MULTIVARIATE ANALYSIS OF YIELD AND RELATIVE CONTRIBUTION OF VARIABLES TO ITS VARIATION UNDER SOME CULTURAL PRACTICES IN SUGAR BEET

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ABSTRACT

The present work was conducted in three field trials that were separately carried out in two successive seasons during 1995/1996 and 1996/1997 at upper Egypt to find out the relative advantage of some cultural practices to yield and quality attributes of sugar beet.

The 1st experiment included 14 treatments which were the combination between two sugar beet varieties and 7 sowing patterns. The 2nd experiment included 10 intercropping treatments representing the various combinations between two sugar beet varieties and five intercropping patterns. The 3rd trial consists of 15 treatments which were the combinations betwen three levels of boron (zero applcation, 0.5 and 1 kg.B./fed.),and five levels of zinc (zero application, 1,2,3 and 4 kg. Zn./fad.).

The important results could be summarized as follow:-

Sowing sugar beet plants as usual in rows 50cm. between rows and 20 and/or 25cm. between hills attained the highest sugar beet roots yield. Moreover, increasing the plant population per unit area by sowing sugar beet in the two sides of banks (1 m. in width), in addition to one more row in the middle of the bank and 20 cm. between hills recorded the highest values of juice purity and sugar yield.

Cultivating intercropping onion with sugar beet (T5), significantly lowered sugar beet yield. However, companion onion with sugar beet attained an additional income represented in the total income 4.1 tons onion (LE. 3200), in addition to the total revenue of the beet itself (LE. 1883). Meanwhile, the highest pure stand of sugar beet produced 31.4 tons/fad. attaining total profit (LE. 2198). Application of 1 kg.B./fad. produced 4.9 ton/fad. over unfertilized treatment. This increase was too limited (1.3 ton/fad.) over check treatment when Zn. element was applied by 1kg.zn./fad.

A principal factor analysis was performed to analyze the relationship between ten variables of sugar beet in three experiments for two cultivars, Sofi and Hilma in a two successive seasons during 1995/96 and 1996/97 at Shandaweel Research Station in Sohag Governorate. These variables were also used in a stepwise multiple linear regression to study the relationship between them and sugar yield to construct a general equation for predicting yield.

Factor analysis indicated that root length, sucrose, purity and sugar yield were the most important in the three experiments. Factor analysis clarified the relationship between correlated variables in the dependence structure. When the relative contributions from root diameter (X1), root number (X3), root/yield (X5), TSS% (X8) and purity (X9), were combined in linear regression equation. Their contribution to yield was 97.53% for the first experiment. Root number (X3), root/yield (X5), sucrose (X7) and purity (X9), shared with 98.24% for the second experiment, while it was 96.86% for root/yield (X5), sucrose (X7) and purity (X9), for third experment. The equations were:

$$1\text{-}Y=-5.8739+0.0479(X1)+0.00001(X3)+0.0509(X5)+0.096(X8)+0.0663(X9) \quad \text{for exp (1)}$$

$$2\text{-}Y=-4.7019+0.00001(X3)+0.0828(X5)+0.2103(X7)+0.0301(X9) \quad \text{for exp (2)}$$

$$3\text{-}Y=-6.089+0.1005(X5)+0.149(X7)+0.0372(X9) \quad \text{for exp (3)}$$

Path coefficient analysis was used to establish the relative importance of yield faddan in three experiments. The results indicated that purity, sucrose and root yield were the major and the most consistent sources accounting for of 80.48%, 98.31% and 96.93% of yield variation in the three experiments, respectively.

INTRODUCTION

Increasing soil productivity become the main goal not only for the producers but also for the policy maker throughout the agricultural organization. Maxmizing soil productivity could occur through the recommended results in respect to some agronomic practices such as nutrition, irrigation and plant population which almost has a direct effect on the final yield specially for sugar beet. Moreover, agricultural intensifications is considered one of the suitable ways for the clever farmers in Egypt to improve land usage and consequently increase unit area productivity. El-Geddawy et al. (1988), found that sugar cane yield was significantly affected when intercropped with wheat. Cane yield was reduced by 18.18% as compared with the pure stand whereas negligible differences in yield of wheat were recorded when grown in pure stand or intercropped in three or five rows between cane ridges. El-Geddawy et al. (1994), pointed out that intercropping sugar beet with cane increased sucrose percentage of sugar beet roots, they added that intercropping beet with cane let to significant reduction in yield of cane stalk and beet roots compared with their yields in the pure stand. Sugar beet grown in 56 cm. row width or less responded with a high sugar yield and sucrose percentage than sugar beet grown in the wider row width (Yonts, and Smith, 1997). Saif (1991) found that application of 0.5 kg.B/fed. or 4kg. 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) cleared 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 procedure Abd-Elhakim (1993). Yield is athecomplex character determined by several variables. Hence, it is essential to detect the characters having the greatest influence on yield and their relative contrbutions to variation of yield. This is useful in designing and evaluating breeding programs. Factor analysis has been used to identify patterns of yield, yield components and the morphological characters in different crops (Walton, 1972, Denis and Adams, 1978, Ibrahim et al., 1984, Seyam et al., 1984, El-Rassas et al., 1990, El-Shazly et al 1992). Also, the stepwise multple linear regression was used to determined a prediction model for yield.

