality namely sucrose, recoverable sucrose, total soluble solids (T.S.S) and juice purity percentages, as well as: Na, K and α amino N are shown in (Table 4). In general, the three cultivars used were significantly different in these traits, except T.S.S %, Top cultivar recorded the highest values of sucrose, recoverable sucrose and Juice purity percentages compared with the other cultivars, whereas Gloria cultivar recorded the lowest recoverable sucrose and juice purity percentages. The increase in sucrose and juice purity contents in Top might be attributed to its ability for more tolerate when it grown under sandy soil conditions, These findings are in similar with those obtained by **Munns and Termaat (1986) and Mekki and El – Gazaar (1999)** On the other hand, the decrease in juice purity in Gloria and Kawemira cultivars mainly due to the increase of Na, K and α amino N and consequently total impurities, however, Top cultivar seemed to be high juice purity due to the reduction of Na, K and α amino N in root juice (Table 4). This means that under sandy soils conditions, the uptake of Na and K was increased by Gloria and Kawemira cultivars compared with Top cultivar, then the impurities in juice was increased and consequently reduced the quality. Such reduction in juice purity was undesirable for sugar processing. These results are in a harmony with those obtained by **Darwish *et al* (1995).**

Table 4: Effect of cultivars on juice quality and impurities content of three sugar beet cultivars by combined analysis in two seasons (2008/ 2009 and 2009/2010)

Cultivars	R .S.Y (ton/fed)	Su %	R Su %	T.S.S. %	J.P %	Na	K	α amino N
						meq/100 g root		
Gloria	2.19	16.90	13.48	21.50	78.60	2.23	6.28	2.23
Kawemira	3.10	17.16	13.83	21.60	79.44	2.12	6.14	2.16
Top	4.16	18.58	15.40	21.80	84.91	2.15	5.74	1.93
LSD 5%	0.123	0.22	0.34	ns	1.21	0.091	0.23	0.09

Key: Recoverable sugar yield (R.S.Y), Sucrose (Su), Recoverable sucrose (R.Su), Total Soluble Solids (T.S.S.), and Juice purity (J.P)

2-2: Effect of boron fertilizers

Increasing of boron rates from zero to 0.50, 0.75, 1.0 kg B/fed. showed a gradually increase in recoverable sugar yield. The increase in recoverable sugar yield estimated by 1.61 ton/fed in comparison with untreated plants, was obtained when plants received the high boron rate

(1.0 kg.B/fed), (Table 5).These results were supported by other studies, Also, **El- Hawary (1994) and Bondok (1996)** stated that sugar yield, sucrose, and recoverable sucrose were increased due to boron application, and juice purity percentages application of high level of boron fertilizer had the highest values of these traits and a gradually increase was noticed due to increasing boron rates from zero to 0.50, 0.75, 1.0 kg.B/fed. On contrast Na, and K and α amino N contents were gradually decreased under the same conditions, such reduction in Na, K and α amino N contents at high boron level is reflected to the increase in juice purity at the same boron application. The increase in sucrose, or recoverable sucrose % under high boron rate estimated by 1.29 and 1.6 % in comparison with untreated plants, respectively Foliar spraying with different micronutrients elements that led to a positive increase in sucrose, T.S.S and purity percentages as reported by **Jaszczolt (1998) and Khalifa and Header (1995)**. On the other hand, **El – Geddawy *et al.* (2000)** pointed that sucrose; purity and T.S.S % were not affected by adding boron fertilizer, while **Genaidy (1988)** indicated that adding boron to sugar beet plants at a rate of 1.0 Kg/fed increased sugar yield and purity % by about 12.0 and 18.0 %, respectively.

Table 5: Effect of boron rates on juice quality and impurities content of sugar beet by combined analysis in two seasons (2008/ 2009 and 2009/ 2010)

Boron rates kg B	R .S.Y (ton/fed)	Su %	R Su %	T.S. S. %	J.P %	Na	K	α amino N
						meq/100 g root		
0	2.42	17.02	13.42	21.8	78.07	2.31	6.35	2.13
0.5	2.93	17.15	13.74	21.5	79.76	2.26	6.28	1.96
0.75	3.96	17.62	14.29	22.0	80.09	2.17	6.19	1.81
1.0	4.03	18.31	15.02	22.5	81.37	2.12	6.11	1.79
LSD 5%	0.12	0.28	0.31	0.25	0.62	0.07	0.16	0.07

Key: Recoverable sugar yield (R.S.Y), Sucrose (Su), Recoverable sucrose (R.Su), Total Soluble Solids (T.S.S.), and Juice purity (J.P)

2-3.Effect of interaction

Recoverable sugar yield, recoverable sucrose, TSS and juice purity percentages, Na, K and α amino N were significantly affected by the interaction between cultivars x boron fertilizer rates. Data in (Table 6) indicated that all cultivars recorded the highest values of recoverable sucrose when it received the high level of boron (0.75 kg.B/fed) and the lowest were noticed when Gloria cultivar received unfertilized boron. For Kawemira and Top cultivars, it could be noticed that generally increasing boron rates from zero up to 1.00 kg.B/fed lead to a gradually decrease in Na, K and α amino N contents, Gloria showed the similar trend. This means that increasing of boron rates up to high level lead to a decrease for Na and K uptake by all cultivars used in most cases, especially when it grown in sandy soil, hence the total impurities in root juice were decreased and consequently lead to an increase of recoverable sugar % in the factory process. These results are in harmony with those obtained by **El – Maghraby *et al.* (1998).** On the other hand, **Nemeat Alla and El – Geddawy (2001)** pointed that foliar spraying with micronutrients decreased TSS%, while sucrose percent was not significantly affected in all varieties used.

