Global Advanced Research Journal of Agricultural Science (ISSN: 2315-5094) Vol. 6(11) pp. 381-386, November, 2017 Issue.
Available online http://garj.org/garjas/home

Full Length Research Paper

Genetic gain of selection for cell membrane thermostability in bread wheat (*Triticum aestivum* L.)

Ebaid M. A. Ibrahim

Department of Genetic, faculty of agriculture, South valley university, Qena, Egypt.
Email: thrawat_ameen@yahoo.com

Accepted 10 November, 2017

The experiment was conducted in 2015/2016 season at research farm of South Valley University, Qena, Egypt to measure the response to selection for cell membrane thermostability (CMS) and yield component in F4 generation in bread wheat under normal and heat stress conditions using 12 families six out of them were derived from across between Giza-168 x sids-12 (population 1) and the other six derived from Shandweel-1 x Qena-25 advanced lines (population 2). The observed response to selection for CMS was 48.63 and 36.68 in the F4 selected families under normal and late sowing date respectively. The means of grain yield of high and low CMS F4 selected families as well as F4 bulks were ranged from 2.20 to 3.37 g in population 1 and 2.24 to 3.15 g in population 2 in the first sowing date while in the second sowing date were ranged from 1.56 to 2.73 g in population 1 and 1.49 to 2.51 g in population2. Significant positive correlated response to selection for grain yield and 1000-grain weight was obtained in the first and late sowing dates of the two populations. Generally, the observed responses to selection for CMS were greater than the predicted responses indicating the inheritance of those traits studied were controlled with dominant gene effects.

Keywords: cell membrane, bread wheat, *Triticum aestivum* L.

INTRODUCTION

Drought due to insufficient soil water supply frequently occurs concurrently with high temperature at the end of wheat growing season in the regions of the world with a Mediterranean climate like Egypt. Drought, depending on its timing and duration, causes 10-61% reduction in grain mass (Cseuz et al.,2002) while heat stress causes 10-15 reduction in grain yield due mainly to reduced single grain weight (Wardlaw and Wrigly,1994).

The current climatic changes resulting from the global warming would aggravate the situation even more by threatening the production and productively of wheat which have evoked concern about the level of tolerance of wheat cultivars to abiotic stresses and the pressing need to improve it.

Plants can resist drought by dehydration avoidance which comprises mechanisms for maintaining high leaf water potential drought by extracting more water from soil (Ludlow, 1989) or by reducing water loss from the plant (Ludlow and Muchow, 1990). Meanwhile, drought tolerance mechanism allows the plant to maintain turger and volume thus continue metabolism even at a low water potential (Nguyen et al., 1997). Such mechanisms include osmotic adjustment and cellular membrane stability, the ability of the plants to limit cell membrane damage during water stress and regaining membrane integrity and membrane-bound activities quickly upen rehydration (Bewely, 1979). Acceleration of phenology and the impairment of the physiology of photosynthesis and grain filling due to

