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Evaluation of some Bread Wheat Genotypes under Soil Salinity Conditions

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ABSTRACT

The present study was carried-out at the Experimental Farm of Sakha Agricultural Research Station, during the two growing season 2017/2018 and 2018/2019 seasons to evaluate sixteen bread wheat genotypes including, 12 promising lines from the local breeding program in addition to four Egyptian cultivars (Giza 171, Sakha93, Sakha95 and Misr3) under normal and soil salinity conditions. The genotypes were arranged in a randomized complete block design with four replications in each condition. The results indicated significant decrease for most studied characteristics by soil salinity. Results based on cluster analysis indicated that Sakha 95 and Giza171 exhibited the highest grain yield under both conditions, moderate values for both yield reduction ratio and stress susceptibility index especially for Sakha 95, moderate values of physiological characters and protein content but they gave the lowest values of both wet and dry gluten contents. So, that Sakha 95 was considered to be moderate tolerant to soil salinity. Otherwise, Line 4, Line 10 and Misr 3 gave a moderate grain yield at both condition. However, there was insignificant difference in grain yield between Misr 3, Sakha 95 and Giza 171 under soil salinity. Also, Line 4, Line 10 and Misr 3 recorded lowest values for both yield reduction ratio and stress susceptibility index, maximum values for physiological characters and moderate values for quality characters. These genotypes considered as a tolerant genotypes to soil salinity and might be used as parents in breeding programs to produce new genotypes with desirable characters related to soil salinity tolerance.

Keywords: Triticum aestivum L., Saline soil, Stress tolerance indices, Cluster analysis

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important grown cereal crop. The flour of wheat is the staple food of many countries including Egypt and its straw used for animal feeding (Milad *et al*., 2013). Increasing wheat production is a main target in Egypt to minimize the gap between wheat consumption and production. The reduction in yield production of the soils affected by salinity is about 30% threatening the livelihoods of the poor farming and having a significant negative impact on food production of Egypt as whole, (El-Lakany *et al*., 1986). Wheat genotypes showed a wide variation for salinity stress tolerance. Therefore, the breeding programs for high and stable yield potential and tolerant to biotic and abiotic stresses is a vital goal for the national plans of wheat development in Egypt.

Salt tolerance can be defined as the ability of the plants to survive and maintain their growth and produce relatively profitable yield under saline conditions. Salinity affects the main physiological and biochemical processes in the plant. It comprises changes in several metabolic and physiological routes, depending on sternness and extent of the stress (Munns, 2005). It exerts a devastating effect on plants into two phases. One of the rapid osmotic phase and another is a slower ion toxicity phase. Osmotic phase suppresses the plant/young leaves growth and development which followed by ionic toxicity due to high accumulation of salt in the leaves and speeds senescence of mature leaves (Munns, 2005). However, bread wheat is considered to be moderate tolerance crop (Colmer *et al*., 2005).

All fractions of photosynthetic pigments in the plants gradually decreased with the rise of salt level (Radi *et al*., 2013). Leaf relative water content (RWC) reflects plant water status and it is used as a meaningful index for dehydration tolerance salinity stress reduced RWC. (EL-Bassiouny and Bekheta, 2005 and Dehnavi *et al*., 2017)

The common responses in plants exposed to saline stress are an increase in osmotic adjustment components, proline is the most important and efficient compatible solute among these components. In general, proline content increased under saline soil compared to normal soil (Verbruggen and Hermans., 2008; Goudarz and Pakniyat 2009 and Tang *et al*. 2015).

Protein content is controlled by genetic, environment and soil fertility. it is significantly affected by environmental factors and their interactions. Positive correlations between environmental factors and wheat grain protein content have been reported during grain filling (Graybosch *et al*., 1996 and Huebner *et al*., 1997). Khan *et al*., (2008) showed that salinity increased grain protein and the wet and dry gluten content of salt tolerant wheat cultivars rather than that salt sensitive ones. Gluten storage proteins divided into two major classes: gliadins that confer extensibility and glutenins that cause elasticity. Regarding to salt stress effect on proteins in wheat grains, Shen *et al*., (2007) found that protein content increased with increasing soil salt content.

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Stress tolerance indices (STI's) were widely used as simple mathematical equations that quantify and compare the grain yields under stressed and non-stressed conditions to differentiate the tolerant/sensitive genotypes. There are various stress tolerance indices such as stress susceptibility index "SSI", (Fischer and Maurer, 1978), a larger values of SSI represent relatively more sensitivity to stress, thus a smaller values of SSI are favored.

Cluster analysis is a valuable biometrical tool aimed to quantify the degree of genetic divergence among the tested genotypes based on their performance and their contributing characters. But, it was found that the run of cluster analysis depending on (STI's) parameter is useful to differentiate wheat genotypes for salt tolerance, [Sing *et al.* (2015) and Darwish *et al.* (2017)].

Our objectives were to (1) Evaluate the influence of salinity soil stress on agronomic, physiological and quality characters of 16 spring bread wheat genotypes. (2) identify the soil salinity tolerant wheat genotypes based on stress tolerance indices (STI's). (3) classify the tested wheat genotypes using cluster analysis depending on the grain yield, physiological, quality treats and stress tolerance indices . The results may be helpful to plan appropriate selection strategies for improving both of grain yield and salt tolerance in wheat crop in Egypt.

MATERIALS AND METHODS

The field experiments were conducted during 2017/2018 and 2018/2019 wheat growing seasons on the Experimental Farm of Sakha Agricultural Research Station, Kafrelsheikh, Egypt. The tested wheat genotypes contained 12 promising lines from the local breeding program in addition to four wheat cultivars Giza 171, Sakha 93, Sakha 95 and Misr 3. Names and pedigree of these genotypes are shown in Table 1.

The experiments were conducted under two conditions; normal soil at 2nd Nattaf Farm and salt affected soil at El-Hamrawy Farm. The soil analysis of the two locations was carried out at the Laboratories of Soil Research Department of Sakha Agricultural Research Station, Agricultural Research Center, Kafrelsheikh, Egypt (Table 2). The meteorological data were recorded for the two winter growing seasons from Sakha Meteorological Station as shown in Table 3.

Table 1. Names and pedigree of the studied wheat genotypes

Ser	Genotype	Pedigree and selection history
1	Line 1	Giza 171 /2/ GIZA164 / SAKHA 61 S.2012-170-020S-010S-04S-0S
2	Line 2	Giza 171 / Vorobey S.2012-171-030S-015S-01S-0S
3	Line 3	Giza 171 / Vorobey S.2012-171-030S-015S-03S-0S
4	Line 4	Giza 171/6/ GIZA 158 /5/ CFN /CNO "S" // RON /3/ BB / NOR 67 /4/ TL /3/ FN / TH //2*NAR 59 S.2012-172-010S-020S-05S-0S
5	Line 5	Sids 12/Sids 13 S.2012-173-020S-010S-02S-0S
6	Line 6	Sids 12/Sids 13 S.2012-173-020S-010S-06S-0S
7	Line 7	GIZA164 / SAKHA 61 /6/ GIZA 158 /5/ CFN /CNO "S" // RON /3/ BB / NOR 67 /4/ TL /3/ FN / TH //2*NAR 59 S.2012-174-010S-07S-01S-0S
8	Line 8	GIZA164 / SAKHA 61 /6/ GIZA 158 /5/ CFN /CNO "S" // RON /3/ BB / NOR 67 /4/ TL /3/ FN / TH //2*NAR 59 S.2012-174-010S-07S-02S-0S
9	Line 9	GIZA 158 /5/ CFN /CNO "S" // RON /3/ BB / NOR 67 /4/ TL /3/ FN / TH //2*NAR 59 S10232-3S-2S-4S-0S
10	Line 10	GIZA164 / SAKHA 61 S.9242-IBR-2BR-5BR-2BR-0BR
11	Line 11	CHEN/AEGILOPS SQUARROSA(TAUS)/ /BCN/3/2* KAUZ/4/GEN*2 //BUC/ FLK /3/ BUCHIN. S.16280-020S-015S-4S-0S.
12	Line 12	VOROBEY CMSS96Y02555S-040Y-020M-050SY-020SY-6M-0Y
13	Giza 171	SAKHA 93 / GEMMEIZA 9 S.6-1GZ-4GZ-1GZ-2GZ-0S
14	Sakha 93	SAKHA92/TR810328 S.8871-1S-2S-1S-0S
15	Sakha 95	PASTOR/SITE/MO/3/CHEN/AEGILOPS SQUARROSA(TAUS)//BCN /4/WBLL1 CMA01Y00158S-040POY-040M-030ZTM-040SY26M-0Y-0SY-0S.
16	Misr 3	ATTILA*2/PBW65*2/KACHU CMSS06Y00582T-099TOPM-099Y-099ZTM-099Y-099M-10WGY-0B-0EGY

