37 Egypt. J. Soil Sci., Vol. 42, No. 4, pp. 625-641 (2002)

Effect of Potassium and Phosphorous Fertilization on Sugar Beet Yield

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TO ILLUSTRATE the interaction effect of various potassium and phosphorous application rates (0, 24 and 48 kg K_2O/fed. and 0,15 and 30 kg P_2O_5/fed.) on sugar beet yield and quality, a series of field trials were conducted during three successive seasons on seven districts at Kafr El-Sheikh Governorate.

The obtained data revealed that the highest root yield (ranged between 33.7 and 42.4 ton/fed.) and sugar yield (ranged between 5.63 and 6.56 ton/fed.) was obtained at Desok location for all fertilization types and rates compared with other locations. Moreover for all districts the root yield and sugar yield were generally increased by the application of phosphorous and potassium fertilization whatever its rate compared with in the control.

Increasing K application rate from 24 to 48 kg K_2O/fed. enhanced the uptake of K by the plants where it induced an increase in K% in leaves and roots while it did not induce any appreciable differences in Na concentration in the plant. On the other hand a reversible relation was detected between K application rate and N concentration in sugar beet root. This was true at the two phosphorous fertilization rate.

The sugar yield and purity of juice were not affected by increasing P application rate from 15 to 30 kg P_2O_5, while the juice purity and sugar yield were increased by the application of 24 kg K_2O/ fed, but purity decreased at higher application rate (48 kg K_2O/fed.) while sugar yield was not affected.

Root yield was directly related to N and K concentration in leave during vegetative growth. While a positive relation was detected between sugar yield and K% in leaf blade and petiole. On the other hand juice purity was inversely proportion to K% in the root .

Finally it could be concluded that application of 15 kg $P_2 O_5$/fed along with 24 kg $K_2 O$/fed. in addition to a basal dose of 60 kg N/fed assumed to be the most suitable fertilization program for all districts at Kafr El-Sheikh Governorate where it produced the highest root yield (30.4 ton/fed.) and sugar yield (5.04 ton/fed.) (as an average over districts) with high juice purity.

Keywords : Clayey soil, Potassium, Phosphorus, Sugar beet

Due to the economic importance of sugar beet, a great deal of trials has been conducted in relation to yield increase. In the last decades, numerous experiments have been conducted to determine the fertilizer requirement, which was mostly emphasized on N and P and less on K supply.

Potassium plays a fundamental role in sucrose synthesis and storage, and sugar beet has a high K requirement. Potassium fertilizer increases root mass, sugar content and extractability. It also affects Na and -amino N contents (Draycott and Cooke, 1966; Kochl, 1977, Beringer *et al.*, 1986; Carter, 1981, Herlihy, 1989). Potassium may be expected to improve the efficiency, of N and P fertilizers and improve beet quality (sugar content and extractability) (Kelarestghi and Bahbahanizadeh, 1994). However, K fertilization must be adjusted with some care since excessive rates can have adverse effect (Orlovius, 1993).

It is important that fertilizers for sugar beet should be correctly balanced and much work in different countries has investigated the effects of N and K on yield and quality (Draycott and Durrant, 1976; Milcheva, 1977; Carter and Traveller, 1981, Adams *et al.*, 1983; Winter, 1990). Kralovic (1991) found that the higher supply of K resulted in the increase of K and Na content in root and at the same time in the decrease of saccharose content. In order to determine the optimum P-K balance of fertilization for sugar beet crop to produce the highest sugar yield and quality, a long term field experiments were conducted in typical sugar beet growing area.

Material and Methods

A series of field experiments were carried out during three successive seasons at seven districts representing Kafr El-Sheikh Governorate to determine the most economically proper K and P fertilization rate to produce the highest sugar beet yield and quality. The experiment was laid out in randomized complete block design with eight fertilization treatments in five replications. Phosphorous was used only in the form of super phosphate and potassium in two forms as K Cl and K_2 SO_4, where two rates of Phosphorous (15 and 30 kg P_2 O_5 / fed in combination with three rates of potassium (0,24 and 48 kg K_2 O/fed) were applied along with a basal dose of 60 kg N / fed.

Pepresentative soil samples from the experimental sites were taken to determine some chemical properties of the soil. Soil chemical analysis was carried out according to Jakson (1958) and listed in Table 1.

TABLE 1. Chemical analysis of representative soil samples for the different districts.

District	PH	EC (mmhos/cm	OM%	N ppm	P ppm	K ppm
El-Riad	8.4	3.12	1.81	33.3	6.8	390
Kelleen	8.4	2.34	1.86	47.5	8.9	440
Sedy Salem	8.2	5.46	1.98	33.3	5.4	540
Desok	8.6	2.73	2.31	47.0	6.1	340
Kafr El-Sheikh	8.3	5.46	2.11	55.1	6.9	480
Biyla	8.4	3.90	1.74	59.5	5.9	260
El-Hamul	8.1	2.26	1.32	34.0	7.3	315

After 12 weeks from planting the leaf blade and petiole were collected for the determination of N, P and K. At harvest time, root yield was determined and five roots/plots were used to determine sucrose content and purity of sugar according to Sach Le Doct (Mc Ginus, 1971). Alfa nitrogen, potassium and sodium concentrations were determined according to Chapman and Paratt (1961).

