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Research Paper

Screening of heat tolerant wheat Genotypes in Bangladesh

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ABSTRACT

Bangladesh is a sub tropical country where only spring wheat is grown in short winter. The spring wheat grown in this region is exposed to chronic heat stress during certain growth stages. Eighty percent of wheat in Bangladesh is grown after *T. aman* rice and the wheat seeding is often delayed. Late planting exposes the wheat to high temperature during its grain filling phase causing significant yield loss. So, heat tolerance needs to be introduced in the new up coming varieties to sustain wheat productivity in Bangladesh. Therefore different issues, strategies and screening for heat tolerance in Bangladesh are discussed in this paper. WRC has given top research priority for development of high yield potential varieties having tolerance to high temperature. The experiment was conducted under irrigated timely seeding (ITS) and irrigated late seeding (ILS) conditions at three location Dinajpur, Joydebpur and Jessore in the cropping rabi season 2011-12. In the screening nursery the genotypes were evaluated for yield and yield contributing characters, heading days, maturity days and disease reaction. There was significant difference in yield and other characters between two seeding times. The genotypes (E-61, E-64, E-75 and E-77) were produced higher number of grain/spike in Dinajpur, Joydebpur and Jessore than all the checks in optimum and late seeding condition. The higher TGW were achieved in E-41 than the checks in optimum and late seeding condition for all locations. The genotypes E-42 and E-79 at Dinajpur and E-16 and E-64 at Jessore were produced higher yield in optimum and late seeding condition than checks. The higher yield (7270kg/ha) was recorded in E-55 and E-61 (6045kg/ha) in Dinajpur, respectively. Finally on the basis of overall performance 18 entries were selected for further evaluation.

Keywords: Wheat; Screening; Heat tolerance; Variety.

INTRODUCTION

Bangladesh is a sub-tropical country where wheat is second growing crop and grown in a short winter that being in November and ends at first week of March in south western part and third week of March in Northern region. The mean temperature of the coolest month (January) ranged from 17-19°C; 1-2 degrees hotter in December, February and 5-6°C hotter in March than February. Due to intensive rice wheat system about 60% of the wheat area is planted late due to delayed harvesting of rice (late variety) and the crop frequently encounter high temperature stress during grain filling period (Mid-End February). Thus large area of wheat is grown under above optimum temperature causing significant yield reduction there is a potential yield decline @ 1.3 % per day when sown beyond optimum time (Saunders, 1998). Globally, about seven million hectares of wheat affected by heat stress throughout the life cycle and 40 % crop faces terminal heat stress (Ruwali and Bhawsar, 1998). High temperature in post anthesis periods shortens the duration of grain filling such that each degree increase in temperature during grain filling results in about 3 days decrease in the duration of filling regardless of cultivars (Bagga and Rawson, 1977). Fisher and Maurer, (1976) demonstrated a 4% reduction in grain yield for every unit reduction in grain yield for every increase in temperature between tillering and grain filling. In a consultancy with NARES representative from the major wheat growing regions in the developing world, heat stress was identification of heat tolerance mechanism with high heritability and the development of mechanisms with heritability and the development of suitable methods to measure these characteristic in large breeding populations (Acevedo and Ceccarelli, 1989). Heat stress is an important constraint to wheat productivity affecting different growth stages specially anthesis and grain filling. It has already been established that heat stress can be a significant factor in reducing the yield and quality of wheat (Stone and Nicolas, 1995). Wheat Research Centre has given top research priority to develop wheat varieties having considerable level of heat tolerance in Bangladesh. To the best of my knowledge, heat tolerance variety of wheat has not been identified appropriately in Bangladesh. Present study deals with relative performance of yield components and yield diverse wheat genotypes in contrast temperatures in order to identify the genotypes relatively tolerant to high temperature at whole plant level on the basis of crop productivity. The objective of the experiment is found out the heat tolerant genotypes.