Table 2. Soil analysis for normal soil (2nd Nattaf Farm) and salt-affected soil (Elhamrawy Farm) during 2017/2018 and 2018/2019 seasons.

Location	Season	Soil depth (cm)	Soil Structure	Ec dsm^{-1}	Soluble cations MeqL^{-1}				Soluble anions MeqL^{-1}		
					Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO^{-}_{3}	Cl^{-}	SO^{2-}_{4}
2nd Nattaf	2017-2018	0-30	Clayey	2.05	5.54	3.89	10.54	0.27	3.11	8.17	8.96
		30-60	Clayey	1.48	3.41	2.43	8.64	0.34	2.61	4.82	7.39
	2018-2019	0-30	Clayey	2.01	5.52	3.95	10.98	0.31	3.24	9.11	8.41
		30-60	Clayey	1.53	3.98	2.34	8.97	0.29	2.82	5.01	7.75
ElHamrawy	2017-2018	0-30	Clayey	8.62	25.41	17.52	46.05	0.51	4.12	37.01	48.36
		30-60	Clayey	6.51	10.73	10.73	41.74	0.39	3.21	28.02	34.34
	2018-2019	0-30	Clayey	8.46	24.48	16.86	47.98	0.63	4.01	38.96	46.98
		30-60	Clayey	6.57	14.25	11.25	41.58	0.52	3.46	31.56	32.58

Table 3. Monthly mean of air temperature (AT ^{O}C), relative humidity (RH %) and rainfall (mm/month) in winter seasons 2017/2018 and 2018/2019 at Sakha location.

Month	AT ^{O}C 2017/18		AT ^{O}C 2018/19		RH%		Rainfall (mm)	
	Max.*	Min.**	Max.*	Min.**	2017/18	2018/19	2017/18	2018/19
December	21.50	15.40	20.22	14.31	65.12	75.63	32.94	21.70
January	18.85	14.03	19.63	12.69	60.00	67.68	9.60	14.90
February	21.53	14.50	19.58	14.95	62.21	70.69	25.20	15.30
March	25.51	16.59	22.05	18.21	67.50	72.21	0.00	17.30
April	27.80	19.94	25.80	20.64	66.32	68.78	10.60	3.90
May	37.00	28.00	33.00	26.29	55.25	57.09	0.00	0.00

*** Max = maximum temperature, ** Min = minimum temperature.**

The genotypes were arranged in a randomize complete block design (RCBD) with four replications under each environment. The area of the experimental unite was 4.2 m^2. All recommended agricultural practices; irrigation, fertilization, weed control and fungicides; were applied at the proper time.

The studied characteristics

Physiological characteristics: At heading stage, flag leaves samples were randomly taken from each plot to estimate photosynthetic pigments of chlorophyll a, chlorophyll b and total chlorophyll according to (Moran, 1982), proline content were determined according to Bates *et al*. (1973) and relative water content (RWC) was estimated according to Ritchie and Nguyen, (1990)

Agronomic characteristics : Days to heading , days to maturity, plant height (cm), number of spikes m^{-2}, number of kernels spike^{-1}, 1000-kernel weight (g), straw yield (Kg plot^{-1}) and grain yield (Kg plot^{-1}) were measured.

Stress Tolerance Indices:

For each genotype, two stress tolerance indices were calculated based on average grain yield under both normal (Yn) and soil salinity condition (Ys) over the two seasons. The low values of these indices indicated salinity stress tolerance. The names, equations and references of the stress tolerance indices are shown in Table (4).

Table 4.The name, equation and reference of some stress tolerance indices

No.	Index name	Formula	Reference
1	Yield reduction ratio (YR)	1-(Ys/Yn)	(Golestani and Assad, 1998)
2	Stress Susceptibility index (SSI)	$[1-(Ys/Yn)]/[1-(\bar{Y}_s/\bar{Y}_n)]$	(Fisher and Maurer, 1978)

- Y_n and Y_s indicate average grain yield of each genotype under normal and stress conditions.

- $\bar{Y}_n$ and $\bar{Y}_s$ indicate average grain yield overall genotypes under normal and stress conditions

Quality characteristics:

A- **Standard germination test:** Germination percentage was expressed in the laboratory by the percentage of normal seedling at the end of testing period according to International Seed Testing Association (I.S.T.A, 1993).

B- **Viability: Electrical conductivity test (EC):** Three replicates of 50 weighed seed from each treatment incubated for 24 hr in 250 ml flask containing 200 ml of distal water at 20°C., after that period the conductivity of solution immediately measured with conductivity meter CMD 830 WPA and expressed as µmohs per centimeter per gram of seed (Matthews and Powell, 1981).

C- Grain quality parameters:

Crude protein content: A known weight of the fine powdered seeds (0.1 g) was digested using a micro-kjeldahl apparatus. The crude protein was calculated by multiplying the total nitrogen by 5.75 (A.O.A.C, 1990).

Wet and dry gluten percentage: were measured in hand washing 25 g flour, according to standard method (AACC, 10-38, Anonymous, 1983).

Statistical analysis

The data were subjected to individual and combined analysis of variance of randomized complete block design over the two experiments (normal and soil salt conditions) for each season, according to Steel *et al*., 1997. As a routine statistical step, Levene test was run prior to the combined analysis to confirm the homogeneity of individual error terms, (Levene, 1960). Least significant difference (LSD) test was used to detect the significant differences among the proper items at the probability level of 0.05 according to Waller and Duncan (1969). In order to assort genotypes according to their grain yield and salinity stress tolerance, agglomerate hierarchical cluster analysis was worked out using the average grain yield, physiological characters, quality characters and the two stress tolerance indices. A dendrogram was constructed based on "Euclidean distance" procedure. Genotypes were clustered by un-weighted pair group method using arithmetic average as outlined by Kovach (1995)

RESULTS AND DISCUSSION

The weather conditions

Minimum and maximum temperatures (°C), relative humidity (RH%) and rain fall (mm) during each month in the two growing seasons are given in Table (3). The 2017/ 2018 season was characterized by highest average temperature during the period from Feb. to May. compared with 2018/2019 season. Also, the first season was the lowest in relative humidity compared with the second season. So that, the first season (2017-2018) was considered dry due to high temperatures and lowest relative humidity overall the season which could affect on all agronomic traits in the first season.

