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Wheat Genotypes (*Triticum aestivum* L.) vary widely in their responses of Fertility traits to high Temperature at Anthesis

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Abstract

High temperature is a major environmental factor which limits the production and productivity of wheat in most cereals growing areas of the world. Eighteen wheat (Triticum aestivum L.) genotypes were screened for high temperature with respect to four traits under field and the polyhouse as normal and stressed conditions during winter session of 2011-12 at Pusa farm, Rajendra Agricultural University, Bihar, India. Spikelet fertility, number of grains per spike, number of effective tillers per plant and pollen sterility were measured and compared to the controls (without heat stress) and Sonalika as a check. The results showed a significant difference among all of the traits in stress and control conditions. On the basis of heat susceptibility index (HSI) the genotypes, Pusa gold, PBW 343, Raj 3765, HD 2888, F5-995 and K0583 were found relatively heat tolerant. Our results suggest that there are significant differences among genotypes that can be used in breeding for heat tolerance at pre anthesis and post anthesis stages and the development of high yielding wheat varieties.

Keywords: Wheat, HSI, High temperature, spikelet fertility, polyhouse.

Introduction

Wheat (*Triticum aestivum* L.) isa self-pollinated and one of the most important cereal grain cropof the world. It is very sensitive crop with respect to terminal temperature or post anthesis heat stress[1]. It occupies second ranks in India in terms of total production and cultivated area after rice[2]. Currently, the production of wheat in India is 94.90 million tonnes and an area is 29.90 million hectare with a yield of about 3 tonnes per hectare[3]. Heat stress or high temperature is an abiotic stress which major limit the yield of wheat in arid, semiarid, tropical, and subtropical parts of the world[4]. When a plant is subjected to water stress[5], high salinity[6] andheavy metal such as arsenic[7] it affected major physiological processes, plant growth and ultimately leads to reduce crop productivity and production**.** Crop like sorghum is relatively salt tolerant because it possess several anatomical and morphological features that enable it to survive in salt affected and water limited environments[8]. Terminal heat stress usually affect the crop at several stages of wheat development like, booting, heading, anthesis and ultimately reduction in grain yield, grain size[9] and grain filling duration[10] in the most growing areas of the world. Optimum temperature during its reproductive stages is 15˚C, and for each 1˚C above optimum, a 3-4% decrease in yield[11,12] during grain filling duration[13,14] was recorded in the Mediterranean environment[15].

Heat stress on or before anthesis decreases crop yield and rate of grain filling duration[16,17,18] respectively. The effect of heat stress on yield and yield attributing traits usually depends on the growth stage during which the high temperature was subjected[19]. The effect of high temperature stress on post anthesis induces several physiological changes in wheat eventually result in smaller size of grain and it may be attributable to decrease ofgrain filling period and grain filling rate or the combined effect of both[20]. The rate of annual crop yield also changed due to increased concentration of CO_2, higher temperature and decreased solar radiation upto certain extent[21]. Due to lack of rain, high temperature and dry soil are favourable condition for some disease in crop like sesame[22]. Theeffect of higher temperature stress on fertility traits in stress condition is more pronounced then the plant under typical normal condition[23]. Most studies in common or bread wheat has focused on heat stress on or around anthesis stage. Although the effect of high temperature during the microsporogenesis has been investigated using microscopy and this study was used to detect differences among heat tolerant and heat sensitive genotypes in high temperature stress condition. Raising the production of wheat is a challenge for the future, there is further need to develop high yielding and heat tolerance wheat varieties suitable for different environments of the country.

In sugarcane soil microorganism also play important roledetermining crop productivity[24] and saline soil are adversely affect metabolic activities in rice[25]. In warmer areas to enhance the production and productivity in wheat cultivation, new set of varieties having heat tolerance is required. The main aim of this study was to understand the effect of high temperature stress on fertility traits and to identify suitable cultivars will then be used in wheat breeding programmes for the development of heat tolerant germplasm suitable for targeted environment.

