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HEAT TOLERANCE IN SOME BREAD WHEAT GENOTYPES UNDER TWO SOWING DATES

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Asmaa M. Badr[1]; M.F. Ahmed[1]; A.M. Esmail[1] and M.A. Rashed[2]
1- Agronomy Dept., Fac. of Agric., Ain Shams Univ., Cairo, Egypt
2- Genetic Dept., Fac. of Agric., Ain Shams Univ., Cairo, Egypt

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ABSTRACT

A 7x7 half diallel cross along with their parental wheat cultivars were evaluated under two sowing dates (19th Nov. and 17th Dec.).The results revealed that mean squares due to sowing dates, genotypes and genotypes x sowing dates interaction were significant for most of the studied traits. Delaying sowing date to Dec. reduced all studied characters compared to the normal sowing date except electrolyte leakage which increased by delaying sowing date. Heterosis over better parents showed that, the best hybrids under stress condition were Misr 2 X Giza 168 and Sids 1 X Giza 168 for grain yield / plant and some of other studied traits. General and specific combining ability mean squares indicated the importance of both additive and non-additive gene effects in the inheritance of the studied traits with few exceptions. However, the additive effect was more important than the non-additive effects in the inheritance of days to 50% heading, plant height, No. of spikes/ plant, No. of kernels / spike and 1000-kernel weight while, the non-additive effects were more important than the additive effects in the inheritance of electrolyte leakage and flag leaf area. The best general combiner parents for grain yield / plant and some of other studied traits were Gemmeiza 11 and Giza 168 under stress condition. The best hybrids for SCA effects were Sakha 93 X Sids 1, Gemmeiza 11 X Giza 168, Misr 2 X Giza 168 and Sids 1 X Giza 168 under stress condition for grain yield / plant and some of other studied traits. The crosses Gemmeiza 11 X Giza 168 (HSI 0.36), Gemmeiza 7 X Giza 168 (HSI 0.58) and Sakha 93 X Giza 168 (HSI 0.60) have recorded the lowest values of heat susceptibility index (HSI), indicating their tolerance to heat stress (late sowing date).

INTRODUCTION

Global warming is predicted to have a general negative effect on plant growth due to the damaging effect of high temperatures on plant development. The increasing threat of climatological extremes including very high temperatures might lead to catastrophic loss of crop productivity and result in wide spread famine **(Bita & Gerats 2013 and Liu et al 2014)**.

Increasing crop productivity while simultaneously reducing the environmental footprint of crop production is considered a major challenge for the coming decades. Even short episodes of heat stress can reduce crop yield considerably causing low resource use efficiency **(Siebert et al 2014)**. Wheat is particularly sensitive to the climatic and agronomic management conditions under which it is grown. Season-long heat stress can reduce photosynthesis and accelerate senescence; if extreme heat stress is experienced during flowering, wheat may also experience decreased pollen viability and stigma deposition, leading to increased grain sterility **(Arshad et al 2017).** The normal activity of heat tolerant genotypes under high temperature may due to lower electrolyte leakage compared to the electrolyte leakage in the sensitive genotypes. Plant breeders should also use membrane thermostability (MTS) as selection markers in the breeding program for development of heat tolerant wheat genotypes as these were shown to be closely associated with yield in wheat **(Bala, 2017).**

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Wheat breeders in Egypt had an essential role in solving this problem upon breeding new early matured wheat varieties coupled by high yielding capacity. Wheat breeders can increase wheat grains production per unit area to minimize the reduction of yield. The development of high yielding and early wheat varieties needs the breeder skill in choice of the parents to be crossed as the first step in his breeding program. Earliness, grain yield, physiological traits, heterobeltiosis, general and specific combining ability are very important parameters for breeding program. Thus, the present investigation aimed to study performance, heterosis and combining ability in F_1 hybrids of seven wheat cultivars under normal and late sowing date.

MATERIALS AND METHODS

The field work in this study was conducted at the Agric. Res. Station. Farm, Fac. of Agric., Ain Shams University at Shalakan, Kalubia Governorate, Egypt. The genetic material used in this investigation included seven Egyptian spring wheat cultivars; the names and pedigree of these cultivars are presented in **Table (1)**.

