

## **EFFECT OF MOLE DRAINS AND COMPOST APPLICATION ON SOME SOIL PROPERTIES, WATER RELATIONS AND ITS PRODUCTIVITY AT NORTH DELTA.**

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### **ABSTRACT**

A field experiment was conducted at Sakha Agricultural Research station, Kafr El-Sheikh Governorate, Egypt to evaluate the effect of mole drain types, mole spacing and compost application on improving some soil physio-chemical properties, some water relations and yields of wheat and sunflower. The experiments were conducted in split-split plots with four replicates.

The most important findings can be summarized as follows:

Sandy mole and narrow mole spacing effects were superior to without sandy mole and wider mole spacing on reducing soil salinity and sodicity. The reductions of salinity were 24.70, 20.16 and 10.30%, respectively, after two seasons from experiment installation under mole distance of 2-m, 4-m and 6-m. While, the corresponding values of SAR<sub>e</sub> were 13.41, 10.62 and 19.40%, respectively. The higher reduction of soil salinity and sodicity, were noticed with increasing rates of compost in both growing seasons.

The construction of mole drain is more effective in reducing soil bulk density and increasing basic infiltration rate. The reducing soil bulk density and increasing basic infiltration rate were higher under sandy mole than mole without sand. The effect of mole spacing on reducing soil bulk density and increasing basic infiltration rate can be arranged according to the following descending order 2m > 4 m > 6 m > compared to data obtained before treatments. The construction of mole with narrow distances between the ploughed lines seemed to be effective in increasing availability of N, P and K especially with high rates of compost.

Sandy mole and narrow mole spacing were superior to without sandy mole and wider mole spacing on improving water application efficiency, field and crop water use efficiencies. The highest values of field and crop water use efficiencies for wheat and sunflower were achieved from the interaction between sandy mole at 6 m spacing combined with application of 20 ton compost fed<sup>-1</sup>.

Mole types, mole spacing and compost rates have highly significant effect on yields and yield components of wheat and sunflower. Sandy mole caused increasing of grain and straw yield of wheat than without sandy mole by 74.30 and 116.1%, respectively. Also, sandy mole caused increasing of seed yield and seed oil content of sunflower than without sandy mole by 48.41 kg fed<sup>-1</sup> and 0.26%, respectively. The effect of mole spacing on wheat and sunflower yields and its components can be arranged according to the following descending order 2m > 4 m > 6 m. Compost application caused high increases in wheat and sunflower yields and its components especially with the high rates. The construction of sandy moles at 2 m spacing combined with addition of 20 ton compost fed<sup>-1</sup> gave the highest production of wheat grain yield (3886.7 kg fed<sup>-1</sup>).

**Keywords:** mole drain, compost, soil properties, wheat, sunflower, clay soils.

### **INTRODUCTION**

Heavy clayey salt affected soils with low permeability in the Nile Delta was not generally adapted for crop production. Therefore, an efficient

drainage system is an important factor to improve these soils to be suitable for crop production in the short time with low cost. The major concern in these soils is to maintain of adequate water infiltration and soil aeration. A secondary drainage, such as mole drain to be an inexpensive at close spacing, intercepted by permanent laterals at wider spacing. Molding is the best suited to clay soils with a minimum clay content of about 30%. Mole drain in clay soil with proper spacing can reduce waterlogging problems. Mole drain is widely used in heavy clay soils to improve the productivity (David, 2002, Moukhtar *et al.*, 2003, and 2012 and Antar, *et al.*, 2008 and 2012). Molding or subsoiling will enhance downward movement of irrigation water carrying off excess salts from surface layers. After wards, regular subsequent irrigations will gradually reduce the salt content in groundwater at least when close to soil surface. The percolating water will constitute a temporary front preventing the saline groundwater in subsurface soil layers from linking with the upper ones (Moukhtar *et al.*, 2003 and 2010 and Antar, *et al.*, 2008 and 2012). Said (2003) showed that the cumulative and basic infiltration rate of the treated soil by subsoil were markedly increased relative to the untreated one. He also pointed out that the treated soil resulted in a decrease in bulk density and penetration resistance in coincidence with an increase in total porosity and macropores relative to the untreated ones. Aiad *et al.*, 2012 and Zamil, 2012 concluded that the E<sub>Ce</sub> and ESP were decreased after mole instillation with and without sandy mole. El-Sanat (2012) revealed that the application of subsoiling at 2 m spacing with 110 kg N fed<sup>-1</sup> gave the highest production of wheat and crop water use efficiency.

Soil organic matter increases agricultural production by improving soil physical, chemical and biological properties. Application of organic residues could increase soil organic matter and buffer effect, improve aggregate stability and enhance water retention capacity (Spaccini *et al.*, 2002). Compost is rich source of nutrients with high organic matter content, physical and chemical properties of soil can be improved by using compost, which may ultimately increase crop yields. Therefore, application of compost is the need of the time, physical, void ratio, water permeability and hydraulic conductivity were significantly improved when farm yard manure (10 ton ha<sup>-1</sup>) was applied in combination with chemical amendments, resulting in enhanced rice and wheat yields in sodic soils (Hussain *et al.*, 2001). Other organic materials like rice straw, wheat straw and rice hulkals improved these physical properties of a saline sodic soils, which in turn significantly increased tillering, plant height, biomass and baddy yield (Hussain *et al.*, 1998). Moreover, Gong *et al.* (2009), Enkeliu *et al.* (2010) and Yassen *et al.* (2010) reported that the growth and yield of wheat was improved by the use of organic fertilizer sources compared with chemical fertilizers. They added that the integrated use of organic and inorganic fertilizers get higher wheat yield.

The current study aims to evaluate the effect of mole drain types (without and with sand), mole spacing (2, 4 and 6 m) and rice straw compost (0, 10, 15 and 20 ton fed.<sup>-1</sup>) on improving some soil physio-chemical properties, some water relations and yields of wheat and sunflower.