The object of this study aimed to subject the obtained results of the yield and yield components to the various statistical procedure such as factor analysis to determine the dependence relationship between yield and yield components. The stepwise multiple linear regression was used to determine a prediction model for yield. Variables acceptance and variables removal as well as the relative contribution for variables acceptance can also be calculated. Path coefficient analysis was used to determine the relative importance of characters to sugar yield. These parameters migh throw some light in planning appropriate selection procedure for improving sugar beet yield.

MATERIALS AND METHODS

The present work was conducted in three field trials carried out in two successive seasons during 1995/1996 and 1996/1997 at Shandaweel Research Staton, Sohag governorate to find out the relative advantage of some cultural practices on yield and quality attributes of sugar beet.

The 1st experiment included 14 treatments representing the interaction between two sugar beet varieties viz Sofi and Hilma and 7 sowing patterns:

1- Sowing sugar beet in rows 50 cm. in width and 15 cm.between hills (S1).
2- Sowing sugar beet in rows 50 cm. in width and 20 cm.between hills (S2).
3- Sowing sugar beet in rows 50 cm. in width and 25 cm.between hills (S3).

4- Sowing sugar beet in the two side of banks one meter in width and 20 cm. between hills (S4).

5- Sowing sugar beet in the two side of banks (1m. in width), in addton to one row in the middle of bank and 20 cm.between hills (S5).

6- Sowing sugar beet in the two sides of banks (1m. in width) in addition one row in the middle of bank and 15 cm. between hills in alternative positon with the hills in the two sides of bank (S6).

7- Sowing sugar beet in the two sides of banks (1m.in width) in addition to one row in the middle of bank and 20cm. between hills in alternative positon with the hills in the two sides of bank (S7).

The 2nd experiment included 10 intercropping treatments which represent the various combinations between two sugar beet varieties viz, Sofi and Hillma and five intercropping patterns:

1- Sowing sugar beet in banks (1m. in width) and 20 cm. between hills (T1).

2- Sowing sugar beet in banks (1m. in width) and 20 cm. between hills in the two sides of bank (T2).

3- Sowing sugar beet in the two sides of banks (1m. in width) in additon to one row of sugar beet, 20 cm. between hills (T3).

4- Sowng sugar beet in the two sides of banks (1m. in width) in addtion to one row of onion in the middle of the bank (T4).

5- Sowing sugar beet in the two sides of banks (1m. in width) 20 cm. between hills in additon to two rows of onion in the middle of the bank (T5).

The 3rd experiment consists of 15-treatments which were the combination between three levels of boron (Zero application, 0.5 and 1 Kg. B./fad.) in the form of sodium borate (11% B.) and five levels of zinc (zero application, 1,2,3 and 4 kg. Zn/fad.), in the form of zinc sulphate(22%). Plot area contains 6 ridges which were 7 m. in length and 50 cm. in width. The micro nutrients were applied once as a soil application after complete mixing with appropriate amounts of sand after thinning.

Sowing dates for sugar beet in the different experiments were 1st October whereas, transplanting onion was 15 day later. Nitrogen fertilizer was added as recommended dose (70 kg. N/fed.) in two equal doses, the 1st after thinning, the other one month later. Plot area was $21m^2$ for the three experiments in the two growing seasons. At harvest yield of root and sugar were calculated (tons/fad.), sugar yield (tons/fad.) =Root yield (tons/fad.) X sucrose % which was determined according to Le-Docte (1927). Puriy % was calculated according the following equation:- apparent purity % = (Sucrose % x 100)/ TSS %. Total Soluble solids percentage (T.S.S.%) was determined using hand refractometer. All cultural practices in sugar beet field were done.

Data analysis:

The collected data were subjected to two types of statistical analysis:

A-simple and combined analysis were done for the two seasons of the avaliable results according to Snedicor and Cochran (1969).

B- Specific analysis was carried out in three methods as follows:-

1- Factor analysis method according to Cattel (1965). 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 factor, 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 roation is to accemtuate 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 variaton in the dependence structure. Since the object was to determine the way in which yield components, related to each other, yield itself was included in this structure.

2- The stepwise multple linear regression as applied by Draper and Smith (1966), was used to compute a sequence of multiple regression equations in a stepwise manner, at each step one variable was added to the regression equation, it was the one the most reduced the error sum of squares. Equivalently, It was the variable that had the highest partial correlation with the dependent variable adjusted for the variables all ready added. Similarly it was the variable which if added, had the highest F value in the regression analysis of variance. Moreover, variables were forced into the regression equation and automatically removed when the values were low.

3- Simple correlation coefficients were computed among characters studied according to method described by Snedicor and Cochran (1969). Path coefficient analysis used to identify the different independent characters which affect the dependent character directly as well as indirectly. It gives us the path in which an independent variable is affecting the dependent variable in a given set of independent variables. The path coefficient analysis proposed by Wright (1921) and utilized by Dewey and Lu (1959), was used in this study for the analysis of yield components. A path coefficient is simply a standardized partial regression coefficient as it measures the direct influence of one variable upon another and permits the separation of the correlation coefficient into components of direct and indirect effects.

