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AGRONOMICAL AND STATISTICAL STUDIES ON THE RESPONSE OF SUGAR BEET TO FOLIAR APPLICATION WITH MICRONUTRIENTS UNDER DIFFERENT MACRONUITRIENTS FORMULA

Nemeat-Alla, E.A.E.* and Samia, G.A. Mohamed**
*** Sugar Crop Res. Inst., ARC, Egypt.**
****Cent. Lab. For Design and Stat. Anal. Res., ARC, Giza, Egypt**

ABSTRACT

Two field experiments were carried out during the two successive seasons of 2001/2002 and 2002/2003 at the Experimental Farm of Sakha Agric. Res. Station at Kafr El-Sheikh Governorate. The parpose was to attain the suitable formula of fertilizer to produce the highest yield and quality. Simple correlation multiple linear regression, stepwise regression, factor analysis and genotypic variability were done.

Data showed that application of 100 kg N + 30kg P_2O_5 + 24 kg K_2O/fed. significantly increased root length and diameter, dry matter accumulation/plant and root/top ratio at harvest time as well as root, top and sugar yields/fed. of sugar beet plants. On the other hand, increasing NPK-fertilizer levels significantly decreased juice quality in terms of TSS, sucrose and juice purity percentages. Application of 60 kg N + 10 kg P_2O_5 + 12 kg K_2O/fed. gave the highest values of the aforementioned traits.

Application of micronutrients three times (at 55, 70 and 85 day after sowing "DAS") produced the highest values of root dimensions, dry matter accumulation/plant at harvest time as well as root, top and sugar yields/fed.

Highly significant correlation coefficients were found between sugar yield (ton/ fed) and root yield (ton/ fed) with all characters .

Root length, root diameter, root fresh weight/ plant, dry mater, root/ top ratio, root yield, top yield, TSS%, sugar percentage and purity are the most prominent on sugar yield variation with R^2 value being 99.37 %.

Stepwise regression analysis detected that root length, root yield/ fed, TSS% and purity were the most important variables affecting sugar yield (ton/ fed).

Factor analysis grouped ten yield contributing characters into three main factors accounting for 88.313% of the total variability in the dependence structure.

It could be concluded that adding 100 kg N + 30 kg P_2O_5 + 24 kg K_2O and three times foliar spraying sugar beet plants with mixture of microelements could be recommended for optimum root and sugar yields per unit area.

INTRODUCTION

Sugar beet (*Beta vulgaris* L.) is the second important sugar crop in the world. The Egyptian government encourages sugar beet growers to decrease the gab between sugar production and consumption. The cost of fertilizers constitutes a significant part of the expenditures required for commercial crop production. Concerning the effect of NPK-fertilizer levels, El-Hennawy *et al.* (1998) and El-geddawy *et al.* (2000) found that root dimensions (length and diameter) were increased by increasing nitrogen levels, Sobh *et al.* (1992) found that application of 24 kg K_2O with 60 kg N+30 kg P_2O_5/fed. gave slight increases in root and foliage yields by 0.73 and 0.80 t/fed., over application of 60 kg N + 30 kg P_2O_5/fed. alone. However, Ghonema and Sarhan (1994) showed that the highest root and sugar yields/fed. were obtained by adding 75 kg N + 60 Kg P_2O_5 + 48 K_2O/fed. While Badawi *et al.* (1995) concluded that addition of 75 Kg N + 15.5 Kg P_2O_5 + 24 kg K_2O/fed. was recommended for raising sugar beet production.

Most of the Egyptian soils suffered from microelements deficiency as a result of the intensive cropping pattern, low organic matter content in soil and alkaline conditions, which decreased the availability of many nutrients. Hassanin and Abu-El-Dahab (1991) and Nemeat- Alla and El-Gedawy (2001) demonstrated that mixed application of microelements gave the highest root and sugar yields. Spraying sugar beet plants with solution of microelements mixture markedly increased root, top and sugar yields (Mohamed, 1993 and Nemeat-Alla, 1997).

Saif (1991) found that application of 0.5 kg B/ fed. or 4 kg. Zn./fed gave the highest values of tops criteria i.e. leaves number, top fresh and dry weight per plant, fresh and dry weight of roots and root dimensions (root length and root diameter). El-Sayed (1993) showed a positive response of TSS% as well as sucrose % due to application of Mn. Osman (1997) found that root length, root diameter and root fresh weight were not significantly affected by micro nutrients mixture (B, Zn, and Mn.) at all levels used. He added that root yield was increased by 13.95%, 11.21%, 9.65% and 11.36% due to applying the higher level of B., Zn., Mn. And their mixture, respectively.

Many crop breeders have turned to growth analysis to attain better selection criteria. They have postulated the importance of selection for some other morphological and chemical characters to achieve high yielding potentiality through applying different statistical techniques like correlation, regression analysis and path coefficient procedures. Factors analysis has been used to identify patterns of yield, yield components and the morphological characters in different crops (El-Shazly *et al.*,1992, Ashmawy *et al.*, 1998 and abd El-Aziz 1999). Also, the stepwise multiple linear regression was used to determine a prediction model for yield.

El-Geddawy *et.al.*, (2000) and Saif (2000) reported that stepwise multiple linear regression was more efficient than the full model regression. It is used to determine the best predictive equation for yield.

The measurements of phenotypic, genotypic and environmental component of variance in sugar yield and other characters have been a matter of great importance. Estimates of the genetic parameters in the population have impacts in methods of practing selection. The genetic advance from selection for a give trait is affected by the mean, the genetic variance and heritability of this trait. The overcome the low heritability of yield, plant breeder are trying to improve this complex trait indirectly by improving the traits known to be associated with yield

The present work was conducted to find out the suitable formula for sugar beet fertilization to attain the highest and the economical yield and quality. Some statistical procedures were used to simple correlation was computed for various characters as outlined by Steel and Torrie (1980).

