Effect of Balanced Fertilization and Ploughing Depth on Elemental Composition of Sugar Beet and some Chemical Properties in Salt Affected Soils

Mashali, S.A.; A.A. Balba; M.R. Khalifa and S.A. Morssi

Soil Department, Faculty of Agriculture
Kafr El-Sheikh, Tanta University, Egypt

Abstract

Two field experiments were carried out during two successive seasons at the experimental farm of Faculty of Agriculture, Kafr El-Sheikh to study the interaction effect of balanced fertilization with NPK (N-rates: 0, 72, 144 and 216 kg N/ha, P-rates: 0, 36 and 72 kg P_2O_5/ha and K-rates: 0, 36, 72 and 108 kg K_2O/ha) and soil ploughing depth (shallow at 15 cm and deep at 30 cm) on some soil properties and uptake of NPK by sugar beet plant (cultivar, Maribo Poli). The soil used had clay texture, 86 meq/L of total soluble salts and belongs to soil order of vertisol.

The results of plant analysis indicated that, NPK concentration were increased in shoots of sugar beet plant under deep ploughing compared with shallow one. The highest value of N concentration was obtained at 216 kg N/ha of N application whereas the highest value of P and K concentration were recorded at 72 kg P_2O_5/ha and 72 kg K_2O/ha, respectively.

Soil analysis after sugar beet harvesting showed that, soil pH and total soluble salts were decreased under deep ploughing (30 cm depth) without any addition of fertilizers. On the other side, addition of NK fertilizers haven't significant decrease on soil pH but superphosphate fertilizer had partial effect on decreasing soil pH in the surface soil layer (0-15 cm). Statistical analysis showed that the relationship between NPK fertilizers and ploughing depths was highly significant in decreasing the electrical conductivity of soil solution.

The calculated values of sodium adsorption ratio (SAR) from soluble Ca^+, Mg^{++} and Na^+ measured in soil solution after harvesting of sugar beet plants and hence exchangeable sodium percentage (ESP) were decreased in the soil surface (0-15 cm) under deep ploughing at 30 cm compared to shallow ploughing at 15 cm. On the other side, the lowest value of SAR (2.27) and ESP (4.44%) were obtained under deep ploughing and addition of 72 kg N/ha, 72 kg P_2O_5/ha and 36 kg K_2O/ha of added fertilizers.

Introduction

Sugar beet has become one of the major winter field crop in Egypt due to its high income to the farmers. Its area tended to increase year after another especially in salt affected soils. Fertilization is one of the most important limiting factor for sugar beet production under Egyptian conditions. Complete and balanced fertilization of NPK is important for high crop production.

Ploughing is one of the main practices operated before sugar beet planting which used to provide the necessary soil conditions favorable to growth of that crop. Agboola (1981) showed that tillage and fertilizers application reduced the organic matter content, soil pH, and slightly increased exchangeable potassium and phosphorus. Rezk *et al*. (1982) found that, tillage operation had a general depressive effect on the EC of the surface of soil.

Many investigators reported that nitrogen is the most limiting nutrient for sugar beet (Kemp *et al.,* 1994, El-Attar *et al.,* 1995 and Rezk *et al.,* 1995). Other researchers concluded that application of phosphorus affected the yield and quality of sugar beet (Abbott and Nelson, 1983, Hegazy *et al.,* 1992 and Abou El-Soud *et al.,* 1994). On the other side, sugar beet plant has an affinity to potassium element, Mittchera (1978) and Ghaly *et al*. (1984) reported that increasing K fertilization rate resulted in increasing K content and sugar root yield.

Therefore, the objective of this research was to investigate the interaction effect between soil ploughing depth and NPK fertilization on some chemical properties of salt affected soil and nutrients uptake by sugar beet plants.

Materials and Methods

A field experiment was conducted at the experimental farm of the Faculty of Agriculture, Kafr El-Sheikh, Tanta Univ., during two successive seasons. Some soil properties of the soil used are shown in Table (1) which had clay texture (50% clay) and belongs to vertisol order.