RESULTS AND DISCUSSION

A-Agronomical study

I-Effect of sowing patterns on sugar beet yield and its attributes:

Data presented in Table 1 point out the influence of sowing patterns on some plant criteria as well as sugar beet root yield and its attributes. The available data revealed obviously that non of the studied parameters showed a significant effect by the used treatments of sowing patterns of sugar beet plants. However, it could be noticed that the 2nd (S2) and 3rd (S3) sowing patterns i.e. sowing sugar beet as usual in rows 50 cm. between rows, 20 cm. and/or 25 cm. between hills attained the highest sugar beet root yield. The advantage in root yield of sugar beet in the above mentioned treatments was considerable and mainly due to the relative increase in the values of root diameter and the values of sugar beet root weight for the individual plants. On the other hand, sowing sugar beet under high density (S4) by sowing beet in the two side of is banks, one meter in length and 20 cm. between hills gave the highest juice quality in terms of TSS% and sucrose %, Moreover, increasing plant population per unit area by sowing sugar beet in the two sides of banks (1 m.width), in addition to one more row in the middle of the bank and 20 cm. between hills recorded the highest values of juice purity% and sugar yield/fad. This result may be due to the higher plant populations, The smaller the root dimension, the higher the juice concentration consequently the higher the total soluble solids (TSS%) and sucrose percentage.

Table 1. Sugar beet sowing patterns in relation to yield and its attributes.

Treat. Sowing Patterns	Root dimension cm.		Fresh weight g/plant		Quality %			Yield tons/ fad.		No.of root th/f.
	Diameter	Length	Root	Top	Sucrose	TSS	Purity	Root	Sugar	
S1	9.3	29.2	1026	597	9.1	17.2	53.72	34.7	1.80	32.57
S2	9.2	30.7	1237	682	10.0	15.91	63.85	37.5	2.54	27.45
S3	9.8	29.9	1090	706	10.3	16.8	62.44	38.1	2.42	24.90
S4	8.9	29.0	1052	602	11.0	17.4	64.83	30.3	2.19	28.01
S5	9.1	29.9	968	608	10.7	16.0	66.77	34.9	2.48	36.3
S6	8.6	31.0	990	549	9.7	17.0	57.92	33.6	1.97	37.5
S7	9.0	31.4	840	572	10.9	18.4	62.24	35.9	2.44	37.3
Varieties										
Sofi	9.3	30.4	1076	670	9.8	16.4	61.31	36.0	2.21	35.3
Hilma	9.0	30.0	982	563	10.6	17.5	62.05	34.0	2.25	36.2
L.S.D.5%										
Sow.p.(s)	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
Varieties(V)	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
SxV	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Concerning varietal effect and in spite of the insignificant influence of varieties on the sugar beet yield and its components, it could be deduced that Sofi variety attained a relative increment over Hilma variety, this advantage is mainly due to the increase in the individual value of root dimension and root fresh weight that was reflected on root yield. However, Juice quality in terms of TSS% and sucrose % were higher in Hilma variety. This result may assure that gene make up plays the main role in respect to the various criteria.

II- Effect of intercropping onion with sugar beet on yield and quality of sugar beet.

The collected data in Table (2) revealed that sowing sugar beet in the two sides of the bank (1m. in width) in addition to one row of sugar beet in the middle of the bank and, 20cm. between hills (T3), surpassed the other treatments in respect to root length, root fresh weight/plant, sucrose %, TSS % and purity % as well as plant population, sugar and root yield ton/fad. Moreover, the results obtained showed that all the pure stand treatments (T1,T2 and T3) recorded higher values in relation to most of the studied characters over the intercropping treatments (T4 and T5). Sugar beet variety Hilma produced higher and sgnificant increase in root yield/ fad. compared with Sofi variety. However, sugar beet variety Sofi attained better values in respect to purity% and sugar yield. Once more, data in Table (2), showed that intercropping onion with sugar beet (T5) significantly lowered sugar beet yield, it could be noticed that growing onion with sugar beet attained an additional income represented in the total income from 4.1 ton onion (LE.200) in addition to the total revenue of beet itself (LE. 1883). However, the highest pure stand of beet produced 31.4 ton/fad., (LE.2198), this finding may considerably encourage intercropping process.

III- Effect of micronutrients on yield and quality of sugar beet

Data in Table (3) showed that neither boron application nor zinc application appeared to be significant for the majority of studied characters of sugar beet.

Regardless significance of the studied characters, Table (3) showed that there was a negligible response in the values of total soluble solids percentage as well as sucrose and purity percentage due to zinc fertlization, this result may indicated that the available amount of these element in the experimental field at Shandaweel Station (Upper Egypt) could be enough to face the amount needed from these trace element.

Table 2. Intercropping onion in relation to yield and yield components of sugar beet.

