*Egypt. J. Plant Breed. 24(1):1– 19(2020)*

# EFFECT OF PLANTING METHOD AND GENOTYPE ON WHEAT GRAIN YIELD AND WATER PRODUCTIVITY IN SALINE SOILS AT NORTH DELTA, EGYPT

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## ABSTRACT

***A field experiment was conducted in private farms at Al-Hafir Area and Dekerness District, Al-Dakahlia Governorate, North Nile Delta during 2017/2018 and 2018/2019 growing seasons to study the effect of raised beds on wheat yield and water productivity in saline soil under farmer's conditions. Each experiment represent one of the salinity levels under investigation which considered as low $S_0$ ($EC_w$ of 0.50 $dSm^{-1}$ and ECe of 2.5 $dSm^{-1}$), medium $S_1$ ($EC_w$ of 4.0 $dSm^{-1}$and ECe of 9.0 $dSm^{-1}$) and high $S_2$ ($EC_w$ of 7.8 $dSm^{-1}$ and ECe of 12.3 $dSm^{-1}$) of the location of study and combined analysis of variance between the three locations. A split plot design was used with four replicate. Three planting methods were tested in main plots, i.e., $T_f$ (traditional flat planting method), $F_{60}$ (furrow width 60 cm) and $F_{120}$ (raised bed widths 120 cm) and four wheat cultivars in sub plots (Shandawel 1, Misr 1, Sakha 94 and Giza 171). The results revealed that the grain yield of the wheat cultivars under less salinity stress conditions ($S_0$) were significantly higher than other salinity levels ($S_1$ and $S_2$). Also, the wheat cultivars showed some differences in salt tolerance. Data showed that concentrations of some of the metals were found above the threshold limits for irrigation water and grain wheat. Grains were found to accumulate Mn, Cr and Mo metals which were beyond recommended dietary limits under El-Hafir 1 and 2 compared with Talkha. The tolerance to salinity of different varieties under salinity conditions can be ordered as: Shandawel 1>Giza 171>Misr 1 >Sakha 94. The grain yield with $F_{120}$ (raised bed widths 120 cm) was superior to the traditional planting method ($T_f$) by 7.3%, followed by $F_{60}$ (furrow width 60 cm) which is seen to be slightly superior to $T_f$ (traditional flat planting method), by 0.8%.The highest grain yield (6.93 ton/ha) was obtained with $F_{120}$ (raised bed widths 120 cm) under $S_0$ ($EC_w$ of 0.50 $dSm^{-1}$ and ECe of 2.5 $dSm^{-1}$) while the lowest yield (4.70 ton/ha) was obtained with the $T_f$ (traditional flat planting method), under $S_2$ ($EC_w$ of 7.8 $dSm^{-1}$ and ECe of 12.3 $dSm^{-1}$). The amount of irrigation water applied (Wa) was affected by salinity level and planting method. Therefore, the values of Wa were increased by 2.4 and 5.9% under $S_1$ ($EC_w$ of 4.0 $dSm^{-1}$and ECe of 9.0 $dSm^{-1}$) and $S_2$ ($EC_w$ of 7.8 $dSm^{-1}$ and ECe of 12.3 $dSm^{-1}$), respectively over $S_0$ ($EC_w$ of 0.50 $dSm^{-1}$ and ECe of 2.5 $dSm^{-1}$). Also, using furrows and raised bed saved water of about 5.3% and 12.2%, respectively comparing to the traditional flat method. Therefore, the highest value of water productivity (WP) was achieved with $F_{120}$ (raised bed widths 120 cm) under low salinity stress, while the lowest value was recorded with $T_f$ (traditional flat planting method) under higher salinity stress. The application of gypsum alleviated the adverse effect of salinity stress on wheat crop.***

Key words: ***Triticum aestivum*, Saline soils, Planting methods, Raised beds, Water productivity.**

# INTRODUCTION

Osmotic stress due to drought and salinity are major forms of stress from abiotic sources that adversely affect plant growth and productivity of which drought is considered as the most devastating (Nakashima *et al* 2012).The water logging and subsequent salinization are the major land degradation processes in irrigated lands of arid and semi-arid conditions (Dwivedi *et al* 1999). However, the Nile Delta is threatened by water logging, soil compaction, stalinization and alkalization (Shalaby *et al* 2012). El Baroudy (2016) used GIS techniques for land suitability assessment and found that about 29% of the study area in Egypt was marginally suitable or unsuitable for wheat crop due to the adverse soil physical and chemical properties. Jungklang *et al* (2015) showed that water-deficit stress decreased plant height and plant fresh weight. Rao *et al* (2013) reported that salt tolerant varieties of wheat showed higher amount of yield at different salinity levels. In response to osmotic stress, many plant species accumulate proline due to the simultaneous abscisic acid-mediated activation of its bio synthesis and in activation of its degradation pathways during stress (Hare *et al* 1999).

Kandil *et al* (2003) evaluated soil and field crops pollution due to different irrigation water qualities (sewage waste water,secondary treated sewage water, water polluted with human activities and wastes, and Canal water). They concluded that the prolonged effects of using low quality water for irrigation reflected in an increase in heavy metals accumulation in soil and plant. Plants when grow on such type of soil or water take up these metals and then find their way to animals and humans (Westfall *et al* 2005). The consumption of toxic metals in food causes incidence of cancer (Arora *et al* 2008). Due to all these reasons it is quite important to monitor these heavy metals for safety assessment of human's health and environment. The purpose of this study was to give an overview of accumulation of potentially toxic elements in edible parts of wheat plants and their transfer to food chain.

