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EFFECT OF TILLAGE METHODS AND DEPTHS ON SUGAR BEET AND RICE YIELDS, SALT DISTRIBUTION AND WATER USE EFFICIENCY IN SALT AFFECTED SOILS AT NORTH DELTA

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ABSTRACT: *Two field experiments were conducted at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, North Nile Delta Region during both seasons of 2010/2011& 2011 to find out the impact of three methods of tillage; disc harrow, chisel and subsoiler plough, with three depths; 15, 25 and 35 cm on sugar beet and rice yields, some soil properties and some water relations. The experimental design was split plots with four replicates, where the main plots were assigned to tillage methods and the sub plot were devoted to tillage depths. The obtained results can be summarized as follows:*

- *The yields of sugar beet were highly significantly affected by methods and depths of the tillage. The plowing at 35cm depth increased root yield by 17.46 and 4.61% compared to plowing at 15 and 25 cm depths, respectively. The average root yields were 15.49, 16.04 and 17.21 ton/fed. with disc harrow, chisel and subsoiler, respectively, while the root yields with tillage depths of 15, 25 and 35cm were 14.47, 16.73 and 17.54 ton/fed., respectively.*
- *The average sugar yield with disc harrow, chisel and subsoiler were 2.565, 2.486 and 2.598 ton/ fed., respectively, and these values were 2.212, 2.646 and 2.790 ton/ fed. with 15, 25 and 35 cm ploughing depths, respectively.*
- *The highest values of k, N, amino-N% and purity percentages of sugar beet juice were produced from subsoiler at 35cm depth.*
- *With rice, the highest significant values of yield and yield components were achieved by using the disc harrow as method of tillage with shallow depth (15cm). The interaction between tillage methods and depths had insignificant effect on such parameters.*
- *The highest values of water applied for sugar beet and rice crop were obtained with tillage by subsoiler at 35cm depth, while the lowest values were scored with tillage by disc harrow at 15cm depth.*
- *The highest value of field water use efficiency with sugar beet roots (6.12kg / m^3) was obtained with tillage by disc harrow at 35cm depth, while the lowest value (5.01 kg/ m^3) was recorded with subsoiling at 15 cm depth. The highest value of crop water use efficiency with sugar beet roots (9.49kg / m^3) was obtained with subsoiler at 25cm depth, while the lowest value (7.54 kg / m^3) was recorded with disc harrow at 15 cm depth.*
- *With rice, disc harrow plowing with 15 cm depth achieved the lowest value of water applied (4767 m^3 /fed) and the highest value of utilization efficiency (0.63 kg grain / m^3). While subsoiler with 35 cm depth led to the converse trend (water applied, 6178 m^3 /fed and water utilization efficiency , 0.28 kg grain / m^3) .*
- *The highest values of basic infiltration rate and cumulative infiltration with sugar beet and rice were achieved by subsoiler with 35 cm depth, while the lowest values were obtained with disc harrow at 15cm depth.*
- *It could be noticed that subsoiling led to leach more salts followed by chisel plough method especially with 35 cm tillage depth.*
- *It can be concluded from the economic evaluation that the highest farmer income from sugar beet was achieved with subsoiling and from rice with disc harrow.*

Key words: *Tillage Depth,Tillage Methods, Sugar Beet ,Rice, Salt Distribution, Water Use Efficiency and Saline Soil.*

INTRODUCTION

Tillage refers to the different mechanical manipulations of the soil that are used to provide the necessary soil conditions favorable to the crop growth. A proper tillage can alleviate soil related constrains , while improper tillage may lead to a range of degradation processes, e.g., deterioration in soil structure, accelerated erosion, depletion of soil organic matter and soil fertility and disruption in water cycles, organic carbon and plant nutrients (Lai,1996). Year's shallow tillage created hardpan at about 15 cm depth. This hardpan influences bulk density, porosity and penetration resistance of soil which directly or indirectly effects on the growth and yield of crops. Hardpan due to subsoil compaction of agricultural soils is a global concern due to adverse effects on crop yield and environment (Hokansson and Reeder, 1994). Soil is basic medium for seed germination, seed emergence, root growth and ultimately crop production. In this context the importance of soil physical and chemical properties in optimizing production has been well recognized. Many management practices such as tillage are carried out to improve the properties of salt affected soil. Tillage management is among the important factors effecting on soil physical properties i.e. soil bulk density, moisture and porosity. Tillage is a practice which is performed to loosen the soil and to produce a good tilth. Among the crop production factors, tillage contributes up to 20% (Ahmad *et al.*1996 and Mahajan 1996). The sustainable use of deep tillage breaks up high density soil layer, improves the water infiltration and movement in soil, enhance root growth, develops and increases crop production potential (Bennie and Botha,1986). Deep tillage of the soil increased corn yield up to 90 % (Varsa *et al*., 1997). The deep tillage method significantly improves soil physical properties as increase in saturated hydraulic conductivity and decrease in bulk density of soil (Naveed *et al*., 2010). Canarache and Dumitra (1987) showed the direct and residual effect of ploughing and disking on soil, pointing that the reduced tillage using disking dose not lead to negative effect on soil physical state. Dumitru (2005) showed the positive effect of ploughing on soil water retention, nutrient movement in clayey texture soil and crop yield. He added that the moderate compactness due to tillage did not affect negatively either the state of the soil or crop yield. Calciu *et al* (2010) reported that the soil bulk density and degree of compactness were strongly affected by the mould-board ploughing . They added that the main impact was determined by the agricultural practices, such as soil tillage type and/or its intensity (depth and frequency) and the variation of these indicators on the profile emphasize that the soil was ploughed at maximum 25 cm depth, at this level there was a slightly compacted layer. Jabro *et al* (2010) found that soil bulk density and penetration resistance were greater in shallow tillage (10 cm depth) than in deep tillage (20 cm depth), whereas saturated hydraulic conductivity was greater with deep tillage than with shallow tillage. Soil water content and soil air- filled pores were slightly greater with deep tillage than those under shallow tillage. Also they reported that although tillage depth had no significant effect on sugar beet population, root yield, or sucrose content, a small difference in sucrose yield between the two depths of tillage may be attributed to reduced soil bulk density, increased water intake, improved aeration, and increased response to nitrogen uptake under deep tillage than under shallow tillage.