Results and Discussion

The effect of various K and P application rates on some chemical constituents of sugar beet

The average of the seven districts data (Fig. 1,2 and 3) revealed that, at various phosphorous application rates, the application of K increased the N, P and

K concentration in sugar beet leaves, however this effect was more pronounced at higher P application rate (30 kg P_2O_5 /fed.). The enhancing effect of K on increasing N concentration in the plant was reported also by Mengel and Kirkby (1987) who found that the applied N was only full utilized by crop when K supply was adequate. While the effect of K and P application on increasing N,P and K concentration in sugar beet leaves was in accordance with the finding of Kapur (1995).

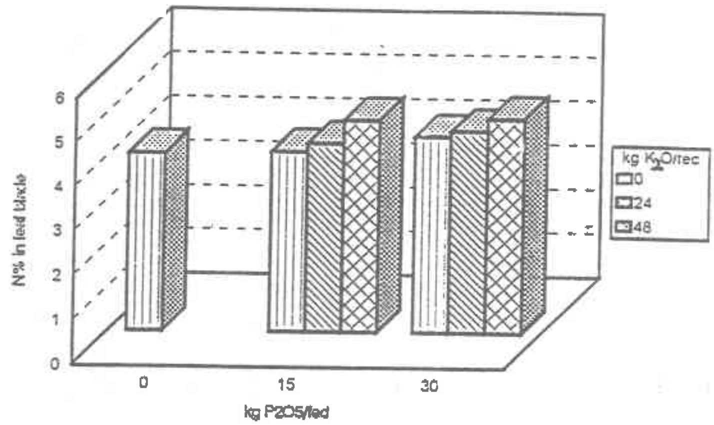

Fig. 1. Effect of various phosphorous and potassium fertilization rates on N% in leaf blade of sugar beet.

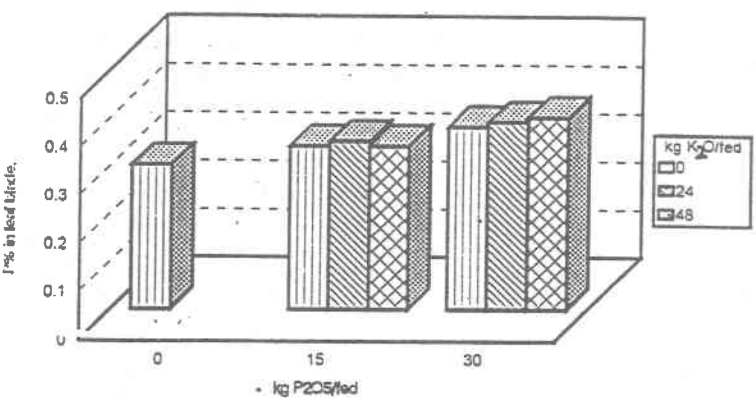

Fig. 2. Effect of various phosphorous and potassium fertilization rates on P% in leaf blade of sugar beet.

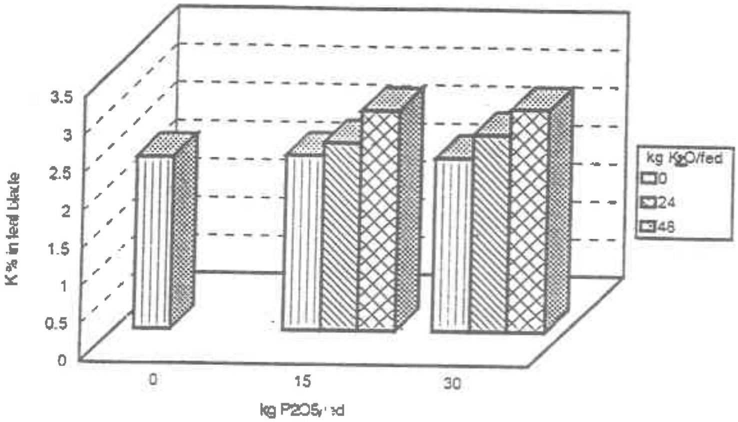

Fig. 3. Effect of various phosphorous and potassium fertilization rates on K% in leaf blade of sugar beet.

Concerning root constituents, it was noticed that increasing K application rate increased K concentration in root and induced a reduction in both Na and N concentration which was true at the two P fertilization rates. This was quit expected where increasing K concentration in the growth media increased its uptake by the plant, while the reduction in Na concentration could be attributed to the antagonism between K and Na. This was in accordance with Jones *et al.* (1991) and Kapur (1995) who stated that increasing K concentration in the substrate increased K uptake and depressed Na absorption by the plant. On the other hand the reduction in N concentration occurred by K application could be attributed to the enhancing effect of K on the incorporation of N into protein thus reducing the concentration of soluble N compounds.

