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# Evaluation of Some New Durum Wheat Genotypes for Growth, Yield and Micronutrients Use Efficiency Under Sandy Soil Conditions.

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**Abstract:** Two field experiments were conducted in successive winter seasons of 2010/2011 and 2011/2012 at the newly reclaimed area in research and production station of National Research Centre, Al-Nubaria district, Al- Behaira Governorate, Egypt, to evaluate eight durum wheat genotypes for growth, yield and micronutrients use efficiency under sandy soil characterized with low available micronutrients content. Results of the combined analysis of the two seasons showed significant differences among the wheat genotypes in all studied traits, *i.e*. growth, yield, yield components and micronutrients concentration of straw and grains. The genotype number (1) showed the highest mean values for plant length, grains and straw yields, while the genotype number (7) gave less values in plant height, grain and straw yield than number (1) but not significance plus the highest mean values for fertility index, grain weight/spike and 1000-grain weight. In addition the data revealed that, genotype number (8) had the highest values of flag leaf blade area and number of spikelets/spike. It was also observed that genotype number (3) was the shortest and earliest genotype. Plus genotype (6) recorded the highest values of straw Fe and Mn content, meanwhile genotypes (7) and (2) recorded the highest concentration of Zn and Cu, respectively. While genotypes 5, 7, 2 and 3 showed the lowest Fe, Mn, Zn and Cu concentration, respectively. The genotype (5) recorded the highest grain concentration from Fe, Mn and Zn, meanwhile, genotype (1) revealed the highest grains concentration of Cu. On the other hand, number (7) recoded the lowest values of Fe, Mn, and Zn and genotypes 4 and 5 recorded the lowest Cu concentration. There were significant differences among genotypes in micronutrients (Fe, Mn, Zn, Cu) uptake, utilization and use efficiency. The genotype (1) recorded the highest values of all micronutrients use efficiency and significantly surpassed other genotypes.

**Key words:** durum wheat, genotypes, Sandy soil, CIMMYT, Egypt, micronutrients use efficiency.

## INTRODUCTION

Durum wheat (*Triticum durum* Desf) is known for its high yield potential and adaptation to relatively dry environments (Varughese *et al*. 1997). The importance of durum wheat attributed multiple usages for human consumption in bread, macaroni industry and its high protein and gluten contents (Rachon *et al*. 2002 and Makowska 2008). Improving durum wheat grain yield and quality had become, in recent years, one of the important breeding goals in not only Mediterranean countries but also in many other countries, due to the increase in market demand. Durum semolina of high protein content is preferred for making macaroni because it produces a hard translucent product that it firm after cooking. Also, semolina having a high content of yellow carotenoid pigments, *i.e*., a gasoline color value of 1.50 or more, is desired because it imparts a desirable rich yellow color to the macaroni. Durum granular, semolina, and durum flour milled from durum wheat are used to manufacture paste and non-paste food products. Paste products are manufactured by mixing water with semolina or durum flour or form unleavened dough, which is formed into different shapes and either cooked and eaten or dried for later consumption (Dick and Matsuo, 1988). Most plant cultivars currently used have been selected for high yields under optimum fertilizer conditions. Consequently, research is needed to select efficient genotypes that will grow and produce under conditions of lower fertilizer input or soil micronutrients deficiencies. This is especially true for the expansion of wheat cultivation which is often growing in reclaimed sandy soil conditions in Egypt, which characterized with low fertility, high pH value and low organic matter content, consequently low available micronutrients in the soil.

Meanwhile, deficiencies of micronutrients in such areas have been shown as yield limiting factor (El-Fouly, 1983). Graham (1984) defined nutrient efficiency of a genotype (for each element separately) as the ability to produce a high yield in a soil that is limited in that element for a standard genotype. Also, Blair (1993) defined nutrient efficiency as the ability of a genotype/cultivar to acquire nutrients from growth medium and/or to incorporate or utilize them in the production of shoot and root biomass or utilizable plant material (seeds, grains, fruits, forage). Nutrient concentration and uptake by different plant genotypes are the most important criteria for identifying the existing genetic specificity of plant nutrition (Saric, 1987). The efficiency should be compared under stress and adequate nutrient supply to verify plant species or genotypic differences in nutrient utilization under sub-optimal and optimal conditions. The differential response of genotypes to nutrient stress is related to uptake, transport and utilization pattern of nutrients within plants.

