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Response of Sugar Beet to Various Forms and Rates of Nitrogenous Fertilizer

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A SERIES of field trials were conducted for three years in seven districts at Kafr-El-Sheikh Governorate to elucidate the most suitable nitrogen fertilization program for sugar beet; where four nitrogen fertilizer sources were used [urea (U), ammonium nitrate (AN), ammonium sulfate (AS) and calcium nitrate (CaN)] at three rates (60, 80, and 100 kg N/fed.) along with a basal application of 15 kg P_2O_5 and 24 kg K_2O/fed.

It was found that potassium concentration in leaf blade and petiole during vegetative growth and potassium concentration in root at harvest time were slightly decreased by increasing nitrogen application rate regardless its source. The reverse was true for nitrogen concentration in leave and root, as it increased by increasing nitrogen application rate for all nitrogen fertilizer sources.

Root yield of sugar beet as well as sugar yield was not affected by changing nitrogen fertilization sources where the root yield recorded 31.84, 31.5, 31.69 and 31.22 ton /fed. and sugar yield was 5.47, 5.44; 5.57 and 5.08 for U, AN, AS, and CaN, respectively (as an average across its rates). While increasing N application rate whatever its source increased root yield and decreased sugar yield.

The sugar yield was found to be directly proportion to potassiun concentration and inversely proportion to N concentration in sugar beet leaves during vegetative growth. Thus the sugar yield at harvest time could be predicted by determining the nutrient status of the leaves during vegetative growth. A negative relation was detected between a nitrogen concentration in the root and sugar yield as well as juice purity.

The highest root yield (about 32.5 ton/fed.) was obtained by application of 100 kg N/fed for all nitrogen sources.

Finally it could be recommended that the most economically fertilization program for sugar beet crop grown at Kafr El-Sheikh Governorate was application of 60 kg N/fed. particularly as ammonium sulfate along with 15 kg P_2O_5 + 24 kg K_2O/fed. which produced the highest sugar yield (about 6 ton/fed.) and the highest juice purity (78%).

Keywords: Clay soil, N forms, N rates, Sugar beet.

Sugar beet provides about 40% of the world's sugar production. Large amount of sugar is formed in the leaves where great part of it used for growth processes during vegetative period while in the late growing period when vegetative growth slows down, a large part is stored in the roots.

However, sugar concentration in the root is influenced to some extent by nitrogen level in the soil. Adequate nitrogen is required to ensure early maximum vegetative growth, while an excessive amount or application of N late during the growing season reduced sugar content. Radenovic and Dobrodol (1988) obtained the highest sugar beet yield by the application of 150 kgN/ha. This was in accordance with Mearlander (1990) who found that root yield, sugar yield and white sugar yield increased with increasing N supply and reached its maximum value at 153, 136 and 129 kg N/ha, respectively. He added that sugar yield and white sugar yield decreased with N levels beyond optimum. Herthly (1992) demonstrated that optimum N application rate for sugar yield and extractable sugar were 150 and 138 kg N/ha, respectively while each 50kg N/ha higher than this rate decreased sugar concentration by 0.3% and extractability by 0.7%. Kelarestghi and Bahbanizadeh (1993) reported that excessive use of N fertilizer assumed to be responsible for the sugar loss.

Material and Methods

A series of field experiments were conducted during three successive seasons at seven districts representing Kafr El-Sheikh governorate to elucidate the most economically effective nitrogen fertilizer source and rate that produced the highest sugar yield with bet quality. The treatments include the application of four nitrogen fertilizer sources (urea, ammonium nitrate, ammonium sulfate and calcium nitrate at three rates (60,80 and 100 kg N/fed.). Other culture practices were carried out in the manner prevailing in the region. The experimental set up of each trail was designed in a randomized complete block with 4 replicates.

Representative 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). The data are listed in Table 1.

TABLE 1.

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	6.2	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 (1971). Alfa nitrogen, potassium and sodium concentrations were determined according to Chapman and Parat (1961).

Results and Discussions

The effect of various nitrogen fertilizer forms and rates on the concentration of N and K in sugar beet

N % and K % in the leaves after 12 weeks from planting

The data presented in Fig. 1 revealed that increasing N application rate, whatever its source, increased N concentration in leaves, which was quite expected. However, urea and ammonium nitrate were more effective in this respect than ammonium sulfate and calcium nitrate.

