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Genetic Characterization and Character Association Study in Bread Wheat (*Triticum aestivum* L.) for Grain Yield and Yield Attributing Traits

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Present research work was carried out at the research farm of Department of Genetics and Plant Breeding, Rama University, Kanpur to investigate the pattern of genetic variability and heritability in the elite genotypes of wheat germplasm. In current study 27 wheat genotypes including checks entries viz., HD 2967 AND PBW 152 have been evaluated in randomized block design in 3 replication and the observations have been recorded on the eleven metric traits viz., Days to 50% flowering, Days to maturity, Flag leaf area (cm^2), Tillers per plant, plant height (cm), spike length (cm), Spikelet per spike, Grain yield per plant (g), Biological yield per plant (g), Test weight (g) and Harvest index (%). The analysis of variance showed significant mean sum of squares due to all traits under study. High estimates of heritability were observed for all of the traits viz., grain yield per plant (98.90%) followed by test weight (95.53%) and harvest index (94.88 %), whereas, high estimates of genetic advance (>20%) in per cent over mean was recorded for the traits grain yield

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per plant (44.26%) followed by spike length (36.12%) and Test weight (28.51%), High heritability accompanied with high genetic advance for the traits showed additive gene action and the selection for such traits would be rewarding.

Keywords: Wheat; Triticum aestivum; genetic variability; heritability; genetic advance.

1. INTRODUCTION

The wheat is a hexaploid (allohexaploid) species (2n =6x= 42) having AABBDD with A, B and D genome. The species of bread wheat may be divided into diploid, tetraploid and hexaploid species with chromosome number 2n=14=AA, 2n=14=BB, 2n=28=AABB and 2n=42=AABBDD respectively with basic chromosome number (x) = 7 [1]. However, genetic studies reveal that *Triticum urartu* is diploid and was used as the donor of the A genome instead of *Triticum monococcum* [2] and Aegilops speltoides, which is wild diploid. It is used as a potential donor for the B genome. Wheat is a self-pollinating annual plant of the genus Triticum in the family Gramineae and is the world's most famous energy-rich grain. It is known as the ``King of Grains'' due to its acreage, high productivity, and prominent position in the international food grain trade. Currently, it is cultivated on an area of approximately 225 million hectares worldwide, with an average production of 3 tons/ha. This indicates that there are significant differences between different cropping environments [3]. It supplies about 25% of protein and 20% of the calories consumed by human beings from the daily diet. According to FAOSTAT, India is the second largest wheat producer in the world after China. Total food grain production is estimated to rice 2. 66% to a now record- 344.43 MT for-2021-22 crop year higher than 291.9 MT last year. In addition, India is set to harvest a record wheat production of 115.75 MT in the 2020-21 crop year on the back of food grain according to latest government of India. According to the Department of Agriculture and Farmers Welfare, the estimated wheat production in India during the year 2021-22 was 106.84 million tonnes. This is higher by 2.96 million tonnes than the last five years' average wheat production of 103.88 million tonnes. However, the final estimates of production of major crops for the year 2022-23 have been released by the same department. As per the estimates, the wheat production during 2022-23 is estimated at record 1105.54 Lakh tonnes which is higher by 28.12 Lakh tonnes than previous year's wheat production of 1077.42 Lakh tonnes and by 48.23 Lakh tonnes than the average wheat production of 1057.31 Lakh tonnes [4].

Genetic variability is a natural phenomenon, and for any crop species to effectively utilise it, systematic collection, appraisal, and classification based on economic characteristics are required. the necessary level of genetic diversity for effective use of direct and indirect selection. Understanding the genetic architecture of various traits and the direct and indirect selection criteria aids in developing breeding plans that maximise genetic variety for plant improvement.

Keeping the above facts in view the present investigation has been carried out to understand the pattern of genetic variability present among available germplasms.