## 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) to evaluate the effect of mole drain types, mole spacing and application rates of rice straw compost on improving some soil physio-chemical properties, some water relations and yields of wheat and sunflower. The station is situated at 31° 05' N latitude 30° 75' E longitude. It has an elevation of about 6 meters above the sea level. The soil has a clayey texture. All agricultural practices were used with the two crops as recommended in the North Delta area. The initial of some soil properties for the experimental field are presented in Table (2). The experiments were conducted in split-split plots with four replicates.

### **The treatments were as follows:**

- 1- Main plots (mole types)  
Mole without sand and mole with sand (sand-filled moles).
- 2- Sub-plots (mole spacing)  
2, 4 and 6 m distances between the ploughed lines at 60 cm depth.
- 3- Sub-sub plots (compost rates of rice straw)  
0.0, 10, 15 and 20 ton fed.<sup>-1</sup>

The meteorological data from Sakha Station during the two growing seasons are presented in Table (1).

In the winter season wheat (*Triticum aestivum*) Sakha 93 variety was planted on December 4, 2010. All plots received a total of 75 Kg Ca-superphosphate/fed., during tillage operation. Nitrogen fertilizer in the form of urea was side dressed at a rate of 75 Kg N/fed, in two doses after 40 and 60 days from the planting. In the summer season sunflower Sakha 53 variety was sown on May, 25th and harvested on September, 15th, 2011. Phosphorus in the form of Ca-superphosphate (15.5% P<sub>2</sub>O<sub>5</sub>) was added through preparation of the soil. Nitrogen fertilizer in the form of urea was side dressed at a rate of 45 Kg N/fed in two doses before the first and second irrigation. The different agricultural practices were performed as recommended for two crops under study.

**Table (1): Climatological data for the two growing seasons in 2010/2011**

Year	Month	Air temp. °C		Mean	Relative humidity %	Wind velocity, km/day at 2m height	Pan evapo. cm/day	Rain, mm
		Max.	Min.					
2010	November	26.8	11.00	18.90	68.10	63.00	0.280	-
	December	22.0	8.30	15.15	70.10	58.30	0.181	20
2011	January	20.3	5.80	13.05	69.10	42.50	0.198	24
	February	23.4	7.40	15.40	70.50	64.00	0.291	16
	March	21.8	6.80	14.30	67.90	77.40	0.336	12
	April	26.5	10.00	18.25	66.40	83.40	0.489	8
	May	29.0	13.00	21.00	57.40	102.50	0.596	-
	June	32.0	17.20	24.60	64.50	113.00	0.722	-
	July	33.0	19.40	26.20	64.40	92.00	0.775	-
	August	32.5	19.20	25.90	68.00	84.00	0.683	-
	September	32.2	17.70	25.00	68.80	74.00	0.616	-
October	28.0	14.00	21.00	65.00	78.00	0.451	-	

**Table (2): The initial of some soil properties for the experimental field**

Soil depth (cm)	Particle size distribution			Texture class	OM %	Bulk density g/cm <sup>3</sup>	Total porosity E%	Basic IR cm/hr
	Sand %	Silt %	Clay %					
0-20	25.85	27.34	46.81	Clayey	1.53	1.31	50.57	0.65
20-40	22.48	27.31	50.21	Clayey	1.45	1.35	49.06	
40-60	27.19	29.10	43.71	Clayey	1.23	1.41	46.79	
Mean	25.17	27.92	46.91	Clayey	1.40	1.36	48.80	
Soil depth (cm)	EC dS/m	SAR	Field capacity %	Wilting point %	Available water %	Available nutrients, ppm		
						N	P	K
0-20	6.89	12.96	42.85	22.76	20.09	23.80	9.51	312
20-40	7.38	13.42	40.56	20.30	20.26	22.60	9.93	325
40-60	7.87	13.79	38.25	20.12	18.13	19.30	9.75	335
Mean	7.38	13.39	40.55	21.06	19.49	21.90	9.73	324

Before planting and after harvesting both crops, soil samples (0-20, 20-40 and 40-60 cm depth) were collected. Some physical and chemical analysis were determined with both crops. Salinity was determined in the saturated soil paste extract according to Page (1982). Soil bulk density and total porosity of the different layers of soil profile from the applied treatments were measured before experiments and after harvesting of both seasons using the core sampling technique as described by Campbell (1994). Infiltration rate was determined using double cylinder infiltrometer as described by Garcia (1978). Wheat plant samples were taken from all treatments for determinations of 1000-kernel weight, biological, grain and straw yields as well as plant height, stem diameter, head diameter, 100-seed weight (g) and seed yield (kg fed<sup>-1</sup>) were

determined of sunflower. Plant samples were taken and dried at 70°C, grounded with a mill and its available N, P and K (ppm) content was determined. Available nitrogen was extracted using 2M KCl and determined by the micro-kjeldahl method (Keeney and Bremner, 1966), available phosphorus was extracted using sodium bicarbonate and determined by spectronic Milton Roy by (Olsen, *et al.*1959) and available potassium was extracted using ammonium acetate at pH 7 and determined by Flame photometer (Klute 1986). Sunflower seed oil was determined as described by the A.O.A.C. method (1990).

**Some water relations:**

**Amount of irrigation water applied:**

Was measured by using a set of cut-throat flumes (30 x 90 cm) according to **Early (1975)**

**Determination of soil moisture percentage:**

Soil moisture content (%) was determined by drying the soil samples at 105°C to constant weight and the moisture content was calculated according to **Singh, (1980)**.

