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Evaluation of Newly Bred Durum Wheat Lines under Salinity Stress

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ABSTRACT

Salt stress have negative impact on crop productivity, so plant breeders interested in obtaining improved lines with high productivity and salt stress tolerance. This study conducted in two seasons (2016/2017 & 2017/2018) to study genetic behavior of nineteen lines of durum wheat, obtained from Arab Center for Studies of Arid Zones and Dry Lands (ACSAD), at Ras-Sudr in two experiments, the first irrigated by salinity of 3900 ppm and the second with 6300 ppm. Variation of lines showed high significance for all traits and three lines, ACSADs: 1487, 1566 and 1567, recorded the highest values for grain yield; its components and straw yield/plant. Results of phenotypic correlation between traits showed positive and significant correlation between grain yield/plant and each of straw yield/plant, spike length, number of spikelets/spike, number of grains/spike and 1000 kernel weight, indicating their significant on grain yield under stress. Six lines in the first group of cluster analysis showed positive association with grain yield, its components and all tolerance indices except SSPI, also their high yield under both conditions. The principle component analysis and cluster analysis revealed positive and high significant correlation between plant grain yield under both conditions, indicating high performance under non-stress resulted in relatively to high yield under stress. The same correlation occurred between both grain yield/plant under non-stress and stress with each of: STI, MP, GMP, and HM; but negative and significant correlation with ATI and SSPI indices. Two best lines, ACSADs 1566 and 1567 can be selected as improved ones under salinity.

Keywords: Durum wheat, saline stress, correlation, tolerance indices

INRRODUCTION

Durum wheat (*Triticum turgidum* subsp. durum (Desf.) Husnot) is one of the most essential cereal species and cultivated worldwide over almost 17 million ha, with a global production of 38.1 million tonnes in 2019 (Agriculture and Agri-Food Canada 2019). The total world global area of saline and sodic soils is estimated to be around 830 million hectares, more than 6% of the world's land (Martinez-Beltran and Manzur 2005 and Acosta-Motos *et al* 2017). Mean while, the salinized arable land will be by 2050 over 50% of total area (Jamil *et al* 2011). Although the actual cost from, it is apparent that losses in yield and profit are significant (McDonald *et al* 2012). Durum wheat Yield reductions under dryland was affected by salinity could be reached 50% b due to the lost of agricultural production varies with crop species, timing, duration, and severity of the stress (James *et al* 2012 and Xie *et al* 2016)

Salinity is one of the major abiotic stresses that adversely affect crop productivity and quality of plants including wheat in worldwide (Chinnusamy *et al* 2005 and Otu *et al* 2018). Globally about 800 million ha of terrestrial land are salt affected, this means that more than 6% of the entire land area (Chutia and Borah 2012). Salinization is a major problem especially in arid and semiarid areas. Egypt suffers from the severe salinity stress, which represents 3% of total land area and affected by low precipitation (≤ 50 ml annual rainfall) and irrigation with saline water (Ghassemi *et al* 1995, Delachiave and Pinho 2003 and Al-Naggar *et al* 2015). Therefore, Incasing wheat production in Egypt was extended to the newly reclaimed lands is a necessity to increase the production to supply the demands of a rapidly growing population and to overcome the gap between consumption and production (Milad *et al* 2016 and Gadallah *et al* 2017).

However, achieving genetic increases in yield under salt stress has consistently proven a difficult challenge for plant breeders (Khayatnezhad and Gholamine 2010). Obviously, the most efficient way to increase wheat yield in Egypt is to improve the salt tolerance of wheat lines (Epstein *et al* 1980, Shannon 1997 and Pervaiz *et al* 2002).

Wheat breeders goals were improvement wheat productivity and reducing salinity stress effects on grain yield and its component which considered to be essential for meeting the growing demand for food under shrinking cultivable land area, for these it is imperative in this context to look for tools to increase the crop productivity as well as ensure protection against loss of potential productivity due to environmental stresses (Kumar *et al* 2012).

Several selection criteria have been proposed for selecting lines based on their performance under stress and/or favorable environments by using a combination of indices (Clarke *et al* 1992; Mohammadi *et al* 2010 Nouri *et al* 2011 and Singh *et al* 2015) aiming at assisting the identification of stable, high yielding, stress tolerant lines: Stress susceptibility index (SSI) (Fischer and Maurer 1978), mean productivity (MP), tolerance index (TOL) (Rosielle and Hamblin 1981), yield stability index (YSI) (Bouslama and Schapaugh 1984), geometric mean productivity (GMP), stress tolerance index (STI) (Fernandez, 1992), harmonic mean of yield (HM) (Jafari *et*

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al 2009 and Dadbakhch *et al* 2011), yield index (YI) (Gavuzzi *et al* 1997), stress susceptibility percentage index (SSPI) and abiotic tolerance index (ATI) (Moosavi *et al* 2008) and sensitivity drought or salinity index (SDI) (Farshadfar and Javadinia 2011). The best indices are those which have high correlation with grain yield in both conditions and would be able to identify potential higher yielding and stress tolerant lines (Fernandez 1990, Mitra 2001, Boussen *et al* 2010, Singh *et al* 2015, Patel *et al* 2019 and Yassin *et al* 2019).

Principal component analysis is one of the most successful techniques for reducing the multiple dimensions of the observed variables to a smaller intrinsic dimensionality of independent variables (Johnson and Wichern 2007 and Singh *et al* 2015). These tolerance indices have been widely used for the evaluation of wheat lines and to improve wheat yield and its stability in stress environments which could be able to distinguish high yielding wheat cultivars in these conditions. (Mohammadi *et al* 2010, Mohammadi *et al* 2011, Anwar *et al* 2011, Singh *et al* 2015 and Yassin *et al* 2019)

In this perspective, the objectives of the study were to investigate the efficiency of salinity selection indices to identify the best salinity tolerant and high yielding of 19 durum wheat lines adapted to both stressed and non-stressed conditions, study the inter-relationships among them and to identify the lines adapted to stressed environment.

MATERIALS AND METHODS

The present investigation was conducted in 2016/17 and 2017/18 seasons under saline conditions at Ras Sudr Agricultural Experiment Station of Desert Research Center at South Sinai Governorate, Egypt (latitude: 29° 37' 26" N, longitude: 32° 42' 43" E and the elevation from sea surface = 36.2 m). The initial plant materials composed of nineteen durum wheat lines (*Triticum turgidum* durum (Desf.) Husnot) were obtained from the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) names, source and pedigree are presented in Table (1). These experiments were conducted to study the effect of two salinity levels of irrigation water i.e. 3900 and 6300 ppm. Mechanical analysis of soil was carried out according to Jackson (1958) as well as Chemical analysis was performed for soil and the two underground well water treatments to determine the content of anions and cations according to Chapman and Pratt (1961) as shown in Table (2).

Table 1. The pedigree, source and origin of the 19 lines of durum wheat.