Material and Methods

Experimental site and Treatments: The experiment was conducted in the research farm at Rajendra Agricultural University, Bihar, in the Pusa (25.590 N, 85.400 E; 52.18 m elevation) in a clay type of soil during the winter season of 2011-12. The experiments for morphological study of wheat genotypes were conducted in heat stressed and normal conditions to understand the basis of genotypic differences in fertility traits. Genotypes were grown in a three rows of 3.0 m length spaced at 22.5 cm between row and 15 cm within row between plants. Genotypes were sown in plastic pots under open condition and allowed for proper development with protective irrigation until booting and heading stage. The pots were transferred inside polyhouse during anthesis stage followed by creating a heat stress environment and recorded the data at different stages i.e. anthesis, grain filling and maturity. Compound microscopy (Olympus) was used to examine pollen viability after heat stress was applied.

Weather: Weekly meteorological data from the date of sowing to harvesting of crop in the year 2011-12 for the temperature (max and min), relative humidity (max and min) and rainfall were recorded with a 12 h photoperiod at night (table 1).

Observation of fertility traits: Observation on four quantitative characters was recorded separately under both conditions. In each plot/pot, five randomly selected plants excluding border ones, to record observations. By taking the data from each replication, the mean value for the treatment was computed for analysis.

Spikelet fertility: Spikelet fertility was counted on the basis of seed setting at the time of harvest and calculated as follows[26].

Spikelet fertility (%)=Number of fertile spikelets/Total number of spikelets per spike X 100.

Pollen sterility: Pollens or microspores were collected from the lower, middle and upper parts of spikes before anthesis. Pollen sterility was assessed by smearing mature anthers in 2 percent acetocarmine stain. The pollen sterility was calculated as[27].

Pollen sterility (%) =Number of unstained pollen grains/Total number of pollen grains X 100

Heat susceptibility index: Heat susceptibility index (HSI) was calculated over stress and non-stress environment by using the formula[28]:
HSI = [l-YD/YP]/D

Where, YD = mean of genotypes in stress environment, YP = mean of genotypes under non-stress environment, D = 1-[mean YD of all genotypes/mean YP of all genotypes].

Table-1
Weekly meteorological data during crop growth period in winter session of 2011-12 under normal and stressed conditions (From 50 to 17 standard meteorological weeks, where: Max-maximum, Min-minimum)

SMW	Dates	Temperature (^{0}C)				Relative Humidity (%)				Rainfall (mm) (N)
		Normal		Stressed		Normal		Stressed		
		Max	Min	Max	Min	Max	Min	Max	Min	
50	10th Dec-16th Dec	18.4	12	23.6	13.1	87	76	89	77	Nil
51	17th Dec-23rd Dec	20	11.3	25.1	12	91.2	74	92.4	75	Nil
52	24th Dec-31st Dec	19.7	9.7	25	10.2	90.7	68	90.9	68.5	Nil
1	1st Jan-7th Jan	20.1	12	24.3	13	90.4	78	90.7	78.7	2.5
2	8thJan-14th Jan	18.6	10	26.2	11.3	90	63	91.3	64	3
3	15th Jan-21st Jan	21	9.4	26.9	10	88	57	87	58	Nil
4	22nd Jan-28th Jan	20.7	6.7	28	7	91	46	91.4	47	Nil
5	29th Jan-4th Feb	22.2	6.5	29.1	7.4	89	42	90.3	43.1	Nil
6	5th Feb-11th Feb	23.7	9.5	30	10.4	87	46	88.2	47.1	Nil
7	12th Feb-18th Feb	24.7	10.5	30.4	11	86	46	87.5	47	Nil
8	19th Feb-25th Feb	26.7	10.9	31.6	12.6	85	45	86.1	46	Nil
9	26th Feb-4th Mar	26.7	9.9	31.7	11.1	80	37	82	38	Nil
10	5th Mar-11th Mar	29.4	11.4	34.6	12	77	45	79.2	46	Nil
11	12th Mar-18th Mar	27.5	11.1	35.9	12.3	88	43	89	43.5	0.9
12	19th Mar-25th Mar	31.9	14.9	39.8	15.6	85	38	86.1	39	Nil
13	26th Mar-1st Apr	35.4	16.3	40.7	17	85	32	86.3	33	Nil
14	2nd Apr-8th Apr	35.4	20.1	37.5	21	77	47	78	47	0.2
15	9th Apr-15th Apr	32.4	20.3	43.4	21.3	84	40	85	41	1.5
16	16th Apr-22nd Apr	37.1	20.6	44.1	21.7	78	34	79	35	Nil
17	23rd Apr-29th Apr	38.9	22	45.2	23.1	69	34	70	35	Nil