MATERIALS AND METHODS

Two field experiments were carried out at Sakha Agricultural Research Station, Agricultural Research Center, Egypt, during 2001/2002 and 2002/2003 seasons. The preceding crop was maize in the two seasons. The chemical analysis of the experimental soil is presented in Table (1). The studied fertilizer treatments were as follows:

Spraying treatments :

1- Spraying with distilled water.
2- Spraying with micronutrients mixture once after 55 days from sowing
3- Spraying with micronutrients mixture twice after 55 and 70 days from sowing.
4- Spraying with micronutrients mixture three times after 55, 70 and 85 days from sowing.

NPK formula treatments:

1- 60 N + 10 P_2O_5 + 12 K_2O (kg/fed.).
2- 80 N + 20 P_2O_5 + 18 K_2O (kg/fed.).
3- 100 N + 30 P_2O_5 + 24 K_2O (kg/fed.).

Table (1): Chemical analysis of the experimental soil (0-30 cm in depth) (2001/2002 and 2002/2003 seasons).

Season	PH 1.2-5	EC mmhas/cm	Organic matter %	Zn	Mo	Fe	Cu	Mn	B
				M eq/l					
2001/2002	8.1	3.44	1.80	0.43	0.22	0.70	0.52	1.90	0.39
2002/2003	8.0	3.29	1.84	0.39	0.24	0.75	0.60	2.00	0.37

A split plot design with four replications was used, The main plots were occupied by number of spraying for micronutrients mixture whereas the fertilizer formula were allocated in the sub-plots.

Solution of micronutrients mixture included zinc sulphate, ammonium molybdate, iron sulphate, manganes sulphate and boric acid (each at the rate of 1.0 g/L.) in addition to copper sulphate (at the rate of 0.5 g/L.).

Each sub-plot has six ridges 55 cm apart and 7m long. Sowing took place on 21st Oct. and 2nd Nov. in both seasons, respectively.

Seed of multigerm cultivar "top" was sown in hills 20 cm apart. Plants were thinned to one plant per hill after 40 days from sowing. Phosphorus fertilizer in the form of calcium super-phosphate (15.5% P_2O_5) was added during land preparation and potassium fertilizer in the form of potassium sulphate (48% K_2O) were added once at the 1st dose of nitrogen which applied in the form of ammonium nitrate (33.3% N) in two equal doses. The first one was applied after thinning and the 2nd dose 25 days later. The other cultural practices for growing sugar beet were conducted as recommended.

At maturity (200 days from sowing), a sample of 10 plants was taken at random to determine root dimensions and dry matter accumulation. TSS% was determine by using hand Refractometer, sucrose percentage was determine according to Le Docte (1927) and juice purity percentage was calculated according the following equation according to Silin and Silin (1977).

Purity % = Sucrose %/TSS%

The analysis of variance was carried out according to Gomez and Gomez (1984). Treatment means were compared by Duncan's Multiple Range Test (Duncan, 1955). All statistical analysis were performed using analysis of variance technique by means of "IRRISTAT" computer Software package.

Simple correlation was computed for various characters as outlined by Steel and Torrie (1980).

When it is needed both multiple linear regression as full model and stepwise were used a cording to Draper and Smith (1966). Both calculate two parameters, coefficient of determination (R^2) and stander error of estimates (SE%), to obtain accurately precise, R^2 should be near to one and SE% should be near to zero. R^2 is the amount of variability due to all independent variables. Whereas, SE % is a measurement of precision, i.e. closeness of predicated and observed yield to each other. On the other hand, stepwise multiple linear regression is used to remove multicolinearity between different yield attributes and to screen independent factors to minimum that had the highest partial correlation with yield Draper and Smith (1966).

Factor analysis method according to Catte (965). The method consists of the reduction of a large number of correlated variables to a smaller number of clusters of variables called factors. After the loading data of the first factors, they were taken into account when the second factor was calculated. The process was repeated on the residual matrix to find out further factors. When the contribution of a factor to the total percentage of the trace was less than 10%, the process stopped. After extraction, the matrix of factor loading was submitted to a varimax orthogonal rotation, as applied by Kaiser (1958). The effect of rotation is to accentuate the larger loading in each factor and suppress the minor loading coefficient and in this way an improvement of opportunity for achieving a meaningful biological interpretation of each factor could be realized. Thus, factor analysis indicates both grouping and percentage contribution to total variation in the dependence structure. Since the object was determine the way in which components, related to each other, yield it was included in this structure.

Analysis of variance for each variable and covariance for each pair of variables were performed for a randomized complete block design.

Genotypic and phenotypic coefficients of variance were calculated according to Burton (1951) as follows:

Broad sense heritabilites (H) was calculated as follows :

$$H = (\text{Genotypic variance/ Phenotypic variance}) \times 100$$

The expected genetic advance under selection (G_s) was calculated from the following formula as suggested by Johnson *et al.* (1955).

$G_s = K. \times$ phenotypic standard deviation $\times$ H.

Where K is the selection differential in standard deviation units. In this investigation, the value used for K is 2.06, which corresponds to selecting the best 5%of the population.

Phenotypic, genotypic and environmental correlation coefficients between all possible combinations of characters were calculated from the phenotypic, genotypic and environmental variance and covariance components according to the procedure obtained by Johnson *et al.* (1955) and Miller *et al.* (1958).

Selection for a given characters among the studying genotypes would seem very effective, but these high estimates of heritability may be due to both of the high genetic variability which occurred between these genotypes and to the confounded effects of the environmental conditions.

