

EFFECT OF SOME SOIL CHARACTERISTICS ON ROOT GROWTH, JUICE QUALITY AND YIELD OF SUGAR BEET

A. F. EL-WAKEEL

Soil and Water Research Institute, Agricultural Research Centre, Giza, Egypt.

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Abstract

A field study was conducted through three successive seasons, "1986-1989", to elucidate the effect of some soil properties on sugar beet constituents. Forty six sites were selected along the sugar beet belt, " Latitude $31^{\circ} - 31^{\circ} 30' N$ ", in the middle Delta sector.

Under the experimental conditions, the results indicated that the reduction of the roots growth, juice quality and the yield of both roots and sugar took place as the level of water table depth was less than 100 cm, and/or the values of the pH or EC " mmhose/ Cm" in the soil paste extract surpassed the Figure 8 . The adversity rate of these factors differed widely among the different sugar beet constituents. However, the values of both exchangeable sodium percent "ESP" and clay percent revealed insignificant effects.

INTRODUCTION

The importance of sugar beet comes not only from its ability to grow in the new reclaimed lands but also for giving high yield of sugar compared with sugar cane. The growth period of sugar beet is about half that of sugar cane. Further-

more, the consumed water by sugar beet to produce one ton of sugar is about 1300 m³, whereas sugar cane plants needs about 4000 m³ of water to produce the same quantity.

Northern Delta is the sector of which sugar beet is successfully grown commercially and produce about 10% of the national sugar production. However, many problems restrict its production, of which, salinity and sodicity of the soil and high water table. In addition, the limited amount of fresh water had enforced the reuse of poor quality water for irrigation a matter that aggravated the problem. It was therefore proposed to investigate the effect of some soil characteristics e.g. water table depth, pH, salinity, sodicity and the texture class on the root growth, juice quality and the yield of this vital crop under field conditions.

MATERIALS AND METHODS

Study area :

The study area is located in the northern part of the middle Delta "Latitude 31°-31° 30' N" Thus, it encompasses most of Kafr El-Sheikh and the western sector of Dakahilya Governorates. The climate is typically Mediterranean with hot dry summers and cool winters. The average annual rainfall is in the range between 160 mm at Baltim to the north, and 66mm at Kafr El-Sheikh to the south.

Methods :

Forty six sites, of about two faddans each "one feddan=4200 m²" were selected to represent soils of different characteristics through the study area. At each, the fluctuation of water table depth "WTD" was recorded through the established pizometers. The soil profiles were dug and the soil samples were collected at 30 cm intervals up to 150 cm depth or to the level of the ground water table. Following Page (1984), the soil samples were analysed for pH, electrical conductivity (EC mmhos/cm), capacity "CEC meq/100g soils" and exchangeable sodium percent "ESP" according to Gohar (1954). Particle size distribution was measured by the pipette method (Piper 1950). Organic matters were estimated according to Walkely

and Black's method, (Page 1984).

The average values of soil constituents throughout the soil profiles were calculated on the weighed volume bases. Table 1 shows the descriptive statistics of the obtained data.

During the three successive seasons 1986/87, 1987/88, 1988/89, the selected fields were ploughed and fertilized with 100 Kg supper phosphate "15.5 % P₂O₅"/feddan during tillage operations. The second half of November was the date of sowing the beet seeds "Trible variety". After thinning, nitrogen fertilizer was applied at a rate of 50 kg N/feddan. At the end of each growing season "200+10 days from planting", the following characters were determined: a) root growth (root length "RL" and diameter "RD"), (b) juice quality (the percentage of total soluble solids "TSS%", sucrose "Suc." and purity "P%". and c) the yield of both fresh root

Table 1. Descriptive statistics of some physical and chemical characters of the selected sites.

