RESPONSE OF SUGAR BEET TO NITROGEN AND POTASSIUM FERTILIZATION UNDER TWO DIFFERENT LOCATIONS

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(Manuscript received 31 October 2011)

Abstract

The present study was carried out under two locations of different conditions i.e at North Sinai region (sandy soil) and El-Sharkia Governorate (Sandy loam) during 2009/2010and 2010/2011 seasons to study response of four sugar beet cultivars (Pleno, Sultan, Toro and Invermono) to four fertilizer formula (80kg N, 80kg N +24kg K_2O, 100kg N + 48kg K_2O/fed and 120kg N + 48kg K_2O/fed). Results revealed that root and sugar yields and root quality could be maximized with the use Toro variety when fertilized with both N and K at the level of 100 Kg N/fed in Sharkia or 120 Kg N/fed in North Sinai with the addition 48kg K_2O/fed in the two location. Meantime, the other varieties also gave adequate yield and quality.

The two irrigation systems (surface and sprinkler) gave good results, but irrigation systems need to be investigated with special emphasis to water use efficiency and water requirements.

These results give clear indication to the success of beet cultivation under North Sinai conditions. Therefore, expanding sugar beet cultivation under this virgin area and establishment beet of a factory might contribute greatly to the development of this area.

INTRODUCTION

Sugar beet (*Beta Vulgaris*, L.) is considered to be a prospective crop for sugar production in Egypt. Its cultivation was introduced recently from about three decates under northern Delta. Nowadays its cultivation expanded to reach about one hundred thousand hectare (240 thousand feddan). Improving Sugar beet productivity is an urgent demand to meet the high consumption of the ever growing population. Selecting the promising cultivars and their suitable formulas for nitrogen and potassium under different soils conditions are among the most important factors affecting sugar beet production.

All sugar beet cultivated genotypes in Egypt are imported from foreign countries so, it is preferable to evaluated them under Egyptian conditions especially under different soils conditions and optimum fertilizer formulae to select the best ones in respect of yield and quality traits.

Therefore, numerous reports discussed the potential productivity of various genotypes with respect to beet yield and quality are listed in the literature by Schwarzbach *et. al.* (1996), Louer (1997), Ramadan and Hassanin (1999), Abou - Salama and El- syaid (2000), Aly (2000), Badawi *et. al.* (2002), Abd El-Razek (2006), Abd El-Razek *et. al.* 2006, Aly (2006) and Azzazy *et. al.* (2007).

Suitable optimum fertilizer formula for sugar beet materially affects root weight, sucrose, root and sugar yields (Azzazy (2000), Chikov *et. al.* (2003), Jozefyova *et. al.* (2004), Pytlarz (2005) and Azzazy *et. al.* (2007).

Therefore, the present study aimed at finding out the proper N and K levels which could be used to maximize the yield and quality of four sugar beet varieties under Sharkia and North Sinai Governorates.

MATERIALS AND METHODS

Two field experiments were conducted in a sandy soil of a private farm in North Sinai region (under sprinkler irrigation system) and a Sandy loam soil of a private farm in El-Sharkia Governorate (under surface irrigation system) during 2009/2010 and 2010/2011 seasons to find out the response of four sugar beet cultivars (Pleno, Sultan, Toro and Invermono) to four fertilizer formula (80kg N/fed, 80kg +24kg K /fed, 100kg N + 48kg K /fed and 120kg N + 48kg K/fed). A split plot design with four replications was used. The main plots were assigned to cultivars and Fertilization formula were randomly distributed in sub plots. Plot size (21m^2) consisted of 5 rows, 7 m long and 60 cm apart. Cultivars were planted on September 6th, 2009 and September 4th, 2010, respectively. Beet was hand seeded 20 cm within rows spacing and thinned to one plant per hill 30 days later. The normal practices of sugar beet cultivation, were maintained at the recommended level to assure optimum production. Harvest was carried out after 210 days from sowing. Root yield and root performance (root length, diameter and weight) were determined.

