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GENETIC ANALYSIS FOR HEAT TOLERANCE IN SPRING WHEAT

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ABSTRACT

Alam MS, Sabah MA, Hoque A, Siddquie NA, Salahin M, Roy UK (2021) Genetic analysis for heat tolerance in spring wheat. *Int. J. Sustain. Crop Prod.* 16(1), 7-14.

To assess genetic variability, heritability, and genetic advance in wheat. Twenty wheat genotypes were studied in non-stress (Irrigated timely sowing) and heat stress (Irrigated late sowing) conditions. The analysis of variances showed highly significant variations (P<0.01) among the genotypes for yield, yield contributing, phenological and physiological characters in both optimum and late sowing heat stress conditions. It was observed that there was a pronounced effect of heat stress on the yield of wheat and reduced the grain yield by about 34.49%. Under optimum sowing conditions, the genotypes showed minimum variations (both for GCV and PCV) for most of the phenological, physiological, and yield contributing traits. In late sowing condition, the chlorophyll content of flag leaf at grain filling stage, biomass, grains spike^{-1}, 1000-grain weight, and grain yield showed more than 10% variation and the rest of showed less amount of genotypic and phenotypic variations. Estimates of heritability for different phenological, physiological and yield contributing traits in ITS condition ranged between 43.29 to 99.20%. Similarly, the estimates of heritability for different phenological, physiological and yield contributing traits in ILS condition ranged between 27.27 to 93.22%. The traits heading days, maturity days, canopy temperature at the vegetative stage, canopy temperature at grain filling stage, biomass, plant height, spikes m^{-2}, grains spike^{-1}, and grain yield exhibited high heritability estimates under ILS condition. Under ITS condition, the traits heading days, plant height, spikes m^{-2}, grains spike^{-1}, 1000-grain weight, and grain yield exhibited more than 10% genetic advance in % of mean and the rest exhibited less than 10%. Biomass, grains spike^{-1} and grain yield had high h^2_b, high GA in % of mean along with a wide range of genetic variation and lower environmental influence under heat stress condition. Direct phenotypic selection for these traits will be rewarding.

Key words: *variability, heritability, genetic advance, heat tolerance and wheat*

INTRODUCTION

Wheat is one of the major cereals that plays an important role to maintain world food security. It occupies the 2nd position next to rice among the cereals in Bangladesh. The demand of wheat is increasing day by day (Hossain *et al*. 2020). Among the different crop genotypes, wheat is showing greater genetic variability and diversity in every corner of the world. Climate change is projecting perilous effects on agricultural production all over the world. Wheat production is to be reduced by about 6% and 18% in timely sown irrigated and late sown wheat respectively as reported by Shetty *et al*. 2013. The enhancement of surface temperature and night temperature clearly demarcated the impact of greenhouse gases. Wheat is a temperate cereal with an optimum temperature regime of 15–18°C during the grain filling stage (Lobell *et al*. 2011) but the daily high temperature of 25–30°C or greater is common across many regions where wheat is grown (Mohammadi and Karimizadeh, 2012). In late sown condition, wheat is often affected due to a sudden rise in temperature resulting in the initiation of the reproductive phase even before completion of the required period for vegetative growth of the crop (Barma *et al.* 2019; Hossain *et al.* 2020, 2019, 2013). This reduces the tillers, spike length, and grain size subsequently causing a substantial loss in yield. Asseng *et al.* (2015) reported that an increase of 1°C reduces grain yield by 6%. Physiological parameters such as chlorophyll content, canopy temperature, and normalized difference vegetation index are widely used as indicators of wheat heat tolerance (Hazratkulova *et al.* 2012). In addition, the effect of climate change is also evident in the quality of wheat, as increased heat results in shriveled wheat grains (Tadesse *et al.* 2013). To adopt new crop varieties to the future climate, we need to understand how crops respond to elevated temperatures and how tolerance to heat can be improved (Halford 2009). Success in crop improvement generally depends on the magnitude of genetic variability and the extent to which the desirable characters are important. Germplasm evaluation will be of great significance for the selection of heat-tolerant genotypes and for improving grain yield under high temperatures. Therefore, it is necessary to investigate the genetic diversity in wheat germplasm in order to broaden the genetic variation in future wheat breeding for increasing production. Thus, the objectives of the research were to identify new sources for the development of heat-tolerant high-yielding wheat genotypes which can be utilized as donor hybridization programme.

