Menoufia J. Plant Prod., Vol. 4 February (2019): 39 - 55

RESPONSE OF THREE SUGAR BEET VARIETIES TO MINERAL AND BIO-K FERTILIZERS AT WEST NUBARIYA REGION

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Received: Nov. 15 , 2018 Accepted: Dec. 23 , 2018

ABSTRACT: ***Two field experiments were carried out during the two successive seasons of 2016/17 and 2017/18 at Nubassed sector, West Nubariya, Egypt, (latitude 30° 47' N and longitude 30° 25' E), El-Beheira Governorate, Egypt to study the influence of mineral K-fertilizer and bio-K (containing Potassium Solubilizing Bacteria KSB-Frateuria aurantia) on sugar beet physiological, qualitative and productivity attributes. Randomized Complete Block Design was used in a split split-plot distribution, with three replications. Three polygerm sugar beet varieties namely MK 4016, Samba and Gloria, allocated in the main plots, three potassium fertilizer rates (0, 24 and 48 kg K_2O/fed) randomly distributed in the sub-plots and two KSB treatments (KSB_0: uninoculated and KSb_1: inoculated with bacteria) randomly applied in the sub-subplots.***

The most important results indicated that; Gloria variety significantly surpassed the other two varieties in root length, root diameter, root fresh weight, root yield (ton/fed) and recoverable sugar yield (ton/fed). Growing sugar beet under 48 kg K_2O/fed recorded the highest values of LAI (at 135 days), root length, root diameter, leaf K content, sucrose %, root K^+ content, sugar loss in molasses%, root fresh weight, root yield, top yield, recoverable sugar yield, recoverable sugar percent and harvest index in comparing with 0 and 24 kg K_2O/fed. The inoculation of sugar beet with KSB significantly increased root length, root diameter, sucrose%, root fresh weight, root yield, top yield and recoverable sugar yield compared with uninoculated treatment.

The interaction between potassium fertilizer rates × inoculation with KSB showed that, there were insignificant differences between applying 24 kg K_2O/fed × inoculation with KSB and with 48 kg K_2O/fed × uninoculation on root fresh weight, sucrose% and recoverable sugar yield in both seasons.

As a result of the present study it might be concluded that, growing sugar beet under the application of 48 kg K2O/fed × inoculation with KSB produced the highest root length, root diameter, sucrose%, root fresh weight, root yield, and recoverable sugar yield in both seasons of this study.

Key words: ***Sugar beet, Beta vulgaris, potassium, KSB, bio-K, Frateuria aurantia, physiological traits, qualitative traits, productive traits.***

INTRODUCTION

In Egypt, sugar production depends on sugar beet and sugarcane. Nowadays, sugar beet became the first source of sugar and shares 58.9 % (1.325 million tons). The total area cultivated with sugar beet in 2016/2017 was 511.648 thousand feddans, with an average productivity of 16.7 tons of roots/fed., which is considered very low (SCC, 2018).

Potassium is one of the essential macronutrient and the most abundantly absorbed cation in higher plants. Because of the introduction of high yielding varieties and hybrids during the progressive intensification of agriculture,

the soils are getting depleted in potassium reserve at a faster rate. As a consequence, potassium deficiency is becoming one of the major constraints in crop production, especially in coarse textured soils. Even in fine textured soils the available fraction is low compared to total K in them. Crops response to K fertilization in soils with high available K. Potassium plays an important role in the growth and development of plants. It activates enzymes, maintains cell turgor, enhances photosynthesis, reduces respiration, helps in transport of sugars and starches as well as nitrogen. In addition to plant metabolism, potassium improves crop quality (Abdel-Mawly and Zanouny, 2004) and increases disease resistance and helps the plant better to withstand stress (Fuchs and Grossman, 1977; Imas and Magen, 2000; Malakotty, 2000, Archana, 2007 and Wang *et al*, 2015).

Plants can uptake potassium from the soil solution. Its availability is dependent upon the K dynamics as well as on total K content. There are three forms of potassium found in the soil viz.; soil minerals, non-exchangeable and available form. Soil minerals make up more than 90 to 98 percent of soil potassium. It is tightly bound and most of it is unavailable for plant uptake. The second is non-exchangeable potassium which acts as a reserve to replenish potassium taken up or lost from the soil solution. It makes up approximately 1 to 10 percent of soil potassium. The third type is available potassium which constitutes 1 to 2 percent. It is found either in the solution or as part of the exchangeable cation on clay mineral (Archana, 2007).

In general, black soils are high, red soils medium and laterite soils low in available potassium. Although K deficiency is not as wide spread as that of nitrogen and phosphorus, many soils which were initially rich in K become deficit in due course due to heavy utilization by crops and inadequate K application, runoff, leaching and soil erosion (Shanware, 2014).