At harvest, a sample of ten guarded plants were taken at random to determine beet quality and technological parameters at Delta Sugar Company lab as follows:

Sugar % (Pol %) was polarimetrically determined on a lead acetate extract of fresh macerated root according to the method of Le-Docte (1927). Meantime, the extract was used to determine beet impurities *i.e.* Na, K and α- amino nitrogen. Na and K were determined using Flame photometer as described by Page (1982). α-amino nitrogen was determined using ninhydrin according to the method of Carruthers *et. al.* (1962). Sugar loss to molasses was calculated using the following equations as mentioned by Devillers (1988).

Sugar loss to molasses (SM) = (V_1+V_2) 0.14 + V_3 (0.25) + 0.5.

where: V_1 = Sodium, V_2 = Potassum, V_3 = α Amino N V_4 = pol %

Extractable sugar (sugar recovery) and extractability were calculated as proposed by Dexter *et. al.* (1967)

Extractable sugar (%) = [V_4 – (SM + 0.6)].

$$\text{Purity \%} = \frac{\text{Extractable}}{\text{pol}} \text{x100}$$

Percentages data were transformed to arcin before statistical analysis. Analysis of variance was computed for each trait in each season according to Snedecor and Cochran (1980). Treatment means were compared using L.S.D. at 5% level of probability. Combined analysis was also carried out for the two locations.

Table 1. Soil mechanical and chemical properties of the experimental sites at North Sinai region in 2009/2010 and 2010/2011 seasons.

Fraction	Seasons	
	2008/2009 Season	2009/2010 Season
A- Mechanical analysis		
Organic matter %	0.76	0.28
Sand %	88.10	77.40
Fine sand %	4.60	11.80
Silt %	3.10	5.70
Clay %	4.20	5.10
Soil texture	Sandy	Sandy
B-Chemical analysis		
pH	7.95	7.75
EC (mmohs /cm) 25c^o	3.50	5.50
Available N (mg/k soil)	21.20	28.80
Available P (mg/k soil)	14.14	15.36
Available K (mg/k soil)	39.00	140.40
Anions mq/L: CO_3^{--}	--	--
HCO_3^-	2.45	2.45
Cl^-	14.80	26.40
SO_4^{--}	19.26	32.28
Cautions mq/L: Ca^{++}	16.80	26.40
Mg^{++}	4.80	10.60
Na^+	14.34	23.74
K^+	0.57	0.39

Table 2. Soil mechanical and chemical properties of the experimental sites at El-Sharkia region in 2009/2010 and 2010/2011 seasons.

Fraction	Seasons	
	2009/10	2010/11
Physical analysis:		
Sand%	75.92	70.72
Silt%	22.00	22.00
Clay%	2.08	7.28
Texture class	Sandy loam	Sandy loam
Chemical analysis:		
pH	8.3	8.2
EC (m.mhos/cm)	0.39	0.32
Organic mattr%	1.34	1.34
Available N ppm	44.00	49.00
Available P ppm	5.00	5.70
Available K ppm	344.00	312.00
Cations (meq/l):		
Ca	0.80	1.20
Mg	-	0.20
Na	1.88	1.80
Cu	1.60	0.02
Fe	8.80	5.40
Mn	0.08	0.20
Zn	0.46	0.36
Anions (meq/L):		
Hco3-	1.60	1.40
Cl-	0.6	0.75
So4-	0.56	1.25
Co3-	-	-

RESULTES AND DISCUSSION

Data in Tables (1) and (2) clearly indicate that the soils of the experimental sites varied greatly in their physical and chemical properties and hence in their soil fertility levels. Due to its sandy textural class, the soil in North Sinai was very poor in its component from organic matter and there by its contend from available N compared with the soil of Sharkia Governorate which had a clay textural class and as well higher organic matter content and hence higher available N. The soil in Sharkia had ratio, a higher K content than in North Sinai.