The equation for computing hertability is:

H = [Genotype variance/(Genotypic variance + Error mean square/ No. of replicates)] and since error mean square is low compared with Genotypic variance and error mean square is further reduced by dividing it by number of replication, the results will be a small addition to Genotypic variance and the denominator of the equation will be almost equal to the numerator.

Consequently, the rate or percent will approach 100%. Even estimating H from a series of experiments, the addition of the interaction variance to the denominator will not affect the estimate considerably, Since the interaction variance is low or negative.

RESULTS AND DISCUSSIONS

The results obtained will be divided into to parts:

I. Agronomical studies.
II. Statistical studies.

I. Agronomical studies:

I.A.1. Growth Characters :

Data in Table (2) showed that increasing the level of NPK-fertilizers significantly increased root dimensions (length and diameter) at harvest in both seasons. Application of 100 kg N + 30 kg P_2O_5 + 24 kg K_2O/fed. recorded the highest values of root length and diameter at harvest, while the application of 60 kg N + 10 kg P_2O_5 + 12 kg K_2O gave the lowest one in the two seasons. These results are in agreement with those of Hassanin and Elayan (2000), El-Geddawy *et al.* (2000) and Nemeat-Alla and El-Geddawy (2001).

Root dimensions (length and diameter) increased by repeating foliar spraying with micronutrients mixture. Application of micronutrients mixture three times resulted in the highest values of roots length and diameter in both seasons (Table 2). These results are in line with those reported by Nemeat-Alla (1997) and Nemeat-Alla and El-Beddawy (2001).

The interaction between the various fertilizer formula rates and application time of microelements mixture had significant effect on root length in the two seasons (Table 3). Beet plants sprayed three times with micronutrients mixture under the application of 100 N 30 P_2O_5 + 24 K_2O kg/fed. produced the highest root length. While beet plants of the control treatment and application of 60 N + 10 P_2O + 12 K_2O Kg/fed. gave the lowest root length.

Table (2): Root length and root diameter as affected by NPK-fertilizer level and application time of micronutrients (2001/2002 and 2002/2003 seasons).

Factor			Root length (cm)		Root diameter (cm)	
			Season			
			01/2002	02/2003	01/2002	02/2003
N	P	K				
60	10	12	22.44 c	24.97 c	10.54 c	10.13 b
80	20	18	24.55 b	26.47 b	11.15 b	11.08 a
100	30	24	26.88 a	28.80 a	11.49 a	11.21 a
Number of spraying						
Without spraying			23.57 d	24.84 d	10.30 d	10.15 d
Once			24.23 c	26.25 c	10.92 c	10.68 c
Twice			25.32 b	27.43 b	11.35 b	11.01 b
Three			26.72 a	28.47 a	11.68 a	11.38 a
Interaction			*	*	NS	NS

Table (3): Root length as affected by the interaction between NPK-fertilizer level and application time of micronutrients (2001/2002 and 2002/2003 seasons).

Number of spraying with micronutrients				
	N	60	80	100
	P	10	20	30
	K	12	18	24
		2001/2002 season		
Without spraying		22.70 f	25.30 e	26.53 d
Once		25.20 e	25.63 e	27.93 c
Twice		25.45 e	26.83 d	30.00 b
Three		26.53 d	28.13 c	30.75 a
		2002/2003 season		
Without spraying		21.58 i	23.90 fg	25.23 d
Once		23.10 h	23.35 gh	26.25 c
Twice		24.18 ef	24.78 de	27.00 b
Three		24.93 d	26.18 c	29.05 a

I.A.2. Dry matter accumulation (g/plant) :

Data in Table (4) showed that dry matter of sugar beet plants was significantly increased with increasing nitrogen, phosphorus and potassium levels in both seasons. The highest dry matter was accumulated with the application of 100 kg N + 30 kg P_2O_5 + 24 kg K_2O/fed. Each increment of applied NPK resulted a significant increase in dry matter/plant. Such effect might be due to the effect of NPK-fertilizer, which resulted in increasing photorynthetic area which followed by more photosythetic production and consequently increased dry matter accumulation/plant. These results are in harmony with those obtained by Nemeat-Alla (1997), Hassanin and Elayan (2000) and Badr (2004).

Table (4): Dry matter accumulation (g/plant) and root/top ratio as affected by NPK-fertilizer level and application time of micronutrients (2001/2002 and 2002/2003 seasons).

Factor			Dry matter (g/plant)		Root/top ratio	
			Season			
			01/2002	02/2003	01/2002	02/2003
N	P	K				
60	10	12	191.23 c	190.83 c	5.14 b	3.72 c
80	20	18	201.71 b	194.75 b	5.58 a	4.01 b
100	30	24	214.39 a	198.63 a	5.64 a	4.93 a
Number of spraying						
Without spraying			198.35 b	193.00 d	5.72	4.36
Once			202.78 a	194.10 c	5.48	4.29
Twice			203.79 a	195.04 b	5.35	4.14
Three			204.86 a	196.15 a	5.26	4.09
Interaction			NS	NS	NS	NS

Repeating the foliar application of microelements mixture resulted in significant differences in dry matter accumulation/plant. The highest values of this tract were obtained when the plants sprayed three times compared with other treatments (Table 4). Similar results were obtained by Mohamed (1993), Nemeat-Alla (1997) and Nemeat-Alla and El-Geddawy (2001).

There was no significant interaction between the two factors under study on dry matter accumulation/plant in both seasons (Table 4).

I.A.3. Root/top ratio :

Data given in Table (4) reveal that application of NPK formula at the rate of 100 kg N + 30 kg P_2O_5 + 24 K_2O/fed. gave the highest root/top ratio in the two seasons. Results from the previous studies of Hassanin and Elayan (2000) showed that root/top ratio increased by increasing N-fertilizer when soil nitrogen was limited.

