Effect of Plant Spacing and Nitrogen Fertilizer Levels on Yield and Yield Components of Sugar Beet under Calcareous Soil Conditions

Nawar, F.R.R. and S.A., Saleh
Field Crops Research Institute, Agric. Res. Center, Giza, Egypt.

ABSTRACT

Two field experiments were conducted at Nubaria Agric. Res. Station during 1999/2000 and 2000/2001 seasons. The objective was to study the effect of four plant spacings (15, 20, 25 and 30 cm between hills), four nitrogen fertilizer levels (50, 60, 70 and 80 kg N/fed.) and their interaction on sugar beet yield. Cv. Trirave was used in this study. A split-plot design with four replicates was used. Results showed that plant spacing significantly affected root diameter, root weight as well as root and sugar yields/fed. The highest diameter and root weight values were obtained by growing sugar beet plant at 30 cm between hills, while the maximum root and sugar yields were obtained at 15 cm between hills. Increasing nitrogen levels up to 80 kg N/fed. markedly increased diameter, weight of roots, sucrose percentage as well as root and sugar yields in both seasons and root length in the first season only. Plant spacing and nitrogen fertilizer levels interaction had a significant effect on root diameter, root weight, root yield and sugar yield during both seasons of the study. The highest root and sugar yields were obtained by growing sugar beet plant at 15 cm between hills and under the application of 80 kg N/fed.Generally, it can be concluded that sowing sugar beet at spacing 15 cm between hills with the addition of 80 kg N/fed. could be recommended for raising sugar beet production under the calcareous soil conditions.

INTRODUCTION

Sugar beet is an important source for sugar production, about 45% of sugar in the world are annually produced from sugar beet. In Egypt, sugar beet has become an important crop for sugar production, especially it can be grown in northern regions of the country in the new reclaimed area. Higher yield of sugar beet is the end-product of many factors such as plant spacing, nitrogen fertilization and other proper cultural practices.

Several experiments have been carried out to determine the best plant spacing giving the highest production. Rathee et al.(1978) stated that root sugar content increased from 16.74 to 18.26% and sugar yield increased from 7.70 to 8.98 t/ha by increasing plant density from 10,000 to 15,000 plants/ha, respectively. Analogides et al.(1981) found that root yield increased but sucrose content decreased with increasing plant density up to 73,000 plants/ha. In Egypt, Hanna et al.(1988) concluded that 46666 plants/fed. produced the highest root and sugar yields/fed. They also showed that the higher sucrose percentage was obtained in the case of 70,000 plants/fed. Herron et al.(1964) found that wide spacing resulted in inferior beet quality and a lower sucrose and purity percentage. Sugar yield was highest in plants at 50x20 cm. They added that root sugar content and sugar yield were highest in plants grown at 20 cm apart between hills in rows. Mahmoud *et al.*(1990) stated that the highest root

yield was produced with 50 and 60 cm distances between ridges, while the highest sugar yield was produced with 40 cm space between hills. Regarding intra-row spacing, 20 cm distance between hills gave the highest root and sugar yields. Finally, El-Kassaby et al.(1991) reported that sowing sugar beet on both sides of ridges, 90 cm apart and 20 cm between hills (46666 plants/fed.) recorded the highest root and sugar yields/fed. Meanwhile, sowing plants on one side of ridges 60 cm apart and 15 cm between hills (46666 plants/fed.) produced the highest sucrose percentage.

Egyptian soil is usually poor in nitrogen supply. Thus, it is the most important fertilizer for raising sugar beet yield, but the quality of yield declines particularly with the high levels of nitrogen. Adding 60 kg N/fed. is considered as the optimum level for sugar beet production (Smith and Martin, 1977; El-Geddawy, 1979; Hassanein, 1979; Basha, 1984; Zeidan et al., 1987; Badawi, 1989; Emara, 1990 and Mahmoud et al., 1990). Raising nitrogen level up to 75 kg N/fed. markedly increased root and sugar yield/fed., (Zalat, 1986).

The interaction between plant density and nitrogen fertilizer levels markedly affected sugar yield and its quality (El-Badry, 1984 and El-Kassaby et al., 1991).

The objective of this investigation was to study the effect of plant spacing, nitrogen fertilizer levels and their interaction on yield of sugar beet cv. Trirave under calcareous soil conditions.