Characters	No Sites	Mean	S. D.	Minimum	Maximum
.WTD "Cm"	46	105.62	30.676	40.00	156.00
Clay %	46	70.88	10.853	35.00	85.00
Organic matter%	46	1.22	0.050	1.12	1.32
pH	46	7.98	0.273	7.60	8.40
ECe "mmhos/cm"	46	7.46	5.661	1.42	25.92
Ca meq/L	46	7.96	4.015	3.43	19.03
Mg meq/L	46	15.38	11.433	3.46	47.95
Na meq/L	46	52.05	42.361	6.26	194.28
K meq/L	46	0.64	0.526	0.16	3.27
(CO ₃ + HCO ₃) meq/L	46	5.24	0.931	3.60	7.16
CL meq/L	46	53.27	44.089	6.70	197.95
SO ₄ meq/L	46	17.99	12.844	1.89	58.70
CEC meq/100 g	46	39.74	5.135	18.90	48.30
ESP	46	15.46	7.692	3.20	36.40

WTD = Water table depth (cm).

"YR" and sugar "YS" ton/ feddan. The values of TSS% and SuC% were determined according to A.O.A.C., (1995) and Le-Docte (1927), respectively.

The relations between soil characteristics and the sugar beet constituents were established and the results were subjected to statistical analysis.

RESULTS AND DISCUSSION

1- Soil characteristics :

Data in Tabl 2 show that the water table depth (WTD) through the investigated sites varied from 40 to 156 cm. This practically indicates the presence of three drainage conditions: a) poor drained soils, where the values of "WTD" is less than 80 cm; b) moderately drained soils "WTD" 80-120 cm" and perfect drained ones "WTD> 120 cm".

Regarding the soil texture, only one site falls in the clay loam class, however the others are clayey, having clay percent of 48-85%.

The organic matter percent was generally low and no great variations were recorded, as the values ranged from 1.13 to 1.32%.

The pH values fall in the alkaline side (7.6 to 8.4). being less than 8 in 22 sites; 8 to 8.2 in 14 sites and more than 8.2 in the others.

The salinity, as expressed by EC- values, varied from 1.42 to 29.92 mmhos/cm, indicating free of salinity ($EC < 4$ mmhos/cm), moderately saline ($EC < 8$ mmhos/cm); highly saline ($EC < 16$ mmhos/cm) and very high saline ($EC > 16$ mmhos/cm) in 17, 15, 10 and 4 sampling sites, respectively.

The ESP values ranged from 3.2 to 36.4, indicating free sodicity conditions ($ESP < 5$) and sodicity ($ESP > 15$) in 24 and 22 sites, respectively.

Regarding salinity and sodicity parameters, the non, moderately high and very high saline non sodic conditions were recorded in 17, 6, and 1 sites, while they were medium, high and very high saline-sodic in 9, 9 and 4 sites, respectively.

Table 2. Some soil properties and sugar beet constituents of the investigated sites.