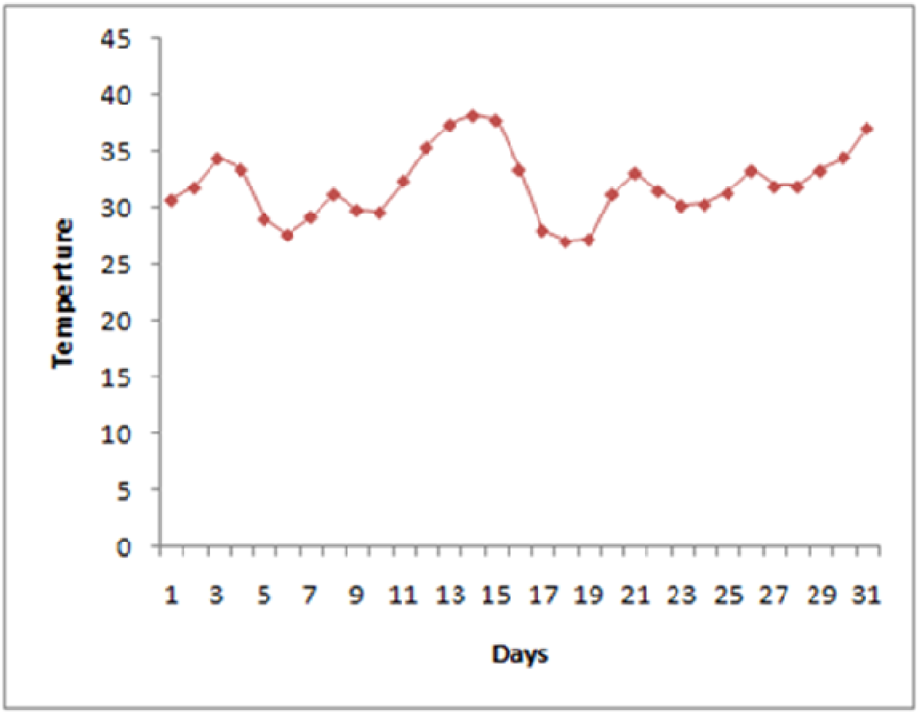

Figure 1: Maximum daily temperatures during March 2016 at the experimental site.

affecting by high temperature resulting in yield losses (stone, 2001).

Many reporters in cellular membrane stability in bread wheat have been published among them (Blum and Ebercon, 1981; Blum et al., 2001; Ibrahim and Quick 2001a; Omara et al., 2006; Kalim et al., 2014 and Pronay 2017). Selection for CMS was carried out in bread wheat by Omara et al., (2010) who obtained significant positive response to the divergent selection for CMS in the five populations which averaged 26.29 and 26.53 in F_4 and F_5 high CMS selections, respectively and 26.21 and 24.3 in the F_4 and F_5 selection for low CMS. Moreover, the association between cellular membrane thermostability and grain yield under heat stress was reported by Blum et al., 2001 to be reasonably strong but not perfect indicating that heat avoidance besides CMS may also support grain yield under high temperature.

The aim of the present study to measure the response to selection for CMS and yield components in F_4 generation.

MATERIAL AND METHODS

Plant materials: The plant material used in this study consisted of 12 families six out of them which were derived from across between Giza-168 X Sids-12 (population 1) and the other six derived from Shandweel-1 X Qena 25 advanced lines (population 2). Selection for high and low CMS applied to two F_2 populations of *Triticum aestivum* L grown under heat stress conditions.

Selection procedure: In 2015-2016 season, Seeds of the F_3 selected families of the two populations along with their relevant F_3 unselected bulks were planted in the field of South Valley University Experimental Farm in normal (22 November) and late (24 December) sowing dates so as to allow the drought stress plants to be exposed to sporadic heat stress waves when temperature rises in March while plants were at anthesis. The Six families and bulk of each population (three high + three low + bulk) were sown into the field of South Valley University Experimental Farm in a randomized complete block design with three replications. Each family was represented in each block by a 10-plant row with rows spaced 50 cm apart and plant within rows set 30 cm from each other. Flag leaf samples were collected from five randomly chosen plants for each family grown in the two sowing date for CMS assay. After maturity, grain yield per plant, number of kernel per spike and 1000 grain weight were determined in five guarded plants randomly chosen from each family.

The recorder temperature during March 2016 indicated the occurrence of waves of high temperature (above 30 ºC which coincided with post flowering stages of plant development **(Figure. 1**).

Cell membrane thermostability assay: The CMS assay was performed according to the protocol described by Blum and Ebercon (1981). CMS was calculated as

Table (1): Means of CMS and grain yield of F_4 selected and bulk families with heritability in the high and low directions

Generation	CMS						Grain yield					
	1st			2nd			1st			2nd		
	Mean	O%	P%	Mean	O%	P%	Mean	CR%	P%	Mean	CR%	P%
Population 1												
F4 bulk	15.05			35.55			2.37			2.13		
F4 selected (H)	22.37	48.63	7.12	48.59	36.68	8.05	3.37	42.19	0.47	2.73	28.17	0.78
F4 selected (L)	11.66	-22.52	6.37	28.43	-20.03	12.14	2.20	-7.20	0.03	1.56	-26.76	0.26
Population 2												
F4 bulk	15.46			45.55			2.54			1.76		
F4 selected (H)	20.17	30.46	7.66	56.60	24.25	12.34	3.15	24.02	11.50	2.51	42.61	0.44
F4 selected (L)	9.69	-37.32	4.96	28.44	-37.56	9.71	2.24	-11.81	0.032	1.49	-15.34	0.11

reciprocal of cell membrane injury after Blum and Ebercon 1981: CMS (%)=[(1-(T1/T2))/(1-(C1/C2))] x 100, where T and C refer to the treatment and control samples, respectively and 1 and 2 refer to the initial and final conductance readings, respectively.