Root weight and root yield/fed:

Average data (Table 3) indicated that under El-Sharkia conditions average root weight and root yield were gradually increased and significantly as nitrogen and potassium level were increased up to 100kg N and 48kg K_2O. The further increment of N significantly decreased both traits in both seasons. Such effect may be due to that large N dressing might have had stimulated more foliage growth than root growth. While, under North Sinai region both traits were increased up to the highest nitrogen level (120 kg N) with the highest K one (48 kg K_2O). This trend was the same in both seasons. The highest nitrogen dressing which yielded the highest average root weight and hence root yield under North Sinai was expected since the nitrogen supplying power of such sandy soil was very low due to its very poor content from organic matter (0.50%) and available N (24.9 ppm).

Further, root yield potential per faddan under El-Sharkia conditions (relatively more fertile soil and surface irrigation) surpassed those under North Sinai under sandy soil and sprinkler irrigation by about 7.24 ton/fed.

The available review of literature in Egypt or in other sugar beet growing countries proved that the increase in root yield potential was mainly related with the increase in nitrogen dressing and this increase greatly depends on soil type and other growing factors (Besheit *et. al.* , 1995, Azzazy 2000, Aly 2006 and Azzazy *et. al.* , 2007). This beneficial effect of N was magnified when the level of K was increased to 48 K_2O/fed. The role of K in enhancing portioning of photosynthesis from the sugar beet foliage to the roots cannot be denied in this connection.

Toro variety exhibited the highest average root weight and root yield and significantly surpassed the other three beet varieties i,e. Pleno, Sultan and Invermon in both locations and seasons (Table 3). These results are in harmony with those reviewed by Aly (2000), Abdel-Razek (2006), Aly (2006) and azzazy *et. al.* (2007).

Table 3.

All interactions among the studied varieties were significantly affected root yield in both seasons. However, the highest root yield was of Toro variety fertilized with 100kgN + 48kgK_2O under El-Sharkia area and the same variety under North Sinai but fertilized with 120kg N + 48 kgK_2O.

Sucrose content:

Root sugar percentage is the most important aspects of quality cane be defined and chemically measured easily.

As mentioned in Table (4) under El-Sharkia location there was a trend of increase in sucrose percentage as nitrogen level was increased from 80 kgN/fed up to 100 kgN/fed and potassium level from zero up to 48 kg K_2O/fed. However, the further nitrogen application up to 120 kgN/fed decreased considerably sucrose % particularly in the second season. These results may show that excess N dressing might have had stimulated vegetative growth of beet rather than root growth meantime overcome the positive effect of potassium on sugar translocation and accumulation in storage roots. Moreover, under North Sinai, sucrose percentage was increased gradually and significantly (p.o <0.05) as nitrogen and potassium levels were increased (Table 4). Such effect may be due to that sandy soil had insufficient nitrogen and potassium to meet the needs of beet crop. Similar findings were reported by Azzay (2000), Chikov *et. al.*(2003) and Pytlarz (2005).

Under El-Sharkia area, root sucrose percentage markedly surpassed those of North Sinai in both seasons (Table 4). Invermono variety gave the highest root sucrose percentage in both seasons and locations followed by Sultan variety, however Pleno variety exhibited the lowest sucrose percentage. The high root sucrose percentage under both locations was expected because weather conditions especially night temperature is favorable for beet growing and sucrose synthesis. These results are in line with those of Schwarzbach *et. al.*(1996), Lauer (1997), Abou-Salama and El-syaid (2000), Aly (2000), Badawi *et. al.* .(2002) and Abd El-Razek (2006). who stated that the variation in sucrose percentage of the studied varieties was mainly due to the variation in their genetic constituents and environmental condition.

The first and second order interactions in both seasons(Table 4) significantly affected root sucrose percentage. These results give evidence that sucrose synthesis and accumulation were greatly correlated to soil and weather conditions (locations), beet varieties and N K fertilization.