MATERIALS AND METHODS

Two field experiments were carried out during the two growing successive seasons of 1999/2000 and 2000/2001 at Nubaria Agric. Res. Station to study the effect of plant spacing (15, 20, 25 and 30 cm between hills) and four nitrogen fertilizer levels (50, 60, 70 and 80 kg N/fed.) on yield and yield components of sugar beet cv. Trirave. Mechanical and chemical analysis of the experimental site are presented in Table (1). The preceding crop was maize for the two seasons.

A split-plot design with three replicates was used. The main plots were occupied by the plant spacing (15, 20, 25 and 30 cm between hills) and nitrogen fertilizer levels (50, 60, 70 and 80 kg N/fed.) were distributed randomly in the sub-plots. The sub-plot area was 12 m^2, consisted of five ridges, each 4 m length and 60 cm apart.

Table 1. Mechanical and chemical analyses of the experimental soil in 2000 and 2001 seasons.

Soil properties	Season	
	2000	2001
Soil particles (%)		
Sand	52.9	53.3
Silt	21.8	20.8
Clay	25.3	25.9
Soil texture	sandy clay loam	sandy clay loam
Chemical properties		
Total N (%)	0.046	0.051
Available N (ppm)	26.30	28.60
Available P (ppm)	9.68	8.40
Available K (ppm)	425.0	403.0
pH	8.2	8.1
E.C. (mmhos/cm)	2.21	1.95
O.M. (%)	0.95	0.98
$CaCO_3$ (%)	22.9	22.5

Sugar beet seeds were sown on October 23rd and 24th in 1999/2000 and 2000/2001 seasons, respectively and plants were thinned after 40 and 50 days from sowing to obtain one plant per hill. At the first irrigation, calcium superphosphate (15.5% P_2O_6) as well as potassium sulphate (48% K_2O) were applied at the rate of 25 kg fertilizer unit/fed. The amount of nitrogen as ammonium nitrate (33.5% N) was divided, at the chosen doses, into two equal portions, before the second and third irrigations. Hoeing and weed control, irrigation and other cultural practices were done for every experimental unit in similar manner whenever possible according to the recommendations for sugar beet cultivation.

At harvest, ten guarded plants were taken at random and the following characters were estimated: root length (cm), root diameter (cm) and root weight (g). Sucrose percentage in the root was estimated according to Le-Docte (1927). Root yield (t/fed.) was estimated on the basis of root yield obtained from the three inner ridges from each sub-plot which was converted to estimate root yield in ton/feddan. Sugar yield (t/fed.) was estimated by multiplying root yield by sucrose percentage.

The collected data were statistically analyzed according to Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

1. Effect of plant spacing

Data presented in Table (2) show that root diameter and root weight were significantly affected by plant spacing. Increasing plant spacing from 15 to 20, 25 and 30 cm between hills increased root diameter and root weight in both seasons. Root length was not affected by plant spacing in both seasons, the highest root diameter and root weight were obtained with spacing 30 cm between hills. On the other hand, the lowest plant spacing (15 cm between hills) recorded the lowest means of root diameter and weight. The decrease in root diameter and root weight with decreasing spacing may be due to competition among plants within the denser plant spacing for nutrients, moisture and light. Similar observations were reported by Khafaga et al.(1975), Mahmoud et al.(1990) and El-Kassaby et al.(1991).

Data presented in Table (3) show that the sucrose percentage was not affected by plant spacing during both seasons of the study. Root yield/fed. and sugar yield/fed. were significantly affected by plant spacing in both seasons. Increasing plant spacing from 15 to 20, 25 and 30 cm between hills decreased root yield/fed. and increased sugar yield/fed. The highest root yield and sugar yield per feddan were obtained from spacing 15 cm between hills in the two seasons. Similar results were reported by Hanna et al.(1988) and El-Kassaby et al.(1991).

2. Effect of N-fertilizer levels

Root diameter, weight and yield/fed., sucrose percentage and sugar yield/fed were significantly affected by nitrogen fertilizer levels, in both seasons, while nitrogen levels had significant effect on root length in the first season only (Tables 2 and 3).

Increasing nitrogen fertilizer levels up to 80 kg N/fed. significantly increased root diameter, weight and yield/fed., sucrose percentage and sugar yield/fed. The increase in root and sugar yields might be attributed to the role of nitrogen in building up metabolites which translocate from leaves to developing roots. The present results are in line with those obtained by El-Badry (1984), Ramadan (1986), Hanna et al.(1988), Badawi (1989) and El-Kassaby et al.(1991).