The complex attribute of grain yield is greatly influenced by numerous environmental variables, biotic and abiotic challenges, such as water logging, salt, etc. Direct selection for yield in crop breeding programmes could be deceptive due to the complexity of the environment. As a result, knowledge of the genetic variability and the correlation between morph-agronomic variables and grain production are essential for successful selection. The correlation coefficient helps to clarify how many qualities relate to grain yield. Breeders can choose genotypes that possess a group of desired features by studying the associations between various variables.

2. MATERIALS AND METHODS

Present experiment was carried out at research farm of Rama university mandhana, Kanpur. The experimental material for the present investigation comprised of 27 wheat genotypes including two checks *viz*., HD 2967 and PBW 52, from germplasm materials available in "Department of Genetics and Plant Breeding, Rama University, Mandhana, Kanpur. The experiment was sown in randomized block design at the experimental field. Each plot consists two rows of 2.5 m spacing of 5cm plant to plant with in the row and 20 cm between the rows. Fertilizer was applied at the rate of 120 kg

N, 60 kg P and 40 kg K. These accessions were raised and followed recommended packages and practices during *Rabi* season, 2022-23 to grow a healthy crop. The observation on 11 quantitative characters *viz*., Days to 50% flowering, Days to maturity, Flag leaf area (cm^2), Tillers per plant, plant height (cm), spike length (cm), spikelets per spike, grain yield per plant (g), biological yield per plant (g), Test weight (g) and harvest index (%), were recorded to estimate genetic variability, heritability and genetic advance.

2.1 Statistical Analyses

Data recorded from all the 27 different genotypes including the check entries for the eleven different highly heritable trait have been subjected to following statistical analysis Analysis of variance [5], Estimation of Heritability (Hanson et al., 1956) and Genetic advance as per cent of mean [6].

3. RESULTS AND DISCUSSION

Analysis of variance: Analysis of variance for all the 27 genotypes including two check entries varied significantly for almost all the traits under study (Table 1).

3.1 Mean Performance of the Entries

Studies on range, mean, coefficient of variation (CV) and standard deviation (SD) for various trait such Days to 50% flowering, Days to maturity, Plant height (cm), Number of tillers per plant, Spike length (cm), number of spekelets per spike, Flag leaf area (cm^2), 1000 grain weigh (g), Biological yield (g), harvest index (%) and Grain yield per plant. Wide range of variability was noted for all the eleven traits under study. phenological traits under study such as Days to 50% flowering (78.88-88.08 days), Days to maturity (117.44-126.11 days), Plant height (66.18-101.93 cm), Tillers per plant (9.17-11.49), Spike length (9.63-14.09 cm), Flag leaf area (25.45-38.77 cm^2 days), Test weight (26.55-40.22 g), Biological yield (12.33-19.77 g), Harvest index (36.14- 57.44 %) and Grain yield per plant (7.99-12.87 g) have exhibited wade range of genetic variability (Table 2).

3.2 Heritability

Estimates of broad-sense heritability (H2bs) associated with percent above average (GA) genetic advances for various traits are shown in Table 3 and Fig. 1. Heritability and genetic growth are important selection parameters. High heritability (>60%) was observed for all traits. Viz., grain yield per plant (98. 90%), followed by test weight (95. 53%), harvest index (94. 88%), and biological yield per plant (90. 33%). flag leaf area (89.77%), panicle length (84.55%), number of shoots per plant (81.62%), days to 50% flowering (75.99%), plant height (70.22%), time to maturity Days (69.17%) indicates that selection for these traits is more valuable in effective breeding programs, except for number of spikelets per spikelet (56.16%), which had moderate heritability. Plant breeders can focus on these traits to make effective selections for genetic improvement. No such trait was observed in the present study, and its heritability is low compared to the traits examined. Current finding is in close agreement with the finding of Gautam et al., [7], Gaur, [8], Sahu et al. [9], Tarkeshwar et al. [10], Kumar et al. [11] and Kumar et al. [12].