Statistical analysis: For statistical analysis the experiments were laid out in randomized block design and completely randomized design under field (without heat stress) and polyhouse (heat stress) conditions, respectively with three replications. The data was statistically evaluated for analysis of variance using SPSS ver. 16.0 for mean, standard errors, and differences in environmental treatments.

Results and Discussion

The results from the analysis of variance indicated that significant differences among all the studied characters in varying environment indicating the influence of temperature on genotypes and fertility traits (table 2). Further, it was observed that the presence of significant genotypes and environment interaction indicated that genotypes were performing differently in different test environments. Similar results were reported by several researchers[29-31]. The per se performance analysis of eighteen bread wheat genotypes for grain yield and yield contributing characters were significantly varied among the genotypes for various fertility traits (figure 1 and table 4) and compare to the Sonalika as a check. Among the genotypes Mons ald's, HD 2285, Iepaca rabe, PBW 343, Raj 3765, HD 2888, VL 914 and K0583 in normal and HD 2285, PBW 343 in stressed has more spikelet fertility then the check Sonalika. Only one genotype, AKAW 4008 in normal and F5-995 in a stressed condition produced highest number of grains per spike than check Sonalika. Four genotypes namely, HD 2733, C 306, Kauz/AA/Kauz and HD 2888 on normal and ten genotypes viz. HD 2285, Iepaca rabe, Pusa gold, PBW 343, Kauz/AA/Kauz, Raj 3765, HD 2888, K0583, SAWSN 3010 and Cuo/79/Prulla in a stressed condition produced a significantly higher number of effective tillers than the check Sonalika, increasing trend in the number of effective tillers showed in stressed may be due to temperature, relative humidity and related prevailing weather conditions stressed.

Only one genotype, F5-995 in normal and four genotypes viz. Iepaca rabe, AKAW 4008, PBW 343 and VL 914 in a stressed condition showed higher pollen sterility then the check Sonalika. It may be due to high temperature and high relative humidity in stressed to affect the tapetal degeneration during meiosis and loss of water from microspore[32]. Similar observation has been reported by some earlier researchers[33,34,35]. Considering most of the fertility traits K0583, Cuo/79/Prulla, PBW 343, Iepaca rabe, HD 2285 and Kauz/AA/Kauz were found promising with good yield potentials.

Heat susceptibility index (HSI) analysis was conducted for three characters namely spikelet fertility, number of grains per spike and pollen sterility (table 3), it is the measure of yield stability[36] based on minimization of yield loss under stress, compared to non-stress condition rather than on yield contributing traits under dry/stress condition per se[37]. The genotypes were differentiated into relatively heat tolerant (HSI<1) and relatively heat susceptible (HSI>1) groups for each trait[38]. Except HD 2733, all genotypes including Sonalika were relatively heat tolerant and AKAW 4008 was most relatively heat tolerant genotype for spikelet fertility. Remaining one genotype HD 2733 was most relatively heat susceptible genotype. For number of grains per spike the genotypes PBW 343, Pusa gold, Raj 3765, K0583 and HD 2888 were relatively heat tolerant and F5-995 was found most relatively heat tolerant. Remaining genotypes i.e. Mons ald's, HD 2285, Iepaca rabe, HD 2733, Halna, Kauz/AA/Kauz, Sonalika, SWASN 3010 and Cuo/79/Prulla were categorised as relatively heat susceptible and AKAW 4008 and C 306 were found most relatively heat susceptible. For pollen sterility all genotypes were showing their HSI value below unity, so these genotypes were relatively heat tolerant. Genotype VL 914 and Kauz/AA/Kauz were most relatively heat tolerant while, no genotype which was susceptible to heat. Only six out of 18 genotypes namely, Pusa gold, HD 2888, Raj 3765, PBW 343 F5-995 and K0583 were found to be relatively tolerant to heat stress for all these characters namely spikelet fertility, number of grains per spike, pollen sterility and these results are in agreement with some earlier workers[39,40]. To characterise crop species phylogenetic and biochemical profiling studies have received considerable attention in recent years[41].