Treat. Intercrop Patterns	Root dimension cm.		Fresh weight g/plant		Quality %			Yield tons/ fad.		No.of root th/fd.	Onion yield kg/f
	Diam.	Length	Root	Top	Sucrose	TSS	Purity	Root	Sugar		
T1	9.8	29.9	967	745	11.2	15.6	71.77	31.1	2.6	29.9	---
T2	10.1	29.1	1018	678	11.5	15.5	74.33	29.6	2.6	30.4	---
T3	9.9	30.8	1129	727	12.0	16.2	74.19	31.4	2.8	42.6	---
T4	9.7	29.9	881	618	11.2	15.7	70.91	28.7	2.3	28.7	2.4
T5	9.5	27.7	744	667	11.1	15.4	71.82	26.9	2.2	29.2	4.1
Varieties											
Sofi	9.6	30.0	895	679	11.9	15.6	76.6	28.0	2.37	31.8	3.32
Hilma	10.1	29.0	999	695	10.9	15.7	69.15	31.2	2.60	32.2	3.11
L.S.D.5%											
Inter.p.(T)	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	3.3	3.4	0.51
Var. (V)	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
(T)x(V)	N.S	N.S	N.S	N.S	N.S	1.44	N.S	N.S	N.S	N.S	N.S

Table 3. Effect of micronutrients on yield and its attributes of sugar beet.

Treat. small elements	Root dimension cm.		Fresh weight g/plant		Quality %			Yield tons/ fad.		No.of root th*/fd.
Kg.B./fad.	Diameter	Length	Root	Top	Sucrose	TSS	Purity	Root	Sugar	
Zero	8.0	32.4	819	446	14.0	12.8	75.84	28.4	2.91	39.5
0.5	7.8	32.1	805	624	14.9	13.4	75.68	27.9	2.77	34.4
1.0	7.9	36.3	867	701	14.5	13.0	72.35	33.3	2.67	33.9
Kg.zn./fad.										
Zero	8.2	35.7	882	667	13.3	12.7	74.56	29.5	3.06	36.0
1	7.5	32.7	691	542	14.8	13.1	76.90	31.1	2.91	35.2
2	8.0	32.3	771	610	14.4	13.3	76.19	29.4	2.81	34.7
3	8.5	33.1	971	783	14.9	13.8	74.08	25.7	2.63	37.9
4	7.3	34.2	835	657	15.0	12.3	71.37	30.3	2.52	36.0
L.S.D.5%										
B.	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
Zn.	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
B.xZn.	N.S	N.S	N.S	N.S	N.S	N.S	N.S	9.62	N.S	N.S

* Th: Thousand

Once more the role of B.element in respect to sugar beet root yield was effective, where applying 1kg B/fad., it attained 4.9 ton/fad. over unfertilized treatment. However, this increase was too limited (1..3 tons/fad) over check treatment when applying Zn. by 1 kg. Zn/fad.

B- Statistical studies:

The mean values for ten characters as well their standard error in three experiments for two cultivars are recorded in Table (4). Slight increase in the average performance of all characters studied was observed in micro nutrient elements experiment Exp. (2) compared with the other two experiments except root diameter, root yield and T.S.S.% characters.

A matrix of simple correlation coefficients for characters under study is also presented in Table (5) for the three experiments. Highly significant positive correlation was found between sugar yield/fad and each of sucrose and purity in the three experiments. The association between sugar yield/fad, and root Length was highly negative significance in Exp. (1) while it was highly positive significant in Exp. (3). Other associations among the different characters are also shown in Table (5). Consequently, these results indicated that selection practiced for the improvement of any one of a set of correlated characters, would automatically improve the other.

Factor analysis consists of the reduction of a large number of correlated variables to a much smaller number of clusters or patterns of variables called factors. Factors were constructed using the principal factor analysis technique to establish the dependent relationshps between variables in three experiments. A principal of factor matrix after varimax rotation for the ten characters in three experiments is given in Table (6). The factor analysis technique divided the ten characters in the three experiments into four main factors in Exp. (1), three main factors in Exp. (2), and two main factors in EXp. (3), which accounted for 100% of the total variability in the dependent structure in the three experiments. For the purpose of interpretation.

Table 4. Mean values and standerd deviaton for ten sugarbeet characters.

Variables	Mean			Standard deviation		
	Exp.(1)	Exp.(2)	Exp.(3)	Exp.(1)	Exp.(2)	Exp.(3)
Root diameter (X1)	9.13	9.82	9.39	1.32	1.43	1.75
Root length (X2)	30.11	29.51	31.16	5.03	4.66	4.47
Root number (X3)	32121.43	32645	34820	6056.54	8099.06	6186.23
Root weight (X4)	1042.09	947.46	1214.55	286.76	307.49	446.89
Root yield (X5)	35.01	29.68	31.86	6.29	4.96	6.71
Top weight (X6)	617.08	685.71	842.53	175.26	171.19	300.38
Sucrose (X7)	10.23	11.41	11.81	1.92	1.69	1.98
T.S.S (X8)	16.95	15.72	15.61	2.66	1.17	1.44
Purity (X9)	61.30	72.61	76.48	12.49	9.55	14.47
Sugar yield (X10)	2.21	2.49	2.9	0.75	0.73	1.05