Table 4.

Juice impurities and sugar loss to molasses:

Significant and gradual increase in the concentration of K, Na and α Amino N were associated with the increase of N and K application, which may be responsible for the linear increase in sugar loss to molasses (Tables 5and 6). This trend was true in both seasons and locations.

Potassium, sodium and α amino N are component of impurities which increase the sugar lost to molasses and hence decrease sugar extraction (extractability percentage) particularly in the case of over use of N and K application. These results are in accordance with those of Pytlarz (2005) and Azzazy *et. al.*(2007). who noticed that the increase in impurities may be attributed to that nitrogen fertilizer enhances vegetative growth, and hence absorption of more nutrients reflecting a marked increase in sugar loss to molasses.

Data in Tables 5 and 6 indicated that in 2009-2010 and 2010-2011 seasons, the differences among varieties in K, Na and α Amino N in addition to the percentage of sugar loss to molasses were significant (p.o<.05). Pleno variety exhibited the highest K and α amino N, root concentrations whereas, Toro variety had the highest Na root concentration. while, Invermono variety recorded the lowest root concentration of juice impurities. Therefore, these varieties in respective order recorded the highest and lowest sugar loss to molasses. In this connection Badawi *et. al.*(2002), Abd El-Razek (2006) and Aly (2006). showed that beet varieties were apparently differed in their quality aspects, due to genetic make-up differences.

Data also cleared that the highest concentration of K and α Amino N and hence sugar loss to molasses was observed under El-Sharkia conditions, while, the highest concentration of Na was of North Sinai and this may be due to higher salinity levels.

All interactions degree among the three variable locations, fertilizer and beet varieties significantly affected concentration of juice impurities (Table 5 and 6) and sugar loss to molasses as well. Worth to be mentioned that sugar loss to molasses which accounts from the three impurities could be used as indicator to their contents in the juice. Therefore, the highest sugar loss to molasses under this trials was recorded for Pleno variety under El-Sharkia area when fertilized with 120kg N + 48kg K_2O (2.84). On the other hand, the lowest average was Invermono variety under North Sinai when fertilized with 80 kg N only. Such effect may be due to that fertilizing beet by both elements might have had increased the uptake of these elements than when fertilized with N alone.

Table 5.

Table 6.

Purity percentage and extracted sugar percentage (sugar recovery):

In both seasons and locations, the lowest N dressing (80 Kg N/fed) alone or with 24kg K_2O/fed exhibited the highest Purity percentage (Table 7). Further, the increase in both N and K level significantly decreased Purity percentage. Such effect may be due to progressive aforementioned increase in impurities and sugar lost to molasses.

Data in Table (7) also cleared that under El-Sharkia area and in both seasons, sugar recovery was significantly increased as nitrogen and potassium rate was increased reaching its maximum value at the rate of 100kg N/fed +48kg K_2O/fed. Therafter, the increasing in N rate up to 120kg/fed significantly reduced this trait. However, under North Sinai and through both seasons, sugar recovery continued to increase reaching its maximum when the highest N rate (120kg) and K (48kg K_2O) levels were used. Those findings are in agreement with those reviewed by Chikov *et. al.*(2003), Jozefyova *et. al.*(2004) and Azzazy *et. Al.*(2007) who observed marked reduction in sugar recovery as nitrogen level was increased.

Regarding variety differences, data in Table (7) clared that Invermono variety recorded significantly the highest Purity and sugar recovery in both seasons and locations. Otherwise, Pleno variety exhibited the lowest value of both traits. Meantime, Sultan and Toro varieties ranked intermediate in both traits. Similar results were reported by Ramadan and hassanin (1999), Abd El-Razek *et.al.*(2006) and Aly (2006).

Average data cleared that Purity and sugar recovery were higher under El-Sharkia area than North Sinai (Table 7).