Table-2
Analysis of variance for design of experiment for fertility traits in wheat

Source of variation	Environments	Spikelet fertility	No. of grains per spike	No. of effective tillers per plant	Pollen sterility
		Mean sum of Squares			
Replication	Normal	250.51	3.88	1.121	87.696
	Stressed	274.19	27.41	1.017	77.573
Treatment	Normal	569.212**	110.021**	9.025**	173.682**
	Stressed	498.675**	96.773**	6.867**	187.304**
Error	Normal	147.491	13.23	1.478	20.694
	Stressed	103.042	13.241	0.617	37.535

** Significant at 1% and 5% probability level

Table-3
Heat susceptibility index (HSI) of wheat genotypes for spikelet fertility, number of grains per spike and pollen sterility

Sl. No.	Genotype	Heat Susceptibility Index (HSI)		
		Spikelet fertility	No. of grains per spike	Pollen sterility
1.	Mons ald's	0.75	3.00	0.35
2.	HD 2285	0.32	5.82	-0.27
3.	Sonalika	0.35	5.07	0.40
4.	Iepaca rabe	0.65	1.04	0.14
5	AKAW 4008	-0.11	11.65	-0.42
6.	Halna	0.89	6.53	-0.15
7.	Pusa gold	0.49	-5.33	0.34
8.	PBW 343	0.04	-2.71	0.03
9.	HD 2733	1.01	7.82	0.40
10.	C 306	0.44	10.01	-0.36
11.	Kauz/AA/Kauz	0.14	3.16	-0.76
12.	Raj 3765	0.30	-3.15	0.26
13.	HD 2888	0.83	-10.13	0.47
14.	VL 914	0.60	2.40	-1.02
15.	F5-995	0.38	-33.51	0.63
16.	K0583	0.73	-6.61	0.23
17.	SWASN 3010	0.57	2.24	-0.03
18.	Cuo/79/Prulla	0.36	2.62	0.29

Table-4
Means, coefficient of variance and standard error of 18 genotypes of wheat, evaluated at RAU, Bihar (India) over two environmental conditions

Sl. No.	Characters	Environment	Mean	CV %	Se(m)
1.	Spikelet fertility	Normal	70.91	17.12	7.01
		Stressed	47.01	21.77	16.88
2.	No. of grains per spike	Normal	44.52	8.17	2.10
		Stressed	43.46	8.37	6.05
3.	No. of effective tillers per plant	Normal	5.55	21.90	0.70
		Stressed	5.45	21.90	1.31
4.	Pollen sterility	Normal	20.93	21.72	2.62
		Stressed	19.34	31.67	10.19

Conclusion

The present study emphasizes that the mean square of genotypes was significant for all the characters studied indicating significant differences exist among the genotypes. Most of the wheat genotypes were more affected when exposed to heat stress during at the time of anthesis. Analysis of variance revealed highly significant differences among the genotypes for the studied all parameters. Considering all the parameters it may be concluded that relatively stable genotypes may be evaluated at various agro climatic regions for grain yield, tolerance to heat along with other contributing characters and can be used as selection criteria in breeding programmes.