MATERIALS AND METHODS

The present study was conducted at the Agronomy Field Laboratory, Dept. of Agronomy and Agricultural Extension, University of Rajshahi during 2018-19. There were two experiments. The first experiment covered the period from mid-November 2018 to mid-March 2019 and the second experiment was covered from the last week of December 2018 to the first week of April 2019 and considered as optimum sowing condition and late sowing condition respectively.

Table 1. List of the twenty wheat genotypes used in the experiment

Entry code	Source
G 01 (BARI Gham 21) check	BARI
G 02 (BARI Gham 26) check	BARI
G 03	CIMMYT
G 04	CIMMYT
G 05	CIMMYT
G 06	CIMMYT
G 07	CIMMYT
G 08	CIMMYT
G 09	CIMMYT
G 10	CIMMYT
G 11	CIMMYT
G 12	CIMMYT
G 13	CIMMYT
G 14	CIMMYT
G 15	CIMMYT
G 16	CIMMYT
G 17	CIMMYT
G 18	CIMMYT
G 19	CIMMYT
G 20	CIMMYT

The soil of the experimental field is silty clay of Gangetic alluvial type having slightly alkaline with a pH value of 7.1 to 8.5, low in organic matter and fertility level. Winter to early dry summer climate prevailed during the experiment. Twenty wheat genotypes (varieties/lines) were used for conducting the study which is presented in Table 1. The experiment was laid out in an Alpha Lattice Design (ALD) with two replications. The experimental plot was first divided into two super-blocks; each super-block was sub-divided into 4 sub-blocks and finally, each sub-block was further divided into 5 plots where genotypes were assigned randomly. Seeds of each genotype were sown in a unit plot size of 5m long with 4 rows. Plot to plot distance of 40 cm, sub-block to sub-block distance of 60 cm, and super-block to a super-block distance of 1.5 m were maintained. The seeds were sown by hand continuously in lines (line to line distance was 20 cm) on 18 November 2018 as optimum sowing and on 22 December 2018 as late sowing in separate but adjacent areas. Each plot was seeded @ 120 kg ha^{-1} to establish a uniform plant population of about 200 plants m^{-2}. Different intercultural operations were done timely. The harvesting for the optimum sowing experiment was completed by mid-March 2019 and the late sowing experiment by the first week of April 2019. Data were collected based on different yield contributing, phenological and physiological characters. The collected data were subjected to analysis by using STAR (Statistical Tools for Agricultural Research) Programme.

Estimation of genotypic and phenotypic variances

The genotypic and phenotypic variances were estimated according to the formula suggested by Johnson *et al.* (1955). The error MS was considered as environmental variances (σ^2_e). Genotypic variances (σ^2_g) and phenotypic variances (σ^2_p) were calculated using the following formula-

$$\sigma^2_g = \frac{GMS - EMS}{r} \text{with (n-1) df}$$

$$\sigma^2_p = \sigma^2_g + \sigma^2_e$$

where, GMS and EMS are the genotypic mean squares and error mean squares respectively and r is the number of replications.

Estimation of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV)

The genotypic and phenotypic coefficients of variations were estimated according to the formula suggested by Burton (1952).

Genotypic coefficient of variation, GCV (%) = $\frac{\sigma_g \times 100}{\bar{x}}$

where, σ_g = Genotypic standard deviation and $\bar{x}$ = Population mean.