The World Bank (1992) stated that the salinization caused by improper irrigation practices affects about 24% of all irrigated land, productivity of about 10% of them declines severely. Also, the expansion in agricultural lands is not viable because of the limited available land; therefore, improving the production per unit area and producing more with less water are the major options available to meet the increasing food demand

(Bruinsma 2003).This can be achieved by using proper irrigation management such as planting method. Hobbs *et al* (2000) reported that raised bed planting contributes to improve water distribution and efficiency without sacrificing yield. On the other hand, the yield loss was 10% with 45-55 cm furrow width for sensitive wheat cultivars and no loss for least sensitive cultivars, while yield loss of all cultivars of wheat with furrow width above 60 cm was confirmed (Fischer *et al* 2005), due to less population per unit area. Zhang *et al* (2007) concluded that raised bed and mulched ridge planting decreased water consumption, increased water use efficiency, and had higher yields than flat planting of winter wheat. Savings in irrigation water use are related to the amount of time a crop is intermittently irrigated as concluded by Beecher *et al* (2005). Freeman *et al* (2007) found that raised bed planted wheat offered crop rotation opportunities with no difference in grain yield versus conventional flat stand. In Mexico, Sayre and Hobbs (2004) found that bed planting with 2 or 3 rows of wheat on top of the beds (70-80 cm) reduced water requirements by 25%, offered more opportunity for mechanical weed control and reduced tillage comparing to flat planting. Also, Hassan *et al* (2005) indicated that wheat raised beds demonstrated 13 %, 36 % and 50 % higher grain yield, water saving and water productivity, respectively. Li *et al (*2008) reported that the wheat yield significantly increased with bed planting (20 or 40 cm) due to the vertical distribution of photo-synthetic active radiation in the winter wheat canopies. Thompson and North (1994) concluded that in all 4 years of growing, raised beds increased winter cereal crop yields compared to the border irrigation design because of the removal of transient winter/spring water logging. While there are many advantages to growing wheat on beds, in saline-sodic situations the performance of wheat on beds can be inferior to conventional tillage on the flat (Yadav *et al* 2002).Finally, Beecher *et al* (2005) reported that permanent raised beds are the recommended irrigation design to achieve high yields in many irrigated crops on heavy clay soils, including maize, soybean, faba bean, canola and winter cereals.

Saline clay soils with low permeability are mostly found in the northern part of Nile Delta. Therefore, the reclamation process of salt affected soils to alleviate its adverse effect may be achieved by application of some soil amendments such as gypsum and compost. These practices are increasingly important tools for improving crop productivity in many regions (Hasanuzzaman *et al* 2014 and Amer 2015).

This investigation aimed to study productivity of cultivars of bread wheat genotypes under different salinity stress and planting methods.

## MATERIALS AND METHODS

A field experiment was conducted in private farms at Al-Hafir (1, 2) Area and Dekerness District (Talkha), Al-Dakahlia Governorate, North Delta, Egypt, during 2017-2018 and 2018-2019 seasons.

The experiments were conducted in each location as a main experiment according to soil salinity and salinity in water irrigation.

**Chemical analysis:** Soil samples were taken from each experimental site before carrying out the experiment from 0-90 cm depth. Soil and irrigation water properties (Tables 1-5) were carried out as follows:

a. Soil pH: with pH meter using (1:2.5) suspension at 25 $^oC$.

b. Electrical conductivity (EC, dS/m-1): was measured using the Electric conductivity meter in water ($EC_w$) and soil ($EC_c$) paste extracts. Elements in water samples were determined according to "Environmental Protection Agency, EPA (1991) by using inductively coupled plasma (ICP) Spectrometry (model Ultima 2 JY Plasma).

c. Soluble cations and anions were determined in the soil paste extract according to Page (1982).

**Table 1. Initial chemical properties of soil in the experimental site before cultivation.**

| Experimental site | Depth (cm) | ECe $dSm^{-1}$ | Cations (meq/L) | | | | Anions (meq/L) | | | | SAR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $Na^+$ | $K^+$ | $Ca^{2+}$ | $Mg^{2+}$ | $CO_3^{-2}$ | $HCO_3^-$ | $Cl^-$ | $SO_4^{-2}$ | |
| S0 Talkha | 0-30 | 1.50 | 7.6 | 0.6 | 3.8 | 2.0 | 0.0 | 2.1 | 6.5 | 5.4 | 4.5 |
| | 30-60 | 1.65 | 8.9 | 0.6 | 5.0 | 2.0 | 0.0 | 3.5 | 8.2 | 4.8 | 4.8 |
| | 60-90 | 2.78 | 15.5 | 0.7 | 8.5 | 2.7 | 0.0 | 4.0 | 8.9 | 14.5 | 6.5 |
| S1 El-Hafir1 | 0-30 | 9.00 | 71.5 | 1.6 | 24.2 | 10.5 | 0.0 | 3.5 | 6.5 | 97.8 | 17.2 |
| | 30-60 | 9.94 | 78.2 | 2.1 | 27.1 | 12.1 | 0.0 | 4.7 | 8.2 | 106.6 | 17.7 |
| | 60-90 | 10.55 | 83.4 | 2.5 | 29.3 | 13.6 | 0.0 | 4.9 | 8.9 | 115.0 | 18.0 |
| S2 El-Hafir 2 | 0-30 | 12.30 | 88.1 | 0.9 | 39.8 | 19.3 | 0.0 | 3.6 | 6.5 | 138.0 | 16.2 |
| | 30-60 | 12.92 | 92.1 | 1.1 | 41.2 | 22.9 | 0.0 | 4.3 | 8.2 | 144.8 | 16.3 |
| | 60-90 | 13.55 | 98.5 | 1.5 | 43.8 | 24.6 | 0.0 | 5.5 | 8.9 | 154.0 | 16.8 |