Tillage plays an important role in the management of water resources and in alleviating water-related constraints to agricultural production and environment quality. Also, appropriate tillage systems can be used to facilitate drainage and decrease water retention in the root zone, increase the rate of infiltration to improve soil water storage, change porosity to influence soil-water evaporation, and enhance macro pore flow to regulate leaching of the agricultural chemical and salts. The reduction of soil moisture content due to tillage operations was increased by increasing the depth with all the ploughs, and the minimum reduction was obtained with no tillage. Also, the maximum reduction was obtained at the top layer (0-10 cm) with the chisel plough, while in the bottom layer (20-30 cm) the maximum reduction was obtained with the rotary plough (Zein Al-Din, 1985). Elkhateeb *et al* (2009) concluded that water requirements of cotton were 3033, 3185 , 3205 , 3319 and 3591 m3/fed., for disc harrow, chisel plough one pass + disc harrow, chisel plough two passes + disc harrow , chisel plough one pass + subsoiler + disc harrow and chisel plough two passes + subsoiler + disc harrow, respectively. Field water use efficiency was calculated for above mentioned treatments and recoded as follow: 0.22, 0.26, 0.28, 0.31 and 0.28 kg/m^3 for the stated treatments, respectively. Also, water application efficiency values were found to be 73.05, 73.63, 75.02, 74.18 and 70.91%, respectively. El-Shahawy *et al* (2001) found that the subsoiler tillage treatment with 60 kg N/fed. gave the highest values of root and gross sugar yields (31.37 and 4.6 ton/fed., respectively).While the lowest values (15.03 and 2.42 ton/fed., respectively) were obtained under chisel plough with 20 cm tillage depth without nitrogen fertilizer. Also the highest values of sucrose %, possible extraction sugar % and sugar purity % (15.98, 13.44 and 83.7%, respectively) were obtained under subsoiler plough without nitrogen fertilizer. Al-Ghazal (1997) showed that in tilled soil the plough of 0-20 cm layer induced higher rooting densities, but restricted proliferation of roots in deeper layers. As a result, the total water uptake from the ploughing layer was greater , while it was less from deeper layers. Shoot growth was higher in the tilled soil at the beginning of the season but it was accelerated in the untilled soil, where roots explored deeper soil. Sayed *et al* (1998) indicated that subsoilling plow is highly affected sugar beet plant characteristics (root and shoot quality and sugar yield). Korany and Khalifa (1998) reported that the tillage methods improved the shoot yield , especially with increasing ploughing depth because of increasing of the root size (length, diameter and volume). Hammoud (1992) found that the weight of sugar beet roots, sucrose percent and total sugar yield were increased under deep plowing (30 cm depth). The aim of this study is to investigate the effect of tillage methods and depths on yield productivity of salt affected soils and water use efficiency at North Nile Delta.

MATERIALS AND METHODS

Two field experiments were conducted at Sakha Agricultural Research Station Farm, Kafr El-Sheikh Governorate during two successive growing seasons (2010 / 2011 and 2011). The location is situated at 31-07N Latitude, 30-37E longitude with an elevation of 6 meters above the mean of sea level. The soil is clayey in texture and saline. Some soil chemical and physical properties are presented in Table (1), according to (Black, 1965).

The experiment was designed in split plots with four replicates. Each plot was 12*30 m (360 m^2). The main plots were occupied by different tillage methods; disc harrow, chisel plough and subsoiler. While tillage depths (15, 25 and 35cm) occupied the subplots. Sugar beet (variety Raspoly) was sown on December, 2nd, 2010 and harvested on May, 15, 2011.While rice (variety Giza 178) was planted in the nursery on May,1st, 2011 , transplanted on June 1st, 2011 and harvested on September, 5th, 2011. Rice seedlings were transplanted in bottom of furrows, 13cm apart in hills (4-5 plants) in three rows keeping the number of seedlings the same as the traditional transplanting method.

Table (1): Some soil chemical and physical properties of the experimental area.

Soil depth cm	PH 1:2.5	Ece dsm^{-1} at 22°c	SAR	Particle size distribution			Texture class	Soil moisture characteristics			Bulk density g/c m^3
				Sand %	Silt %	Clay %		F.C%	P.W. P. %	available water	
0-20	8.29	26.80	25.54	26.48	27.43	46.09	clay	40.45	20.18	20.27	1.29
20-40	8.13	17.70	20.52	22.48	27.31	50.21	clay	38.25	19.15	19.10	1.37
40-60	7.98	13.31	18.00	27.14	29.01	43.71	clay	35.85	17.52	18.33	1.41

The studied characters for sugar beet were:

1-Root lengths and diameter (cm) for all treatments were measured at harvesting (4 roots in 4 replicates for each treatment).
2-Root yield was weighed for all treatments at harvesting (ton / fed.).
3-Sucrose concentration and juice purity (%) for all treatments were determined in Delta Sugar Company at El-Hamoul, Kafr El-Sheikh Governorate.
4-Gross sugar yield (ton / fed.) = root yield (ton / fed.)* Sucrose percentage.

All the agronomic practices were performed according to the usual recommendations in the area.

The studied characters for rice were:

1- Rice grain and straw yield in ton / fed.
2- Plant height in cm.
3- 1000 - grain weight in gm.

Data were statistically analyzed according to Snedecor and Cochran (1971).

Water measurements:-

1- The amount of irrigation water applied was measured by cut- throat flume (30*90 cm) and calculated as m^3 / fed. (Early, 1975).
2- Actual water consumptive use was calculated according to the following equation described by Israelson and Hansen (1962).

$$Cu = \sum_{i=1}^{n} \frac{(\theta_2 - \theta_1)}{100} * Bd * d * 4200$$

Where:

Cu= water consumptive use (m^3 / fed.).
n = number of irrigations.
$\theta_2$and θ_1: soil moisture content (%) after irrigation and before the next irrigation respectively.
Bd = bulk density (g / c m^3).
d : depth of root zone (cm)

Some irrigation efficiencies:-

1-Irrigation application efficiency (Ea):

Values of irrigation application efficiency (Ea) for each treatment were obtained by dividing the irrigation water stored on the applied irrigation water (Downy, 1970):

$$Ea = Ws*100 / Wd$$

Where:

Ea: water application efficiency.
Ws: water stored.
Wd: water delivered to the field plot.