Imbalanced or over dose use of chemical fertilizers has the negative environmental impacts and also increasing costs of crop production, therefore, there is an urgent need to imply eco-friendly and cost effective agro-technologies to increase crop production. Therefore, the utilization of potassium solubilizing microorganisms (KSMs) is considered as a sound strategy in improving the productivity of agricultural lands. This new technique is also claimed to show the ability to restore the productivity of degraded, marginally productive and unproductive agricultural soils (Basak and Biswas, 2012).

The use of potassium solubilizing bacteria (KSB) would be a novel solution to convert insoluble form of soil potassium into soluble form. These potassium solubilizing bacteria are able to solubilize rock potassium through production and secretion of organic acids (Han and Lee, 2005).

It can enhance mineral dissolution rate by producing and excreting metabolic by-products that interact with the mineral surface and these potassium solubilizing bacteria are also capable of solubilizing mineral powder such as mica, illite and orthoclases through production and excretion of organic acids (Friedrich *et al.*, 1991). Meena *et al.* (2014) illustrated that, potassium solubilizing microorganisms (KSMs) are a rhizospheric microorganism which solubilizes the insoluble potassium (K) to soluble forms of K for plant growth and yield. K-solubilization is carried out by a large number of saprophytic bacteria (*Bacillus mucilaginosus*, *Bacillus edaphicus*, *Bacillus circulans*,

***Acidothiobacillus ferrooxidans*, *Paenibacillus* spp.) and fungal strains (*Aspergillus* spp. and *Aspergillus terreus*). Sayyed *et al.* (2012) stated that *Frateuria aurantia* are capable of solubilizing potassium. Certain crops require a good amount of potash. These biofertilizers are used in crops like banana. They can increase crop yield by 20–25%.**

The aim of this recent study was to examine the effect of replacing mineral potassium fertilizers partially or totally using potassium solubilizing bacteria (*Frateuria aurantia*).

MATERIALS AND METHODS

Two field experiments were carried out during the two successive seasons of 2016/17 and 2017/18 at Nubassed sector, West Nubariya, Egypt, (latitude 30° 47′ N and longitude 30° 25′ E), El-Beheira Governorate, Egypt to study the influence of mineral potassium fertilizer (K-fertilizer) and bio potassium (bio-k) which containing potassium souliablizing bacteria (KSB) (*Frateuria aurantia*, 1×10^9 bacterial cells/ml) on sugar beet yield, yield components, growth characters and chemical compositions.

Randomized Complete Block Design in a split split-plot arrangement, with three replications was used. Three polygerm sugar beet varieties namely *MK 4016*, *Samba* and *Gloria* (beets seeds were brought by Sugar Crops Research Institute) allocated in main plots, three potassium fertilizer rates (0, 24 and 48 kg K_2O/fed) in form of potassium sulphate (48% K_2O) were applied after50 days from sowing (with the second dose of nitrogen fertilizer) randomly distributed in sub-plots and two Potassium Solubilizing Bacteria (KSB) treatments (KSB_0: uninoculated and KSB_1: inoculated with bacterial strain of *Frateuria aurantia*, were randomly applied in the sub-sub-plots (20 m^2 including 8 ridges of 0.5 m width and 5.0 m long).

Sugar beet varieties were sown at the 9th and 12th of September in the 1st and 2nd season, respectively. Phosphorus fertilizer was added as calcium super phosphate (15.5%) at the rate of 30 kg $P_2 0_5$/fed during seed bed preparation.

The inoculation with potassium solubilizing bacteria KSB (*Frateuria aurantia*) was applied two times. The first by mixing about 100 ml of bacterial suspension/ one kg seeds before sowing and the second by adding about 50 ml (2.5%) of bacterial suspension beside beets root after thinning and then beets were irrigated immediately (about one month from sowing). Nitrogen was applied as ammonium nitrate (33.3%) at the rate of 80 kg N/fed, in two equal doses. The 1st added after thinning and before the 2nd irrigation, while, the 2nd was added immediately before the third irrigation. Other treatments were applied as recommended by the Ministry of Agriculture, Egypt.

Some characteristics of the experimental soil were determined according to the method of EL- Khodre and Bedaiwy (2008) (Table, 1).

Studied characters:

1- Physiological characters:

Ten random plants were chosen from the 2nd, 3rd and 4th inner rows of each sub- sub-plot in both seasons of the study to determine the following traits:

- **Crop Growth Rate CGR (g/day) in the period (between 135 and 165 days) and (165 and 195 days). It was calculated by the following formula as described by Gardner *et al.* (1985).**

$CGR = (W_2-W_1) / (T_2-T_1)$

Where: W_1 and W_2 refer to total dry weight at time T_1 and T_2, respectively.