Site No.	Soil Characters					Root growth		Juice quality			Yield	
	WTD	pH	ECe	ESP	Caly %	RL	RD	TSS	Suc.	P	RY	Sy
1	40.0	8.4	21.80	30.3	82.0	18.5	16.4	25.14	13.58	54.02	5.83	0.97
2	48.0	8.1	7.80	17.9	87.0	24.2	22.7	23.98	14.86	61.97	10.25	1.52
3	52.0	8.3	12.37	21.8	52.0	21.6	23.7	23.86	15.48	64.88	8.77	1.36
4	62.0	8.2	12.37	15.7	84.0	24.2	25.6	22.63	16.08	71.10	11.86	1.91
5	65.0	8.4	5.48	21.8	67.0	24.3	25.8	22.54	15.08	66.90	13.38	2.02
6	95.0	8.2	9.65	19.4	58.0	20.9	27.3	22.78	15.90	69.80	14.75	2.35
7	67.0	8.3	17.38	31.9	81.0	20.3	18.7	24.78	13.76	55.53	7.20	0.99
8	70.0	8.0	7.10	18.2	76.0	28.9	26.4	23.70	15.30	64.56	13.46	2.06
9	102.0	7.8	2.52	8.1	68.0	30.0	26.7	21.87	17.26	78.92	17.20	2.97
10	117.0	7.6	3.15	10.0	84.0	31.6	25.4	21.73	18.05	83.06	18.90	3.41
11	110.0	8.1	6.84	15.3	85.0	30.4	26.3	22.48	16.13	71.75	17.24	2.78
12	82.0	7.6	6.19	13.7	64.0	31.8	26.2	22.64	16.20	71.24	17.92	2.90
13	82.0	7.6	3.99	12.3	67.8	31.9	25.5	21.48	18.36	85.43	17.93	3.29
14	86.0	7.7	1.68	4.8	72.0	32.6	29.4	21.87	17.56	80.29	18.20	3.20
15	87.0	8.3	9.29	22.2	83.0	30.7	22.6	22.64	16.30	71.96	14.63	2.38
16	92.0	8.3	10.71	20.9	81.0	27.3	23.7	23.45	16.25	69.30	12.80	1.96
17	93.0	7.8	2.33	7.5	82.0	35.4	27.2	21.46	17.28	80.52	19.30	3.34
18	93.0	8.3	8.00	20.4	79.0	34.3	26.9	23.26	15.92	68.44	15.56	2.95
19	93.0	7.9	4.40	14.3	48.0	34.1	26.7	22.46	17.25	76.80	18.64	3.18
20	73.0	8.3	25.92	32.7	63.5	20.7	17.3	25.82	13.18	51.05	8.48	1.12
21	96.0	7.9	3.31	10.1	35.0	35.7	27.4	21.58	17.23	79.84	19.80	3.41
22	117.0	7.7	3.55	10.7	80.0	41.2	27.9	22.18	18.53	83.54	21.90	4.06
23	107.0	8.3	12.46	21.3	68.0	31.5	19.7	23.45	15.03	64.09	21.72	1.91
24	110.0	7.9	3.14	9.5	66.0	42.7	32.3	21.98	17.46	79.44	21.35	3.73
25	110.0	8.2	13.44	22.7	67.0	31.9	20.2	23.97	15.26	63.66	12.83	1.96
26	112.0	8.0	3.69	12.4	48.0	41.7	31.8	22.76	19.35	85.02	23.47	4.54
27	112.0	7.8	2.55	7.1	68.0	44.0	31.6	21.32	18.27	85.69	23.70	4.33
28	115.0	7.7	2.64	9.2	85.0	43.2	31.4	21.45	17.85	82.22	22.30	3.98
29	120.0	8.2	4.16	10.5	75.0	46.8	32.6	21.55	17.83	82.74	24.60	4.39
30	103.0	8.1	9.52	16.9	67.0	35.4	27.5	22.86	15.78	69.03	19.30	3.05
31	125.0	8.2	7.06	15.3	60.0	44.2	30.9	23.85	16.24	86.09	22.18	3.60
32	106.0	7.9	11.66	20.3	62.0	38.6	21.4	23.80	15.62	65.63	15.36	2.40
33	128.0	8.0	2.88	10.6	76.0	46.2	32.0	21.07	17.93	85.10	23.70	4.25
34	131.0	8.4	7.60	16.6	78.0	45.9	32.1	23.07	16.52	71.61	23.50	3.88
35	75.0	8.2	20.80	36.4	75.5	26.8	19.2	24.58	13.82	56.22	8.63	1.19
36	135.0	8.2	7.94	17.6	67.0	46.8	30.7	23.13	16.07	69.48	22.57	3.63
37	116.0	7.7	14.20	25.8	76.0	33.2	21.9	23.95	15.37	64.18	12.54	1.93
38	145.0	7.6	4.63	12.1	76.0	47.2	33.8	21.78	17.73	81.4	25.77	4.57
39	145.0	7.6	1.42	3.2	64.0	48.6	33.2	21.46	18.63	86.81	26.30	4.90
40	145.0	7.6	1.75	4.9	77.0	49.2	36.5	22.52	19.93	88.50	30.70	6.12
41	147.0	7.6	2.98	9.0	84.0	47.4	32.8	21.56	18.74	85.67	25.60	4.73
42	150.0	7.7	1.78	6.0	72.0	49.7	36.4	21.37	18.20	85.17	30.70	5.59
43	152.0	8.0	6.98	14.8	67.0	48.3	31.6	22.98	17.83	77.59	24.85	4.43
44	152.0	7.6	5.66	12.5	67.0	48.7	33.5	22.79	18.03	80.17	46.42	4.76
45	155.0	7.8	11.05	12.4	72.0	37.4	22.5	23.18	15.63	67.43	16.94	2.65
46	156.0	7.7	2.28	9.4	73.0	47.8	35.6	21.07	18.92	89.80	29.70	5.62

RL = root length (cm)

RD = root diameter (cm)