2- Water distribution efficiency:-

It is expressing the uniformity of the distribution of irrigation water along the irrigated field. It was determined according to Michael (1978) using the following equation:

$$Ed = 100 (1- y/D.$$

Where:-

Ed = water distribution efficiency %.
Y =Average numerical absolute deviation in depth of water stored.
D = Average depth of water stored during the irrigation.

3- Crop water use efficiency:

Calculated in kg / m^3 according to Abdel-Rasool *et al* (1971) as follows:
C.W.U.E. = yield (kg/fed.) / water consumptive use (m^3/fed.)

4- Field water use efficiency: was calculated as follows:

F.W.U.E. = yield (kg/fed.) / water applied (m^3 / fed.).

5- Salt distribution patterns in clay soils.

Soil samples were collected from three soil profiles before planting, after harvesting sugar beet and rice for each treatment at three depths (0-20), (20-40) and (40-60) to study the salinity distribution through soil profile as mean values of the soil depths.

RESULTS AND DISCUSSION

Effect of tillage methods and depths on:

1-Sugar beet:

1-1-Sugar beet yield:

Data in Table (2) indicate that the yields of roots, shoots and sugar are highly significantly affected by methods and depths of tillage. The tillage methods improve the root yield especially with deeper ploughing depth due to increase the root size (length and diameter). The average root yields are 15.49, 16.04 and 17.21 ton/fed., while the average shoot yields are 6.56, 7.04 and 7.38 ton/fed. with disc harrow, chisel and subsoiler ploughs , respectively . The sugar yield is an important parameter of sugar beet because it is the final form that the consumer uses. Sugar yield is related not only to root yield but also to its sucrose content. The average sugar yields with disc harrow, chisel and subsoiler ploughs are 2.565, 2.486 and 2.598 ton/ fed., respectively. Consequently, the root yields with subsoiler plough are increased by 10.08 and 6.86 % ,the shoot yields are increased by 11.2 and 4.70 % , while the sugar yield are increased by 1.4 and 6.2 % over that achieved with the disc harrow and chisel ploughs, respectively.

In regard to the effect of the tillage depths, the obtained data reveal that the root, shoot and sugar yields are increased significantly by increasing ploughing depth. The deeper ploughing depth tends to improve the plant growth, increases the root size (length and diameter) , increases the water storage in the effective root zone and subsequently raises the water use efficiency. The root yields for tillage depths at 15, 25 and 35cm are 14.47, 16.73 and 17.54 ton/fed respectively, the shoot yields are 5.93, 7.09 and 7.95 ton/fed, respectively, while the sugar yields are 2.212, 2.642 and 2.790 ton/fed, respectively.

It is clear from the data that the interaction between tillage methods and ploughing depths has highly significant effect on sugar beet yield. The using of subsoiler plough at 25 cm depth achieves the highest values of root yield (18.53 ton/fed.), shoot yield (8.11 ton/fed.) and sugar yield (2.784 ton fed.). While the lowest yields of root, shoot and sugar (13.99, 5.25 and 2.209 ton /fed, respectively) are recorded with disc harrow at 15 cm depth.

Table (2): Sugar beet yield and its components as affected by different treatments.

Treatment		Root (ton /fed)	Shoot Ton/fed	Sugar %	Sugar Ton/fed
tillage	depth*				
Disc harrow (M1)	D1	13.99	5.25	15.78	2.209
	D2	15.57	6.69	16.49	2.567
	D3	16.90	7.73	17.28	2.919
Mean		15.49	6.56	16.52	2.565
Chisel plough (M2)	D1	14.30	5.96	15.43	2.207
	D2	16.63	7.13	15.54	2.582
	D3	17.18	8.02	15.54	2.668
Mean		16.04	7.04	15.5	2.486
Subsoiler (M3)	D1	15.12	6.58	14.68	2.220
	D2	17.99	7.46	15.51	2.789
	D3	18.53	8.11	15.01	2.784
Mean		17.21	7.38	15.07	2.598
F test-M		**	**	**	**
Mean	D1	14.47	5.93	15.30	2.212
Mean	D2	16.73	7.09	15.85	2.646
Mean	D3	17.54	7.95	15.94	2.790
F test-D		**	**	ns	**
LSD	0.05 %	0.218	0.179	0.748	0.082
LSD	0.01 %	0.299	0.245	1.03	0.112
	M*D	**	**	ns	*

* $D_{1= 15\ cm}$ $D_{2= 25\ cm}$ $D_{3= 35\ cm}$

Regarding to sugar percentage, data reveal that the tillage methods has a highly significant effect on sugar percentage. The highest value of sugar percentage (16.52 %) is obtained with disc harrow followed by chisel (15.5 %) , while the lowest value was recorded with subsoiler (15.07 %). On contrary to this, the tillage depths as well as their interaction with the tillage method have insignificant effect on sugar percentage. These results are in full agreement with those reported by Korany and Khalifa (1998). They found that increasing plowing depth tends to improve the sugar beet growth.

1.2. The yield components of sugar beet:

1.2.1: Root length and diameter (root size):

The data in Table (3) show that the plowing by subsoiler causes higher increases in root length and diameter compared to disc harrow and chisel. The root lengths are 22.8, 23.7 and 24.13 cm , while the root diameters are 11.93, 12.17 and 12.60 cm with disc harrow, and chisel subsoiler ploughs, respectively. Also, increasing the ploughing depth from 15 to 25 or 35cm increases the root length from 21.47 to 23.47 or 25.70 cm, respectively, and increases the root diameter from 11.23 to 12.30 or 13.17cm, respectively.

The interaction between tillage methods and depths has insignificant effect on root diameter. These results are supported by the data obtained by El-Shahawy *et al* (2001) and Sayed *et al* (1998).

Table (3): The yield components of sugar beet as affected by different treatments.