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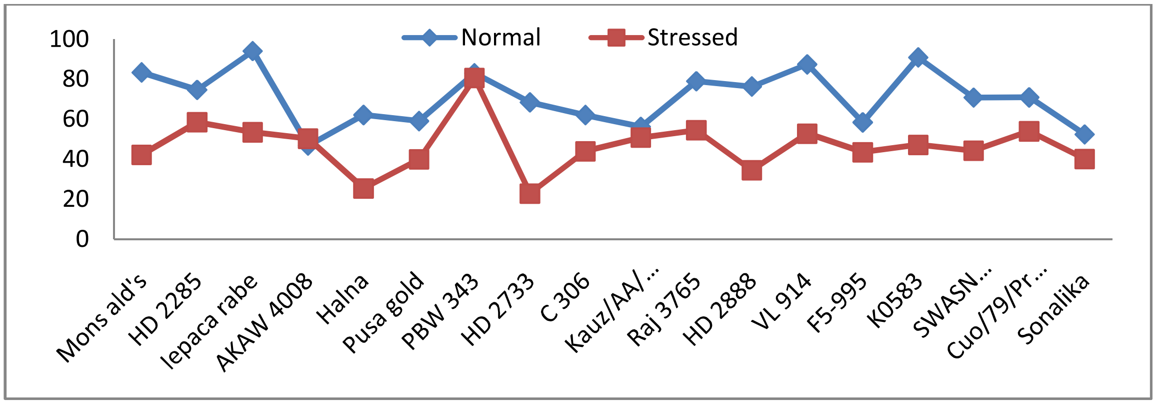
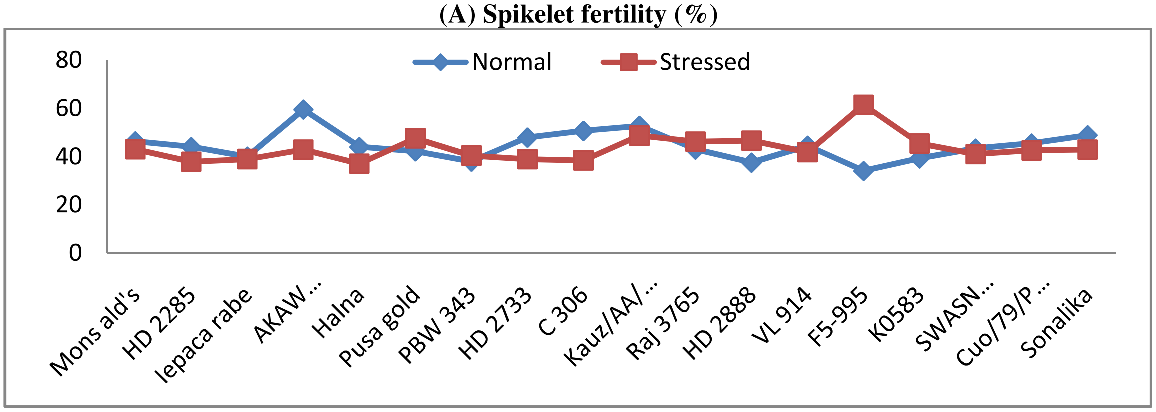
References