The experiments were carried out in split plot design with three replicates. The main treatments were ploughing depth (15 and 30 cm), while the subtreatments were different rates of NPK fertilizers. Nitrogen was added in the form of urea (46% N) at four rates of application (0, 72, 144 and 216 kg N/ha). Every rate was added in three equal portions after thinning and before the second and the third irrigation. Potassium sulphate (48% K_2O) was added at four rates of application (0, 36, 72 and 108 kg K_2O/ha). Each rate was applied in two equal portions, after thinning and before the second irrigation. Superphosphate fertilizer (15.5% P_2O_5) was added before planting at three rates of application (0, 36 and 72 kg P_2O_5/ha).

Table (1): Mean values of some chemical properties of the studied soil before planting

Soil characteristics	Soil depth, 0-15 cm
Electrical conductivity, dS/m (paste)	8.56
pH (1: 2.5 soil/water ratio)	8.85
Soluble cations, meq/L (paste):	
Ca^{++}	18.00
Mg^{++}	23.00
Na^{+}	42.00
K^{+}	2.00
Total carbonate (%)	3.42
Sodium adsorption ratio (SAR)	9.3
Exchangeable sodium percentage (ESP), %	11.12
Total nitrogen (%)	0.20
Available-P, $NaHCO_3$-extractable P (mg/kg)	12.08
Available-K, NH_4OAC-extractable K (mg/100 g)	21.84

Sugar beet cultivar (Maribo Marina Poli) was sown on November and harvested at the end of May (about 200 days). All agricultural practices were carried out according to conventional local recommendation of the Ministry of Agriculture, Egypt.

Plant samples (leaves) were collected from each plot at the end of every season. Each sample was washed with distilled water and dried in oven at 70^{o}C. Wet digestion was used in H_2SO_4-H_2O_2 mixture to determine the concentration of the three major elements (NPK) according to Chapman and Pratt (1961).

After harvesting, soil samples were taken at 0-15 cm depth, dried and prepared for chemical analysis. The electrical conductivity (EC) and water soluble cations (Ca^{++}, Mg^{++} and Na) were determined in the soil water ratio at 1: 5 according to Page *et al.,* 1982. SAR and ESP were calculated from values of soluble cations according to the following equations:

$$\text{SAR} = \frac{\text{Na}^{+}}{\sqrt{(\text{Ca}^{++} + \text{Mg}^{++})/2}} \text{ \& ESP} = \frac{\text{ESR}}{1 + \text{ESR}} \text{ x 100 (Black, 1983).}$$

Where: ESR = -0.0126 + 0.01475 SAR

Soil reaction (pH) was measured in soil suspension (1: 2.5 soil/water ratio). Data were statistically analyzed according to Snedecor and Cochran (1980) using multiple range test at 5% and 1% levels.

Results and Discussion

Root yield of sugar beet crop:

Data presented in the first part of this work by the same authors (Khalifa *et al.,* 2000) showed that, addition of 216 kg N/ha + 72 kg P_2O_5/ha + 108 kg K_2O/ha were considered the most suitable needs from nutrients for sugar beet plants under deep ploughing (30 cm). The general mean of roots yield was about 96 and 89 ton/ha for different NPK treatments under deep and shallow ploughing, respectively. The corresponding values were 26 and 21 ton/ha without any addition of fertilizers. Whereas mean values of the sucrose percentage were found to be 16.5 and 15.1% at different treatments of NPK under shallow and deep ploughing, respectively. The corresponding values were 12 and 11% without any addition of fertilizers. That means, deep ploughing may be encouraged the roots of sugar beet to penetrate and move through the soil and getting the best of their nutritive needs from the soil.

N, P and K concentration in shoots of sugar beet plant:

Table (2) indicated that N concentration was increased in shoots of sugar beet plant under deep ploughing compared with shallow one, where N concentration was 2.98% and 2.24% without any addition of fertilizers, respectively. Application of N increased N concentration in shoots of sugar beet up to 5.32% under deep ploughing and 216 kg N/ha. Addition of P fertilizer encouraged nitrogen uptake by sugar beet plants, where the highest value of N concentration was obtained under the second level of P (72 kg P_2O_5/ha). This may be due to that, the deep ploughing facilitated the root distribution, and consequently increased the absorption area of plants to nutrients. On the other hand, data showed that increasing of added potassium had no effect on concentration of N in shoots, where the highest value of N concentration was obtained at N_{216} P_{72} K_0 for both shallow and deep ploughing.