Table 1. ANOVA for 11 traits of wheat germplasm for randomized block design

Source of variation	Replications	Treatments	Error
df	2	26	52
Days to 50% Flowering	5.22	16.69**	0.93
Days to maturity	5.86	19.99**	1.74
Plant Height (cm)	3.61	139.07**	10.03
Number of tillers per plant	2.193	4.473**	0.242
Spike length (cm)	3.304	5.621**	0.517
Number of spikelets per spike	3.231	5.000**	1.41
Flag leaf area (cm^2)	1.8	36.54**	0.7
1000 grains weight (g)	3.76	51.54**	1.88
Biological yield per plant (g)	2.31	15.71**	1.24
Harvest index (%)	3.74	112.22**	2.16
Grain yield per plant (g)	0.57	5.341**	0.153

, Significant at 5% and 1% level of probability respectively.*

Table 2. The mean performance of genotypes for 11 characters in wheat germplasm

S. No.	Genotypes	Days to 50% Flowering	Days to maturity	Plant Height (cm)	Tillers per plant	Spike length (cm)	Spikelets/ spike	Flag leaf area (cm2)	Test weight (g)	Biological yield per plant (g)	Harvest index (%)	Grain yield per plant (g)
1	NW 5054	80.97	123.06	66.18	10.59	14.09	17.5	33.7	28.24	17.74	45.7	10.3
2	CRDC-4	85.48	124.23	86.23	10.27	10.78	17.44	28.63	32.09	17.87	49.61	11.05
3	CHAP-10	81.52	121.09	84.38	10.08	10.23	15.9	32.82	36.63	14.76	53.71	10.05
4	TUKURU	78.11	124.11	101.93	9.67	10.63	17.48	32.54	35.08	15.55	36.14	7.99
5	SR-89	84.41	123.26	89.36	9.3	11.06	17.89	29.45	26.55	17.97	48.7	10.94
6	SR-86	83.25	124.76	87.92	11.25	11.62	17.12	29.34	32.46	18.49	48.78	11.21
7	KING BIRD#1	82.04	119.56	88.69	10.64	11.92	16.35	25.45	33.12	15.34	47.39	9.42
8	SR-177	81.56	123.1	86.55	10.33	10.86	16.54	28.11	29.83	12.33	57.44	9.26
9	POSTOR	83.26	123.3	92.57	10.54	11.14	16.81	29.65	28.3	14.48	46.78	8.91
10	NRI 88	84.62	126.08	89.73	10.47	10.17	17.34	34.37	31.55	15.04	42.46	8.54
11	PGQ	83.32	122.69	80.24	10.63	10.36	15.72	28.88	34.22	16.42	49.59	10.3
12	K-508	83.32	122.25	81.15	11.08	9.7	17.97	34.27	29.48	17.08	51.65	10.99
13	RAJ 4120	84.01	124.1	86.78	10.75	11.05	18.47	28.43	36.21	19.77	44.87	11
14	K-1317	80.59	124.23	85.07	10.9	11.23	17.19	34.4	32.75	19.56	37.3	9.53
15	K-818	79.87	126.09	79.67	9.79	9.77	16.75	32.73	31.21	14.85	50.54	9.64
16	AKURI	79.09	122.58	84.61	10.73	10.73	17.77	36.53	28.12	16.54	42.95	9.28
17	PUSA 2733	83.2	124.49	86.89	10.89	10.52	17.92	38.77	27.92	15.93	44.12	9.19
18	SR-152	79.77	117.44	91.45	10.39	11.37	17.56	32.89	29.72	18.95	39.98	9.8
19	RAJ 4037	84.71	121.4	88.39	10.57	11.61	18.41	33.51	28.62	19.15	41.24	10.12
20	PBW 243	83.53	124.96	83.37	11.49	10.79	16.58	33.95	37.91	18.33	53.95	12.87
21	DABU	85.34	122.43	85.33	10.61	11.21	18.47	29.86	29.51	15.94	51.84	10.41
22	RAJ 3404	88.08	126.11	84.13	10.97	10.49	17.04	32.09	31.76	16.55	54.25	11.13
23	DH 3171	83.29	120.06	92.14	10.65	9.63	16.48	30.72	31.05	15.48	43.9	8.95
24	HD-2888	83.79	125.16	95.86	10.41	9.83	16.18	30.57	31.75	19.28	42.49	10.41
25	SONALIKA	83.51	120.99	91.32	10.52	9.99	15.96	27.36	30.79	15.76	46.64	9.51
26	HD-2967	83.69	118.93	80.4	9.17	10.92	18.18	32.48	37.99	16.55	51.05	10.61
27	PBW 52	80.62	122.87	87.14	10.24	14.08	16.48	26.05	40.22	17.72	53.09	11.58
	Mean	82.83	122.94	86.57	10.47	10.95	17.16	31.37	31.95	16.79	47.25	10.07
	Min	78.11	117.44	66.18	9.17	9.63	15.72	25.45	26.55	12.33	36.14	7.99
	Max	88.98	126.11	101.93	11.49	14.09	18.47	38.77	40.22	19.77	57.24	12.87
	SE(d) ±	0.84	1.55	3.45	0.27	0.38	0.42	0.63	0.82	0.6	1.32	0.29
	C.D. at 5%	2.5	1.11	5.74	1.34	1.76	1.95	1.87	1.75	0.7	3.34	0.28
	C.V. (%)	3.11	2.83	5.56	5.47	7.63	4.78	5.89	3.76	3.95	4.19	3.16