Concerning the effect of N fertilization on potassium concentration in leaf blade and petiole of sugar beet plant, it could be noticed from Fig. 2 and 3 that there was a reverse relation between K% in blade and petiole and N application

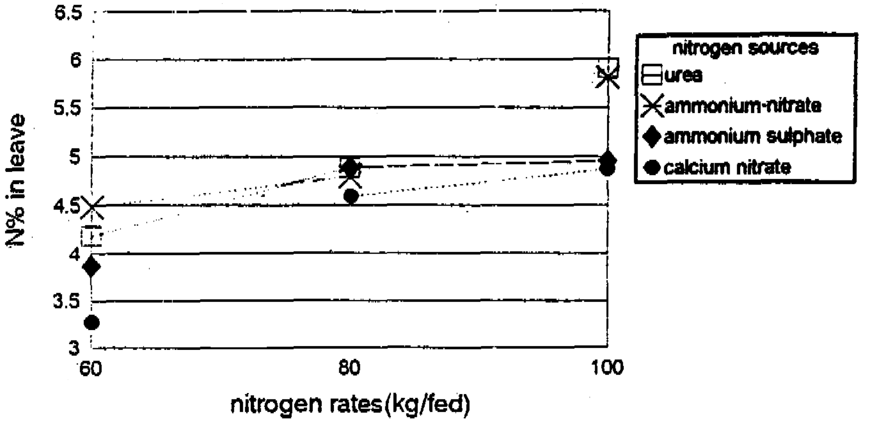


Fig. 1. Effect of various nitrogen sources and rates on N% in sugar beet leaves.

rates which was true for all N sources used. This could be attributed to the dilution effect where increasing N application rate produced vigorous vegetative growth. The depression effect of higher N application rate on K concentration was more pronounced with urea and ammonium sulfate and less effective with calcium nitrate. In this respect, Jones *ct al.* (1991) postulated that, at several N levels, increase of NH_4 -N tended to depress K concentration, which could be attributed to interferes of NH_4 -N with the diffusion of K from the clay lattice as well as competing with K for plant uptake, but increasing the level of Ca tends to nullify the effects of increased N.

Nitrogen compound concentration in roots at harvest time

The effect of nitrogenous fertilization on the concentration of Nitrogen compounds in sugar beet roots was illustrated in Fig. 4. It could be observed from this figure that increasing N application rate (regardless its source) increased the accumulation of N compounds in the roots. However, there were no differences between various N application sources in this respect. This was in harmony with the finding of Mengel and Kirkby (1987) and Agabani *et al.* (1993) who reported that the roots of sugar beet grown at high level of N nutrition are generally characterized by low sugar contents and high concentration of amino compounds.

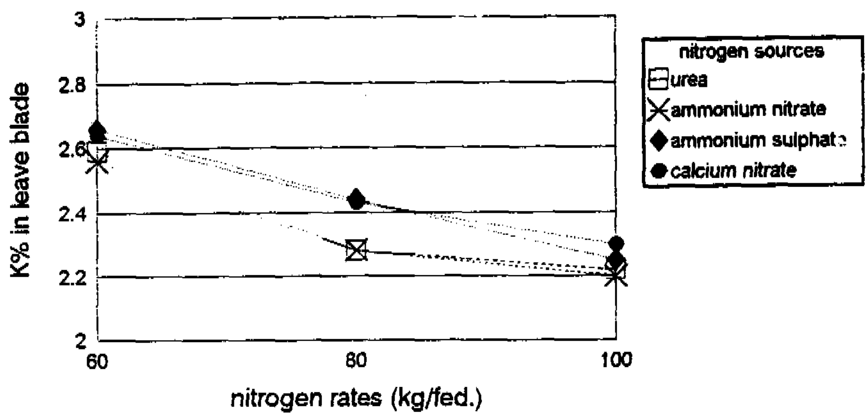


Fig. 2. Effect of various nitrogen sources and rates on K% in sugar beet leaf blade.