The results showed that, also phosphorus content in sugar beet was higher under deep ploughing than shallow one. The highest value of P concentration was 5.75 mg P/g dry matter of plant under deep ploughing and $N_{144}P_{72}K_{72}$ treatment. This result indicated that, higher dose of added-N (216 kg N/ha) may be increasing the vegetative growth and decreasing phosphorus absorption by plants. On the other hand, potassium absorption by sugar beet plants was increased with increasing added K up to 108 kg K_2O/ha under different treatments of other nutrients (N and P), but the concentration of K in plant shoots was higher under deep ploughing than its under shallow one. Maximum concentration of K in the shoots was obtained at $N_{72}P_{36}K_{108}$ of added fertilizers under deep ploughing. These results indicated that deep ploughing lowered fertilizer requirements and gave the best uptake at balanced fertilization. This was in agreement with the studies of Bajpai and Joshi (1992) and Hamissa (1995).

Table (2): Concentration of N, P and K in sugar beet plant (shoots) as affected by soil ploughing depth and increment rates of NPK fertilizers.

Fertilizer treatments	Shallow ploughing at 15 cm			Deep ploughing at 30 cm		
	N %	P mg/g plant	K mg/g plant	N %	P mg/g plant	K mg/g plant
$N_0P_0K_0$	2.24	2.12	21.45	2.98	2.87	36.27
$N_{72}P_{36}$ K_0	2.24	2.20	36.27	3.40	2.97	42.12
K_{36}	3.19	2.29	37.05	4.05	4.16	65.52
K_{72}	2.87	2.94	42.12	4.69	3.77	72.15
K_{108}	3.62	2.47	44.85	3.83	3.30	76.05
Mean	2.98	2.48	40.07	3.99	3.54	63.96
$N_{144}P_{36}$ K_0	2.66	2.88	38.22	3.51	3.48	42.90
K_{36}	3.30	2.14	40.17	3.51	3.22	50.70
K_{72}	3.41	3.10	50.70	3.73	4.60	58.50
K_{108}	3.09	2.87	57.72	3.41	3.43	59.67
Mean	3.12	2.75	46.70	3.54	3.68	52.94
$N_{216}P_{36}$ K_0	4.04	3.27	40.95	4.36	3.72	49.92
K_{36}	4.15	2.21	42.90	4.26	3.43	53.82
K_{72}	3.30	2.67	47.97	3.73	3.60	68.25
K_{108}	2.34	2.53	66.30	4.05	3.02	70.20
Mean	3.46	2.67	49.53	4.10	3.44	60.55
$N_{72}P_{72}$ K_0	2.56	2.34	37.05	4.15	4.06	48.75
K_{36}	3.09	2.46	47.97	3.51	4.80	51.87
K_{72}	3.19	4.04	53.82	4.15	5.48	60.45
K_{108}	2.56	3.87	54.60	3.83	4.13	64.35
Mean	2.85	3.30	48.36	3.91	4.62	56.36
$N_{144}P_{72}$ K_0	2.77	3.64	40.17	4.26	4.36	49.92
K_{36}	2.98	2.20	42.12	3.64	5.07	56.55
K_{72}	2.98	3.80	44.07	4.26	5.75	63.57
K_{108}	3.09	4.12	62.40	3.73	3.79	68.25
Mean	2.97	3.44	47.19	4.05	4.74	59.57
$N_{216}P_{72}$ K_0	4.90	3.95	44.85	5.32	5.02	53.82
K_{36}	3.30	4.35	44.85	3.73	4.50	55.77
K_{72}	3.73	4.55	52.82	4.15	4.70	64.35
K_{108}	3.62	3.69	62.40	4.68	4.39	68.25
Mean	3.89	4.14	51.48	4.47	4.65	60.55
General mean	3.21	3.13	47.22	4.01	4.11	60.49

Effect of soil ploughing depth and NPK treatments on soil pH and EC:

Data presented in Table (3) show the mean values of soil pH and EC in the soil solution of surface layer (0-15 cm) after harvesting sugar beet crop. The results showed that soil pH and EC were decreased under deep ploughing (30 cm) compared to the shallow one (15 cm) without any addition of fertilizers, where soil pH was 8.87 and 8.70 while EC was 2.11 and 0.83 dS/m under shallow and deep ploughing, respectively. Decrease of soil pH under deep ploughing may be due to that the deep ploughing buried the organic matter deeper in the soil, where decomposition of organic matter in soil produced organic acids which led to decrease soil pH (Ali and Abo Habaga, 1995). On the other side, EC decreasing of soil solution may be due to increasing penetration of water under deep ploughing which led to leaching the salts through the soil profile.

Table (3): Mean values of soil pH and EC (dS/m) as affected by increment rates of NPK fertilizers after harvesting sugar beet crop.

NK treatments		Shallow ploughing (15 cm)				Deep ploughing (30 cm)			
N kg/ha	K kg K_2O/ha	P_1 (36 kg P_2O_5/ha)		P_2 (72 kg P_2O_5/ha)		P_1 (36 kg P_2O_5/ha)		P_2 (72 kg P_2O_5/ha)	
		pH	EC	pH	EC	pH	EC	pH	EC
72	0	8.80	0.77	8.57	1.21	8.55	0.58	8.51	0.81
72	36	8.66	1.03	8.96	0.93	8.52	0.67	8.56	0.55
72	72	8.68	1.18	8.40	1.45	8.60	0.80	8.26	0.64
72	108	8.66	0.89	8.62	0.91	8.53	0.68	8.59	0.86
Mean		8.70	0.97	8.64	1.13	8.55	0.68	8.48	0.72
144	0	8.71	1.21	8.60	0.73	8.41	0.68	8.58	0.63
144	36	8.77	0.85	8.83	0.98	8.66	0.53	8.50	0.85
144	72	8.78	0.62	8.80	0.99	8.25	0.55	8.44	0.62
144	108	8.79	1.33	8.63	1.14	8.44	0.88	8.58	0.80
Mean		8.76	1.00	8.72	0.96	8.44	0.66	8.53	0.73
216	0	8.61	0.96	8.60	1.18	8.57	0.56	8.58	1.03
216	36	8.53	0.84	8.70	0.76	8.50	0.68	8.59	0.58
216	72	8.86	0.63	8.80	0.68	8.57	0.60	8.57	0.67
216	108	8.82	0.75	8.60	0.86	8.66	0.62	8.55	0.67
Mean		8.71	0.80	8.68	0.87	8.58	0.62	8.60	0.74
General mean		8.72	0.92	8.68	0.99	8.52	0.65	8.53	0.73

Significance for	Parameters						
	D	P	T	D X P	T X D	T X P	T X D X P
Soil pH	*	*	ns	*	ns	**	ns
EC	*	**	**	**	ns	**	**

D = Ploughing depth T = NK treatments P = P-treatments

*, ** = significant and highly significant at 5% and 1%, respectively.

Application of NK fertilizers to the soil haven't significant decrease on soil pH but superphosphate fertilizer had a significant effect on decreasing soil pH in the surface soil layer (0-15 cm). This is because the acidity effect of superphosphate which dissolve to give a solution with pH value of about 1.48 (Lindsay, 1979). Statistical analysis showed that the interactions between P and NK fertilizers had highly significant effect on soil pH and also between ploughing operation and P only. The lowest value of soil pH was 8.25 under deep ploughing and 144 kg N/ha + 72 kg K_2O/ha + 36 kg P_2O_5/ha of added fertilizers. It can be concluded that, decreasing soil pH was considered an important goal for many agriculture practices in our soils which increases availability of most nutrients. Therefore, addition of acidic fertilizers such as superphosphate is an important goal not only to its acidulation effect but also to balanced fertilization with N and K fertilizers.

Statistical analysis in Table (3) showed that the relationships between NPK fertilizers and ploughing depths were highly significant in decreasing EC of soil solution.