MATERIALS AND METHODS

Selection basis of the genotypes: Adaptation of wheat to such areas through genetic improvement is a way to alleviate the productivity level. Development of effective selection and breeding methodology is important to develop heat tolerant varieties. The pre-requisites of a genetic improvement program for heat tolerance are the identification of heat tolerance mechanisms with high heritability and the development of suitable methods to measure these characteristics in large breeding populations (Acevedo and Ceccarelli, 1989). Analyzing physiological determinants of yield responses to heat may help in breeding for high yield and stability under heat stress conditions. However, before planning breeding for heat tolerance the following points should be taken in consideration:

- Genetic and physiological basis of heat tolerance
- Confounding effects of heat, drought
- Stages of plant growth to be used as selection criteria
- Efficient and accurate tests to select for the component physiological mechanisms that confer heat tolerance.

Traits associated with selection heat tolerant genotypes**:** Several investigators indicated that wheat varieties differ markedly in their response to heat stress. High temperature stress indirectly reduces yield by directly affecting various yield components. Hence, grain yield as a selection criterion for heat stress remains the most reliable yardstick. However at the early generation, yield cannot deploy as a salient criterion because it would involve harvesting, threshing and weighing a large unmanageable number of lines. So, it is desirable to use yield components and traits conferring heat tolerance in stress environments for rapid screening of germplasm (Ortiz-Ferrara, et al., 1994; Sohu, et al., 2001). The use of morphological and physiological traits as indirect selection criteria for grain yield is an analytical breeding approach which implies a better understanding of the factors controlling development growth and grain yield (Shorter, et al., 1991).

Many selection criteria based on morphological, physiological and biochemical traits have been suggested for screening heat tolerance in wheat. Few morphological and physiological traits related to heat tolerance have been identified as selection criteria for heat tolerance.

Traits associated with heat tolerance	**References**
Good early vigor	Mann, 1994
Final above ground biomass at harvest	Shpiler and Blum, 1944; Acevedo et al., 1991; Kholi et al., 1991; Hu and Rajaram 1994
More tillering	Acevedo et al., 1991; Jgiku et al., 1991
Grains spike^{-1}	Acevedo et al., 1991; Jgiku et al., 1991
High 1000 grain weight	Sodu et al., 2001 hede et al. 1999
High harvest index	Al-Khatib and Paulsen, 1990
Faster grain filling	Hu and Rajaram, 1994, Rahman et al., 1997
Shorter crop duration	Bruckner and Frohberg 1987, Sharma 2001
Canopy Temperature Depression	Reynolds, et al., 1994 & 1998, Amani, et al., 1996, Rahman et al., 1997
Stomatal conductance	Reynolds, et al., 1994 & 1998, Fischer et al., 1998
Chlorophyll content	Cooli et al., 1991, Reynolds et al., 1994, Rahman et al., 1997, Hede et al., 1999, Barma et al., 2006
Membrane thermo stability	Shanahan et al., 1990; Reynolds et al. 1994 Fokar et al., 1998 a & b; lbrahim and Quick et al., 2001, Blum and Nguyen, 2001, Barma et. al., 2006

***Experimentation in research field*:** A total of 88 materials including four checks (Shatabdi, Prodip, BARI Gom-25 and BARI Gom-26) were used in this trial. The experiment was conducted under irrigated timely seeding (ITS) and irrigated late seeding (ILS) conditions at Wheat Research Centre (WRC), Dinajpur, Joydebpur and Jessore. The trial was set-up in split-plot design with 2 replications. The seeding dates were in the main plots and the genotypes in the sub plots. Unit plot size was 2.5m long 6 rows with 20cm. and 40cm. space between rows and entries, respectively. Experiments were fertilized at the rate of 100:30:50:20:1 kg ha^{-1} of NPKSB. All Irrigated experiments were given three irrigations namely 1st at CRI, 2nd at heading and the 3rd at grain filling stage. 2/3 Urea of the total was used at the final land preparation and 1/3 was applied at the 1st irrigation or at CRI stage.

***Data collection and statistical analysis*:** Data were recorded on different agronomic characters. Before harvesting data were recorded on number of heading, maturity days, plant height and number of spike per square meter. Also before harvesting disease notes on BpLB and leaf rust were taken following double-digit system and modified Cobb's scale, respectively. An area of 4 rows and 2 m. long plot was harvested .After harvesting data were recorded on 1000-grain weight grain/ spike, spikelet/spike and yield grain (g/plot) were converted into grain yield (kg/ ha). The collected data were statistically analyzed with Crop stat software and the means were compared by LSD.