Treat. tillage	depth*	Root Length (cm)	Root diameter (cm)	K%	N%	Amino (N %)	Quality (%)
Disc harrow (M1)	D1	20.5	10.8	7.43	3.92	3.78	72.95
	D2	22.9	11.9	7.24	3.93	3.5	74.25
	D3	25.0	13.1	7.33	3.72	3.75	73.2
Mean		22.8	11.93	7.33	3.87	3.68	73.47
Chisel plough (M2)	D1	21.6	11.2	7.91	3.22	2.84	73.38
	D2	23.5	12.1	7.17	3.82	4.38	71.53
	D3	26	13.2	7.21	3.39	3.83	72.14
Mean		23.7	12.17	7.10	3.48	3.68	72.35
Subsoiler (M3)	D1	22.3	11.7	7.22	4.23	3.9	71.5
	D2	24	12.9	7.76	5.09	5.41	66.4
	D3	26.1	13.2	7.91	4.8	5.06	64.5
Mean		24.13	12.60	7.63	4.71	4.79	67.47
F Test-M		**	*	ns	ns	ns	*
Mean	D1	21.47	11.23	7.52	3.79	3.51	70.61
Mean	D2	23.47	12.30	7.39	4.28	4.43	70.72
Mean	D3	25.70	13.17	7.48	3.97	4.21	69.95
F test-D		**	**	ns	ns	**	**
LSD	0.05 %	0.286	1.45	0.537	0.450	0.547	0.88
LSD	0.01 %	0.3925	1.99	0.548	0.626	0.750	1.17
	M*D	ns	ns	ns	ns	ns	**

* $D_{1= 15\ cm}$ $D_{2= 25\ cm}$ $D_{3= 35\ cm}$

2-Rice yield and its contributing variables:

2.1: Plant height:

It is clear from the data in Table (4) that plant height of rice is highly significantly affected by methods and depths of tillage. Using disc harrow surpasses the chisel plough and subsioler in increasing plant height (109.42, 107.50 and 106.17 cm, respectively). Also, it can be observed from the data that increasing tillage depth from 15 cm to 35 cm decreases the plant height from 110.1 cm to 104.5 cm. The interaction between tillage methods and depths has a high significantly effect on plant height Therefore, the longest top plants are achieved by disc harrow with 25 cm depth (111.5 cm) while the shortest plants are recorded with subsoiling at 35 cm tillage depth (103.5 cm). This may be due to the positive effect of disc harrow with shallow depth on encouraging plant growth under submergence condition.

1.2.2. Sugar beet quality:

The statistical analysis (Table 3) shows insignificant effect of tillage methods and depths as well as their interactions on k%, N% and amino-N% in root of sugar beet with the exception of the tillage depths that has high significant effect on amino-N%. The values of amino-N with 15, 25 and 35 cm are 3.51, 4.43 and 4.21% , respectively. The data show also that the juice quality is significantly affected by tillage methods and depths as well as their interactions. The values of juice quality % as affected with tillage methods takes the following descending order: disc harrow- > chisel- > subsoiler plough .The increasing of tillage depth from 15 cm to 35 cm decreases the quality from 70.61% to 69.95 %. The highest quality value is achieved with the disc harrow at 25 cm tillage depth (74.25 %), while the lowest value is recorded with subsoiling tillage at 35 cm depth (64.5 %). These results are in harmony with those obtained by El-Shahawy *et al* (2001).

Table (4): Rice yield and its contributing variables as affected by tillage methods and depths

Treat. tillage	Depth *	Grain yield (ton/fed)	Straw yield (ton/fed)	Plant height(cm)	00-grain weight
Disc harrow (M_1)	D1	3.00	5.10	111.3	15.15
	D2	2.93	4.73	111.5	13.14
	D3	2.75	4.03	105.5	10.61
Mean		2.89	4.62	109.42	12.97
Chisel plough (M_2)	D1	2.588	4.86	110.50	13.11
	D2	2.375	4.75	107.50	10.83
	D3	2.030	3.83	104.50	10.54
Mean		2.330	4.48	107.50	11.49
Subsoiler (M_3)	D_1	2.485	4.66	108.5	12.89
	D_2	2.288	4.41	106.5	10.69
	D_3	1.951	3.42	103.5	10.53
Mean		2.240	4.16	106.17	11.37
F test		**	**	**	**
Mean D_1		2.691	4.87	110.1	13.72
Mean D_2		2.499	4.73	108.5	11.55
Mean D_3		1.944	3.76	104.5	10.56
F test		**	**	**	**
LSD 0.05 %		0.22	0.42	0.48	0.15
LSD 0.01 %		0.29	0.14	0.66	0.20
M*D		NS	NS	**	NS

2.2: 1000- grain weight:

It can be observed from the data that the tillage methods have insignificant effect on 1000-grain weight, while it is significantly affected by tillage depths. The 1000-grain weight is decreased with increasing tillage depth from 15 cm to 35 cm by about 20.13%. The interaction between tillage methods and depths has insignificant effect on 1000-grain weight.

2.3 Grain and straw yields:

It is clear from the data presented in Table (4) that tillage methods and depths significantly affected the rice grain and straw yields. Using of disc harrow, chisel or subsoiler for soil tillage produce 2.89, 2.33 or 2.24 ton grain/fed, respectively and produce 4.72, 4.48 or 4.16 ton straw /fed, respectively. Concerning the effect of tillage depths on grain and straw yields, it can be observed from the data that increasing the ploughing depth from 15 cm 35 cm decreases the grain yield from 2.691 to1.944 ton /fed, while the straw yield is decreased from 4.87 to 3.76 ton /fed, respectively. The interaction between tillage methods and depths has insignificant effect on grain and straw yields. Therefore, general conclusion can be deduced that the highest significant values of yield or yield components of rice are achieved using disc harrow with shallow tillage depth.

3. Some water relations:

3.1. Sugar beet.

3.1.1. Amount of water applied:

Data in Table (5) declare that the amounts of irrigation water applied to sugarbeet are clearly affected by different tillage treatments. The amount of water applied with subsoiling (3093 m^3/fed) is higher than those applied with disc harrow (2653.7 m^3/fed) or chisel plough (2861.9 m^3/fed). The amount of water applied is increased from 2780 to 2953 m^3/fed with increasing the tillage depth from 15 to 35 cm. Therefore, the highest amount of water is applied with subsoiling at 35 cm depth (3158.8 m^3 /fed), while the lowest amount is applied with disc harrow at the shallowest tillage depth (2525.4 m^3/fed). It is worthy to mention that the highest water saving percentage (20.05%) is achieved with disc harrow at 15cm depth. These results are supported by El-Khateeb *et al* (2009) and Jabro *et al* (2010).

Table (5): Amounts of water applied, stored and consumed by sugar beet with tillage methods and depths (season 2009/2010).

