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Studies on Variability, Heritability and Genetic Advance in Some Quantitative and Qualitative Traits in Bread Wheat (*Triticum aestivum* L.) under Rainfed Condition

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A B S T R A C T

Present investigation was carried out to study the variability parameters of quantitative as well as qualitative traits and their contribution towards seed yield which may be used as selection criteria for yield improvement in wheat under rainfed condition. Thirty six genotypes of wheat were studied for two consecutive years 2014-2015 and 2015-2016 following Randomized Block Design (RBD) with two replications in this experiment at Kalyani District of West Bengal. A wide range of variability was observed in all characters except chlorophyll- a, chlorophyll-b, total chlorophyll content that indicating sufficient scope for further selection in these traits under rainfed situation. High PCV, GCV, heritability, GA, GA % of mean was observed in the characters viz., Number of grains spike^{-1}, Amylose content, Flag leaf area, Number of florets spike^{-1} and Test weight under rainfed condition in 36 genotypes of wheat. It implies that, these characters showed predominance of additive gene action. Therefore stabilizing selection should be followed for accumulation of alleles exhibiting additive gene action.

Introduction

Wheat is the second most important food crops after rice and it contributes nearly about 1/3rd of the total food grain production (Tandon, 2000). Wheat crop has wide adaptability as it can be grown in the tropical, sub-tropical and in the temperate zone and the cold tracts of the far north, beyond even 60 degree north latitude. In West Bengal wheat cultivation is not traditional. The annual production of wheat in West Bengal during 2014-15 was 0.91 mt with 2815 kg/ ha productivity in 0.31 M ha cultivated area (DAC, GOI). The condition in West Bengal is little bit different from rest of the country for wheat. It has been largely introduced in the state with the obtained of more high yielding dwarf wheat varieties through CIMMYT, Mexico. Yield of wheat is generally cultivated

in West Bengal in the month of November using residual fertility of soil under typical agro-climatic condition of state. The optimum time for growing of wheat is middle of November.

In order to meet increasing demands of food due to rising population and income, food production in India and other south Asian countries need to be increased. Of the world's poor, 70% live in rural areas and are often at the mercy of rainfall based resources of income. Of the 1.5 billion ha (11% of the world's land surface of 13.4 billion ha) of crop land worldwide, 1.223 billion ha (82%) is rainfed. About 70% of the world's staple food continues and will continue to be harvested from rainfed areas. In India rainfed agriculture occupies 67 percent net sown area (94 M ha), contributing 44 percent of food grains and supporting 40 percent of the population. In view of the growing demand for food grains in the country, there is a need to increase the productivity of rainfed areas from the current 1 t ha^{-1} to 2 t ha^{-1} in the next two decades. Rainfed agriculture will play a major role in India's food security and sustainable economic growth. These rainfed regions have limited access to irrigation that is about 15 per cent compared to 48 per cent in the remaining irrigated sub regions. These areas are considered to have vast untapped potential for increasing production in future by upgrading rainfed agriculture (Rockstrom *et al.,* 2007). For population rich and low income rainfed regions, it is important to know where and at what cost the additional food can be produced with current technology and/or what alternative technologies will be needed to meet the desired production targets. Improving the productivity of wheat under moisture stress is one of the primary goals of the wheat breeding programmes in India. Uttar Pradesh, Punjab, Haryana, Rajasthan are the major wheat producing states and account for almost 80% of the total production in India. Only 13% (3.82 M ha) of the total wheat area is rainfed. The major rainfed wheat areas are in Madhya Pradesh, Gujarat, Himachal Pradesh, Maharashtra, West Bengal and Karnataka.Rainfed wheat productivity was 1720 kg/ha whereas Irrigated wheat productivity was 3165 kg/ ha (Global Theme on Agroecosystem, ICRISAT). Better understanding of the genetic basis of this variability and character association will improve the efficiency of wheat improvement for rainfed areas.

The success of a crop improvement program depends upon the amount of genetic variability existing in the germplasm. To bring the heritable improvements in economic characters through selection and breeding, estimation of genetic parameters must be made before starting a program.

There are different techniques available to compute the genetic parameters and the index of transmissibility of characters. Heritability estimates provides information about the extent to which a particular character can be transmitted to the successive generations. Knowledge of heritability of a trait thus guides a plant breeder to predict behavior of succeeding generations and helps to predict the response to selection.

High genetic advance coupled with high heritability estimates offer a most suitable condition for selection (Larik *et al.,* 1989). Therefore, availability of good knowledge of heritability and genetic advance existing in different yield parameters is a pre requisite for effective plant improvement exercise (Haq *et al.,* 2008).

Present investigation has been undertaken to evaluate the variability in a number of thirty six wheat genotypes including four check varieties for yield & its attributing characters and biochemical traits under rainfed situation.