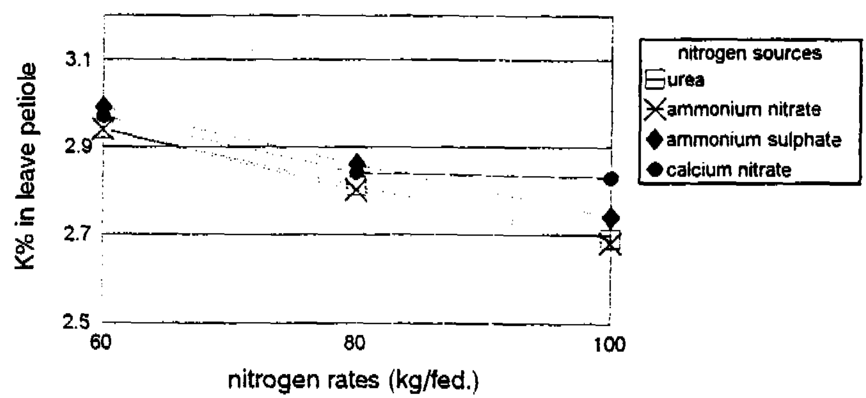


Fig. 3. Effect of various nitrogen sources and rates on K% in sugar beet leaf petiole.

Potassium concentration in the roots at harvest time

There were no appreciable differences between various N sources concerning their effect on K% in roots where it ranged between 5.95 and 6.25%. However, K% in roots exhibit a little decrease by increasing N application rate (Fig. 5).

Sugar beet root yield

It could be noticed from the data presented in Fig. 6 that there was little differences between various nitrogen sources concerning their effect on root yield where it ranged between 31.22 to 31.84 ton / fed for all sources of nitrogen (as an average across its rate). On the other hand, for all forms of N fertilizer used, increasing its application rate up to 100 kgN/fed. increased the root yield. This could be attributed to that, at higher N level the photosynthates are diverted to protein synthesis and thus increased the dry matter accumulation in the root.

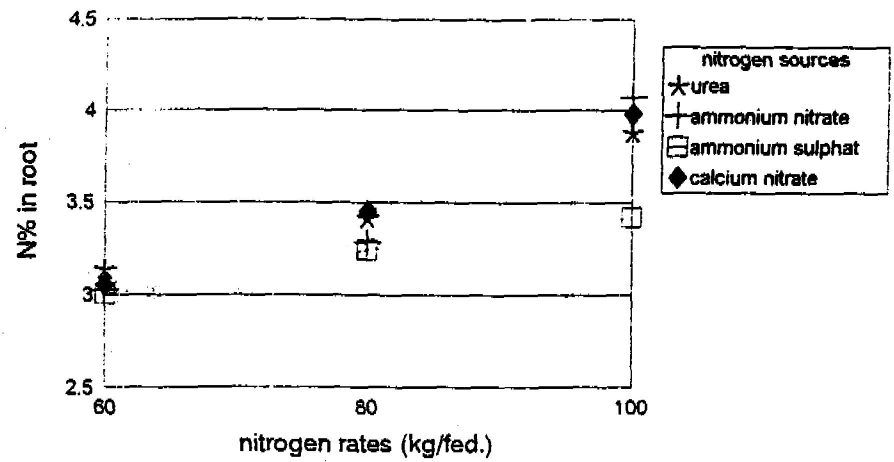


Fig. 4. Effect of various nitrogen sources and rates on nitrogen concentration in sugar beet root.

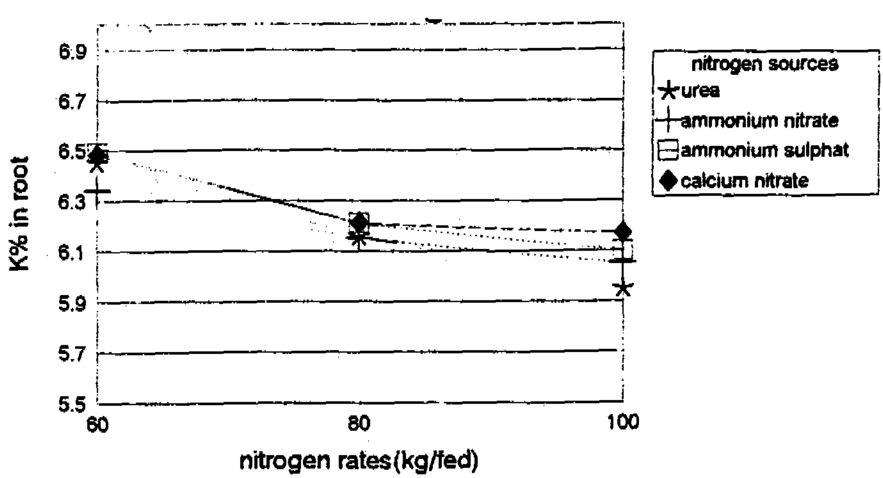


Fig. 5. Effect of various nitrogen sources and rates on potassium concentration in sugar beet root.