**Table 2. Chemical analysis of irrigation water for the three locations.**

| Experiment site | ECw (dS/m) | Cations (meq/L) | | | | Anions (meq/L) | | | | | SAR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $Na^{+}$ | $K^{+}$ | $Ca^{2+}$ | $Mg^{2+}$ | $CO_3^{-2}$ | $HCO_3^{-}$ | $Cl^{-}$ | $SO_4^{-2}$ | Na $Co_3$ | |
| $S_0$ (Talkha) | 0.41 | 1.7 | 0.3 | 1.0 | 0.7 | 0.0 | 3.4 | 0.7 | -0.5 | - | 1.8 |
| $S_1$(Al-Hafir 1) and $S_2$(Al-Hafir 2) | 8.80 | 61.22 | 1.19 | 7.04 | 22.83 | 0.0 | 8.02 | 60.85 | 23.41 | - | 15.84 |

**Table 3. Chemical analysis of irrigation water for the three locations.**

| Elements analysis | Concentration (mg/L) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $NH_4$ | $No_3$ | Zn | P | Mn | $Cu^{+}$ | Co | Cr | Ni | Mo | Pb |
| $S_0$ (Talkha) | 0.20 | 0.76 | 0.21 | 0.01 | 0.033 | 0.03 | 0.05 | 0.003 | 0.02 | 0.01 | 0.12 |
| $S_1$(Al-Hafir 1) and $S_2$(Al-Hafir 2) | 3.22 | 18.76 | 0.01 | *<1.5 | 0.215 | 0.083 | *<0.2 | *<0.2 | 0.01 | *<0.2 | 0.02 |

* Soil Physical analysis: Undisturbed soil samples were collected from the depth sequence of 0-30 cm and prepared to determine soil physical properties as follows:

a. Particle size distribution of soil in percent was measured using pipette method according to Gee and Bauder (1986).

b. Soil bulk density was determined from the volume - mass relationship for each core sample according to Klute (1986).

**Table 4. Some initial soil physical properties and water constants of the experimental site before cultivation.**

| Location | Depth (cm) | Particle size distribution (%) | | | Texture class | F.C% | W.P% | Available water% | B. density g/cm$^3$ | pH |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Sand | Silt | Clay | | | | | | |
| Talkha | 0-30 | 26.1 | 28.3 | 45.6 | Clayey | 43.1 | 22.3 | 20.8 | 1.22 | 8.1 |
| | 30-60 | 29.2 | 23.1 | 47.7 | Clayey | 42.8 | 21.8 | 21.0 | 1.30 | 8.0 |
| | 60-90 | 26.5 | 26.0 | 47.5 | Clayey | 39.9 | 20.9 | 19.0 | 1.33 | 8.0 |
| Al-Hafir1 | 0-30 | 27.5 | 29.3 | 43.2 | Clayey | 41.3 | 20.8 | 20.5 | 1.21 | 8.2 |
| | 30-60 | 27.1 | 28.5 | 44.4 | Clayey | 39.0 | 19.8 | 19.2 | 1.25 | 8.1 |
| | 60-90 | 24.2 | 29.5 | 46.3 | Clayey | 40.8 | 20.3 | 20.5 | 1.20 | 7.9 |
| Al-Hafir 2 | 0-30 | 26.5 | 28.3 | 45.2 | Clayey | 41.3 | 21.6 | 19.7 | 1.15 | 8.0 |
| | 30-60 | 25.1 | 29.5 | 45.4 | Clayey | 39.0 | 22.5 | 16.5 | 1.19 | 7.9 |
| | 60-90 | 24.5 | 30.5 | 45.0 | Clayey | 40.8 | 21.3 | 19.5 | 1.20 | 7.9 |

Four Egyptian bread wheat cultivars were grown under farmer's conditions in three locations at Al-Dakahlia Governorate with different soil and water salinity levels.

**Plants analysis**

Grain samples were washed with tap water and distilled water followed by deionized water, and then air-dried. A 5.0 g sample ground in a metal free mill was digested in concentrated HNO3 for 24 hr. The mixture was then heated to boiling point on an electric plate heater until the formation of nitrous fumes stopped. Then, the mixture was boiled until the digesting solution became a faint yellow sticky paste, and diluted with 10% (vol./vol.) HNO3 solution to 10 mL in a test tube for analysis. Plant samples were extracted according to AOAC (2012).

**The treatments were as follows:**

Each experiment represent one of the salinity levels under investigation which considered as low, medium and high saline soils of the location of study. Three locations with three salinity levels of water ($EC_w$) and soil (ECe) were:

$S_0$: Soil salinity of 2.5 dS/m and water salinity of 0.5dS/m, Talkha.

$S_1$: Soil salinity of 9.0 dS/m and water salinity of 4.0 dS/m, Al-Hafir(015-16).

$S_2$: Soil salinity of 12.3 dS/m and water salinity of 7.8 dS/m, Al-Hafir(016-17).

In each location, combined analysis of variance between the three locations was done according to Snedecor and Cochran (1992) for all the studied traits. The differences among means were tested using least significant difference (LSD).

The experimental treatments were arranged in split plot design with four replicates.

1- Three planting methods were assigned to main plots as follows:

$T_f$: Traditional flat planting method.

$F_{60}$: Furrow width 60 cm.

$F_{120}$: Raised bed width 120 cm.

2- Wheat varieties: Four wheat varieties were assigned to sup plots as follow:

**$V_1$:** Shandawel 1, **$V_2$**: Misr 1, **$V_3$**: Sakha 94 and **$V_4$**: Giza 171.

Field area in each location was divided into 48 plots (7 x 6 m). The experiment was planted in 15 November in the three locations. All plots received 100 kg superphosphate/fed (15.5% $P_2O_5$) before cultivation and nitrogen fertilizer was applied at 75kg N/fed as recommended. The recommended agricultural practices were done in both growing seasons.

Water measurements: Irrigation water was applied to each plot to reach its length end and it was measured by cut-throat flume 30x90 cm.

Field capacity and permanent wilting point were calculated from soil moisture tension curve (Black 1965). Available water value is the difference between them.