**Water consumptive use:**

Water consumptive use by growing plants was calculated based on soil moisture depletion (SMD) according to the following equation (**Hansen *et al.*, 1979**).

$$Cu = SMD = \sum_{i=1}^{i=4} \frac{\theta_2 - \theta_1}{100} \times D_{bi} \times \frac{D_i}{100} \times 4200$$

Where:

**Cu=Water consumptive use (m<sup>2</sup>/fed.) in the effective root zone.**

**θ<sub>2</sub>=Gravimetric soil moisture percentage after irrigation**

**θ<sub>1</sub>=Gravimetric soil moisture percentage before next irrigation.**

**D<sub>bi</sub>=Soil bulk density (kg/m<sup>3</sup>)**

**D<sub>i</sub>=Soil layer depth, m**

**i=Number of soil layers (1-4)**

**Irrigation application efficiency (E<sub>a</sub>):**

Irrigation application efficiency was calculated according to the following equation described by Downy (1970).

$$E_a = (w_s/w_a) \times 100$$

Where:

W<sub>s</sub> and W<sub>a</sub> are the volumetric water stored in effective root zone and water applied, respectively.

**Water productivity (WP):**

Water productivity is generally defined as crop yield per cubic meter of water consumption. Water production can be also defined as crop production per unit amount of water used. Concept of water productivity in agricultural production system is focused on producing more food with the same water resources, or producing the same amount of food with less water resources. It was calculated according to Ali *et al.*, (2007).

$$WP = \frac{Y}{ET}$$

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Where:

WP = Water productivity (kg/m<sup>3</sup>)  
Y = Yield (kg fed<sup>-1</sup>.)  
ET = Total water consumption of the growing season m<sup>3</sup> fed<sup>-1</sup>.  
= Water consumptive use, m<sup>3</sup> fed<sup>-1</sup>.

**Productivity of irrigation water (PIW):**

Productivity of irrigation water (PIW) was calculated according to **Ali et al., (2007)**:

$$PIW = \frac{Y}{IW}$$

Where:

PIW = Productivity of irrigation water (kg/m<sup>3</sup>)  
Y = Yield (kg fed<sup>-1</sup>.)  
IW = Irrigation water applied, m<sup>3</sup> fed<sup>-1</sup>.

**Statistical analysis:** Data obtained are subjected to statistical analysis according to **Snedecor and Cochran (1980)**.

## RESULTS AND DISCUSSIONS

**Soil salinity (ECe) and sodicity (SARe):**

Salinity and sodicity of the soil as affected by different mole types, mole spacing and compost rates under wheat and sunflower cultivation are shown in Table (3). Data clearly showed that the construction of mole drain is more effective in decreasing of soil salinity and sodicity than before experiment instillation in the topsoil up to 60cm depth. The mean values of ECe and SARe before experiment were 7.38 dS/m and 13.39, respectively. While, after treatments installation values of EC<sub>e</sub> varied from 5.11 to 6.95dS/m and SARe from 10.92 to 13.02 under all treatments for both seasons. Data also, showed that sandy mole effects were superior to without sandy mole on reducing soil salinity and sodicity. The reduction in soil salinity were higher under mole without sandy and mole with sand, respectively about 14.89 and 18.08 % in first season, 19.31 and 22.23 % in the second season than before experiment. The corresponding values of SARe were 7.50 and 9.48 %, 10.13 and 11.94%, respectively.

Concerning mole drain spacing, results in Table (3) showed that, ECe and SARe of soil are decreased with decreasing mole drain spacing in both growing seasons. The reductions of salinity were 24.7, 20.16 and 10.3%, respectively under mole distance of 2, 4 and 6-m after harvesting of both crops. The corresponding values of SARe were 13.41, 10.62 and 19.40%, respectively. Results could be attributed mainly to that mole forms many lines with big crack extent from soil surface to mole depth (50- 60cm deep) and also numerous effective capillary cracks is formed. All these cracks together break the soil matrix and encourage downward of water as well as solute movement. The soil cracks life may be several months or years (Moukhtar *et al*, 2002a and Antar *et al.*, 2012). Moukhtar *et al*, (2003b) reported that, moling or subsoiling enhance downward movement of irrigation

water carrying off excess salts from surface layers. After wards, regular subsequent irrigations will gradually reduce the salt content in groundwater at least when it is close to soil surface. The percolating water will constitute a temporary front preventing the saline groundwater in subsurface soil layers from linking with the upper ones. These results are in agreement with those obtained by El-Sanat (2012) and Zamil (2012).

**Table (3):ECe and SARE of soil (0-60 cm depth) before experiments and after harvesting wheat and sunflower.**

Treatments			ECe dS/m	SARE	Rate of change		ECe dS/m	SARE	Rate of change		
					ECe	SARE			ECe	SARE	
Before experiments											
			7.38	13.39	-	-	7.38	13.39	-	-	
Mole type	Mole spacing m	Compost rates ton fed <sup>-1</sup>	After one season (wheat crop)				After two seasons (sunflower crop)				
			ECe	SARE	Rate of change	Rate of change	ECe	SARE	Rate of change	Rate of change	
Mole	2-m	0	6.29	12.38	14.77	7.54	6.11	12.18	17.21	9.04	
		10	6.05	12.12	18.02	9.48	5.76	11.85	21.95	11.5	
		15	5.89	11.98	20.19	10.53	5.53	11.6	25.08	13.37	
		20	5.65	11.74	23.44	12.32	5.37	11.43	27.24	14.64	
	Mean			5.97	12.06	19.11	9.67	5.69	11.77	22.87	12.14
	4-m	0	6.63	12.71	10.16	5.08	6.39	12.48	13.41	6.79	
		10	6.49	12.69	12.06	5.23	6.18	12.25	16.26	8.51	
		15	6.15	12.25	16.67	8.51	5.91	11.99	19.92	10.46	
		20	6.02	12.11	18.43	9.56	5.63	11.7	23.71	12.62	
	Mean			6.32	12.44	14.33	7.1	6.03	12.11	18.33	9.59
	6-m	0	6.95	13.02	5.83	2.76	6.53	12.6	11.52	5.89	
		10	6.75	12.8	8.54	4.41	6.24	12.32	15.45	7.99	
		15	6.35	12.42	13.96	7.24	6.03	12.12	18.29	9.48	
		20	6.15	12.25	16.67	8.51	5.78	11.88	21.68	11.28	
	Mean			6.55	12.62	11.25	5.73	6.15	12.23	16.74	8.66
Mean			6.28	12.37	14.89	7.5	5.96	12.04	19.31	10.13	
Sandy mole	2-m	0	6.05	12.12	18.02	9.48	5.75	11.82	22.09	11.77	
		10	5.95	12.05	19.38	10	5.54	11.6	24.93	13.37	
		15	5.75	11.82	22.09	11.73	5.29	11.36	28.32	15.16	
		20	5.31	11.36	28.05	15.16	5.11	10.92	30.76	18.45	
	Mean			5.77	11.84	21.89	11.59	5.42	11.43	26.53	14.68
	4-m	0	6.43	12.51	12.87	6.57	6.05	12.12	18.02	9.48	
		10	6.09	12.18	17.48	9.04	5.85	11.92	20.73	10.98	
		15	5.91	11.98	19.92	10.53	5.65	11.74	23.44	12.32	
		20	5.85	11.92	20.73	10.98	5.48	11.54	25.75	13.82	
	Mean			6.07	12.15	17.75	9.28	5.76	11.83	21.99	11.65
	6-m	0	6.74	12.8	8.67	4.41	6.45	12.54	12.6	6.35	
		10	6.38	12.48	13.55	6.79	6.11	12.18	17.21	9.04	
		15	6.11	12.18	17.21	9.04	5.91	11.98	19.92	10.53	
		20	5.98	12.05	18.97	10.01	5.69	11.78	22.89	12.02	
	Mean			6.3	12.38	14.6	7.56	6.04	12.12	18.16	9.49
Mean			6.05	12.12	18.08	8.48	5.74	11.79	22.23	11.94	