The reduction in amino N content due to K fertilization was also reported by Pardo and Cuadalix (1993) and Orlovius (1993).

The relation between K % in sugar beet root and both Na and N was illustrated in Fig. 4 and 5 which revealed that N and Na concentration were inversely related to K concentration in sugar beet root. This relation could be expressed by the following regression equations:

N% = 5.78 - 0.39 K% in the root   r = -0.775

Na% = 3.06 - 0.095 K% in the root   r = -0.636

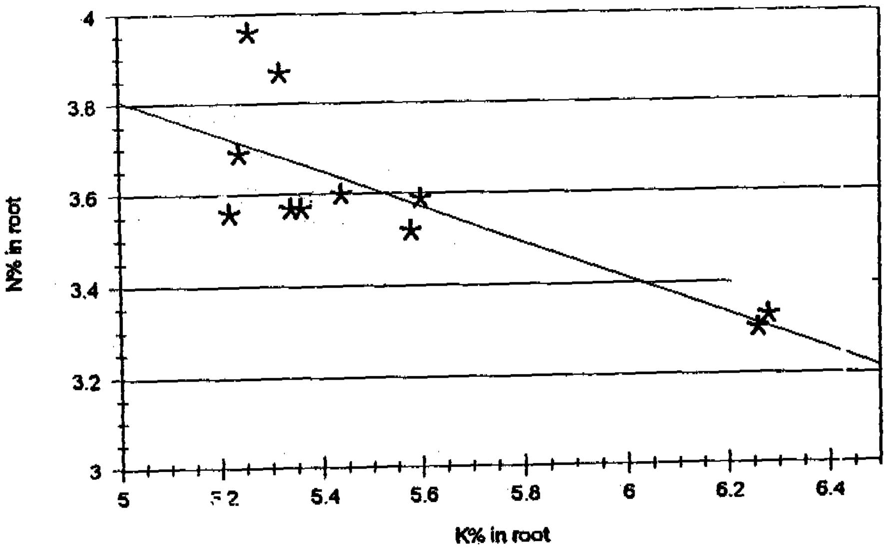

Fig. 4. Relation between K concentration in sugar beet root and N percentage.

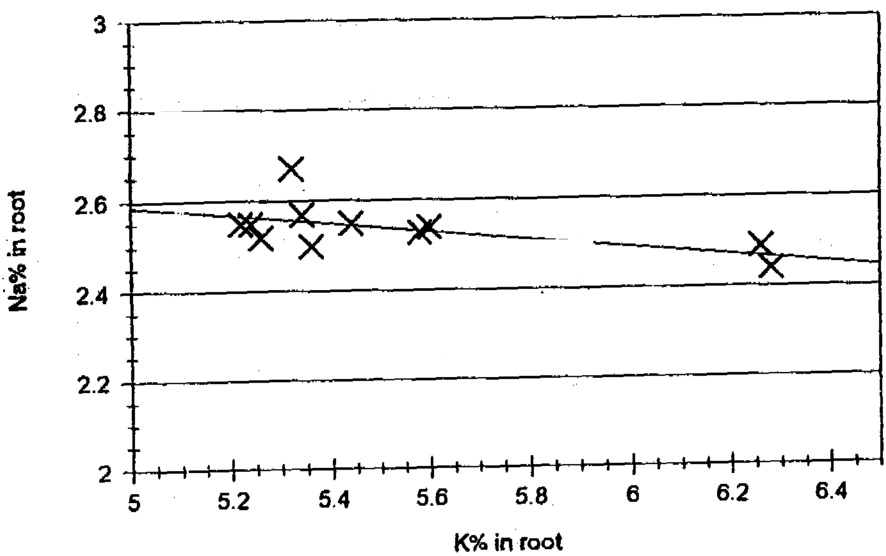

Fig. 5. Relation between K concentration in sugar beet root and Na percentage.

The effect of various P and K fertilization rate on sugar beet root yield

The sugar beet root yield was greatly affected by potassium and phosphorous fertilization as it was illustrated in Fig. 6. Regardless phosphorous application rate, it was found that the application of 24 and 48 kg K_2O / fed. increased the root yield by 2.26 and 2.35 ton / fed over the control, respectively. While the application of P was less effective, the increase in yield due to the application of 15 and 30 kg P_2O_5 / fed. was 1.85 and 1.82 ton/fed, respectively (as an average over K fertilization).

The highest root yield was obtained by the application of either 48 kg K_2O / fed. along with 15 kg P_2O_5 / fed., or the application of 24 kg K_2O / fed. in combination with 30 kg P_2O_5 / fed. This was in accordance with the finding of Ramon and Christman (1989).