Selection Procedure of the genotypes**:** Since genetic variability exists in regard to tolerance to high temperatures, there is potential scope to identify the best genotypes adapted to high temperature environment.

- The nurseries and trials are planted both in optimum and late planting in different location. The late-planted crop is exposed to heat stress during post anthesis phase. The genotypes performed better under heat stress (late planting) are selected. Early maturing genotypes can escape heat stress but they possess less biomass and less yield potential. So, medium maturity is the best option to manipulate high biomass and yield potential along with considerable heat tolerance.
- It is absolutely clear that high temperature stress indirectly reduces yield by directly affecting various yield components. Hence, yield as a criterion to select against heat stress, especially in yield trials, remains the most reliable yardstick. However, at the segregating population level, yield cannot be deployed as a selection criterion because it would involve harvesting, threshing and weighing a large, unmanageable number of lines. Therefore, a combination of empirical observations and quantitative measurements might be the best route for selecting bread wheat that is tolerant to heat stress. An experienced plant breeder can make relatively subjective judgments on biomass, number of spikes, tillering capacity, stand establishment, leaf senescence and grain filling period. The empirical judgments should be supported by properly analyzed yield trials and quantitative measurements to support the associations of characters involved in heat stress tolerance.

RESULTS AND DICCUSSION

Native and exotic germplasm of different sources were put into this trial in the name of HTWYT along with four checks and all are planted at two dates.

Effect of heat stress on heading and maturity days: The data presented in Table 1 showed that the genotypes differed significantly for heading and maturity days. The genotypes E-30, E-42 and E-43 were relatively earlier in heading than all the checks in across the seeding dates. Environmental effect on the number of days required for the occurrence of different growth stages of wheat varied with genotypes (Araus, et al., 2007). The data presented in Table 3 showed that the genotypes differed significantly for heading and maturity over location. The genotypes E-30, E-33, E-42 and E-43 at Dinajpur, Joydebpur and Jessore were comparatively earlier in heading than all of the checks at optimum and late seeding condition. Decrease in duration of crop life cycle with delay in sowing date and coincidence of terminal heat stress in grain filling period caused lower biological yield. This effect of late sowing has also been reported by Rane, et al., (2007)

Effect of heat stress on plant height: The genotypes were significantly influenced by seeding dates for plant height. In optimum seeding condition, three genotypes were found shorter than the all four checks. In both optimum and late seeding condition three genotypes (E-30, E-33 and E-42) in Dinajpur, Joydebpur and Jessore are found shorter than all the checks. The genotypes E-30, E-42 and E-43 were found significantly shorter height than all the checks at late seeding condition.

Effect of heat stress on grain/spike: The genotypes were significantly influenced by seeding dates for grains/spike. 1000grain weight and yield were significantly influenced by seeding dates. The highest number of grains/spike in optimum seeding dates was recorded in E-61 whereas in late seeding condition E-64 was produced highest number of grains/spike. The yield reduction of wheat under high temperatures is associated with a less number of grains/spike and smaller grain size (Gibson and Paulsen, 1999). The genotypes (E-61, E-64, E-75 and E-77) were produced higher number of grains / spike in Dinajpur, Joydebpur and Jessore all the checks in optimum and late seeding condition.

Effect of heat stress on 1000-grain weight and yield: The highest TGW under both seeding condition was achieved by entry 41 (Table 2). The genotypes E-61 (5224kg/ha) and E-75 (4628kg/ha) was the highest yielder in optimum and late seeding condition, respectively. Yield, heading days, short duration, short height, heat tolerant, physical grain characteristics, disease reaction etc, were the most important selection criteria, so these were given most priority during selection. The genotypes were significantly influenced by seeding dates for grain yield presented in Table 5. The higher 1000 grain weight were achieved in E-41 than the checks in optimum and late seeding condition. Field data suggests that yield losses can be in the order of 190 kg/ha for every one degree rise in average temperature and in some situations having a more serve effect on yield loss than water availability (Kuchel, et al., 2007; Bennett, et al., 2012).The genotype E-42 and E-79 at Dinajpur and E-16 and E-64 at Jessore were produced higher yield in optimum and late seeding condition than the checks. The highest yield was recorded in E-55 (7270kg/ha) and E-61 (6045kg/ha) in optimum and late seeding condition in Dinajpur, respectively.