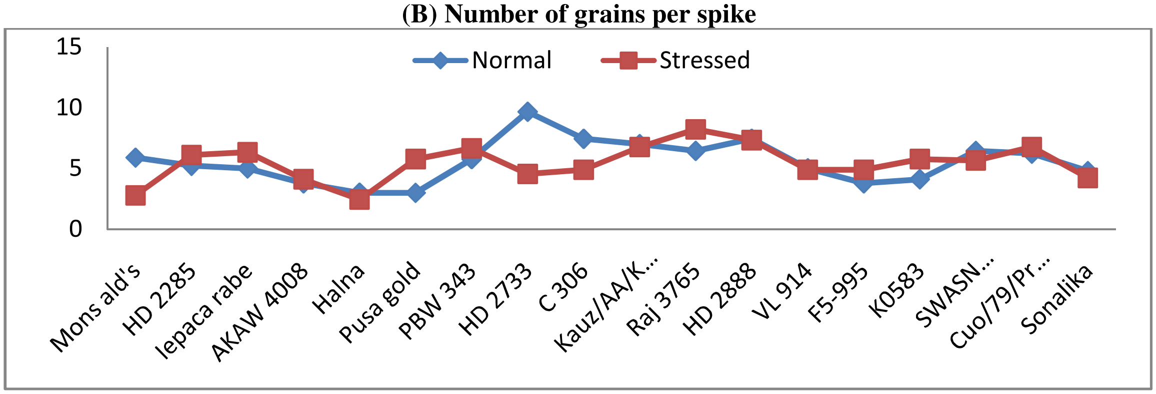
1. Barnabas B.K. Jager and Feher A., The effect of drought and heat stress on reproductive processes in cereals, *Plant, CellEnv.*, **31,** 11-38 **(2008)**
2. Mahesh K.S., Chandrashekara K.T., Rajashekar N. and Jagannath S., Physiological behaviour of few Cultivars of Paddy (*Oryzasativa* L.) during Seed Germination and early Growth, subjecting to distillery Effluent Stress, *Int. Res. J. Biological Sci.,* **2(9),** 5-10 **(2013)**
3. FAOSTAT, Food and Agriculture Organization of the United Nations, Food Outlook **(2012)**
4. Fischer R.A., Physiological limitation to producing wheat in semitropical and tropical environments and possible selection criteria. In *Proc. Int. Symp.Wheats for More TropicalEnvironments*, 209-230. Mexico, DF, CIMMYT **(1986)**



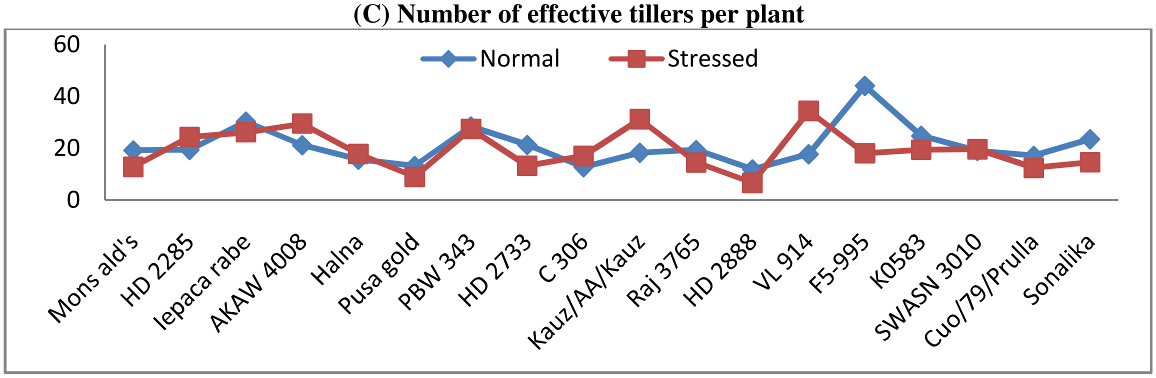
(A) Spikelet fertility (%)



(B) Number of grains per spike



(C) Number of effective tillers per plant



(D) Pollen sterility

Figure-1

Differences in mean performance of fertility traits for 18 wheat genotypes and under normal and stressed conditions

5. Rady M.M. and Gaballah M.S., Improving Barley Yield Grown Under Water Stress Conditions, *Res.J.Recent Sci*., **1(6),** 1-6 **(2012)**

6. Sikha S., Sunil P., Arti J. and Sujata B., Impact of Water-deficit and Salinity stress on Seed Germination and Seedling Growth of Capsicum annuum 'SolanBharpur, *Int. Res. J. Biological Sci.*, **2(8),** 9-15 **(2013)**

7. Indira C., Genotypic Differences in Effects of Arsenic on Growth, and Concentration of Arsenic in Rice (*Oryzasativa*) genotypes, *Res. J. Recent Sci*., **2(3),** 49-52 **(2013)**

8. Rani C.R., Reema C., Alka S. and Singh P.K., Salt Tolerance of Sorghum bicolor Cultivars during Germination and Seedling Growth, *Res. J. Recent Sci.,* **1(3),** 1-10 **(2012)**

