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Genetic variability analysis in bread wheat (*Triticum aestivum* L.) genotypes for early heat tolerance and grain zinc content

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Abstract
During 2019-20 at RPCAU Farm, Pusa, 30 bread wheat genotypes were investigated using a Randomized Block experimental design with three replications in two different environments: early and timely sown conditions to determine the genetic variability among the wheat genotypes examined in terms of early heat tolerance and grain zinc content. Plant height, seedling length, canopy temperature, tiller / plant, ear length, flag leaf area, relative water content, days to 50% flowering, no. of grain / spike, chlorophyll content, spike fertility, test weight, days to maturity, HI, grain yield / plant, grain zinc content, and heat susceptibility index were among the 17 quantitative traits measured. Variance analysis showed extremely significant variations for all parameters (variability, heritability and genetic advance as percent of mean) among the genotypes under both the sowing conditions. The traits *viz*., spike length, flag leaf area, tiller per plant, relative water content, and Zn content showed high heritability coupled with high genetic advance as percent of mean in both environments, suggesting that simple selection scheme would be successful for these attributes to carry genetic improvement in the desired direction.

Keywords: Variance, heritability, coefficient of variability, genetic advance as percent of mean, heat tolerance, quantitative traits

1. Introduction

Wheat (*Triticum* spp.) is one of the most commonly cultivated crop among all the cereals to satisfy the need for more than 50 per cent of their calories and protein consumed by one-third of the global population. It supplies more nutrition compared to any other crop, ranking first in area coverage and second in overall production after maize (FAOSTAT, 2019) [2]. Heat stress is among the major abiotic constraints which impede the production and productivity of wheat, during both germination and grain filling as the crop is adapted for cultivation in cooler climatic regions. Wheat breeding systems also need to assimilate the production of heat resistant genotypes as a prime target in addition to regular yield enhancement objective. Wheat crops experience high terminal heat stress in eastern Gangetic plains and breeding are suggested for early maturing genotypes that enables wheat genotypes to avoid the stress (Joshi *et al*., 2007) [7]. Micronutrient deficiency, especially zinc (Zn) paucity, is a global nutritional hitch affecting over a third of the global population (Stein *et al*., 2010) [15].

In Plant Breeding, the basic goal is to grow genotypes with potential of high yield and satisfactory superiority. To solve the problems of a narrow genetic base and to develop precise information about genetic variability, which reveals the presence of variation and thus provides the basis for an effective selection scheme, as well as evaluation for genetic diversity among well-adapted and elite germplasm offer genetic variation estimates among them that can be further selected as parents directly in hybridization program (Rajshree and Singh, 2018) [12]. Keeping these considerations insight, this present experiment was carried out to estimate the variability for morpho-physiological traits with desired features for hybridization for grain yield along with zinc content in grain.

2. Materials and Methods

This study was accomplished at experimental plot of RPCAU, Pusa, Bihar, India during *Rabi* 2019-20. The experiment included 30 hexaploid bread wheat (*Triticum aestivum* L.) genotypes with variety HD-2967 serving as check for grain yield under both the timely and early planting conditions, and variety WB-02 serving as check for grain Zn content. For the cultivation of selected 30 genotypes, two different climatic conditions were considered: early and timely planting. The trial was carried out using Randomized Block Design with three replications. In each replication, all genotypes were seeded in a plot divided into a number of rows (5) of 3 m isolated by a spacing of 20 cm under both early and timely sown conditions. Irrigation was supplied in the field at regular intervals based on rainfall patterns and prescribed agronomic approaches were applied to produce healthy and superior crops. Observations were noted for 17 quantitative characters *viz.*, tiller / plant (TPP), flag leaf area (FLA), spike fertility (SF), plant height (PH), number of grain / spike (GPS), seedling length (SL), days to 50% flowering (DFF), canopy temperature (CT), relative water content (RWC), ear length (EL), chlorophyll content (CHL), test weight (TGW), days to maturity (DM), HI, grain yield / plant (GY), heat susceptibility index (HSI) and grain zinc content (ZnC). X-ray Flourescence Spectrophotometer (XRF) was used to assess grain zinc content at ICRISAT, Hyderabad, India. To perform statistical analysis of the recorded data on different attributes, WINDOSTAT version 7.0 was employed. Separate analysis of variance (ANOVA) was carried out for all the studied traits.