Table (1): Mean values of soil analysis for the experimental sites during 2016/17 and 2017/18 seasons

Characteristic	Unite	Value
Soil texture	---	sand Loamy
E.C.	ds m^{-1}	0.86
pH	---	8.01
Organic matter	%	o.67
P	mg kg^{-1}	5.10
K	mg kg^{-1}	82.00
NO_3-N	mg kg^{-1}	0.31

- Leaf area index (LAI) was determined at the age of 135 days from sowing according to the following equation:

LAI = leaf area / plant land area (area occupied by plant)

Where, leaf area was determined as described by Watson (1952).

- Leaf K^+ content (% of Dry weight): at 135 days random samples were collected, washed, dried at 70° C and used to determine K concentration using Flame photometer (Chapman and Pratt, 1961).

At harvest time (195 days from sowing), the other three inner rows (5^{th}, 6^{th} and 7^{th}) were harvested to study the following parameters.

- Root length (cm).
- Root diameter (cm).

2- Qualitative characters:

- Sucrose % (Pol. %) was determined polarmetrically according to method of Le-Docte (1927).
- Purity% was calculated according to the equation of (Devillers, 1988) as follow:

Purity%= 99.36 -14.27 × (K^+ + Na^+ + α - N) / Pol. %

Where, K, Na and α-amino N determined as millequivalent/100 gm beet.

- Na^+, K^+ and α-amino N were determined as millequivalent/100 gm beet.
- Sugar loss in molasses (SM %) was calculated according to the following equation of Devillers (1988).

Sugar loss to molasses (SM) = (K^+ + Na^+) × 0.14 + K^+ × 0.25 +0.5

Where, K, Na and α-amino N determined as millequivalent/100 gm beet.

3- Productivity traits:

- Root fresh weight (g).
- Root yield (ton/fed).
- Top yield (ton/fed).
- Sugar recovery% was calculated according to Cooke and Scott (1993) using the following equation:

Sugar recovery %= Pol. % - [0.29 + 0.343 × (K^+ + Na^+) + α - N (0.094)]

- Recoverable sugar yield (ton/fed.) was calculated from the following equation as reported by Mohamed (2002):

Recoverable sugar yield (ton/fed) = Roots yield (ton/fed) × Sugar recovery%

- Harvest Index:

Harvest Index = Root yield / Biological yield

The collected data were statically analyzed according to Snedecor and

Cochran (1994). The least significant difference (LSD at 5%) was used to compare means.

RESULTS AND DISCUSSION

- Physiological characters:

Data in Table (2) showed that the tested sugar beet varieties did not significantly differ in LAI (at 135 days), CGR (135-165), CGR (165-195), and leaf potassium content in both seasons. However, there were significant differences among tested varieties in root length in the second season and root diameter in both seasons. Where, the highest values of root length in the second season and root diameter in both seasons were recorded by *Gloria* variety. In contrary, the least values of length in the second season and root diameter in both seasons were produced by *Samba* variety with insignificant difference with *MK4014* variety. These results might be due to the genetic makeup of those varieties. Differences among varieties were also reported by Abdelaal and Tawfik (2015); Campbell and Fugate (2015), Abd El-Rahman *et al*. (2017) and Salem *et al*. (2018).

Treating sugar beet with potassium fertilizer caused significant increase in LAI (at 135 days) in the 1st season, root length, root diameter and leaf K content in both seasons compared with 0 kg K_2O/fed (control treatment). However it did not cause any significant effect on LAI (at 135 days) in the 2nd season, CGR (135-165) and CGR (165-195) in comparing with control treatment in both seasons. where, the highest values of LAI (at 135 days) in the 1st season, root length, root diameter and leaf K content in both seasons were produced by adding 48 kg K_2O/fed. However, there were insignificant differences between 24 or 48 kg K_2O/fed on LAI (at 135 days) in the 1st season only, root length, root diameter and leaf K content in both seasons. On the other hand, the least values of these characters were recorded by control treatment (0 kg K_2O/fed) in both seasons with insignificant difference from 24 kg K2O/fed, which, produced mid values between 48 and 0 kg K2O/fed. These results could be expected, since, the application of potassium fertilizer increase photosynthetic output and the efficient transport of photosynthetic products to storage organ. Application of suitable potassium fertilizers might be e favorable factor for sugar beet production (Fathy *et al*., 2009). These results are in a line with those obtained by Ismail and Abo El-Ghait (2004), Fathy *et al.* (2009) and Nafei *et al.* (2010) whose reported that potassium fertilizer level at 36 Kg K_2O/fed gave significant increase in root length and diameter compared with control treatment (0 kg K_2O/fed).

In addition, data in Table (2) stated that, inoculation of sugar beet plants with potassium solubilizing bacteria (KSB) *Frateuria aurantia* had insignificant effect on LAI (at 135 days), CGR (135-165), CGR (165-195) and leaf K content. However it significantly increased root length and root diameter compared with uninoculated treatment in both seasons. These results were in the same trend with those obtained by Öztekin *et al.* (2015) who showed that, tomato plant height, stem diameter, fresh and dry weights of vegetable parts increased by the application of bio-fertilizer (Symbion-K as bio-fertilizer containing *Frateuria aurantia*) compared with not treated plants. Kammar *et al.* (2016) stated that, inoculation of sunflower with KSB *Frateuria aurantia* strains performed better with respect to plant height, number of leaves compared to uninoculated control and reference strain.