Application time of microelements failed to induce any significant effect on root/top ratio in both seasons (Table 4). Repeating foliar application with micronutrients tended to decrease top/root ratio, but the difference did not reach the level of significance ($P > 0.05$).

There was no significant interaction between NPK-fertilizer and number of foliar application with microelements on root/top ratio in both seasons (Table 4).

I.B. Top, root and sugar yields/fed.:

I.B.1. Top yield (t/fed.):

Data in Table (5) showed that top yield of sugar beet plants was significantly increased with increasing nitrogen, phosphorus and potassium levels.

Each increment of applied NPK-fertilizer showed significant effect on top yield/fed. in both seasons. The highest top yield was obtained from applying 100 kg N + 30 kg P_2O_5 + 24kg K_2O/fed. in the two seasons. Similar results were obtained by El-Hennawy *et al.* (1998) and Hassanin and Elayan (2000). They found that increasing phosphorus and nitrogen rates gave the highest top yields/fed.

Foliar application with microelements mixture increased top yield in both seasons (Table 5). Application of microelements mixture three times gave the highest top yield/fed. The obtained results are in agreement with those found by Nemeat-Alla (1997) and Nemat-Alla and El-Geddawy (2001)

The interaction between NPK-fertilizer level and application time of microelements had a significant effect on top yield/fed. in both seasons (Table 6).

I.B.2. Root yield (t/fed.):

Root yield/fed. was significantly affected by nitrogen, phosphorus and potassium level in both seasons (Table 5). Application of NPK-fertilizer at the rate of 100 kg N+ 30 kg P_2O_5 + 24 kg K_2O recorded the highest root yield/fed. (29.27 and 31.59 t/fed in the first and the second season, respectively). While application of NPK-fertilizer at the rate of 60 kg N + 10 kg P_2O_5 + 12 kgK_2O gave the lowest values of root yield/fed. in both seasons. The present results coincide with those obtained by El-Hennawy *et al.* (1998) and Nemeat-Alla and El-Geddawy (2001) how found that increasing nitrogen level significantly increased root yield.

Table (5): Root, top and sugar yields/fed. as affected by NPK-fertilizer level and application time of micronutrients (2001/2002 and 2002/2003 seasons).

Factor			Root yield (ton/fed.)		Top yield (ton/fed.)		Sugar yield (ton/fed.)	
			01/2002	02/2003	01/2002	02/2003	01/2002	02/2003
N	P	K						
60	10	12	23.45 b	24.26 c	10.31 c	9.73 c	3.48 c	3.30 b
80	20	18	27.91 a	28.14 b	11.00 b	10.41 b	3.71 a	3.36 b
100	30	24	29.27 a	31.59 a	12.29 a	11.30 a	3.79 a	4.10 a
Number of spraying with micronutrients								
Without spraying			25.89 c	26.27 d	9.60 c	8.90 d	3.59 c	3.45 c
Once			26.49 b	27.78 c	10.66 c	9.69 c	3.60 c	3.61 b
Twice			26.94 b	28.55 b	11.98 b	11.37 b	3.71 b	3.69 b
Three			28.18 a	29.37 a	12.97 a	11.97 a	3.83 a	3.78 a
Interaction			NS	NS	*	*	NS	NS

Beet plants sprayed with mixture of microelements three times recorded the highest root yield per feddan (28.18 and 29.37 tons/fed. in the first and second season, respectively). Similar results were obtained by Nemeat-Alla (1997) and Nemeat-Alla and El-Geddawy (2001).

The interaction between NPK-fertilizer and application time of micronutrients had no significant effect on root yield/fed. in the two seasons (Table 5).

I.B.3. Sugar yield (t/fed.):

The results in Table (5) show that sugar yield per feddan was significantly affected by nitrogen, phosphorus and potassium level in both seasons. The highest sugar yield was resulted from 100 kg N + 30kg P_2O_5 + 24kg K_2O/fed. Similar results were obtained by El-Hennawy *et al.* (1998) and Hassanin and Elayan (2000).

Table (6): Top yield (t/fed) as affected by the interaction between NPK-fertilizer level and application time of micronutrients (2001/2002 and 2002/2003 seasons).

Number of spraying with micronutrients				
	N	60	80	100
	P	10	20	30
	K	12	18	24
		2001/2002 season		
Without spraying		8.26 h	9.79 g	10.76 e
Once		9.75 g	10.32 f	11.91 c
Twice		11.14 d	11.83 c	12.96 b
Three		12.17 c	12.08 c	13.53 a
		2002/2003 season		
Without spraying		7.79 g	9.15 f	9.76 e
Once		8.84 f	9.63 e	10.59 d
Twice		10.86 d	11.26 c	11.99 b
Three		11.44 c	11.62 b	12.86 a

Sugar yield was increased by repeating foliar spraying with micronutrients mixture. These observations are in the line with those reported by Nemeat-Alla (1997) and Nemeat-Alla and El-Geddawy (2001).

The interaction between the two factors under study appeared insignificant effect on sugar yield/fed. in the two seasons (Table 5).

I.C. Quality parameters :

I.C.1. Total soluble solids percentage (TSS%):

Data in Table (7) showed that TSS% was significantly affected by nitrogen, phosphorus and potassium level in both seasons. TSS% was gradually decreased by increasing nitrogen, phosphorus and potassium levels. Excessive addition of nitrogen, phosphorus and potassium reduced TSS%. Similar results were reported by Hassanin and Elayan (2000).

Foliar spraying of sugar beet plants with micronutrients mixture led to decrease TSS% in root juice, but the difference did not reach the level of significance in both seasons (Table 7). Similar results were obtained by Nemeat-Alla and El-Geddawy (2001).

There was no significant interaction between NPR-fertilizer level and number of foliar application with microelements in respect to TSS% in both seasons (Table 7).