9. Lobell D.B., Sibley A. and Ortiz-Monasterio J.I., Extreme heat effects on wheat senescence in India, Nat climate change, 1-4, Macmillan publishers limited **(2012)**

10. Rane J., Pannu R.K., Sohu V.S., Saini R.S., Mishra B., Shoran J., Crossa J., Vargas M. and Joshi K., Performance of yield and stability of advanced wheat cultivar under heat stress environments of the indo-gangetic plains, *Crop Sci.,* **47,** 1561-1572 **(2007)**

11. Acevedo E., Nachit M. and Ortiz-Ferrara G., Effect of heat stress on wheat and possible selection tools for use in breeding for tolerance. In: D.A. Saunders (ed.), Wheat for the non-traditional warm areas; 401-421, Mexico, DF. CIMMYT **(1991)**

12. Wardlaw I.F., Dawson I.A., Munibi P. and Fewster R., The tolerance of wheat to high temperatures during reproductive growth, II. Survey procedures and general response patterns, *Aust. J. Agri. Res.,* **40,** 1-13 **(1989)**

13. Mian M.A., Mahmood A., Ihsan M. and Cheema N.M., Response of different wheat cultivars to post anthesis temperature stress, *J Agri Res*., **45,** 269-277 **(2007)**

14. Gibson L.R. and Paulsen G.M., Yield components of wheat grown under high temperature stress during reproductive growth, *Crop Sci.,* **39,** 1841-1846 **(1999)**

15. Jalal Kamali M.R. and Duveiller E., Wheat Production and Research in Iran: A Success Story. In: International Symposium on Wheat Yield Potential: Challenges to International Wheat Breeding, Mexico, D.F. CIMMYT (**2008**)

16. Wardlaw I.F. and Moncur L., The response of wheat to high temperature following anthesis: I, The rate and duration of kernel filling, *Aust. J. Plant Physiol*., **22,** 391–397 **(1995)**

17. Stone P.J., Savin R., Wardlaw I.F. and Nicolas M., The influence of recovery temperature on the effect of a brief heat shock on wheat: I, Grain growth, *Aust. J. Pl. Physiol.,* **22,** 945-954 **(1995)**

18. Randall P.J. and Moss H.J., Some effects of temperature regime during grain filling on wheat quality, *Aust. J. Agri. Res*., **41,** 603-617 **(1990)**

19. Vos J., Effect of temperature and nitrogen supply on post-floral growth of wheat: measurements and simulations, Agricultural Research Reports, No. 911, PUDOC, PhD thesis, University of Wageningen, the Netherlands **(1981)**

20. Hasan M. A. and Ahmad J. U., Kernel growth physiology of wheat under late planting heat stress*, J Nat Sci.,* **33,** 193-204 (**2005)**

21. Suryavanshi P., Babu S., Baghel J.K. and Suryavanshi G., Impact of Climate Change on Agriculture and their Mitigation Strategies for Food Security in Agriculture: A Review, *ISCA J. Biological Sci.,* **1(3),** 72-77 **(2012)**

22. Andrea M.H., Yuraima M., Dasybel P. and Hernan L., Genetic variability of *Macrophominaphaseolina* Affecting Sesame: phenotypic traits, RAPD markers and interaction with the Crop, *Res. J. Recent. Sci*., **2,** 110-115 **(2013)**

23. Hall A.E., Breeding for heat tolerance, *Plant Breed. Rev*., **10,** 129–168 **(1992)**

24. Dhanraj N.B., Bacterial Diversity in Sugarcane (*SaccharumOfficinarum*) Rhizosphere of Saline Soil, *Int. Res. J. Biological Sci.,* **2(2),** 60-64 **(2013)**

25. Zinnah K.M.A., Zobayer N. Sikdar S. U. Liza L. N. Chowdhury M. A. N. and Ashrafuzzaman M., In Vitro Regeneration and Screening for Salt Tolerance in Rice (*Oryzasativa* L.), *Int. Res. J. Biological Sci.,* **2(11**), 29-36 **(2013)**