Statistical procedures:

I- Expected: The expected response to selection for CMS was calculated according to the (Falconer, 1989) $R = h^2 i\sigma p$ where R is the expected response, h^2 is the heritability, i is the standardized selection differential and σP is the phenotypic standard deviation

II- Correlated response to selection: In this study the indirect response to selection (CR_x) was calculated according to the formula of (Falconer 1989).

III- Brood sense heritability: Heritability is defined according to (Mather and Jinks 1971)

RESULTS AND DISCUSSION

Mean performance of selected families: The means of CMS value of unselected F_4 bulk of the two populations as measured in the first and late sowing date in South Valley University farm extended 15.05 to 35.55% in population 1 in the first and late sowing date respectively. While in population 2 the mean of CMS value extended from 15.46 to 45.55% in the first and late sowing date (Table 1). However, the means of the highest CMS score within each of the three families in the population 1 displayed comparable means which ranged from 22.37% to 48.59% in the first and late sowing date whereas those with the lowest CMS values showed variable means extended from 11.66 to 28.43 in the first and late sowing date. Meanwhile, in population 2 the mean of the highest CMS score ranged from 20.17 to 56.60 in the first and late sowing date while, in the lowest CMS values showed means extended from 9.69 to 28.44%. These results corresponded well to the results obtained from Ibrahim and Qiuck (2001b) and by Omara et al., 2006 and Omara et al., 2010. The above finding of our present study was similar to Blum et al., (2001) who studied 49 breeding lines varied significantly ($P<0.01$) for CMS and yield under heat stress.

I-Response to selection for CMS of F_4 families:

Significant positive response to selection for CMS were obtained in the high and low directions in the first and late sowing date in the two populations. The analysis of variance (Table 3) revealed significant differences between the high CMS F_4 selections and the low CMS. The observed responses to selection for higher CMS varied considerably among the two populations being 48.63 and 36.68, in population 1 but 30.46 and 24.25 in population 2 in the first and late sowing date respectively. **T**he observed response to selection in first and second sowing dates were greater than predicted response indicating that the dominance gene effects are involved in the inheritance of that trait. In the low direction, the observed response to selection was negative -22.52 of population 1 and -37.32 of population 2 in the first sowing date while in the late sowing date were – 20.03 and – 37.56 in population 1 and 2 respectively..

II-Correlated response to selection for CMS.

1- **Grain yield per plant**: The means of grain yield per plant (g) of the high CMS and low CMS F_4 selected families as well as F_4 bulks of the two populations as measured in the first and late sowing date are given in Table 1. Significant positive correlated response to selection for grain yield was obtained in the first and late

Table (2): Means of Number of kernel and 1000 grain weigh of F_4 selected families and bulk with heritability in the high and low directions

Generation	Number of kernel						1000 grain weigh					
	1st			2nd			1st			2nd		
	Mean	CR%	P%	Mean	CR%	P%	Mean	CR%	P%	Mean	CR%	P%
Population 1												
F4 bulk	61.66			64.00			38.56			33.29		
F4 selected (H)	73.55	19.28	9.65	66.11	3.29	12.52	45.73	18.59	0.43	41.03	23.25	2.53
F4 selected (L)	60.33	-2.16	1.53	61.33	-4.17	8.64	34.40	-10.78	0.38	25.31	-23.97	0.56
Population 2												
F4 bulk	65.00			60.66			38.94			23.46		
F4 selected (H)	67.11	3.24	0.74	60.88	0.36	2.44	47.10	20.95	0.22	41.14	75.36	0.38
F4 selected (L)	64.22	-1.2	0.79	60.11	-0.91	4.32	34.91	-10.34	0.21	24.57	4.73	4.22

Table (3): The analysis of variance of F_4 families in the high and low directions for CMS and grain yield.