Table (2): Effect of potassium fertilizer rates (kg K_2O/fed) and inoculation with KSB (*Frateuria aurantia*) on some physiological characters LAI, CGR (g/day), root length (cm), root diameter (cm) and leaf potassium content (%) of three sugar beet varieties during 2016/17 and 2017/18 seasons.

Treatments	LAI at 135 days		CGR (135-165) (g/day)		CGR (165-195) (g/day)		Root length (cm)		Root diameter (cm)		Leaf K^+ content	
	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
Varieties: (A)												
MK 4016	4.46 a	4.01 a	2.14 a	2.26 a	2.14 a	2.41 a	27.15 a	28.09 b	11.28 ab	12.11 b	3.47 a	3.42 a
Samba	4.46 a	4.03 a	2.09 a	2.23 a	2.00 a	2.39 a	27.06 a	27.83 c	10.94 b	12.00 b	3.41 a	3.31 a
Gloria	4.50 a	4.17 a	2.22 a	2.31 a	2.24 a	2.52 a	27.39 a	28.50 a	11.62 a	12.61 a	3.55 a	3.58 a
KgK_2O/fed: (B)												
0 (Kg K_2O/fed)	3.96 b	3.59 a	1.98 a	2.08 a	2.07 a	2.21 a	26.46 b	27.12 b	10.93 b	11.31 b	3.37 b	3.28 b
24KgK_2O/fed	4.18 ab	4.11 a	2.18 a	2.62 a	2.28 a	2.80 a	27.63 ab	29.21 ab	11.53 ab	13.06 ab	3.52 ab	3.49 ab
48KgK_2O/fed	4.59 a	4.46 a	2.42 a	2.77 a	2.59 a	3.02 a	28.50 a	30.86 a	12.12 a	14.11 a	3.66 a	3.88 a
KSB: (C)												
KSB_0 (uninoculated)	4.12 a	3.90 a	2.23 a	2.40 a	2.37 a	2.58 a	27.38 b	28.51 b	11.38 b	12.35 b	3.63 a	3.37 a
KSB_1 (inoculated)	4.41 a	4.16 a	2.20 a	2.50 a	2.26 a	2.70 a	27.72 a	29.45 a	11.73 a	13.06 a	3.44 a	3.73 a
Interaction effect												
A×B	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
A×C	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
B×C	Ns	Ns	Ns	**	Ns	**	**	**	**	**	Ns	Ns
A×B×C	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns

Ns insignificant at 0.05, ** Significant at 0.01 probability levels. Means with the same letter(s) within each main effect are not significantly difference at 0.05 level of probability.

There was insignificant interaction between varieties × potassium fertilizer rates and between varieties × inoculation with KSB treatments or among varieties × potassium fertilizer rates × inoculation with KSB treatments on tested physiological characters in both seasons of this study, as shown in Table (2).

Data in Table (3) demonstrated that, there was insignificant interaction between potassium fertilizer rates × inoculation with KSB treatments on LAI (at 135 days) and leaf K^+ content. However, it had significant effect on CGR (135-165) and CGR (165-195) in the 2nd season only. Moreover, there was significant effect on root diameter in both seasons. Where, the highest values of CGR (135-165) and CGR (165-195) in the 2nd season, root length and root diameter in both seasons were produced from 48 kg K_2O/fed × inoculation with KSB. Data cleared that, the inoculation of sugar beet with KSB under 24 kg K_2O/fed generally caused significant increase in CGR (135-165), CGR (165-195), root length and root diameter compared with uninoculated plants.

- Qualitative characteristics:

Data in Table (4) confirmed that, there were insignificant difference among studied varieties on sucrose%, purity%, Na^+, K^+, α-amino N and sugar loss in molasses (SM%) in both seasons, except for α-amino N, where the difference was reached 0.05 level of significance only in the first season. The highest value of α-amino N was recorded by *Samba* variety which did not significantly differ from *MK4016* variety. On the other hand, the least value of α-amino N was produced by *Gloria* variety. Differences among varieties were also reported by Abdelaal and Tawfik (2015), Abd El-Rahman *et al*. (2017) and Salem *et al*. (2018).