26. Gupta R. Guhey A. Jadhav A. and Ahad I., Physiological boost to improve the yield of rice germplasm under different water regimes, *Res. J. Sci.,* **2(1),** 87-90 **(2011)**

27. Waheed A., Ahmad H., Abbasi F.M., Hamid F.S., Shah A.H., Safi F.A. and Ali H., Pollen sterility in wide crosses derivatives of rice (*Orizasativa* L.), *J. Mater. Env. Sci.*, **4(3),** 404-409 **(2013)**

28. Fisher R.A. and Maurer R., Drought resistance in spring wheat cultivars I. Grain yield responses, *Aust. J. Agri. Res.,* **29,** 897-912 **(1978)**

29. Menshawy A.M.M., Evaluation of some early bread wheat genotypes under different sowing dates: 1 Earliness characters, *Fifth plant breeding conf. (May)*, *Egypt J. Pl. Breed*., **11(1),** 25-40 **(2007)**

30. Abd El-Majeed S.A. Mousa A.M. and Abd El-Kareem A.A., Effect of heat stress on some agronomic traits of bread wheat (*Triticum aestivum* L.) genotypes under Upper Egypt conditions, *Fayoum J. Agric Res and Dev*., **19(1),** 4-16 **(2005)**

31. El-Morshidy M. A. Kheiralla K. A. Abdel-Ghani A. M. and Abd El-Kareem A. A., Stability analysis for earliness and grain yield in bread wheat, *Second Plant Breeding. Conf.* (October 2), AssiutUniv: 199-217 **(2001)**

32. Saini H.S., Sedgley M. and Aspinall D., Developmental anatomy in wheat of male sterility induced by heat stress, water deficit or abscisic acid, *Aust. J. Pl. Physiol*., **11,** 243-253 **(1984)**

33. Jager K., Fabian A. and Barnabas B., Effect of water deficit and elevated temperature on pollen development of drought sensitive and tolerant winter wheat (*Triticum aestivum* L.) genotypes, *Acta Biologica Szegediensis*, **52(1),** 67-71 **(2008)**

34. Lalonde S., Beebe D. and Saini H.S., Early signs of disruption of wheat anther development associated with the induction of male sterility by meiotic-stage water deficit, *Sex Pl. Repro.,* **10,** 40-48 **(1997)**

35. Dorion S., Lalonde S. and Saini H.S., Induction of male sterility in wheat by meiotic stage water deficit is preceeded by a decline in invertase activity and changes in carbohydrate metabolism in anthers, *Pl. Physiol,* **111,** 137-145 **(1996)**

36. Bruckner P.L. and Frohberg R. C., Stress tolerance and adaptation in spring wheat, *Crop Sci*., **27,** 31–6 **(1987)**

37. Clarke J.M., Smith T.T.F., McCaig T.N. and Green D.G., Growth analysis of spring wheat cultivars of varying drought resistence, *Crop Sci*., **24,** 537-541 **(1984)**

38. Al-Qtayk S.M., Performance of yield and stability of wheat genotypes under high stress environments of the central region of Saudi Arabia, *JKAU: Met., Env. Arid Land Agri. Sci.,* **21(1),** 81-92 **(2010)**

39. Mahmoud A.M., Genotype × Environment interactions of some bread wheat Genotypes (*Triticum aestivum* L.), *Aust J. Agric. Sci.,* **37(4),** 119-138 **(2006)**

40. Kheiralla K.A., Mohamed A., El-Morshidy M., Motawea H. and Saeid A.A., Performance and stability of some wheat genotypes under normal and water stress condition, *Aust J. Agric. Sci*., **35(2),** 74-94 **(2004)**

41. Sharma A. and Sharma P., Genetic and Phytochemical analysis of Cluster bean (*Cyamopsistetragonaloba* (L.) Taub) by RAPD and HPLC, *Res.J.Recent Sci*., **2(2),** 1-9 **(2013)**