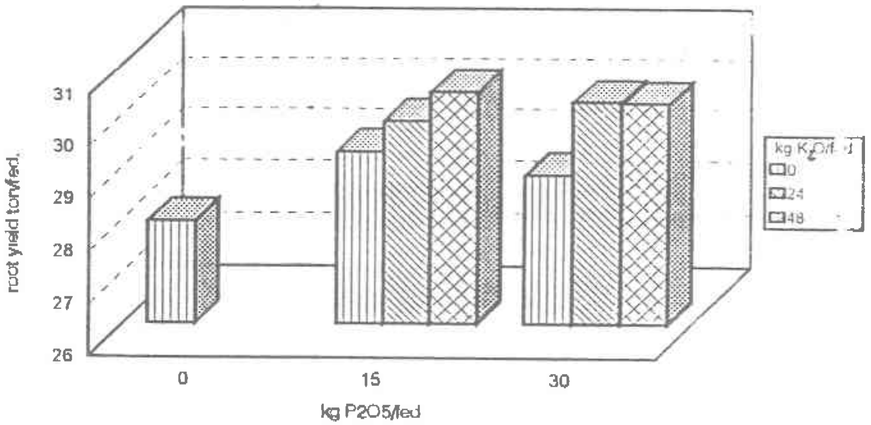

Fig. 6. Effect of various phosphorous and potassium fertilization rates on sugar beet root yield.

It is worth to mention here that the root yield at harvest was highly related to K concentration in leaf petiole and leaf blade during vegetative growth (r=0.78), and N concentration in leaf blade (r=0.71). This relation revealed that the sugar beet root yield could be predicted during vegetative growth by the determination of N and K in leaf blade and petiole (Fig. 7-9).

The effect of various P and K fertilization rate on sugar yield

The application of P fertilization either alone or in combination with K fertilizer increased sugar yield. However the highest sugar yield was obtained by the application of 15 kg P_2O_5 / fed. along with 24 kg K_2O/ fed. The excessive application of either P or K did not induce any further increase in sugar yield as it could be noticed from Fig. 10. The increase in sugar yield due to K and P application could be attributed to the involvement of P in ATP formation which is stimulated by the presence of K^+. As ATP is essential in photosynthesis process, thus the presence of P and K promotes the rate of CO_2 assimilation. In

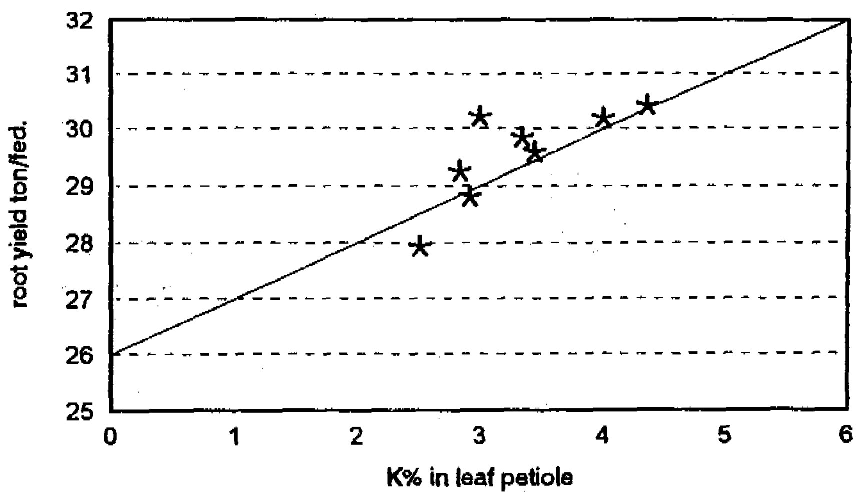

Fig. 7. Relation between potassium concentration in petiole during vegetative growth and sugar beet root yield.

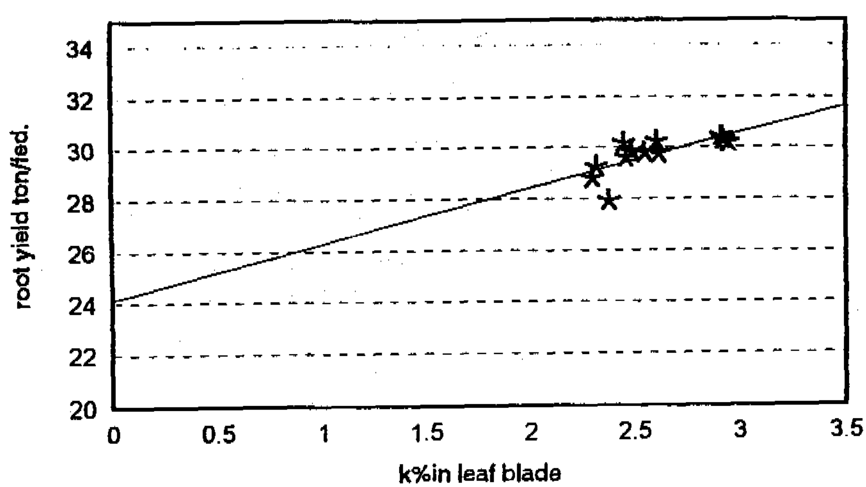

Fig. 8. Relation between potassium concentration in leaf blade during vegetative growth and sugar beet root yield.

this recpect, Watanabe and Yoshida (1970) stated that the efficiency of leaves in the transformation of solar energy into ATP, required for the assimilation of photosynthates, depends considerably on the level of K and P nutrition. While Milcheva (1990) found that K fertilization exerted a positive effect on sugar content but the effect depending on K rate.