I.C.2. Sucrose percentage :

The data in Table (7) cleared that sucrose percentage was significantly affected by NPK-fertilizer levels in the two seasons. Increasing NPK-fertilizer level significantly decreased sucrose percentage. The highest sucrose percentage was obtained from application of 60 kg N + 10 kg P_2O_5 + 12 kg K_2O per feddan in both seasons. Similar results were obtained by El-Hannawy *et al.* (1998).

Table (7): Total soluble solids (TSS), sugar percentage and juice purity as affected by NPK-fertilizer level and application time of micronutrients (2001/2002 and 2002/2003 seasons).

Factor			TSS%		Sugar percentage		Juice purity %	
			Season					
			01/2002	02/2003	01/2002	02/2003	01/2002	02/2003
N	P	K						
60	10	12	18.16 a	16.80 a	14.85 a	13.59 a	81.88	80.96
80	20	18	16.49 b	16.31 a	13.31 b	12.97 b	81.40	80.56
100	30	24	16.014 b	15.37 b	21.93 c	12.37 c	30.82	80.01
Number of spraying with micronutrients								
Without spraying			17.01	16.33	18.86	13.12	81.79	88.90
Once			16.93	16.12	13.76	12.98	81.53	80.63
Twice			16.88	16.11	13.60	12.93		80.36
Three			16.78	16.08	13.57	12.87	80.90	80.12
Interaction			NS	NS	NS	NS	NS	NS

Foliar spraying of microelements mixture revealed no significant differences in sucrose percentage in both seasons (Table 7). Increasing number of spraying with microelements decreased sucrose percentage in beets at harvest, but the differences did not reach the level of significance.

The interaction between NPK-fertilizer level and number of foliar spraying with micronutrients had no significant effect on sucrose percentage in the two seasons (Table 7).

I.C.3. Juice purity percentage :

The results in Table (7) showed that juice purity of sugar beet plants at harvest was significantly decreased with increasing the level of NPK-fertilizer in both seasons. Similar results were obtained by Nemeat-Alla and El-Geddawy (2001).

Repeating foliar spray with micronutrients mixture decreased juice purity percentage in sugar beet roots in both seasons (Table 7). Similar results were obtained by Nemeat-Alla and El-Geddawy (2001).

There was no significant effect on juice purity percentage due to the interaction between the two factors under study (Table 7).

Table (8): Mean values standard deviation for ten sugar beet characters

Variables	Mean	Standard deviation
Root length (X1)	25.85	2.28
Root diameter (X2)	10.93	0.76
Dry matter (X3)	199.84	13.24
Root/ top ratio (X4)	4.80	0.81
Root yield/ T/fed (X5)	27.76	3.37
Top yield/ T/fed (X6)	10.84	1.51
TSS Percentage (X8)	16.53	1.05
Sugar percentage(X9)	13.34	0.93
Purity (X10)	80.94	0.73
Sugar yield (X7)	3.68	0.34

Simple correlation coefficients:

Correlation coefficients for sugaı yield and its attributes are shown in Table (9). Results indicate positively and highly significant correlation coefficients between sugar yield/ fed and each of root length (cm), root diameter (cm), dry matter, root/top ratio, root yield (ton/ fed) and top yield (ton/ fed). Purity was found to be highly significant and negatively correlated with sugar yield. While T.S.S% and sugar percentage were found to be not significant and negative correlated with sugar yield.

Highly significant positive correlation was found between root yield (ton/fed) and root length (cm), root diameter (cm), dry matter, root/ top ratio and top yield ton/ fed. While T.S.S %, sugar percentage and purity were found to be highly significant and negatively correlated with root yield ton/ fed. The previous results indicate that selection for these characters would improve the productivity of sugar beet crop because of their highly significant correlation with yield. These results are similar to those reported by **El-Geddawy *et.al* (2000), and Saif (2000).**

Multiple linear regression analysis:

Multiple linear regression and stepwise analysis were estimated to determine the most contributing factors to yield (Y). Multiple coefficient of determination (R^2) for full model i.e. the amount of y variability due to all independent variables, was estimated for all characters and was compared to (R^2) of stepwise analysis Tables (10 and 11). The results of multiple linear regression presented in Tables (10 and 11), shows the predication equation for root yield and sugar yield are formulated as follows (model 1 and model 2):

The second model

[2] $\acute{Y}$ = -2.3813 - 0.0063X1* - 0.0044X2 + 0.0003X3 - 0.0045X4+ 0.1337X5** -0.0026X6 + 0.0194X8 + 0.2383X9**- 0.0118X10.

R^2 = 99.37 SE% =0.77

Table (9): Simple correlation coefficients between sugar beet yield and its components (combined analysis for both seasons of 2003 and 2004)

Variable	X1	X2	X3	X4	X5	X6	X8	X9	X10	X7
Root length Cm (X1)	1.00									
Root diameter (X2)	0.64**	1.00								
Dry matter (X3)	0.18**	0.41**	1.00							
Root/ top ratio (X4)	-0.11	0.22**	0.41**	1.00						
Root yield/ T/fed (X5)	0.81**	0.73**	0.43**	0.26**	1.00					
Top yield/ T/fed (X6)	0.67**	0.83**	0.45**	0.22**	0.69**	1.00				
TSS Percentage (X8)	-0.43**	-0.29**	-0.19**	0.12	-0.57**	-0.16*	1.00			
Sugar percentage(X9)	-0.53**	-0.34**	-0.20**	0.13	-0.64**	-0.21**	0.99**	1.00		
Purity (X10)	-0.84**	-0.48**	-0.11	0.28**	-0.70**	-0.45**	0.52**	0.62**	1.00	
Sugar yield (X7)	0.66**	0.69**	0.41**	0.42**	0.84**	0.72**	-0.05	-0.12	-0.47**	1.00

* and ** indicate significant at 0.05 and 0.01 levels of significance.