Application of rice straw compost reduced soil salinity and sodcity. The higher reduction of soil salinity and sodcity, were noticed with increasing rates of compost. The decreases of soil salinity and sodcity with application compost harvesting of are more pronounced after harvesting the second

season compared to after harvesting of the first season (Table, 3). This may be due to the improved soil physical properties such as bulk density, porosity, aggregates stability and infiltration rate that affect water-air relationships in the root zone (Doran and Parking, 1994).

**Soil bulk density and total porosity:**

Soil bulk density is considered as one of the most important parameters which indicate the status of soil structure and consequently, soil water, air and heat regime (Richards, 1954). Results in Table (4) show that, soil bulk density was reduced after harvesting of first and second seasons. The average value of soil bulk density was 1.36  $\text{Mgm}^3$  before installation of the treatments and, its values were 1.25 and 1.21  $\text{Mgm}^3$  after harvesting of the first and second seasons, respectively. Data also showed that soil bulk density after the second season was somewhat reduce under mole filled with sand (1.24  $\text{Mgm}^3$ ) compared to mole without sand (1.26  $\text{Mgm}^3$ ). The narrow soil distances between the ploughed lines seemed to be effective in lowering soil bulk density than wider mole spacing. The lowest values are achieved with 2 m spacing while the highest values were obtained with 6 m mole spacing (Table 4). This means that mole effects were superior to those obtained before application the treatments on reducing soil bulk density. It could be attributed to the effects of mole types or distances on breaking soil clods and bigger granular into smaller crumbs as well as breaking and cracking the compacted layers (Amer, 1999, Abdel-Mawgoud *et al.*, 2006 and Antar *et al.*, 2008). Results show also that, applied of rice straw compost led to reduce soil bulk density especially with the high rates and after harvesting of the second season. The beneficial effect of compost in improving the bulk density is due to the increase of soil organic matter content which consequently encourages soil aggregates.

Soil porosity values (Table, 4) had taken almost the opposite trend to that encountered with bulk density. The results indicate that the values of bulk density were increased and values of total porosity were decreased for all treatments (Table, 4).

**Infiltration rate:**

The basic infiltration rate (BIR) as affected by different mole types, mole spacing and compost rates under wheat and sunflower cultivation are shown in Table (4). Data showed that the construction of mole drain is more effective in increasing BIR compared to data obtained before experiment instillation. The mean value of BIR before experiment was 0.65  $\text{cmhr}^{-1}$  while, after treatments installation values of BIR varied from 0.95 to 1.45  $\text{cmhr}^{-1}$  under all treatments for both seasons. Data also, showed that sandy mole effects were superior to without sandy mole on increasing BIR. The increasing in BIR were higher under mole filled with sand than without sandy mole about 0.2  $\text{cmhr}^{-1}$  in first season and 0.1  $\text{cmhr}^{-1}$  in the second season.



**Table (4): Soil bulk density, total porosity (0-60 cm depth) and basic infiltration rate (IR) before experiments and after harvesting of wheat and sunflower for all treatments.**

Treatments			Soil bulk density (Mg/m <sup>3</sup> )	Soil porosity (%)	IR (cmhr <sup>-1</sup> )	Soil bulk density (Mg/m <sup>3</sup> )	Soil porosity (%)	IR (cmhr <sup>-1</sup> )
Mole type	Mole spacing m	Compost rates ton fed <sup>-1</sup>	Before experiments					
			1.36	48.80	0.65	1.36	48.80	0.65
			After one season (wheat crop)			After two seasons (sunflower crop)		
Mole	2-m	0	1.31	50.57	1.15	1.28	51.69	1.36
		10	1.29	51.32		1.26	52.45	
		15	1.26	52.45		1.23	53.58	
		20	1.24	53.20		1.22	53.96	
		Mean	1.28	51.89		1.25	52.92	
	4-m	0	1.32	50.19	1.05	1.29	51.32	1.25
		10	1.31	50.67		1.28	51.69	
		15	1.29	51.32		1.25	52.83	
		20	1.27	52.08		1.23	53.58	
		Mean	1.30	51.07		1.26	52.36	
	6-m	0	1.34	49.43	0.95	1.30	50.94	1.11
		10	1.32	50.19		1.28	51.69	
15		1.30	50.94	1.26		52.45		
20		1.28	51.69	1.24		53.20		
Mean		1.31	50.56	1.27		52.07		
Mean			1.30	51.17	1.05	1.26	52.45	1.24
Sand mole	2-m	0	1.27	52.08	1.35	1.22	53.96	1.45
		10	1.25	52.83		1.20	54.72	
		15	1.21	54.34		1.17	55.85	
		20	1.18	55.47		1.12	57.74	
		Mean	1.23	53.68		1.18	55.57	
	4-m	0	1.28	51.69	1.23	1.25	52.83	1.32
		10	1.26	52.45		1.23	53.58	
		15	1.24	53.20		1.22	53.96	
		20	1.21	54.34		1.15	56.60	
		Mean	1.25	52.92		1.21	54.24	
	6-m	0	1.29	51.32	1.21	1.27	52.08	1.26
		10	1.28	51.69		1.25	52.83	
15		1.26	52.45	1.24		53.20		
20		1.24	53.20	1.18		55.47		
Mean		1.27	52.17	1.24		53.39		
Mean			1.25	52.92	1.26	1.21	54.40	1.34