**Water productivity (WP):** Was calculated according to Molden and Sakthivadivel (1999) as follow:WP (kg/$m^3$) = Grain yield (kg)/Water applied ($m^3$)

**Crop yield:** The grain yield of each plot at maturity was weighed and adjusted as ton/ha.

**Statistical analysis:** The data were statistically analyzed by analysis of variance and the combined analysis was done according to Gomez and Gomez (1984). Means of the studied treatments were compared by the least significant difference (LSD) at 5% level of significance which was developed by Waller and Duncan (1969).

## RESULTS AND DISCUSSION

### Effect of salinity and planting methods on wheat grain yield

Regarding the effect of salinity on wheat, data in Tables (5 through 8) indicated that grain yields of wheat varieties were significantly higher with less stress condition ($S_0$) than that with higher salinity levels($S_1$ and $S_2$). Regardless the planting methods, the grain yield varied between 3.77 to 6.61 ton/ha, where the lowest grain yield was obtained with higher salinity level ($S_2$) while the highest grain yield was achieved under lower soil and water salinity ($S_0$) which represents nearly non-stress conditions. Therefore, the obtained yield with the used salinity levels can be arranged as the following descending order: $S_0$> $S_1$> $S_2$.

Also, the cultivated varieties under this study showed some differences in salt tolerance, where wheat was classified into the moderate salt tolerant crop according to Maas and Hoffman (1977). According to the grain yield, the Egyptian wheat Shandawel-1 was ranked as most tolerant to

**Table 5. Grain yield of wheat (ton/ha) and irrigation water applied ($m^3$/ha) as affected by salinity and planting methods in the 1st location (2017/2018 season).**

| Planting method | Variety | Salinity level of soil (ECe) and irrigation water (ECw) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 2.5 dS/m and 0.5 dS/m (S0) | | 9.0 dS/m and 4.0 dS/m (S1) | | Mean | | - (%) yield |
| | | Yield | $W_a$ | Yield | $W_a$ | yield | $W_a$ | |
| Traditional ($T_f$) | Shandawel 1 | 5.27 | 5765 | 4.54 | 6070 | 4.91 | 5918 | 13.9 |
| | Misr 1 | 6.24 | 5765 | 4.56 | 6070 | 5.40 | 5918 | 26.9 |
| | Sakha 94 | 5.31 | 5765 | 3.70 | 6070 | 4.51 | 5918 | 30.3 |
| | Giza 171 | 5.90 | 5765 | 4.20 | 6070 | 5.05 | 5918 | 28.8 |
| | Mean | 5.68 | 5765 | 4.20 | 6070 | 4.94 | 5918 | 25.9 |
| | LSD 5% | 0.72 | | 0.5 | | | | |
| Furrow 60 cm ($T_f$) | Shandawel 1 | 5.86 | 5589 | 4.68 | 5732 | 5.27 | 5661 | 20.1 |
| | Misr 1 | 6.37 | 5589 | 4.65 | 5732 | 5.51 | 5661 | 27.0 |
| | Sakha 94 | 5.54 | 5589 | 3.76 | 5732 | 4.65 | 5661 | 32.1 |
| | Giza 171 | 6.38 | 5589 | 4.39 | 5732 | 5.39 | 5661 | 31.2 |
| | Mean | 6.04 | 5589 | 4.32 | 5732 | 5.18 | 5661 | 28.5 |
| | LSD 5% | 0.71 | | 0.45 | | | | |
| Raised beds 120 cm ($F_2$) | Shandawel 1 | 6.88 | 5258 | 5.02 | 5316 | 5.95 | 5287 | 27.0 |
| | Misr 1 | 7.17 | 5258 | 4.65 | 5316 | 5.91 | 5287 | 35.1 |
| | Sakha 94 | 6.42 | 5258 | 4.16 | 5316 | 5.29 | 5287 | 35.2 |
| | Giza 171 | 7.02 | 5258 | 5.05 | 5316 | 6.04 | 5287 | 28.1 |
| | Mean | 6.87 | 5258 | 4.70 | 5316 | 5.78 | 5287 | 31.8 |
| | LSD 5% | 0.66 | | 0.51 | | | | |

**- (%) yield: percentage of decreasing yield**.

salinity comparing to other varieties since it recorded the highest yield (5.22 t/ha) and the lowest yield reduction under both $S_1$ and $S_2$ salinity levels (28.1 and 34.9%, respectively). Misr 1 and Giza 171 were moderate tolerant to salinity, especially with $S_1$, while Sakha 94 had less tolerance and recorded the lowest yield (4.59 t/ha) with high yield reduction with both salinity levels (36.9 and 38.5%, respectively).

Therefore, the mean grain yield and the tolerance to salinity of different varieties under salinity condition can be ordered approximately as: Shandawel 1>Giza 171>Misr 1 >Sakha 94 as shown in Table (6). The decrease of the grain yield may relate to the adverse effect of the osmotic stress due to drought and salinity which is the vital problem that limits crop productivity.

**Table 6. Grain yield of wheat (ton/ha) and irrigation water applied ($m^3$/ha) as affected by salinity and planting methods in the 2nd location (2018/2019 season).**