Factor two (B), included three variables in Exp.(1), four variables in Exp.(2) and five variables in Exp.(3), which accounted for 27.41%, 32.03% and 48.59%, respectively of the total variance in the dependence structure,i.e. root diameter cm. (X1) (h^2 = 0.841), top yield gm. (X6), (h^2=0.727) and root weight gm. (X4),(h^2 = 0.795) in the first experiment, whereas it was (h^2= 0.724), for root diameter cm . (X1), (h^2= 0.529), for TSS. (X8), (h^2= 0.825), for root weight gm. (X4) and (h^2= 0.621), for top weight (X6), in the second experiment. Third experiment showed that root diameter cm. (X1), (h^2= 0.786), root weight gm. (X4), (h^2= 0.812), root yield ton/fed. (X5), (h^2= 0.546), TSS. (X8), (h^2= 0.429), and top weight gm. (X6), (h^2= 0.569).

Factor three included three variables in both Exp. (1) and (2), which accounted for 20.37% and 23.79% of the total variance in the dependent structure respectively i.e. root length cm. (X2), (h^2= 0.665), root number (X3), (h^2= 0.519), and root yield ton/fed. (X5), (h^2= 0.737), for first experiment and sucrose yield/fed. (X10), (h^2= 0.941), root number (X 3), (h^2= 0.474), and root yield ton/fed. (X10), (h^2= 0.941), and root yield ton/fed. (X5), (h^2= 0.776), for second experiment. Factor four included one variables in Exp. (1) only and accounted for 16.41% of the total variance and loaded variable h^2= 0.984, Table (6), this variable was T.S.S.

In comparing the factor analysis in the three experiments, it was concluded that the variables were grouped to four factors in Exp. (1), three factors in Exp. (2) and two factors in Exp. (3) The three experiments gave the same variables in factor one (A), same variables in factor (B), except variables (x8) and (X5). Factor three(C) have the same variables in Exp. (1) and (2), except variable (X2) and

Table 5. A matrix of simple correlation coefficients in three experments.

EXP. (1)

Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9
Root D. (X1)	1.000								
Root L. (X2)	-.333*	1.000							
Root N. (X3)	-.275*	0.359**	1.000						
Root W. (X4)	0.652**	-.033	-.236	1.000					
Root Y. (X5)	-.097	0.369**	0.209	0.071	1.000				
Top W. (X6)	0.533**	-.109	-.135	0.599**	0.138	1.000			
Sucrose (X7)	0.452**	-.559**	-.219	-.009	-.359**	-.072	1.000		
T.S.S (X8)	0.112	0.092	-.037	-.042	-.068	-.064	0.256	1.000	
Purity (X9)	0.315*	-.545**	-.155	0.011	-.223	-.014	0.700**	-.499**	1.000
Sugar Y. (X10)	0.418**	-.422**	-.075	0.058	0.159	0.066	0.739**	-.232	0.862**

EXP. (2)

Root D. (X1)	1.000								
Root L. (X2)	-.172	1.000							
Root N. (X3)	-.156	-.005	1.000						
Root W. (X4)	0.633**	0.127	-.032	1.000					
Root Y. (X5)	0.083	-.130	0.283	0.011	1.000				
Top W. (X6)	0.321*	0.245	-.043	0.634**	-.014	1.000			
Sucrose (X7)	-.429**	0.519**	0.245	-.043	-.109	0.107	1.000		
T.S.S (X8)	0.019	0.469**	0.079	0.334*	-.069	0.262	0.478**	1.000	
Purity (X9)	-.498**	0.320*	0.216	-.235	-.094	-.008	0.865**	-.024	1.000
Sugar Y. (X10)	-.389*	0.296	0.414**	-.117	0.488**	0.068	0.780**	0.189	0.775**

EXP. (3)

Root D. (X1)	1.000								
Root L. (X2)	-.389**	1.000							
Root N. (X3)	-.251*	0.145	1.000						
Root W. (X4)	0.839**	-.324*	-.236	1.000					
Root Y. (X5)	0.326**	-.005	-.004	0.375**	1.000				
Top W. (X6)	0.608**	-.170	-.060	0.714**	0.259*	1.000			
Sucrose (X7)	-.425**	0.432**	0.235	-.506**	-.219	-.243	1.000		
T.S.S (X8)	0.541**	-.315*	0.026	0.432**	0.263*	0.335**	-.064	1.000	
Purity (X9)	-.607**	0.539**	0.184	-.602**	-.306*	-.376**	0.821**	-.489**	1.000
Sugar Y. (X10)	-.313*	0.499**	0.228	-.321*	0.384**	-.125	0.754**	-.122	0.706**

* and ** denotes significant at 5% and 1%.

(X10). Therefore, we could suggest that factor one only those factors loading greater than 0.50 were considered important. Factor one (A) included four variables which accounted for 35.81%, 44.18% and 51.40% of the total variance for Exp. (1), Exp. (2) and Exp. (3), respectively Table (6). The four variables in the three experiments were sugar yield ton/fad. (X10), purity (X9), sucrose (X7) and root length (X2). The four loaded variables X10, X9, X7, and X2 were 0.97219, 0.97145, 0.96984 and 0.66497 for the first experiment and 0.94141, 0.78869, 0.94144 and 0.59591 for the second experiment whereas, it was 0.93047, 0.83758 and 0.46316 for the third experiment in their communality h^2 for three experiments as shown in Table (6). This factor might be responsible for purity (X9) and sucrose (X7) more than any other origin of sugar beet plant. Similar conclusion might be drawn about the dependent structure from the simple correlation matrix Table (5). Characters grouped together to form a factor had sgnificant correlation coefficents with such factor (A) and factor two (B) were the same in the three experiments. These were the most important factors affecting sugar yield/fed. of sugar beet.