This was in accordance with the finding of Sabolic (1987) who found that increasing N application rate increased the yield of sugar beet root.

The root yield could be predicted during vegetative growth by determining N concentration in the leaves at 12 weeks from planting (Fig. 7) where a positive relation was found between these two parameters, which could be expressed by the following equation: Root yield at harvest = 26.38 + 1.08 x N% in the leaves after 12 weeks from planting $r^2 = 0.71$

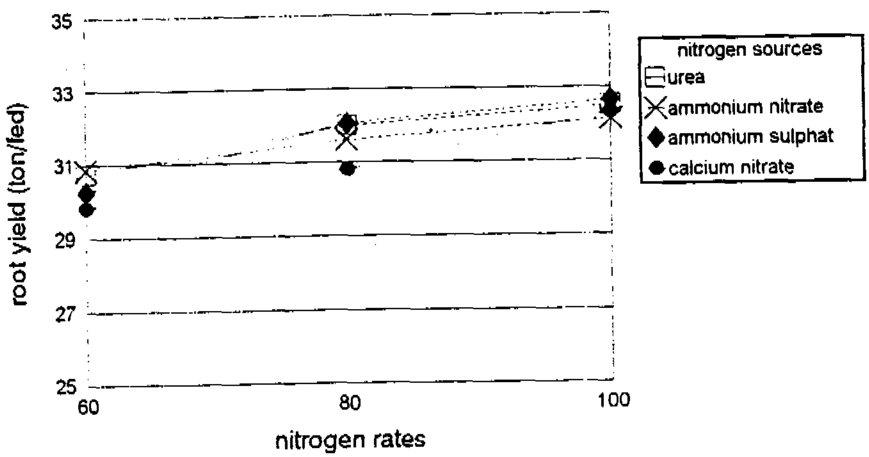


Fig. 6. Effect of various nitrogen sources and rates on potassium concentration in sugar beet root yield .

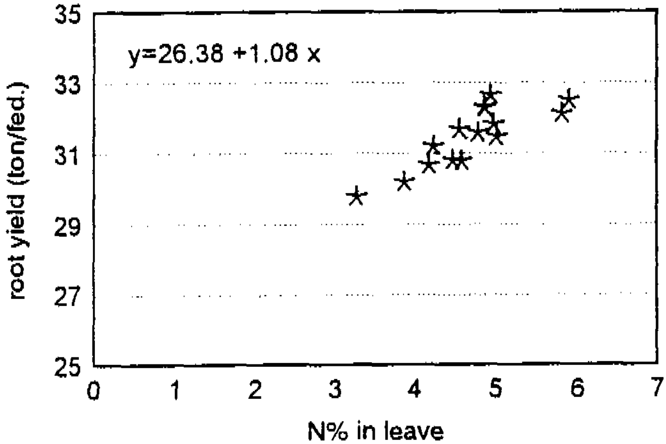


Fig. 7. Relation between sugar beet root yield and nitrogen concentration in the leave.

Sugar yield

The data of sugar yield revealed that increasing N fertilization rate decreased the sugar yield. The effect was more pronounced at higher level whatever the forms of N fertilization (Fig. 8).