No.	Names	Pedigree and/or selection history
G1	ACSAD 1453	TERBOL97-5/ACSAD1229 ACS-D-9565(2006)-0IZ-12IZ-1IZ-0IZ
G2	ACSAD 1483	AZEGHAR-1/3/MN2//BCR/GRO1 /4/ SOMAT_3/YEBAS _8//RASCON_ 37/ 2*TARRO_2 ACS -D -9720 (2007) - 2IZ -1IZ-1IZ-0IZ
G3	ACSAD 1487	BCR/GRO1// MGNL1/3/BICREDERAA -1//19912 HASHADI / WAHA ACS -D - 9778 (2008)- 25IZ - 3IZ-1IZ-0IZ
G4	ACSAD 1541	AGHRASS-1/3/MRF1//MRB16/RU /4/ ACSAD 1311 ACS -D -9960 (2009) -1IZ -2IZ-2IZ-0IZ
G5	ACSAD 1551	AGHRASS-1/3/MRF1//MRB16/RU /4/ ACSAD 1331 ACS -D -9964 (2009) - 8IZ -3IZ-1IZ-0IZ
G6	ACSAD 1553	AGHRASS-1/3/MRF1//MRB16/RU /4/ ACSAD 1331 ACS -D -9964 (2009) - 8IZ -3IZ-2IZ-0IZ
G7	ACSAD 1561	MSBL-1//KRF/HCN /3/ ACSAD 1317 ACS -D -9967 (2009) - 20IZ -3IZ-3IZ-0IZ
G8	ACSAD 1565	BCR/LKS4//MRF1/STJ2 /3/ STJ3 // BCR / LKS-4 ACS -D - 10048 (2010)- 7IZ - 1IZ-3IZ-0IZ
G9	ACSAD 1566	BCR/LKS4//MRF1/STJ2 /3/ ACSAD 1347 ACS -D - 10051 (2010)- 1IZ - 1IZ-1IZ-0IZ
G10	ACSAD 1567	BCR/LKS4//MRF1/STJ2 /3/ ACSAD 1347 ACS -D - 10051 (2010)- 1IZ - 1IZ-2IZ-0IZ
G11	ACSAD 1568	BCR/LKS4//MRF1/STJ2 /3/ ACSAD 1347 ACS -D - 10051 (2010)- 12IZ - 1IZ-3IZ-0IZ
G12	ACSAD 1569	GBY/4/QUADLETE//ERP/3/UNK/5/TERBOL97-1 /6/ OMRABI5 / AZEGHAR-2 ACS -D - 10119(2010)- 1IZ - 3IZ-1IZ-0IZ
G13	ACSAD 1573	MSBL-1//KRF/HCN/3/ ACSAD 1317 ACS-D – 9967 (2009)- 18IZ-2IZ – 2IZ- 0IZ
G14	ACSAD 1575	TER-1// MRF1/STJ2/6/ GBY/4/ QUADLETE//ERP/3/UNK/5/TERBOL97-1 ACS-D-10053 (2010) – 14IZ-2IZ-1IZ-0IZ
G15	ACSAD 1589	ACSAD 1355 /3/ ICASYR-1//MRF-2/T.DIDS SY 20123 ACS - D - 10350 (2012)- 19IZ - 2 IZ-1IZ
G16	ACSAD 1591	ACSAD 1105 / OMRABI 5 ACS - D - 10364 (2012) - 24IZ - 1IZ-1IZ
G17	ACSAD 1593	ACSAD 1105 // AZEGHAR-2/MURLAGOST-2 ACS - D - 10366 (2012)- 15IZ - 1IZ-3IZ
G18	ACSAD 1595	ACSAD 1105 // AZEGHAR-2/MURLAGOST-2 ACS - D - 10366 (2012)- 18IZ - 3IZ-1IZ
G19	ACSAD 1605	ACSAD 1187 /3/ SEBATEL-2//WDZ6/GIL4 ACS - D - 10373 (2012) - 9IZ -3IZ-3IZ

ACSAD ; Arab Center for the Studies of Arid Zones and Dry Lands, Syria.

Table 2. Soil and irrigation water analysis for the experimental site at Ras Sudr region over two seasons.

A) Soil mechanical analysis of the experimental site

Depth (cm)	Coarse sand %	Fine sand %	Silt %	Clay %	Texture
0-15	22.61	45.49	16.48	15.33	Sandy loam
15-30	35.20	28.40	18.96	17.10	Sandy loam

B) Soil chemical analysis at 0-15 and 15-30 cm depth

Depth (cm)	pH	EC_e dSm^{-1}	$CaCo_3$	Soluble cations (mg/100g)				Soluble anions (mg/100g)			
				Na^+	Ca^{++}	Mg^{++}	K^+	CO_3^-	HCO_3^-	Cl^-	SO_4^{--}
0-15	7.49	8.54	45.62	48.04	21.21	41.86	1.62	-----	10.85	51.48	27.35
15-30	7.81	8.84	48.34	43.24	19.26	46.80	2.23	-----	11.6	56.23	20.24

C) Irrigation water chemical analysis

Salinity level (ppm)	pH	EC dSm^{-1}	Soluble cations (mg/100g)				Soluble anions (mg/100g)			
			Na^+	Ca^{++}	Mg^{++}	K^+	CO_3^-	HCO_3^-	Cl^-	SO_4^{--}
3900	7.65	6.09	36.38	24.73	15.17	0.31	-----	4.65	62.75	31.29
6300	8.66	9.84	40.25	32.58	22.91	0.37	-----	5.69	65.51	47.30

Surface gated pipe irrigation (GPI) system was applied in these experiments; there is no effective amount of rainfall registered in the two growing seasons for Meteorological data (the monthly mean of temperature, relative humidity and wind speed) are presented in Table (3).

Sowing date was 15 and 18 November in the two seasons, respectively while plot area was of 5 x 5 m. The recommended dose of phosphatic fertilizer at rate (50 Kg P_2O_5/fed.) was added during seed bed preparation, whereas nitrogen fertilizer at rate of 60 kg N/fed. was applied as ammonium sulfate (20.5% N) where 1/3 of the amount was incorporated in dry soil before sowing, 1/3 was added one week before panicle initiation growth stage 18 and the rest was added at grain filling period growth stage 50 of Zadoks' scale (Zadok *et al* 1974).

Table 3. Monthly average weather data at Ras sudr during 2016/17 and 2017/18 growing seasons.