Treatment		Water applied m^3/fed	Water stored m^3/fed	Water consumed m^3/fed	Irrigation application efficiency (%)
Tillage types	Depth tillage(cm)				
Disc harrow	15	2525.4	1963.50	1854.3	77.76
	25	2673.72	1980.72	1930.7	74.08
	35	2761.92	2039.94	1938.30	73.86
	Mean	2653.7	1994.72	1907.8	75.23
Chisel plough	15	2796.78	2011.38	1770.7	71.92
	25	2850.96	2052.12	1837.9	72.00
	35	2937.90	2084.46	1978.6	70.95
	Mean	2861.9	2049.32	1862.4	71.62
Subsoiler	15	3018.96	2104.62	1827.8	69.71
	25	3101.28	2138.22	1895.0	68.95
	35	3158.82	2163.84	1954.7	68.85
	Mean	3093.0	2135.56	1892.5	69.17

3.1.2 Actual water consumptive use of sugar beet:

From the obtained data (Table 5), it can be noticed that the highest value of water consumptive use by sugar beet is recorded with subsoiler at 35cm depth (1954.7 m^3/fed.), while, the lowest value is detected with chisel plough at 15cm depth (1770.7 m^3/fed.).

3.1.3. Water application efficiency:

Water application efficiency is one of the most important criteria used to describe the field irrigation efficiency. The highest value of water application efficiency for sugar beet means less values of deep percolation below the root zone and surface runoff at the tail end of the irrigated area. Generally, irrigation application efficiency value is increased as the amount of water applied decreased. It is obvious from the data that the maximum value of water application efficiency (77.76%) is obtained by disc harrow with 15 cm depth, while the minimum water application efficiency (68.85%) is obtained from tillage by subsoiler at 35cm depth.

3.1.4 Field and crop water use efficiencies (FWUE & CWUE):

Data of FWUE & CWUE are presented in Table (6). These efficiencies determine the capability of plants to convert the applied or consumed water to crop yield. The highest value of FWUE (6.12 kg/ m^3) is obtained with tillage by disc harrow at 35cm depth, while the lowest value (5.01 kg/ m^3) is given by plowing subsoiler at 15cm depth. Concerning the CWUE in terms of kg root/ m^3 of water consumed, the data reveal that the subsoiling treatment achieves value of CWUE higher than those obtained with disc harrow or chisel plow .The increasing of tillage depth from 15 to 35 cm increases CWUE value from 8.11 to 8.96 kg root / m^3. The highest value of crop water use efficiency (9.49 kg/ m^3) is achieved with subsoiler at 25cm depth, while the lowest value (7.54 kg/ $m^{3)}$ is recorded with disc harrow at 15 cm depth.

3.1.5 Soil moisture extraction pattern with sugar beet:

Data of soil moisture extraction from the effective root zone by sugar beet roots are shown in Table (7). The results illustrate that the major extraction of soil moisture is occurred in the upper layer (0 - 20 cm), but it is decreased in the subsurface layer. Therefore, the minimum extraction of soil moisture occurs in the deepest layer (40 to 60cm) with all methods and depths of tillage. Also, it can be concluded that about 50 - 60% of total water consumed by sugar beet plants is extracted from 0-20 cm layer under different tillage treatments .This behavior may be due to that the most effective of its roots are concentrated in the top layer.

Table (6): Values of field water use efficiency (FWUE) and crop water use efficiency (CWUE) with sugar beet under different treatments.

Treatment		Water applied m^3/fed.	Water consumptive m^3/fed.	Root yield kg/fed.	FWUE kg root /fed.	CWUE kg root /fed.	Sugar kg/fed.	FWUE kg sugar /fed	UE kg sugar /fed.
Tillage types	Depth tillage cm								
Disc harrow	15	2525	1854	13990	5.54	7.54	2210	0.88	1.19
	25	2674	1931	15570	5.82	8.06	1920	0.72	0.99
	35	2762	1938	16900	6.12	8.72	2200	0.79	1.14
Mean		2653.7	1907. 7	15486.6	5.83	8.11	2110	0.80	1.11
Chisel plough	15	2797	1770	14300	5.11	8.08	2200	0.78	1.24
	25	2851	1838	16630	5.83	9.05	2580	0.90	1.40
	35	2938	1979	17180	5.85	8.68	2670	0.91	1.35
Mean		2862.0	1862.3	16036.7	5.59	8.6	2483	0.86	1.33
Subsoiler	15	3019	1828	15120	5.01	8.72	2220	0.74	1.21
	25	3101	1895	17990	5.80	9.49	2790	0.90	1.47
	35	3159	1955	18530	5.87	9.48	2780	0.88	1.42
Mean		3093.0	1892.7	17213.3	5.56	9.23	2596.7	0.84	1.37

Table (7): Mean values of soil moisture extracted by sugar beat from different layers as affected by different treatments in 2009 season.

Tillage treatment		Soil moisture extraction		
Type	Depth (cm)	Soil layers cm		
		0-20	20-40	40-60
Disc harrow	15	50.17	32.26	17.57
	25	56.74	28.25	15.02
	35	59.76	30.06	10.18
Chisel plough	15	51.58	31.16	17.26
	25	51.73	32.85	15.42
	35	57.03	32.18	10.79
Subsoiler	15	55.49	29.22	10.29
	25	57.11	31.56	11.33
	35	60.51	28.65	10.84

3.2 Rice crop:

3.2.1: Amount of water applied:

The amount of irrigation water delivered to each rice plot was measured and shown in Table (8). The amount of water applied to rice field with subsoiling tillage (5576 m^3 /fed) is higher than those applied with disc harrow or chisel plough (4995 or 5073 m^3 /fed, respectively). On the other hand, the increasing of tillage depth from 15 cm to 35 cm markedly increases amount of water required for rice crop. Consequently, subsoiler method with 35cm tillage depth receives the highest amount of irrigation water (6178 m^3/fed), while the lowest value (4767 m^3/fed) is given by disc harrow with 15 cm tillage depth.

3.2.2 Water utilization efficiency:

It can be noticed from the data in Table (8) that water utilization efficiency of rice is higher with disc harrow than those with chisel or susoiler plough (0.54, 0.46 or 0.39 kg/ m^3, respectively). Also, utilization value is in somewhat decreased with increasing the tillage depth. Therefore, disc harrow with 15 cm depth tillage considered the best treatment with rice since it achieves the highest water utilization efficiency (0.63 kg rice grain/ m^3) ,while the lowest value is recorded under subsoiler plough with 35cm depth (0.28 kg grain / m^3).

