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Research Article

HEAT STRESS INDICES, CORRELATION AND REGRESSION ANALYSIS OF WHEAT GENOTYPES FOR YIELD POTENTIAL

Pronay Bala[1]* and Sripati Sikder[2]

[1]Department of Agricultural Sciences, Hazi Lalmia City College, Gopalganj, Bangladesh.
[2]Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh

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A B S T R A C T

This study was conducted to identify heat tolerant genotypes through heat tolerance indices of wheat genotypes in response to heat stress. In this respect eight wheat genotypes viz., Pavon-76, Prodip, BARI Gom-25, BARI Gom-26, BAW-1143, BAW-1146, BAW-1147 and BAW-1148 were used as study materials. Three experiments were conducted during 2011-12 and 2012-13. The experiment, wheat genotypes were evaluated in relation to heat tolerance in field condition by seeding them at November 27 (normal), December 17 (late) and January 7 (very late growing condition) over two successive years. Different heat tolerance indices viz. mean pproductivity (MP), geometric mean productivity (GMP), Heat Tolerance Index (HTI), tolerance (TOL), yield stability index (YSI), relative efficiency index (REI) and heat iintensity index (HII) were evaluated based on grain yield under stress and non-stress conditions. The results showed BAW-1143, BARI Gom-25, BARI Gom-26 and Prodip showed high Heat Tolerance Index (HTI) , Geometric Mean Productivity (GMP) and high Mean Productivity (MP).Canopy temperature , flag leaf proline, seed size and harvest index showed mostly positive and meaningful correlation with yield in both stress and non-stress environments.

INTRODUCTION

Heat stress is the most important stress factor that affects between 25 and 30 million hectares of wheat annually in the world and thereby causing significant grain yield reduction (Battisti and Naylor,(2009). It has thus posed a severe threat to wheat production in many countries, particularly when it occurs during reproductive and grain filling phases. Unlike drought and salinity stresses, changes in ambient temperatures occur within hours. Therefore, plants need to suppress and respond to the adverse. For healthy wheat growth and a good yield, the range of the optimum temperatures was 18 to 24°C. Temperatures above 28 to 32°C for short periods (e.g.,5 to 6 days) found to cause about 20% or more wheat yield losses (Stone and Nicolas 1994). This is because heat stress causes an array of physiological, biochemical and morphological changes in wheat which reduce tillering capacity, shortens grain filling period and accelerates crop senescence (Elbashier *et al*. 2012).

In Bangladesh, wheat improvement programme for heat stress environment is still running based on late planting yield performance. It has not taken account the growth and physiological sensitivity in relation to heat tolerance. So, selection of heat tolerant genotypes by screening advance lines through a standard procedure and to evaluate their performance through physiological and yield attributes at late seeding warmer condition in Bangladesh environments would be an important step to develop heat tolerant variety and also achieving high yield potential of wheat under high temperature condition. Heat tolerance indices which provide a measure of heat based on yield loss under heat stress condition in comparison to normal have been used for screening heat tolerance genotypes(Mitra,2001).It is against this background that this research was conducted. The main objectives of this study were to generate information on the extent of heat stress induced changes in wheat which can be used in breeding for heat tolerant wheat.

MATERIALS AND METHODS

The experiment was conducted in the research farm and laboratory of Crop physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur during the period from November to April of 2011-12 and 2012-2013. The test crop was wheat. Seeds were collected from the Wheat Research Centre, Bangladesh Agricultural research Institute, Nashipur, Dinajpur. For conducting the present investigation eight genotypes viz. Prodip, BARI Gom-

* **Corresponding author:** Pronay Bala
Department of Agricultural Sciences, Hazi Lalmia City College, Gopalganj, Bangladesh

25, BARI Gom-26, BAW-1143, BAW-1146, BAW-1147, BAW-1148 and Pavon-76, were used as experimental materials. Their characteristics are given below: (Afroz and Mostafa, 2014). It was laid out in a split plot design with three replications. The unit plot size was 3m × 2m having a plot to plot and block to block distance of 0.75 m and 1.0m, respectively. For crop cultivation the management practice recommended by WRC was followed.