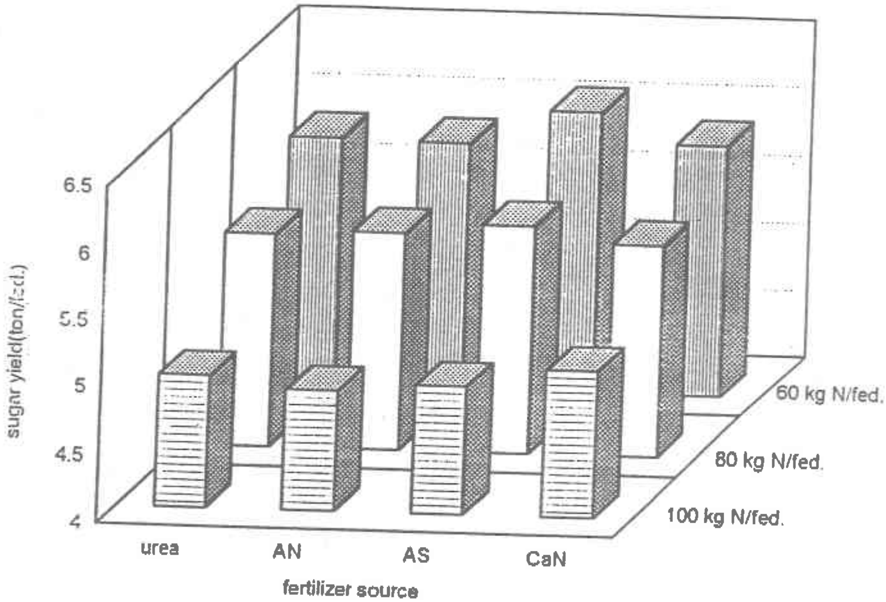


Fig. 8. Effect of various nitrogen fertilizer sources and rates on sugar yield (ton/fed).

It is worth to mention here that the average of the date collected from the seven districts at Kafer El-Sheikh Governorate during three years revealed that every addition of one kg N/fed. over the basal rate (60-kg N/fed) reduced the sugar production by 22.5 kg/fed. This finding confirmed those of Mengel and Kirkby (1987) who demonstrated that the reduction in N supply resulted in a considerable increase in sugar content of the roots and hence an improvement of sugar yield.

Concerning the relation between sugar yield and N concentration in the roots, the data presented in Fig. 9 revealed that the sugar yield was inversely proportion to N concentration in the root. This relation could be expressed by the following equation:

Sugar yield = 8.86 - 0.97 x N% in the root $r^2 = 0.94$

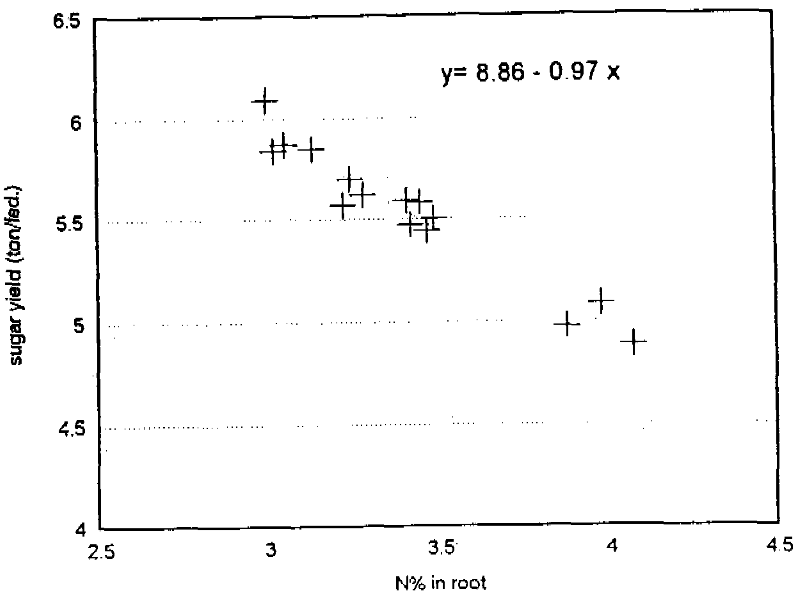


Fig. 9. Relation between sugar yield and nitrogen concentration in sugar beet root.

It was noticed also that there was a close relation between potassium concentration in leaf blade and petiole after 12 weeks from planting and sugar yield at harvest time (Fig. 10 and 11), where the sugar yield could be predicted during the vegetative growth using the following equations :

Sugar yield at harvest = 0.7 + 1.97 x K% in leave blad (after 12 weeks) $r^2 = 0.89$

Sugar yield = -2.4 + 2.69 x K% in petiole (after 12 weeks) $r^2 = 0.80$

On the other hand, the sugar yield was found to be positively related to K% in the root at harvest time (Fig. 12) which was represented by the following equation:

Sugar yield = - 7.47 + 2.08 x K% in root $r^2 = 0.77$

The decrease in sugar yield at higher level of N - nutrition could be due to the utilization of carbon skeleton produced from photosynthesis in amino acid synthesis rather than sugar production. This was in accordance with the finding of Yagodin (1984) who postulated that at vigorous N uptake, most of the carbon fixed in photosynthesis is spent in the biosynthesis of various nitrogenous compounds rather than carbohydrate, thus intensive N nutrition brings down the content of carbohydrate.