Table (10): Accepted and removed variables according to stepwise analysis and their relative contribution (R2) in root yield variance in sugar beet, (model 1)

Variable		Full model regression		Stepwise regression		Prediction equation
Accepted	Removed	R^2	SE%	R^2	SE%	
X1	X2+x3+x4+X6	81.03	5.43	65.10	7.20	Y=-2.9920+1.1898X1**
X1 + X4	X2 +X3+X6			77.25	5.84	Y=-11.3902+1.2445X1** +1.4536X4**
X1+X2+X4	X3+X6			79.45	5.58	Y=-14.9684+1.035X1** +0.9364X2**+1.1950X4**
X1+X2+X3+X4	X6			80.60	5.45	Y=-18.4481+1.0324X1**+ 0.7522X2**+0.321X3**+1.0166X4**

R^2%= coefficient of determination SE% = standard error

Table (11): Accepted and removed variables according to stepwise analysis and their relative contribution (R2) in sugar yield variance in sugar beet, (model 2)

Variable		Full model regression		Stepwise regression		Prediction equation
Accepted	Removed	R^2	SE%	R^2	SE%	
X5	X1+X2+x3+x4+X6+X8+X9+X10	99.37	0.77	70.81	5.05	Y=1.3091+0.0855X5**
X5 + X8	X1+X2+x3+x4+X6+X9+X10			98.56	1.13	Y=-3.1809+0.1229X5** + 0.2089X8**
X1+X5+X8	X2+x3+x4+X6+X9+X10			98.85	1.01	Y=-3.0552-0.0137X1** + 0.1306X5**+0.2099X8**
X1+X5+X8+X10	X2+x3+x4+X6+X9			98.90	0.99	Y=-4.7306-0.0086X1**+ 0.1302X5**+0.207X8** +0.0198X10*

R^2%= coefficient of determination SE% = standard error

The relative contribution (R^2) for yield factors explained that 81.03% of total variation in root yield could be linearly related to variation in all variables, and 18.97% could be due residual in (model 1). While in the second model the relative contribution (R^2) for yield factors explained that 99.37% of total variation in sugar yield could be linearly related to variation in all variables, and 0.63% could be due residual.

The standard error was 5.43 % and 0.77% in models 1 and 2 respectively. In this analysis all variables added in predication equation, as more variables made the interpretation of association more complex. On the other hand, some variables my contribute little to accuracy of prediction of equation. In addition, given that the numbers of observations were much greater than the number of potential x variables unaer consideration, the addition of a new variable will always increases R^2 but it will not necessary increase the precision of the estimate of the response. This is because of the residual sum of squares reduction could be less than the original residual mean square. If one degree of freedom was removed from the residual degrees of freedom, the resulting of mean square may get large. At this point, the stepwise multiple linear regression analysis was carried out to determine the best variables accounted for most of variance in yield

Stepwise regression analysis:

The stepwise multiple regression analysis was used to determine the best variables that mostly reduced the variance of yield. This was done by introducing the variables in order of importance. Tables (8 and 9) demonstrate the accepted and removed variables and reduction in yield variance caused by each variable. The accepted variables had in highest coefficient of multiple determination with the yield adjusted for variables already added. Table (10) Show that the accepted variables were root length (X1), root top ratio (X4), root diameter (X2) and dry matter (X3). Those variables were responsible for 65.10%, 77.25%, 79.45% and 80.60%, respectively of root yield variance, with standard error equal to 7.20%, 5.84%, 5.58% and 5.45%, respectively.

As previously mentioned, the root length (X1) and root top ratio (X4) were the most important variables in stepwise analysis in this model.

<u>The first model:</u>

[1] $\acute{Y} = -18.4481+1.0324X1^{**}+0.7522\,X2^{**}+0.0321X3^{**}+1.0166X4^{**}$

The second model Table (10) the accepted variables were root yield (X5), TSS% (X8), root length (X1) and purity (X10). Those variables were responsible for 70.81%, 98.56%, 98.85% and 98.90% respectively of sugar yield variance, with standard error equal to 5.05%, 1.13%, 1.01% and 0.99% respectively.

As previously mentioned the root yield (X5) and T.S.S% (X8) were the most important variables in stepwise analysis in this model 2.

<u>The second model</u>

[2] $\acute{Y} = -4.7306 - 0.0086X1^{**} + 0.1302\,X5^{**} + 0.207X8^{**} + 0.0198X10^{*}$

Factor analysis :

Results of factor analysis are shown in Tables (12 and 13). Factors were constructed by applying the principal factor analysis approach to establish the dependent relationship between yield components in sugar beet. Factor analysis grouped the studied ten characters into three main factors. Factor greater than 0.50 were considered important the results indicate that the three obtained factors explained 88.313% of total variation in the dependent structure. Factor 1 accounted for 54.52% of the total variability and included six variables, i.e. root length, root diameter, root yield, top yield, sugar yield and purity. These variables had equal importance and high communality with factor 1.

Table (12): The results of factor analysis for ten variables elated to sugar beet

Variable	Factors			Communality
	Factor 1	Factor 2	Factor 3	(h^2)
Root length Cm (X1)	0.871	- 0.526	0.187	1.07
Root diameter (X2)	0.858	- 0.315	- 0.269	0.907
Dry matter (X3)	0.642	- 0.333	- 0.722	1.04
Root/ top ratio (X4)	0.186	0.136	- 0920	0.899
Root yield/ T/fed (X5)	0.900	- 0.363	- 0.265	1.01
Top yield/ T/fed (X6)	0.882	- 0.188	- 0.279	0.911
Sugar yield (X7)	0.885	- 0.126	- 0.431	0.984
TSS Percentage (X8)	- 0.298	0.988	- 0.102	1.07
Sugar percentage(X9)	- 0.384	0.996	- 0.133	1.15
Purity (X10)	- 0.712	0.623	- 0.393	1.04
Latent roots	5.452	2.187	1.192	8.831
Factor variance ratio %	54.523	21.874	11.917	88.31

Factor 2 included two variables, which accounted for 21.87%of total variance. These two variables were TSS% and sugar perecentage.