Similarly, the phenotypic coefficient of variation was calculated from the following formula-

Phenotypic coefficient of variation, PCV (%) =$\frac{\sigma_g \times 100}{\bar{x}}$

where, σ_p= Phenotypic standard deviation and
$\bar{x}$= Population mean.

Estimation of heritability

Heritability in the broad sense (h^2_b) was estimated for different traits by the formula suggested by Johnson *et al.* (1955) and Hanson *et al.* (1956). Heritability estimates from a single environment was completed using the following formula-

Heritability in the broad sense, $h^2_b = \frac{\sigma^2_g}{\sigma^2_p} \times 100$

where, σ^2_g = Genotypic varianceand, σ^2_p = Phenotypic variance.

Estimation of genetic advance (GA)

The expected genetic advance (GA) for different traits under selection was estimated using the formula suggested by Johnson *et al.* (1955).

Genetic advance (GA) = h^2_b.i. σ_p

where, h^2_b= Heritability in broad sense (decimal);

i = Selection differential, the value of which is 1.76 at 10% level of selection intensity and

σ_p= Phenotypic standard deviation.

Estimation of genetic advance in percent of mean

The genetic advance in percent of mean was calculated by using the following formula proposed by Comstock and Robinson (1952) as follows:

GA % mean = $\frac{GA}{\bar{x}} \times 100$

where, GA = Genetic advance $\bar{x}$ = Population mean.

RESULTS AND DISCUSSION

Variations among the genotypes and their response to selection for phenological, physiological and different yield contributing characters under ITS and ILS conditions are presented in Table 2 and 3.

Heading days (HD)

The co-efficient of variation (CV%) was very low for this trait under both ITS (0.97%) and ILS (0.87%) conditions which indicates that the reliability level of results for this trait was high. Under ITS condition, the lower and close GCV (10.82%) and PCV (10.87%) indicated a narrow range of genotypic variability along with less influence of environment for the expression of this trait. Under ILS condition, the GCV (2.84%) and PCV (2.97%) was low and close to each other which also indicated narrow range of genotypic variability along with less influence of environment for the expression of this trait. Barma *et al*. (1990) and Rahman (2009) reported a narrow range of variation among genotypes for this trait. Under ITS condition, high estimates of broad-sense heritability (99.2) along with lower genetic advance in percent of mean (18.97) indicate that predominance of non-additive gene action was present. Under ILS condition, the estimates of broad-sense heritability (91.39) was high and genetic advance in percent of mean (4.78) was low. The above results suggest that improvement through phenotypic selection for this trait is feasible under both ITS and ILS condition but it may not be rewarding.

Maturity days (MD)

The co-efficient of variation (CV%) was very low for this trait under both ITS (1.04%) and ILS (0.55%) conditions which indicates that the reliability level of results for this trait was high. Under ITS condition, the low and close GCV (3.51%) and PCV (3.67%) indicated narrow range of genotypic variability along with less influence of environment for the expression of this trait. Under ILS condition, the GCV (0.8%) and PCV (0.97%) was very low and close to each other which also indicated narrow range of genotypic variability along with less influence of environment for the expression of this trait. Patil *et al*. (2003) also reported low GCV and PCV for this trait. Under ITS condition, the broad-sense heritability was high (91.92) and genetic advance in percent of mean was lower (5.93) indicates that predominance of non-additive gene action was present. Under ILS condition, the broad-sense heritability was higher (68.03) and genetic advance in percent of mean was low (1.17). The above results suggest that the probability of improvement through phenotypic selection for this trait is few to zero under ITS condition and zero under ILS condition.

Canopy temperature at the vegetative stage (CT_{vg})

The co-efficient of variation (CV%) was very low for this trait under both ITS (1.89%) and ILS (1.77%) conditions which indicates that the reliability level of results for this trait was high. Under ITS condition, the PCV (2.64%) was higher than GCV (1.84%) indicating that the environment had played a major role in the expression of this trait. Under ILS condition, the GCV (3.47%) and PCV (3.89%) were low and close to each other which indicated a narrow range of genotypic variability along with less influence of environment for the expression of this trait. Under ITS condition, the broad-sense heritability was moderate (48.56) and genetic advance in percent of mean was low (2.25) indicates that predominance of non-additive gene action was present.