Growing sugar beet plants under the application of potassium fertilizer caused significant differences in sucrose%, K^+, α-amino N and sugar loss in molasses (SM %) compared with control treatment in both seasons. There were three types of effects resulted by fertilizing sugar beet plants with potassium fertilizer on studied technological characters in comparing with control treatment. The 1st one was on traits, which, did not significantly differed between fertilized plants and control such as purity % and root Na^+ content (millequivalent/100 gm beet) in both seasons. The 2nd was on traits, which, significantly increased by applying beets plants with potassium fertilizer compared with unfertilized plants such as sucrose %, root K^+ content (millequivalent/100 gm beet) and sugar loss in molasses percentage in both seasons. The 3rd was on traits which significantly decreased by applying beets plants with potassium fertilizer compared with unfertilized plants such as α-amino N (millequivalent/100 gm beet) in both seasons. Generally, data in Table (4) cleared that, there were insignificant differences between applying sugar beet plants with 24 or 48 kg K_2O/fed on tested technological characters. These results similar to those obtained by Khalil *et al.* (2001) and Abdel-Mawly and Zanouny (2004) whose reported that, total soluble solids, refineable sugar and purity percentages of sugar beet root juice increased as K fertilizer increased.

The inoculation of beets plants with KSB significantly increased sucrose % in the 1st season compared with uninoculated treatment, however it did not significantly affect sucrose% in the 2nd season, purity percentage, Na^+, K^+, α-amino N and sugar loss in molasses percentage (SM %) in both seasons. There was insignificant interaction between varieties × potassium fertilizer rates and between varieties × inoculation with KSB treatments or among varieties × potassium fertilizer rates × inoculation with KSB treatments on tested qualitative characters in both seasons of this study, as shown in Table (4).

Table (3): Interaction between potassium fertilizer rates (kg K_2O/fed) and Bio-K treatments on some physiological characters (LAI at 135 days, CGR between (135-165), (165-195) in (g/day), root length (cm), root diameter (cm) and leaf potassium content (% dry weight) of during 2016/17 and 2017/18 seasons.

Treatments		LAI at 135 days		CGR (135-165) (g/day)		CGR (165-195) (g/day)		Root length (cm)		Root diameter (cm)		Leaf K^+ content	
		2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
0 kg K_2O	KSB_0	3.84 a	3.38 a	2.09 a	1.94 d	2.18 a	2.08 e	26.30 d	26.39 d	10.81 c	10.78 e	3.60 a	3.09 a
	KSB_1	4.08 a	3.81 a	1.88 a	2.21 d	1.96 a	2.34 d	26.61 d	27.84 cd	11.06 bc	11.83 d	3.15 a	3.46 a
24 kg K_2O	KSB_0	4.08 a	3.90 a	2.29 a	2.51 c	2.31 a	2.68 cd	27.67 c	28.47 c	11.51 b	12.33 c	3.70 a	3.25 a
	KSB_1	4.29 a	4.32 a	2.08 a	2.72 b	2.24 a	2.92 c	27.59 c	29.94 b	11.56 b	13.78 b	3.33 a	3.72 a
48 kg K2O	KSB_0	4.44 a	4.41 a	2.32 a	2.76 ab	2.63 a	2.99 b	28.17 b	30.67 ab	11.83 b	13.94 ab	3.59 a	3.77 a
	KSB_1	4.73 a	4.50 a	2.52 a	2.79 a	2.56 a	3.06 a	28.83 a	31.06 a	12.40 a	14.28 a	3.74 a	4.00 a

Means with the same letter(s) within each main effect are not significantly difference at 0.05 level of probability.

Table (4): Effect of potassium fertilizer rates (kg K_2O/fed) and inoculation with KSB (*Frateuria aurantia*) on some qualitative characters (sucrose%, purity%, Na^+, K^+, α-amino N and sugar loss in molasses (SM%) of three sugar beet varieties during 2016/17 and 2017/18 seasons.

Treatments	Sucrose%		Purity%		Na^+		K^+		α-amino N		SM (%)	
	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
Varieties: (A)												
MK 4016	18.41 a	18.13 a	86.82 a	87.69 a	3.09 a	2.86 a	3.83 a	3.28 a	2.86 a	2.38 a	2.43 a	2.18 a
Samba	18.30 a	18.27 a	86.81 a	87.66 a	3.12 a	2.99 a	3.75 a	3.26 a	2.87 a	2.39 a	2.40 a	2.19 a
Gloria	18.59 a	18.33 a	86.83 a	87.77 a	3.21 a	2.86 a	3.81 a	3.30 a	2.83 b	2.36 a	2.44 a	2.19 a
Kg K_2O/fed: (B)												
0 (Kg K_2O/fed)	18.18 c	18.04 b	86.86 a	87.40 a	3.13 a	3.09 a	3.58 b	3.16 b	2.88 a	2.59 a	2.34 b	2.17 b
24 (Kg K_2O/fed)	18.53 b	18.51 ab	86.81 a	87.67 a	3.19 a	3.02 a	3.84 a	3.34 a	2.84 ab	2.36 b	2.44 a	2.23 a
48 (Kg K_2O/fed)	18.98 a	18.87 a	86.95 a	87.95 a	3.21 a	2.94 a	3.88 a	3.29 a	2.80 b	2.30 b	2.46 a	2.20 a
KSB: (C)												
KSB_0:(uninoculated)	18.44 b	18.35 a	86.80 a	87.64 a	3.19 a	3.05 a	3.76 a	3.28 a	2.85 a	2.37 a	2.42 a	2.20 a
KSB_1: (inoculated)	18.72 a	18.51 a	86.94 a	87.66 a	3.14 a	2.98 a	3.80 a	3.21 a	2.83 a	2.52 a	2.42 a	2.17 a
Interaction effect:												
A×B	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
A×C	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
B×C	**	**	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
A×B×C	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns

Ns insignificant at 0.05, ** significant at 0.01 probability levels. Means with the same letter(s) within each main effect are not significantly difference at 0.05 level of probability.