Table 6. The results of factor analysis of ten variables in three experiments in sugar beet.

Variables	Common Factor Coefficient				h^2	Var.	Common Factor Coefficient			h^2	Var.	Common Factor C.		h^2
	A	B	C	D			A	B	C			A	B	
Sucrose Y.(X10)	0.96	0.12	0.16	-.13	0.97	(X7)	0.96	0.05	0.13	0.94	(X10)	0.96	0.11	0.93
Purity (X9)	0.88	-.01	-.20	-.41	0.97	(X9)	0.83	-.25	0.19	0.79	(X7)	0.83	-.22	0.74
Sucrose (X7)	0.87	-.01	-.31	0.35	0.97	(X10)	0.71	-.05	0.66	0.94	(X9)	0.78	-.47	0.84
Root L. (X2)	-.54	-.09	0.60	0.09	0.67	(X2)	0.67	0.33	-.20	0.59	(X2)	0.66	-.17	0.46
Root D. (X1)	0.43	0.77	-.16	0.21	0.84	(X1)	-.56	0.64	0.01	0.72	(X1)	-.41	0.79	0.79
T.S.S. (X8)	-.11	-.01	-.03	0.98	0.98	(X8)	0.46	0.55	-.10	0.53	(X4)	-.41	0.80	0.81
Root N. (X3)	-.04	-.30	0.65	0.02	0.52	(X3)	0.19	-.04	0.66	0.47	(X3)	0.35	-.07	0.13
Top W. (X6)	-.04	0.85	0.03	-.09	0.73	(X5)	-.18	0.05	0.86	0.78	(X5)	0.22	0.71	0.55
Root Y. (X5)	-.04	0.19	0.83	-.09	0.74	(X4)	-.12	0.89	0.02	0.83	(X8)	-.16	0.64	0.43
Root W. (X4)	-.03	0.89	-.05	-.02	0.79	(X6)	0.12	0.78	0.01	0.62	(X6)	-.18	0.74	0.67
Total					8.18					7.22				6.24
Contribution of	2.93	2.24	1.66	1.34			3.19	2.31	1.72			3.21	3.03	
factor% of total communality	35.8	27.4	20.3	16.4	100		44.1 8	32.0	23.8	100		51.4	48.6	100

h^2= Communality
R^2 = 97.63% for all variables
R^2 = 97.53% for acceptance variables
Y = -5.8739+0.0479 (X1)+0.0001(X3)-0.0509(X5)+0.096(X8)+0.0663(X9) For exp. (1).
R^2 = 98.56% for all variables
R^2 98.24% for acceptance variables
Y = -4.7019+0.00001(X3)+0.0828(X5)+0.210(X7)+0.301(X9). For exp. (2).
R^2 = 97.12% for all variables
R^2 = 96.86 for acceptance variables
Y = -6.089+0.1005(X5)+0.249(X7)+0.0301(X9). For exp. (3).

From the previous results, it can be concluded that factor analysis indicates all grouping and percentage contribution to total variation in the dependence structure. Factor analysis gave the best results, which will help in planning appropriate selection procedure in improving sugar beet crop.

Generally, 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 selected in breedng programs.

Path analysis cannot construct a prediction equation for sugar yield, with this point of view, the multiple linear regression analysis could construct a prediction equation and measure the relative contrbution of accepted variables related to sugar yield. However, when stepwise multiple linear regression analysis was taken under consideration, five variables were accepted as significantly contributing to variation in sugar yield/fed. For Exp. (1), four variables for Exp. (2) and three variables for Exp. (3).

These variables were root yield/fed. (X5) and purity %(X9), in all experiments, root number (X3), in Exp. (1) and (2),sucrose %(X7), in Exp. (2) and (3), while root diameter cm.% (X1) in Exp. (1) and TSS % (X8) in Exp. (1).

The prediction equations were formulated as follows:-

$$Y=-5.8739+0.0479(X1)+0.00001(X3)+0.0509(X5)+0.095(X8)+0.0663(X9) \text{ for Exp.(1).}$$

$$Y=-4.7019+0.0001(X3)+0.0828(X5)+0.2103(X7)+0.0301(X9) \text{ for Exp. (2).}$$

$$Y=-6.089+0.1005(X5)+0.249(X7)+0.0372(X9) \text{ for Exp. (3).}$$

Path coefficient analysis concerned the contributon of independent variables to a dependent variable. The results in Table (7) and Figs. (1,2 and 3), revealed that purity and sucrose were of the most prominent direct effecs on sugar yield with the highest relative importance values of (35.435% and 4.92%), (11.98% and 19.66%) and (13.95% and 12.96%), for the three experiments, respectively as estimates of