Reynolds *et al.* (1997) reported sensitivity of canopy temperature to environmental fluxes along with moderate heritability. Under ILS condition, the broad-sense heritability was higher (79.35) and genetic advance in percent of mean was lower (5.44) also indicates that predominance of non-additive gene action was present. Selection for this trait will not be effective for both ITS and ILS conditions.

Table 2. Components of phenotypic variation, heritability and genetic advance for phenological and physiological characters in optium and late sown conditions

Components	**HD**	**MD**	**CT_{vg}**	**CT_{gf}**	**SPAD**	**Biomass**
ITS						
Ranges	**53.50-83.00**	**98.00-110.50**	**22.25-24.15**	**24.20-28.70**	**38.05-46.60**	**9457.50-12722.50**
σ^2_g	44.91	12.81	0.18	1.23	6.25	548533.95
σ^2_p	45.27	13.93	0.37	1.34	8.26	893848.78
GCV (%)	10.82	3.51	1.84	4.45	6.09	6.61
PCV (%)	10.87	3.67	2.64	4.43	7.01	8.44
h^2_b (%)	99.20	91.92	48.56	91.97	75.65	61.37
GA % (i=10%)	11.74	6.04	0.52	1.87	3.83	1021.14
GA % of mean	18.97	5.93	2.25	7.17	9.33	9.12
CV (%)	0.97	1.04	1.89	1.26	3.46	5.25
ILS						
Ranges	**58.50-64.50**	**84.50-87.50**	**19.35-21.95**	**25.55-30.10**	**28.75-44.50**	**5330.0-9610.0**
σ^2_g	3.02	0.48	0.52	1.88	9.10	1325141.55
σ^2_p	3.31	0.70	0.66	2.12	15.88	1539705.05
GCV (%)	2.84	0.80	3.47	4.86	8.06	15.14
PCV (%)	2.97	0.97	3.89	5.17	10.65	16.32
h^2_b (%)	91.39	68.03	79.35	88.43	57.32	86.06
GA % (i=10%)	2.92	1.00	1.13	2.27	4.02	1879.56
GA % of mean	4.78	1.17	5.44	8.05	10.74	24.72
CV (%)	0.87	0.55	1.77	1.76	6.96	6.09

ITS= Irrigated timely sowing, ILS= Irrigated late sowing, Heading days, MD= Maturity days, CT_{vg}= Canopy temperature at vegetative stage, CT_{gf}= Canopy temperature at grain filling stage, SPAD= Chlorophyll content at grain filling stage, σ^2_g= Genotypic variances, σ^2_p= Phenotypic variances, GCV= Genotypic co-efficient of variation, PCV= Phenotypic coefficient of variation, h^2_b= Broad sense heritability, GA= Geneticadvance.

Table 3. Componentsof phenotypic variation, heritability and genetic advance for yield and primary yield contributing characters in optium and late sown conditions