Table 1. The names and pedigrees of used cultivars in the study

Name	Pedigree and / or selection history
Sakha 93 (P1)	Sakha 92TR 810328 S 8871-1S-2S-1S-0S
Gemmeiza 11 (P2)	BOW"S"KVZ"S"//7C/SERI82/3/GIZA168/SAKH61. GM7982-2GM-1GM-2GM-1GM-0GM.
Gemmeiza 10 (P3)	MAYA 74 "S" /ON//160-147/3/BB / GLL/4/CHAT "S"/5/CROW"S". GM5820-3GM-1GM-2GM- 0GM.
Gemmeiza 7 (P4)	CMH74 A. 630/5x//Seri 82/3/Agent CGM 4611-2GM-3GM-1GM-0GM.
Misr 2 (P5)	SKAUZ / BAV92
Sids 1 (P6)	HD2172/PAVON "S"// 1158.57/ MAYA 74 "S". SD46-4SD-2SD-ISD-OSD.
Giza 168 (P7)	MRL/Buc//SERI CM 93046-8M-0Y-0M-2Y-0B

A half diallel set of crosses was achieved among the seven parents in the 2014/15 growing season to obtain 21 F_1 crosses excluding reciprocals. In the 2015/2016 growing season the seeds of the F_1 hybrids as well as their respective parents were sown on the two sowing dates, i.e., 19^{th} of November (recommended sowing date) and 17^{th} of December (late sowing date). A separate complete randomized blocks design field experiment with three replicates was devoted for each sowing date. The experimental plot was one row; the row was 3 m in length and 25 cm in width. Plants were spaced at 20 cm within the row, and one plant was left per hill where plants were thinned after about 3 weeks of sowing. The soil of the experiment was clay in texture with ph 7.98 and 8.98, EC 2.39 and 2.88 dsm^{-1} and total N 0.5 and 0.15% at the two depths of 0-15 and 15-30 cm, respectively. Soil analysis was done at the Central Laboratory, Faculty of Agriculture, Ain Shams Univ., Egypt. The preceding summer crop (2015) was soybean. The average, maximum and minimum degrees of temperature as well as the relative humidity at the experimental area during 2015/16 season are presented in **Table (2)**.

Table 2. The average degrees of maximum and minimum temperature (^{o}C) and relative humidity (R.H %) at the experimental area during the 2015/2016 growing season

Month	Max temp.	Min temp.	Aver. R.H [%]
Nov. (2015)	30.2	12.8	64.6
Dec. (2015)	23.5	7.2	64.05
Jan. (2016)	22.9	3.8	62.25
Feb. (2016)	31.2	5.9	57.35
Mar. (2016)	33.3	11.3	54.85
Apr. (2016)	40.7	13.3	53.5
May. (2016)	40.3	16.6	47.6

Days to heading were expressed as number of days from sowing till completely emergence of the main stem spike from the sheath for flag leaf of 50% of plants per plot. Cell membrane stability and electrolyte leakage were determined according to the method of **Iqbal & Bano (2009) and Kong et al (2005)**, respectively. Flag leaf area (cm^2), Plant height (cm), Number of spikes/plant, Number of grains/spike, 1000-kernel weight (g) and Grain yield per plant (g) were recorded on a randomely sample of 10 guarded plants of each plot. The heat susceptibility index (HSI) was calculated for each genotype according to the formula of **Bhardwaj et al (2017).** The mean squares of genotypes, sowing dates and replications for the studied traits were tested for significance according to **Gomez and Gomez (1984).** The heterosis was determined as percentage deviation of the F_1 hybrids mean from the better parent The variation among parent and F_1 crosses was partitioned into general (GCA) and specific (SCA) combining ability as illustrated by **Griffing (1956)**, method (2), model 1.