CONCLUSION

From the above discussions the genotypes (E-61, E-64, E-75 and E-77) were produced higher number of grains per spike in Dinajpur, Joydebpur and Jessore than all the checks in optimum and late seeding condition. The higher TGW were achieved in E-41 than the checks in optimum and late seeding condition for all locations. The genotypes E-42 and E-79 at Dinajpur and E-16 and E-64 at Jessore were produced higher yield in optimum and late seeding condition than checks. The higher yield (7270kg/ha) was recorded in E-55 and E-61(6045kg/ha) in Dinajpur, respectively. Finally on the basis of overall performance 18 entries were selected for further evaluation.

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Table- 1: Effect of seeding date on heading, maturity, plant height of the selected genotypes of HTWYT, 2011-12.

Genotype	Heading (days)		Maturity (days)		Plant height (cm.)	
	ITS	ILS	ITS	ILS	ITS	ILS
Shatabdi	72	69	110	103	103	95
Prodip.	67	63	107	96	97	89
BARI Gom 25	66	62	106	96	97	92
BARI Gom26	66	63	106	95	95	88
E -5	64	61	108	97	99	91
E -9	69	64	108	97	94	89
E -13	67	63	105	95	99	92
E -15	67	63	105	96	97	86
E -16	67	64	108	96	100	93
E -18	68	65	106	99	98	98
E -30	62	60	104	93	80	76
E -33	61	62	102	95	86	86
E -41	63	62	107	98	96	89
E -42	60	60	103	94	85	82
E -43	61	59	103	93	90	82
E -55	71	70	111	102	103	94
E -61	66	74	111	104	99	89
E -64	66	65	107	98	94	92
E -75	66	65	107	98	96	98
E -77	71	70	111	103	103	97
E -79	72	69	112	102	103	96
E -81	71	70	112	102	101	98
LSD (5%)	**1.50**		**3.31**		**4.71**	
CV (%)	**2.0**		**2.8**		**4.5**	
F test	**		*		**	

- Data expressed in mean value * for 5% level of significance ** for 1% level of significance; I irrigated Timely Sown = ITS , Irrigated Late Sown = ILS

Table- 2: Effect of seeding date on heading maturity and plant height of the selected genotypes of HTWYT, 2011-12

Genotype	Grains/ spike		TGW (g)		Yield (kg/ha)	
	ITS	ILS	ITS	ILS	ITS	ILS
Shatabdi	50.1	48.3	50.7	41.1	4837	4009
Prodip	51.9	46.7	54.6	41.6	4809	3223
BARI Gom -25	46.4	41.1	50.9	44.0	4823	3879
BARI Gom -26	53.6	51.7	44.3	40.1	4744	3746
E -5	44.3	44.7	48.9	42.4	4655	3873
E -9	46.8	43.4	49.8	39.8	4767	3529
E -13	49.9	45.9	51.4	47.1	5050	4292
E -15	44.3	42.4	52.8	46.3	5117	3633
E -16	48.1	45.1	53.1	46.2	4971	3959
E -18	45.4	45.4	42.6	38.3	4598	3948
E -30	43.2	38.4	51.7	43.6	4728	3700
E -33	46.2	54.0	48.2	36.1	4587	4166
E -41	45.1	45.4	57.1	51.2	4433	3608
E -42	41.4	45.5	48.9	41.5	4369	4266
E -43	42.8	42.7	45.9	40.8	4470	4303
E -55	55.5	54.3	39.8	31.2	5536	3378
E -61	63.4	57.5	42.3	35.2	5224	3862
E -64	60.0	63.4	40.0	34.4	4772	4186
E -75	59.2	61.4	41.5	37.2	4368	4628
E -77	62.1	61.6	38.6	32.4	4113	3688
E -79	51.6	48.3	41.2	30.5	5219	3742
E -81	58.7	60.6	408	31.1	4765	3727
LSD (5%)	**5.89**		**3.17**		**374.6**	
CV (%)	**10.5**		**6.6**		**8.1**	
F test	*		**		**	

- Data expressed in mean value * for 5% level of significance ** for 1% level of significance; I irrigated Timely Sown = ITS , Irrigated Late Sown = ILS

Table -3: Interaction effect of different seeding time and genotypes on heading days and maturity in over locations.