Components	**PH**	**SPM**	**SPS**	**GPS**	**TGW**	**Grain Yield**
ITS						
Ranges	**57.0-100.0**	**325.50-473.50**	**14.60-21.60**	**31.10-52.70**	**31.12-45.08**	**3850.0-5050.0**
σ^2_g	88.24	952.95	1.55	42.57	10.41	109328.95
σ^2_p	106.78	1157.24	3.58	48.70	12.37	138338.82
GCV (%)	10.45	8.09	7.25	15.83	8.02	7.44
PCV(%)	11.49	8.91	11.02	16.93	8.74	8.37
h^2_b (%)	82.64	82.35	43.29	87.41	84.14	79.03
GA %	15.03	49.30	1.44	10.74	5.21	517.34
GA % of mean	16.71	12.92	8.40	26.05	12.95	11.65
CV (%)	4.79	3.75	8.30	6.01	3.48	3.84
ILS						
Ranges	**67.0-97.0**	**312.50-408.0**	**15.75-20.0**	**27.50-53.15**	**23.05-32.85**	**1875.0-3656.50**
σ^2_g	43.16	832.89	0.49	36.29	7.67	278341.30
σ^2_p	56.07	1009.43	1.19	43.68	13.32	298577.25
GCV (%)	7.41	8.16	3.99	16.33	10.02	18.13
PCV (%)	8.44	8.98	6.22	17.91	13.21	18.78
h^2_b (%)	76.98	82.51	41.19	83.09	57.57	93.22
GA %	10.14	46.14	0.79	9.66	3.70	896.52
GA % of mean	11.43	13.05	4.51	26.19	13.38	30.82
CV (%)	4.05	3.76	4.77	7.36	8.60	4.89

ITS= Irrigated timely sowing, ILS= Irrigated late sowing, PH= Plant height, SPM= Spikes per meter^2, SPS= Spikelets per spike, GPS= Grain per spike, TGW=1000-grain weight, HI= Harvest index, σ^2_g= Genotypic variances, σ^2_p= Phenotypic variances, GCV= Genotypic co-efficient of variation, PCV= Phenotypic coefficient of variation, h^2_b= Broad sense heritability, GA= Genetic advce

Canopy temperature at grain filling stage (CT_{gf})

The co-efficient of variation (CV%) was very low for this trait under both ITS (1.26%) and ILS (1.76%) conditions which indicates that the reliability level of results for this trait was high under ITS condition, the GCV (4.45%) and PCV (4.43%) was low and close to each other which indicated narrow range of genotypic variability along with less influence of environment for the expression of this trait. Under ILS condition, the PCV (5.17%) was higher than GCV (4.86%) indicating that the environment had played a major role in the expression of this trait. Under ITS condition, the broad-sense heritability was high (91.97) and genetic advance in percent of mean was lower (7.17) indicates that predominance of non-additive gene action was present. Under ILS condition, the thebroad-sense heritability was high (88.43) and genetic advance in percent of mean was lower (8.05) also indicates that predominance of non-additive gene action was present. Rahman (2009) observed lower genetic advance along with moderate heritability for canopy temperature in spring wheat. The above results suggest that the probability of improvement through phenotypic selection for this trait is few to zero under both ITS and ILS conditions.

Chlorophyll content of flag leaf at grain filling stage (SPAD)

The co-efficient of variation (CV%) was very low for this trait under both ITS (3.46%) and ILS (6.96%) conditions which indicates that the reliability level of results for this trait was high. Under ITS condition, the PCV (7.01%) was higher than GCV (6.09%) indicating that the environment had played a major role for the expression of this trait. Under ILS condition, the PCV (10.65%) was much higher than GCV (8.06%) indicating that the environment had played a significant role for the expression of this trait. Under ITS condition, the broad sense heritability was higher (75.65) and genetic advance in percent of mean was lower (9.33) indicates that predominance of non-additive gene action was present. Under ILS condition, the broad sense heritability was moderate (57.32) and genetic advance in percent of mean was moderate (10.74) indicates that both additive and non-additive gene action were present. The direct phenotypic selection has limited chances for the improvement of this trait under both ITS and ILS conditions. Barma (2005) reporteda moderately high estimate of broad-sense heritability coupled with a moderate genetic advance in percent of mean for chlorophyll content. Similar result was obtained by Mishra and Marker (2013) for chlorophyll content.