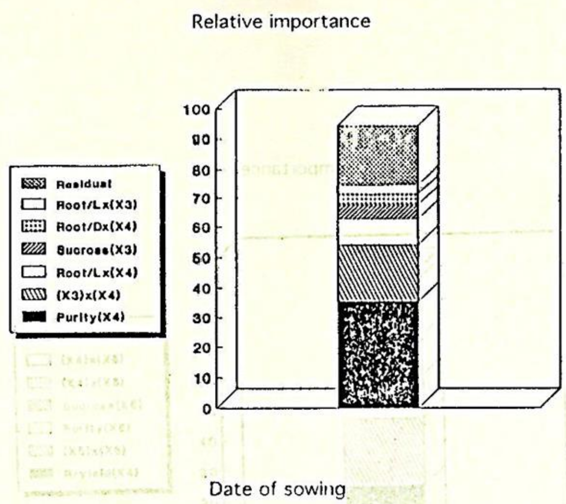

Fig. 1. Components (direct and Joint effects) of plant yield variation in sugar beet.

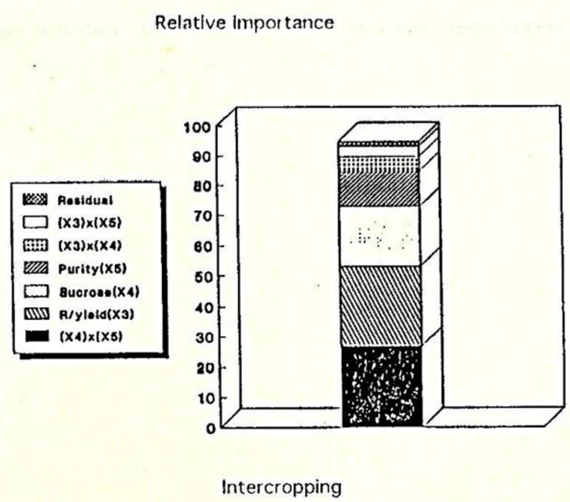

Fig. 2. Components (direct and Joint effects) of plant yield variation in sugar beet.

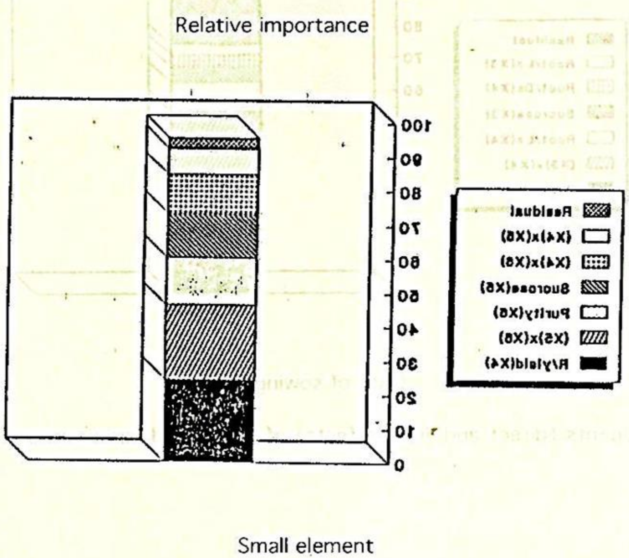

Fig. 3. Components (direct and Joint effects) of plant yield variation in sugar beet.

Table 7. Components (direct and joint effects) of sugar yield variation in sugar beet.

Source of variation	EXP.(1)		Source of variation	EXP.(2)		Source of variation		
	CD	RI%		CD	RI%		CD	RI%
Root diameter (X1)	0.015	1.023	Root diameter (X1)	0.001	0.074	Root diameter (X1)	0.000	0.000
Root length (X2)	0.027	1.817	Root number (X2)	0.002	0.182	Root length (X2)	0.0009	0.052
Sucrose (X3)	0.073	4.917	Root yield (X3)	0.321	26.47	Root weight (X3)	0.0007	0.041
Purity (X4)	0.523	35.43	Sucrose (X4)	0.238	19.66	Root yield (X4)	0.416	24.27
(X1)x(X2)	-.013	0.908	Purity (X5)	0.145	11.98	Sucrose (X5)	0.222	12.96
(X1)x(X3)	0.029	2.028	(X1)x(X2)	0.000	0.033	Purity (X6)	0.239	13.96
(X1)x(X4)	0.056	3.793	(X1)x(X3)	-.003	0.231	(X1)x(X2)	-.0002	0.012
(X2)x(X3)	-.049	3.347	(X1)x(X4)	0.013	1.040	(X1)x(X3)	-.0002	0.012
(X2)x(X4)	-.129	8.737	(X1)x(X5)	:0.011	0.941	(X1)x(X4)	0.0026	0.152
(X3)x(x4)	0.273	18.489	(X2)x(X3)	0.015	1.238	(X1)x(X5)	-.0026	0.152
			(X2)x(X4)	0.011	0.925	(X1)x(X6)	-.0038	0.222
			(X2)x(x5)	0.008	0.644	(X2)x(X3)	0.0004	0.023
			(X3)x(X4)	-.060	4.970	(X2)x(X4)	-.0002	0.012
			(X3)x(X5)	-.041	3.369	(X2)x(X5)	0.012	0.699
			(X4)x(X5)	0.322	26.55	(X2)x(X6)	0.0154	0.898
						(X3)x(X4)	-.012	0.723
						(X3)x(X5)	0.012	0.711
						(X3)x(X6)	0.015	0.875
						(X4)x(X5)	-.1336	7.791
						(X4)x(X6)	-.1934	11.28
						(X5)x(X6)	0.3788	22.09
Residual	0.195	19.521	Residual	0.0169	1.691	Residual	0.0307	3.07
Total contribution	1.000	80.479	Total contribution	1.000	98.31	Total contribution	1.000	96.93