Genotype	Heading (days)						Maturity (days)					
	Dinajpur		Joydebpur		Jessore		Dinajpur		Joydebpur		Jessore	
	ITS	ILS	ITS	ILS	ITS	ILS	ITS	ILS	ITS	ILS	ITS	ILS
Shatabdi	78	76	68	65	69	68	114	109	107	98	110	101
Prodip	72	70	62	60	67	61	109	103	103	92	108	95
Bari Gom- 25	71	78	61	69	66	60	109	104	104	90	104	95
Bari Gom- 26	75	71	61	69	63	60	112	104	102	89	104	94
E -5	72	67	58	68	63	58	110	105	104	91	110	95
E -9	75	69	66	64	66	60	113	105	107	92	105	94
E -13	73	69	62	61	67	69	110	104	103	88	103	94
E -15	72	68	65	63	64	69	110	105	103	92	102	93
E -16	72	70	64	63	65	60	111	105	105	90	107	95
E -18	72	69	67	64	67	63	112	105	103	96	102	96
E -30	68	66	59	56	61	58	108	102	102	84	103	93
E -33	68	67	60	54	60	58	107	102	102	88	98	93
E -41	71	68	58	55	64	60	111	104	102	93	107	97
E -42	69	66	57	52	58	58	110	102	100	87	100	93
E -43	70	67	56	54	58	57	109	103	100	84	99	93
E -55	80	75	67	65	70	68	116	106	106	101	113	100
E -61	80	77	63	68	63	55	116	108	110	102	107	102
E -64	74	69	63	61	65	62	110	105	105	93	108	98
E -75	73	70	62	69	65	63	111	106	105	90	105	98
E -77	79	74	67	66	71	68	114	106	107	102	114	101
E -79	81	74	66	62	71	69	116	105	107	100	114	101
E -81	79	76	67	67	69	66	117	107	107	100	113	101
LSD 5%)	**2.60**						**5.73**					
CV (%)	**2.0**						**2.8**					
F test	**						**					

- Foot notes are same as shown in table -1.

Table- 4: Interaction effect of different seeding time and genotypes on plant height and grains spike^{-1} in over location.

Genotype	Plant height (cm)						Grains/Spike					
	Dinajpur		Joydebpur		Jessore		Dinajpur		Joydebpur		Jessore	
	ITS	ILS	ITS	ILS	ITS	ILS	ITS	ILS	ITS	ILS	ITS	ILS
Shatabdi	105	97	98	95	107	95	49.9	49.6	52.5	48.8	48.0	46.5
Prodip	105	95	86	85	101	86	54.7	49.0	50.1	46.1	51.0	45.0
Bari Gom- 25	108	96	87	89	98	93	53.8	41.2	41.4	48.0	44.0	43.0
Bari Gom- 26	102	91	86	85	97	88	59.8	57.5	48.7	49.6	52.5	48.0
E -5	104	99	93	86	99	88	46.2	43.9	42.4	48.6	44.5	41.5
E -9	98	100	90	82	95	86	46.2	39.5	49.1	48.3	45.0	42.5
E -13	106	98	95	90	96	89	48.6	40.4	55.7	50.3	45.5	43.0
E -15	105	90	91	82	95	86	46.7	45.3	43.7	40.3	42.5	41.5
E -16	106	101	92	88	101	91	52.3	46.4	46.9	52.0	45.0	37.0
E -18	106	106	94	88	100	94	50.0	50.1	45.4	49.2	41.0	37.0
E -30	88	79	73	70	82	78	38.5	35.7	49.2	43.9	42.0	35.5
E -33	89	89	85	81	89	83	54.6	51.0	36.4	56.4	47.5	54.5
E -41	107	96	84	85	97	85	50.3	42.1	42.1	45.1	43.0	49.0
E -42	96	86	78	71	87	81	49.1	46.0	35.1	47.6	40.0	43.0
E -43	102	88	83	82	87	78	47.1	49.6	38.9	40.0	42.5	38.5
E -55	107	102	94	91	109	91	53.4	56.7	58.2	56.3	55.0	50.0
E -61	100	92	94	82	103	93	65.8	68.0	61.4	55.2	63.0	49.5
E -64	100	95	84	88	97	93	64.7	68.8	54.3	60.6	61.0	61.0
E -75	101	103	91	95	96	98	63.7	62.2	57.8	65.2	56.0	57.0
E -77	105	96	95	95	109	101	66.6	64.3	63.7	61.6	56.0	69.0
E -79	107	100	94	90	107	97	51.9	46.3	51.4	49.5	51.5	49.0
E -81	104	105	94	91	107	99	53.5	61.3	64.2	60.0	58.5	60.5
LSD (5%)	**8.15**						**10.20**					
CV (%)	**4.5**						**10.5**					
F test	**NS**						**					