| Plant in Method | Variety | Salinity level of soil (ECe) and irrigation water(ECw) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 2.5 dS/m and 0.5 dS/m ($S_0$) | | 12.3 dS/m and 7.8 dS/m ($S_2$) | | Mean | | - (%) yield |
| | | Yield | $W_a$ | Yield | $W_a$ | yield | $W_a$ | |
| Traditional ($T_f$) | Shandawil 1 | 6.89 | 5875 | 4.21 | 6262 | 5.55 | 6069 | 38.9 |
| | Misr 1 | 6.23 | 5875 | 3.77 | 6262 | 5.00 | 6069 | 39.5 |
| | Sakha 94 | 6.21 | 5875 | 3.65 | 6262 | 4.93 | 6069 | 41.2 |
| | Giza 171 | 5.98 | 5875 | 3.81 | 6262 | 4.90 | 6069 | 36.3 |
| | Mean | 6.33 | 5875 | 3.86 | 6262 | 5.09 | 6069 | 39.0 |
| | LSD 5% | 0.55 | - | 0.22 | - | - | - | - |
| Furrow 60 cm ($T_{60}$ cm) | Shandawil 1 | 7.09 | 5679 | 4.20 | 5932 | 5.65 | 5806 | 40.8 |
| | Misr 1 | 6.43 | 5679 | 3.81 | 5932 | 5.12 | 5806 | 40.7 |
| | Sakha 94 | 6.41 | 5679 | 3.70 | 5932 | 5.06 | 5806 | 42.3 |
| | Giza 171 | 6.13 | 5679 | 3.85 | 5932 | 4.99 | 5806 | 37.2 |
| | Mean | 6.52 | 5679 | 3.89 | 5732 | 5.20 | 5806 | 40.2 |
| | LSD 5% | 0.58 | - | 0.27 | - | - | - | - |
| Raised beds 120 cm ($F_{120}$) | Shandawil 1 | 7.65 | 5238 | 4.50 | 5498 | 6.08 | 5368 | 41.2 |
| | Misr 1 | 6.83 | 5238 | 4.00 | 5498 | 5.42 | 5368 | 41.4 |
| | Sakha 94 | 6.88 | 5238 | 3.95 | 5498 | 5.42 | 5368 | 42.6 |
| | Giza 171 | 6.62 | 5238 | 4.11 | 5498 | 5.37 | 5368 | 37.9 |
| | Mean | 7.00 | 5238 | 4.14 | 5498 | 5.57 | 5368 | 40.8 |
| | LSD 5% | 0.65 | - | 0.28 | - | - | - | - |

**- (%) yield: percentage of decreasing yield.**

Concerning the effect of planting methods (Table 7), the grain yield with planting on 120 cm-raised beds ($F_{120}$) was superior to other two planting methods (5.26 ton /ha) with 7.3% increase, followed by 60 cm-furrows ($F_{60}$) which is seen to be slightly superior to the traditional planting method ($T_f$), where it gave 4.85 ton grain/ha with 0.8% increase over $T_f$ (

4.70 ton/ha). Therefore, the grain yield with different planting methods can be ranked as follow: $F_{120} > F_{60} > T_f$. The positive effect of raised beds on wheat yield may be attributed to: a- the better vertical distribution of photo-synthetic active radiation in wheat canopies (Li *et al* 2008), b- the wheat plants in the outside rows on the beds normally tiller well and appear to spread and cover the gap to the extent that all the light is captured; thereby lead to favoring tillering, later and less erect types, c- raised beds reduced anoxia associated with the irrigation event due to non-flooding of the plant bases (Fischer *et al* 2005), and d-weeds germinate in wheat is generally much lower on the surfaces of beds compared with conventional flat layouts, probably due to the drier soil surface of the beds Ram *et al* (2005).

The data also indicated that the grain yield was clearly affected by the interaction of salinity level with planting method. However, the highest grain yield (6.93 ton/ha) was obtained with wheat planted on120cm-raised beds ($F_{120}$) under low salinity condition ($S_0$) while the lowest yield (4.70 ton/ha) was obtained with the traditional flat method ($T_f$) under the highest salinity level ($S_2$). So, it could be observed that the decreases in grain yield due to salinity were slightly higher with the furrows or raised beds than that with flat method as shown in Table (7). The decreases in the grain yield under $S_1$were lower than $S_0$by 29.2, 30.4 and 31.9 % with $T_f$, $F_1$ and $F_2$, respectively, while the corresponding reductions under $S_2$ were 35.7, 38.1 and 40.3%, respectively. These results are w harmony with the observation of Sharma *et al* (2002) who found that in saline–sodic situations the performance of wheat on beds can be inferior to conventional tillage on the flat.

**Effect of salinity level and planting method on applied seasonal water (<u>Wa</u>)**

The total amounts of irrigation water applied (Wa) throughout the two seasons are affected by planting method and salinity level in the three locations as shown in Table (7). The mean values of Wa's affected by the salinity levels were 5567, 5706 and 5897m$^3$/ha under $S_0$, $S_1$and $S_2$, respectively. Therefore, the value of Wa were increased by 2.4 and 5.9 % with $S_1$ and $S_2$, comparing to $S_0$, respectively, which may be due to leaching requirement applied with each salinity level.

**Table 7. Mean values of grain yield (t/ha) and irrigation water ($m^3$/ha) with different varieties as affected by salinity levels.**

| Wheat variety | Salinity level of soil (ECe) and irrigation water(ECw)* | | | | | | | | Mean | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $S_0$ | | $S_1$ | | - (%) yield | $S_2$ | | - (%) yield | | | |
| | Yield | Wa | Yield | Wa | | Yield | Wa | | yield | - (%)yield | Wa |
| Shandawil 1 | 6.61 | 5567 | 4.75 | 5706 | 28.1 | 4.30 | 5897 | 34.9 | 5.22 | 31.5 | 5723 |
| Misr 1 | 6.55 | 5567 | 4.62 | 5706 | 29.5 | 3.86 | 5897 | 41.0 | 5.01 | 35.3 | 5723 |
| Sakha 94 | 6.13 | 5567 | 3.87 | 5706 | 36.9 | 3.77 | 5897 | 38.5 | 4.59 | 37.7 | 5723 |
| Giza 171 | 6.34 | 5567 | 4.55 | 5706 | 28.2 | 3.92 | 5897 | 38.2 | 4.94 | 33.2 | 5723 |
| Mean | 6.40 | 5567 | 4.41 | 5706 | 31.3 | 3.96 | 5897 | 38.2 | 4.94 | 34.4 | 5723 |

***$S_0$: ECe of 2.5 dS/m and ECw of 0.5 dS/m, $S_1$: ECe of 9.0 dS/m and ECw of 4.0 dS/m and $S_2$: ECe of 12.3 dS/m and ECw of 7.8 dS/m. – yield (%): - (%) yield: percentage of decreasing yield**

Concerning the planting method, the mean values of irrigation water applied for the three locations under traditional flat ($T_f$), furrow 60 cm ($F_{60}$) and raised bed 120 cm ($F_{120}$) were 6051, 5766 and 5354 $m^3$/ha, respectively. Also data show that using of furrows and raised beds saved about 5.3% (330 $m^3$/ha) and 12.2% (764 $m^3$/ha), respectively comparing to that with traditional method. Therefore, beds are always more efficient where water is limited (Fischer *et al* 2005) may be related to limitation of percolated water due to smaller area exposed to the irrigation water. Also, saving in irrigation water use is related to the amount of time the cultivated area is irrigated Beecher *et al* (2005).