The results of Levene test (1960) proved the homogeneity of separate error variances for all studied traits that permits to apply combined analysis

Physiological and biochemical characteristics:

Results in Table (5) showed that soil salinity stress decreased the concentration of photosynthetic pigments (chlorophyll a, chlorophyll b and total chlorophyll) in the leaves. The concentrations of chlorophyll a was 10.66 mg L^{-1} and 7.59 mg L^{-1} in the first season and 12.0 mg L^{-1} and 7.8 mg L^{-1} in the second one under normal and soil salinity, respectively. Meanwhile, chlorophyll b concentration was 2.99 mg L^{-1} and 2.41 mg L^{-1} in the first season and 3.89 mg L^{-1} and 2.69 mg L^{-1} in the second one under normal and soil salinity, respectively. The same trend was observed for total chlorophyll, where soil salinity decreased the total chlorophyll from 13.66 mg L^{-1} to 10.0 mg L^{-1} in the first season and from15.89 mg L^{-1} to 10.79 mg L^{-1} in the second one for normal and soil salinity, respectively.

These results are in agreement with Radi et al. (2013) and disagree with Ouhaddach et al. (2018), who reported that the chlorophyll content increased under salt stress conditions. The decrease in chlorophyll under salinity condition may be due to the changes in number and size of chloroplast and disorganization of grana and thylakoids (Motos et al., 2017). Results also showed a significant differences among genotypes under normal soil where the highest values of chlorophyll a, chlorophyll b and total chlorophyll were recorded in the genotypes Sakha 95, Misr 3, Giza 171and Line 10 in the two seasons with insignificant differences among them for chlorophyll b in the second season. While, under soil salinity the highest values of chlorophyll a, b and total were obtained from Misr 3, Line 6, Line 9, Line 10 and Line 12 in both seasons.

Table 5. Mean values of chlorophyll A, chlorophyll B and total chlorophyll for 16 wheat genotypes evaluated under normal and soil salinity conditions in the two wheat growing seasons 2017 / 2018 and 2018 /2019.

Character	Chlorophyll a (mg l^{-1})						Chlorophyll b (mg l^{-1})						Total chlorophyll (mg l^{-1})					
Season	2017/2018			2018/2019			2017/2018			2018/2019			2017/2018			2018/2019		
Genotypes	N	S	Mean	N	S	Mean	N	S	Mean	N	S	Mean	N	S	Mean	N	S	Mean
Line 1	10.94	8.04	9.49	11.34	7.51	9.42	2.80	2.46	2.63	3.53	2.57	3.05	13.74	10.50	12.12	14.86	10.07	12.47
Line 2	9.94	6.88	8.41	11.40	7.56	9.48	2.72	2.40	2.56	3.63	2.47	3.05	12.67	9.28	10.97	15.03	10.03	12.53
Line 3	10.12	6.37	8.24	11.40	7.09	9.24	2.91	2.35	2.63	3.67	2.44	3.05	13.04	8.71	10.88	15.06	9.53	12.30
Line 4	10.25	8.30	9.27	12.50	8.05	10.28	3.25	2.63	2.94	4.32	3.56	3.94	13.50	10.93	12.21	16.83	11.61	14.22
Line 5	10.67	7.62	9.14	12.04	8.02	10.03	2.89	2.22	2.56	3.93	3.76	3.84	13.55	9.85	11.70	15.97	11.78	13.87
Line 6	10.65	8.41	9.53	11.88	8.06	9.97	2.98	2.52	2.75	3.50	3.13	3.31	13.63	10.93	12.28	15.37	11.19	13.28
Line 7	10.51	7.66	9.08	11.62	8.55	10.09	2.80	2.21	2.51	3.95	3.14	3.55	13.31	9.88	11.59	15.58	11.69	13.64
Line 8	10.79	7.93	9.36	11.68	6.78	9.23	2.98	2.42	2.70	3.88	2.42	3.15	13.78	10.34	12.06	15.56	9.20	12.38
Line 9	10.34	7.91	9.13	11.37	8.45	9.91	2.92	2.58	2.75	3.81	3.07	3.44	13.27	10.49	11.88	15.18	11.51	13.35
Line 10	11.04	8.15	9.59	12.45	8.15	10.30	3.28	2.61	2.95	3.95	3.13	3.54	14.32	10.76	12.54	16.40	11.28	13.84
Line 11	10.22	6.78	8.50	11.40	7.53	9.46	2.93	2.26	2.59	3.64	2.96	3.30	13.15	9.04	11.10	15.04	10.49	12.76
Line 12	9.55	7.27	8.41	11.32	8.14	9.73	2.55	2.20	2.37	3.71	3.30	3.50	12.10	9.47	10.78	15.03	11.44	13.23
Giza 171	11.01	7.20	9.11	12.12	7.19	9.65	3.18	2.44	2.81	4.03	2.83	3.43	14.19	9.64	11.92	16.14	10.01	13.08
Sakha 93	10.42	6.87	8.64	12.52	7.36	9.94	3.15	2.26	2.70	3.93	2.58	3.25	13.56	9.13	11.35	16.45	9.94	13.19
Sakha 95	12.36	7.44	9.90	13.54	7.60	10.57	3.22	2.38	2.80	4.38	2.77	3.58	15.59	9.82	12.70	17.93	10.37	14.15
Misr 3	11.80	8.53	10.17	13.43	8.45	10.94	3.32	2.70	3.01	4.32	3.23	3.77	15.12	11.23	13.18	17.75	11.68	14.71
Mean	10.66	7.59	9.12	12.00	7.78	9.89	2.99	2.41	2.70	3.89	2.96	3.42	13.66	10.00	11.83	15.89	10.74	13.31
Salinity F test		**			**			*			**			**			**	
Geno LSD 5%		0.76			0.64			0.33			0.40			0.90			0.72	
S X G LSD 5%		1.07			0.90			0.47			0.57			n.s			1.02	

N: Normal condition **S: Soil salinity condition** **Geno : genotype** **n.s.: not significantly different.**

Table 6. Mean values of relative water content (RWC) and proline content for 16 wheat genotypes evaluated under normal and soil salinity conditions in the two wheat growing seasons 2017 / 2018 and 2018 /2019.

Character	Relative water content (%)						Proline content (mg g FW^{-1})					
Season	2017/2018			2018/2019			2017/2018			2018/2019		
Genotypes	N	S	Mean	N	S	Mean	N	S	Mean	N	S	Mean
Line 1	82.12	78.29	80.20	84.64	76.58	80.61	0.29	0.35	0.32	0.22	0.31	0.27
Line 2	79.43	75.41	77.42	84.03	78.07	81.05	0.26	0.29	0.28	0.22	0.30	0.26
Line 3	80.72	76.14	78.43	85.12	79.69	82.40	0.21	0.31	0.26	0.25	0.33	0.29
Line 4	78.94	75.91	77.43	86.85	83.80	85.33	0.28	0.35	0.32	0.28	0.46	0.37
Line 5	80.59	76.55	78.57	85.33	79.43	82.38	0.24	0.33	0.28	0.26	0.40	0.33
Line 6	80.83	77.86	79.35	84.62	80.06	82.34	0.29	0.38	0.33	0.25	0.40	0.33
Line 7	80.66	76.26	78.46	84.06	80.11	82.09	0.21	0.32	0.27	0.26	0.36	0.31
Line 8	79.60	74.71	77.15	84.89	79.00	81.95	0.29	0.37	0.33	0.26	0.37	0.31
Line 9	79.52	74.66	77.09	84.45	80.40	82.43	0.25	0.37	0.31	0.23	0.39	0.31
Line 10	80.38	78.92	79.65	86.46	77.59	82.02	0.28	0.39	0.33	0.26	0.37	0.31
Line 11	80.27	75.54	77.91	84.87	77.76	81.32	0.21	0.31	0.26	0.24	0.35	0.30
Line 12	77.66	72.17	74.92	85.07	78.39	81.73	0.27	0.29	0.28	0.23	0.38	0.30
Giza 171	82.60	76.99	79.79	85.12	79.21	82.16	0.23	0.34	0.29	0.25	0.36	0.31
Sakha 93	79.57	73.91	76.74	84.41	77.18	80.80	0.22	0.30	0.26	0.26	0.39	0.32
Sakha 95	81.23	72.97	77.10	86.27	80.26	83.26	0.24	0.30	0.27	0.24	0.34	0.29
Misr 3	84.04	79.67	81.86	86.33	82.38	84.35	0.24	0.36	0.30	0.29	0.45	0.37
Mean	80.51	76.00	78.25	85.16	79.37	82.26	0.25	0.33	0.29	0.25	0.37	0.31
Salinity F test		**			**			**			**	
Geno LSD 5%		2.24			1.69			0.03			0.03	
S X G LSD 5%		n.s			n.s			n.s			0.04	