3. Interaction effect

The interaction between plant spacing and nitrogen fertilizer levels had significant effect on root diameter, weight and yield/fed. and sugar yield/fed. in both seasons as shown in Tables (4 and 5). Maximum root diameter, weight, root yield and sugar yield were produced by growing sugar beet plant at 30 cm between hills and under the application of 80 kg N/fed. in both seasons. Similar

Table 2. Root length, root diameter and root weight of sugar beet as affected by plant spacing and nitrogen fertilizer in 1999/2000 and 2000/2001 seasons.

Treatment	Root length (cm)		Root diameter (cm)		Root weight (g)	
	1999/2000	2000/2001	1999/2000	2000/2001	1999/2000	2000/2001
Plant spacing (cm)						
15	23.7	22.4	9.5	8.9	611	650
20	23.5	22.5	10.8	9.4	679	799
25	23.7	23.0	11.5	10.6	892	953
30	24.0	24.6	12.4	11.7	942	973
$L.S.D_{0.05}$	NS	NS	0.3	0.5	27	49
Nitrogen level (kg N/fed.)						
50	23.2	23.2	10.8	9.7	744	804
60	23.6	23.1	11.1	10.0	774	824
70	24.1	23.2	11.1	10.3	791	846
80	24.0	23.0	11.3	10.6	817	903
$L.S.D_{0.05}$	0.4	NS	0.4	0.6	39	65

Table 3. Root yield, sucrose percentage and sugar yield of sugar beet as affected by plant spacing and nitrogen fertilizer in 1999/2000 and 2000/2001 seasons.

Treatment	Root yield (ton/fed.)		Sucrose (%)		Sugar yield (ton/fed.)	
	1999/2000	2000/2001	1999/2000	2000/2001	1999/2000	2000/2001
Plant spacing (cm)						
15	25.957	25.077	15.99	15.97	4.209 a	3.874 a
20	25.029	23.838	15.69	16.00	3.529 b	3.687 b
25	21.157	21.726	16.14	16.28	3.531 b	3.339 c
30	18.821	18.285	16.82	15.97	3.254 c	3.314 c
$L.S.D_{0.05}$	0.451	0.416	NS	NS	0.148	0.112
Nitrogen level (kg N/fed.)						
50	22.316	21.343	15.35	15.54	3.455	3.306
60	22.386	22.087	15.79	15.77	3.548	3.429
70	22.742	22.493	16.13	16.16	3.580	3.636
80	23.516	23.004	16.44	16.68	3.942	3.845
$L.S.D_{0.05}$	0.654	0.545	0.47	0.63	0.263	0.195

Table 4. Root length, root diameter and root weight of sugar beet as affected by the interaction between plant spacing and nitrogen fertilizer in 1999/2000 and 2000/2001 seasons.

Plant spacing (S)	Nitrogen level (N)	Root length (cm)		Root diameter (cm)		Root weight (g)	
		1999/2000	2000/2001	1999/2000	2000/2001	1999/2000	2000/2001
15	50	23.7	22.8	9.4	8.6	579	619
	60	23.4	22.3	9.6	8.7	612	637
	70	23.9	22.4	9.3	8.9	617	653
	80	23.8	22.1	9.7	9.3	639	692
	Mean	23.7	22.4	9.5	8.9	611	650
20	50	22.8	22.3	10.3	8.7	639	793
	60	23.7	22.4	10.9	9.5	677	801
	70	23.8	22.1	10.9	9.7	680	856
	80	23.6	23.1	11.1	9.6	722	799
	Mean	23.5	22.5	10.6	9.4	679	799
25	50	23.1	22.9	11.3	10.1	845	924
	60	24.2	23.1	11.4	10.5	887	927
	70	23.9	23.2	11.7	10.8	913	953
	80	23.6	22.8	11.7	11.1	923	10.11
	Mean	23.7	23.0	11.5	10.6	892	953
30	50	23.1	24.8	12.1	11.5	912	925
	60	23.3	24.6	12.3	11.3	919	937
	70	24.7	24.9	12.6	11.6	953	978
	80	24.9	24.1	12.7	12.5	984	1054
	Mean	24.0	24.6	12.4	11.7	942	973
$L.S.D_{0.05}$							
S		NS	NS	0.3	0.5	27	49
N		0.4	NS	0.4	0.6	39	65
S x N		NS	NS	0.9	1.2	88	103

Table 5. Root yield, sucrose percentage and sugar yield of sugar beet as affected by the interaction between plant spacing and nitrogen fertilizer in 1999/2000 and 2000/2001 seasons.