**Table 8. Mean values of grain yield (t/ha) and irrigation water ($m^3$/ha) as affected by planting methods under different salinity levels.**

| Planting method | Salinity level of soil (ECe) and irrigation water($EC_w$)* | | | | | | | | +- (%) due to p. method | | +- (%) due to salinity | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ($S_0$) | | (S1) | | ($S_2$) | | Mean | | | | Grain yield | | $W_a$ | |
| | Yield | Wa | Yield | Wa | Yield | Wa | Yield | Wa | Yield | Wa | $S_1$ | $S_2$ | $S_1$ | $S_2$ |
| $T_f$ | 6.00 | 5820 | 4.25 | 6070 | 3.86 | 6262 | 4.70 | 6051 | 0.0 | 0.0 | -29.2 | -35.7 | 4.3 | 7.6 |
| $F_1$ | 6.28 | 5634 | 4.37 | 5732 | 3.89 | 5932 | 4.85 | 5766 | 0.8 | -5.3 | -30.4 | -38.1 | 1.7 | 5.3 |
| $F_2$ | 6.93 | 5248 | 4.72 | 5316 | 4.14 | 5498 | 5.26 | 5354 | 7.3 | -12.2 | -31.9 | -40.3 | 1.3 | 4.8 |
| Mean | 6.40 | 5567 | 4.45 | 5706 | 3.96 | 5897 | 4.94 | 5723 | 4.4 | -8.8 | -30.5 | -38.0 | 2.4 | 5.9 |

***$S_0$: ECe of 2.5 dS/m and ECw of 0.5 dS/m, $S_1$: ECe of 9.0 dS/m and ECw of 4.0 dS/m and $S_2$: ECe of 12.3 dS/m and ECw of 7.8 dS/m.**

On the other hand, the data indicated that the Wa was affected clearly by the interaction of salinity level with planting method. However, the highest Wa (6262 $m^3$/ha) was obtained with wheat planted with $T_f$ under the highest salinity level ($S_2$) while the lowest Wa (5248 $m^3$/ha) was achieved with $F_{120}$ under low salinity condition ($S_0$). However, it could be observed that the Wa as affected by salinity level was slightly higher with the flat method than that with furrows or raised beds. The increases in Wa under $S_1$ comparing to $S_0$ were 4.3, 1.7 and 1.3 % with $T_f$, $F_1$ and $F_2$, respectively, while the corresponding increases under $S_2$ were 7.6, 5.3 and 4.8 %, respectively. Finally, it can be concluded the usefulness of permanent raised beds technology in terms of higher yields, irrigation water savings, increased water productivity and higher profitability (Hassan *et al* 2005), with less local machinery and labor costs.

Data in Table (9) showed the results of heavy metals and elements in wheat grains. The irrigation with low quality water generally leads to a change in chemical properties of soil and consequently micro-nutrient and heavy metal contents in growing plants at sites under study.

The lower values were for Talkha then El-Hafir 1 but the higher values were for El-Hafir 2 to all varieties. NPK concentrations were lower under Talkha whereas increased under El-Hafir1 then 2, Misr 1 gave high value for N and K under three locations while Misr 1 and Sakha 94 gave high value with P. The maximum admissible concentration of Cu should be 3 mg/kg (DW) in wheat set by the EC and FAO/WHO (1984).

**Table 9. The mean concentration (% and mg/kg) of elements and heavy metals in wheat grain under three location.**

| Location | Variety | (%) | | | mg/Kg | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | K | P | Zn | Pb | Co | Cu | Mn | Ni | Mo | Cr |
| Talkha | Shandawil 1 | 1.68 | 0.008 | 0.23 | 10.0 | *<0.2 | *<0.05 | *<1.5 | *<2 | *<1.6 | *<0.01 | *<0.02 |
| | Misr 1 | 2.52 | 0.022 | 0.25 | 9.20 | *<0.2 | *<0.05 | *<1.5 | *<2 | *<1.6 | *<0.01 | *<0.02 |
| | Sakha 94 | 1.70 | 0.018 | 0.22 | 6.70 | *<0.2 | *<0.05 | *<1.5 | *<2 | *<1.6 | *<0.01 | *<0.02 |
| | Giza 171 | 2.44 | 0.006 | 0.25 | 17.1 | *<0.2 | *<0.05 | *<1.5 | *<2 | *<1.6 | *<0.01 | *<0.02 |
| El-Hafir 1 | Shandawil 1 | 2.32 | 0.03 | 0.27 | 15.0 | *<0.2 | *<0.05 | 2.10 | 15.30 | *<1.6 | 5.30 | 0.97 |
| | Misr 1 | 2.42 | 0.05 | 0.28 | 12.70 | *<0.2 | *<0.05 | 0.40 | 7.80 | *<1.6 | *<0.01 | 0.85 |
| | Sakha 94 | 2.20 | 0.022 | 0.26 | 18.20 | *<0.2 | *<0.05 | 3.46 | 12.77 | *<1.6 | *<0.01 | 0.99 |
| | Giza 171 | 2.33 | 0.02 | 0.28 | 19.1 | *<0.2 | *<0.05 | 1.20 | 23.90 | *<1.6 | 1.45 | 0.91 |
| El-Hafir 2 | Shandawil 1 | 2.58 | 0.16 | 0.28 | 29.1 | *<0.2 | *<0.05 | 2.70 | 20.30 | *<1.6 | 15.7 | 2.20 |
| | Misr 1 | 2.67 | 0.25 | 0.29 | 23.8 | *<0.2 | *<0.05 | 0.60 | 11.80 | *<1.6 | *<0.01 | 1.95 |
| | Sakha 94 | 2.63 | 0.03 | 0.27 | 17.8 | *<0.2 | *<0.05 | 4.50 | 17.77 | *<1.6 | *<0.01 | 2.60 |
| | Giza 171 | 2.70 | 0.16 | 0.33 | 20.40 | *<0.2 | *<0.05 | 1.50 | 31.90 | *<1.6 | 4.70 | 2.50 |