Concerning the effect of drain spacing on the basic infiltration rate, data show that, 2 m spacing increased the basic infiltration rate more than the other drain spacing. The effect of mole spacing on the basic infiltration rate can be arranged according to the following descending order 2m > 4 m > 6 m > compared to data obtained before planting treatments. This may be due to the subsurface tillage such as mole drain gave the top soil layer a chance to dry and permitted for shrinkage and formation of water passage ways which allowed a rather easier movement of water into mole or subsoil line. Similar results were obtained by Abdel-Mawgoud *et al.*, (2006) and Antar *et al.* (2012).

**Available nutrients:**

Results in Table (5) show that, availability of N, P and K were increased after harvesting of both crops as a result of applied treatments (mole types and spacings as well as compost rates). The average values of N, P and K were 21.90, 9.73 and 324.0 ppm, respectively before conducting the treatments. While, after treatments installation values of N, P and K were varied from 24.79 to 88.60 ppm, 9.45 to 18.10 ppm and 315.60 to 485.00 ppm, respectively under all treatments for both seasons.

**Table (5): Available of N, P and K (ppm) in soil before and after harvesting of wheat and sunflower under all treatments.**

Treatments			N	P	K	N	P	K
Mole type	Mole spacing m	Compost rates ton fed <sup>-1</sup>	Before experiments					
			21.90	9.73	324.0	21.90	9.73	324.00
			After one season (wheat crop)			After two seasons (sunflower crop)		
Mole	2-m	0	46.50	12.35	375.0	33.53	10.41	341.51
		10	65.10	13.65	408.0	59.92	11.82	382.6
		15	70.20	15.71	423.0	66.32	13.15	413.7
		20	82.70	17.20	445.0	76.80	15.75	426.5
	4-m	0	37.30	11.78	355.8	26.57	9.65	326.98
		10	46.40	12.83	369.7	42.62	10.33	361.56
		15	53.40	14.31	390.5	46.68	12.38	355.70
		20	72.80	15.80	410.9	78.51	14.19	395.80
	6-m	0	33.60	11.63	335.8	24.79	9.45	319.50
		10	39.50	12.91	346.5	38.50	10.11	328.43
		15	48.30	13.39	356.8	41.85	11.75	337.80
		20	65.40	14.11	385.5	56.37	13.89	368.90
Sand mole	2-m	0	49.2	12.90	391.0	41.82	11.38	365.2
		10	71.8	14.20	435.0	66.30	12.67	315.6
		15	78.4	16.30	462.0	71.20	14.12	436.5
		20	88.6	18.10	485.0	82.70	16.91	445.1
	4-m	0	42.9	12.30	375.0	37.60	10.40	359.10
		10	56.9	13.15	385.0	51.80	11.30	376.50
		15	69.4	14.60	415.0	63.50	13.20	392.00
		20	83.2	16.50	448.0	79.50	15.60	416.00
	6-m	0	36.5	11.92	363.0	32.90	9.75	351.50
		10	47.7	13.12	370.0	43.80	11.50	346.50
		15	61.3	13.60	380.0	53.70	12.70	365.50
		20	76.5	14.10	425.0	69.40	13.20	390.50

The narrow distances between the ploughed lines and sandy mole seemed to be effective in increasing availability of N, P and K compared to wider mole spacing and mole without sand. This is due to improved drainage conditions near the drain line which caused water-air balance in the root zone, and increasing the amount of available nutrients for the plant. Similar results were obtained by Moustafa *et al.* (1987), Sharma and Komal (1998) and Ibrahim *et al.* (1999). Also, compost application led to high increases in availability of N, P and K especially with the high rates. The beneficial effect of compost in improving the availability of N, P and K are due to the increase

of soil organic matter content which consequently encourages soil aggregate, which caused water-air balance in the root zone, and consequently increasing the amount of available nutrients. The same results were obtained by **Shams El-Din (2001)**.

**Some water relations:**

**Amount of irrigation water applied:**

The average amount of irrigation water included the rainfall delivered to each treatment is presented in Table (6). The mole drain spacing at 6 m received the lowest amount of irrigation water as compared to 2 m and 4 m spacing. Also, mole without sand received the lowest amount of water applied, compared to sandy mole. It is obvious from the obtained data that the highest values of water applied to wheat are obtained with sandy mole at 2 m spacing ( $2517.53 \text{ m}^3 \text{ fed}^{-1}$ ), while the lowest value was recorded with 6 m spacing under mole without sand treatment ( $1947.81 \text{ m}^3 \text{ fed}^{-1}$ ). Also, the highest value of water applied to sunflower was recorded with sandy mole at 2 m spacing ( $2736.9 \text{ m}^3 \text{ fed}^{-1}$ ), while the lowest value is obtained under mole without sand at 6 m spacing ( $2224.83 \text{ m}^3 \text{ fed}^{-1}$ ). These results are in agreement with those obtained by Zamil (2012) and El-Sanat (2012).