TSS = total soluble solids %

Suc. = sucrose %

P = purity %

RY = root yield (ton /fed)

SY = sugar yield (ton /fed)

II- Effect of some soil characteristics on sugar beet constituents.

a) Water table depth :

With regard to the individual effect of soil factors on sugar beet components (Tables 2&3) the root growth, as expressed by length and diameter, and accordingly the yield, were more affected by the level of "WTD" compared to the juice quality components (TSS %, Suc. %, and P %). In comparison to those of the perfectly drained soils, the reduction rate in the moderately drained ones reached to about 30-35% for both (RL) and (RY) and about half of that for (RD) but it was rather limited (4-8 %) for (Suc.) and (P). Under the poor drained conditions the corresponding values reached 50-61 %, 32% and 17-24%, respectively. However, the values of (TSS) component showed 7-8% increase. Regarding sugar yield, the reduction rate was more pronounced in both moderately and poorly drained soils compared with the perfect ones, reaching 31 % and 69% , respectively.

b) Soil salinity and sodicity :

Owing to the salinity and sodicity parameters of the soils, the investigated soils could be classified into six categories, being non saline-non sodic (NS-NA); moderately saline-non sodic (MS-NA); highly saline-non sodic (HS-NA); moderately saline sodic (MS-A); highly saline sodic (HS-A) and very highly saline sodic (VHS-A).

Results in Table 3, indicate that all values of sugar beet constituents, except "TSS", showed different decreases in all soil categories compared to the first one. Although there is no reduction, in the second category, the reduction rate varied from 10 to 20% for root length and juice quality components and from 25 to 35% for root and sugar yields under the third one. The adverse impact under the fourth category, (MS-A) was similar to that of the third (HS-NA). This indicated that the sodicity conditions added to the adverse effects of salinity. the progressive reduction in sugar beet constituents continued with increasing salinity and sodicity values to reach the peak under the last category (VHS-A) being about 47%, 42%, 25%, 36%, 67%, and 76%, for RL, RD, Suc., P, RY and SY, respectively. Meanwhile, the values of TSS showed about 16% increase. Noteworthy, decreasing the purity and increasing TSS values indicate the accumulation of soluble salts in the juice. Molass production will increase on the account of sucrose recovery. Sugar which is the end product will be adversely affected. These results are in agreement with those ob-

Table 3. Effect of Some soil characteristics on sugar beet constituents

Soil Char	Class	No. of sites	RL		RD		TSS		Suc.		P		RY		SY	
			AV.	%	AV.	%	AV.	%	AV.	%	AV.	%	AV.	%	AV.	%
WTD (Cm)	>120	13	46.7	100	32.3	100	22.3	100	17.7	100	79.8	100	253	100	4.5	100
	80-120	24	34.9	74.7	26.7	82.7	22.5	101	16.9	95.5	73.2	91.7	18.1	71.5	3.10	68.9
	< 80	9	23.3	49.9	21.9	67.8	24.1	108	14.6	82.5	60.7	76.1	9.8	38.7	1.4	31.1
pH	< 8.00	22	41.1	100	29.1	100	21.8	100	17.8	100	81.9	100	22.6	100	4.06	100
	8-8.2	14	32.2	78.3	25.3	86.9	23.5	107.9	15.8	88.8	67.7	82.7	15.4	68.1	2.50	61.6
	> 8.2	10	29.9	72.7	23.7	81.4	23.7	108.7	15.3	86.6	64.8	79.1	13.9	61.5	2.17	53.4
Sal. & Alk.	NS-NA	17	41.1	100	30.8	100	21.7	100	18.2	100	83.9	100	23.0	100	4.20	100
	MS-NA	6	42.8	104	30.7	99.7	22.4	103.2	17.5	96.0	78.3	93.3	23.0	100	4.04	96.2
	HS-NA	1	37.4	91.0	22.5	73.1	23.2	106.9	15.6	85.7	67.4	80.3	16.9	73.5	2.65	63.1
	M.S-A	9	33.7	82.0	27.6	89.6	23.4	106.9	15.8	86.8	68.2	81.3	17.0	73.9	2.71	64.5
	HS-A	9	30.1	73.2	23.1	75.0	23.4	107.8	15.7	86.3	67.0	79.9	13.7	56.6	2.14	51.0
	VHS-A	4	21.6	52.6	17.9	58.1	25.1	115.7	13.6	74.7	54.2	64.6	7.5	32.6	1.02	24.3
Texture	L.C.	20	38.7	100	27.2	100	22.7	100	16.8	100	74.4	100	19.0	100	3.24	100
	H.C.	25	36.0	93.0	27.8	100	22.7	100	16.7	100	74.3	100	18.6	97.9	3.20	98.8

Sal. & Alk = Salinity and sodicity

NS-NA = Non saline-non sodic.