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There are also large differences in tolerance to Fe deficiency among field grown wheat genotypes (Hanson *et al*., 1996). Wheat genotypes differ in tolerance to Zn deficiency (Graham *et al*., 1992 and Cakmak *et al*., 1996a), with durum wheat being generally less tolerant than bread wheat (Rengel and Graham, 1995 and Cakmak *et al*., 1996b).

A number of reports have been published on wheat genotype that differs in Zn or Mn efficiency (Rengel and Graham, 1996; Pearson and Rengel, 1997). Efficient genotype takes up more of a particular nutrient and grows better than inefficient ones in environments with low availability of that nutrient. The objective of this study was evaluation of some new durum wheat genotypes for growth yield and micronutrients use efficiency under micronutrients deficient sandy soil conditions.

## MATERIALS AND METHODS

Two field experiments were conducted in successive winter seasons of 2010/2011 and 2011/2012 at the newly reclaimed soil in research and production station of National Research Centre (NRC), Al-Nubaria district, Al-Behaira Governorate, Egypt.

The tested wheat genotypes are presented in Table (1). Sowing dates were 17$^{th}$ and 16$^{th}$ November in the two seasons respectively. Grains were hand drilled in rows 20 cm apart in plots 3.5 m length and 3 m width with total area 10.5 m$^2$, grains covered by thin layer of soil after drilled then irrigated by sprinkler method (irrigation at 4-5 days interval, for two hours through each irrigation with 300 L/h sprinkler discharge).

**Table 1:** Pedigree and origin of assessment wheat genotypes.

| Genotype | Pedigree |
|---|---|
| 1 | DUKEM_12/2*RASCON_21. CDSS92B1403-E-2M-0Y-0M-0Y-1B-0Y |
| 2 | F0SKAL_1/PELA_2//BRA_2. CDSS94Y00500T-F-1M-0Y-0B-1Y-0B |
| 3 | GREEN_14//YAV_l0/AUK. CDSS93Y54-3Y-4Y-0B-0Y-2B-0Y |
| 4 | GRVAND_2/MCK_2. CDSS94Y00104S-8M-0Y-0B-2Y-0B |
| 5 | HUI/YAV_1//LOTUS_5/3/RASCON_20. CDSS92Y4242-1Y-030M-0Y-0M-0B-1Y-0B |
| 6 | ISLOM_1/DUKEM_2. CDSS93B00107S-7M-0Y-0B-1Y-0B |
| 7 | KUCUK. CD91B2620-G-8M-030Y-030M-2Y-0M-2Y-0B |
| 8 | MINIMUS/COMB DUCK_2//CHAM_3. CD98225-A-3Y-040M-040YRC-7M-0Y |

Phosphorus was added at the rate of 200 kg/fed. calcium superphosphate 15.5% $P_2O_5$ and 100 kg/fed. Potassium sulfate (48% $K_2O$) before sowing. Nitrogen was added at the rate of 90 kg/fed. in the form of ammonium nitrate (33.5% N) in 6 portions at sowing, 21 days after sowing and every 10 days. Experimental soil was sandy and poor in organic material. The soil mechanical and chemical analyses were determined according to Page (1982) and presented in Table (2).The other practices of growing wheat were properly used for the management of the experimental plots throughout the cropping season.

Days to 50% heading, Flag leaf bald area (cm$^2$) and No. of leaves/tiller were recorded during 75 to 85 days after sowing in each plot. At harvest (in accordance with the optimum harvest time for each genotype), Plant height (cm) recorded then twenty spikes were taken randomly from the inner rows in each plot to estimate the following characters:

1- No. of grains/ spike. 2- Grain weight/spike (g)
3- No. of spikelets/spike. 4- 1000 grains weight (g)
7- Fertility index % (calculated by dividing No. of fertile spikelets per spike/total number of spikelets per spike.