Materials and Methods

The wheat germplasm consisted of thirty six genotypes were collected from Directorate of Wheat Research, Karnal through All India Coordinated Wheat & Barley Integrated Project of Kalyani Centre, BCKV. The experiment was conducted during Rabi season for two consecutive years 2014-2015 and 2015-2016 at District Farm, AB Block, BCKV, Kalyani, West Bengal following RBD design with two replications. The important characters considered in the present investigation were days to heading, days to flowering, days to maturity, plant height, number of tillers plant^{-1}, spike length, number of spikelets spike^{-1}, number of florets spike^{-1}, number of grains spike^{-1}, weight of grains spike^{-1}, flag leaf area, number of spikes plant^{-1}, chlorophyll-a content, chlorophyll-b content, total chlorophyll content, test weight, amylose content, dry gluten content, grain protein content and yield plant^{-1}. Genotypic and phenotypic variances, genotypic and phenotypic coefficient of variability, broad sense heritability were computed according to the method suggested by Singh and Chaudhary (1985).

Results and Discussion

The analysis of variance illustrated significant differences among the genotypes against all the characters under study whereas, differences over the years were non-significant for all the traits i.e. days heading, days to flowering, days to maturity plant height, number of tillers plant^{-1}, spike length, number of spikelets spike^{-1}, number of florets spike^{-1}, number of grains spike^{-1},weight of grains spike^{-1}, flag leaf area, number of spikes plant^{-1},chlorophyll-a, chlorophyll-b, total chlorophyll content, test weight and yield plant^{-1} as well as quality traits i.e. dry gluten content & amylose content and protein content. A wide range of variability was observed in all characters except chlorophyll-a, chlorophyll-b, total chlorophyll content that indicating sufficient scope for further selection in these traits under rainfed situation. ANOVA of all the characters under study was represented in Table 1.

The average performance of 36 genotypes estimated on pooled data of yield attributing traits & quality parameters along with grand mean, SE (m), SE (d) and CD are presented in Table 2. As revealed by C.D. value, significantly early heading (53.50 days) as well as early flowering (59.50 days) were recorded in genotypes MP 3429 followed by UP 2915 and UAS 374 which exhibited significant earliness over check varieties. Early maturing genotype was recognized as HD 3204 (111.25 days) followed by MP 3429 and UP 2915 whereas genotype K 1415 (121.00 days) was found to be late in maturity.

In the present findings, early maturing genotypes HD 3204, MP 3429 and UP 2915 showed relatively better yield than late maturingones. Maximum plant height was observed in genotype HD 2888© (124.10 cm) followed by JWS 146, HD 3203 and MACS 6660. Maximum number of tillers plant^{-1} was noticed in AKAW 3891(9.10) followed by HD 3204, WH 1080©, MACS 6659 and K 1417.

Maximum spike length in HD 3204 (14.41 cm) followed by WH 1080©, HD 3202, MACS 6659 and HI 1612 showing significant higher value than all other three checks. Genotype K 1417 had maximum number of spikelets spike^{-1} (21.60) followed by UP 2915, MP 1304, MP 1306 and K 1415 showing significantly higher value than check varieties under study. The number of florets spike^{-1} was recorded maximum in UP 2915 (83.80) followed by MP 1304, MP 1306, K 1415 and HD 3203 which showed significantly higher value than checks.

Highest number of grains spike^{-1} was recorded in genotype HD 3205 (68.25) and was being followed by UP 2915, MP 1306, K 1415 and HD 3203 and also they attained significantly higher value than all the checks under study. Genotype K 1416 (1.54 g) possessed least weight of grain spike^{-1} and its highest value was shown by HD 3204 (2.90 g) followed by UAS 375, WH 1080©, NIAW 2547 and MACS 6659. The genotype DBW 180 recorded maximum flag leaf area (26.53 cm^2) followed by DBW 178, MACS 6660, DBW 179 and AKAW 3891. Genotype AKAW 3891 recorded maximum number of spikes plant^{-1} (8.15) and it was followed by MACS 6659, HD 3204, NI 5439© and WH 1080©. The highest chlorophyll-a content was recorded in genotype PBW 737 (0.229 mg/g) followed by MP 1305, MP 1306, HD 3205 and K 1415 while highest amount of chlorophyll-b content was recorded by MP 1304 (0.133 mg/g) followed by MP 1303, UAS 375, WH 1080© and MP 3429.

Comparing the mean values obtained for the character total chlorophyll content from different genotypes, it was observed that the mean value ranged between 0.194 to 0.337 mg/g of fresh tissue. Highest amount of total chlorophyll content was obtained in the genotype MP 1304 (0.337 mg/g) followed by MP 1303, MP 1305, UAS 375 and WH 1080© and they showed significantly higher value than HD 2888©, NI 5439©, MP 3288©. Test weight was least in genotype MP 1304 (32.02 g) and highest in genotype HD 3202 (50.70 g) followed by HD 2888©, HD 3204, DBW 178 and WH 1180 showing significantly higher value than all other three check varieties.