The treatment factors A and B was

Main plot treatment: Three growing conditions

1. Normal sowing condition (Sowing at 27 November)
2. Late sowing or post- anthesis heat stress condition (Sowing at 17 December)
3. Very late sowing or extreme post-anthesis heat stress condition (Sowing at 07 January for 2011-12 and 2012-13)

Sub plot treatment**:** Eight wheat genotypes viz. Prodip, BARI Gom-25, BARI Gom-26,

BAW-1143, BAW-1146, BAW-1147, BAW-1148 and Pavon-76 (as check).

The cultivation method of this crop was followed by

The sample were collected from an area of 1 meter ×1 meter from the centre of each plot by cutting the plant at the ground level and was collected in a cloth back $2' \times 1.5'$. The samples were dried in the sun, threshed and cleansed and dry weights of grain, straw and husk were recorded. The biological yield and grain yield were expressed in ton per hectare (t/ha). Grain yield was also adjusted to 12% moisture content.

Stress tolerance indices were calculated by the following formula

Mean Productivity (MP) =(Ys+Yp)/2 (Hossain *et al*. 1990)
Higher values of MP is good for heat tolerance

Geometric Mean Productivity (GMP) = √Yp. Ys (Fernandez 1992

Higher values of GMP is good for heat tolerance
Heat Tolerance Index (HTI) = Ys. Yp/Xp^2 (Fernandez 1992)
Heat tolerant genotypes exhibits high HTI values
Tolerance (TOL)= Yp-Ys(Hossain *et al.*,1990)
Yield stability index (YSI) =Ys/Yp (Lin *et al*. 1986)
Higher values of YSI categorized the genotypes as stable ones in contrasting environments.
Yield index =$\overline{Ys}$/ Ys (Gavuzzi *et al*.,1997)
Relative efficiency index (REI)=Ys/Xs×Yp/Xp (Raman et al.,2012)

Heat Intensity Index (HII) = 1-X_s / X_p (Fisher and Maurer 1978)

Here,
Ys = Genotypic yield under stress
Yp = Genotypic yield under non-stress
Xp = mean yield of all genotypes under non-stress conditions
Xs = mean yield of all genotypes under stress conditions

The data were analyzed by partitioning the total variance with the help of computer by using MSTAT-C computer package (Russell, 1994). The treatment means were compared using Duncan's Multiple Range Test (DMRT) (Duncan, 1955) at P≤0.05. Correlation and Regression analysis was also done and level of significance was tested with t-test (Singh and Choudhary 1985).

RESULTS AND DISCUSSION

Heat stress tolerance indices

Heat tolerance is the ability of the plant to grow and produce economic yield under high temperature. Some heat tolerance indices based on yield are shown in Table 1 and 2.

The results indicate that several of the genotypes were superior for heat tolerance based on the stress indices and on the consistency of their reactions across environments. But the magnitude of differences in genotypes was sufficient to provide some scope for selecting genotypes with improved heat stress tolerance. BAW-1143, BARI Gom-25, BARI Gom-26 and Prodip showed high Heat Tolerance Index (HTI) and Geometric Mean Productivity (GMP) and high Mean Productivity (MP). Mean productivity (MP) is defined as average yield of genotype under heat stress and non-stress environments and high mean productivity designated more tolerance to stress. Based on the MP index, the BAW-1143, BARI Gom-25, BARI Gom-26 and Prodip were identified as tolerant. Therefore, according to these results, selection based on MP will improve mean yield under both conditions. Based on HTI, the genotypes BAW-1143 (0.72), BARI Gom-25 (0.55), BARI Gom-26 (0.59) and Prodip (0.52) showed the highest tolerance to heat stress. Geometric mean productivity (GMP) is often used by breeders interested in relative performancece, since heat stress may can very in severity in field environment over years. The study of GMP showed more comprehensive results. Based on this index, BAW-1143, BARI Gom-25, BARI Gom-26 and Prodip were revealed as tolerant, and had high yield under both conditions. This makes GMP the most accurate criterion in selecting genotypes with tolerance to heat stress and high yield under both stressed and non-stressed conditions. Yield index (YI) and yield stability index (YSI) are expected to have high yield under stressed and low yield under non -stressed condition Mohammadi *et al*. (2010). According to Sareen *et al.* (2012), these indices are still important in differentiating genotypes with stress tolerance and susceptibility.