Plant spacing (S)	Nitrogen level (N)	Root yield (ton/fed.)		Sucrose (%)		Sugar yield (ton/fed.)	
		1999/2000	2000/2001	1999/2000	2000/2001	1999/2000	2000/2001
15	50	25.013	24.393	15.42	15.32	3.914	3.645
	60	25.381	24.854	16.43	15.50	4.115	3.786
	70	26.451	25.193	15.99	16.31	4.275	3.914
	80	26.983	25.864	16.14	16.75	4.532	4.153
	Mean	25.957	25.077	15.99	15.97	4.209	3.874
20	50	25.198	23.146	15.21	16.01	3.831	3.451
	60	24.934	23.886	15.36	16.31	3.421	3.684
	70	24.234	24.001	15.98	15.98	3.132	3.732
	80	25.751	24.321	16.23	15.71	3.735	3.883
	Mean	25.029	23.838	15.69	16.00	3.529	3.687
25	50	20.321	20.245	15.33	15.83	3.014	3.145
	60	20.981	21.367	15.51	15.94	3.534	3.243
	70	21.345	22.415	16.75	16.61	3.617	3.445
	80	21.983	22.876	16.98	16.75	3.958	3.521
	Mean	21.157	21.726	16.14	16.28	3.531	3.339
30	50	18.731	17.583	15.42	15.01	3.061	2.981
	60	18.249	18.241	15.68	15.33	3.121	3.001
	70	18.956	18.361	15.78	16.03	3.294	3.451
	80	19.346	18.954	16.41	17.53	3.542	3.824
	Mean	18.821	18.285	15.82	15.97	3.254	3.314
L.S.D$_{0.05}$							
S		0.451	0.416	NS	NS	0.148	0.112
N		0.654	0.545	0.47	0.63	0.263	0.195
S x N		1.875	1.241	NS	NS	0.873	0.314

results were reported by El-Badry (1984), Hanna et al.(1988) and El-Kassaby et al.(1991).

Generally, it could be concluded that the highest values of root yield and sugar yield were obtained by planting sugar beet at 15 cm between hills and adding 80 kg N/fed.

REFERENCES

Analogides, D.A., T.H. Ouounides, and S. Spasses. 1981. Growth analysis of sugar beet with references to plant population and sowing. Hellenic Sugar Industry Quarterly Bulletin, 46: 433-447. C.F. Field Crop Abst., 37 (10): 7330, 1984.

Badawi, M.A. 1989. A preliminary study on the effect of some cultural practices on the growth and yield of sugar beet. J. Agric. Sci. Mansoura Univ., 14 (2): 984-993.

Basha, M.A. 1984. Effect of sowing method, plant population and fertilization on growth and yield of sugar beet. M.Sc. Thesis, Fac. of Agric., Zagazig Univ., Egypt.

El-Badry, O.Z.M. 1984. Weed competition in sugar beet. Ph.D. Thesis, Fac. of Agric., Cairo Univ., Egypt.

El-Gaddawy, I.H.M. 1979. Effect of nitrogenous and potassium fertilization on morphology, chemical constituent and yield of sugar beet. M.Sc. Thesis, Fac. Agric., Ain Shams Univ., Egypt.

El-Kassaby, A.T., S.E. El-Kalla, A.A. Leilah, and H.S. El-Khatib. 1991. Effect of planting patterns and levels of N and K-fertilization on yield and quality of sugar beet. J. Agric. Sci. Mansoura Univ., 16 (7): 1497-1504.

Emara, T.K.S.E. 1990. Effect of irrigation intervals, growth regulators and NK fertilizers on yield and quality of sugar beet. M.Sc. Thesis, Fac. of Agric., Mansoura Univ., Egypt.

Hanna, A.S., A.T. El-Kassaby, A.N. Attia, and M.A. Badawi. 1988. Studies on the inter-relationships among planting dates, hill spacings, varieties and nitrogen fertilization in sugar beet (*Beta vulgaris*, L.). J. Agric. Sci. Mansoura Univ., 13 (2): 598-605.

Hassanein, M.A.E. 1979. Response of sugar beet to NPK fertilizers under Egyptian conditions. Agron. J., 67: 389-393.

Herron, G.M., D.W. Grimes, and R.E. Finkner. 1964. Effect of plant spacing and fertilization on yield, chemical and sucrose percent and evapotranspiration of sugar beet in Kancas. 1. Yield of roots, purity, percent sucrose and evapotranspiration. J. Amer. Soc. Sugar Beet Tech., 12 (8): 686-698.