RESULTS AND DISCATION

A. Analysis of variance

Results in **Table (3)** revealed that mean squares due to genotypes for days to 50% heading, flag leaf area, plant height, membrane stability index, electrolyte leakage, 1000-grain weight and grain weight/plant on the two sowing dates were highly significant (P .01), indicating the presence of adequate genetic variability in the used genetic material. Mean squares of sowing dates (D) as main source of variation were highly significant for all studied traits, which show that there is a difference in growth and yield at different sowing dates. However, the interactions between sowings and genotypes (G X D) were also highly significant for all studied traits except the interactions of G X D for number of spikes/plant were insignificant, indicating that the performance and the ranks of different wheat genotypes are moderately or high affected by the sowing dates for most investigated traits. Other studies revealed significant interaction values between wheat genotypes and sowings for one or more of these studied traits as reported by **Hamam et al (2015); Rahman et al (2015) and Uddin et al (2015).**

General and specific combining ability mean squares **Table (3)** were found to be significant for all studied traits at the two sowing dates and their combined analysis except electrolyte leakage for GCA in the second sowing date and No. of spikes / plant for GCA and SCA in the two sowing date. This results suggesting that the additive and non-additive gene effects had important effect in the expression of these traits. In this connection **Ram et al (2014), Singh et al (2014) and Saeed & Khalil (2017)** revealed also that additive and non-additive genetic variance played a predominant role in the inheritance of most traits.

The ratios of GCA/SCA variance were greater than unity for days to 50% heading, plant height, No. of spikes/ plant, No. of kernels / spike and 1000-kernel weight at the two sowing dates and the combined data, membrane stability index in normal sowing date and grain yield / plant in the second sowing date, indicating that the additive type of gene action is of great importance in the inheritance of these traits. However, the GCA/SCA ratios were less than unity for electrolyte leakage (EL) and flag leaf area in different sowings and their combined data, membrane stability index in late sowing and grain yield / plant in normal sowing date, illustrating that both traits are mainly controlled by the non- additive gene effects. In this respect **Kamaluddin et al (2007) and Titan et al (2012)** indicated the preponderance of additive gene action inheritance of 1000 seed weight and grain yield / plant, while **Pancholi et al (2012) and Saeed & Khalil (2017)** revealed the preponderance of non-additive gene action (dominance and epitasis) inheritance of days to heading, flag leaf area, plant height, No. of kernels / spike, 1000-grain weight and grain yield / plant in wheat.

Interactions of the GCA as well as the SCA with sowing dates were significant for all studied traits expect No. of spikes/ plant. Such results reveal that nature and the magnitude of both types of gene action varied from one sowing date to another illustrating the importance of sowing dates as effective factor in declaring GCA and SCA variances. For membrane stability index and No. of kernels / spike there were higher magnitude of GCA x environments interaction as compared to the SCA x environments interaction, indicating the high sensitivity of GCA to environments than the SCA for these traits and vice versa for each of days to 50% heading, electrolyte leakage, flag leaf area, plant height, 1000-kernel weight and grain yield / plant where the SCA may be more sensitive to the environments than the GCA values.

2- Mean performance of wheat parental genotypes and F_1 hybrids under normal and late sowing date

Means for all studied traits are presented in **Table (4)**. Values show the diversity and the differential responses of wheat genotypes from normal to late sowing date. Table 4 shows notable reduction in all studied traits for parents and hybrids except electrolyte leakage which shows remarkable increase. **Al-Jebory 2013 and Grigorova et al 2011** reported that electrolyte leakage increased under heat stress; it is indicator on cellular membranes damage. The parental variety Sakha 93 had the lowest value for flag leaf area and plant height at the late sowing date, high value for no. of spikes/ plant under the two sowing dates and recorded high value of heat susceptibility index (HSI) (1.24), heat susceptible genotype. The cultivar Gemmeiza 11 was good parent in days to heading, plant height, membrane stability index, electrolyte leakage and No. of kernels / spike under normal and stress condition and for 1000 – Kernel weight under late sowing date, it is considered moderately heat tolerant genotype. **Bhardwaj et al (2017)** classified the genotypes according to HSI value in to four different categories i.e. highly heat tolerant (HSI < 0.50), heat tolerant (HSI: 0.51- 0.75), moderately heat tolerant (HSI: 0.76 –1.00) and heat susceptible (HSI > 1.00).