Table 3. Estimates of PCV, GCV, heritability and genetic advance in 25 germplasm lines of Wheat

Genotypes	Range			Variance		h^2 (BS) (%) (Hb)	Genetic Advance	Coefficient of Variation		% contribution
	Min	Max	Mean	var (g)	var (p)		GA% mean	GCV (%)	PCV (%)	
Days to 50% Flowering	78.88	85.96	82.73	3.66	4.49	75. 99	4.30	2.31	4.56	3.11
Days to maturity	119.06	127.61	124.35	5.07	6.71	69.17	3.24	1.81	6.08	2.77
Plant Height (cm)	66.78	102.13	86.97	37.33	46.36	70.22	14.11	17.22	15.13	4.78
Tillers per plant	4.57	6.89	5.88	0.27	0.31	81.62	16.21	8.82	9.48	17.88
Spike length (cm)	8.13	12.59	9.45	1.15	1.26	84.55	36.12	11.33	11.89	14.55
spikelets/ spike	15.52	18.27	16.97	0.53	0.94	56.16	6.64	4.29	7.72	11.89
Flag leaf area (cm2)	24.85	37.87	30.87	9.58	10.38	89.77	18.55	9.43	11.88	9.45
Test weight (g)	26.25	40.32	31.96	12.25	13.03	95.53	28.51	11.15	12.90	10.56
Biological yield per plant (g)	12.33	19.37	16.59	3.16	3.39	90.33	22.16	10.71	11.10	7.41
Harvest index (%)	37.74	58.84	48.86	28.45	30.31	94.88	24.69	14.12	14.33	8.55
Grain yield per plant (g)	5.79	10.07	8.07	0.99	1.05	98.90	44.26	13.34	13.27	9.12

Table 4. Estimates of genotypic correlation coefficient computed between 11 characters wheat germplasm