**Water consumptive use:**

Results in Table (6) showed that, there were no obvious differences between water consumptive use values under mole types and mole spacing treatments for either wheat and sunflower crops. The mean values of water consumptive use were  $1248.07$  and  $1251.73 \text{ m}^3 \text{ fed}^{-1}$ , for without sandy mole and sandy mole, respectively under wheat and it were  $1372.91$  and  $1390.02 \text{ m}^3 \text{ fed}^{-1}$  under sunflower. Water consumptive use for both wheat and sunflower were decreased with the increasing mole spacing (from 2 to 6 m). Water consumptive use mean values were  $1268.6$ ,  $1262.6$  and  $1218.6$  with wheat and  $1464.2$ ,  $1274.9$  and  $1305.3$  with sunflower for 2-m, 4-m and 6-m mole spacing, respectively. This finding is supported by Zamil (2012) and El-Sanat (2012).

**Water application efficiency:**

Data in Table (6) show that, water application efficiency mean values were  $59.09$  and  $62.63\%$  for sandy mole and mole without sand, respectively under wheat crop. The corresponding values were  $71.39$  and  $69.68\%$ , respectively under sunflower. Results in Table (6) show that, the narrow mole spacing was superior to wider mole spacing on improving water application efficiency. The mean values of water application efficiency were  $56.18$ ,  $60.12$  and  $66.29\%$  under wheat and its values were  $69.20$ ,  $70.59$  and  $71.83$  for 2-m, 4-m and 6-m mole spacing, respectively under sunflower. These results are in agreement with those of Zamil (2012) and El-Sanat (2012).

**Field and crop water use efficiencies (productivity of irrigation water):**

Data in Table (7) show that, the establishment of more grain types and its seemed to be effective in producing relatively high values of field and crop water use efficiency for both crops. Mole types resulted in somewhat different for field and crop water use efficiency. Field water use efficiency mean values of wheat for sandy mole and mole without sand were  $1.39$  and  $1.34$ , for grain and  $1.71$  and  $1.63 \text{ kg/m}^3$ , respectively for straw. The corresponding values of crop water use efficiency were  $2.40$  and  $2.57 \text{ kg/m}^3$ , for grain and  $2.93$  and  $3.02$

kg/m<sup>3</sup> for straw, respectively. The mean values of field and crop water use efficiency with sunflower were 0.41 and 0.71 kg seed/m<sup>3</sup>, respectively for sandy mole and 0.41 and 0.73 kg seed/m<sup>3</sup>, respectively for mole without sand.

The narrow mole spacing were superior to wider mole spacing on reducing field water use efficiency and increasing crop water use efficiency. Field water use efficiency mean values of wheat for 2-m, 4-m and 6-m mole spacing were 1.31, 1.36 and 1.44 kg/m<sup>3</sup> with grain and 1.61, 1.66 and 1.75 kg/m<sup>3</sup>, respectively with straw. On the other hand, crop water use efficiency mean values for 2-m, 4-m and 6-m mole spacing were 2.53, 2.52 and 2.41 kg/m<sup>3</sup> with grain and 3.08, 2.93 and 2.91 kg/m<sup>3</sup>, respectively with straw. The mean values of field & crop water use efficiency of sunflower were 0.39, 0.41 and 0.42 kg /m<sup>3</sup> & 0.71, 0.72 and 0.74 kg seed/m<sup>3</sup> for 2-m, 4-m and 6-m mole spacing, respectively.

**Table (6): Water applied, water consumptive use and water application efficiency as affected by different treatments under cultivation of wheat and sunflower crops.**

Mole type	Mole spacing (m)	Compost rates ton fed <sup>-1</sup>	Wheat crop			Sunflower crop		
			Water applied (m <sup>3</sup> fed <sup>-1</sup> )	Water consumptive use (m <sup>3</sup> fed <sup>-1</sup> )	Water application efficiency (%)	Water applied (m <sup>3</sup> fed <sup>-1</sup> )	Water consumptive use (m <sup>3</sup> fed <sup>-1</sup> )	Water application efficiency (%)
Mole	2-m	0	2349.30	1271.50	57.37	2526.70	1438.87	69.35
		10						
		15						
		20						
	4-m	0	2145.92	1260.80	62.19	2365.80	1367.95	68.26
		10						
		15						
		20						
	6-m	0	1947.81	1211.90	68.33	2224.83	1311.90	71.44
		10						
		15						
		20						
Mean			2147.68	1248.07	62.63	2372.44	1372.91	69.68
Sand mole	2-m	0	2517.53	1265.60	54.98	2736.96	1489.59	69.04
		10						
		15						
		20						
	4-m	0	2303.60	1264.40	58.05	2459.55	1381.85	72.92
		10						
		15						
		20						
	6-m	0	2123.41	1225.20	64.25	2339.35	1298.62	72.22
		10						
		15						
		20						
Mean			2314.85	1251.73	59.09	2511.95	1390.02	71.39

**Table(7):Field and crop water use efficiency (kg/m<sup>3</sup>) as affected by different treatments under cultivation of wheat and sunflower crops.**