N: Normal condition **S: Soil salinity condition** **Geno : genotype** **n.s.: not significantly different.**

The results of relative water content (RWC) showed that soil salinity stress reduced RWC compared to normal soil from 80.51 % to 76.0 % in the first season and from 85.0 % to 79.0 % in the second one. Which agrees with a previous findings of EL-Bassiouny and Bekheta (2005) and Dehnavi *et al*. (2017). The reduced of RWC may be due to the decreased availability of water from the soil solution as a result of lowered osmotic potential triggered by the toxic effects of the sodium and chloride ions (Munns 2005). Accordingly, an increase in resistance to water flow from soil to plant under salinity has been observed in many species (Navarro *et al*., 2007 and Álvarez *et al*., 2012). Misr 3, Giza 171, Line 1 and Sakha 95 recorded the highest percentage of RWC under normal condition in the first season, while in the second one Misr 3, Sakha 95, Line 4 and Giza 171 gave the highest values. Under soil salinity condition, the highest percentage were obtained from Misr 3, Line 10 and Line 1 in the first season, and Line 4, Line 9, Misr 3 and Sakha 95 in the second one (Table 6). Proline content increased under soil salinity compared to that under normal soil from 0.25 to 0.33 in the first season and from 0.25 to 0.37 in the second one (Table 6).

In general, the common responses in plants exposed to soil salinity stress are an increase in osmotic adjustment such as, proline which is the most important and efficient compatible solute (Tang *et al*., 2015). Also it has been reported that it have antioxidant properties, and can act as a molecular chaperone to protect the structure of biological macromolecules during salinity and drought stress, thus conferring plant tolerance (Ashraf and Fooland, 2007 and Tang *et al*., 2015). Line 10 , Line 6, Line 8, Line 9 and Misr 3 gave the highest proline content under soil salinity condition in the first season, while in the second one Line 4 , Misr 3, Line 5 and Line 6 recorded the highest values. Under normal condition , Line 1, Line 4, Line 6, Line 8 and Line 10 ranked the first, while in the second one Line 4, Misr 3, Line 5 and Line 6 gave the highest proline content in the leaves. Interaction between salinity and genotypes was significant for photosynthetic pigments (chlorophyll a, b and total) in both seasons and proline only in the second season, where Misr 3, Sakha 95, Line 4, Line 5 and Line 10 gave the highest values of chlorophyll a, chlorophyll b and total chlorophyll. Regarding the results in Table (6) revealed that Misr 3, Line 4 , Line 5 and Line 6 recorded the highest proline content in the leaves in the second season.

Agronomic characters :

The results in Table (7) indicated that salinity caused early heading compared with that under normal condition and varied from 87 to 81 days and from 102 to 90 days in both seasons, respectively. Also, the same trend was achieved for number of days to maturity under soil salinity compared with normal conation from 133 to 119 days in the first season and from 150 to 132 days in the season one. Plant height decreased from 98 cm to 84 cm in the first season and from 119 cm to 107 cm in the second season under salinity stress compared with the normal one. In the meantime, Table (8) showed that soil salinity stress led to decrease in number of spikes m^{-2} from 400 to 332 in the first season and from 409 to 345 in the second one. Also, salinity caused decrease in number of kernels $spike^{-1}$ from 50 to 40 and from 54 to 45 in both seasons, respectively. 1000-kernel weight decreased under salinity stress from 42.68 g to 39.27 g in the first season and from 45.78 g to 41.45 g in the second one. Grain yield results in Table (9) showed that soil salinity stress reduced grain yield compared to normal soil from 2.33 kg $plot^{-1}$ to 1.45 kg $plot^{-1}$ and from 3.29 kg $plot^{-1}$ to 1.72 kg $plot^{-1}$ at both seasons, respectively. Also, salinity decreased straw yield from 6.40 kg $plot^{-1}$ to 3.40 kg $plot^{-1}$ and from 6.90 kg to 3.77 kg $plot^{-1}$ at both seasons, respectively.

Table 7. Mean values of days to heading , days to maturity and plant height for 16 wheat genotypes evaluated under normal and soil salinity conditions in the two wheat growing seasons 2017 / 2018 and 2018 /2019.

Character	Days to heading (day)						Days to maturity (day)						Plant height (cm)					
Season	2017/2018			2018/2019			2017/2018			2018/2019			2017/2018			2018/2019		
Genotypes	N	S	Mean	N	S	Mean	N	S	Mean	N	S	Mean	N	S	Mean	N	S	Mean
Line 1	84	79	81	107	89	98	131	117	124	153	132	142	101	88	94	119	113	116
Line 2	92	86	89	108	94	101	136	122	129	153	135	144	103	85	94	133	116	124
Line 3	87	82	85	102	89	95	131	120	126	150	133	141	105	91	98	124	114	119
Line 4	92	84	88	107	87	97	135	122	129	152	129	141	98	84	91	118	115	116
Line 5	85	81	83	97	88	92	132	117	124	146	129	138	81	73	77	108	95	101
Line 6	86	81	83	95	88	92	131	120	126	149	130	139	91	80	86	114	101	108
Line 7	86	80	83	99	89	94	130	118	124	149	131	140	118	90	104	133	121	127
Line 8	86	80	83	96	87	91	130	117	123	147	130	138	99	83	91	116	114	115
Line 9	88	80	84	100	90	95	135	120	128	150	132	141	94	79	86	124	110	117
Line 10	80	75	77	95	87	91	129	114	121	147	130	138	96	81	89	115	103	109
Line 11	88	80	84	104	93	99	132	117	124	149	130	140	97	84	90	114	103	108
Line 12	93	84	88	110	96	103	136	122	129	154	135	144	105	93	99	129	110	119
Giza 171	88	81	84	105	93	99	137	119	128	154	132	143	103	98	100	126	109	118
Sakha 93	88	82	85	101	92	97	136	120	128	152	135	143	79	73	76	103	89	96
Sakha 95	88	81	84	104	93	99	132	118	125	149	132	140	101	85	93	121	104	113
Misr 3	88	80	84	104	92	98	133	119	126	151	133	142	93	86	89	118	99	108
Mean	87	81	84	102	90	96	133	119	126	150	132	141	98	84	91	119	107	113
Salinity F test		**			**			**			**			**			**	
Geno LSD 5%		2.24			1.73			2.45			1.59			6.49			4.25	
S X G LSD 5%		n.s			2.45			n.s			2.24			n.s			6.01	

N: Normal condition S: Soil salinity condition Geno : genotype n.s.: not significantly different.

Table 8. Mean values of number of spikes m^{-2} , number of kernels $spike^{-1}$ and 1000-kernel weight for 16 wheat genotypes evaluated under normal and soil salinity conditions in the two wheat growing seasons 2017 / 2018 and 2018 /2019.