Data in Table (5) illustrated that, there were insignificant interaction between potassium fertilizer rates (kg K_2O/fed) and Bio-K treatments on purity%, Na^+, K^+, α-amino N and sugar loss in molasses (SM%) in both seasons. On the other hand, there was significant interaction between potassium fertilizer rates (kg K_2O/fed) and Bio-K treatments on sucrose % in both seasons. Where, the highest value of sucrose percentage was produced by 48 kg K_2O/fed × inoculation with KSB in both seasons. Data cleared that, there was insignificant difference between treating beets plants with 24 kg K_2O/fed plus inoculation with KSB and 48 K_2O/fed plus uninoculation with KSB in the both seasons. In contrary, the least value of sucrose percentage was recorded by control treatment without inoculation with KSB in both seasons.

- Productivity traits:

Data in Table (6) illustrated that, tested sugar beet varieties did not significantly differ in root fresh weight (g), root yield (ton/fed), top yield (ton/fed), sugar recovery (%), recoverable sugar yield (ton/fed) and harvest index in both seasons, except, for root fresh weight, root yield and recoverable sugar yield in the second season. *Gloria* variety significantly surpassed the other two varieties in root fresh weight, root yield and recoverable sugar yield in the second season of the study. Differences among varieties were also reported by Abdelaal and Tawfik (2015); Campbell and Fugate (2015), Abd El-Rahman *et al*. (2017) and Salem *et al*. (2018).

The application with potassium fertilizer caused significant increase in root fresh weight; root yield; top yield, recoverable sugar yield and harvest index in both seasons, although the increase in sugar recovery percentage was significant only in the 2nd season. The highest values of root fresh weight, root yield, top yield, recoverable sugar yield, sugar recovery percentage and harvest index were recorded by treating sugar beet plants with 48 kg K_2O/fed. On the other hand, the least values of these traits were obtained from sugar beet plants grown under control treatment. These results might be accepted since, potassium increase photosynthetic output and efficient transport of photosynthetic products and deposition in storage organ. These results are in a harmony with those obtained by Fathy *et al.* (2009) whose illustrated that adding high level of potassium caused significant increase on contents of sugar, yield of recoverable sugar and some quality features. Nafei *et al.* (2010) reported that, potassium fertilizer level at 36 Kg K_2O/fed gave significant increase in root and sugar yields. In general, potassium at the level 36 kg K_2O/fed was more effective than at 18 kg K_2O/fed.

The inoculation of sugar beet plants with KSB had insignificant effect on sugar recovery percentage and harvest index compared with uninoculated treatment in both seasons. In contrary, it significantly increased root fresh weight; root yield; top yield and recoverable sugar yield compared with uninoculated treatment in both seasons. These results are agree with those obtained by Kammar *et al.* (2016) whose stated that, inoculated sunflower with KSB *Frateuria aurantia* strains performed better with respect to head diameter, test weight, seed yield and potassium content at harvest.

There was insignificant interaction effect between varieties × potassium fertilizer rates and between varieties × inoculation with KSB treatments or among varieties × potassium fertilizer rates × inoculation with KSB treatments on tested productivity traits in both seasons of this study, as shown in Table (6).

Data in Table (7) demonstrated that, there was insignificant interaction

Table (5): Interaction effect between potassium fertilizer rates (kg K_2O/fed) and Bio-K treatments on some qualitative characters (Sucrose%, purity%, Na^+, K^+, α-amino N and sugar loss in molasses (SM%) during 2016/17 and 2017/18 seasons

Treatments		Sucrose%		Purity%		Na^+		K^+		A-amino N		SM%	
		2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
0 kg K_2O	KSB_0	18.12 d	17.93 d	86.77 a	87.50 a	3.20 a	3.10 a	3.58 a	3.15 a	2.88 a	2.41 a	2.35 a	2.16 a
	KSB_1	18.24 cd	18.14 c	86.95 a	87.29 a	3.05 a	3.08 a	3.58 a	3.17 a	2.88 a	2.76 a	2.32 a	2.17 a
24 kg K_2O	KSB_0	18.42 c	18.27 c	86.66 a	87.53 a	3.19 a	3.04 a	3.97 a	3.35 a	2.85 a	2.39 a	2.49 a	2.23 a
	KSB_1	18.64 b	18.74 b	86.95 a	87.80 a	3.19 a	3.00 a	3.71 a	3.34 a	2.83 a	2.34 a	2.39 a	2.22 a
48 kg K_2O	KSB_0	18.77 b	18.86 b	86.97 a	87.87 a	3.18 a	2.99 a	3.74 a	3.33 a	2.81 a	2.31 a	2.40 a	2.22 a
	KSB_1	19.19 a	18.88 a	86.92 a	88.03 a	3.23 a	2.88 a	4.01 a	3.26 a	2.78 a	2.29 a	2.52 a	2.17 a

Means with the same letter(s) within each main effect are not significantly difference at 0.05 level of probability.