Month	Average(C°)	Min. T† (C°)	Max. T† (C°)	R.H. ●%	W.S.♦ km/h	Amount Rainfall (mm)
			2016/17 season			
Nov.2016 (Mean)	20.35	14.60	26.10	61.09	18.00	2
Dec.2016 (Mean)	15.85	10.30	21.40	58.15	22.80	3
Jan.2017 (Mean)	14.20	8.60	19.80	60.52	17.64	3
Feb.2017(Mean)	14.95	9.10	20.80	62.21	26.88	2
March.2017 (Mean)	17.60	11.40	23.80	70.35	32.00	3
April.2017 (Mean)	21.25	14.50	28.00	76.53	26.88	2
May.2017 (Mean	25.10	17.90	32.30	65.89	23.04	0
			2017/18 season			
Nov.2017 (Mean)	22.65	16.06	29.23	70.26	19.98	3
Dec.2017 (Mean)	17.65	11.33	23.97	66.87	25.31	5
Jan.2018 (Mean)	15.82	9.46	22.18	69.60	19.58	4
Feb.2018(Mean)	16.45	10.01	22.88	71.54	29.84	2
March.2018 (Mean)	19.25	12.31	26.18	80.90	35.52	2
April.2018 (Mean)	23.23	15.66	30.80	88.01	29.84	0
May.2018 (Mean)	27.43	19.33	35.53	75.78	25.57	0

†T= Temperature, ● R.H. %= Relative humidity percentage, ♦ W.S.= Wind speed.

The combined data after testing for homogeneity as the following traits; number of days to heading (days), number of days to maturity (days), plant height (cm.), number of spikes/plant, number of spikelets/spike, 1000 kernel weight (g.), number of grains per spike and grain yield for each individual plant (g.) under the two salinity levels non-stress (S1- 3900 ppm) and stress (S2 - 6300 ppm) conditions were subjected to analysis according to Gomez and Gomez (1984) to estimate the simple statistic i.e., mean, standard error and simple correlation.

For each genotype, ten salt tolerance indices were calculated based on average grain yield under normal (Yn) and stress (Ys) sites over the two seasons. The names, equations and references of the stress tolerance indices are shown in (Table, 4). Salt tolerance indices were analyzed by cluster and principal component analysis with Software program 'SPSS' v 16.0 (SPSS Inc. 2007 Chicago, IL, USA) software program. While, principal component analysis (PCA) and Cluster analysis identifies variable which are further clustered into main group and subgroups using methods (Ward 1963 and Kumar *et al* 2009). This was done to interpret relationships among selection criteria, to compare lines on the basis of salt tolerance indices and to identify lines or groups of lines with a certain level of salt tolerance. All the statistical analysis was performed using SPSS v 16.0.

Table 4. Drought tolerance indices Index, Formula, Reference and Stress

No.	Index name	Formula	Reference
	The high values of these indices indicated to saline stress tolerance		
1	Mean Productivity (MP)	(Yn+Ys)/2	Rosielle and Hamblin (1981)
2	Harmonic Mean (HM)	(2*Yn*Ys)/(Yn+Ys)	Jafari *et al* (2009).
3	Geometric Mean Productivity (GMP)	$(Yn*Ys)^{0.5}$	Fernández (1992)
4	Stress Tolerance Index (STI)	$(Yn \times Ys)/(\acute{Y}n)^2$	Fernandez(1992)
5	Yield Index (YI)	Ys/Ý s	Gavuzzi *et al* (1997)
6	Yield Stability Index (YSI)	Ys/Yp	Bouslama and Schapaugh (1984)
7	Sensitivity drought or salinity index (SDI)	(Yni - Ysi) / Yni	Farshadfar and Javadinia (2011)
8	Abiotic tolerance index (ATI)	((Yni - Ysi) / (Yn / Ys)) * (√Yni * Ysi)	Moosavi *et al* (2008)
	The low values of these indices indicated to saline stress tolerance		
9	Tolerance Index (TOL)	Yn-Ys	Rosielle and Hamblin (1981)
10	Stress Susceptibility Percentage Index (SSPI)	Tol*100/(2*Ý n)	Moosavi *et al* (2008)
11	Stress Susceptibility Index (SSI)	[1-(Ys/Yn)]/[1-(Ý s / Ý n)]	Fischer and Maurer (1978)

- Yn and Ys indicate to average grain yield of each genotype under normal and stress conditions
- Ý n and Ý s indicate to average grain yield overall lines under normal and stress conditions

RESULTS AND DISCUSSION

Analysis of variance

Highly significant differences (P <.05) effects were observed among lines (G) tested for all studied agronomic traits under each; non stress (S1), stress (S2) conditions and combined (Table 5). In addition to the three traits; Days to 50% heading (days), no. of spikes/plant and straw yield/plant recorded highly significant variance of years under S1, S2 and combined. All measured traits were also highly and significantly (P < .05) affected by the variation of salinity stress, as well as the Interaction G.×S. had significant effects under Ras sudr conditions, which indicated that lines were differing for genes controlling traits under both treatments, suggesting the importance of genotype assessment under different environments to identify the best ones for a particular treatment. In general, these results are in harmony with those reported by Al-Naggar *et al* (2015), Abdelsalam and Kandil (2016), Ragab and Taha (2016), Darwish *et al* (2017), Patel *et al* (2019) and Yassin *et al* (2019).

Table 5. Analysis of variance for 19 durum wheat lines under the two salinity levels non-stress (S1) and stress (S2) over the two seasons and it's combined at Ras surd conditions.

SOV		df	Days to 50% heading (days)	Plant height (cm.)	No of spikes/ Plant	Spike length (cm.)	No of spikelets/ spike	No of grains/ spike	1000-kernel weight (g.)	Grain yield/ Plant (g.)	Straw yield/plant (g.)
S1	Y.	1	49.34**	2.53	2.84**	0.10	0.62	35.92	0.008	0.12	62.50**
	G.	18	148.22**	363.50**	8.62**	0.96**	14.80**	235.23**	0.61**	97.95**	378.41**
	G.× Y.	18	2.47**	1.66	0.19	0.12	0.81	32.37	0.01	1.77	64.97
	Error	76	1.08	2.67	0.40	0.17	1.72	76.59	0.012	3.82	87.42
S2	Y.	1	34.81**	4.24	1.06**	0.56	5.56	139.37	0.07	9.87	94.55
	G.	18	78.21**	205.99**	12.74**	3.13**	47.76**	3064.13**	0.82**	169.39**	916.00**
	G.× Y.	18	3.59**	4.57	0.22	0.07	0.48	86.65	0.02	3.83	25.09
	Error	76	1.65	5.73	0.68	0.71	6.08	215.44	0.11	25.04	76.22
Comb.	Y.	1	5700.01**	410.00	6.26**	1.78	18.49	58.98	0.08	21.63	378.68**
	S.	1	0.63	1924.67**	13.68**	2.98**	38.07**	2675.26**	1.80**	161.03**	1781.18**
	Y.×S.	1	83.52**	62.10	0.21	0.32	3.75	8.03	0.07	8.95	25.87
	G.	18	216.18**	8482.02**	20.56**	7.012**	129.97**	1013.70**	4.11**	710.85**	2659.41**
	G.×Y.	18	10.25**	7.47	0.80	0.08	2.60	5.67	0.01	6.49	35.00
	G.×S.	18	3.81**	2403.80**	20.35**	3.16**	40.69**	141.67**	1.52**	303.14**	1022.34**
	G.×S.×Y.	18	22.24**	2.43	0.06	0.03	0.60	17.35	0.01	2.46	17.72
	Error	144	1.34	814.35	5.56	2.12	21.03	105.95	0.11	114.62	137.85