**Table 2:** Physico-chemical properties of the experimental site (average of the two seasons).

| Item | Value | | Element | Value | |
|---|---|---|---|---|---|
| Physic properties | | | Available macro element (mg/100g) | | |
| Sand% | 90.8 | | P | 0.12 | VL |
| Silt% | 4.0 | | K | 9.92 | L |
| Clay% | 5.2 | | Mg | 18.00 | L |
| Texture | Sandy | | Ca | 92.00 | M |
| | | | Na | 13.18 | VL |
| Chemical properties | | | Available microelement (ppm) | | |
| PH | 8.66 | H | Fe | 8.15 | L |
| Ec(dS/m) | 0.11 | L | Mn | 7.50 | L |
| CaCO3% | 5.2 | L | Zn | 0.10 | VL |
| O.M% | 0.24 | VL | Cu | 0.12 | VL |

H= high, M = medium, L=low, VL= very low, according to Ankerman and Large (1974)
Texture: Hydrometer method (Bouyoucos, 1954).
PH and Ec: in 1:2.5 soil/water suspension (Chapman and Pratt, 1978).
O.M: Black method (Isaac and Johnson, 1984).
CaCO3: Collin, s Calcimeter (Alison and Moodle, 1965).
P: NaH CO3Extraction at PH 8.5 (Olsen *et al*., 1954).
K, Ca, Na and Mg: NH4-OAc extraction at PH7 (Jackson, 1973).
Fe, Mn, Zn and Cu: DTPA extraction at PH7.3 (Lindsay and Norvell, 1978).

At harvest stage; the whole plot was harvested to determine grain and straw yield in ton per hectare. In addition, grain and straw were sampled for determination of some micronutrients content. The dry ashing technique was used to extract micronutrients from dried straw and grains as described by Chapman and Pratt (1978). Micronutriments were measured using Atomic Absorption Spectrophotometer Berken Elmer 1100-B.

***Design and Statistical Analysis:***

The field experimental design was randomized complete block in three replications for each trail. The obtained data were subjected to regular statistical analysis of variance; differences between means of genotypes were tested for significant against LSD values at 5% level of probability in both seasons according to (Snedecor and Cochran 1990), the homogeneity of error test for two seasons was not significant (Bartlett 1937); since, a combined analysis was done. The MSTAT computerized package program was subjected to the regular statistical analysis of variance (Nissen *et al*., 1985).

## RESULTS AND DISCUSSION

### *1. Vegetative Growth, Yield and its Components Characters:*

Mean values of some growth parameters, yield and its components for eight durum wheat genotypes from the combined analysis over two seasons are presented in Table (3). Analysis of variance revealed significant differences between means of the eight durum wheat genotypes for all studied traits, *i.e*., Days to 50% heading, plant height (cm), Flag leaf bald area ($cm^2$), No. of grains per spike, grain weight/spike (g), No of spikelets/spike, fertility index, 1000 grains weight (g), grain and straw yields/ha with the exception of No. of leaves /tiller. The genotype number (1) showed the highest mean values for plant height, grains and straw yields, followed by genotype number (7) in the same three previous traits without significance. In the same time the genotype number (7) gave the highest mean values for fertility index, grain weight/spike and 1000-grain weight. In addition the data revealed that, genotype number (8) had the highest values of flag leaf blade area and number of spikelets /spike. It was also observed from the data in Table (3) that the genotype number (3) was the earliest maturing genotype, where recording the lowest days to 50% heading (76 day) and had the lowest plant height (64.63 cm). Meanwhile, the genotypes 4, 6 and 8 ranked the lowest values in most studied traits. The differences between the tested genotypes and the superiority of such genotypes could mainly be attributed to the differences in their genetic constitution and their adaption to the environmental conditions. In this connection, Ferrante *et al*., (2012) obtained higher levels of varietal differences in yield and its components among durum wheat cultivars. Also, Fischer, (2007) and Pedro *et al*., (2011 and 2012) reported that modern cultivars of durum wheat clearly vary in fruiting efficiency which has shown to be relevant when comparing promising lines of durum wheat as well as a potential selection criterion.