Table (6): Effect of potassium fertilizer rates (kg K_2O/fed) and inoculation with KSB (*Frateuria aurantia*) on some productivity traits (Root fresh weight (g), root yield (ton/fed), Top yield (t/fed), Sugar recovery (%), Recoverable sugar yield (ton/fed) and Harvest index (HI) of three sugar beet varieties during 2016/17 and 2017/18 seasons

Treatments	Root fresh weight (g)		Root yield (ton/fed)		Top yield (ton/fed)		Sugar recovery (%)		Recoverable sugar yield (ton/fed)		Harvest index (HI)	
	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
Varieties: (A)												
MK 4016	1013.3 a	1013.1 b	27.36 a	27.35 b	16.54 a	17.75 a	15.47 a	15.51 a	4.27 a	4.26 b	0.62 a	0.60 a
Samba	1022.4 a	1003.3 c	26.98 a	27.09 b	16.26 a	17.54 a	15.38 a	15.61 a	4.19 a	4.25 b	0.63 a	0.62 a
Gloria	1026.9 a	1037.8 a	27.89 a	28.02 a	17.00 a	18.03 a	15.62 a	15.71 a	4.40 a	4.42 a	0.62 a	0.61 a
Kg K_2O/fed: (B)												
0 (Kg K_2O/fed)	814.39 c	934.17 c	24.82 c	25.85 c	16.01 c	17.27 c	15.32 a	15.36 c	3.83 c	4.00 c	0.61 c	0.60 b
24 (Kg K_2O/fed)	1092.5 b	1093.9 b	28.19 b	29.95 b	17.07 b	18.17 b	15.57 a	15.81 b	4.42 b	4.76 b	0.62 b	0.62 a
48 (Kg K2O/fed)	1155.8 a	1165 a	29.39 a	31.46 a	17.43 a	19.04 a	15.99 a	16.22 a	4.73 a	5.12 a	0.63 a	0.62 a
Bio-K (KSB): (C)												
KSB_0:(uninoculated)	1008.15b	1053.70b	27.22 b	28.45 b	16.62 b	17.73 b	15.49 a	15.67 a	4.25 b	4.49 b	0.62 a	0.62 a
KSB_1: (inoculated)	1023.89a	1077.22a	27.65 a	29.09 a	17.12 a	18.58 a	15.78 a	15.86 a	4.40 a	4.65 a	0.62 a	0.61 a
Interaction effect:												
A×B	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
A×C	Ns	NS	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
B×C	**	**	**	**	Ns	Ns	Ns	**	**	**	Ns	Ns
A×B×C	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns

Ns insignificant at 0.05, ** Significant at 0.01 probability levels. Means with the same letter(s) within each main effect are not significantly difference at 0.05 level of probability.

Table (7): Interaction effect between potassium fertilizer rates and Bio-K treatments on some productivity traits (Root fresh weight (g), root yield (ton/fed), Top yield (ton/fed), Sugar recovery (%), Recoverable sugar yield (ton/fed) and Harvest index, HI) during 2016/17 and 2017/18 seasons.

Treatments		Root fresh weight (g)		Root yield (ton/fed)		Top yield (ton/fed)		Sugar recovery (%)		Recoverable sugar yield (ton/fed)		Harvest index	
		2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
0 kg K_2O	K SB_0	814.9 d	931.1 d	24.68 c	25.14 e	15.76 a	16.73 a	15.23 a	15.27 b	3.78 c	3.86 d	0.61 a	0.60 a
	K SB_1	813.9 d	937.2 d	24.96 c	26.57 d	16.26 a	17.82 a	15.41 a	15.45 b	3.88 c	4.13 c	0.61 a	0.60 a
24 kg K_2O	K SB_0	1050.6 c	1070.6 c	28.53 b	28.91 c	17.22 a	17.72 a	15.41 a	15.56 b	4.44 b	4.52 c	0.63 a	0.62 a
	K SB_1	1134.4 b	1147.8 b	27.85 b	30.99 b	16.92 a	18.63 a	15.72 a	16.06 a	4.41 b	5.00 b	0.62 a	0.62 a
48 kg K_2O	K SB_0	1150 ab	1159.4 ab	27.52 b	31.31 a	16.89 a	18.75 a	15.84 a	16.18 a	4.53 b	5.08 ab	0.63 a	0.63 a
	K SB_1	1161.7 a	1170.6 a	30.33 a	31.61 a	17.57 a	19.34 a	16.15 a	16.27 a	4.93 a	5.16 a	0.63 a	0.62 a