4. Basic infiltration and cumulative infiltrated depth:

The obtained data presented in Table (9) show that using subsoiler as a method of tillage followed by chisel and disc harrow has an appreciable increase in the basic intake rate and cumulative infiltrated depth after harvesting of sugar beet and rice compared to those obtained before experiment. With respect to tillage depth, the data show that as the depth of tillage increases, the basic intake rate and cumulative infiltrated depth are increased. The highest values of basic infiltration rate and cumulative infiltration with sugar beet and rice are achieved by subsoiler with 35 cm depth, while the lowest values are obtained with disc harrow at 15cm depth. These results are in agreement with those reported by Versa *et al.* (1997).

Table (8): Amounts of irrigation water applied and water utilization efficiency with rice (2010).

Tillage types	Depth tillage cm	Rice grain yield kg/fed.	Water applied m^3/fed.	Water utilization efficiency kg/ m^3
Disc harrow	15	3000.0	4767.0	0.63
	25	2933.0	4836.0	0.61
	35	2050.0	5382.0	0.38
	mean	2661.0	4995	0.54
Chisel plough	15	2588.0	4785.0	0.54
	25	2375.0	5018.0	0.47
	35	2030.0	5418.0	0.37
	mean	2331.0	5073.0	0.46
Subsoiler	15	2485.0	5025.0	0.49
	25	2188.0	5525.0	0.40
	35	1751.0	6178.0	0.28
	mean	2141.3	5576	0.39

Table (9): Infiltration rate and cumulative before treatment& planting and after harvesting sugar beet and rice.

treatment	Depth (cm)	Before treatment		Before planting		After harvesting sugar beet		After harvesting rice	
		IR cm/hr	Cum .cm/hr	B-IR cm/hr	Cum. cm/hr	B-IR cm/hr	Cum. cm/hr	B-IR cm/hr	Cum .cm/hr
Disc harrow	15			0.5	4.4	0.5	6.1	0.6	6.5
	25			0.5	5.4	0.6	6.9	0.7	7.3
	35			0.6	5.5	0.7	5.9	0.8	7.9
	Mean	0.4	4.6	0.53	5.1	0.60	6.3	0.70	7.2
Chisel plough	15			0.5	4.5	0.6	5.7	0.7	6.9
	25			0.6	5.0	0.7	7.2	0.8	7.6
	35			0.7	5.9	0.8	6.6	1.0	8.1
	Mean	0.4	4.6	0.60	5.1	0.70	6.5	0.83	7.5
Subsoiler	15			0.6	5.1	0.8	6.7	0.8	7.5
	25			0.7	6.0	0.9	7.9	0.9	8.2
	35			0.8	6.8	1.0	8.1	1.2	8.9
	Mean	0.4	4.6	0.70	5.97	0.90	7.57	0.97	8.2

5. Soil salinity and sodium adsorption ratio:

Soil salinity values after harvesting of sugar beet and rice crops and their rates of change as affected by different tillage treatments are shown in Tables (10 and 11). The obtained data reveal that soil salinity is decreased after harvesting of sugar beet from 19.27dS/m (before experiment) to 12.89, 11.03 and 10.26 dS/m with disc harrow, chisel and subsoiler ploughs, respectively. While after harvesting of rice crop, the soil salinity values are decreased from 19.27dS/m to 9.49, 9.42 and 9.18 dS/m for the stated methods of tillage, respectively .The change of salinity decreases after harvesting of sugar beet as compared to that before planting are 33.1, 42.6 and 46.8 % for disc harrow, chisel plough and subsoiler, respectively, while after harvesting of rice crop, the rate of changes are 50.8, 51.1 and 52.3 % for the same treatments, receptivity. Therefore, the leaching efficiency of salts from the soil with either sugar beet or rice can be arranged in the following descending order: subsoiling › chisel plough› disc harrow. The values of sodium adsorption ratio take approximately the same trend.

6- Economic Evaluation:-

Economic evaluation of different treatments for sugar beet and rice are listed in Table (12) to compare total cost , income and net return under types of tillage. Total income of sugar beet is based on the productivity of root yield, while the total income of rice is based on productivity of grain yield. Total costs included the costs of tillage installation, agricultural practices, fertilizers, pesticide and land rent of sugar beet and rice are affected by types of tillage. The highest net return value (2310 LE/fed.) is achieved with subsoiling under cultivation of sugar beet ,while under cultivation of rice the highest value of net return (1320 LE/fed.) is obtained with disc harrow. The highest values of investment factor are resulted with subsoiling under cultivation of sugar beet crop and with chisel plough under cultivation of rice. It can be concluded that the highest farmer income from sugar beet is achieved with subsoiling and from rice with disc harrow.

REFERENCES

Abd El-Rassol, S.F., H.W. Tawodros, W.I. Miseha and F.N. Mahrous (1971). Effect of irrigation and fertilization on water use efficiency by wheat fertilizer Con. Ain Shams Univ., Cairo.

Ahmad N, Rashid M, Vaes AG (1996). Fertilizers and their use in Pakistan, NFDC publ. No.4/96. 2nd Ed. Islamabad . p.274.

Al-Ghazal, A.A. (1997). Influence of two tillage systems on vegetative growth ,root development, water uptake and yield of wheat crop. J. Ajric. Sci. Mansoura Univ., 22 (7): 2421-2429.

Bennie Tp , Botha Fjp (1986). Effect of deep tillage and controlled traffic on root growth, water use efficiency and yield of irrigated maize and wheat. Soil and tillage Res. 7:85-95.

Black, C.A. (1965). Methods of soil analysis, Amer. Soc. Agro. Inc., Madison, Wisconsin, U.S.A.

Calciu, I, S.L. Stefanescu, E. Dumitra and M. Dumitrascu (2010). Impact of conventional agriculture on soil environment –field study in two areas og Sa Agroterra Agigea, Constanta. Research Journal of Agricultural Science, 42(1),2010.

Canarache, A. and E. Dumitru (1987). Related to direct and residual effect of soil tillage upon soil physical propertied .In Theoretical and applied Plant Growing Problems, 8 (3): 195-208 (In Romanian) .