Characters	**Days to 50% Flowering**	**Days to maturity**	**Plant Height (cm)**	**Tillers per plant**	**Spike length (cm)**	**spikelets/ spike**	**Flag leaf area (cm2)**	**Test weight (g)**	**Biological yield per plant (g)**	**Harvest index (%)**	**Grain yield per plant (g)**
Days to 50% Flowering	1.000	0.181	0.001	0.195	-0.316*	0.447**	-0.215	-0.101	0.150	0.370**	0.428**
Days to maturity		1.000	-0.028	0.166	-0.060	0.042	0.090	-0.057	0.094	0.105	0.159
Plant Height (cm)			1.000	-0.107	-0.375*	-0.108	-0.237	0.014	-0.043	-0.456**	-0.428**
Tillers per plant				1.000	0.035	-0.121	0.161	-0.080	0.241	0.034	0.225
Spike length (cm)					1.000	0.289*	-0.245*	0.144	0.365*	0.024	0.466**
spikelets/ spike						1.000	0.565**	-0.344**	0.376*	-0.221	0.085
Flag leaf area (cm2)							1.000	-0.273	0.099	-0.347*	-0.220
Test weight (g)								1.000	0.130	0.341*	0.444**
Biological yield per plant (g)									1.000	0.356*	0.586**
Harvest index (%)										1.000	0.708**
Grain yield per plant (g)											1.000