***,** Denote significance at P ≤0.05 and 0.01 probability level, respectively.**

Mean performance of durum wheat lines under nonstress and stress conditions

Under salinity stress, all agronomic traits were affected, it is clear that all traits decreased significantly with S2 conditions compared with S1 conditions. Mean performances combined across the two seasons under non stress (S1), stress (S2) conditions as well as combined data for yield and its components of 19 durum wheat lines are presented in Tables (6, 7 and 8). For Days to 50% heading (days) the three lines ACSAD 1565, ACSAD 1573 and ACSAD 1567 were the earliest under S1, S2 and combined without significant differences among them, which had values ranged from 70.67 days for ACSAD 1567 under S2 to 78.18 days for ACSAD 1567 under S1 treatments. While, the two lines ACSAD 1551 and ACSAD 1593 were the tallest and shortest lines (96.33 cm.) and (96.33 cm.), respectively under combined for plant height. Regarding number of spikes/plant, the highest number was recorded by ACSAD 1541 (8.83, 8.00 and 8.42 spikes/plant for S1, S2 and combined, respectively) followed by the three lines ACSAD 1553, ACSAD 1589 and ACSAD 1605 with significant differences under stress, non stress conditions as well as the combined data (Table 6).

Table 6. Mean performance combined across the two growing seasons for Days to 50% heading, Plant height and No of spikes/plant of 19 durum wheat lines under non-stress (S1) and stress (S2) conditions.

Lines	Days to 50% heading			Plant height			No of spikes/plant		
	S1	S2	Comb	S1	S2	Comb	S1	S2	Comb
ACSAD 1453	88.67	77.00	82.83	102.67	86.33	94.50	6.50	5.50	6.00
ACSAD 1483	85.83	74.83	80.33	94.17	77.83	86.00	6.17	5.33	5.75
ACSAD 1487	90.17	78.50	84.33	93.17	78.67	85.92	4.67	4.00	4.34
ACSAD 1541	92.50	81.17	86.83	103.17	84.67	93.92	8.83	8.00	8.42
ACSAD 1551	92.83	80.33	86.58	105.00	87.67	96.33	4.83	4.17	4.50
ACSAD 1553	89.17	77.83	83.50	96.67	81.33	89.00	7.83	7.17	7.50
ACSAD 1561	80.83	71.83	76.33	99.00	83.17	91.08	4.83	3.5	4.17
ACSAD 1565	77.17	70.83	74.00	91.00	75.33	83.17	5.50	4.17	4.84
ACSAD 1566	82.83	74.50	78.67	96.33	81.50	88.92	6.83	5.83	6.33
ACSAD 1567	78.16	70.67	74.42	88.00	74.33	81.17	4.5	3.17	3.84
ACSAD 1568	86.83	76.83	81.83	92.50	77.50	85.00	4.5	2.83	3.67
ACSAD 1569	90.00	80.67	85.33	102.00	86.00	94.00	6.33	5.67	6.00
ACSAD 1573	78.18	71.17	74.67	85.33	72.17	78.75	5.83	5.50	5.67
ACSAD 1575	89.67	76.83	83.25	97.67	82.67	90.17	7.67	6.83	7.25
ACSAD 1589	81.17	70.83	76.00	90.83	76.83	83.83	6.67	6.17	6.42
ACSAD 1591	85.50	77.00	81.25	92.67	81.00	86.83	5.93	4.73	5.33
ACSAD 1593	82.67	72.67	77.67	76.17	62.50	69.33	5.83	4.17	5.00
ACSAD 1595	86.17	74.83	80.50	92.00	78.17	85.08	7.33	6.17	6.75
ACSAD 1605	90.50	80.17	85.33	93.50	79.33	86.42	7.83	7.45	7.64
Average	85.73	75.71	80.72	94.31	79.32	86.81	6.23	5.28	5.76
L.S.D. 0.05									
Y.	0.39	0.48	0.43	n.s	n.s	n.s	n.s	n.s	0.14
S.			n.s			0.45			0.25
G.	1.20	1.48	0.74	1.88	2.75	0.53	0.73	0.95	0.61
G.× Y.	1.70	2.09	0.93	n.s	n.s	n.s	n.s	n.s	n.s
Y.×S.			1.32			1.68			n.s
G.×S.			1.32			2.38			0.68
G.×S.×Y.			1.87			n.s			n.s

Table 7. Mean performance combined across the two growing seasons for Days to 50% heading Spike length, No. of spikelets/spike and No. of grains/spike of 19 durum wheat lines under non-stress (S1) and stress (S2) conditions.

Lines	Traits								
	Spike lenght			**No. of spikelets/spike**			**No. of grains/spike**		
	S1	**S2**	**Comb**	**S1**	**S2**	**Comb**	**S1**	**S2**	**Comb**
ACSAD 1453	7.17	6.75	6.96	22.67	20.67	21.67	66.00	64.67	65.34
ACSAD 1483	7.00	6.42	6.71	22.00	19.00	20.50	59.50	57.83	58.67
ACSAD 1487	7.33	6.83	7.08	22.14	20.67	21.41	70.17	66.00	68.09
ACSAD 1541	6.75	6.42	6.59	19.33	18.67	19.00	69.33	60.17	64.75
ACSAD 1551	7.25	6.75	7.00	20.67	20.00	20.34	65.50	62.67	64.09
ACSAD 1553	6.25	5.92	6.09	19.67	18.33	19.00	62.33	56.83	59.58
ACSAD 1561	6.50	5.67	6.09	20.00	18.33	19.17	65.00	60.50	62.75
ACSAD 1565	6.17	5.50	5.84	18.00	15.67	16.84	64.00	62.17	63.09
ACSAD 1566	7.17	6.92	7.05	22.67	22.33	22.50	73.83	68.83	71.33
ACSAD 1567	6.25	6.00	6.13	20.67	18.33	19.50	69.50	66.00	67.75
ACSAD 1568	6.83	6.25	6.54	18.67	17.33	18.00	63.00	59.33	61.17
ACSAD 1569	6.42	5.92	6.17	22.00	18.67	20.34	62.33	59.50	60.92
ACSAD 1573	6.67	6.25	6.46	20.00	17.67	18.84	62.50	61.83	62.17
ACSAD 1575	6.75	6.16	6.46	21.25	19.33	20.29	67.67	60.17	63.92
ACSAD 1589	6.58	6.04	6.31	19.67	17.33	18.50	61.00	59.17	60.09
ACSAD 1591	6.42	5.58	6.00	17.33	16.33	16.83	63.17	59.33	61.25
ACSAD 1593	6.25	5.67	5.96	19.00	16.00	17.50	67.67	64.50	66.09
ACSAD 1595	6.17	6.00	6.09	20.00	18.00	19.00	64.33	61.50	62.92
ACSAD 1605	7.08	6.50	6.79	22.00	20.33	21.17	69.67	65.33	67.50
Average	6.68	6.19	6.44	20.41	18.58	19.49	65.45	62.07	63.76
L.S.D. 0.05									
Y.	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
S.			0.09			0.47			1.27
G.	0.42	0.40	0.29	1.22	1.20	0.65	4.68	4.52	3.22
G.× Y.	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
Y.×S.			n.s			n.s			n.s
G.×S.			0.13			0.82			4.56
G.×S.×Y.			n.s			n.s			n.s