2.1 Phenotypic and Genotypic Variances

Phenotypic and genotypic variance (σ^2p and σ^2g) were assessed using the given formula as proposed by Panse and Sukhatme (1957)

$$\sigma^2 g = \frac{MSS(genotypes) - \sigma^2 e}{r}$$

$$\sigma^2 p = \sigma^2 g + \sigma^2 e \text{ [When Cov. G x E=0]}$$

Where,

σ^2e = Environmental variance *i.e.* error variance = MSS (error)

r = Number of replication

2.2 Coefficient of Variability

Burton and De Vane (1953) [1] suggested a method to compute the available variability among the genotypes for GY and its attributing traits.

Genotypic coefficient of variability (GCV)

$$(GCV) = \frac{\text{Genotypic Standard Deviation}}{\text{General Mean}} \times 100$$

$$= \frac{\sigma_g}{\bar{X}} \text{ x } 100$$

Phenotypic coefficient of variability (PCV)

$$(PCV) = \frac{\text{Phenotypic Standard Deviation}}{\text{General Mean}} \times 100$$

$$= \frac{\sigma_P}{\bar{X}} \text{ x } 100$$

According to Sivasubramanian and Menon (1973) [14], the values were labelled as high (20% and above), moderate (10-20%) and low (0-10%).

2.3 Heritability (Broad sense)

In broad sense, heritability was measured as the ratio of genotypic to phenotypic variation, and is stated in percentage (Johnson *et al.* 1955) [6].

$$h^2 \text{ (broad sense)} = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

Where

σ^2g = Genotypic variance

σ^2p = Phenotypic variance

h^2 = Heritability (broad sense)

2.4 Genetic Advance (GA)

The Genetic advance was measured using the formula proposed by Lush's (1949) followed by Johnson *et al.* (1955) [6].

Genetic advance (G.A) = K. σ p. h^2

Where,

K = Selection differential which is 2.06 at 5% selection intensity in large

sample from normally distributed population

σ p = Phenotypic standard deviation

h^2 = Heritability in broad sense

Genetic advance as percentage of mean (GAM) was calculated by following formula:

$$GAM = \frac{GA}{\bar{x}} \times 100$$

Where,

GA = Genetic advance

$\bar{X}$ = Mean of the trait

3. Result and Discussion

For all the studied traits, the analysis of variance revealed significant differences among the genotypes. Jan *et al.* (2015) [5], Kumar *et al.* (2016) [9] and Taneva *et al.* (2019) [16], reported significant variation for different wheat traits. Therefore, it is inferred that there was relatively adequate variation in the material used for their analysis which gives the plant breeder enough scope for further improvement to choose superior and desire genotypes.

3.1 Variability parameters under timely sown condition

The genotypic (σ^2g) and phenotypic variance (σ^2p) were calculated for studied characters under analysis and presented in table 2. The genotypic estimates of variability was observed highest for flag leaf area (29.19), grain zinc content (25.50), harvest index (25.28), number of grain per spike (23.98), spike fertility (23.23), days to maturity (19.79), thousand grain weight (14.37) and seedling length (13.88). The highest phenotypic variability was observed for plant height (82.99) then by harvest index (41.23), number of grain per spike (35.05), spike fertility (34.81), flag leaf area (31.59), days to maturity (26.83), grain zinc content (25.90), relative water content (19.15), thousand grain weight (17.21), seedling length (14.78) and days to 50% percent flowering (11.02).