Table 1 Heat tolerance indices on seed yield of eight wheat genotypes under normal and high temperature stress conditions for 2011-12

Genotype	GMP	HTI (Rank)	MP	YSI	TOL	REI	RHI	YI
Prodip	2.90	0.52(4)	3.09	0.49	2.11	1.03	1.00	1.03
BARI Gom-25	3.00	0.55(3)	3.18	0.50	2.10	1.13	1.03	1.08
BARI Gom-26	3.09	0.59(2)	3.27	0.51	2.11	1.20	1.04	1.12
BAW-1143	3.43	0.72(1)	3.56	0.58	1.89	1.47	1.18	1.32
BAW-1146	2.81	0.49(5)	3.00	0.48	2.1	0.99	0.98	0.98
BAW-1147	2.75	0.47(6)	2.94	0.48	2.05	0.95	0.98	0.96
BAW-1148	2.67	0.44(7)	2.86	0.48	2.02	0.90	0.98	0.93
Pavon-76	1.89	0.22(8)	2.14	0.36	2.02	0.45	0.73	0.57
Heat intensity index (HII)				0.509				

Table 2 Heat tolerance indices on seed yield of eight wheat genotypes under normal and high temperature stress conditions for 2012-13

Genotype	GMP	HTI (Rank)	MP	YSI	TOL	REI	RHI	YI
Prodip	2.99	0.51(4)	3.18	0.49	2.15	1.04	1.01	1.02
BARI Gom-25	3.12	0.56(3)	3.29	0.52	2.07	1.13	1.06	1.09
BARI Gom-26	3.18	0.58(2)	3.35	0.53	2.07	1.18	1.08	1.12
BAW-1143	3.63	0.76(1)	3.78	0.57	2.05	1.54	1.17	1.33
BAW-1146	2.99	0.51(5)	3.18	0.49	2.15	1.04	1.01	1.02
BAW-1147	2.84	0.47(6)	3.05	0.47	2.2	0.94	0.96	0.95
BAW-1148	2.72	0.42(7)	2.91	0.47	2.08	0.86	0.97	0.91
Pavon-76	1.94	0.22(8)	2.21	0.36	2.09	0.44	0.73	0.56
Heat intensity index (HII)				0.506				

The heat tolerance indices proved to be the most useful for the evaluation of genotypic performance under heat stress (Fernandez 1992). HTI, GMP and YSI were all correlated with yield under heat stress, whereas HTI and GM were more highly correlated with yield under low-stress conditions than YSI. This results are in conformity with those of Boussen *et al.* (2010) and Karimizadeh and Mohammadi (2011) in durum wheat and Abdolshahia *et al.* (2012) and Anwar *et al.* (2011) in aestivum wheat. A suggest that selection based on TOL will result in increased yield under optimal conditions.Similar resultswere reported by Sio-Se Mardeh *et al*.(2006).

Abiotic stress tolerance is a key component and in some cases the major factor in improving yield in crops. Heat stress is an important constraint and will play an increasing role in yields due to global climate change.

Strength of association among traits

The strength of association between grain yield and different morpho-physiological traits in a heat stress environment was determined using simple correlation analysis. Result of this study showed positive and significant correlation between grain yields with other traits (Table 3).