Character	Number of spikes m^{-2}						Number of kernel $spike^{-1}$						1000-kernel weight (g)					
Season	2017/2018			2018/2019			2017/2018			2018/2019			2017/2018			2018/2019		
Genotypes	N	S	Mean	N	S	Mean	N	S	Mean	N	S	Mean	N	S	Mean	N	S	Mean
Line 1	389	330	359	418	338	378	44	39	42	52	44	48	40.27	34.70	37.49	47.17	39.61	43.39
Line 2	418	319	368	385	345	365	52	41	46	53	43	48	45.94	33.39	39.66	46.00	40.08	43.04
Line 3	391	310	350	407	335	371	39	36	38	49	41	45	44.26	36.81	40.53	34.09	31.35	32.72
Line 4	405	358	382	415	345	380	54	47	50	58	47	52	45.49	45.23	45.36	46.38	41.71	44.04
Line 5	416	329	372	401	365	383	48	38	43	47	44	45	44.72	40.46	42.59	41.14	41.10	41.12
Line 6	420	298	359	416	348	382	42	35	39	57	45	51	36.08	33.33	34.71	47.98	45.75	46.86
Line 7	375	287	331	373	302	338	49	38	43	47	42	45	40.11	38.54	39.33	41.51	40.80	41.15
Line 8	373	322	347	385	348	367	45	38	41	50	45	48	37.85	34.91	36.38	39.86	43.18	41.52
Line 9	370	341	355	428	341	384	51	40	46	59	46	52	34.68	42.19	38.43	51.56	40.96	46.26
Line 10	323	342	332	389	305	347	44	41	42	44	43	43	39.31	45.52	42.41	45.27	36.80	41.03
Line 11	422	336	379	422	308	365	55	36	45	58	43	50	49.25	38.68	43.96	47.05	37.83	42.44
Line 12	398	358	378	418	386	402	49	36	43	59	47	53	41.34	39.38	40.36	46.38	47.39	46.89
Giza 171	440	341	391	433	360	396	60	51	55	67	56	61	46.68	43.89	45.29	53.08	46.16	49.62
Sakha 93	395	320	357	384	336	360	49	34	42	44	43	44	34.25	31.62	32.93	46.09	40.35	43.22
Sakha 95	433	382	407	440	375	408	56	43	50	66	49	58	52.91	50.27	51.59	50.76	46.50	48.63
Misr 3	428	345	386	433	390	411	56	41	49	59	45	52	49.83	39.45	44.64	48.22	43.68	45.95
Mean	400	332	366	409	345	377	50	40	45	54	45	50	42.68	39.27	40.98	45.78	41.45	43.62
Salinity F test		**			**			**			**			**			**	
Geno LSD 5%		42.51			41.57			4.30			4.69			2.72			3.98	
S X G LSD 5%		n.s			n.s			6.08			6.64			3.85			5.62	

N: Normal condition **S: Soil salinity condition** **Geno : genotype** **n.s.: not significantly different.**

Table 9. Mean values of grain yield $plot^{-1}$ and Straw yield $plot^{-1}$ for 16 wheat genotypes evaluated under normal and soil salinity conditions in two wheat growing seasons 2017 / 2018 and 2018 /2019.

Character	Grain yield $plot^{-1}$ (Kg)						Straw yield $plot^{-1}$ (Kg)					
Season	2017/2018			2018/2019			2017/2018			2018/2019		
Genotypes	N	S	Mean	N	S	Mean	N	S	Mean	N	S	Mean
Line 1	1.91	1.44	1.67	3.21	1.49	2.35	5.64	3.35	4.49	7.58	3.61	5.59
Line 2	2.54	1.33	1.94	3.16	1.57	2.36	7.37	3.38	5.38	7.69	3.82	5.75
Line 3	2.21	1.33	1.77	2.72	1.40	2.06	7.44	3.39	5.41	7.23	3.85	5.54
Line 4	2.43	1.83	2.13	3.32	1.69	2.51	6.82	4.08	5.45	6.84	3.94	5.39
Line 5	2.33	1.51	1.92	2.90	1.68	2.29	6.79	2.95	4.87	7.44	3.58	5.51
Line 6	1.82	1.12	1.47	3.28	1.83	2.55	5.66	2.82	4.24	6.78	3.72	5.25
Line 7	2.10	1.04	1.57	2.38	1.42	1.90	6.69	3.42	5.06	5.15	3.88	4.52
Line 8	2.07	1.14	1.60	3.01	1.75	2.38	5.74	2.80	4.27	6.72	3.49	5.11
Line 9	1.96	1.62	1.79	3.74	1.61	2.67	6.18	3.69	4.94	6.48	3.66	5.07
Line 10	1.91	1.77	1.84	2.84	1.55	2.19	5.77	3.48	4.63	6.73	3.50	5.12
Line 11	2.88	1.22	2.05	3.30	1.38	2.34	6.55	3.28	4.91	6.45	2.75	4.60
Line 12	2.52	1.38	1.95	3.27	1.88	2.57	7.45	4.07	5.76	7.66	4.62	6.14
Giza 171	3.38	1.80	2.59	4.14	2.11	3.12	7.90	3.10	5.50	6.75	4.37	5.56
Sakha 93	2.07	0.91	1.49	3.02	1.53	2.28	5.54	2.38	3.96	5.99	3.46	4.72
Sakha 95	2.88	1.88	2.38	4.38	2.45	3.41	5.28	4.57	4.92	7.49	4.11	5.80
Misr 3	2.32	1.84	2.08	4.06	2.2	3.14	5.65	3.62	4.63	7.38	3.99	5.68
Mean	2.33	1.45	1.89	3.29	1.72	2.51	6.40	3.40	4.90	6.90	3.77	5.33
Salinity F test		**			**			**			**	
Geno LSD 5%		0.35			0.31			n.s			0.87	
S X G LSD 5%		0.50			0.44			n.s			n.s	

N: Normal condition **S: Soil salinity condition** **Geno : genotype** **n.s.: not significantly different.**

In general, the mean of all genotypes decreased significantly under soil salinity for all characters at both seasons. This may be due to that salinity affect the plant by one or more of decreasing water availability, nutrients imbalance and specific ion effect. These results agrees with those obtained by Kumar *et al*. (2012) who reported that increasing salinity levels caused a significant decreases in grain yield, biological yield and 1000-kernel weight. Darwish *et al*. (2017) reported a significant decrease under salinity soil condition for all characters they studied, except 1000-kernel weight in one season. Also, Gadallah *et al*. (2017) reported that all studied agronomical traits were decreased with increasing of salinity levels.

The results in Tables (7, 8 and 9) showed that, the studied genotypes significantly differenced in all studied agronomic characters. The earliest genotype was Line 10 at heading at both seasons and maturity in the first season. While, Line 5 was the earliest maturity in the second season. Line 7 was the tallest genotype and Sakha 93was the shortest one. However, Misr 3 and Sakha 95 gave the highest number of spikes m^{-2}. Giza 171 in both seasons , Line 4 in the first season and Sakha 95 in the second seasons recorded the largest number of kernels $spike^{-1}$.

The heaviest 1000- kernel weight was achieved by Sakha 95 in the first season and Giza 171 in the second one. Highest grain and straw yields recorded by Giza 171 and Sakha 95 in the both growing seasons. These results are in harmony with those reported by Darwish *et al*. (2017) and Al-Naggar *et al*. (2015 a, b) who found a significant differences among the tested wheat genotypes for all studied characters.