Table 2 represents Phenotypic coefficient of variance (PCV) and Genotypic coefficient of variance (GCV) for different traits under investigation. PCV for various characters varied from 4.11 to 19.62 and that of GCV varied from 2.01 to 19.47. The highest PCV was recorded for grain zinc content (19.62) which is followed by flag leaf area (18.09), seedling length (14.74), no. of tiller per plant (19.50), harvest index

(12.43), thousand grain weight (9.98), plant height (9.54), number of grain/spike (9.16), spike fertility (8.23) and grain yield per plant (8.08). The highest value of GCV was observed for grain zinc content (19.47) followed by number of tiller/plant (18.15), flag leaf area (17.39). These results were in line with Singh *et al*. and Ibrahim *et al*. (2019) [3]. The discrepancies between the values of PCV and GCV is small, signifying the characters were less affected by the environment and genotypes displaying additive gene action can be enhanced and chosen for these traits under stress condition for improvement under heat tolerance which also supported the findings of Jagashoran and Mishra (2005) [4].

3.2 Variability parameters under early sown condition

High genotypic variance was recorded for flag leaf area (30.89), grain zinc content (24.98), days to fifty percent flowering (27.15) and rest of the traits showed low genotypic variance. High phenotypic variance was noted for plant height (88.04), flag leaf area (35.70), days to 50% percent flowering (30.58), spike fertility (29.14), days to maturity (39.61), grain zinc content (25.90), harvest index (24.24), thousand grain weight (18.30), RWC (14.94) and number of grain/spike (11.61).PCV for different traits varied from 4.64 (relative water content) to 20.60 (grain zinc content). The highest PCV value was recorded for grain zinc content (20.60) followed by flag leaf area (18.24), number of tillers/plant (16.04), seedling length (15.87), thousand grain weight (10.19) and plant height (9.62). GCV values varied from 1.56 (relative water content) to 20.23 (grain zinc content). The highest GCV value was recorded for grain zinc content (20.23) followed by flag leaf area (16.97), seedling length (15.09), Thousand grain weight (9.10) and number of tiller per plant (14.91).

The traits like test weight, days to 50% flowering and HI displayed high proportion of heritability with moderate GAM under early sown condition, whereas, number of grain/spike, spike fertility, thousand grain weight, harvest index & grain yield in timely sown condition. Also high degree of heritability with low genetic advance were displayed by days to maturity under early sown whereas, by canopy temperature, days to maturity & days to 50% flowering under normal condition. Kumar *et al*. (2016) [9] and Verma *et al*. (2013) [17] recorded high degree of heritability along with high GAM for HI and low GAM for days to 50% flowering.

Table 1: ANOVA for various polygenic traits in hexaploid wheat in both conditions

Characters	Mean sum of squares (MSS)					
	Replication		Treatments		Error	
	Timely	Early	Timely	Early	Timely	Early
Plant height (cm)	58.428	19.84	97.8*	99.93*	75.58	82.09
Seedling length (cm)	0.557	3.17	42.55**	19.51**	0.89	0.66
Number of tiller per plant	1.25	0.75	4.14**	2.46**	0.20	0.12
Flag leaf area (cm^2)	5.25	0.93	89.97**	97.49**	2.4	4.80
RWC (%)	293.356	495.85	27.32*	18.35*	15.07	13.24
Days to 50 per cent flowering	61.81	9.20	27.45**	84.89**	2.81	3.43
Canopy temperature (°C)	10.7	17.01	5.06**	2.73**	0.62	0.72
Ear length (cm)	5.27	0.06	1.56**	0.91**	0.34	0.44
Number of grains per spike	532.33	685.46	83.01**	14.05*	11.07	10.40
Spike fertility	38.64	23.09	81.29**	50.89**	11.57	18.27
Chlorophyll content (SPAD)	32.83	10.26	7.18*	9.82**	5.34	3.72
1000- grain weight (g)	69.07	52.56	45.97**	47.51**	2.84	3.70
Days to maturity	167.74	173.70	66.42**	106.12**	7.03	6.35
Yield per plant (g)	116.08	104.65	7.27**	5.69**	1.20	1.17
Harvest index (%)	224.13	433.85	91.8**	51.00**	15.94	10.86
Grain Zn content	144.74	43.60	76.9**	75.85**	0.39	0.91