The parental variety Gemmeiza 10 was heat susceptible genotype and late in heading and short under two sowing dates. The parental variety Gemmeiza 7 was moderately heat tolerant, late in heading, tall and best in No. of spikes/ plant and 1000 – Kernel weight. The parental variety Misr 2 was moderately heat tolerant, tall and best in No. of spikes/ plant and 1000 – Kernel weight. The parental variety Sids 1 was moderately heat tolerant, late in heading under late sowing date, low in flag leaf area, tall, best in No. of spikes/ plan and No. of kernels / spike under two sowing date. The parental variety Giza 168 was heat susceptible, the earliest in heading and tall under late sowing date.

The hybrid P2 X P7 was highly heat tolerant and best in most studied traits. Also the two hybrids (P1 X P7 and P4 X P7) were heat tolerant and best in most studied traits. Therefore, these previous crosses could be used as a genetic resource for improving grain yield and its attributes under heat stress condition.

In general, delaying sowing date caused drastic decrease in most studied traits especially grain yield/plant, 1000-kernel weight. This reduction in yield at the late sowing date may be due to higher temperatures during grain filling period compared to those in normal sowing date.

C. Heterosis

Percentage of heterosis relative the better parent (heterobeltiosis) for all studied traits under the two sowing dates are presented in **Table (5).** The best hybrids were; P3 X P7 and P4 X P7 for days to 50% heading at the normal sowing date and none of the 21hybrids showed negative significant desirable heterotic effects (earliness) relative to their respective earlier parent at the late sowing date. The cross P3 X P5 had desirable heterotic effects for flag leaf area (27.39%) under heat stress and none of the 21hybrids showed positive significant desirable heterotic effects for plant height at the late sowing date. The best hybrid was P1 X P4 for membrane stability index (23.61%) under late sowing date. Under heat stress conditions, the hybrid P4 X P7 showed the highest negative and significant value for electrolyte leakage. None of the crosses at the normal and late sowing date had positive and significant heterosis for number of spikes/plant. The cross P3 X P7 had the best positive significant heterosis at the late sowing for number of kernels/spike. The three crosses; P1 X P3, P1 X P6 and P3 X P6 recorded positive significant heterosis at the late sowing date for 1000-kernel weight. The cross P5 X P7 recorded the best positive significant heterosis at the stress condition for grain yield/plant. These results are in harmony with those obtained by **Farooq et al (2014)**, **Hamam (2014) and Gul et al (2015).**

D. Combining ability effects

D.1. General combining ability effects (GCA)

Estimates of GCA effects of each variety for different studied traits are presented in **Table (6)**. The best general combiner parents under normal sowing date were the parental varieties Gemmeiza 11 and Sids 1 for days to 50% heading, Gemmeiza 10 and Gemmeiza 7 for flag leaf area, Gemmeiza 7, Misr 2 and Sids 1 for plant height, Gemmeiza 11 for membrane stability index, Misr 2 for electrolyte leakage, Sids 1 for No. of spikes / plant, Gemmeiza 7, Sids1 and Giza 168 for No. of kernels/spike, Gemmeiza 11, Gemmeiza 7 and Misr 2 for 1000 – Kernel weigh and Gemmeiza 7 and Sids 1 for Grain yield /plant. This would indicate that these parents can be considered as good combiner parents for these traits under recommended sowing date.

Table 4. Mean performance of the bread wheat parental genotypes and their F1 crosses for all studied traits under normal (D1) and late (D2) sowing dates and Heat susceptibility index (HSI)