Biomass

The co-efficient of variation (CV%) was very low for this trait under both ITS (5.25%) and ILS (6.09%) conditions which indicates that the reliability level of results for this trait was high. Under ITS condition, the PCV (8.44%) was much higher than GCV (6.61%) indicating that the environment had played a significant role for the expression of this trait. Under ILS condition, the PCV (16.32%) was higher than GCV (15.14%) indicating that the environment had played a major role for the expression of this trait. Under ITS condition, the broad-sense heritability was slightly higher (61.37) and genetic advance in percent of mean was lower (9.12) indicates that predominance of non-additive gene action was present. Under ILS condition, the broad-sense heritability was high (86.06) and genetic advance in percent of mean was higher (24.72) indicates that additive fixable gene action was present. In case of ITS condition, limited improvement may be possible through the phenotypic selection and in case of ILS condition, the phenotypic selection will be rewarding. Sharma *et al*. (1995) found high co-efficient of variation, high heritability and high genetic advance in percent of mean for this trait.

Plant height (PH)

The co-efficient of variation (CV%) was very low for this trait under both ITS (4.79%) and ILS (4.05%) conditions which indicates that the reliability level of results for this trait was high. Under ITS condition, the PCV (11.49%) was higher than GCV (10.45%) indicating that the environment had played a major role for the expression of this trait. Under ILS condition, the PCV (8.44%) was higher than GCV (7.41%) indicating that the environment had played a major role for the expression of this trait.Under ITS condition, the broad-sense heritability was high (82.64) and genetic advance in percent of mean was moderate (16.71) indicates that both additive and non-additive gene actions were present.Under ILS condition, the broad-sense heritability was higher (76.98) and genetic advance in percent of mean was moderate (11.43) indicates that both additive and non-additive gene actions were present. Patel *et al.* (2012) found high heritability and moderate genetic advance in percent of mean for this trait. The direct phenotypic selection has limited chances for the improvement of this trait under both ITS and ILS conditions.

Spikes m^{-2} (SPM)

The co-efficient of variation (CV%) was very low for this trait under both ITS (3.75%) and ILS (3.76%) conditions which indicates that the reliability level of results for this trait was high. Under ITS condition, the PCV (8.91%) was slightly higher than GCV (8.09%) indicating that the environment had played a decent role for the expression of this trait. Under ILS condition, the PCV (8.98%) was slightly higher than GCV (8.16%) indicating that the environment had played a decent role for the expression of this trait. Under ITS condition, the broad sense heritability was high (82.35) and genetic advance in percent of mean was moderate (12.92 indicates that both additive andnon-additive gene actions were present. Similar results were reported by Choudhary *et al.* 2015; Ramanuj *et al.* 2018; Raaj *et al*. 2018; and Thakur *et al*. 2018. The above authors also reported the PCV value being more than the GCV values for all the traits studied by them in wheat genotypes. Under ILS condition, the broad sense heritability was high (82.51) and genetic advance in percent of mean was moderate (13.05) indicates that both additive and non-additive gene actions were present. Chandra *et al.* (2004) also found high heritability and moderate genetic advance in percent of mean for this trait. The direct phenotypic selection has limited chances for the improvement of this trait under both ITS and ILS conditions.

Spikelets spike^{-1} (SPS)

The co-efficient of variation (CV%) was very low for this trait under both ITS (8.30%) and ILS (4.77%) conditions which indicates that the reliability level of results for this trait was high. Under ITS condition, the PCV (11.02%) was much higher than GCV (7.25%) indicating that the environment had played a significant role in the expression of this trait. Under ILS condition, the PCV (6.22%) was much higher than GCV (3.99%) indicating that the environment had played a significant role for the expression of this trait. Under ITS condition, the broad-sense heritability was moderate (43.29) and genetic advance in percent of mean was lower (8.40) indicates that predominance of non-additive gene action was present.Under ILS condition, the broad-sense heritability was moderate (41.19) and genetic advance in percent of mean was lower (4.51) indicates that predominance of non-additive gene action was present. Phenotypic selection may provide some improvement under both ITS and ILS conditions but it may not be effective. The above finding of heritability were in agreement with the work of Ramanuj *et al.* (2018), Kumar *et al.* (2018), Hakimi *et al.* (2017) and Kumar *et al.* (2017).