Table 8. Mean performance combined across the two growing seasons for Days to 50% heading, Plant height and No of spikes/plant of 19 durum wheat lines under non-stress (S1) and stress (S2) conditions.

Lines	Traits								
	1000-kernel weight			**Grain yield/plant**			**Straw yield/plant**		
	S1	**S2**	**Comb**	**S1**	**S2**	**Comb**	**S1**	**S2**	**Comb**
ACSAD 1453	44.8	41.4	43.1	22.60	15.95	19.27	43.32	31.55	37.44
ACSAD 1483	46.7	42.6	44.6	13.91	13.60	13.76	29.04	26.23	27.64
ACSAD 1487	49.4	45.0	47.2	23.15	17.57	20.36	45.52	32.29	38.90
ACSAD 1541	45.8	41.1	43.5	16.26	11.93	14.10	31.69	23.61	27.65
ACSAD 1551	49.5	46.5	48.0	15.68	12.04	13.86	29.05	23.19	26.12
ACSAD 1553	44.8	42.0	43.4	21.88	17.15	19.51	42.4	30.1	36.25
ACSAD 1561	45.7	41.8	43.8	13.35	9.65	11.50	25.1	17.33	21.22
ACSAD 1565	43.0	40.6	41.8	14.62	10.45	12.53	27.74	19.6	23.67
ACSAD 1566	53.9	49.7	51.8	24.90	19.68	22.29	45.60	35.17	40.39
ACSAD 1567	45.9	41.0	43.4	23.21	19.19	21.20	42.96	32.07	37.52
ACSAD 1568	45.3	42.6	43.9	12.04	7.67	9.85	20.94	13.15	17.05
ACSAD 1569	42.5	39.6	41.1	16.64	13.29	14.96	30.55	23.65	27.10
ACSAD 1573	41.6	38.2	39.9	15.12	13.02	14.07	27.63	23.45	25.54
ACSAD 1575	43.4	38.8	41.1	22.41	15.92	19.17	41.71	27.58	34.65
ACSAD 1589	42.0	39.1	40.5	17.04	14.25	15.65	31.28	25.17	28.23
ACSAD 1591	44.4	41.1	42.8	16.35	11.73	14.04	32.18	21.59	26.89
ACSAD 1593	43.8	40.5	42.1	16.40	11.36	13.88	31.64	21.1	26.37
ACSAD 1595	40.7	37.5	39.1	19.18	14.14	16.66	35.5	25.42	30.46
ACSAD 1605	42.5	39.6	41.0	12.85	8.58	10.72	22.79	14.87	18.83
Average	45.0	41.5	43.3	17.77	13.54	15.65	33.51	24.59	29.05
L.S.D. 0.05									
Y.	n.s	n.s	n.s	n.s	n.s	n.s	1.95	1.91	0.88
S.			0.50			0.30			0.88
G.	1.30	1.52	1.00	2.25	2.58	1.74	6.02	5.89	4.26
G.× Y.	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s	n.s
Y.×S.			n.s		n.s				n.s
G.×S.			0.80			0.92			1.24
G.×S.×Y.			n.s			n.s			n.s

The three lines ACSAD 1487, ACSAD 1551 and ACSAD 1566 had the highest number for spike length ranged from 7.33 cm. for ACSAD 1487 under S1 to 6.92 cm. for ACSAD 1566 under S2 treatments, respectively. Concerning number of spikelets/spike, the genotype ACSAD 1566 recorded the highest number 22.67, 22.33 and 22.50 spikelets/spike under S1, S2 and combined, respectively followed by the six lines ACSAD 1453, ACSAD 1483, ACSAD 1487, ACSAD 1569, ACSAD 1575 and ACSAD 1605 without significant differences under one and/or the two treatments as well as the combined data. Mean while, the genotype ACSAD 1566 had the highest no. of grains/spike (73.83, 68.83 and 71.33 grains/spike) under the two treatments and combined respectively, followed by the two lines ACSAD 1487 and ACSAD 1567 with significant differences (Table, 7).

Regarding to 1000-kernel weight, grain yield/plant and straw yield/plant the genotype ACSAD 1566 had the highest values (51.80 g., 22.29 g. and 40.39 g.) for combined, respectively followed by the two lines ACSAD 1487 and ACSAD 1567 for grain yield/plant and straw yield/plant with significant differences under non stress, stress conditions as well as the combined data (Table,8). Evaluation lines under salinity stress conditions considered as a tool for enabling to differentiate among lines and select the tolerant one(s). The variance of genotypic performance under salinity stress was early reported for one and/or more traits by several investigators (El-Hendawy *et al* 2005, Panahi *et al* 2006, Turki *et al* 2006, Abdelsalam and Kandil 2016, Dadshani *et al* 2019, Yassin *et al* 2019 and Gadimaliyeva *et al* 2020).

Phenotypic correlations

The relationship between each pair traits under study plays an important role in durum wheat breeding programs. Correlation coefficient values among all traits under study combined their original data across the two growing seasons and the two salinity treatments are presented in Table (9). A positive and significant correlation was found between; days to 50% heading and each of plant height, spike length, grain yield/plant and straw yield/plant and between plant height and both traits no. of spikelets/spike and 1000-kernel weight. As well as no. of spikes/plant and each of grain yield/plant (g) (0.913**) and straw yield/plant (g) (0.874**) and spike length with each of no. of spikelets/spike, no. of grains/spike, 1000-kernel weight, grain yield/plant and straw yield/plant. The most important positive and highly significant relationships were the correlation coefficient between grain yield/plant and each of spike length (cm.) (0.659**), no. of spikelets/spike (0.827**), no. of grains/spike (0.878**), 1000-kernel weight (g.) (0.663**) and straw yield/plant (g.) (0.986**). This indicated that such traits had the greatest influence on grain yield under respective stress environments. the previous results are in agreement with these findings of (Ayed *et al* 2014, Naghavi and Khalili, 2017, Dadshani *et al* 2019 and Gadimaliyeva *et al* 2020).