Khafaga, E.E., I.M.A. El-Ghaffar, M.K. Adawei, and T.M. Fayed. 1975. Studies on the relation of spacing of ridges, drills and hills on yield and sugar content of sugar beet. Agric. Res. Rev., 53: 73-82.

Le-Docte, A. 1927. Commercial determination of sugar in the beet root using the Sachr-Le-Docte Process. Inter. Sugar J. 29: 488-492.

Mahmoud, E.A., N.A. Khalil, and S.Y. Besheet. 1990. Effect of nitrogen fertilization and plant density on sugar beet. II. Root weight, root top and sugar quality. 4th Conf. of the Egyptian Society of Crop Science, Fac. Agric., Cairo Univ., vol. 11, Sept. 15-16/1990.

Ramadan, B.S.H. 1986. Effect of plant density, thinning time and nitrogen fertilization on growth, yield and quality of sugar beet. M.Sc. Thesis, Fac. Agric., Cairo Univ., Egypt.

Rathee, S.S., K.L. Behl, and D.P. Singh. 1978. Effect of varying levels of nitrogen and plant densities on sugar production of two varieties of sugar beet (*Beta vulgaris*, L.). Indian J. Agric. Res., 12 (1): 19-22.

Smith, G.H. and S.S. Martin. 1977. Effect of plant density and nitrogen fertilization on purity components of sugar beet. Crops Sci., 17: 469-477.

Snedecor, G.W. and W.G. Cochran. 1967. Statistical Methods, Sixth Edition, Iowa Univ. Press, Amer. Iowa, U.S.A.

Zalat, S.S. 1986. Studies on sugar beet. M.Sc. Thesis, Fac. of Agric., Zagazig Univ., Egypt.

Zeidan, E.M., M.E. Salah, E.M. El-Naggar, and S.S. Zalat. 1987. Sugar beet yield and quality as affected by nitrogen and potassium fertilization levels. Accepted for publication in January 1987, Zagazig J. of Agric. Research.

الملخص العربى

تأثير مسافات الزراعة والتسميد النتروجينى على محصول بنجر السكر ومكوناته تحت ظروف الأراضى الجيرية

فتحى رجب رمضان نوار ، سيد عبد العزيز صالح

معهد بحوث المحاصيل الحقلية ، مركز البحوث الزراعية ، الجيزة

أجريت هذه الدراسة فى محطة البحوث الزراعية بالنوبارية خلال عامى ١٩٩٩/٢٠٠٠ و ٢٠٠٠/٢٠٠١ لدراسة تأثير أربع مسافات زراعة (١٥، ٢٠، ٢٥، ٣٠ سم بين الجور) وأربعة مستويات من التسميد النتروجينى (٥٠، ٦٠، ٧٠، ٨٠ كجم نتروجين/فدان) والتفاعل بينهم على محصول بنجر السكر ومكوناته تحت ظروف الأراضى الجيرية. وقد أتبع تنفيذ القطع المنشقة مرة واحدة فى أربع مكررات واستخدم صنف البنجر Trirave. وقد أوضحت النتائج الآتى:

١) أثـرت مسـافات الـزراعة معـنوياً علـى قطر الجذر، وزن الجذر، محصول الجذور ومحصول السـكر/فدان فى كلا موسمى الزراعة. وكان أكبر قطر للجذر وأعلى وزن للجذر باستخدام مسافة ٣٠ سم بين الجور، بينما أعلى محصول للجذور والسكر/فدان بلغ أقصاه باستخدام مسافة ١٥ سم بين الجور.

٢) أدت زيادة مستويات التسميد النتروجينى حتى ٨٠ كجم/فدان إلى زيادة معنوية فى قطر الجذر ووزن الجذور ومحصول الجذور والسكر/فدان والنسبة المئوية للسكر فى كلا الموسمين، وطول الجذر فى الموسم الأول فقط.

٣) أدى الـتفاعل بيـن مسافات الزراعة والتسميد النتروجينى إلى زيادة معنوية فى قطر الجذر ووزن الجذور، ومحصول الجذور والسكر/فدان فى الموسمين.

ويمكـن التوصـية من نتائج هذه الدراسة بزراعة بنجر السكر على مسافة ١٥ سم وإضافة ٨٠ كجم نتروجين للفدان.