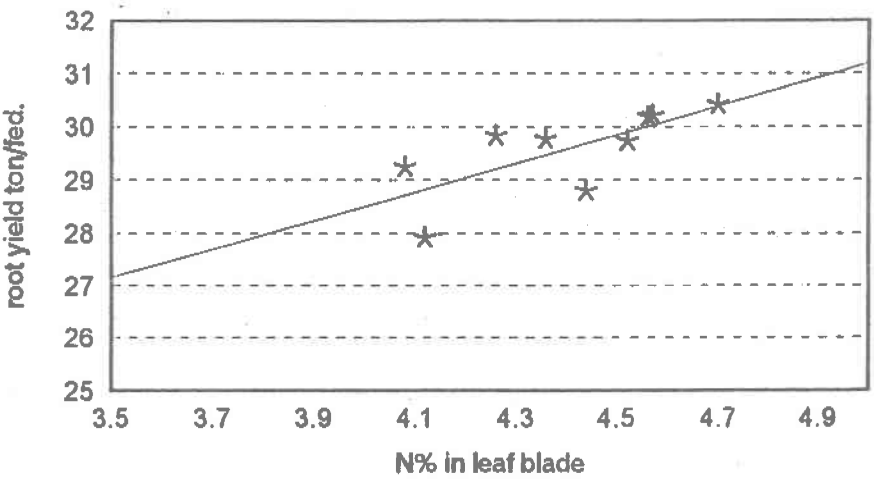

Fig. 9. Relation between N concentration in leaf blade during vegetative growth and growth and root yield at harvest.

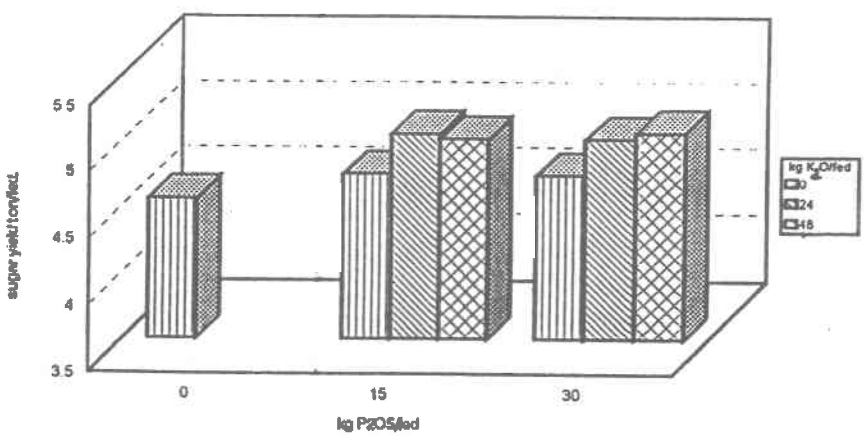

Fig. 10. Effect of various phosphorous and potassium fertilization rates on sugar yield.

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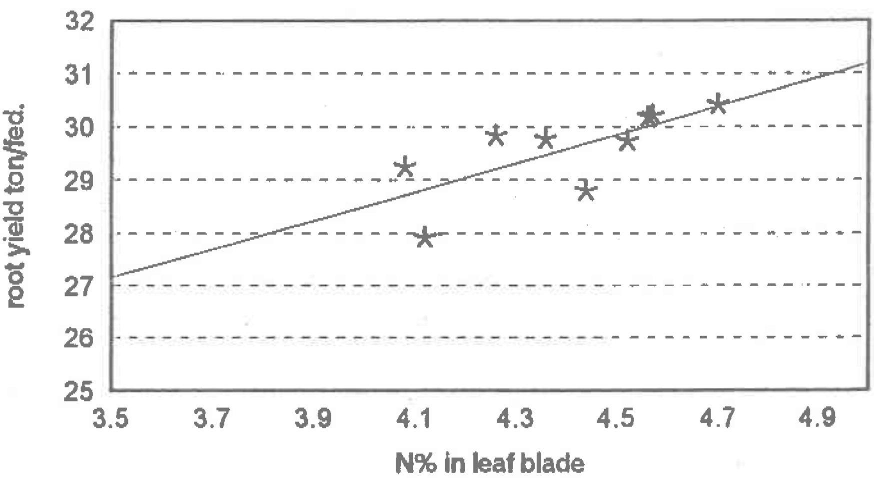

Fig. 9. Relation between N concentration in leaf blade during vegetative growth and growth and root yield at harvest.