The interaction between salinity and wheat genotypes significantly differed for days to heading and maturity and plant height in the second season, number of kernels spike^{-1}, 1000-kernel weight and grain yield over both seasons. The results also showed that Line 4, Line 5, Line 6, Line 8 and Line 10 showed early heading and maturity under salinity condition in the second season, The tallest plants were produced from Line 2 , Line 7 , Line12 and Giza 171 under normal condition. While, Sakha 93 was the shortest one under soil salinity condition in the second season.

Concerning the interaction effect between salinity and genotypes, the results indicated that Line 4, Line 11 ,Sakha 95 and Misr 3 recorded the highest number of kernels spike^{-1} values under normal condition in the first season, however Giza 171 and Sakha 95 gave the highest values under normal condition in the second season. The two cultivars Misr 3 and Sakha 95 produced the heaviest 1000-kernel weight under normal condition in both seasons, Line 11 under normal condition in the first season and Line 9 and Giza 171in the second season. The two cultivars Giza 171 and Sakha 95 produced the highest grain yield under normal condition in both growing seasons, in addition to Line 11 in the first season and Misr 3 in the second one. These results are in harmony with those reported by Nasab *et al*. (2014) who found insignificant interactions for number of spikes m^{-2} and 1000-kernel weight. Meanwhile, Darwish *et al*. (2017) and Hagras *et al*. (2018) reported a significant interactions between genotypes and soil salinity for days to heading, days to maturity , plant height, number of spikes m^{-2}, number of kernels spike^{-1} and grain yield.

Stress tolerance indices :

The stress susceptibility index (SSI) and yield reduction ratio (YR) estimates based on mean of grain yield over two years to determine the relative tolerance of bread wheat genotypes to soil salinity stress. Hamam and Negim (2014) reported that, the mean SSI over two years appeared to be a suitable selection indexto distinguish the resistant genotypes for salinity. The genotype which had low values of these indices would be more tolerant to soil salinity stress. Selection based on YR and SSI favors genotypes with low yield potential under normal condition and high yield under stress condition.

Results in Table 10 showed that, the highest grain yielding genotypes under normal condition were Giza 171(3.76 Kg plot^{-1}) and Sakha 95(3.64 Kg plot^{-1}), whereas Line 7 had the least value (2.24 Kg plot^{-1}). However, Sakha 95 (2.16 Kg plot^{-1}) and Giza 171 (1.95 Kg plot^{-1}) had the highest grain yield under soil salinity condition. Meanwhile, Sakha 93 gave the least value being (1.22 Kg plot^{-1}).

Results indicated that Line 10 and Misr 3 had the lowest values for SSI (0.68, 0.72) and YR (0.30, 0.31), respectively. This indicate that these two genotypes were tolerant to soil salinity. Whereas, Line 11 and Sakha 93 had the highest values for both SSI (1.32, 1.18) and YR (0.58, 0.52),respectively. Which indicated that these two genotypes were sensitive to soil salinity condition. These results agrees with that obtained by Darwish *et al*., (2017) who found that Giza 171 was moderately tolerant to soil salinity , also Hagras *et al*., (2018) reported that Sakha 95 and Giza 171 were moderate soil salinity tolerance.

Table 10 . Estimates of stress tolerance indices (YR and SSI) of 16 bread wheat genotypes based on grain yield under normal and soil salinity conditions across the two seasons.

Genotypes	Grain yield (Kg plot^{-1})		Stress tolerance indices	
	Yn	Ys	YR	SSI
Line 1	2.56	1.47	0.43	0.97
Line 2	2.85	1.45	0.49	1.11
Line 3	2.47	1.37	0.45	1.01
Line 4	2.88	1.76	0.39	0.88
Line 5	2.61	1.59	0.39	0.89
Line 6	2.55	1.47	0.42	0.96
Line 7	2.24	1.23	0.45	1.02
Line 8	2.54	1.44	0.43	0.98
Line 9	2.85	1.61	0.43	0.99
Line 10	2.37	1.66	0.30	0.68
Line 11	3.09	1.30	0.58	1.32
Line 12	2.90	1.63	0.44	0.99
Giza 171	3.76	1.95	0.48	1.09
Sakha 93	2.54	1.22	0.52	1.18
Sakha 95	3.64	2.16	0.40	0.92
Misr 3	3.19	2.02	0.31	0.72

Quality traits:

The soil salinity caused decrease in germination percentage and viability (by increase E.C value) compared with normal condition as shown in Table (11). Germination % decreased under salinity stress compared with that under normal from 97% to 88% in the first season and from 93 % to 83 % in the second season. Salinity stress increased electrical conductivity compared with that under normal condition, from 13.10 to 17.55 µ-mhos in the first season and from 14.26 to 17.94 µ-mhos in the second season. Abd El-Kareem and El-Saidy (2011) reported that water stress reduced germination percentage. Table (12) illustrated that soil salinity stress caused an increase in protein content compared to normal condition from 12.89% to 13.70% in the first season and from 13.02 % to 13.83 % in the second season. Wet gluten content was increased under salinity soil from 25.72% to 31.80 % in the first season and from 23.84% to 30.62 % in the second season compared to normal soil. Salinity increased dry gluten content compared to normal condition from 9.44% to 11.91% in the first season and from 8.88% to 11.33% in the second season. Kahrizi and Sedghi (2013) showed that gluten content changed very little with salinity and Houshmand *et al*., (2014) reported that salt and drought stress caused significant increment in grain protein content, wet and dry gluten contents.

There were significantly differences among genotypes on germination% and viability (Table 11). Line 8, Sakha 93 and Misr 3 recorded the highest germination percentage in the first season. Meanwhile, Line 9, Line 10, Sakha 93 and Misr 3 recorded the highest germination% in the second season. Line 2, Line 5 and Giza 171 recorded the highest viability (by decreased E.C value) in the first season, while Line 5, Line 9, Sakha 93 and Misr 3 showed the highest viability in the second season. On the other hand, Line 6 recorded the lowest viability (by increasing E.C value) in both seasons. Meanwhile, the results in Table (12) revealed that, Line 2 recorded the highest protein content in both seasons. However, Sakha 93 cultivar recorded the lowest protein content in both seasons. Line 9 recorded the highest wet gluten content in the first season and Sakha 93 in the second season. Regarding dry gluten content, Table (12) showed that the highest values were obtained by Line 7 in the first season and Sakha 93 in the second season. In the meantime, Line 3 recorded the lowest dry gluten content in both seasons. These results agreed with those reported by Zheng *et al*., (2009) and Kahrizi and Sedghi (2013).

Table 11. Mean values of germination percentage and electrical condactivity (µhoms) for 16 wheat genotypes evaluated under normal and soil salinity conditions in the two wheat growing seasons 2017 / 2018 and 2018 /2019.