The lowest value of soil EC (0.53 dS/m) was obtained at 144 kg N/ha + 36 kg P_2O_5/ha + 36 kg K_2O/ha treatment under deep ploughing at 30 cm. Heavy clay soil from Nile delta needs to deep ploughing to reduce the water table of ground water and hence decreasing the total soluble salts of soil solution. Decreasing the total soluble salts in the soil solution after harvesting the sugar beet crop, may be related to plant healthy growing and better uptake of nutrients.

Effect of soil ploughing depth and NPK treatments on soluble Ca^{++}, Mg^{++} and Na^{+}:

Data in Table (4) showed that the soil solution after harvesting of sugar beet plant contained higher amounts of soluble Ca^{++}, Mg^{++} and Na^{+} under shallow ploughing (15 cm) than its value under deep ploughing (30 cm) without any addition of fertilizers ($N_{.0}P_0K_0$ treatment). Soluble Ca^{++} was 4.60 and 4.2; soluble Mg^{++} was 6.10 and 3.80; soluble Na^{+} was 11.00 and 6.25 meq/L under shallow and deep ploughing, respectively. This decrease in soluble cations under deep ploughing may be attributed to improving soil permeability and hydraulic conductivity which increase the movement of soluble cations through the soil profile. These results were confirmed by those obtained by Agboola (1981) and Rezk *et al*. (1982).

Addition of different fertilizers at different rates led to decreasing soluble cations in the soil solution. That is clear from difference values between control treatment ($N_{.0}P_0K_0$) and general mean (Table 4). This may be attributed to good plant growth and hence more absorption of cations from soil solution and/or insoluble compounds precipitation such as Ca and Mg phosphates. Values of general means for soluble cations indicated that the order of decreasing was Mg^{++} > Ca^{++} > Na^{+} (see Table 4).

The interaction between different fertilizer treatments and soil ploughing depths showed highly significant relationships in decreasing the amounts of soluble Ca^{++}, Mg^{++} and Na^{+} with one exception for Mg^{++} ion under ploughing depth and NK treatment.

Table (4): Effect of soil ploughing depth and different rates of NPK fertilizers on soluble Ca^{++}, Mg^{++} and Na^{+} (meq/L) in soil after harvesting sugar beet crop.

NK treatments		Shallow ploughing (15 cm)						Deep ploughing (30 cm)					
N kg/ha	K kg K_2O/ha	P_1 (36 kg P_2O_5/ha)			P_2 (72 kg P_2O_5/ha)			P_1 (36 kg P_2O_5/ha)			P_2 (72 kg P_2O_5/ha)		
		Ca^{++}	Mg^{++}	Na^{+}	Ca^{++}	Mg^{++}	Na^{+}	Ca^{++}	Mg^{++}	Na^{+}	Ca^{++}	Mg^{++}	Na^{+}
72	0	2.20	0.90	5.20	3.20	2.90	7.17	1.50	0.80	5.00	3.10	1.20	5.85
72	36	2.40	2.50	5.80	3.80	2.80	6.15	2.20	1.10	5.50	2.80	2.40	3.65
72	72	2.25	3.10	8.20	3.70	4.00	9.50	1.70	3.00	5.35	2.30	1.10	4.65
72	108	2.70	1.00	6.20	3.50	2.70	5.95	1.60	0.90	5.85	3.30	2.20	5.45
Mean		2.39	1.88	6.35	3.55	3.10	7.19	1.75	1.45	5.43	2.88	1.73	4.90
144	0	2.40	1.90	7.90	3.30	2.10	5.11	1.60	0.90	5.00	3.10	2.00	4.17
144	36	2.90	2.20	7.50	4.00	2.70	5.47	2.60	2.10	6.50	1.90	2.20	5.38
144	72	1.40	1.20	4.60	2.90	1.70	4.45	1.40	1.10	4.30	2.30	0.80	4.40
144	108	3.00	2.60	9.00	3.00	2.60	6.25	2.40	1.20	8.18	2.80	1.90	5.25
Mean		2.43	1.98	7.25	3.30	2.28	5.32	2.00	1.33	6.00	2.53	1.60	4.80
216	0	1.60	1.90	7.00	4.20	2.00	7.00	1.30	1.30	6.25	4.20	1.90	6.50
216	36	3.60	1.90	6.75	3.30	1.80	5.25	2.40	0.50	6.60	2.00	1.60	4.35
216	72	2.70	1.90	5.00	3.10	1.00	4.75	2.50	0.90	4.50	2.50	1.00	4.00
216	108	1.40	2.10	6.10	2.80	2.70	6.50	1.30	1.30	5.75	2.20	2.30	4.85
Mean		2.33	1.95	6.21	3.35	1.88	5.88	1.88	1.33	5.78	2.73	1.70	4.93
General mean		2.38	1.93	6.60	3.40	2.42	6.13	1.88	1.26	5.73	2.71	1.68	4.88