	Days to heading		Flag leaf area (cm2)		Plant height (cm)		Membrane stability index (MSI)		Electrolyte leakage (EL)	
Genotypes	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**
Sakha 93 (P1)	87.33	89.67	56.70	49.98	93.03	85.63	83.50	67.17	5.90	9.03
Gemmeiza 11 (P2)	86.00	85.33	61.99	58.19	105.93	102.83	89.10	76.17	4.93	7.63
Gemmeiza 10 (P3)	92.00	89.33	62.31	56.55	87.83	88.57	86.50	71.77	4.83	9.57
Gemmeiza 7 (P4)	94.00	86.67	76.00	56.83	112.30	110.83	82.40	63.53	10.73	15.97
Misr 2 (P5)	86.33	89.33	56.16	51.93	114.77	111.53	85.10	65.67	5.57	7.10
Sids 1 (P6)	87.33	91.67	54.03	51.25	113.50	112.43	84.93	74.30	8.10	9.20
Giza 168 (P7)	93.33	85.00	72.45	56.09	102.77	101.50	89.10	70.50	5.87	13.33
Parents mean	**89.47**	**88.14**	**62.81**	**54.40**	**104.30**	**101.90**	**85.80**	**69.87**	**6.56**	**10.26**
P1 X P2	91.33	85.67	72.44	57.24	98.73	95.97	89.30	78.87	5.73	8.67
P1 X P3	91.33	88.00	83.91	58.31	93.37	85.70	85.27	79.60	7.80	8.97
P1 X P4	91.67	89.67	72.20	64.73	105.17	98.60	84.67	83.03	3.63	6.00
P1 X P5	93.33	87.67	71.91	52.93	106.73	96.77	85.53	79.10	6.37	10.63
P1 X P6	91.33	89.00	71.30	62.53	104.30	99.57	82.67	75.93	6.33	8.33
P1 X P7	90.33	89.33	68.82	47.98	101.03	94.07	83.10	73.80	8.53	11.90
P2 X P3	89.33	86.67	68.11	42.68	104.80	97.13	83.90	76.23	9.57	11.50
P2 X P4	88.33	89.33	81.09	69.59	109.00	106.33	86.93	75.20	6.30	8.53
P2 X P5	87.33	85.67	69.41	64.83	111.07	108.17	91.00	74.00	3.20	15.33
P2 X P6	88.33	85.67	67.71	63.73	110.40	109.77	87.80	75.03	5.37	8.73
P2 X P7	89.33	88.67	78.53	60.54	109.00	102.90	82.50	74.53	6.80	8.23
P3 X P4	92.00	88.67	62.92	57.81	107.40	100.83	81.63	79.10	6.37	6.73
P3 X P5	93.33	88.00	79.14	72.04	105.83	101.27	79.83	76.40	7.10	11.73
P3 X P6	92.67	90.67	82.80	57.90	111.27	97.90	75.30	76.53	8.43	8.90
P3 X P7	90.33	89.33	81.08	63.93	111.30	93.90	82.50	77.87	8.77	9.63
P4 X P5	95.33	88.33	74.25	66.55	106.13	112.80	84.80	71.57	3.73	10.47
P4 X P6	92.33	89.00	69.62	56.24	115.93	109.50	87.83	80.63	3.30	7.50
P4 X P7	89.33	86.67	59.58	49.15	117.10	109.07	83.50	79.07	4.20	8.30
P5 X P6	90.00	87.33	83.18	64.74	113.80	107.27	87.20	72.97	6.63	8.33
P5 X P7	91.33	89.33	68.20	55.49	112.23	108.87	83.20	68.00	4.67	6.40
P6 X P7	90.33	88.33	64.58	53.79	109.73	103.03	86.80	73.03	6.97	9.43
Crosses mean	**90.90**	**88.14**	**72.89**	**59.18**	**107.82**	**101.88**	**84.54**	**76.21**	**6.18**	**9.25**
General mean	**90.55**	**88.14**	**70.37**	**57.98**	**106.95**	**101.88**	**84.85**	**74.63**	**6.28**	**9.50**
LSD 5%										
G	0.98	3.53	2.86	2.63	5.75	4.22	4.37	3.05	2.02	2.14

Table 4. Cont.