Table 9. Coefficients of correlation between the studied traits for 19 durum wheat lines over Combined for the salinity treatments and two seasons.

Traits	Days to 50% heading (days)	Plant height (cm.)	No of spikes/ Plant	Spike length (cm.)	No of spikelets/ spike	No of grains/ spike	1000-kernel weight (g.)	Grain yield/ Plant (g.)
Plant height (cm.)	0.640**							
No of spikes/Plant	0.403	0.265						
Spike length (cm.)	0.472*	0.414	0.080					
No of spikelets/spike	0.393	0.664**	0.177	0.809**				
No of grains/spike	0.006	-0.079	-0.103	0.607**	0.778**			
1000-kernel weight (g.)	0.455	0.474*	-0.197	0.626**	0.787**	0.221		
Grain yield/Plant (g.)	0.527*	0.393	0.913**	0.659**	0.827**	0.878**	0.663**	
Straw yield/plant (g.)	0.504*	0.384	0.874**	0.594*	0.767**	0.236	0.198	0.986**

***,** Denote significance at P ≤0.05 and 0.01 probability level, respectively.**

Salt tolerance indices.

Screening methods for characterizing salt tolerance indices and adaptation of lines to different salinity stress treatments S1 and S2 are presented in (Table 10). According to grain yield/plant in non-stress (Yp) and under salinity stress conditions (Ys) eleven quantitative stress tolerant indices were calculated and presented in Table 10 across seasons.

The six lines ACSAD 1453, ACSAD 1487, ACSAD 1553, ACSAD 1566, ACSAD 1567 and ACSAD 1575 exhibited the highest values and similar ranks for mean productivity (MP), harmonic mean (HM), geometric mean productivity (GMP), stress tolerance index (STI), Yield Index (YI) and abiotic tolerance index (ATI) as well as for tolerance index (TOL) except the genotype ACSAD 1553 which considered to be the best parameters for selection under salinity stress conditions. Therefore, these lines were considered the most tolerant and high-yielding under salinity stress and non- stress conditions (Table 10). Meanwhile the two lines ACSAD 1483 and ACSAD 1573 displayed the highest values for Yield Stability Index (YSI) and lowest values of Sensitivity drought or salinity index (SDI), tolerance index (TOL), Stress Susceptibility Percentage Index (SSPI) and Stress Susceptibility Index (SSI) as well as grain yield under stress and non-stress condition. Farshadfar *et al* (2013) indicated that the lines with high STI usually have high difference in yield in two different conditions and GMP and MP parameters as well as STI had similar ranks for the lines and suggested that these three parameters are equal for screening tolerant lines. Similar findings were obtained by Boussen *et al* (2010), Turki *et al* (2014), Singh *et al* (2015), Sahar *et al* (2016), Darwish *et al* (2017), Mohammadi and Abdulahi (2017), Dadshani *et al* (2019), Patel *et al* (2019) and Yassin *et al* (2019)therefore, breeders should select this parameter for selection of salinity stress-tolerant lines

Correlation analysis between grain yield and salinity indices

Grain yield under stress and non-stress conditions across the two seasons and salinity tolerance/resistance indices as well as correlation coefficient are presented in Table 11. There was highly positive significant correlation between grain yield under non-stress conditions (Yp) and grain yield under stress (Ys) (r = 0.836**). This indicates that high yield performance under non-stress condition resulted in relatively high yield under stress conditions. Both (Ys) and (Yp) were highly significant and positively correlated (P<0.01) with mean productivity (MP), harmonic mean (HM), geometric mean productivity (GMP), stress tolerance index (STI), yield index (YI) and abiotic tolerance index (ATI), which indicated that they were better predictors of Ys and Yp and these criteria were more effective in identifying high yielding lines. These six indices are useful to discriminate salt tolerant and yield stable lines under different saline conditions.

Table 10. Mean values of different salinity indices for nineteen tested durum wheat lines across the two seasons.

Lines	MP	HM	GMP	STI	YI	YSI	SDI	ATI	TOL	SSPI	SSI
ACSAD 1453	19.28	18.70	18.99	1.14	1.18	0.71	0.29	96.18	6.65	5907.83	1.24
ACSAD 1483	13.76	13.75	13.75	0.60	1.00	0.98	0.02	3.25	0.31	275.40	0.09
ACSAD 1487	20.36	19.98	20.17	1.29	1.30	0.76	0.24	85.73	5.58	4957.24	1.01
ACSAD 1541	14.10	13.76	13.93	0.61	0.88	0.73	0.27	45.94	4.33	3846.75	1.12
ACSAD 1551	13.86	13.62	13.74	0.60	0.89	0.77	0.23	38.10	3.64	3233.76	0.97
ACSAD 1553	19.52	19.23	19.37	1.19	1.27	0.78	0.22	69.80	4.73	4202.11	0.91
ACSAD 1561	11.50	11.20	11.35	0.41	0.71	0.72	0.28	31.99	3.70	3287.06	1.16
ACSAD 1565	12.54	12.19	12.36	0.48	0.77	0.71	0.29	39.26	4.17	3704.61	1.20
ACSAD 1566	22.29	21.98	22.14	1.55	1.45	0.79	0.21	88.03	5.22	4637.42	0.88
ACSAD 1567	21.20	21.01	21.10	1.41	1.42	0.83	0.17	64.63	4.02	3571.35	0.73
ACSAD 1568	9.86	9.37	9.61	0.29	0.57	0.64	0.36	31.99	4.37	3882.29	1.52
ACSAD 1569	14.97	14.78	14.87	0.70	0.98	0.80	0.20	37.95	3.35	2976.12	0.85
ACSAD 1573	14.07	13.99	14.03	0.62	0.96	0.86	0.14	22.45	2.10	1865.63	0.58
ACSAD 1575	19.17	18.62	18.89	1.13	1.18	0.71	0.29	93.38	6.49	5765.68	1.22
ACSAD 1589	15.65	15.52	15.58	0.77	1.05	0.84	0.16	33.12	2.79	2478.62	0.69
ACSAD 1591	14.04	13.66	13.85	0.61	0.87	0.72	0.28	48.74	4.62	4104.38	1.19
ACSAD 1593	13.88	13.42	13.65	0.59	0.84	0.69	0.31	52.40	5.04	4477.51	1.29
ACSAD 1595	16.66	16.28	16.47	0.86	1.04	0.74	0.26	63.23	5.04	4477.51	1.10
ACSAD 1605	10.72	10.29	10.50	0.35	0.63	0.67	0.33	34.15	4.27	3793.45	1.39
Std. Error	0.81	0.76	0.09	0.06	0.08	0.03	0.01	0.58	0.03	0.96	0.01

While, grain yield in stress condition (Ys) was significantly and positively corrected with stress susceptibility percentage index (SSPI) and Stress susceptibility index (SSI) indicating that these two criteria were more effective in identifying high yielding cultivars under salinity stress conditions. In generally, the observed relations were consistent with those reported by Boussen *et al* (2010), Farshadfar *et al* (2013), Singh *et al* (2015), Sahar *et al* (2016), Mohammadi and Abdulahi (2017), Patel *et al* (2019), Yassin *et al* (2019) and Gadimaliyeva *et al* (2020).