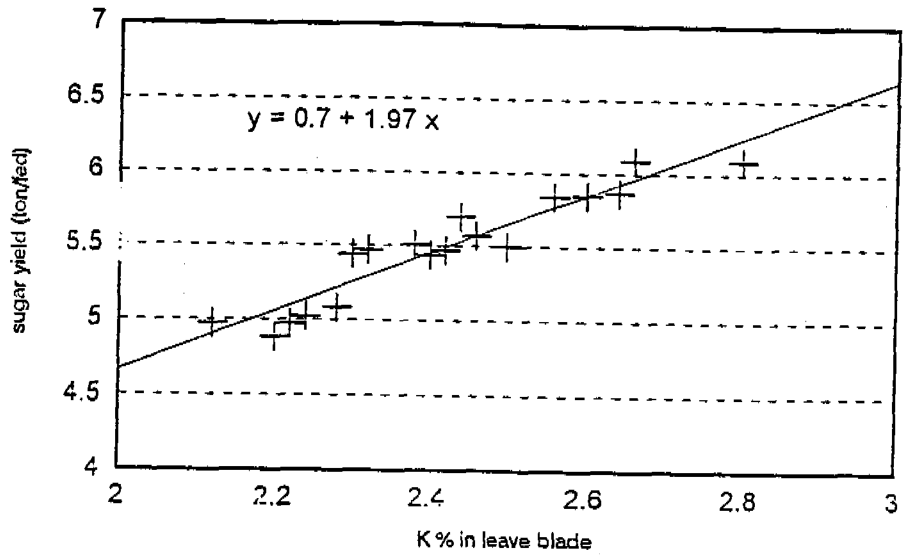


Fig. 10. Relation between sugar yield and potassium concentration in leave blade.

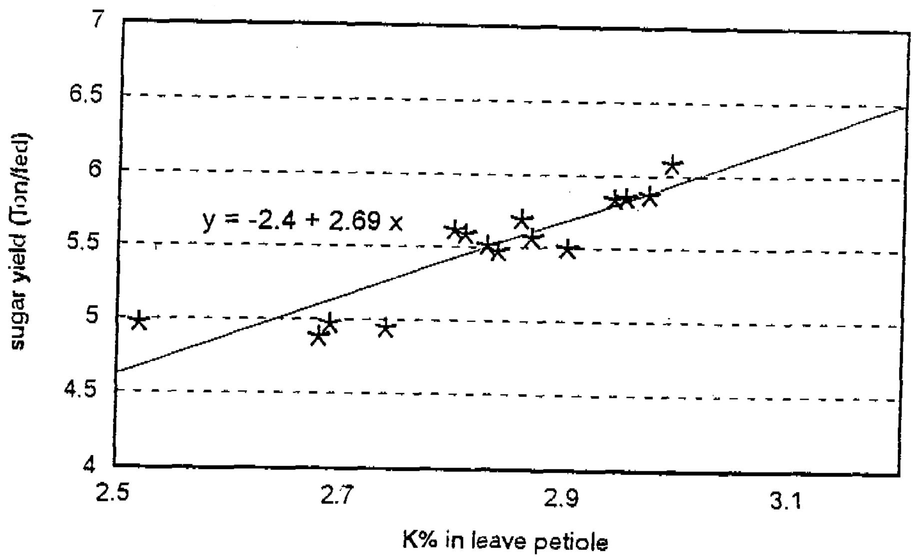
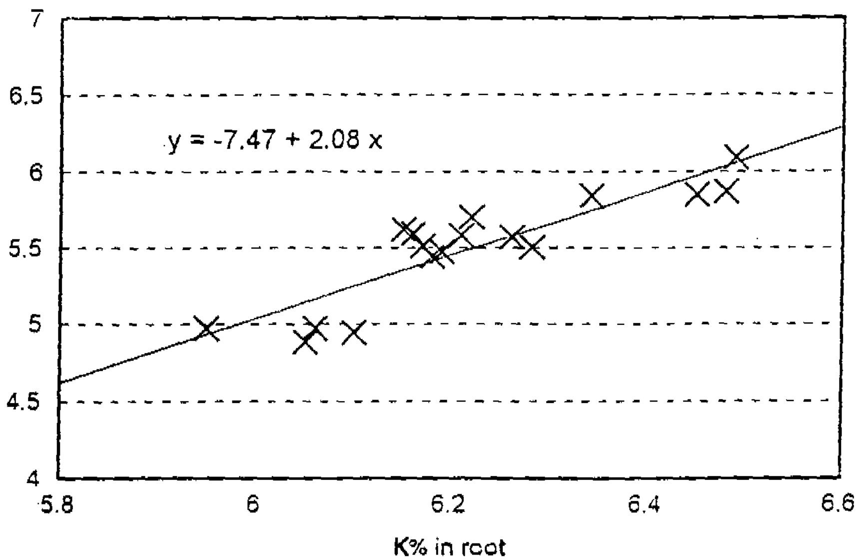