Genotypes	No. of spikes/ plant		No. of kernels / spike		1000 – Kernel weight (g		Grain yield / plant		HSI
	D1	D2	D1	D2	D1	D2	D1	D2	
Sakha 93 (P1)	12.03	9.30	56.90	52.00	40.00	29.83	21.03	9.93	1.24
Gemmeiza 11 (P2)	10.63	8.70	70.63	69.90	49.67	40.33	20.30	13.47	0.79
Gemmeiza 10 (P3)	10.23	8.73	60.60	53.37	40.33	19.87	16.37	8.47	1.13
Gemmeiza 7 (P4)	11.53	9.43	65.47	50.87	59.83	40.23	22.77	15.20	0.78
Misr 2 (P5)	10.57	9.43	62.20	58.00	59.67	40.00	19.00	11.82	0.89
Sids 1 (P6)	12.77	10.17	75.37	70.10	49.40	30.00	16.17	10.70	0.79
Giza 168 (P7)	10.90	10.00	71.67	55.97	40.00	39.70	20.87	11.47	1.06
Parents mean	**11.24**	**9.39**	**66.12**	**58.60**	**48.41**	**34.28**	**19.50**	**11.58**	
P1 X P2	10.33	8.83	62.27	57.37	50.00	40.33	20.87	13.47	0.83
P1 X P3	11.13	8.47	71.30	57.67	39.83	39.33	16.03	9.87	0.90
P1 X P4	10.03	9.80	68.57	57.80	49.90	36.00	18.20	8.77	1.22
P1 X P5	10.70	9.30	67.70	58.17	40.33	39.33	18.73	12.47	0.78
P1 X P6	11.30	10.97	65.00	48.80	40.00	35.67	20.13	13.55	0.77
P1 X P7	10.97	10.70	63.30	59.20	49.67	39.67	17.80	13.27	0.60
P2 X P3	10.07	9.80	64.97	59.63	39.87	30.00	21.10	9.13	1.33
P2 X P4	8.97	8.83	69.17	67.60	60.23	40.33	18.90	11.98	0.86
P2 X P5	9.87	9.00	69.57	62.17	50.33	39.67	21.20	14.13	0.78
P2 X P6	10.43	9.03	68.80	63.23	50.40	39.67	25.57	13.03	1.15
P2 X P7	10.83	10.27	73.23	70.53	51.33	40.00	19.37	16.40	0.36
P3 X P4	12.53	9.03	75.83	60.70	40.37	40.33	27.13	9.40	1.53
P3 X P5	10.73	9.47	60.93	56.23	60.17	40.33	16.87	8.93	1.10
P3 X P6	11.03	10.00	71.63	59.43	50.10	39.33	22.77	10.07	1.31
P3 X P7	11.90	10.13	79.30	59.87	40.33	39.33	21.60	9.37	1.33
P4 X P5	11.17	9.77	83.20	60.73	41.50	37.00	21.33	14.23	0.78
P4 X P6	11.83	8.63	68.10	57.47	40.33	38.67	27.47	10.00	1.49
P4 X P7	10.97	9.50	79.77	66.63	50.83	40.33	16.67	12.53	0.58
P5 X P6	11.40	10.37	73.47	51.47	40.00	35.67	26.10	13.73	1.11
P5 X P7	10.33	9.83	75.60	63.77	49.17	39.50	24.93	16.63	0.78
P6 X P7	10.33	9.00	72.57	63.33	50.33	40.00	27.73	14.80	1.09
Crosses mean	**10.80**	**9.56**	**70.68**	**60.09**	**46.91**	**38.59**	**21.45**	**12.18**	
General mean	**10.91**	**9.52**	**69.54**	**59.71**	**47.28**	**37.52**	**20.96**	**12.03**	
LSD 5%									
G	ns	ns	2.16	3.25	1.07	1.02	2.87	2.04	

The best general combiner parents under stress condition were the parental varieties Gemmeiza 11 for days to 50% heading, Gemmeiza 11, Gemmeiza 7 and Misr 2 for flag leaf area, Gemmeiza 11, Gemmeiza 7, Misr 2 and Sids 1 for plant height, Sakha 93, Gemmeiza 11 and Gemmeiza 10 for membrane stability index, Sids 1 for electrolyte leakage, Giza 168 for No. of spikes / plant, Gemmeiza 11 and Giza 168 for No. of kernels/spike, Gemmeiza 11, Gemmeiza 7, Misr 2 and Giza 168 for 1000 – Kernel weigh and Gemmeiza 11, Misr 2 and Giza 168 for grain yield /plant. This would indicate that the previous mentioned parental genotypes could be used in breeding programs for improving wheat productivity. These results are in harmony with those obtained by **Singh et al (2014)**, **Ram et al (2014) and Saeed & Khalil (2017)**.