Table 3 Correlation coefficient of morpho-physiological characters with grain yield 2011-12 and 2012-13

Characters	2011-12			2012-13		
	Growing condition					
	Normal	Late	Very late	Normal	Late	Very late
Days to heading	0.98*	0.93*	0.59ns	0.99*	0.99*	0.95*
Days to anthesis	0.96*	0.98*	0.91*	0.95*	0.99*	0.99*
Plant height (cm)	0.67**	0.79**	0.71*	0.56ns	0.54ns	0.70**
Spike length(cm)	0.85*	0.69**	0.82*	0.87*	0.77**	0.80*
Canopy temperature depression	0.82*	0.75**	0.89*	0.36ns	0.79**	0.83*
Total chlorophyll at anthesis	0.72**	0.85*	0.52ns	0.56ns	0.82*	0.51ns
Flag leaf proline	0.85*	0.78*	0.86*	0.80*	0.80*	0.89*
Seed size	0.99*	0.98*	0.99*	0.98*	0.98*	0.99*
Biological yield	0.08ns	0.35 ns	0.58ns	0.21ns	0.37ns	0.61**
Harvest index	0.68*	0.71**	0.85*	0.73**	0.77**	0.89*

*,** Significant at 0.05 and 0.01 probability levels respectively and ns means no significant

Strong correlation and positive significant correlation were revealed for grain yield with days to anthesis (0.91 to 0.99**), Spike length (0.69* to 87**), Canopy temperature depression (0.75 to 0.89**), flag leaf proline (0.78 to 0.89**), seed size (0.98 to 0.99**). These results were in agreement with that of Kumar *et al.* (1998); Ashok Kumar *et al*. (2000); Singh *et al.*(2009) and Saktipada *et al*.(2008). Singh and Chaudhary (1985) suggested that if the correlation coefficient between a causal factor and the effect (i.e. grain yield) is almost equal to its direct effect, then correlation explains the true relationship and direct selection through this trail will be effective.

Regression analysis

Regression was used to further investigate the relationship between some physiological characters to average yield of wheat (Figure 1-2).

The relationship (slope) was positive between CTD and average yield indicating that higher CTD or cooler canopy provided a yield benefit (Figure 1).

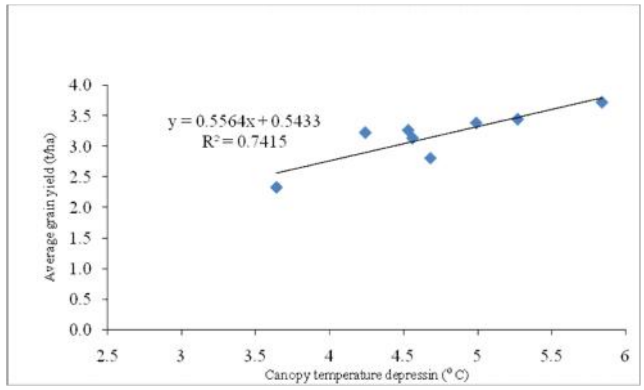

Figure 1 Relationship between Canopy temperature depression and average yield of eight genotypes of both years.

The linear relationships as estimated were y = 0.55x + 0.543, R^2= 0.741, r = 0.86. The positive relationship indicated that yield increased with the increasing of canopy temperature depression for each genotype. The linear equation stated that for every increased of 1º C CTD about 0.64 t yield were increased per hectare. The R^2 values for eight genotypes indicated that the 74% increase in average yield. Similar results were found by Mason and Singh (2014).

Relationship between flag leaf prilone and average yield was also positive (Figure 2). This relation indicating that higher flag leaf proline was better in case of yield.

The linear relationships as estimated were y = 0.253x + 2.220, R^2= 0.813, r = 0.90.