Fig. 11. Relation between sugar yield and potassium concentration in leave petiol.



ig. 12. Relation between sugar yield and potassium concentration in root.

uice purity

The data presented in Fig. 13 revealed that the juice purity was not affected y changing the N fertilization sources but it decreased by increasing its pplication rate.

The purity of the juice was highly dependent on the concentration of amino cid and K in the roots. The relation between juice purity and N% could be xpressed by the following equation:

uice purity = 83.86 - 2.04 x N% $r^2 = 0.86$

This equation reflects the negative relation between juice purity and in turn ugar extractability, and N concentration, where every one unit increase in N oncentration reduced the juice purity by 0.97 unit. This reflects the injurious ffect of the presence of highly concentration of N compounds on sugar xtractability (Fig. 14).

On the other hand, the data presented in Fig. 15 revealed a weak positive elation between juice purity and K% in the roots, as it could be noticed from the ollowing equation:

uice purity = 55.52 + 3.43 x K% in the root $r^2 = 0.515$

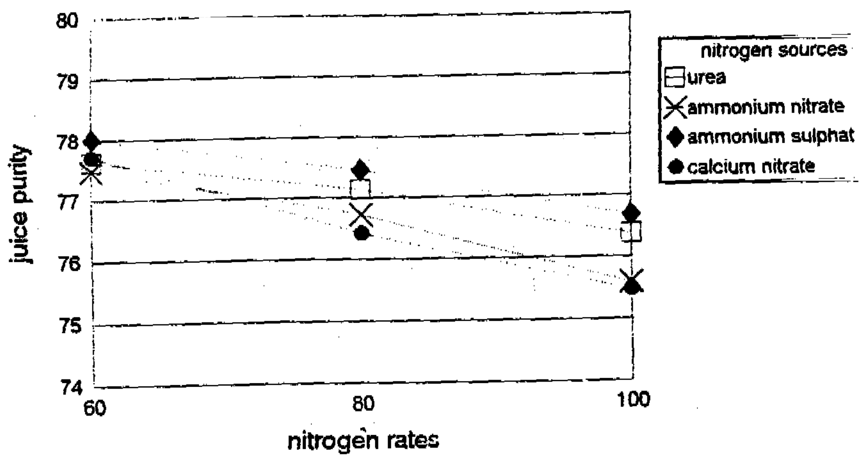


Fig. 13. Effect of various nitrogen sources and rates on juice purity.

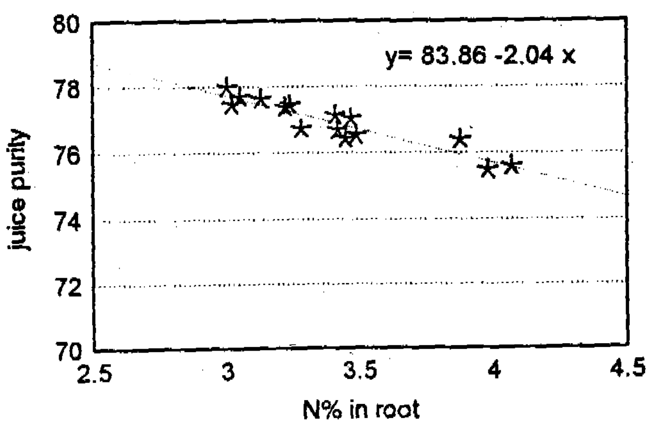


Fig. 14. Relation between juice purity and nitrogen concentration in sugar beet root.

Conclusion

From the forgoing discussion, it could be concluded that the mos economically N fertilization program for growing sugar beet at Kafer El-sheiki Governorate to obtain the highest sugar yield and highest juice purity was th application of 60 kg N/fed whatever its source.