Means with the same letter(s) within each main effect are not significantly difference at 0.05 level of probability.

between potassium fertilizer rates × inoculation with KSB treatments on top yield (ton/fed) and harvest index in both seasons. On the other hand, there was significant interaction between potassium fertilizer rates × inoculation with KSB on root fresh weight, root yield and recoverable sugar yield in both seasons. However, significant effect was noticed on sugar recovery percentage only in the 2nd season. The highest values of root fresh weight, root yield, recoverable sugar yield in both seasons were reported by the combination of 48 kg K_2O/fed × inoculation with KSB in both seasons. The former treatment produced the highest sugar recovery percentage in the 2nd season. On the other hand, the least values of root fresh weight, root yield, recoverable sugar yield in both seasons and sugar recovery percentage in the second season were produced by control (0 kg K_2O/fed) × uninoculated treatment. These results showed that, the effect of interaction between potassium fertilizer rates and inoculation with KSB treatments acted dependently on root fresh weight, root yield, recoverable sugar yield in both seasons and sugar recovery in the second season. In addition, it acted independently on top yield and harvest index in both seasons and sugar recovery% in the 1st season, as shown in Table (7).

Acknowledgment:-

The author would thanks Dr/ Ahmed S. Barakat for his valuable help in submit the appropriate bacterial strain used in this work.

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استجابة ثلاثة اصناف من بنجر السكر للتسميد البوتاسي المعدنى والحيوى فى منطقة غرب النوبارية

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الملخص العربى

اجريت تجربتان حقليتان خلال موسمى ٢٠١٦-٢٠١٧ و ٢٠١٧-٢٠١٨ فى حوض نوباسيد بمنطقة النوبارية بمحافظة البحيرة – ج.م.ع. لدراسة تاثير التسميد البوتاسي المعدنى و الحيوى (يحتوى على البكتيريا الميسرة للبوتاسيوم *Frateuria aurantia*) على الصفات الفسيولوجية و صفات الجودة و الانتاجية فى بنجر السكر.

تم استخدام تصميم القطاعات العشوائية الكاملة و كان توزيع المعاملات بنظام القطع المنشقة مرتين حيث تم توزيع الاصناف المختبرة (*MK 4016 , Samba and Gloria*) عشوائيا فى القطع الرئيسية و تم توزيع مستويات السماد البوتاسى (24 and 48 kg K_2O/fed) عشوائيا فى القطع المنشقة بينما تم توزيع معاملات التسميد الحيوى (ملقحة وغير ملقحة بالبكتريا) فى القطع تحت المنشقة.

وقد اوضحت النتائج ما يلى:

- تفوق الصنف جلوريا على الصنفين الاخرين تحت الدراسة فى طول وقطر ووزن الجذر وكذا محصول الجذور و السكر المستخلص.
- ادى نمو نباتات البنجر تحت ظروف التسميد البوتاسي بمعدل ٤٨ كجم (بو٢أ) للفدان الى الحصول على اعلى قيم من دليل المساحة الورقية وطول وقطر الجذر ومحتوى الاوراق والجذور من البوتاسيوم والنسبة المئوية للسكروز والسكر المفقود فى المولاس والسكر المستخلص والوزن الطازج للجذر ومحصول الجذور والعرش والسكر المستخلص ومعامل المحصول بالمقارنة بالمعاملة بمستوى صفر و ٢٤ كجم (بو٢أ) للفدان.
- ادى تلقيح نباتات بنجر السكر بالبكتيريا الميسرة للبوتاسيوم الى زيادة معنوية فى طول وقطر ووزن الجذر و النسبة المئوية للسكروز ومحصول الجذور والعرش والسكر المستخلص مقارنة بالنباتات الغير ملقحة.
- لم يكن هناك فرق معنوى نتيجة تلقيح نباتات بنجر السكر النامية تحت مستوى ٢٤ كجم (بو٢أ) للفدان والنباتات الغير ملقحة و النامية تحت مستوى ٤٨ كجم (بو٢أ) للفدان على الوزن الطازج للجذر والنسبة المئوية للسكروز ومحصول السكر المستخلص.
- من النتائج المتحصل عليها فى هذه الدراسة يمكن التوصية بتسميد نباتات بنجر السكر بمستوى ٤٨ كجم (بو٢أ) للفدان مع التلقيح بالبكتيريا الميسرة للبوتاسيوم للحصول على اعلى قيم من طول وقطر ووزن الجذر و النسبة المئوية للسكروز ومحصول الجذور ومحصول السكر المستخلص خلال موسمى هذه الدراسة.

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