Significance for	Parameters						
	D	P	T	D X P	T X D	T X P	T X D X P
Ca^{++}	**	**	**	**	*	**	**
Mg^{++}	**	**	**	**	ns	**	**
Na^{+}	**	*	**	**	**	**	**

D = Ploughing depth T = NK treatments P = P-treatments

*, ** = significant and highly significant at 5% and 1%, respectively.

Calculated SAR and ESP after harvesting sugar beet crop:

The calculated values of SAR and hence ESP were decreased in the soil surface (0-15 cm) under deep ploughing at 30 cm compared to shallow ploughing at 15 cm (Table 5). This reflect the higher amounts of soluble Na^+ at shallow ploughing compared to deep ploughing (Table 4). The values of SAR were 4.76 and 3.14 without any addition of fertilizers ($N_0P_0K_0$) under shallow and deep ploughing, respectively. The corresponding values for ESP were 7.66 and 5.62%, respectively. That means, deep ploughing was succeeded in decreasing soil salinity and alkalinity compared to shallow one (Table 1).

Data showed that under the same treatments of P and soil ploughing depth, addition of NK fertilizers had higher significant effect on the calculated SAR and ESP. The lowest value of SAR (2.27) and ESP (4.44%) were obtained under deep ploughing and addition of 72 kg N/ha + 72 kg P_2O_5/ha + 36 kg K_2O/ha. On the other hand, P application had highly significant effect on SAR and ESP, where increasing P addition decreased calculated SAR and ESP (Table 5). Conformation of soluble phosphate compounds such as Na-Phosphates almost led to leaching more Na^+ ions and hence decreasing SAR and ESP. Statistical analysis showed that all interactions between NPK treatment and soil ploughing depth had highly significant effect on the calculated SAR and ESP.

Table (5): Calculated sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP%) as affected by soil ploughing depth and different rates of NPK fertilizers after harvesting sugar beet crop.

NK rates		Shallow ploughing (15 cm)				Deep ploughing (30 cm)			
N kg/ha	K kg K_2O/ha	P_1 (36 kg P_2O_5/ha)		P_2 (72 kg P_2O_5/ha)		P_1 (36 kg P_2O_5/ha)		P_2 (72 kg P_2O_5/ha)	
		SAR	ESP	SAR	ESP	SAR	ESP	SAR	ESP
72	0	4.23	6.97	4.09	6.80	4.70	7.62	4.01	6.71
72	36	3.71	6.36	3.40	5.92	4.30	7.06	2.27	4.44
72	72	5.02	8.00	4.86	7.79	3.52	6.10	3.58	6.14
72	108	4.58	7.67	3.38	5.88	5.27	8.30	3.31	5.79
Mean		3.46	7.25	3.93	6.60	4.45	7.27	3.29	5.77
144	0	5.43	8.46	3.12	6.87	4.54	7.39	2.60	4.89
144	36	5.69	7.58	2.99	5.39	4.25	7.02	3.82	6.49
144	72	4.12	6.83	2.93	5.30	3.84	6.49	3.59	6.18
144	108	5.38	8.43	3.73	6.37	5.87	9.01	3.62	6.23
Mean		4.91	7.83	3.19	5.98	4.63	7.48	3.41	5.95
216	0	5.30	8.38	3.99	6.67	5.47	6.83	3.73	6.37
216	36	4.08	6.81	3.29	5.79	5.49	8.55	3.25	5.71
216	72	3.30	5.79	3.31	5.84	3.48	6.01	3.10	5.52
216	108	4.63	4.49	3.93	6.63	5.04	8.05	3.23	5.70
Mean		4.33	7.12	3.63	6.23	4.87	7.36	3.33	5.83
General mean		4.54	7.40	3.59	6.27	4.65	7.37	3.34	5.85

Significance for	Parameters						
	D	P	T	D X P	T X D	T X P	T X D X P
SAR	**	**	**	**	**	**	**
ESP	**	**	**	**	*	**	**

D = Ploughing depth   T = NK treatments   P = P-treatments

*, ** = significant and highly significant at 5% and 1%, respectively.