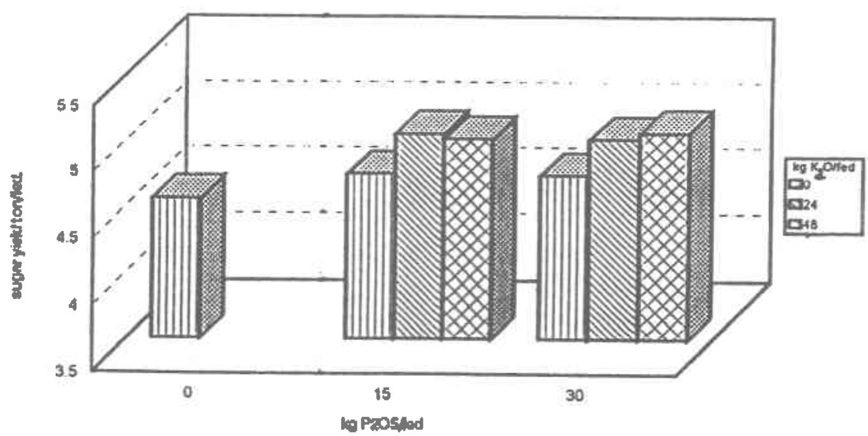

Fig. 10. Effect of various phosphorous and potassium fertilization rates on sugar yield.

Relationship between K% in the petiole during vegetative growth and sugar yield at harvest was presented in Fig. 11. It shows that maximum sugar yield was obtained when K% in petiole was between 3 and 3.5%. Concentration in excess of 3.5% did not induce a further increase in sugar yield. However, the relation between K concentration in leaf blade and sugar yield, Fig. 12 reflect that sugar yield was directly related to K% in leaf blade during vegetative growth. This relation revealed the vital role of K in carbohydrate metabolism in the leaf and its translocation to the root. In this respect, Tisdal and Nelson (1975) stated that photosynthesis decreased with insufficient potassium, and the translocation of sugar from the leaves to storage organs was greatly reduced. The obtained results are in agreement with those obtained by Orlovius (1993) who found that the formation of sugar and transport to the root was largely dependent on the leaf K content.

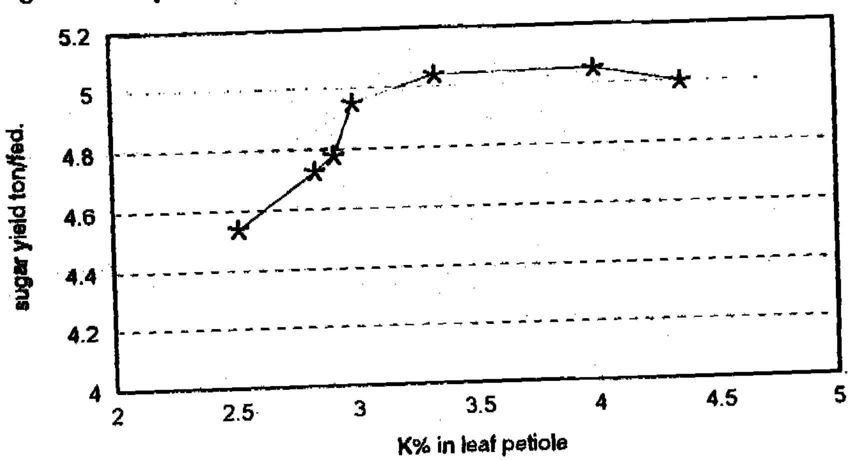

Fig. 11. Relation between potassium concentration in petiole during vegetative growth and sugar yield at harvest.

The effect of various P and K fertilization rate on juice purity

The refined sugar extraction depends to a large extent on juice purity. Herthly (1992) demonstrated that the small amounts of nutrients contained in beets could markedly affect refined sugar extraction. The data presented in Fig. 13 illustrated that juice purity was slightly increased by the application of 24 kg K_2O / fed. while further increase in K application rate induced a reverse effect as it decreased the juice purity to be lower than that of the control. This was true at the two phosphorous application rates. It seems that the most of K taken up by