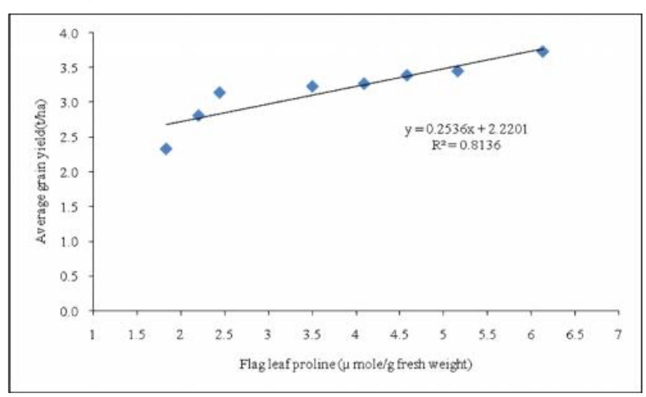

Figure 2 Relationship between average flag leaf proline and average yield of eight genotypes of both years

The positive relationship indicated that yield increased with the increasing of flag leaf proline for each genotype. The linear equation stated that for every increased of 1 μ mole/g fresh weight of flag leaf proline about 0.25 t yield were increased per hectare. The R^2 values for eight genotypes indicated that the 81% increase in average yield. These results were similar to Singh *et al.* (2014).

Relationship between total flag leaf chlorophyll at anthesis and average yield were also positive (Figure 2).

This relation indicating that higher flag leaf chlorophyll was better in case of yield.

The linear relationships as estimated were y = 3.842x - 5.470, R^2= 0.876, r = 0.94.

The positive relationship indicated that yield increased with the increasing of total flag leaf chlorophyll for each genotype.

CONCLUSION

The results indicate that several genotypes were superior for heat tolerance based on the stress indices and on the consistency of their reactions across environments. BAW-1143, BARI Gom-25, BARI Gom-26 and Prodip showed high Heat Tolerance Index (HTI) , Geometric Mean Productivity (GMP) and high Mean Productivity (MP). Based on the MP index, the BAW-1143, BARI Gom-25, BARI Gom-26 and Prodip were identified as tolerant. Therefore, according to these results, selection based on MP will improve mean yield under both conditions.

References

Abdolshahia, R., Safariana, A., Nazaria, M., Pourseyedib S. and Mohamadi-Nejad, G.. 2012. Screening drought-tolerant genotypes in bread wheat (*Triticum aestivum* L.) using different multivariate methods. Archives Agron. Soil Sci.,1-20.

Afroz, D. and Mostafa, M. R. M. 2014. Plant Varieties Developed by the NARS Institute and Agricultural Universities of Bangladesh. Dhaka, BARC.pp. 29-35.

Anwar J., Subhani, G. M., Hussain, M., Ahmed, J. ,Hussain, M. and Munir, M. 2011. Drought tolerance indices and their correlation with yield in exotic wheat genotypes. Pakistan J. Bot., 43(3): 1527-1530.

Ashok Kumar, R. Samdarshi ,B. and Kumar ,A. 2000. Correlation studies on yield and yield attributes of wheat. Gujrat Ag. *Uni. Res. J*., 25(8): 5-8.

Battisti, D. S. and Naylor, R. L. 2009. Historical warning of future food insecurity with unprecedented seasonal heat. *Science*. 323 (5911): 240-244.

Boussen, H., Ben Salem, M. ,Slama, A., Mallek-Maalej, E. and Rezgui, S. 2010. Evaluation of drought tolerance indices in durum wheat recombinant inbred lines. Options Mediterraneennes. A no.95:79-83.

Duncan, D. B. 1955. Multiple range and multiple F-tests. *Biometrics*.11 (1). pp 1-42.

Elbashier, E.M.E., Tahir, I. A. S., Saad, A. S. I. and Ibrahim,A. S. 2012. Wheat genotypic variability in utilizing nitrogen fertilizer for cooler canopy under a heat stressed environment. *African J. Agri. Res*. 7(3):385-392.