**Table 3:** Vegetative growth, yield and some yield components characters of wheat genotypes.

| Genotypes | Days to 50 % heading | Plant height (cm) | Flag leaf bald area ($cm^2$) | No. of leaves /tiller | No. of grains/spike | Grain weight/ spike (g) |
|---|---|---|---|---|---|---|
| 1 | 79.67 | 78.30 | 16.89 | 4.03 | 44.67 | 2.19 |
| 2 | 85.33 | 73.68 | 16.22 | 4.00 | 35.00 | 1.24 |
| 3 | 76.00 | 64.63 | 15.65 | 4.00 | 56.56 | 2.01 |
| 4 | 84.67 | 69.05 | 15.73 | 4.00 | 21.22 | 0.47 |
| 5 | 80.00 | 77.62 | 16.07 | 4.03 | 40.78 | 1.50 |
| 6 | 85.67 | 71.08 | 14.61 | 4.00 | 49.00 | 1.11 |
| 7 | 84.33 | 77.45 | 17.80 | 4.00 | 47.89 | 2.64 |
| 8 | 85.67 | 72.67 | 19.48 | 4.07 | 42.00 | 0.84 |
| LSD 5% | 3.91 | 5.18 | 1.42 | NS | 1.39 | 0.016 |
| Genotypes | No. of spikelets/ spike | Fertility index % | 1000 grains weight (g) | Grain yield/ha (ton) | Straw yield/ha (ton) | |
| 1 | 15.07 | 93.36 | 49.03 | 4.60 | 14.20 | |
| 2 | 15.60 | 95.83 | 35.53 | 4.40 | 9.90 | |
| 3 | 14.60 | 97.78 | 34.79 | 4.40 | 13.80 | |
| 4 | 13.33 | 90.11 | 22.31 | 3.20 | 13.00 | |
| 5 | 16.27 | 87.16 | 36.88 | 4.40 | 12.40 | |
| 6 | 15.17 | 97.85 | 22.66 | 2.70 | 8.30 | |
| 7 | 15.00 | 100.00 | 55.17 | 4.30 | 13.30 | |
| 8 | 17.87 | 81.20 | 20.11 | 2.60 | 9.70 | |
| LSD 5% | 0.89 | 3.67 | 0.91 | 1.30 | 4.70 | |

### *2. Micronutrients Concentration in Straw and Grains:*

As shown in Table (4), there are significant differences in straw and grains micronutrients content among genotypes, which exhibited a wide variability in their ability to uptake and translocate Fe, Mn, Zn and Cu. Regarding straw micronutrients concentration, results revealed that genotype (6) recorded the highest values of Fe and Mn content, meanwhile genotypes numbers 7 and 2 recorded the highest concentration of Zn and Cu, respectively. While, genotypes, 5, 7, 2 and 3 plus 6 showed the lowest Fe, Mn, Zn and Cu concentration, respectively. Concerning grains micronutrients concentration it is clear that the genotype number (5) recorded the highest grain concentration from Fe, Mn and Zn, meanwhile, genotype (1) revealed the highest grains concentration from Cu. On the other hand, genotype (7) recoded the lowest values of Fe, Mn, and Zn and genotypes number 4 and 5 recorded the lowest Cu concentration. The differences between flax plant genotypes in their seed micronutrients content were reported by Khalifa *et al*. (2011).

**Table 4:** Micronutrients concentration (mg $kg^{-1}$) in straw and grains of durum wheat genotypes.

| Genotypes | Straw | | | | Grains | | | |
|---|---|---|---|---|---|---|---|---|
| | Fe | Mn | Zn | Cu | Fe | Mn | Zn | Cu |
| 1 | 178 | 11 | 67 | 1.5 | 54 | 28 | 44 | 10.5 |
| 2 | 143 | 14 | 35 | 4.5 | 46 | 27 | 61 | 7.5 |
| 3 | 113 | 6 | 88 | 1.0 | 38 | 20 | 61 | 6 |
| 4 | 176 | 20 | 54 | 3.0 | 38 | 31 | 68 | 3.0 |
| 5 | 103 | 7 | 77 | 1.5 | 79 | 50 | 106 | 3.0 |
| 6 | 337 | 23 | 77 | 1.0 | 54 | 32 | 65 | 7.5 |
| 7 | 108 | 6 | 95 | 1.5 | 32 | 19 | 30 | 4.5 |
| 8 | 194 | 13 | 77 | 1.5 | 43 | 34 | 63 | 9.0 |
| LSD 5% | 8.87 | 3.79 | 3.97 | 0.59 | 4.58 | 1.73 | 5.83 | 1.12 |

### *3. Micronutrients Efficiency of Durum Wheat Genotypes:*

Table (5) illustrates the genotypic differences in micronutrients (Fe, Mn, Zn, Cu) uptake, utilization and use efficiency. It is clear that there were significant differences between all durum wheat genotypes under study in their micronutrients uptake, utilization and use efficiency as follows:

#### *3.1. Uptake Efficiency:*

Data presented in Table (5) indicated that genotype number (5) significantly surpassed in the Fe uptake efficiency other genotypes. While, number (5) significantly surpassed all genotypes in Mn and Zn uptake efficiency, with the exception of genotype number 4 in Mn and genotypes 7 and 3 in Zn. In addition, the genotype number (2) significantly surpassed in the Cu uptake efficiency other genotypes. The differences between genotypes in their tolerance to Zn deficiency were reported by Graham *et al*., (1992); Cakmak *et al*., (1996a).