**, ** Significant at 5% and 1% level of probability respectively.*

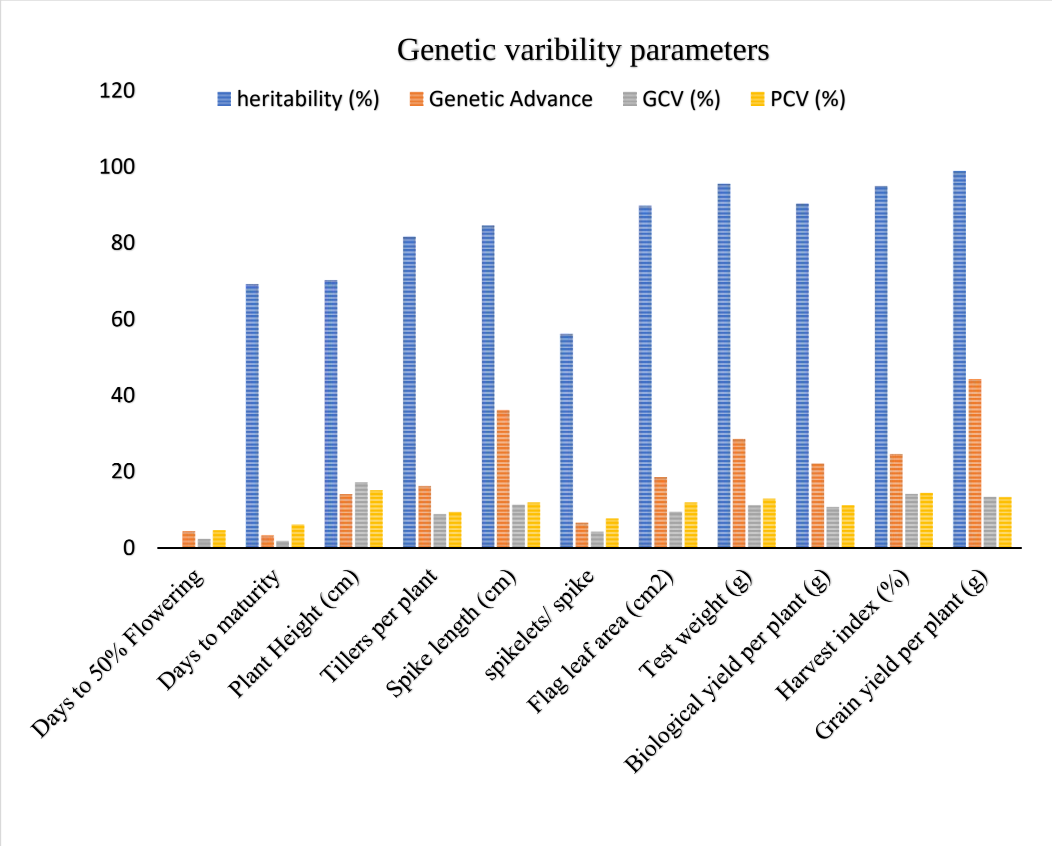

Fig. 1. Genetic variability parame

3.3 Genetic Advance

Genetic advance is the enhancement in the mean genotypic value of selected individual over the parental population. High estimates of genetic advance (>20%) in per cent over mean was recorded for the traits grain yield per plant (44.26%) followed by spike length (36.12%), Test weight (28.51%), harvest index (24.69%) and biological yield per plant (22.16%) (Table 3) and (Fig. 1). While, moderate (10-20%) genetic advance in percent over mean were found for flag leaf area (18.55%), Tillers per plant (16.21%) and plant height (14.11%). Further, low level (<10%) of genetic advance were observed for number of spikelets per spike, days to 50% flowering and days to maturity. Similar outcome has also been recorded by Kumar et al. [11], Kumar et al. [12] in his study on wheat germplasm variability study.

3.4 Coefficient of Variation

Highest values of phenotypic coefficient of variation (PCV) along with genotypic coefficient of variation were estimated for grain yield per plant followed by spike length, Test weight, harvest index and biological yield per plant (g) respectively as shown in Table 3. The high variance due to genotype as well as phenotype has been observed for some traits like plant height, harvest index, grain yield per plant (g), Test weight and flag leaf area. The highest contribution towards variability was made by days to 50% flowering, days to maturity, plant height and number of spikelets per spike. Mishra et al. [13], Gautam et al. [7] Suhel et al. and (2012) also reported similar finding for most of the traits in his study.

In term of percentage contribution of each individual traits, tillers per plant (17.88%) have contributed more toward the total genetic variability followed by Spike length (14.55), Spikelet/spike (11.89), Test weight (10.56%), Grain yield per plant (9.12%) and Harvest index (8.55%). While three traits viz., plant height (4.78%), Days to 50% flowering (3.11%) and Days to maturity (2.77%) exhibited very less contribution toward the total genetic variability (Fig. 2).