Finally, it can be concluded that application of boron fertilizer to sugar beet cultivars, especially when it grown in sandy soils is very important, which lead to an increase in the root yield and also increased recoverable sugar percent and sugar yield, and decreased Na, K and α amino N uptake in root juice, hence the impurities was decreased and consequently the Juice purity % was increased.

Table 6: Interaction between sugar beet cultivars and boron rates on juice quality and impurities content of sugar beet by combined analysis in two seasons (2008/2009 and 2009/ 2010)

Cultivars	Boron rates kg B	R.S.Y ton/fed	Su %	R.Su %	T.S.S %	J.P %	Na	K	α amino N
							meq/100 g root		
Gloria	0	3.92	17.0	13.31	20.80	81.7	2.01	6.54	4.39
	0.5	4.62	17.12	13.66	21.00	81.5	1.98	6.07	3.55
	0.75	3.87	18.34	15.36	22.30	82.2	1.34	5.64	3.12
	1.0	4.06	17.95	15.00	21.70	82.7	1.09	5.99	2.36
Kawemira	0	٢,٤٠	17.01	13.36	21.03	80.8	2.11	6.71	4.01
	0.5	٢,٨٠	17.25	١٣,٨٤	21.01	82.1	1.87	6.22	3.64
	0.75	4.55	18.85	15.93	22.45	83.9	1.42	5.56	2.43
	1.0	4.20	18.33	15.43	22.00	83.3	1.13	5.87	2.22
Top	0	2.91	17.14	13.51	21.13	81.1	2.20	6.44	3.98
	0.5	3.64	17.35	13.92	21.01	82.5	2.03	6.11	3.61
	0.75	4.07	18.21	15.30	22.13	82.2	1.14	5.74	2.76
	1.0	3.98	17.93	15.10	21.24	84.4	1.16	5.46	2.81
LSD 5%		0.143	NS	0.21	0.23	0.52	0.08	0.24	0.09

Key: Recoverable sugar yield (R.S.Y), Sucrose (Su), Recoverable sucrose (R.Su), Total Soluble Solids (T.S.S.) and Juice purity (J.P)

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الملخص العربي

إستجابة محصول وجودة بعض اصناف بنجر السكر للتسميد الورقي بعنصر البورون في الأراضي الرمليه بمنطقة النوبارية

محمد مصطفى عبد الرحمن[1] - كمال محمد عجمي[2] - مجدي سعد الدين محمد على[3]

١- قسم بحوث الفسيولوجي و الكيمياء. ٣- قسم المحافظه علي الاصناف.

٢- قسم بحوث المعاملات الزراعية.

معهد بحوث المحاصيل السكرية – مركز البحوث الزراعية- جيزة

أجريت هذه الدراسة خلال موسمي 2008/2009 and 2009/2010 في منطقة غرب النوبارية. و كان هدف البحث هو دراسة إستجابة محصول وجودة بعض اصناف بنجر السكر للتسميد الورقي بعنصر البورون في الأراضي الرملية.

أشارت النتائج المتحصل عليها أن اصناف بنجر السكر محل الدراسة (Kawemira-Gloria-Top) بينها إختلافات معنوية في طول ومحيط الجذر ومحصول الجذور ومحصول السكر وكان الصنف (Top) الأعلي في محصول الجذور و محصول السكر و النسبة المئوية للسكر القابل للاستخلاص و النسبة المئوية لنقاوة عصير الجذور من الصنفين الاخريين وبتطبيق معدلات البورون محل الدراسة (0.0-0.5-0.75-1.0) kg B / fed)) تحقق زيادة تدريجية و معنوية بزيادة مستوى إضافة البورون من 0.0 إلى ٠,٧٥ وكان هناك زياده معنوية في محصول الجذور تقدر (٦,٣٨ – ٩,٦٨ طن/فدان) عن المعدل الاقل(0.5 kg B/fed) والغير معامل (0.0 kg B/fed) بالترتيب وعند زيادة المعدل الي(1.0 kg B/fed) اعطي زيادة في محصول السكر والسكر المستخلص تقدر(١,٨٤ – ١,٦١ طن/فدان) عن الغير معامل (0.0 kg B/fed). و قد بينت النتائج أنه لاتوجد إختلافات معنوية بين المعدل (0.75 -1.0 kg B /fed) في النسبة المئوية للسكر القابل للاستخلاص و النسبة المئوية لنقاوة عصير الجذور و على كلاً من محصول الجذور ومحصول السكر. كان هناك تأثير معنوي للتفاعل بين الاصناف ومعدلات البورون حيث أعطي الصنف توب بصفة علمة اعلي محصول جذور ومحصول سكر يليه الصنف كواميرا ثم الصنف جلوريا وذلك عند استخدام معدل(0.75 kg B / fed).