Items	Population 1				Population 2			
	1st		2nd		1st		2nd	
	CMS	Grain yield	CMS	Grain yield	CMS	Grain yield	CMS	Grain yield
Among F_4 families (H)	54.69**	0.83**	146.25**	0.445**	33.47**	0.28**	135.15**	0.43**
Among F_4 selected (H)	21.73**	0.115**	27.78**	0.27**	25.17**	0.009**	65.33**	0.02
F_4 selected vs F_4 bulk	120.64**	2.26**	383.18**	0.79**	50.06**	0.82**	274.79**	1.25**
Error	0.06	0.03	0.022	0.002	0.009	0.007	0.019	0.001
Among F_4 families (low)	20.22**	0.024*	82.28**	0.273**	31.92**	0.071*	96.27**	0.067**
Among F_4 selected (low)	17.40**	0.004	66.49**	0.04	10.57**	0.001	40.41**	0.02
F_4 selected vs F_4 bulk	25.86**	0.064**	11385**	0.75**	74.63**	0.37**	207.99**	0.16**
Error	0.037	0.002	0.85	0.004	0.007	0.006	0.018	0.012

*, ** Significant at 5% and 1% respectively.

sowing dates of the two populations (Table 3). In the population 1 the correlated response to selection was 42.19 and 28.17 in both sowing date respectively, on the other hand, in population 2 was 24.02 and 42.61 in the first and late sowing dates. Generally, the dominance gene effects are involved in the inheritance of that trait since the correlated response was greater than predicted response (Table 1). The analysis of variance of grain yield per plant for two populations revealed highly significant in both sowing dates of F_4 selected of high direction (Table 3) while, low selected families showed not significant. The mean grain yield per plant was reduced from 3.37 g. in the first sowing date to 2.73 in the late sowing date this reduction due to heat stress. These results were agreement with that reported by Blum et al., (2001) on CMS being correlated with grain yield under heat stress but not under favorable conditions. Similar positive associations between CMS and grain yield in wheat under drought and heat stress were also reported by Shanahan et al.,(1990), Tripathy et al.,(2000) and Ibrahim and Quick (2001b).

Table (4): The analysis of variance of F_4 families in the high and low directions for Number of kernel and 1000 grain weight.

Items	Population 1				Population 2			
	1st		2nd		1st		2nd	
	Number of kernel	1000 grain weight	Number of kernel	1000 grain weight	Number of kernel	1000 grain weight	Number of kernel	1000 grain weight
Among F_4 families (H)	135.86**	38.92*	62.08*	47.94	6.97	50.54**	25.42	234.7**
Among F_4 selected (H)	44.77**	11.57**	88.11*	4.54	8.11	0.91	12.44	0.49
F_4 selected vs F_4 bulk	318.02**	115.59*	10.03	134.75**	4.69	149.82*	51.25	70.3.13*
Error	1.11	1.07	6.25	0.44	17.47	2.19	11.75	7.67
Among F_4 families (low)	5.55	14.22	54.0*	48.01**	2.09	12.19**	40.22	0.92
Among F_4 selected (low)	0.33	1.80	73.0*	0.46	0.78	0.048	33.44	0.07
F_4 selected vs F_4 bulk	16.0**	25.3**	16.0	143.12**	4.67	36.49*	53.77*	2.76
Error	2.47	0.93	11.33	0.34	13.25	1.72	18.22	2.01

*, ** Significant at 5% and 1% respectively.

2- **Number of kernel:** Selection for high CMS applied to F_3 families produced significant positive correlated response in number of kernel of the F_4 selection of the two populations in both sowing dates in population 1 while, the differences between F_4 selected were not significant in both sowing dates in population 2 (Table 4). Meanwhile, selection for Lower CMS resulted in number of kernel significant positive correlated in the first sowing date but not significant in the late sowing date in population 1 while in population 2 the reverse was true. Similar results was obtained by Omara et al., 2010 using selection for CMS in F_3 generation did not produce correlated response in grain yield under either favorable or drought stress conditions and Elameen et al., (2013) using selection for bread wheat under drought stress who found significant positive correlations for 1000 grain weight (32.34) and number of kernel 24.8%.

3- **1000 grain weight:** The correlated response to selection for CMS in 1000 grain weight was 18.59% and 23.28 in the first and late sowing date in population 1 respectively (Table 2). On the other hand, in population 2 was 20.95 and 75.36 in the first and late sowing date. The analysis of variance of 1000 grain weight revealed significant differences between F_4 selection in the first sowing date in population 1 but not significant in both sowing date in population 2 (Table 4). The fact that correlated response in the F_4 families selected for high CMS in 1000 grain weight were manifested under drought stress lends further support to the crucial role of CMS in sustaining grain filling under high temperature (Saadalla et al., (1990), Foker et al., 1998, omara et al., 2010)

REFERENCES

Bewley GD (1979). Physiological aspects of desiccation tolerance. Ann. Rev. Plant physiol. 30:195-238.