Factor 3 included two variables, which accounted for 11.92% of total variance. These two variables were dry matter and root top ratio. The sign of the loading indicates the direction of the relationship between the factor and variable.

The results of the current study indicated that the estimated communalties Table (13) were adequate for conclusion since both obtained factors contributed 88.313 to the total variability of the dependent structure.

Factor 1 had high loading for the included variable Table (13). The correlation between these variables and factor 1 is given by the suitable factor loading. These results are on line with those reported by Abd El-Aziz *et al.* (1999) and El-Geddawy *et al.* (2000)

The factor analysis approach is one that can be used successfully for analysis of a large amount of multivariate data and it should be applied more frequently in the field of crop research. Interpretation of the meaning of the factor isolated from a factor analysis could be a subjective procedure. The greatest benefit of factor analysis can be delineating areas of future research designed to test the validity of the suggested factors. Using factor analysis by plant breeders has the potential of increasing the comprehension of causal relationships of variables and can help to determine the nature and sequence of traits to be selection in breeding programs.

Table (13): Summary of factor loading for ten variables of sugar beet

Variable	Loading	% of total communality
Factor 1		54.523
Root length Cm (X1)	0.871	
Root diameter (X2)	0.858	
Root yield/ T/fed (X5)	0.900	
Top yield/ T/fed (X6)	0.882	
Sugar yield (X7)	0.885	
Purity (X10)	-0.712	
Factor 2		21.874
TSS Percentage (X8)	0.988	
Sugar percentage(X9)	0.996	
Factor 3		11.917
Dry matter (X3)	0.722	
Root/ top ratio (X4)	-0.920	
Cumulative variance		88.313

Genetic parameters:

Estimates of phenotypic, genotypic and environmental variance for some characters in sugar beet obtained from the analysis of variance are presented in Table (14). Results showed similar phenotypic and genotypic variances trend concerning the studied characters namely, root length, root diameter, rot/ top ratio, root yield, top yield and sugar yield. The highest values phenotypic and genotypic variance were 0.413 and 0.385 for root yield in the first season. With regard to environmental effects, results in Table (15) clear that sugar yield gave the lowest values of environmental variance (0.007 and 0.008 in the first and second seasons, respectively).

Estimates of phenotypic coefficient of variation (P.C.V) genotypic coefficient of variation (G.C.V), heritability (H%), genetic advance selection (Gs) and advance is ranged from 2.06 for the second season in sugar yield character to 5.25 in the first season in root/ top ratio characters. While genetic advance under selection, (Gs), is ranged between 0.57 and 6.02 over two seasons. In general, heritability estimates were high and comparable for most of the studied characters.

Table (14): Estimates of phenotypic, genotypic and environmental variance for some sugar beet characters in two season's 2003/2004.

Characters	Season	Variance		
		Phenotypic	Genotypic	Environmental
Root length	2003	0.279	0.194	0.340
	2004	0.360	0.250	0.440
Root diameter	2003	0.044	0.015	0.117
	2004	0.044	0.013	0.123
Root/ top ratio	2003	0.076	0.007	0.278
	2004	0.087	0.003	0.022
Root yield	2003	0.413	0.385	0.113
	2004	0.161	0.118	0.173
Top yield	2003	0.125	0.116	0.038
	2004	0.081	0.070	0.043
Sugar yield	2003	0.005	0.003	0.007
	2004	0.003	0.0005	0.008

Table: (15) Estimates of phenotypic coefficient of variation (P.C.V), genotypic coefficient of variation (G.C.V), heritability (H%), genetic advance under selection (Gs) and genetic advance (%) of general mean (Gs%) for some sugar beet characters in two season's 2002/2003.

Characters	Season	P.C.V	G.C.V	H%	Gs	Gs% of x
Root length	2003	2.12	1.77	69.53	75.65	3.03
	2004	2.24	1.87	69.44	85.82	3.21
Root diameter	2003	1.89	1.11	34.09	14.73	1.33
	2004	1.94	1.06	29.45	12.72	1.18
Root/ top ratio	2003	1.42	1.55	9.21	5.25	0.97
	2004	2.22	1.35	37.14	7.16	1.69
Root yield	2003	2.33	2.25	93.22	123.44	4.49
	2004	1.43	1.23	73.29	60.58	2.16
Top yield	2003	3.16	3.04	92.43	67.45	6.02
	2004	2.72	2.52	86.41	50.66	5.75
Sugar yield	2003	1.90	1.54	65.35	9.52	2.56
	2004	1.37	0.62	20.00	2.06	0.57

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دراسات محصولية وإحصائية على استجابة بنجر السكر للرش بالعناصر الصغرى تحت معادلات سمادية مختلفة للعناصر الكبرى

السيد أحمد السيد نعمت الله*، سامية جودة عطية محمد**
* معهد بحوث المحاصيل السكرية – مركز البحوث الزراعية
** المعمل المركزى لبحوث التصميم والتحليل الإحصائى – الجيزه – مصر

أقيمت تجربتان حقليتان خلال موسمى الزراعـة ٢٠٠١/٢٠٠٢، ٢٠٠٢/٢٠٠٣م وذلـك بالمزرعة البحثية لمحطة البحوث الزراعية بسخا – كفرالشيخ. وقد تم تنفيذ تلك التجارب لتقـدير احتياجات نبات بنجر السكر من السماد النيتروجينى والفوسفورى والبوتاسى وكذلك لعدد مـرات الرش بمخلوط من العناصر الصغرى للحصول على أعلى إنتاجية وجوده عالية.