D.2. Specific combining ability effects (SCA)

Specific combining ability effects for the studied traits are presented in **Table (7).** Results show that the crosses P2 X P4, P2 X P5, P3 X P4, P3 X P7 and P4 X P7 had negative and significant effect under the recommended sowing date but non-hybrid had negative significant effects at the late sowing date for days to 50% heading. Negative significant SCA effects for days to 50% heading were also recorded by **Singh et al (2014) and Saeed & Khalil (2017).** Positive and significant SCA effects were recorded by the crosses P1 X P3, P1 X P4, P1 X P6, P2 X P4, P2 X P7, P3 X P5, P3 X P7, P4 X P5 and P5 X P6 under normal and heat stress treatments, P1 X P2, P1 X P5 and P3 X P6 under normal treatment and P2 X P5 and P2 X P6 under heat stress treatment for flag leaf area. Positive and significant SCA effects were recorded by **Farooq et al (2006) and Saeed & Khalil (2017)**. Regarding plant height, positive and significant SCA effects were recorded by the crosses P3 X P6, P3 X P7 and P4 X P7 under normal treatment. Under late sowing date none of crosses had positive and significant SCA effects, this shows the importance of additive genes for inheritance of this trait. **Farooq et al (2006)**, **Pancholi et al (2012)** and **Ram et al (2014)** recorded positive and significant SCA effects for plant height. Regarding membrane stability index positive significant SCA effects were recorded by the crosses P4 X P6 under normal and heat stress treatments, P2 X P5 at the recommended sowing and P1 X P2, P1 X P3, P1 X P4, P1 X P5, P3 X P4, P3 X P5, P3 X P7 and P4 X P7 at the late sowing date. **Dhanda & Munjal (2006) and Yildirim et al (2009)** recorded positive and significant SCA effects for this trait. Concerning electrolyte leakage, negative and significant SCA effects was recorded by P1 X P4, P4 X P6 and P4 X P7 under normal and heat stress treatments, P2 X P5 and P4 X P5 at the recommended sowing date and P2 X P4, P2 X P7, P3 X P4 and P5 X P7 at the late sowing date. **Yildirim et al (2009)** recorded negative and significant SCA effects for this trait. Regarding the number of spikes/plant, positive and significant SCA effects are recorded by the cross P3 X P4 at the recommended sowing date and P1 X P6 at the late sowing date. Concerning number of kernels/spike, The effects of SCA for this trait showed that the crosses P1 X P3, P1 X P4, P1 X P5, P3 X P4, P4 X P5, P4 X P7 and P5 X P7 at the two sowing dates, P3 X P6, P3 X P7 and P5 X P6 at the recommended sowing date and P2 X P4 and P2 X P7 at the late sowing date recorded positive and significant SCA values. Concerning 1000-kerenel weight, SCA effects for this trait demonstrated that the crosses; P1 X P2, P1 X P7, P2 X P6, P3 X P5, P3 X P6 and P6 X P7 at the normal and late sowing dates, P1 X P4, P2 X P4, P2 X P7 and P4 X P7 at the recommended sowing date and P1 X P3, P1 X P5, P3 X P4, P3 X P7 and P4 X P6 under late sowing date recorded positive significant SCA values. With respect to grain yield / plant, data of SCA effects showed that the crosses; P5 X P7 and P6 X P7 under the two sowing dates, P2 X P6, P3 X P4, P4 X P6, P5 X P6 at the recommended sowing date and P1 X P6 and P2 X P7 under the late sowing had positive significant SCA values. In general, the previous crosses seemed to be good combinations for increasing wheat grain yield.

From the above mentioned results, it could be concluded that the genotypes Gemmeiza 11, Sids 1, P1 X P7and P2 X P7 had best values for membrane stability index, electrolyte and heat susceptibility index so, it considered as heat tolerance genotypes. It also concluded that membrane stability index, electrolyte leakage and heat susceptibility index could be used as effective selection criteria for screening wheat genotypes for heat tolerance especially if the breeder has large genetic pool in the shortest time possible.

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