Fernandez,G. J. 1992. Effective selection criteria for assessing plant stress tolerance. In: Proceedings of international symposium on Adaptation of vegetables and other food crops in Temperate and water stress. Aug13-16, Taiwan. pp. 257-270.

Fischer, R. A. and. Maurer, R .1978. Drought resistance in spring wheat (*Triticum aestivum* L.) cultivars. I. Grain yield response. *Aust. J. Agric. Res*., 29:897-912.

Gavuzzi, P., Rizza, F., Palumbo, M., Campaline, R.G., Ricciardi, G.L., Borghi, B.1997. Evaluayion of field and laboratory predictors of drought and heat tolerance in wheat cereals. *Canadian Journal of Plant Scienc*.77:523-531.

Hossain, A.B., Sears, A., Cox, G T. S. and Paulsen, G.M.Z.1990. Desiccation tolerance and its relationship to assimilate partitioning in winter wheat. *Crop Sci*.,30:622-627.

Karimizadeh, R. and Mohammadi, R. 2011. Association of canopy temperature depression with yield of durum wheat genotypes under supplementary irrigation and rain-fed conditions. *AJCS*.5 (2):138-146.

Kumar, P., Dube S. D. and Chauhan, U. S. 1998. Relationship among yield and some physiological traits in wheat. Indian *J. Agric. Sci*. 6: 175- 179.

Lin, C. S., Binas, M. and Lefkovitch, L.P. 1986. Stability analysis where do we stand? Crop Sci. 26: 894-900.

Mason, R. E. and Singh, R. P. 2014. Considerations when deploying canopy temperature to select high yielding wheat breeding lines under drought and heat stress. *Agronomy*.4: 191-201.

Mitra, J.2001. Genetis and genetic improvement ofdrought resistance in crop plants. *Cuttent Science*.,80:758-762.

Mohammadi, R., Armion, M., Kahrizi, D., and Amri, A. 2010. Efficiency of screening techniques for evaluating durum wheat genotypes under mild drought conditions. *J.Plant Prod*.4 (1): 11-24.

Raman, A., Verulkar,S.B., Mandal,N.P., Varier,M., Shukla,V.D. Dwivedi,J.L., Singh,B.N.,Singh,&O.N., Swain,P., Mall,A.K., Robin,S., Chandrababu,R., Jain,A., Ram,T., Hittalmani, S., Haefele,S., Piepho,H.P. and Kumar, A. 2012. Drought yield index to select high yielding rice lines under different drought stress severities.Rice, 5.1-12.

Russell, O. F. 1994. MSTAT-C v. 2. 1 (A computer based data analysis software. Crop Soil Sci. Dep. Michigan State Univ. USA.

Saktipada, M., Bakshi, A., Barai, B. K and Murmu, K.2008. Character association for grain yield components in wheat . *Envi. Ecol*. 26 (1): 145-147.

Sareen, S., Tyagi, B. S. , Tiwari V. and Sharma, I.2012. Response estimation of wheat synthetic lines to terminal heat stress using stress indices. *J. Agric. Sci*.vol.4 (10): 97-104.

Singh, R. K. and Chaudhury, B. D. 1985.Biometrical methods in quantitative genetic analysis (Revised Ed.). Kalyani publisher, Ludhiana, India. 5-6 pp.

Singh, P., M. Agrawal and S. B. Agrawal. 2009. Evaluation of physiological, growth and yield responses of a tropical oil crop (Brassica campestris L. Var. Ktranti) under ambient ozone pollution at varying NPK levels. *Environ. pollut.* 157:871-880.

Singh, N.P., P. K. Pal and S. K. Vaishali. 2014. Morpho-physiological characterization of Indian wheat genotypes and their evaluation under drought condition. *African J. Biotechnol.*13 (20): 2022-2027.

Sio-Se, Msrdeh A., A. Ahmadi, K. Poustini and V. Mohammadi. 2006. Evaluation of drought resistance indices under various environmental conditions. *Field Crops Research.* 98, 222-229.

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