References

Abbott, J.L. and J.M. Nelson (1983). Phosphorus fertilization and sugar yields of fall planted sugar beets. Agr. J., 72: 185-188.

Abou El-Soud, M.A.; M.R. Kalifa and M.S.M. Abo Soliman (1994). Effect of different methods of phosphorus application on sugar beet yield and quality under salt affected soil condition. J. Agric. Res. Tanta Univ. 16: 341-351.

Agboola, A.A. (1981). The effects of different tillage and management practices on the physical and chemical properties of soil and maize yield in Orian forest zone of western Nigeria. Agron. J. 73: 247-251.

Ali, R.A. and M.M. Abo Habaga (1995). Change of soil characteristics and wheat crop associated with recycling of cotton residues under different types of tillage systems. J. Agric. Sci. Mansoura Univ. 20: 464-473.

Bajpai, R.K. and B.S. Joshi (1992). Effect of phosphorus levels on yield and nitrogen and potassium content of rice in three soil types of eastern Madhya Pradesh. Advances in Plant Sciences 5: 29-36. (C.F. Rice Abstract, 1993. 16, No. 4).

Black, C.A. (1983). Methods of soil analysis. Soil Sci. Soc. Amer. Inc. PUl. Madison, Wisconsin, USA.

Chapman, H.D. and Pratt (1961). Diagnostic criteria for plants and soil. University of California, division of Agricultural Sciences, Barkely, California.

El-Attar, H.A.; Y.A. Darweesh; M.K. El-Haris, and F.A. Askar (1995). The effect of NPK fertilization o the yield components of sugar beet at Northern Nile Delta. J. Agric. Sci. Mansoura Univ. 20: 3635-3643.

Ghaly, S.; I.M. Abd El-Aziz and M. Moorsy (1984). Response of sugar beet to potassium and boron fertilization on Egyptian soils. Second Conf. A.R.C. Giza 9-11 April.

Hamissa, A.M.I. (1995). Study on the effect of some fertilizers on productivity Agric. Crop. Ph.D. Thesis Soils, Tanta Univ.

Hegazy, M.H.; M.S.M. Abo Soliman; K.M. Sayed and M.A. Abo El-Soud (1992). Effect of rate and time of K fertilization on yield and quality of sugar beet. Egypt. J. Appl. Sci. 7: 396-403.

Kemp, P.D.; A.M. Khani and J.P. Millner (1994). The effect of plant population and N level on sugar yield and juice purity of sugar beet. Proceedings. Annual Conference. Agronomy Society of New-Zealand. 24: 131-134.

Khalifa, M.R.; A.A. Balba; S.A. Mashali and S.A. Morssi (2000)). Impact of soil ploughing depth and different rates of NPK fertilizers on some soil properties, yield and quality of sugar beet plant grown in salt affected soil. J. Agric. Res. Tanta Univ.

Lindsay, W.L. (1979). Chemical eqilibria in soil. Printed in USA. Chapter II and III.

Mittchera, M. (1978). Effect of potassium fertilizer on yield and quality of sugar beet (C.F. Field Crops Abst., 34, No. 1).

Page, A.L.; R.H. Miller and D.R. Keeney (1982). Method of soil analysis. Amer. Soc. Agr. Inc.

Resk, M.M.; S.A. Gaheen; M.M. Ibrahim and S. Ibrahim (1982). Effect of different tillage operations and water status on rice plants cultivated at the Northern part of the Nile Delta soils. J. Agric. Res. Tanta Univ. 8: 303-319.

Snedecor, G.W. and W.G. Cochran (1980). Statistical methods. 7th ed. 225-330.