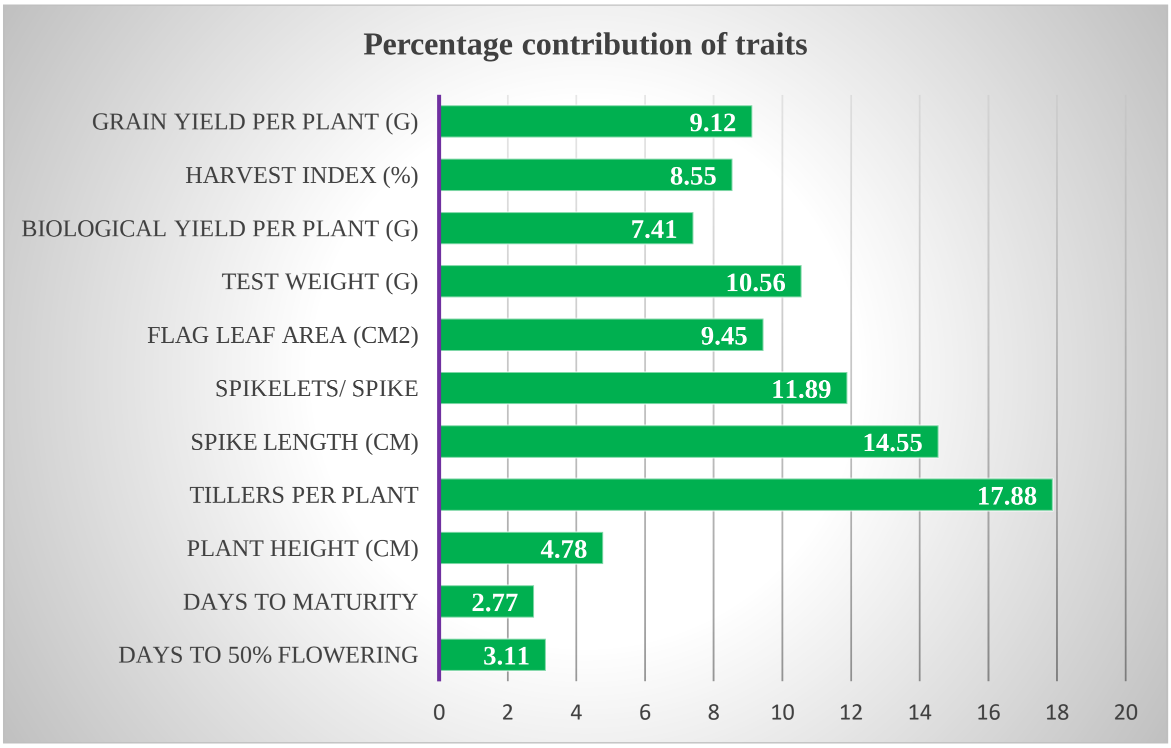

Fig. 2. Trait wise contribution (%) towards total genetic variability

3.5 Correlation Coefficients Estimates

The estimation of genotypic and phenotypic correlation coefficients is computed among eleven characters of indigenous lines of wheat under study are presented in Table 4. At genotypic level, days to 50% flowering exhibited highly significant and positive correlation with number of spikelets per spike (0.447**) followed by harvest index (0.320*), grain yield per plant (0.428). It possessed significant negative correlation with spike length (-0.316*). Days to maturity did not exhibit highly significant positive or negative correlation with any of the traits under study.

Spike length per plant has shown highly significant and positive correlation with grain yield per plant (0.466**) followed by biological yield per plant (0.385*) and number of spikelets per spike (0.289). Number of spikelets per spike possessed significant positive association with flag leaf area and biological yield per plant with the correlation coefficient values 0.565** and 0.376*. flag leaf area has significant but negative correlation with harvest index (-0.347*). Test weight (1000-grains weight) showed significant positive association with grain yield per plant (0.444**) and harvest index (0.341*). The trait biological yield per plant exhibited significant positive correlation with grain yield per plant and harvest index respectively with correlation coefficient of 0.586** and 0.356* respectively. Further, harvest index showed positive and significant association with grain yield (0.708**). Similar finding has also been found been recorded by

4. CONCLUSION

High heritability accompanied with high genetic advance indicated that the heritability is due to additive genetic effect and selection may be effective while high heritability coupled with low genetic advance indicates pre-dominance of non-additive gene action while low heritability is exhibited due to influence of environmental interaction rather than genotypic selection for such characters may not be rewarding. The high magnitude of heritability couple with high genetic advance in per cent of mean was observed for grain yield per plant followed by spike length, test weight, harvest index and biological yield per plant; which indicated that good response to selection is likely to be observed for these characters. The existence of high character heritability with moderate genetic advance for flag leaf area, number of tillers per plant and plant height indicate that these characters may also provide good response to selection owing to their moderate transmissibility and variability.

At genotypic level, days to 50% flowering exhibited highly significant and positive correlation with number of spikelet's per spike followed by harvest index, grain yield per plant. Days to maturity did not exhibit highly significant positive or negative correlation with any of the traits under study. Plant height exhibited highly significant and negative correlation with harvest index followed by grain yield per plant, spike length and flag leaf area. Number of tillers per plant exhibited highly significant and positive correlation with biological yield per plant and grain yield per plant. Test weight (1000-grains weight) showed significant positive association with grain yield per plant and harvest index. The trait biological yield per plant exhibited significant positive and negative correlation with grain yield per plant and harvest index respectively with correlation coefficient respectively. Further, harvest index showed positive and significant association with grain yield.

Thus, harvest index and grain yield per plant emerged as closely correlated yield attributes. The strong positive association of grain yield with one or more of the above traits has also been observed by previous workers Singh et al. [3]; Sharma and Singh, 2009; Anwar et al., 2009; Aydin et al., 2010; Soni et al., 2011; Singh et al., 2012; Vimal et al., 2016; Kushawaha et al., 2018; Sidhu and Gill, 2019, Kumar et al., 2020.

CONFERENCE DISCLAIMER

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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