Blum A, Ebercon A (1981). Cell membrane stability as a measure of drought and heat tolerance in wheat. Crop Sci 21:43–47.

Blum A, Kuvela N, Nguyen HT (2001). Wheat cellular thermotolerance is related to yield under heat stress. Euphytica 117: 1762—1768.

Cseuz L, Pauk J, Kertesz Z, Matuz J, Fonad P, Erdei L (2002). Wheat breeding for tolerance to drought stress at the Cereal Research Non-Profit Company. Acta Biol Szeged 46: 25-26.

Elameen T, Akbar H, Gaime A (2013). Genetic analysis and selection for bread wheat (*Triticum aestivum* L) yield and agronomic traits under drought conditions. International journal of plant breeding 7 (1): 61 – 68.

Falconer DS (1989). Introduction to quantitative genetics. 3rd ed, Longman Scientific and Technical, England.

Fokar M, Blum A, Nguyen HT (1998). Heat tolerance in spring wheat II. Grain filling. Euphytica. 104:9-15

Ibrahim AM, Quick JS (2001a). Heritability of heat tolerance in winter and spring wheat. Crop Sci. 41: 1401 – 1404.

Ibrahim AM, Quick JS (2001b). Genetic control of high temperature tolerance in wheat as measured by membrane thermal stability. *Crop Sci*., 41: 1405-1407.

Kalim U, Khan NU, Khan SJ, Khan MI, Khan IU, Gul S, Rahman H, Khan RU (2014). Cell memberane thermostability studies through goint segregation andlysis in various wheat populations. *Pak. J. Bot.,* 46(4): 1243-1252.

Ludlow MM (1989). Strategies of response to water stress In: Kreeb KH, Richter H, Hinckley TM (eds) Structural and functional responses to environmental stresses, SPD Academic.

Ludlow MM, Muchow RC (1990). A critical evaluation of traits for improving crop yields in water limited environments. Adv. Agron 43:107-153.

Mather K, Jinks JL (1971). Biometrical genetics (2nd edition), chapman and Hall, Ltd., London

Nguyen HT, Chanra BR, Blum A (1997). Breeding for drought resistance in rice: physiology and molecular genetics considerations. Crop Sci 37:1426-1434.

Omara MK, Ibrahim EMA, Bhaa E, Abd Elfatah, Mahmoud El-Rawy A (2010). selection for cell membrane thermostability and stomatal frequency under drought and heat stress conditions in wheat (*Triticum aestivum* L). Assiut J. of Agric. Sci.,41:74 – 100

Omara MK, Mohamed NA, El-Sayed EN, El-Rawy MA (2006). Selection for cell membrane thermostability in bread wheat (*Triticum aestivum* L.) Assiut J of Agric. Sci., 37 (4): 61 -76.

Pronay B (2017). Evaluation of heat tolerance of wheat genotypes through membrane thermostability test. MAYFEB Journal of Agricultural Science 2: 1 – 6.

Saadalla MM, Shanahn JF, Quiick JS (1990). Heat tolerance in winter wheat: I. hardening and genetic effects on membrane thermostability. Crop Sci. 30: 1243 – 1247

Shanahan JF, Edwards IB, Quicq JS, Fenwick JR (1990). Membrane thermostability and heat tolerance of spring wheat. Crop Sci. 30: 247-251.

Stone P (2001). The effects of heat stress on cereal yield and quality in: A.S. Basra (Ed) crop responses and adaptations to temperature stress, Food products press, Binghamton, NY, pp. 243-291

Tripathy JN, Zhang J, Robin S, Nguyen TT, Nguyen HT (2000). QTLs for cell membrane stability mapped in rice (*Oryza sativa* L.) under drought stress. Theor Appl Gent. 100:1197-1202.

Wardlaw LF, Wrigley CW (1994). Heat tolerance in temperate cereals: an overview. Aust. J. Plant physiol. 21: 695 – 703.