أجريت التحليلات الإحصائية التالية: تحليل التباين، الارتباط البسيط، الانحـدار المتعـدد الخطي ، تحليل العامل والتباين الوراثي.

ويمكن تلخيص أهم النتائج فيما يلى :

تشير النتائج المتحصل عليها على أن زيادة معدلات السماد النيتروجينى والفوسفورى والبوتاسى لنبات بنجر السكر أدت الى زيادة معنوية فى طول وقطر الجذر، المادة الجافة المتجمعه بالنبات وكذلك نسبة الجذور الى العرش وقت الحصاد وكذا محصول الفدان من الجذور والعرش والسكر.

وقد أدت إضافة ١٠٠كجم نتروجين + ٣٠ كجم فو٢أ٥ + ٢٤ بو٢أ/ فدان الى الحصول على أعلى القيم لكل الصفات سابقة الذكر. ومن ناحية أخرى، أدت زيادة معدلات السماد النيتروجينـى والفوسفورى والبوتاسى الى نقص معنوى فى كل من صفات المواد الصلبة الذائبة ونسبة السكروز ونسبة نقاوة العصير فى جذور بنجر اسكر وقت الحصاد. أدت إضـافة ٦٠كجـم نيتـروجين + ١٠كجم فو٢أ٥ + ١٢ كجم بو٢أ الى الحصول على أعلى القيم من هذه الصفات.

تشير النتائج أيضا الى أن إضافة مخلوط العناصر الصغرى ثلاث مرات (عند ٥٥، ٧٠، ٨٥ يوما من الزراعة) أدت الى الحصول على أعلى القيم من كل من طول وقطر جذور بنجر السكر، المادة الجافة المتجمعه بالنبات وكذا محصول الفدان من الجذور والعرش والسكر. بينما لم يكن هناك أى تأثير معنوى لعدد مرات الرش على كل من نسبة الجذور الى العرش وكذا المواد الصلبة الذائبة ونسبة نقاوة العصير عند الحصاد.

ونستخلص من هذه الدراسة:

١- أن إضافة السماد النيتروجينى والفوسفورى والبوتاسى بمعدل ١٠٠كجم نيتروجين + ٣٠كجـم فو٢أ٥ + ٢٤كجم بو٢أ مع الرش بمخلوط العناصر الصغرى ثلاث مرات يمكن أن ينصح بـه للحصول على أعلى محصول من الجذور والسكر لوحدة المساحة تحت ظروف هذه الدراسة.

٢- دلت نتائج تحليل الارتباط البسيط علي وجود ارتباطا معنويا موجبا بين محصول السكر وكل من طول الجذر، قطر الجذر ،الوزن الجاف، النسبة بين محصول الجذر والمجموع الخضري، محصول الجذر بالطن/ فدان والمحصول الخضري بينما دلت صفة النسبة المئوية للنقاوة علي

وجود ارتباط معنويا سالبا مع محصول السكر وأيضا دلت النتائج على عدم وجـود ارتبـاط معنويا بين محصول السكر والنسبة المئوية للمواد الذائبة الكلية ، والنسبة المئوية لسكر.

٣- أوضحت نتائج تحليل الانحدار المتعدد أن كل الصفات قد أسهمت في محصول السكر بنسـبة ٩٩,٣٧ % وكذلك بالنسبة لمحصول الجذر بالطن/ فدان قد أسهمت الصفات بنسبة ٨١,٠٣%.

٤- أوضحت نتائج تحليل الانحدار المرحلي المتعدد أن أكثر الصفات إسهاما فى محصول السكر هي محصول الجذر(طن/ فدان) ، طول الجذر، النسبة المئوية للمواد الذائبة الكلية ، والنسـبة المئوية للنقاوة. وان نسبة المساهمة كانت ٩٨,٩٠% من جملة المتغيرات تحت الدراسة.

٥- أوضحت نتائج تحليل الانحدار المرحلي المتعدد أن أكثر الصفات إسهاما فى محصول الجـذر (طن/ فدان) هى وكل من طول الجذر، قطر الجذر ، والنسبة بين محصول الجذر والمجموع الخضري قد أسهمت الصفات بنسبة ٨١,٠٣ % من جملة المتغيرات تحت الدراسة.

٦- أظهرت نتائج تحليل العامل أن الصفات تحت الدراسة تجمعت في ثلاث عوامل وقد أسهمت هذه العوامل بحوالي ٨٨,٣١% في التباين الكلي لمحصول السكر وضم العامل الأول طـول الجذر، قطر الجذر، محصول الجذور، محصول العرش، محصول السكر والنسـبة المئويـة للنقاوة وقد ساهم هذا العامل بحوالى ٥٤,٥٢% من التباين الكلى لمحصول السكر. أما العامل الثانى فقد ساهم بحوالى ٢١,٨٧% من التباين الكلى لمحصول السكر وضم النسـبة المئويـة للمواد الذائبة الكلية والنسبة المئوية للسكر وضم العامل الثالث الوزن الجـاف والنسـبة بـين محصول الجذر ومحصول العرش وقد ساهم بحوالى ١١,٩١% فى التباين الكلى لمحصـول السكر.

٧- ودلت النتائج عند تقدير درجة التوريث أن معظم الصفات ذات إسهاما عاليا وتقع مـا بـين ٢٩,٤٥% - ٩٣,٢٢% في كلا الموسمين ماعدا محصول السكر والنسـبة بـين المجمـوع الجذرى والمجموع الخضري