- Foot notes are same as shown in table -1.

Table- 5: Thousand grain weight (TGW) and yield over location as influenced by seeding time.

Genotype	TGW (g)						Yield (kg/ha)					
	Dinajpur		Joydebpur		Jessore		Dinajpur		Joydebpur		Jessore	
	ITS	ILS	ITS	ILS	ITS	ILS	ITS	ILS	ITS	ILS	ITS	ILS
Shatabdi	51.8	46.1	52.9	40.2	47.5	37.0	5955	4735	4713	4560	4743	3633
Prodip	55.1	37.5	56.8	41.8	52.0	45.5	5675	3345	3853	2628	4900	3698
Bari Gom- 25	53.4	45.3	53.3	42.6	46.0	44.0	6700	4005	3498	3540	4273	3893
Bari Gom- 26	48.2	42.8	46.2	39.4	38.5	38.0	6000	3960	4065	3825	4168	3453
E -5	51.4	42.9	48.9	42.5	46.5	42.0	5150	4495	3593	3020	5223	4103
E -9	52.6	38.7	51.4	39.1	45.5	41.5	5975	4665	4323	3173	4003	2750
E -13	56.2	54.0	50.0	43.9	48.0	43.5	6460	4970	4165	3908	4525	3998
E -15	58.0	51.3	51.4	45.2	49.0	42.5	6400	4415	4530	3053	4420	3430
E -16	56.9	52.6	51.9	41.9	50.5	44.0	5680	4330	4280	3500	4953	4048
E -18	47.9	41.8	43.5	32.7	36.5	37.5	5780	4490	4103	3945	3913	3410
E -30	57.6	44.5	52.5	42.9	45.0	43.5	5425	4065	4113	2403	4645	4633
E -33	48.6	36.1	49.2	35.2	47.0	37.0	5475	5025	3710	3235	4575	4238
E -41	60.0	51.7	59.7	49.4	53.0	52.5	5115	4375	3603	3180	4583	3270
E -42	50.4	46.3	53.2	40.2	43.0	38.0	6975	5300	2450	3573	3683	3925
E -43	46.9	43.8	48.8	38.2	42.0	40.5	5875	5348	3220	3520	4315	4040
E -55	45.3	36.0	39.2	31.3	35.0	26.5	7270	4510	3593	3160	4245	2436
E -61	49.5	36.5	38.0	33.7	39.5	35.5	5520	6045	5038	2895	5115	3645
E -64	41.7	36.5	39.2	32.7	39.0	34.0	5475	5355	3830	3258	5010	3945
E -75	46.6	39.7	41.8	36.4	36.0	35.5	5320	5670	4078	4018	3705	4195
E -77	41.0	34.0	39.8	33.1	35.0	30.0	4700	4860	4660	3090	2978	3215
E -79	42.2	35.1	41.8	30.3	37.0	26.0	7125	4980	4573	3360	3960	2885
E -81	43.9	31.9	38.6	30.8	40.0	30.5	6270	4690	4353	3050	3673	3440
LSD (5%)	**5.49**						**648.9**					
CV (%)	**6.6**						**8.1**					
F test	**NS**						**					

- Foot notes are same as shown in table -1.