Table 11. Spearman rank correlation coefficients of Yn, Ys and eleven salinity tolerance indices for the nineteen durum wheat lines

Trait	Yn	Ys	MP	HM	GMP	STI	YI	YSI	SDI	ATI	TOL	SSPI	SSI
Yn	1												
Ys	0.836**	1											
MP	0.781**	0.987**	1										
HM	0.888**	0.979**	0.909**	1									
GMP	0.985**	0.983**	0.943**	0.869**	1								
STI	0.975**	0.942**	0.965**	0.994**	0.994**	1							
YI	0.910**	0.938**	0.982**	0.989**	0.986**	0.976**	1						
YSI	0.440	0.217	0.262	0.259	0.281	0.243	0.461	1					
SDI	-0.440	-0.104	-0.240	-0.300	-0.281	-0.243	-0.435	-0.923**	1				
ATI	0.674**	0.889**	0.803**	0.778**	0.791**	0.801**	0.678**	-0.336	0.336	1			
TOL	0.260	0.683**	0.428	0.395	0.324	0.343	0.244	-0.712**	0.780**	0.784**	1		
SSPI	0.260	0.641**	0.442	0.405	0.458	0.462	0.265	-0.745**	0.632**	0.628**	0.861**	1	
SSI	-0.434	-0.097	-0.255	-0.292	-0.274	-0.236	-0.428	-0.876**	0.925**	0.343	0.777**	0.635**	1

***,** Denote significance at P ≤0.05 and 0.01 probability level, respectively.**

Cluster analysis

The cluster analysis based on Ward's method and Euclidean distance was performed to classify the lines on the basis of yield, its components and salt tolerance indices across salinity treatments. The genetic diversity among the tested lines considered to be the key to get reliable and sustainable production of crops. The cluster analysis hierarchical classified lines into clusters which exhibit high homogeneity within a cluster and high heterogeneity between clusters.

In the present work, Lines were grouped into various clusters on the basis of their performance under various conditions which is displayed in a dendrogram (Fig. 1). This dendrogram for nineteen durum wheat lines were estimated based on grain yield and its related characters. The following two lines were the most closely related for each; G 6 and 14 (similarity = 96.25%), G 8 and 13 (similarity = 95.81%), G 15 and 18 (similarity = 94.71%), G2 and 16 (similarity = 95.68%) and G 4 and 12 (similarity = 94.60%).

The lines were classified into two main groups (clusters) where the first main cluster contained two sub clusters; 1st sub cluster included 3 lines (G 6, 14 and 1) that had the highest mean values for each of number of spikelets/spike, while the 2nd sub cluster included 3 lines (G3, 6 and 9) that recorded the highest values for 1000 kernel weight, gain and straw yield/plant which revealed that the grouping of these lines in one cluster that had better performance in yield and its attributes could be used as promising lines under salinity stress conditions.

Meanwhile, the 3rd cluster included the earliest in heading 2 lines (G8 and 13). The second main cluster consists of three sub clusters; 1st sub cluster included 6 lines (G 8, 13, 15, 18, 2 and 16), while the 2nd sub cluster included 3 lines (G4, 12 and 5) and the 3rd cluster included 3 lines (G 7, 11 and 19). Similar results were obtained by Farshadfar *et al* (2013), Singh *et al* (2015), Bhattarai *et al* (2017) and Yassin *et al* (2019) also concluded lines which had high performance were positively associated with yield and its components and grouped in one cluster.

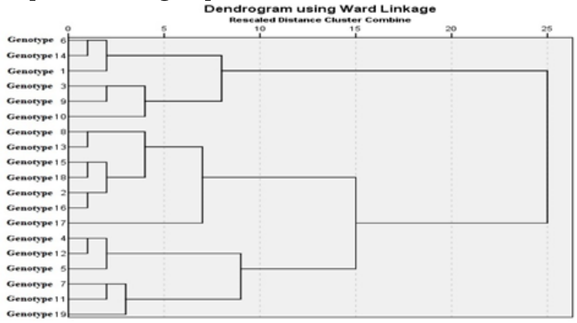

Fig. 1. Dendrogram resulting from cluster analysis of nineteen durum wheat lines based on grain yield, its components and tolerance indices.

Principle component analysis

In order to identify salinity tolerant lines, three dimensional plots based on Yp, Ys, stress tolerant indices were drawn (Fig. 2). Selection of lines that have high PCA1 and low PCA2 are suitable for both salinity treatments conditions. Therefore, ACSAD 1553, ACSAD1566 and ACSAD1567 are the superior lines for both S1 and S2 conditions with high PC1 and low PC2. The relationships among salinity tolerance indices are graphically displayed in a plot of two first principal components (PC1 and PC2) analysis (Fig. 2). The first and second components justified 99.46 % of the variations between criteria (62.68 and 36.79 % for PC1 and PC2, respectively). The PC1 mainly distinguishes the STI, MP, GMP and HM indices from the other remained indices, and the PC2 distinguishes the two indices SDI and SSI from the indices which related to each other based on the PC1 scores (Fig. 2). One of the interesting interpretations of this plot is that the cosine of the angle between the vectors of the eleven indices approximates the correlation coefficient between them. The cosine of the angles does relatively translate into correlation coefficients, since the plot of principal components analysis does explain most of the variation in a data set. Therefore, it could be concluded that the STI, MP, GMP and HM indices are positively associated with each other (Fig. 1). Also, positive associations were observed between ATI and SSPI with Yp. Similar findings were obtained by Farshadfar *et al* (2013), Singh *et al* (2015) and Gadimaliyeva *et al* (2020).