The genotype DBW 180 was observed to have highest value of protein (14.85%) followed by NI 5439©, WH 1080©, PBW 737 and JWS 146 which indicated significantly higher value than HD 2888©, MP 3288©. Highest amylose content was recorded in genotype MACS 6660 (36.05%) followed by AKAW 3891, MACS 6659, HD 2888© and UP 2915 which indicated significantly higher value than check varieties. Lowest percentage of gluten was recorded in K 1416 (9.70%) followed by WH 1181, HD 3203, WH 1180 and HD 3202. It was maximum in BRW 3761 (14.54%) followed by PBW 737, DBW 178, NIAW 2547 and UP 2915. Gluten comprises of 2 subunits glutenin and gliadin. Heat stress during grain filling period glutenin content decreases (Blumenthal *et al.,* 1995) but, gliadin content increases which ultimately lead to high gluten content but reducing the gluten strength.

A drop off in gluten strength finally affects the baking quality of wheat. This verdict is crutched by Dias and Lidon (2009). Maximum yield plant^{-1} was observed in HD 3204 (17.90 g) followed by WH 1080©, AKAW 3891, MACS 6659 and HD 3205 showing significantly higher value than all other three check varieties whereas minimum yield plant^{-1} was noticed in the genotype K 1415 (10.92 g) followed by K 1416, WH 1181, NW 6046 and HD 2888©. In general the present results are in agreement to those of Drawinkel *et al.,* (1977), Jain *et al.,* (1992) and Kumar *et al.,*(1994) who found that delay in sowing is directly associated with consistent reduction in grain yield.

The mean values, range, variances due to phenotype, genotype and environment, coefficient of variation (CV), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2) in broad sense, genetic advance (GA) and genetic advance as percentage mean of 36 genotypes of wheat for pooled data on twenty characters are presented in Table 3. Genotypic and phenotypic variance were indicated to have higher value for characters such as number of florets spike^{-1}, number of grains spike^{-1}, plant height, days to heading, days to flowering and amylose content.

Table.1 Analysis of variance for different characters of 36 bread wheat (*Triticumaestivum* L.) genotypes

Sl. No.	Characters	Source of Variance with d.f.		
		Replication(1)	Genotypes(35)	Error(35)
1.	Days to heading	0.222	91.601**	0.701
2.	Days to flowering	0.281	90.767**	1.81
3.	Days to maturity	0.031	14.911**	0.967
4.	Plant Height(cm)	3.659	148.106**	3.742
5.	No. of Tillers Plant^{-1}	1.531	2.055**	0.083
6.	Spike length(cm)	1.7	6.868**	0.161
7.	No. of spikelets spike^{-1}	1.1	13.273**	0.097
8.	No. of florets spike^{-1}	11.186	252.214**	1.22
9.	No. of Grains spike^{-1}	2.961	165.926**	1.634
10.	Wt. of grains spike^{-1}(g)	0.007	0.245**	0.006
11.	Flag leaf area(cm2)	1.656	25.695**	0.022
12.	No of Spikes plant^{-1}	0.823	1.421**	0.088
13.	Chl-a (mg/g)	0	0.001**	0
14.	Chl-b (mg/g)	0	0.001**	0
15.	Total Chl (mg/g)	0	0.003**	0
16.	Test wt.(g)	2.832	37.075**	0.759
17.	Grain Protein (%)	0.596	1.177**	0.006
18.	Amylose(%)mg	0.038	53.818**	1.741
19.	Dry Gluten (%)	1.219	4.782**	0.027
20.	Yield plant^{-1}(g)	11.826	5.963**	0.315

**significant at 1%,*significant at5%

Table.2 Mean performance estimated on pooled data of different characters among the genotypes of breadwheat