Treatments			Wheat crop				Sunflower	
Mole type	Mole spacing m	Compost rates ton fed <sup>-1</sup>	FWUE		CWUE		FWUE	CWUE
			Grain	Straw	Grain	Straw	Seed	Seed
Mole	2-m	0	1.09	1.35	2.03	2.50	0.34	0.60
		10	1.29	1.53	2.38	2.83	0.37	0.65
		15	1.42	1.72	2.62	3.18	0.43	0.75
		20	1.46	1.89	2.88	3.50	0.46	0.80
	4-m	0	1.14	1.43	1.94	2.44	0.34	0.59
		10	1.33	1.65	2.26	2.82	0.39	0.67
		15	1.48	1.77	2.51	3.01	0.42	0.73
		20	1.61	1.94	2.73	3.30	0.48	0.83
	6-m	0	1.24	1.56	1.99	2.50	0.36	0.61
		10	1.39	1.73	2.25	2.78	0.40	0.69
		15	1.58	1.89	2.54	3.04	0.44	0.75
		20	1.67	2.03	2.69	3.28	0.49	0.82
Sand mole	2-m	0	1.05	1.35	2.09	2.69	0.32	0.59
		10	1.24	1.50	2.48	2.99	0.36	0.66
		15	1.35	1.64	2.68	3.26	0.42	0.76
		20	1.54	1.87	3.07	3.71	0.45	0.84
	4-m	0	1.11	1.36	2.02	2.48	0.35	0.62
		10	1.30	1.57	3.37	2.86	0.37	0.65
		15	1.42	1.71	2.59	3.12	0.44	0.78
		20	1.51	1.85	2.75	3.37	0.49	0.88
	6-m	0	1.23	1.42	2.13	2.46	0.36	0.65
		10	1.38	1.67	2.39	2.89	0.38	0.69
		15	1.48	1.78	2.56	3.09	0.44	0.79
		20	1.51	1.88	2.71	3.26	0.51	0.92

Data (Table, 7) also showed that, field and crop water use efficiency for both wheat and sunflower were increased with the increasing application rates of compost (from 10 to 20 ton fed<sup>-1</sup>) with all mole treatments. Data in Table (7) revealed that the highest values (3.07 and 3.71 kg/m<sup>3</sup>) of crop water use efficiency were achieved with 20 ton fed<sup>-1</sup> at 2 m spacing under sandy mole for wheat (grain and straw). Also, the highest value (0.92 kg/m<sup>3</sup>) of crop water use efficiency was achieved with 20 ton fed<sup>-1</sup> at 6 m spacing under sandy mole for sunflower seed. The highest values of field and crop water use efficiencies may be due to higher yield obtained and less amount of water applied or consumed. These results are in harmony with those obtained with Zamil (2012) and El-Sanat (2012).

**Yield and its components:**

Data in Table (8) presented the mean values of wheat and sunflower yields and their components as affected by mole types, mole spacing and compost rates. Results showed that, mole types, mole spacing and compost rates had highly significant effect on yields and yield components of wheat and sunflower. Sandy mole treatment caused increasing of grain, straw, biological yields and 1000 grain weight of wheat than without sand mole by 74.30, 116.1, 185.43 kg fed<sup>-1</sup> and 0.31 g , respectively. Also, sand mole caused increase of seed yield, seed oil content, plant height, head diameter

and 100 seed weight of sunflower than without sandy mole by 48.41 kg fed<sup>-1</sup>, 0.26%, 5.99cm, 1.03cm and 0.05 g, respectively.

**Table (8):Yield and their components of wheat and sunflower as affected by different treatments.**

Treat.	Wheat				Sunflower					
	Grain yield kg fed <sup>-1</sup>	Straw yield kg fed <sup>-1</sup>	Biological yield kg fed <sup>-1</sup>	1000 grain weight (g)	Seed yield kg fed <sup>-1</sup>	Seed oil content %	Plant height (cm)	Stem diameter (cm)	Head diameter (cm)	100 seed weight (g)
<b>Mole type (T)</b>										
Mole	2997.1	3657.7	6656.67	58.23	972.43	32.46	163.34	1.86	17.58	6.78
Sandy mole	3071.4	3773.8	6842.10	58.54	1020.84	32.72	169.33	1.99	18.61	6.83
F.test	**	**	**	**	**	**	**	*	**	*
<b>Mole spacing (S)</b>										
2-m	2961.3	3554.8	6474.3	58.77	978.60	31.41	162.94	1.83	17.58	6.74
4-m	2841.58	3406.3	6248.7	57.71	949.76	31.29	158.38	1.79	16.97	6.56
6-m	2738.5	3311	6089.3	56.43	933.62	31.04	157.92	1.77	16.28	6.39
F.test	**	**	**	**	**	**	**	*	**	**
LSD 0.05	80.44	46.28	87.42	0.097	8.44	0.024	1.151	0.035	0.052	0.026
LSD 0.01	110.20	63.41	119.78	0.133	11.57	0.033	1.577	0.048	0.072	0.036
<b>Compost rate (ton/fed) (C)</b>										
0	2349.3	2863	5269.8	52.19	808.27	28.67	139.15	1.40	12.81	5.32
10	2756.0	3246	6000.2	55.42	889.98	31.11	156.02	1.67	15.83	6.06
15	3033.3	3633	6666.7	59.51	1013.62	32.29	167.93	1.83	17.86	6.79
20	3249.7	3952	7146.61	63.43	1104.11	32.86	175.88	2.30	21.27	8.08
F.test	**	**	**	**	**	**	**	**	**	**
LSD 0.05	88.6	50.59	101.31	0.111	9.89	0.059	0.732	0.042	0.064	0.076
LSD 0.01	117.57	67.07	134.32	0.148	13.11	0.078	0.971	0.056	0.084	0.101
<b>Interaction</b>										
T x S	**	**	**	**	**	**	**	*	**	**
T x C	**	**	*	**	**	**	**	**	**	**
S x C	NS	**	NS	**	*	NS	**	NS	**	NS
T x S x C	NS	NS	NS	**	NS	NS	**	NS	**	*

The effect of mole spacing on wheat and sunflower yields and its components can be arranged according to the following descending order 2m > 4 m > 6 m. Whereas, 2-m mole spacing led to increase the grain, straw, biological yields and 1000 grain weight of wheat by 222.8, 243.8, 385 kg fed<sup>-1</sup> and 2.34 g, respectively than 6-m mole spacing. Also, 2-m mole spacing caused increase of seed yield, seed oil content, plant height, head diameter and 100 seed weight of sunflower by 44.98 kg fed<sup>-1</sup>, 0.37%, 5.02cm, 1.3 cm and 0.35 g, respectively than 6-m mole spacing. Such findings may be attributed to the effect of mole types and spacing on improving soil properties which caused water-air balance in the root zone, and increasing the amount of available nutrients for the plant. Similar results were obtained by Moukhtar *et al.*, (2002, 2003 and 2012) Antar *et al.*, (2008 and 2012) and Aiad *et al.*, (2012)