MS-NA = Medium saline - non sodic.

HS-NA = Highly saline - non sodic

L.C. = Clay

H.C. = Heavy clay.

MS-A = Medium saline - sodic.

HS-A = High saline - sodic.

VHS-A = Very high saline - sodic.

AV. = averages.

tained by Ashor and Thalooth (1971), Allam and Ali (1982), and Shehata (1989).

c) Clay percent :

As previously mentioned, the texture of the soils, except one, are of clay class (48 to 85% clay). To discuss the impact of clay% on the sugar beet constituents, the soils were separated into two categories with a limit of 70% clay. Results in Tables 2 & 3 show that the increase of clay percent over 70% had resulted in a decrease of about 7%, 2%, and 1% of the values of RL, RY, and Sy, respectively, however the other constituents were not greatly affected.

Summation of soil characteristics that are significantly correlated to each of the sugar beet components seems to be more close and practical in predicting their levels under different soil conditions than depending on the individual factors and interrelations.

Following the full model regression analysis, the best equations as well as the values of multiple "r" are given in Table 4. The regression of the studied sugar beet components on the four independent soil factors are highly significant, (r values ranged from 0.8900-9421).

The stepwise regression model was applied to identify the contribution rate of each of the independent variables (Table 4 and Fig 1). It appears that the contribution of some soil factors are omitted from the given equations. This is due to their insignificant effects. In general soil salinity was the only factor that affected significantly the variation of TSS components, however the other ones were significantly affected by WTD and EC-variables. Noteworthy, the contribution rate of the effective variables varied according to the sugar beet components. For example, WTD (X_1) and EC- (x_2) accounted for 78.19% and 5.58% on of the variations of "RL" compared to 2.6% and 84.16% for "P", respectively. However, the residual values representing the impact of other factors were outside the scope of the present study, in addition to the experimental errors.

From the practical point of view, the studied soils could be arranged according to the sugar beet production into three categories. The first produced more than 17 tons fresh roots or 2.9 tons sugar/feddan. The soils are well drained, free to moderately saline, non sodic and having pH values less than 8. The second soils produced 12-17 tons roots or 1.9-2.9 tons sugar/feddan. The soils are poorly to moderately drained and moderately saline-sodic. The third soils gave less than 12 tons roots or

Table 4. Regression equation, multiple regression "r" and partial contribution of the soil factors on the variations of sugar beet constituents.

Beet Character	Model	Regression equations	r	Partial contribution					Residual
				X ₁	X ₂	X ₃	X ₄	Total	
R.L.	Full	$Y = 14.56 + .237X_1 - 5831X_2 + .1066X_3 - .0175X_4$	.9157	-	-	-	-	-	-
	S.W	$Y = 14.57 - .2333X_1 - .04478X_2$	.9152	78.19	5.58	n.s	n.s	83.77	16.23
R.D	Full	$Y = 25.28 + .721X_1 - .748X_2 + .1313X_3 - .032X_4$	.8911	-	-	-	-	-	-
	S.W	$Y = 24.46 + .0678X_1 - .5760X_2$	.8879	12.35	66.49	n.s	n.s	78.84	21.16
TSS	Full	$Y = 21.94 - .0022X_1 + .1449X_2 + .0227X_3 + .0057X_4$	.912	-	-	-	-	-	-
	S.W	$Y = 21.3764 + .1286X_2$	.9072	n.s	82.83	n.s	n.s	82.83	17.70
Suc.	Full	$Y = 17.21 + .0136X_1 - .149X_2 - .0494X_3 -$	.9170	-	-	-	-	-	-
	S.W	$Y = 16.566 + .0156X_1 - .263X_2$	.9148	80.51	3.14	n.s	n.s	83.65	16.35
P.	Full	$Y = 78.8155 + .06554X_1 - .9592X_2 -$	.9357	-	-	-	-	-	-
	S.W	$Y = 75.89 + .0797X_1 - .11073X_2$	.9315	2.60	84.16	n.s	n.s	86.76	13.24
RY	Full	$Y = 11.45 + .127X_1 - .5538X_2 - .0006X_3 - 0.323X_4$	.9421	-	-	-	-	-	-
	S.W	$Y = 8.9133 + .1283X_1 + .5354X_2$	.9406	70.98	17.50	n.s	n.s	88.48	11.52
SY	Full	$Y = 1.95 + .0238X_1 - .0955X_2 - .0207X_3 - .0038X_4$	.9308	-	-	-	-	-	-
	S.W	$Y = 1.4267 + .0248X_1 - .1173X_2$	.9292	66.62	19.72	n.s	n.s	86.34	13.66