*** < Detection limit according to land and water institute, ARC.**

In this study, average values were lower than the permissible limit in all varieties in Talkha then El-Hafir1and 2 except Sakha 94 were 3.46 and 4.50 mg/kg respectively, whereas lower varieties were Misr 1 and Giza 171. The value of Zn was not high for three locations except (Giza 171 variety) variety was high than permissible limit under El-Hafir 2. Mn concentration was lower from standard value to four varieties under Talkha condition, while was very high in El-Hafir1 and 2 than permissible limit, Misr 1 gave low value (7.80 and 11.80, respectively) and Giza 171 gave high value (23.90 and 31.90 respectively). Ni, Co and Pb concentrations in all of the studied samples were low than the standard value for the wheat varieties which were*<0.2, *<1.6 and *<0.2, respectively according to Pescod (1992). The Cr content in wheat grains was found to be higher than the permissible limit of 0.02 mg/kg in almost all varieties with El-Hafir1 and 2 reported in Table (9). Misr 1 gave low value while Sakha 94 gave high value. On the other hand, four varieties were under permissible limit with Talkha location. The concentration value of Mo in our current study was high standard range for tow location El-Hafir1 and 2 with Shandawil 1 and Giza 171 varieties while Misr 1 and Sakha 94 have been under permissible limit. Talkha location was under permissible limit with all varieties.

**Water productivity (WP) as affected by salinity levels and planting methods**

The concept of water productivity, are being used either as the yield or net income per unit of water used in ET. When water supplies are limiting, the yield or the net income from unit of water should be maximize. WP values were decreased under salinity levels of $S_1$ and $S_2$ (1.16 and 0.78 kg/m$^3$) comparing to that with low salinity stress, $S_0$(0.68 kg/m$^3$) as shown in Table (10). The reasons for the decrease in WP under salinity stress are related to the decrease of the yield in addition to increase of water applied.

Concerning the response of WP to the planting on the raised beds, the data show that the values of WP were increased by 8.2 or 26.6 % with $F_{60}$ or $F_{120}$, respectively over that with the traditional flat method. The increase of WP with wheat planted on the beds is related mainly to increase of its yield in addition to the decrease in the water applied. These results are in agreement with those obtained by Hobbs *et al* (2000), Hassan *et al* (2005) and Zhang *et al* (2007).

Due to the converse response of WP to salinity stress and planting on raised beds, the highest value (1.32 kg/m$^3$) was achieved with $F_{120}$under $S_0$,while the lowest value (0.62 kg/m$^3$) was recorded with $T_f$ under higher salinity stress,$S_2$. This behavior was in somewhat similar to that observed by Eid (2015).

**Table 10. Water productivity (kg grain/m$^3$ water) as affected by planting methods under different salinity levels.**

| Planting method | Salinity level | | | | +- (%) of WP due to: | | |
|---|---|---|---|---|---|---|---|
| | $S_0$ | $S_1$ | $S_2$ | Mean | P. method | $S_1$ | $S_2$ |
| $T_f$ | 1.03 | 0.70 | 0.62 | 0.78 | 0.0 | -32.1 | -39.9 |
| $F_{60}$ | 1.11 | 0.76 | 0.66 | 0.84 | 8.2 | -31.6 | -40.8 |
| $F_{120}$ | 1.32 | 0.89 | 0.75 | 0.99 | 26.6 | -32.8 | -43.2 |
| Mean | 1.16 | 0.78 | 0.68 | 0.87 | 17.4 | -32.1 | -41.3 |

## CONCLUSIONS

a- The cultivated varieties under this study showed some differences in salt tolerance. The grain yield and the tolerate to salinity of these varieties under salinity stress condition can be ordered as: Shadwel 1>Giza 171>Miser 1 >Sakha 94.

b- Concentrations of some of the metals were found above the threshold limits for irrigation water and grain wheat. Grains were found to accumulate Mn, Cr and Mo metals which were beyond recommended dietary limits under El-Hafir 1 and 2. It is recommended that treatment facility must be installed to reduce heavy metals and turbidity of the wastewater being used for downstream irrigation**.**

c- The raised bed planting technology is useful in terms of higher yields, irrigation water savings, and higher water productivity compared with the conventional flat planting method.

d- The decrease in grain yield due to salinity was slightly higher with beds than that with flat method. The reasons for the decrease in WP under salinity stress are related to the decrease of the yield in addition to increase of water applied. The increase of WP with wheat planted on the beds is related mainly to increase of its yield in addition to the decrease in the water applied. Therefore, beds are always more efficient where water is limited may be related to limitation of percolated water due to smaller area exposed to the irrigation water and also, to the amount of time the planted area is irrigated**.**

## ACKNOLEDGMENT

For enhancing food security in Arab countries project (ICARDA) for funding.

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# تأثير طريقة الزراعة والتركيب الوراثي علي محصول حبوب القمح وإنتاجية المياه في الأرض الملحية بشمال الدلتا، مصر

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٣. قسم بحوث تكنولوجيا البذور –معهد بحوث المحاصيل الحقلية– مركز البحوث الزراعية– الجيزة–مصر.