CD = Coefficient of determination

RI%= Relative importance

their relative conribution to the total variation of sugar yield. Root yield character also reflect direct effect on sugar yield with relative importance values of (26.47% and 24.27%), for experiments (2) and (3), respectively.

The analysis also demonstrated that (purity) x (sucrose), in the three experiments with indirect effects through sugar yield were (18.48%, 26.55% and 22.09%), for experiments (1), (2) and (3), respectively, (root length)x(purity) with indirect effects 8.74% for exp. (1), (purity)x(root yield) and (sucrose)x(root yield) reflects indirect effects through sugar yield with relative importance values of (3.37%, 4.97% and 11.28%), for experiments (2) and (3), respectively, contributing to the total variation of sugar yield. Other direct and indirect effects for the rest of the studied characters were negligible.

The total contribution of the above mentioned characters of the three experiments overall variation in sugar yield were 80.48%, 98.31% and 96.93% for all experiments Table (7).

Multiple linear correlation coefficients given in table (7) were 0.8048, 0.9831, and 0.9693 for the three experiments, respectively. These results indicated that characters under investigation included the actual yield components.

In general, the results obtained herein indicated that purity, sucrose, and root yield were the major and the most consistent sources accounting for varation as total contribution to sugar yield variation with values of 80.48%, 98.31% and 96.93%, for the three experiments, respectively. Therefore, it is important for the breeder to consider these characters in formulating his breeding programs to obtain the best gain in selection.

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التحليل العاملي المتعدد والمساهمة النسبية لكل عامل من عوامل المحصول تحت بعض العوامل الزراعية لمحصول بنجر السكر

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أوضحت دراسة التحليل العاملي لعشر صفات من صفات المحصول لبنجر السكر لثلاث تجارب، هي تجربة مسافات الزراعة، وتجربة التحميل وتجربة العناصر الصغري وذلك لموسمي الزراعة ١٩٩٥ / ١٩٩٦، ١٩٩٦ / ١٩٩٧ لصنفين من اصناف بنجر السكر هما صوفي. وهيلما وذلك بمحطة البحوث الزراعية بشندويل بمحافظة سوهاج. الاهمية الكبري لكل من طول الجذر، نسبة السكر، النقاوة ومحصول السكر للفدان.

كما اوضح التحليل العاملي المتعدد العلاقة بين الصفات المرتبطة ببعضها ومدي تاثير كل منها علي الآخر من جهة وتاثيرها في كمية المحصول من جهة آخري. كما تبين من البحث ان التجربة الاولي فصلت متغيراتها الي اربعة عوامل ساهمت ب ٣٥.٨٪، ٣٧.٤٪، ٣٠.٤٪، ١٦.٤٪ وذلك من التباين الكلي للمحصول. وفصلت التجربة الثانية متغيراتها الي ثلاث عوامل ساهموا بنسبة ٤٤.٣٪، ٣٣.٠٣٪ و ٢٣.٨٪ وذلك من التباين الكلي للمحصول. كما فصلت التجربة الثالثة متغيراتها الي عاملين اسهموا ب ٥١.٤٪، ٤٨.٦٪ من التباين الكلي للمحصول.

كما وجد في تحليل الانحدار المتعدد ان نسبة ما يساهم به كل من قطر الجذر، عدد الجذور، محصول الجذور، المادة الكلية الصلبة و النقاوة هو ٩٧.٥٣٪ من جملة المتغيرات تحت الدراسة، وذلك للتجربة الاولي. وفي التجربة الثانية كانت نسبة المساهمة ٩٨.٣٤٪ لكل من عدد الجذور، محصول الجذر، السكروز، والنقاوة - كما اوضحت التجربة الثالثةان نسبة المساهمة كانت ٩٦.٨٦٪ لكل من محصول الجذر، السكروز والنقاوة وذلك من جملة المتغيرات تحت الدراسة.

كما اوضح تحليل معامل المرور للتجارب الثلاثة الاهمية النسبية لكل من محصول الجذور، السكروز، والنقاوة وذلك من خلال تاثيراتهم المباشرة وغير المباشرة علي محصول السكر طن / فدان.

وتشير النتائج السابقة ان الصفات المدروسة هي اكثر الصفات مساهمة في المحصول في التجارب الثلاثة، وانه يجب علي مربي النبات ان يضعها في الاعتبار في برامج الانتخاب وانتاج اصناف جديدة ذات قدرة محصولية عالية.