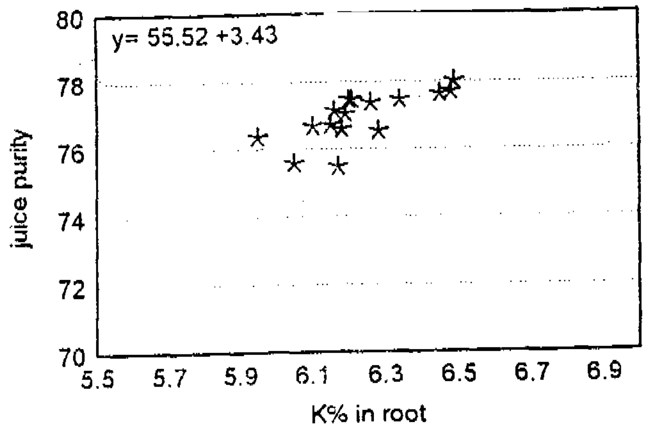


Fig. 15. Relation between juice purity and potassium concentration in sugar beet root.

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استجابة بنجر السكر لصور ومعدلات مختلفة من الأسمدة النتروجينية

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معهد بحوث الأراضى والمياه والبيئة - مركز البحوث الزراعية - الجيزة - مصر .

أقيمت سلسلة من التجارب الحقلية على مدى ثلاث سنوات بسبعة مواقع بمحافظة كفر الشيخ لاختيار اكثر برامج التسميد مناسبه لبنجر السكر حيث استخدمت أربعة مصادر من الاسمدة النتروجينيه هى - اليوريا ، ونترات الأمونيوم ، وكبريتات الأمونيوم ، ونترات الكالسيوم ، بثلاثة معدلات هى ٦٠. ٨٠، ١٠٠ كجم N/فدان بالاضافة لكميات موحدة من الفوسفات والبوتاسيوم بمعدلى ١٠ كجم فو $_٢$أ$_٥$ ، ٢٤ كجم بو $_٢$أ / فدان لكل معاملات التجربة .

وقد وجد أن تركيز البوتاسيوم فى أنصال الاوراق وعرقها الوسطى خلال النمو الخضرى والتركيز فى الجذور عند الحصاد نقص قليلا لزيادة المعدل المضاف من النتروجين بغض النظرعن مصدره. وكان العكس صحيحا لتركيز النيتروجين فى الاوراق والجذور حيث ازداد بزيادة النيتروجين المضاف أيا كان مصدره .

هذا ولم يتأثر محصول الدرنات وكذلك محصول السكر بإختلاف مصدر النيتروجين المضاف حيث سجل محصول الجذور ٨٤ر٣١ ، ٥٠ر٣١، ٦٩ر٣١، ٢٢ر٣١ طن / فدان بينما سجل ناتج السكر من ٤٧ر٥ ، ٤٤ر٥، ٥٧ر٥، ٨٠ر٥ طن /فدان باستعمال اليورياونترات الآمونيوم وكبريتات الأمونيوم ونترات الكالسيوم على الترتيب محسوبا كمتوسطات للمعدلات الثلاثة من كل نوع سماد ، بينما ادت زيادة المعدلات فى كل الاحوال لزيادة فى محصول الدرنات وقلة فى ناتج السكر منها .

وعلى ذلك نجد أن ناتج السكر يتناسب طرديا بشكل مباشر مع تركيز البوتاسيوم وعكسيا مع تركيز النتروجين فى الأوراق خلال موسم النمو الخضرى ، ومن ثم فإن محصول السكر وقت الحصاد

يمكن أن يستدل عليه بتقدير تركيز العنصر فى خلال موسم النمو الخضرى ، هذا وقد رصدت علاقة عكسية بين تركيز النتروجين فى الجذور وناتج السكر منها ونقاوة العصير رغم زيادة المحصول الناتج وزنا حيث بلغ ٥ر٣٢ طن / فدان بإضافة ١٠٠ كجم N/ فدان من اى مصدر من المصادر المستعملة .

أخيرا يمكن التوصية باستخدام ٦٠ كجم N خاصة إذا كانت الصورة المضافة هى كبريتات الأمونيوم ، ١٥ كجم فو $_2$أ$_5$ ، ٢٤ كجم بو $_2$أ / فدان كأفضل برنامج تسميدى لمحصول بنجر السكر النامى فى أراضى محافظة كفر الشيخ من الناحية الاقتصادية حيث ينتج أعلى محصول سكر (حوالى ٦ طن / فدان) وأعلى نسبة نقاوة للعصير (٧٨٪) .