Results in Table (8) show that, compost application caused high increases in wheat and sunflower yields and its components than without compost. Also, wheat and sunflower yields and its components were

increased as result of increasing rates of compost. However, the applied of 15 & 20 ton fed<sup>-1</sup> compost led to increase the grain, straw, biological yields and 1000 grain weight of wheat by 10.06 & 17.91, 11.92 & 21.75, 11.11 & 19.11 and 7.38 & 14.45%, respectively than 10 ton fed<sup>-1</sup> compost treatment. Also, 15 & 20 ton fed<sup>-1</sup> compost caused increase of seed yield, seed oil content, plant height, head diameter and 100 seed weight of sunflower by 13.89 & 24.06, 3.79 & 5.63, 7.63 & 12.73, 12.82 & 34.37 and 12.05 & 33.33 %, respectively than 10 ton fed<sup>-1</sup> compost. Beneficial effects of compost applications to crops are many and varied. Most of them are due to soil quality improvement and nutrient enhancement which resulted increases in crop quality and yield (Jack, 1995).

**Conclusion:**

It can be concluded that the combination between sandy mole at 2 m spacing and application of compost at 20 ton fed<sup>-1</sup> under cultivation of wheat and sunflower were the appropriate treatments to improve some soil chemical and physical properties, increase available nutrients and increase crop and water productivity of salt affected soils at North Delta.

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**تأثير انفاق الصرف و اضافة الكمبوست علي بعض خواص التربه والعلاقات المائيه و انتاجيه المحاصيل في شمال الدلتا**  
**محمود ابو الفتوح محمود عياد**  
**معهد بحوث الاراضى والمياه والبيئة - مركز البحوث الزراعيه - مصر**

أجريت تجربة حقلية بالمزرعة البحثية بمحطة البحوث الزراعية بسخا بمحافظة كفر الشيخ لتقييم أنواع إنفاق الصرف (انفاق الصرف بدون رمل - انفاق الصرف الرملية) وأبعاد خطوط المول (2 ، 4 ، 6 متر) ومعدلات وإضافة من كمبوست قش الارز (صفر ، 10 ، 15 ، 20 طن للفدان) على تحسين بعض خواص التربة وبعض العلاقات المائية ومحصول كل من القمح (موسم 2010/2011م) وعباد الشمس (موسم 2011م) بالأراضي الطينية المتأثرة بالأملاح وتم استخدام التصميم الاحصائى القطع المنشقة مرتين فى اربعة مكررات حيث مثلت القطع الرئيسية أنواع المول بينما وضعت ابعاد خطوط المول فى القطع الشقية الاولى كما وضعت معدلات إضافة الكومبوست فى القطع الشقية الثانية.

ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى:

- 1- استخدام انفاق الصرف الممتلئه بالرمل على مسافة 2 متر بين انفاق الصرف أدت الي انخفاض قيم التوصيل الكهربى ونسبه ادمصاص الصوديوم مقارنة بالمول بدون رمل على مسافه 6 متر بين انفاق الصرف
  - 2- حدث انخفاض لقيم التوصيل الكهربى مع مسافات المول 2م و 4م و 6م كانت 24.70 و 20.16 و 17.45% و أيضا نسبه إنخفاض ادمصاص الصوديوم 13.41 و 10.62 و 9.08% وأيضا حدث انخفاض لملوحة التربه مع زياده معدلات الكمبوست خلال موسمى الدراسه
  - 3- تناقصت الكثافه الظاهريه وزياده معدل التشرب الاساسى مع أنفاق الصرف الممتلئه بالرمل مقارنة بالمول بدون رمل وايضا حدث تناقص للكثافه الظاهريه وزياده معدل التشرب الاساسى مع زياده مسافات بين أنفاق الصرف من 2 متر اكبر من 4 متر اكبر من 6 متر مقارنة قبل تطبيق المعاملات
  - 4- زاد تيسر النيتروجين و الفوسفور و البوتاسيوم بتناقص المسافه بين أنفاق الصرف وايضا زياده معدلات الكمبوست وإضافة مادة مائنه مقارنة بالمول بدون رمل والمسافه الواسعه تعمل علي تحسين كفاءه الري التطبيقية وايضا استخدام المياه
  - 5- تحصل علي أعلى القيم لكفاءه استخدام مياه الري المضافه وكفاءه استخدام المحصول لمياه الري المستهلكه المستهلك بالنسبه لمحصول القمح وعباد الشمس مع أنفاق الصرف الممتلئه بالرمل على مسافه 6متر و اضافة 20 طن كمبوست للفدان
- وجد تأثير عالي المعنويه نتيجة تأثير نوع المول والمسافه بين المول ومعدلات الكمبوست علي المحصول ومكوناته لمحصول القمح وعباد الشمس حيث أدت انفاق الرمل الممتلئه بالرمل ادت الي زياده الحبوب والقش للقمح مقارنة بالمول بدون رمل حيث كانت الزيادة 74.30 كجم للفدان و 116.1 كجم للفدان وأيضا زياده في محصول البذور ونسبه الزيت لعباد الشمس وكانت 48.41 كجم للفدان و 0.26% للزيت تأثير المسافه بين انفاق الصرف يمكن ترتيبها تنازليا  $6 < 4 < 2$  متر علي محصولي القمح وعباد الشمس و اضافة الكمبوست ادت الي زياده محصول القمح وعباد الشمس ومكوناتها وبخاصه مع المستويات العاليه وتطبيق نظام الصرف بالمول على مسافة 2 متر مع اضافة 20 طن كمبوست للفدان اعطيت انتاجيه لمحصول القمح حبوب 3886.7 كجم.

**قام بتحكيم البحث**

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