Interactions among the three variables exhibited significant effect on both Purity and sugar recovery. These results give an evidence that both traits were not independently affected but depends on the variables combination. Data in table (7) also indicated that Invermono recorded the highest Purity percentage in both seasons and locations under 80kg N dressing and the same trend was also obtained for sugar recovery in both seasons and under 100kg N +48kg K_2O at El-Sharkia area and 120kg N +48kg K_2O under North Sinai, respectively.

Table 7.

Sugar yield (ton/fed):

Data in Table (8) showed that sugar yield (ton/fed) was maximized to 5.90 and5.82 ton/fed in 2009/10 and 2010/11 seasons respectively, under El-Sharkia area when fertilized with 100kg N/fed and 48kg K_2O/fed. Therefore, the further N dressing (120kg N/fed) decreased insignificantly sugar yield. However, sugar yield gradually and significantly was increased under the higher N and K dressing in both seasons. Similar results were recorded by Jozefyova *et.al.*(2004), Pytlars (2005) and Azzazy *et.al.*(2007). who found that increasing nitrogen rate to 120 kg N/fad decreased sugar yield. Such effect may be due to the reduction observed in both root yield and sugar recovery%.

Significant differences have been observed among the used varieties with respect to sugar yield (ton/fed) (Table 8). The highest sugar yield was recorded by Toro variety in both seasons and locations. The other three varieties (Pleno, Sultan and Invermono) exhibited moderate sugar yield. These findings are greatly attributed to the high root yield and appropriate root quality aspects previously observed. Though sugar yield of beet cultivated under El-Sharkia area significantly surpassed those under North Sinai. Sugar yield greatly differed among varieties and locations as reported by Abd El-Razek *et.al.*(2006) and Aly (2006).

All possible interactions order among locations, varieties and N fertilization significantly affected sugar yield. Therefore, Toro variety fertilized with 100kg N + 48kg K_2O/fed under El-Sharkia area or with 120kg N +48kg K_2O/fed under North Sinai gave the highest sugar yield/fed (Table 8).

Conclusion:

Under the two given environments of this work, root and sugar yields with high root quality have been maximized with Toro variety fertilized with both N and K at the level of 100 or 120 kg N + 48 kg K_2O/fed. Meantime, the other varieties also gave adequate yield and quality.

These results give clear indication to the success of beet cultivation under North Sinai conditions. Therefore, expanding sugar beet cultivation under this virgin area and establishment of a sugar beet factory might contribute greatly in the development of this area.

Table 8.

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إستجابة بنجر السكر للتسميد النيتروجينى والبوتاسى تحت ظروف منطقتين مختلفتين

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أجريت هذة الدراسة بموقعين الاول بشمال سيناء (التربة الرملية ونظام الرى بالرش) والثانى بالشرقية (التربة الطميية الرمليه ونظام الرى السطحى بالغمر) خلال موسمى 2010/2009 و 2011/2010 وذلك لدراسة استجابة اربع اصناف من بنجر السكر (بلينو، سلطان، تورو و انفرمونو) لاربع توليفات من التسميد النيتروجينى والبوتاسى (80كجم ن/فدان ،80كجم ن + 24كجم بو/فدان ، 100كجم ن + 48 كجم بو / فدان و 120 كجم ن+ 48 كجم بو /فدان). اظهرت النتائج تحت ظروف هذة الدراسة يمكن الحصول على اعلى محصول من الجذور والسكر وكذلك اعلى جودة للعصير بزراعة الصنف تورو واستخدام توليفة من التسميد النيتروجينى والبوتاسى بمعدلات 100 او 120 كجم نيتروجين + 48 كجم بوتاسيوم /فدان. اوضحت النتائج دلالة كبيرة لامكانبية نجاح زراعة بنجر السكر تحت ظروف الاراضى الرملية بشمال سيناء وامكانية التوسع فى زراع المحصول فى هذة المنطقة مع انشاء مصنع لانتاج سكر البنجر للمساهمة فى تنمية هذة المنطقة.