***أجريت تجربة حقلية في مزارع خاصة بشمال الدلتا محافظة الدقهلية فى ثلاث مناطق الحفير(١، ٢) و طلخا خلال موسمي ٢٠١٧– ٢٠١٨ و٢٠١٨–٢٠١٩ لدراسة تأثير طرق الزراعة والتركيب الوراثي علي محصول حبوب القمح وكفاءة استخدام المياه. تم اجراء ٣ تجارب تشمل كل تجربة مستوى ملوحة مختلف(ملوحة ماء الري والتربة) حيث اعتبر الموقع الاول $S_0$: (٠,٥٠ ديسيسيمنز/مل ماء الري و ٢,٥ ديسيسيمنز/مل للتربة)، والموقع الثانى $S_1$(٤,٠ ديسيسيمنز/مل لماء الري و ٩,٠ ديسيسيمنز/مل للتربة) والموقع الثالث $S_2$ (من ٧,٨***

***ديسيسيمنز/مل لماء الري و ١٢,٣ ديسيسيمنز/مل للتربة) وقد تم استخدام تصميم قطع منشقة مرة واحدة لكل تجربه مع أربعة مكررات. تم اختبار ثلاث طرق زراعة في القطع الرئيسيه: $T_f$ (طريقة زراعة مستوية تقليدية)، $F_{60}$ (المصاطب المرفوعة عرض ٦٠ سم) و $F_{120}$ (المصاطب المرفوعة عرض ١٢٠ سم) مع أربعة أصناف قمح تم اختبارها في القطع الشقية (شندويل ١، جيزة ١٧١، سخا ٩٤، مصر١) حيث اعتبر كل موقع كتجربة مستقلة. أظهرت النتائج زيادة محصول الحبوب للقمح النامي في البيئة الأقل إجهادًا $S_0$ (٠,٥٠ ديسيسيمنز/مل ماء الري و ٢,٥ ديسيسيمنز/مل للتربة) بشكل ملحوظ مقارنة مع مستويات الملوحة الأخرى $S_1$ (٤,٠ ديسيسيمنز/مل لماء الري و ٩,٠ ديسيسيمنز/مل للتربة)$S_2$ (من ٧,٨ ديسيسيمنز/مل لماء الري و ١٢,٣ ديسيسيمنز/مل للتربة). أظهرت الأصناف تحت الدراسة بعض الاختلافات في تحمل الملوحة. ايضا ، اوضحت نتائج التحليل الكيميائى للمياه وجود بعض العناصر الثقيله بمعدل اعلى من المسموح به فى منطقتى الحفير ١،٢ ، ايضا اختلفت الاصناف فى استجابتها لامتصاص هذة العناصر حيث وجدت بعض العناصر بتركيزات اعلى من المسموح به عالميا فى حبوب القمح مثل المنجنيز والكروم والموليبدنم. ولذلك يمكن ترتيب متوسط إنتاجية الحبوب والقدرة على تحمل الملوحة للأصناف المختلفة على النحو التالي: شندويل ١> جيزة ١٧١> مصر١ > ثم سخا ٩٤. وفيما يتعلق بتأثير طريقة الزراعة، فإن محصول الحبوب مع $F_{120}$ (المصاطب المرفوعة عرض ١٢٠ سم) كان أعلى من $T_f$بنسبة ٧,٣٪، تليها $F_{60}$ (المصاطب المرفوعة عرض ٦٠ سم) التي تعتبر متفوقة قليلا على $T_f$(طريقة زراعة مستوية تقليدية) بنسبة ٠,٨٪. لذلك يمكن ترتيب إنتاجية الحبوب مع طرق الزراعة على النحو التالي: $F_{120} > F_{60} > T_f$. وبالتالي،تم الحصول على أعلى محصول حبوب (٦,٩٣ طن/هكتار) باستخدام$F_{120}$ (المصاطب المرفوعة عرض ١٢٠ سم) و$S_0$(٠,٥٠ ديسيسيمنز/مل ماء الري و ٢,٥ ديسيسيمنز/مل للتربة) بينما تم الحصول على أقل إنتاجية (٤,٧٠ طن/هكتار) مع $T_f$ (طريقة زراعة مستوية تقليدية) و$S_2$ (من ٧,٨ ديسيسيمنز/مل لماء الري و ١٢,٣ ديسيسيمنز/مل للتربة). وتأثرت كمية مياه الري المضافة (Wa) بالملوحة وطرق الزراعة. لذلك تم زيادة قيم (Wa) بنسبة ٢,٤ و ٥,٩٪ مع $S_1$ (٤,٠ ديسيسيمنز/مل لماء الري و ٩,٠ ديسيسيمنز/مل للتربة) و $S_2$ (من ٧,٨ ديسيسيمنز/مل لماء الري و ١٢,٣ ديسيسيمنز/مل للتربة) عن $S_0$(٠,٥٠ ديسيسيمنز/مل ماء الري و ٢,٥ ديسيسيمنز/مل للتربة)،على التوالي. أيضا،استخدام $F_{60}$ (المصاطب المرفوعة عرض ٦٠ سم) و$F_{120}$ توفر حوالي ٥,٣٪ و ١٢,٢٪ ،على التوالي مقارنة بالطريقة التقليدية. ولذلك يمكن ملاحظة أن تأثر (Wa) بمستوى الملوحة كان أعلى بقليل مع الطريقة المستوية منهم علي مصاطب. لذلك تم تحقيق أعلى قيمة لإنتاجية المياه (WP) باستخدام $F_{120}$ (المصاطب المرفوعة عرض ١٢٠ سم) تحت إجهاد ملوحة منخفض،بينما تم تسجيل أقل قيمة مع $T_f$ (طريقة زراعة مستوية تقليدية) تحت إجهاد ملوحة أعلى.***