**: Significance at level of 1% * Significance at level of 5%

Table 2: Genetic parameters of different traits in hexaploid wheat in both environments

No.	Traits	σ^2_g		σ^2_p		GCV		PCV		h^2(broad sense) %		GA as% of Mean	
		Timely	Early	Timely	Early	Timely	Early	Timely	Early	Timely	Early	Timely	Early
1.	Plant height (cm)	7.40	5.94	82.99	88.04	2.85	2.50	9.54	9.62	8.90	6.80	1.75	1.34
2.	Seedling length(cm)	13.88	6.28	14.78	6.94	14.29	15.09	14.74	15.87	93.90	90.50	28.53	29.58
3.	Tiller/plant	1.313	0.78	1.51	0.90	18.15	14.91	19.50	16.04	86.60	86.40	34.80	28.55
4.	Flag leaf area(cm^2)	29.19	30.89	31.59	35.70	17.39	16.97	18.09	18.24	92.40	86.50	34.43	32.52
5.	RWC(%)	4.08	1.70	19.15	14.94	2.44	1.56	5.30	4.64	21.30	11.40	2.33	1.09
6.	Days to 50% flowering	8.21	27.15	11.02	30.58	3.55	5.97	4.11	6.34	74.50	88.80	6.30	11.59
7.	Canopy temp.(^{0}C)	1.48	0.67	2.10	1.39	5.57	3.64	6.64	5.25	70.40	48.10	9.63	5.20
8.	Ear length(cm)	0.40	0.16	0.75	0.60	5.74	3.57	7.81	6.94	54.00	26.40	8.69	3.78
9.	No. of grains per spike	23.98	1.21	35.05	11.61	7.57	1.68	9.16	5.19	68.40	10.50	12.91	1.12
10.	Spike fertility	23.23	10.87	34.81	29.14	6.72	4.67	8.23	7.64	66.70	37.30	11.32	5.87
11.	Chlorophyll content(SPAD)	0.61	2.03	5.95	5.76	2.01	3.59	6.27	6.06	10.30	35.30	1.33	4.40
12.	Thousand grain weight(g)	14.37	14.60	17.21	18.30	9.12	9.10	9.98	10.19	83.50	79.80	17.17	16.74
13.	Days to maturity	19.79	33.25	26.83	39.61	3.69	4.67	4.30	5.10	73.80	84.00	6.54	8.82
14.	Yield per plant	2.02	1.50	3.23	2.68	6.39	5.55	8.08	7.41	62.60	56.20	10.43	8.58
15.	Harvest index(%)	25.28	13.38	41.23	24.24	9.74	7.29	12.43	9.81	61.30	55.20	15.71	11.16
16.	Grain Zn content	25.50	24.98	25.90	25.90	19.47	20.23	19.62	20.60	98.50	96.40	39.79	40.93

4. Conclusion
The success of the crop improvement programme depends on availability of materials, present variability &heritability and the knowledge of quantitative characters with grain yield. Important discrepancies for all the characters were seen in the combined variance study for two locations.

Analysis of variance (ANOVA) displayed significant variations among mean of all the studied characters in two different environments i.e. early and timely sown conditions. The greater value for PCV than the GCV revealed the environmental influence for all the studied traits under both the environments and High heritability coupled with high GAM was perceived for seedling length, number of tiller / plant, RWC, flag leaf area & grain zinc content in these two environments that suggested that these traits could be modified in desired direction employing selection.

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6. Competing interests
We declare that there is no competing interest.

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