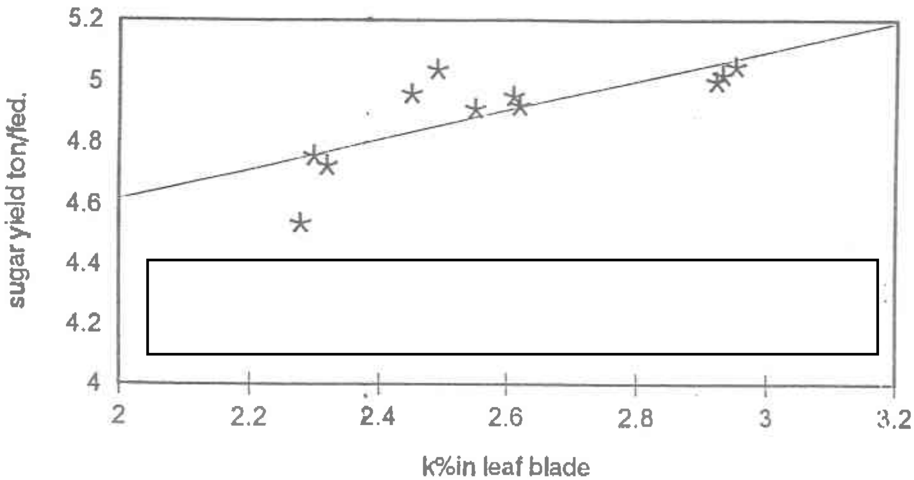

Fig. 12. Relation between potassium concentration in leaf blade during vegetative growth and sugar yield at harvest.

the plant was stored in the leaves where it concerned in physiological processes, however an excess of K supply increased the amount of K transferred to the roots, causing a reduction in juice purity. The reverse relation that was noticed between K% in the root and juice purity inspite of the enhancing effect of K on sugar production confirmed this hypothesis (Fig. 14).

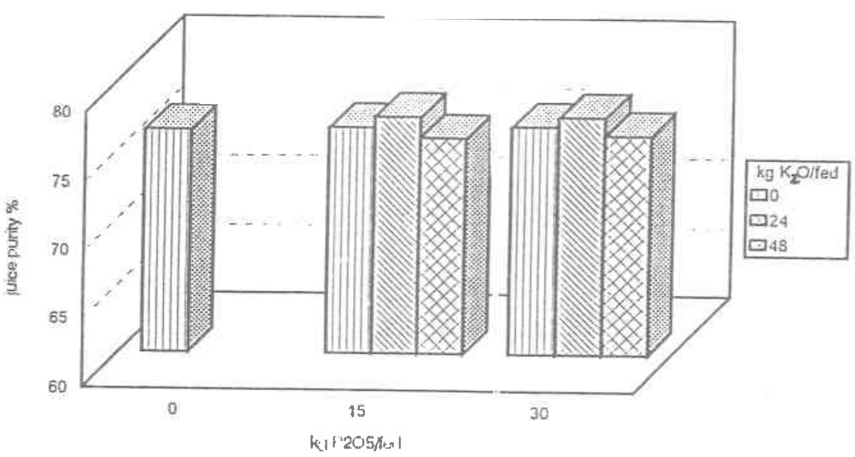

Fig. 13. The effect of various phosphorous and potassium fertilization rates on juice purity.

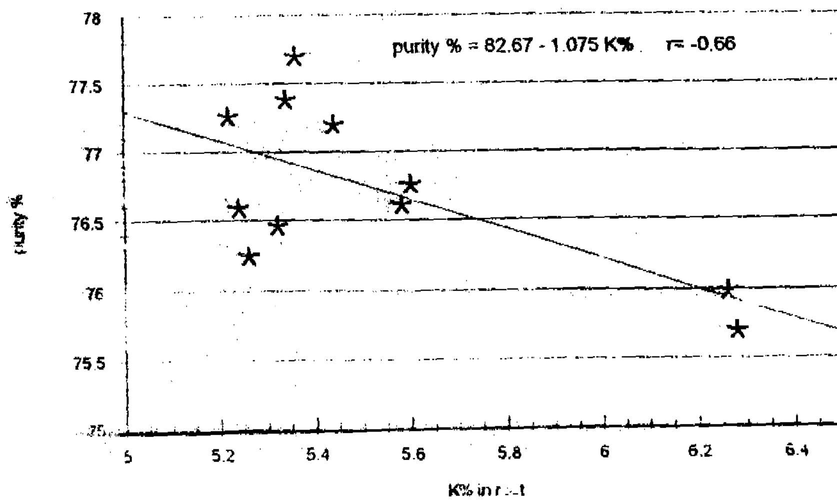

Fig. 14. The relation between K concentration in sugar beet root and juice purity .

This was in accordance with the finding of Mengel and Kirkby (1987) who stated that increasing K nutrition to an adequate level is generally accompanied by an increase in sugar content but a highly level of K increased K concentration in the root which disturbs crystallization during sugar refining and thus affects the sugar output.

It is worth to mention here that the juice purity was inversely related to summation of K, Na and alpha nitrogen concentration in the roots rather than their individual concentration where the relation coefficient between juice purity and K % in the root was (0.66) while the relation coefficient between juice purity and the summation of K, Na and alpha nitrogen concentration was (-0.89) as it could be noticed from Fig.14 and 15.This was in accordance with Maranghan (1990) and Pardo and Cuadalix (1993) who postulated that K together with Na and alpha nitrogen have deleterious effect on juice purity. However K also depresses the alpha nitrogen and the two effects seems to counteract each other.