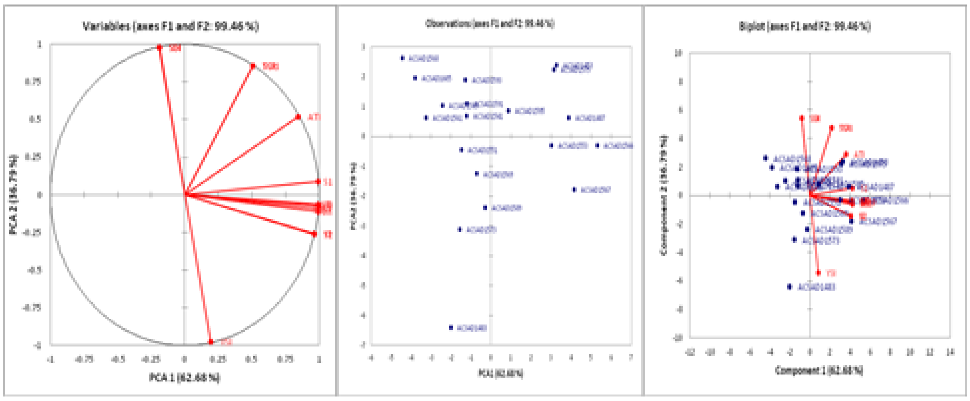

Fig. 2. Biplot analysis for principal component of salinity tolerance indices in 19 durum wheat lines

CONCLUSION

Selection of salinity tolerant lines should be well adopted to stress and non-stress conditions. In the present study, the three lines ACSAD 1487, ACSAD 1566 and ACSAD 1567 had the highest mean performance for yield and its components, high positive correlation was recorded between grain yield /plant (Yp , Ys) and each of spike length, no. of spikelets/spike, no. of grains/spike, 1000-kernel weight and straw yield/plant as well as the mean productivity (MP), harmonic mean (HM), geometric mean productivity (GMP), stress tolerance index (STI), yield index (YI) and abiotic tolerance index (ATI) indices. In addition, cluster and PCA analysis showed that STI, MP, GMP and HM indices are the best indices for selecting salinity tolerant lines and two lines ACSAD 1566 and ACSAD 1567 are equally produced high grain yield both in non stress and salinity stress conditions. Based on principle component analysis it can be concluded that Ys can discriminate salinity tolerant lines with high grain yield under stress condition and should be used for screening for salinity tolerant lines. Therefore, plant breeders should pay attention to severity of salinity stress when selecting drought-tolerant wheat lines.

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تقييم سلالات مرباه حديثا من القمح القاسي تحت ظروف الإجهاد الملحي

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وحدة تربية النبات ـ قسم الاصول الوراثية النباتية ـ مركز بحوث الصحراء ـ المطرية ـ القاهرة ـ مصر

يعد الإجهاد الملحي أحد الإجهادات البيئية التى لها تأثير سالب فى إنتاجية محصول القمح القاسي بالأراضي الجديدة، لذا يهتم مربو النبات بالحصول على تراكيب وراثية محسنة ذات قدرة إنتاجية ومتحملة للإجهاد الملحي، وذلك بهدف زراعة الأصناف المناسبة ذات الإنتاجية العالية والمستقرة تحت ظروف الإجهاد مما يؤدي إلى زيادة إنتاجية وحدة المساحة بالأراضي الهامشية. أجريت هذه الدراسة فى موسمين ٢٠١٧/٢٠١٦ و ٢٠١٨/٢٠١٧ في محطة بحوث راس سدر للتجارب الزراعية التابعة لمركز بحوث الصحراء – محافظة جنوب سيناء، جمهورية مصر العربية. بهدف دراسة السلوك الوراثي لعدد تسعة عشر تركيبا وراثيا من القمح القاسي تم الحصول عليها من المركز العربي لدراسات المناطق الجافة والأراضي الجافة (أكساد)، حيث كان الإختبار لصفات عدد الأيام للطرد (الأيام) ، إرتفاع النبات (سم) ، عدد السنابل/النبات، عدد السنيبلات/سنبلة، وزن ١٠٠٠ حبة (جم) ، عدد الحبوب بالسنبلة، محصول الحبوب للنبات (جم) ووزن محصول القش/نبات (جم)، في تجربتين منفصلتين الأولى تحت ظروف الرى بمستوى ملوحة 3900 جزئ بالمليون والثانية تحت ظروف الرى بمستوى ملوحة 6300 جزئ بالمليون والتى تمت زراعتها فى تصميم القطاعات الكاملة العشوائية لكل تجربة فى ثلاث مكررات وقد تم تحليل البيانات بعد عمل التحليل المجمع عبر الموسمين بعد إختبار التجانس ويمكن تلخيص النتائج فيما يلي: أظهر تباين التراكيب الوراثية معنوية عالية لكل الصفات تحت الدراسة ولقد إختلفت التراكيب الوراثية فيما بينها في معظم الصفات تحت الدراسة حيث سجل ثلاثة تراكيب وراثية التركيب أكساد 1487 و أكساد 1566 و أكساد 1567 أعلى القيم لصفتي وزن محصول الحبوب ومكوناته والقش/النبات. أوضحت نتائج الإرتباط المظهري بين الصفات تحت الدراسة وجود إرتباط موجب ومعنوي بين محصول الحبوب/نبات وكلٍ من محصول القش/نبات، طول السنبلة، عدد السنيبلات/سنبله، عدد الحبوب/سنبلة ووزن 1000 حبة مما يدل على أن هذه الصفات لها تأثير كبير على صفة محصول الحبوب/نبات تحت بيئة الإجهاد الملحي. أظهرت 6 تراكيب وراثية أكساد 1487 و أكساد 1453 و أكساد 1553 و أكساد 1566 و أكساد 1567 و أكساد 1575 أعلى القيم المظهرية وتشاركت في المجموعة الأولى من التحليل العنقودي وأظهرت إرتباطا موجبا مع المحصول ومكوناته وفي دلائل التحمل الأتية : دليل تحمل الإجهاد (STI) ومتوسط الإنتاجية (MP) والمتوسط الهندسي للإنتاجية (GMP) والمتوسط المتوازن (HM) ودليل التحمل غير الحيوي (ATI) بالإضافة إلى محصولهم العالي تحت بيئة الإجهاد وعدم الإجهاد ولذلك يمكن إعتبار هذه التراكيب من أكثر التراكيب تحملاً للإجهاد الملحي. أظهر التحليل المتعدد وجود إرتباطاً موجباً وعالي المعنوية بين محصول حبوب النبات تحت بيئة عدم الإجهاد (Yp) وبين محصول حبوب النبات تحت بيئة الإجهاد (Ys) مما يدل على أن أداء المحصول العالي تحت ظروف عدم الإجهاد أسفر عن محصولاً عالياً نسبياً تحت ظروف الإجهاد. كما كان هناك إرتباطاً موجباً وعالي المعنوية بين كلٍ من محصول النبات تحت ظروف عدم الإجهاد (Yp) ومحصول النبات تحت ظروف الإجهاد (Ys) وكلٍ من دلائل التحمل الآتية: STI، MP، GMP، HM ، وإرتباط سالب ومعنوي مع ATI و SSPI والتى تعد أفضل دلائل تحمل الإجهاد الملحي كفاءةً في تحديد التراكيب الوراثية ذات المحصول العالي في كلٍ من ظروف عدم الإجهاد والإجهاد. وأفضل سلالتين من القمح القاسي أكساد 1566 و أكساد 1567 والتي يمكن إنتخابها كسلالات محسنة للزراعة تحت الظروف الملحية و/أو يمكن إستخدامها كمصادر وراثية مفيدة لبرامج تربية القمح المستقبلية تحت ظروف الإجهاد الملحي في راس سدر.