Grains spike^{-1} (GPS)

The co-efficient of variation (CV%) was very low for this trait under both ITS (6.01%) and ILS (7.36%) conditions which indicates that the reliability level of results for this trait was high. Under ITS condition, the PCV (16.93%) was higher than GCV (15.83%) indicating that the environment had played a major role for the expression of this trait.Under ILS condition, the PCV (17.91%) was higher than GCV (16.33%) indicating that the environment had played a major role for the expression of this trait. Under ITS condition, the broad sense heritability was high (87.41) and genetic advance in percent of mean was higher (26.05) indicates that additive fixable gene action was present. Under ILS condition, the broad sense heritability was high (83.09) and genetic advance in percent of mean was higher (26.19) also indicates that additive fixable gene action was present. Similar result was obtained by Mishra and Marker (2013) for grains spike^{-1}, tillers plant^{-1}, plant height and spike length. These results are also in accordance with that of Riaz-ud-din *et al.* (2010) under normal and late planting conditions.

1000-grain weight (TGW)

The co-efficient of variation (CV%) was very low for this trait under both ITS (3.48%) and ILS (8.60%) conditions which indicates that the reliability level of results for this trait was high. Under ITS condition, the PCV (8.74%) was slightly higher than GCV (8.02%) indicating that the environment had played a decent role for the expression of this trait. Under ILS condition, the PCV (13.21%) was much higher than GCV (10.02%) indicating that the environment had played a significant role for the expression of this trait. Under ITS condition, the broad sense heritability was high (84.14) and genetic advance in percent of mean was moderate (12.95) indicates that both additive and non-additive gene actions were present. Under ILS condition, the broad sense heritability was moderate (57.37) and genetic advance in percent of mean was moderate (13.38) indicates that both additive and non-additive gene actions were present. Phenotypic selection may provide some improvement for this trait under both ITS and ILS conditions but it may not be rewarding. Similar result was obtained by Riaz-ud-din *et al.* (2010) under normal and late planting conditions. High value of heritability for 1000-Grain weight in wheat have also been reported by Naveen *et al.* (2014), Rajput (2018) and Kyosev in different genotype of wheat.

Grain yield

The co-efficient of variation (CV%) was very low for this trait under both optium (3.48%) and late sowing (8.60%) conditions which indicates that the reliability level of results for this trait was high. Under optium condition, the PCV (8.37%) was slightly higher than GCV (7.44%) indicating that the environment had played a decent role for the expression of this trait. Underlate sowing condition, the PCV (18.78%) was slightly higher than GCV (18.13%) indicating that the environment had played a decent role for the expression of this trait.Under optium condition, the broad-sense heritability was higher (79.03) and genetic advance in percent of mean was moderate (11.65) indicates that both additive and non-additive gene actions were present. Under ILS condition, the broad-sense heritability was high (93.22) and genetic advance in percent of mean was high (30.82) which indicates that additive fixable gene action was present. Phenotypic selection may provide some improvement for this trait under optium sowing condition but under late sowing condition, improvement through phenotypic selection will be rewarding. The results obtained are in agreement with the results reported by Singh *et al*. 2013 and Khairnar *et al*. 2018.

CONCLUSION

The present study showed the presence of considerable variations among wheat genotypes for some traits with high heritability and genetic advance which gives an opportunity to plant breeders for the improvement of these traits. It is interesting to note that the differences between GCV and PCV values were minimum implying influence of additive gene effects and least influence of environment. Hence selective could be effective for these traits. The significant impact of the heat stress on performance of the wheat genotypes especially on the grain yield underlines the urgent need for breeding for heat tolerance. However, the significant genotypic effect obtained indicates the existence of sufficient genetic variability among the wheat genotypes that can be exploited in the heat tolerance breeding programs. Reliably, genotypes G14, G15, and G20 are highly tolerant to heat stress with high yield under late sowing environments.

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