#### *3.2 Utilization Efficiency:*

The data in Table (5) revealed that there were significant differences between means of eight durum wheat genotypes under study for micronutrients utilization efficiency, where genotype number (7) gave the highest values of utilization efficiency for Fe and Mn. In addition, genotype number (2) showed significantly surpass in Zn utilization efficiency as compared with the other genotypes under this study. On the other side, genotype number (5) recorded the highest value of Cu utilization efficiency and significantly surpassed other all genotypes. In this context Romeheld (1998) reported that genotypic differences in nutrient use efficiency are linked with root nutrient acquisition capacity or with utilization by the plant, or both.

**Table 5:** Micronutrients efficiency of durum wheat genotypes.

| Genotypes | Uptake efficiency ( g plant nutrients/g soil nutrient ) | | | | Utilization efficiency (grains wt. / plant nutrients) | | | | Use efficiency (grains wt. /g nutrients in soil) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fe | Mn | Zn | Cu | Fe | Mn | Zn | Cu | Fe | Mn | Zn | Cu |
| 1 | 0.143 | 0.013 | 4.86 | 0.153 | 1.83 | 17.18 | 4.33 | 68.63 | 0.259 | 0.230 | 20.97 | 10.49 |
| 2 | 0.093 | 0.013 | 2.76 | 0.181 | 2.37 | 15.96 | 6.57 | 50.46 | 0.220 | 0.200 | 18.19 | 9.10 |
| 3 | 0.090 | 0.008 | 6.26 | 0.083 | 2.73 | 26.96 | 3.17 | 119.17 | 0.246 | 0.220 | 19.86 | 9.93 |
| 4 | 0.123 | 0.017 | 3.83 | 0.097 | 1.34 | 8.86 | 3.48 | 68.67 | 0.163 | 0.147 | 13.19 | 6.60 |
| 5 | 0.360 | 0.015 | 6.35 | 0.070 | 2.47 | 14.13 | 3.07 | 141.67 | 0.222 | 0.213 | 19.44 | 9.72 |
| 6 | 0.137 | 0.012 | 3.10 | 0.063 | 1.03 | 10.68 | 3.69 | 91.13 | 0.140 | 0.123 | 11.39 | 5.69 |
| 7 | 0.090 | 0.008 | 6.22 | 0.083 | 2.81 | 27.01 | 3.20 | 119.17 | 0.252 | 0.220 | 19.86 | 9.93 |
| 8 | 0.110 | 0.010 | 4.44 | 0.083 | 1.19 | 11.31 | 2.41 | 66.73 | 0.130 | 0.117 | 10.69 | 5.35 |
| LSD 5% | 0.040 | 0.0015 | 0.52 | 0.020 | 0.45 | 2.32 | 0.76 | 19.50 | 0.042 | 0.032 | 2.83 | 1.44 |

#### *3.3. Use Efficiency:*

Concerning micronutrients use efficiency, the data clearly indicate that genotype number (1) recorded the highest values of all micronutrients use efficiency and significantly surpassed other genotypes with the exception of genotypes 7, 3, 5 and 2. The superiority of those genotypes in micronutrients use efficiency reflects their efficiency which led to high grain yield, this finding is in harmony with Khabaz-Saberi *et al*. (1997), who mentioned that, the efficient durum wheat genotypes had greater Mn uptake from Mn deficient soil, and produced higher grain yield, relative grain yield and above ground biomass and generally maintained higher seed Mn concentration. The efficiency of these genotypes also may be attributed to developed morphological and/or physiological mechanisms to improve acquisition and use efficiency of mineral nutrients when grown on poor and infertile soils. This is in agreement with Rengel (1997) who screened wheat genotypes tolerant to Zn and Mn stress, and mentioned that genotypes tolerant to Zn deficiency released greater amounts of phytosiderophore, 2-deoxymugineic acid, than the sensitive genotypes. In addition, several mechanisms constitute the physiological bases of Zn efficiency. These are enhancement of root growth (Dong *et al*., 1995), root uptake and root-to-shoot translocation of Zn (Cakmak *et al*., 1996a and Rengel and Graham, 1996), release of Zn-mobilizing phytosiderophores from roots (Cakmak *et al*., 1996b and Erenoglu *et al*., 1996) and internal utilization of Zn (Cakmak *et al*., 1996b and Rengel, 1995).

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