Early, A.C. (1975). Irrigation scheduling for wheat in punjab, Cento Sci. Prog. Optimum use of water in Agric. Rpt.17, lyallpur, Pakistan, 3-5 March, pp, 115-127.

Elkhateeb , H., M. Khodeir and M. Saied (2009). Effect of different tillage systems on some water requirements and cotton crop yield. Misr J.Ag.Eng., 26(3):1104-1119.

Tale 10 11

Tale 12

El-Shahawy, M.I., M.S. El-Yamani, Maani; . Z.M. Abou Amou and Asmaa A. El-Basuony (2001). Influence of tillage and nityogen fertilization levels on yield,quality and chemical composition of sugar beet crop.J.Agric.Sci.Mansoura Univ.,26(2):1177-1190.

Downy, L. A. (1970). Water use by maize at three plant densities. Exper. Agro.7:161-169.

Dumitru, E. (2005): Conservative soil tillage between traditional and preservative in sustainable agriculture, 197 pp. (In Romanian).

Hammoud, H.S. (1992). Some factors affecting sugar beet yield in some Egyptian soils. Msc. Thesis, Fac. of Agric. KafrEl-Shekh, Tanta Univ., Egypt.

Hokansson, I. and R.C. Reeder (1994). Subsoil compaction by vehicles with high axle load-extent persistence and crop response. Soil tillage and Research, 29:277-304.

Israelson, O. W. and V. E. Hansen (1962). Irrigation principles and practices, 3rd Edition. John Wiley & Sons. Inc. New york.

Jabro, J.D., WB Stevens, W.M. Jversen and R.G Evans (2010). Tillage depth effects on soil physical properties, sugar beet yield, and sugar beet quality. Communications in soil science and plant analysis. Volume 41 (7): 908-916.

Korany, M.S and M.A. El-Said Khalifa (1998). Effect of tillage methods and nitrogen fertilizer on sugar beet production .Misr J.Ag.Eng. 15(2):261-275.

Lai, R. (1996). Axle load and tillage effects on crop yields on a Mollic Ochraqualt in Northwest Ohio. Soil tillage and Research, 37:143-160.

Mahajan, K.K. (1996). Management of phosphorus and farm yard manure in maize – wheat system in mid hills subhumd zone of Himachal Pradesh . J . Hill Res . 9 (3): 480-485.

Michael, A.M. (1978). Irrigation theory and practice. Vikas publishing house. New Delhi, India.

Naveed, L.K., U.M. Acmat, U. Farah and M.I. Bodla (2010). Effect of tillage and farm yard manure on physical properties of soil. International Research Journal of Plant Science 1(4): 75-82.

Sayed, K.M., R.E. Knany, A.I.N. Abdel-Aal and A. S.A. Abdel-Mawgoud (1998). Subsoiling plow and nitrogen fertilizer types in relation to quality of sugar beet. J. Agric. Sci. Mansoura Univ.,23(12): 6323-6333.

Snedecor, G.W. and W.G. Cochran (1967). Statistical methods, 6thed. Oxford and IBH. Publishing co., Culcutta, India.

Versa Ec, chang sk, Abolaji JQ, Farquhar DA, Olsen FJ(1997). effect of deep tillage on soil physics characteristics and corn (zea maysl) root growth and production soil and tillage Res. 43: 219-228.

Zein Al-Din, A.M. (1985). comparative study between different tillage methods. M.Sc . Thesis, Ag. Eng m Dep., Fac. Of Ag. Alex. Univ.

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تأثير طرقِ وأعماقِ الخدمة على انتاجيةِ بنجر السكّرَ والأرزَّ وتوزيعَ الأملاحِ بالتربة و كفاءةً اَستخدام المياة في الأراضى المتاثرة بالأملاح في شمال الدلتا

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معهد بحوث الأراضى والمياة والبيئة– مركز البحوث الزراعية

الملخّص العربى

أجريت "تجربتين حقلِيتين في محطةِ البحوث الزراعية بسخا ،محافظة كفر الشّيخ بشمال الدلتا خلال الموسم الشتوى (٢٠١٠/٢٠١١) والصيفى (٢٠١١) لدراسة تأثيرِ ثلاثة مِنْ طرقِ الخدمة ؛ المحراث القرصى ، المحراث الحفار والمحراث تحت التربة، بثلاثة أعماقِ ١٥، ٢٥ و٣٥ سنتيمتر على انتاجية الأرزَّ وبنجر السكّرَ، بَعْض خواص الأرض الكيميائية والطبيعية وعلاقاتِها المائيه. وكان التصميم التجريبي قطع منشقة مع أربعة مكررات، حيث خُصّصتْ القطع الرئيسية لطرقِ الخدمة و خُصّصتْ القطع المنشقة لأعماقِ الخدمة.وبينتْ النَتائِج أنّ :

* محصول بنجر السكّرِ تاثر معنويا بطرقِ وأعماقِ الخدمة. و أدّى الحِرثَ على عمق ٣٥ سنتيمترإلى زيادةِ محصول جذور البنجر بحوالى ١٧.٤٦ و٤.٦١ % مقارنة بالأعماق ١٥ و ٢٥ سنتيمترِ، على التوالي.
* كان متوسط محصول جذور البنجرِ ١٥.٤٩، ١٦.٠٤ و١٧.٢١ طَنّ / فدان مع المحراث القرصى ، المحراث الحفار والمحراث تحت التربة ،على التوالي . وكان متوسط محصول جذور البنجرِ مع أعماقِ الخدمة ١٥ ،٢٥ ،٣٥ سنتيمتر ١٤.٤٧، ١٦.٧٣ و١٧.٥٤ طَنّ / فدان، على التوالي. بينما كان محصول السُكّرِ حوالى ٢.٥٦٥، ٢.٤٨٦ و٢.٥٩٨ طَنّ / فدان مع المحراث القرصى ، المحراث الحفار والمحراث تحت التربة ، على التوالي، وحوالى ٢.٢١٢، ٢.٦٤٦ و٢.٧٩٠ طَنّ / فدان مع اعماق الخدمة ١٥، ٢٥ و٣٥ سنتيمتر ، على التوالي.
* كانت أعلى القيم للبوتاسيوم والنيتروجين الأميني % ودرجة نقاوةِ مع الحرث تحت التربة لعمق ٣٥ سنتيمترِ.
* في الموسم الثاني، تم الحصول على اكبر قيم لمحصولَ الأرزِّ ومكوناته باستعمال المحراث الحفارمع عمق خدمة ١٥سم ، بينما كان تأثيرالتفاعل بين طرقِ وأعماقِ الخدمة على هذه الصفات غير معنوى.
* أعلى قيمة للماءِ المضافِ لبنجر السكر والأرز كانت مَع المحراث تحت التربة بعمقِ ٣٥ سنتيمترِ. بينما تحققت اقل قيمة مَع المحراث القرصي على عمقِ ١٥ سنتيمترِ .
* القيمة الأعلى لكفاءةِ إستخدام الماءِ الحقليِ لبنجر السكر (٦.١٢ كيلوجرام جذور/متر مكعب) تحققت مَع المحراث القرصى على عمقِ ٣٥ سنتيمتر ؛بينما اقل قيمة (٥.٠١ كج جذور/ متر مكعب) مع الحرث تحت التربة لعمق ١٥ سم .