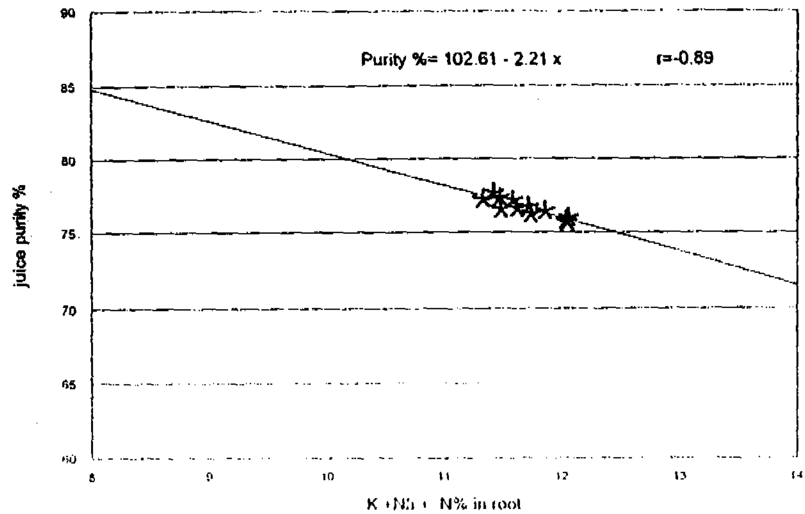

Fig. 15. The relation between the concentration of K + Na + N in juice and the juice purity .

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(*Recevied* 12/2000)

تأثير التسميد بالبوتاسيوم والفوسفور على محصول بنجر السكر

محمد صالح خضر ، ليلى السيسى و أحمد محمد أحمد على
معهد بحوث الاراضى والمياه والبيئة و مركز البحوث الزراعية – الجيزة – مصر .

أقيمت سلسلة من التجارب الحقلية خلال ثلاثة أعوام (بالموسم الشتوى) لدراسة أثر التفاعل بين الفوسفور والبوتاسيوم بمعدلاتهم المختلفة (صفر ، ٢٤ ، ٤٨ كجم بو٢ أ / فدان ، صفر ، ١٥ ، ٣٠ كجم فو٢ أ٥ / فدان) على محصول بنجر السكر ونوعيته .

وقد تبين من النتائج المتحصل عليها أن أعلى محصول للدرنات (تراوح بين ٣٣,٢ ، ٤٢,٤ طن / فدان) و محصول السكر (تراوح بين ٥,٦٣ ، ٦,٥٦ طن / فدان)قد تحصل عليه فى موقع مركز دسوق بالنسبة لنوعية السماد والمعدلات مقارنة بالمواقع الأخرى وعلاوة على ذلك فإنه مع إضافة الفوسفور والبوتاسيوم كان محصول الدرنات والسكر يزداد عموماً مع المعدلات المختلفة بالمقارنة بمعاملة الكنترول .

وزيادة معدل البوتاسيوم من ٢٤ كجم إلى ٤٨ كجم بو٢ أ / فدان تؤدى الى زيادة الممتص من البوتاسيوم بواسطة النبات والتى تؤدى الى زيادة نسبة البوتاسيوم (٪) فى الأوراق والدرنات بينما لم تؤد الى زيادة ملموسة فى تركيز الصوديوم فى النبات . ومن ناحية أخرى وجدت علاقة عكسية بين إضافة معدلات من البوتاسيوم وتركيز النيتروجين فى درنات البنجر وكان ذلك أيضاً بالنسبة لمعدلات الفوسفور .

محصول السكر ونقاوة العصير لم تتأثر بزيادة معدل الفوسفور من ١٥ الى ٣٠ كجم فو٢ أ٥ بينما إزداد محصول السكر وتحسنت نقاوة العصير وذلك باستخدام ٢٤ كجم بو٢ أ / فدان بينما انخفضت النقاوة باستخدام المعدل العالى من البوتاسيوم ٤٨ كجم بو٢ أ / فدان فى حين أن محصول السكر لم يتأثر .

وجدت علاقة مباشرة بين محصول الدرنات وتركيز النتروجين والبوتاسيوم فى الأوراق خلال مرحلة النمو الخضرى حيث كانت هناك علاقة موجبة بين محصول السكر والنسبة المئوية للبوتاسيوم في كل من النصل والعنق. ومن ناحية أخرى كانت هناك علاقة عكسية بين النقاوة وتركيز البوتاسيوم فى الدرنات .

أخيراً يمكن استنتاج ان إضافة البوتاسيوم بمعدل ٢٤ كجم بو٢أ / فدان مع ١٥ كجم فو٢أ٥ بالإضافة الى استخدام النتروجين بمعدل ٦٠ كجم ن / فدان تعتبر أفضل برنامج تسميد لبنجر السكر لمختلف مراكز محافظة كفر الشيخ والتى تعطى حوالى ٣٠,٤ طن/فدان درنات بنجر السكر ومحصول السكر ٤. ,٥ طن/ فدان وذلك كمتوسط عام لجميع المراكز مع نقاوة عالية للعصير.