Character	**Germination percentage %**						**Electrical condactivity (µhoms)**					
Season	**2017/2018**			**2018/2019**			**2017/2018**			**2018/2019**		
Genotypes	**N**	**S**	**Mean**	**N**	**S**	**Mean**	**N**	**S**	**Mean**	**N**	**S**	**Mean**
Line 1	96	91	93	92	83	87	10.12	16.17	13.15	12.99	19.64	16.32
Line 2	100	84	92	96	80	88	9.98	13.37	11.67	11.49	15.60	13.54
Line 3	96	87	91	89	79	84	17.55	24.37	20.96	19.02	29.44	24.23
Line 4	96	87	91	91	83	87	13.79	18.14	15.96	15.56	15.86	15.71
Line 5	100	88	94	96	84	90	7.93	15.57	11.75	9.86	16.52	13.19
Line 6	92	76	84	88	72	80	21.17	29.92	25.55	23.41	31.50	27.46
Line 7	95	85	90	91	84	87	17.33	21.29	19.31	16.72	19.46	18.09
Line 8	99	95	97	87	85	86	12.75	13.54	13.15	14.22	15.67	14.94
Line 9	95	92	94	96	92	94	12.42	12.55	12.48	11.43	14.36	12.89
Line 10	99	92	95	96	88	92	13.34	15.11	14.22	11.40	15.67	13.53
Line 11	97	88	93	92	84	88	13.75	17.24	15.49	16.08	18.47	17.27
Line 12	92	85	89	88	83	85	16.19	17.04	16.62	15.42	16.66	16.04
Giza 171	100	85	93	96	79	87	10.05	14.25	12.15	11.32	15.95	13.63
Sakha 93	100	92	96	96	88	92	10.13	23.72	16.93	11.34	15.45	13.39
Sakha 95	100	85	93	96	73	85	9.46	17.25	13.35	11.35	17.36	14.36
Misr 3	100	92	96	96	88	92	10.71	14.32	12.51	11.23	14.79	13.01
Mean	97	88	93	93	83	88	12.92	17.74	15.33	13.93	18.28	16.10
Salinity F test		**			**			**			**	
Geno LSD 5%		1.77			3.14			0.50			0.64	
S X G LSD 5%		2.51			4.44			0.71			0.90	

N: Normal condition S: Soil salinity condition Geno : genotype n.s.: not significantly different.

Interaction between salinity and genotypes was significant for all quality studied characters. Table (11) reveled that, the highest germination percentage was observed in Line 2, Line 5, Line 8, Line 10, Giza 171, Sakha 93, Sakha 95 and Misr 3 in the first season, and Line 2, Line 5, Line 9, Line 10, Giza 171, Sakha 93, Sakha 95 and Misr 3 in the second season under normal condition. Regarding viability (E.C), the highest viability by decreasing E.C value was observed in Line 8 and Line 5 under the normal condition in both seasons. In the meantime, Line 6 recorded the lowest viability (by increase E.C value) under soil salinity condition in both seasons. The highest protein content was detected in Line 2 under soil salinity condition in the first season and Line 2, Line 4, Line 5 and Line 12 in the second season (Table 12). Turki *et al*., (2012) showed that salt accumulation increased protein content in five varieties and one accession of durum wheat. This variation may be related to the relatively stable nitrogen metabolism under salt stress, which might contribute to the higher protein concentration. Zheng *et al*., (2009) reported that the protein content of cultivars under study increased as salt concentration increase.

Table 12. Mean values of crude protein % , wet gluten % and dry gluten % for 16 wheat genotypes evaluated under normal and soil salinity conditions in the two wheat growing seasons 2017 / 2018 and 2018 /2019.

Character	**Crude protein %**						**Wet gluten %**						**Dry gluten %**					
Season	**2017/2018**			**2018/2019**			**2017/2018**			**2018/2019**			**2017/2018**			**2018/2019**		
Genotypes	**N**	**S**	**Mean**	**N**	**S**	**Mean**	**N**	**S**	**Mean**	**N**	**S**	**Mean**	**N**	**S**	**Mean**	**N**	**S**	**Mean**
Line 1	14.24	14.45	14.35	14.27	14.59	14.43	26.64	27.79	27.21	25.40	27.11	26.25	10.28	10.35	10.31	9.83	9.96	9.89
Line 2	14.44	14.54	14.49	14.57	14.67	14.62	29.33	31.76	30.55	25.19	30.07	27.63	10.45	11.60	11.03	9.07	10.83	9.95
Line 3	14.21	14.34	14.27	14.34	14.47	14.41	20.47	26.48	23.47	18.79	24.88	21.83	6.95	9.15	8.05	6.60	8.75	7.67
Line 4	12.86	14.50	13.68	12.99	14.63	13.81	29.44	30.96	30.20	28.91	30.36	29.63	10.88	12.01	11.45	10.60	11.24	10.92
Line 5	12.67	14.50	13.58	12.80	14.63	13.72	24.92	32.59	28.75	22.12	30.16	26.14	9.48	11.60	10.54	8.52	10.92	9.72
Line 6	11.19	12.77	11.98	11.32	12.90	12.11	20.65	24.68	22.67	18.84	24.23	21.53	7.60	9.28	8.44	7.20	9.09	8.15
Line 7	11.26	12.77	12.01	11.39	12.90	12.15	23.64	37.12	30.38	22.19	36.07	29.13	8.95	16.08	12.51	8.40	15.27	11.83
Line 8	14.15	14.28	14.21	14.28	14.41	14.35	25.60	34.08	29.84	23.20	31.92	27.56	8.83	14.04	11.43	8.28	12.36	10.32
Line 9	12.77	14.29	13.53	12.90	14.42	13.66	26.88	39.75	33.31	25.63	38.53	32.08	9.40	14.53	11.97	9.01	13.64	11.33
Line 10	12.57	12.69	12.63	12.70	12.83	12.77	29.13	33.25	31.19	27.80	32.44	30.12	10.71	12.85	11.78	10.52	12.20	11.36
Line 11	10.95	12.77	11.86	11.08	12.90	11.99	21.69	25.80	23.75	19.57	25.56	22.57	8.28	9.36	8.82	6.80	9.07	7.93
Line 12	14.27	14.46	14.36	14.40	14.59	14.50	27.36	32.71	30.03	25.63	30.84	28.23	9.72	11.92	10.82	9.79	11.51	10.65
Giza 171	12.73	14.32	13.52	12.86	14.45	13.66	26.89	31.27	29.08	23.04	28.96	26.00	10.33	11.00	10.67	9.12	10.36	9.74
Sakha 93	11.07	11.32	11.19	11.20	11.45	11.33	32.48	33.44	32.96	32.40	33.24	32.82	11.88	12.81	12.35	11.60	12.28	11.94
Sakha 95	12.73	12.89	12.81	12.86	13.02	12.94	20.09	28.05	24.07	17.48	27.77	22.63	7.63	9.92	8.77	7.43	9.77	8.60
Misr 3	14.20	14.28	14.24	14.33	14.41	14.37	26.31	39.07	32.69	25.28	37.71	31.49	9.72	14.09	11.91	9.33	14.00	11.67
Mean	12.89	13.70	13.29	13.02	13.83	13.42	25.72	31.80	28.76	23.84	30.62	27.23	9.44	11.91	10.68	8.88	11.33	10.10
Salinity F test		**			**			**			**			**			**	
Geno LSD 5%		0.03			0.05			0.46			0.50			0.25			0.20	
S X G LSD 5%		0.04			0.08			0.65			0.71			0.36			0.28	

N: Normal condition S: Soil salinity condition Geno : genotype n.s.: not significantly different.

The Table (12) recorded the maximum increase in wet gluten content produced from the Line 9 under soil salinity stress in the two seasons. While, the lowest values observed in Line 6 and Sakha 95 under normal condition in the first season. While, Sakha 95 recorded the lowest percentage in the second season. In the meantime, Table (12) showed that the highest percent of dry gluten under soil salinity condition observed in Line 7 in both seasons. While, the lowest values were obtained by Line 3 under normal condition in the both seasons. These results agree with those reported by Kahrizi and Sedghi (2013).

Cluster analysis

Cluster analysis is an effective tool for classifying objects into groups. The cluster analysis was used as an efficient procedure to emerge the structural relationships among tested genotypes and provides a hierarchical classification of them. In the present work, based on Euclidean distance, the tested genotypes were classified according to grain yield, stress tolerance indices, physiological and quality characters were discriminated as shown in dendrogram graph (Fig. 1). Mean values of grain yield, stress tolerance indices, physiological and quality characters under each studied cluster, are present in Table (13). Accordingly, the features of each cluster were describe and discussed below.