* القيمة الأعلى لكفاءةِ إستخدام الماءِ المحصوليِ لبنجر السكر(٩.٤٩ كيلوجرام جذرِ / متر مكعب) تحققت مَع المحراث تحت التربة على عمقِ ٢٥ سنتيمترِ بينما كانت اقل قيمة (٧.٥٤ كج جذور/ متر مكعب) مع المحراث القرصي على عمقِ ١٥.
* بالنسبة للأرزِّ، تم الحصول علي اقل قيمة للماءِ المضاف (٤٧٦٧ متر مكعب /فدان) و أعلى كفاءةِ إستخدامِ للمياة (٠.٦٣ كيلوجرام حبوبِ / متر مكعب) مع المحراث القرصى على عمق ١٥ سنتيمترِ، بينما حقق المحراث تحت التربة و عمقِ ٣٥ سنتيمترِ اكبر قيمة للماء المضاف (٦١٧٨ متر مكعب/فدان) واقل كفاءة إستخدامِ للمياه (٠.٢٨ كيلوجرام حبوب/ متر مكعب).
* اكبر القيم لمعدلِ التسرّبِ الأساسيةِ والتجميعى مع بنجر السكّرِ والأرزِّ تحققت مع الحرث العميق و عمق ٣٥ سنتيمترِ ، بينما اقل القيم تحققت مع المحراث القرصى و عمق ١٥ سنتيمترِ.
* اكبر معدل لغسيل أملاحِ التربة بعد حصاد كلا من البنجر والأرز تحقق مع المحراث تحت التربة يلية المحراثِ الحفار خاصة مع عمق ٣٥ سم.
* اتضح من الدراسة ان اعلى عائد للمزارع تحقق مع معاملة الحرث تحت التربة لمحصول بنجر السكر بينما تحقق اعلى عائد من محصول الارز مع المحراث القرصى.

Table (10): Soil salinity and its rate of change after harvesting of sugar beet and rice crops as affected by methods and depths of tillage.

Tillage method	ECe before exp.	ECe after harvesting of sugar beet – Tillage depth (cm)			Mean	Rate of change % for tillage depth			Mean	ECe after harvesting of rice – Tillage depth (cm)			Mean	Rate of change % for tillage depth			Mean
		15	25	35		15	25	35		15	25	35		15	25	35	
Disc harrow	19.27	15.7	13.35	9.61	12.89	18.53	30.72	50.13	33.1	11.15	9.43	7.88	9.49	42.14	51.06	59.11	50.8
Chisel plough	19.77	10.95	11.91	10.24	11.03	43.18	38.19	46.86	42.7	8.54	10.3	9.43	9.42	55.68	46.55	51.06	51.1
Subsoiler	19.27	10.71	10.4	9.67	10.26	44.42	46.03	49.82	46.8	9.12	9.51	8.92	9.18	52.67	50.65	53.71	52.3
Mean	19.44	12.45	11.89	9.84	11.39	35.38	38.31	48.94	40.9	9.6	9.75	8.74	9.36	50.16	49.24	54.63	51.4

Table (11): Sodium adsorption ratio and its rate of change after harvesting of sugar beet and rice crops as affected by tillage methods and depths.

Methods of tillage	SAR before exp.	SAR after harvesting of sugar beet – Tillage depth (cm)			Mean	Rate of change % for tillage depth			Mean	SAR after harvesting of rice – Tillage depth (cm)			Mean	Rate of change % for tillage depth			Mean
		15	25	35		15	25	35		15	25	35		15	25	35	
Disc harrow	21.35	18.7	18.0	15.27	17.32	12.41	15.69	28.48	18.86	16.47	15.07	13.8	15.11	22.86	29.41	35.36	29.21
Chisel plough	21.35	16.3	17.0	15.8	16.37	23.65	20.37	26.0	23.34	14.4	15.73	15.13	15.09	32.55	26.32	29.13	29.33
Subsoiler	21.35	16.13	15.9	15.33	15.79	24.45	25.53	28.2	26.06	14.97	15.2	14.73	14.97	29.88	28.81	31.01	29.9
Mean	21.35	17.04	16.97	15.47	16.49	20.17	20.53	27.56	22.75	15.28	15.33	14.55	15.06	28.44	28.18	31.83	29.48

Table (12): Economic evaluation of different treatments for sugar beet and rice.

Agronomic practices	Production cost LE/fed.			Profit LE/fed.			Net return			Investment factor		
	Disc harrow LE/fed.	Chisel plough LE/fed.	Sub soiler LE/fed.	Disc harrow LE/fed.	Chisel plough LE/fed.	Sub soiler LE/fed.	Disc harrow LE/fed.	Chisel plough LE/fed.	Sub soiler LE/fed.	Disc harrow LE/fed.	Chisel plough LE/fed.	Sub soiler LE/fed.
Sugar beet												
plow	150	150	210									
Variable cost	1930	1930	2030	-	-	-	-	-	-			-
Total	3080	3080	3240	4650	4800	5550	1570	1720	2310	1.51	1.56	1.71
Rice												
Variable cost	2740	2740	2740	4060	3262	3136	1320	522	396	1.48	1.41	1.14
Total	3820	3820	3980	8710	8060	8686	2890	2242	2706	2.28	2.11	2.18