Full = Full model regression
 S.W = Step wise model regression
 ** = Highly significant
 n.s. = not significant

X₁ = WTD "cm"
 X₁ = EC "mmhos/cm"
 X₁ = ESP
 X₁ = Clay %

PARTIAL CONTRIBUTION OF SOIL FACTORS

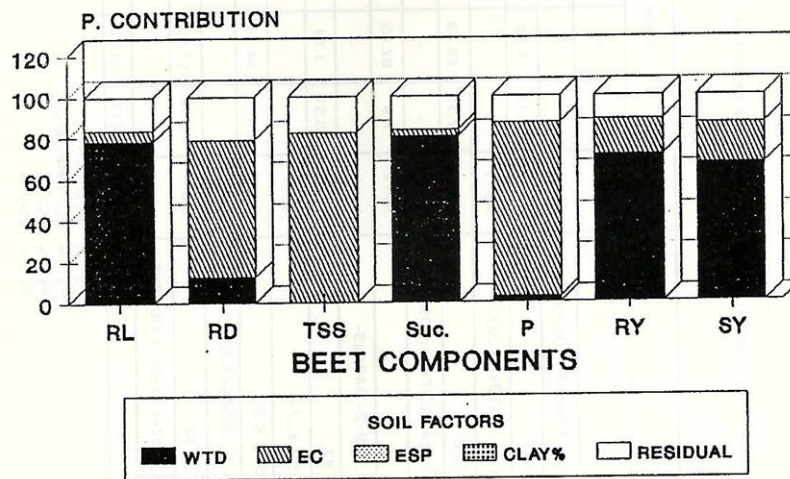


Fig.1

less than 1.9 tons sugar/feddan. The soils are poorly drained and highly to very highly saline-sodic.

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تأثير بعض خواص التربة على نمو الجذور وصفات العصير وإنتاجية بنجر السكر

عطا فوزى الوكيل

معهد بحوث الأراضى والمياه - مركز البحوث الزراعية - الدقى - الجيزة

أقيمت دراسة حقلية لتحديد تأثير بعض خواص التربة على نمو الجذور وصلاحية العصير وإنتاجية بنجر السكر وذلك خلال المواسم الزراعية ١٩٨٧/٨٦ ، ١٩٨٨/٨٧ ، ١٩٨٩/٨٨ حيث تم اختيار ٤٦ موقعا ممثلة لنوعيات الأراضى المختلفة بنطاق زراعة هذا المحصول بمنطقة وسط الدلتا (خط عرض ٣١° - ٣٠° ، ٣١° شمالا) وتحت الظروف التجريبية أوضحت النتائج مايلى :

١ - انخفضت قيم نمو الجذور (معبرا عنها بالطول والقطر) ودرجة نقاوة العصير وكذلك قيم المحصول انخفاضا معويا عندما قل عمق مستوى الماء بالأرض عن ١٠٠ سم من سطح التربة أو ارتفعت قيم كل من درجة التوصيل الكهربائى (ملليموز / سم) أو الأس الأيدروجينى بمستخلص عجينة التربة المشبعة عن الرقم ٨ .

٢ - لم تظهر قيم كل من معيار القلوية (E S P) أو نسبة الطين أى علاقة معنوية مع مكونات المحصول.