It could be seen, from Table (13) and dendrogram (Fig. 1), that the cluster analysis discriminated the aimed genotypes into two major clusters namely; A and B. However, the first main cluster divided into three sub clusters which could be named, 1, 2 and 3. The sub cluster number one consisted of five genotypes (Line 1, Line 8, Line 5, Line 9 and Line 6). The genotypes in this cluster in general had moderate values for most studied characters *i.e.* grain yield, tolerance indices, physiological and quality characters. The 2nd sub cluster include two genotypes (Line 7 and Sakha 93) that had low values of grain yield at both conditions and high values of stress tolerance indices. These genotypes recorded moderate values for total, a, and b chlorophyll contents, proline content, while they gave highest values for both wet and dry gluten contents.

Considering the 3rd sub cluster, it comprised of four genotypes namley Line 2, Line 12, Line 3 and Line 11. These genotypes had moderate grain yield at both conditions and high values of stress tolerance indices. They reflected a minimum values for physiological characters and both wet and dry gluten contents, but they had the highest protein content.

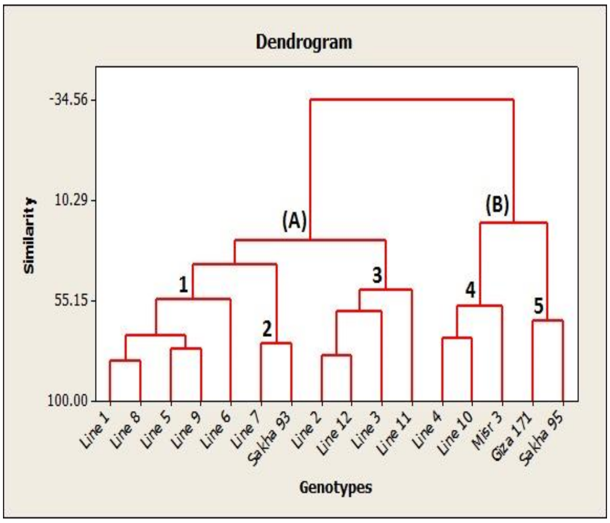

Fig. 1. Dendrogram showing the distance among 16 wheat genotypes based on the mean values of grain yield, physiological characters, quality characters and stress tolerance indices, as combined data over both seasons 2017/2018 and 2018/2019.

The 2nd main cluster consisted of two sub clusters (4 and 5). Cluster number 4 represented by three genotypes namely; Line 4, Misr 3 and Line 10 which gave moderate grain yield at both conditions and lowest values of stress tolerance indices. They had maximum values of physiological characters and moderate values for quality characters. cluster number 5 included two genotypes *i.e.* Giza 171 and Sakha 95 which gave the highest grain yield at both conditions and moderate values of stress tolerance indices especially for Sakha 95. Also, they recorded a moderate values of physiological characters and protein content, but they gave the lowest values of both wet and dry gluten contents.

Table 13. Summary of hierarchical cluster analysis represents the classification of tested wheat genotypes based on the mean values of grain yield, physiological characters, quality characters and stress tolerance indices, as combined data over both seasons 2017/2018 and 2018/2019.

Cluster	Included genotypes	Grain yield		Stress tolerance indices		Physiological characters					Quality characters		
						Chlorophyll							
		N	S	YR	SSI	Total	a	b	RWC	Proline	Protein	Wet gluten	Dry gluten
1	Lines 1 , 8, 5 , 9 ,6	2.62	1.52	0.42	0.96	12.54	9.52	3.02	80.21	0.31	13.59	27.54	10.21
2	Line 7 and Sakha93	2.39	1.23	0.49	1.1	12.44	9.44	3	79.52	0.29	11.67	31.32	12.16
3	Lines 2 ,12,3and 11	2.83	1.44	0.49	1.11	11.82	8.94	2.88	79.4	0.28	13.81	26.01	9.37
4	Line 4, Misr 3 and line 10	2.81	1.87	0.33	0.76	13.45	10.09	3.36	81.77	0.33	13.58	30.89	11.51
5	Giza 171 and Sakha 95	3.7	2.06	0.44	1.01	12.96	9.81	3.15	80.58	0.29	13.23	25.44	9.45

Finally, in the present work and based on cluster analysis which indicate that the two cultivar Sakha 95 and Giza 171 exhibited the highest grain yield under both conditions, moderate value for both yield reduction ratio and stress susceptibility index, moderate values of physiological characters and protein content but they gave the lowest values for both wet and dry gluten contents. So, Sakha 95 and Giza 171 moderately tolerant for soil salinity. On the other hand, Line 4, Misr 3 and Line 10 were considered a highly tolerant for soil salinity since they gave the moderate grain yield at both conditions , lowest values for both yield reduction ratio and stress susceptibility index, maximum values for physiological characters and moderate values for quality characters. So, these genotypes high tolerant for soil salinity. Therefore, these genotypes were highly tolerant for soil salinity and might be used as parents in breeding programs to produce new genotypes with desirable characters related to soil salinity tolerance.

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تقييم بعض التراكيب الوراثية من قمح الخبز تحت ظروف الأراضي الملحية

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أجريت هذه الدراسة بالمزرعة البحثية لمحطة البحوث الزراعية بسخا ، خلال موسمي ٢٠١٨/٢٠١٧ و ٢٠١٩/٢٠١٨ لتقييم ستة عشر تركيب وراثي من قمح الخبز عبارة عن اثنا عشر سلالة مبشرة من برنامج التربية المحلية بالإضافة إلى أربعة أصناف مصرية (جيزة ١٧١، سخا ٩٣ ، سخا ٩٥ ومصر ٣) تحت ظروف الأراضي العادية والأراضي المتأثرة بالملوحة . وكان التصميم المستخدم قطاعات كاملة العشوائية في أربعة مكررات لكل موقع. أشارت النتائج إلى انخفاض كبير في جميع الصفات المدروسة باستثناء محتوى البرولين واختبار التوصيل الكهربائي الذي زاد في الأراضي المتأثرة بالملوحة. بناءً على التحليل العنقودي أظهرت النتائج أن الصنفين سخا ٩٥ وجيزة ١٧١ أعطيا أعلي محصول حبوب تحت ظروف الأراضي العادية والمتأثرة بالملوحة ، وكانت قيم الانخفاض في المحصول ودليل الحساسية للملوحة متوسطة خاصة للصنف ٩٥ وكذلك الصفات الفسيولوجية ونسبة البروتين، لكنها أعطت أقل القيم للجلوتين الرطب والجاف وبذلك فيكون الصنف سخا ٩٥ متوسط الحساسية للزراعة تحت ظروف الأراضي الملحية ، وعلي الوجه الاخر سجلت قيم متوسطة لمحصول الحبوب تحت كلا البيئتين للتراكيب الوراثية السلالة ٤ والسلالة ١٠ والصنف مصر ٣ و الذي اعطي محصولا لا يقل معنويا عن الصنفين سخا ٩٥ وجيزة ١٧١ تحت ظروف الأراضي المتأثرة بالملوحة بالإضافة الي ان نسب الانخفاض في المحصول ودليل الحساسية للملوحة كانت الاقل مقارنة بجميع التراكيب الأخرى، كذلك كانت هذه التراكيب هي الأفضل بالنسبة للصفات الفسيولوجية والتكنولوجية ، و بناءً علية فإن هذه التراكيب (السلالة ٤, السلالة ١٠ و مصر ٣) هي الاكثر تحملا لملوحة التربة و يمكن استخدامها في برامج التربية لتحمل ملوحة التربة.