Genotypes	Days to heading	Days to flowering	Days to maturity	Plant Height (cm)	No. of Tillers Plant^{-1}	Spike length (cm)	No. of spikelets spike^{-1}	No. of florets spike^{-1}	No. of Grains spike^{-1}	Wt. of grains spike^{-1} (g)	Flag leaf area (cm^{2})	No of Spikes plant^{-1}	Chl-a (mg/g)	Chl-b (mg/g)	Total Chl (mg/g)	Test wt. (g)	Grain Protein (%)	Amylose (%)mg	Dry Gluten (%)	Yield plant^{-1} (g)
AKAW 3891	66.25	72.00	115.00	100.00	9.100	12.955	16.750	50.250	42.000	2.405	25.210	8.150	0.209	0.104	0.313	42.905	12.550	34.600	12.643	16.630
BRW 3761	67.50	73.25	115.00	100.28	6.500	11.755	18.950	56.850	47.400	2.240	24.430	5.700	0.219	0.088	0.307	37.945	12.785	18.750	14.541	13.720
CG 1018	62.25	68.25	114.00	101.66	7.850	10.943	12.150	48.600	46.350	2.350	15.160	6.650	0.208	0.078	0.286	44.315	12.400	26.125	12.674	15.940
DBW 178	81.75	87.75	120.25	94.88	7.600	10.965	20.300	60.900	49.550	2.205	26.170	5.250	0.162	0.069	0.231	46.830	12.500	27.700	14.504	15.685
DBW 179	72.00	77.00	119.50	100.53	7.650	13.228	19.350	77.400	53.600	2.320	25.300	5.400	0.142	0.053	0.195	42.915	12.400	21.500	11.505	14.740
DBW 180	66.50	72.25	114.50	110.97	6.650	11.273	14.250	57.000	50.950	1.925	26.530	5.450	0.145	0.062	0.207	41.970	14.850	25.045	12.050	13.550
HD 3202	65.25	71.00	112.50	98.72	7.700	13.760	13.200	52.800	42.750	2.545	17.250	6.600	0.219	0.069	0.288	50.695	12.400	18.280	10.028	15.660
HD 3203	75.50	81.00	115.25	118.79	5.950	11.258	19.750	79.000	64.800	1.700	18.520	5.100	0.217	0.069	0.286	36.670	12.250	26.625	9.990	12.865
HD 3204	62.25	65.75	111.25	98.72	8.900	14.405	15.350	61.400	57.500	2.900	16.570	7.500	0.214	0.088	0.302	47.215	12.000	18.980	10.033	17.895
HD 3205	72.25	78.25	118.00	96.39	7.950	13.073	19.350	77.460	68.250	2.095	24.030	6.700	0.221	0.078	0.299	35.700	11.925	14.630	12.115	16.100
HI 1612	77.50	81.25	114.75	104.04	6.900	13.508	16.900	67.600	62.850	2.420	20.160	5.300	0.21	0.073	0.283	39.585	12.990	19.530	11.323	15.820
JWS 146	63.25	69.00	120.50	120.14	5.700	9.585	14.050	56.200	39.000	1.610	19.150	5.150	0.175	0.076	0.251	40.970	13.880	23.950	10.776	12.720
K 1415	77.50	82.75	121.00	92.54	5.650	7.715	20.600	82.400	55.950	1.755	23.800	5.200	0.219	0.083	0.302	39.025	11.750	20.85	13.400	10.920
K 1416	74.00	78.50	115.00	103.21	5.100	7.735	18.800	56.400	48.100	1.540	20.550	5.300	0.195	0.046	0.241	32.905	11.900	21.000	9.700	11.020
K 1417	75.25	80.75	117.00	97.46	7.950	12.830	21.600	64.800	56.700	2.210	22.290	6.700	0.179	0.068	0.247	39.855	12.620	23.370	11.731	15.865
MACS 6659	67.00	73.50	117.75	100.64	8.450	13.625	18.800	75.200	56.500	2.585	24.220	7.500	0.182	0.086	0.268	42.185	12.025	34.100	13.873	16.480
MACS 6660	71.75	77.75	115.00	118.16	6.900	11.745	16.900	50.700	47.300	1.880	25.490	6.800	0.185	0.064	0.249	33.725	13.150	36.050	10.033	14.415
MP 1303	74.00	79.75	115.25	101.96	7.450	13.505	19.150	76.600	65.000	2.250	23.600	6.100	0.210	0.126	0.336	35.820	11.655	25.125	12.530	15.750
MP 1304	75.25	81.00	120.00	102.55	5.800	9.510	20.950	83.800	59.500	2.015	21.370	4.900	0.204	0.133	0.337	32.015	12.950	23.900	13.945	12.985
MP 1305	67.25	73.00	116.75	94.04	7.200	11.450	14.900	60.00	47.150	2.330	21.320	6.15	0.223	0.110	0.333	39.075	13.050	18.200	12.339	15.240

Genotypes	Days to heading	Days to flowering	Days to maturity	Plant Height (cm)	No. of Tillers Plant^{-1}	Spike length (cm)	No. of spikelets spike^{-1}	No. of florets spike^{-1}	No. of Grains spike^{-1}	Wt. of grains spike^{-1} (g)	Flag leaf area (cm^{2})	No of Spikes plant^{-1}	Chl-a (mg/g)	Chl-b (mg/g)	Total Chl (mg/g)	Test wt. (g)	Grain Protein (%)	Amylose (%)mg	Dry Gluten (%)	Yield plant^{-1} (g)
MP 1306	63.00	68.50	118.00	101.54	6.200	10.605	20.800	83.200	66.200	2.475	22.720	5.950	0.221	0.096	0.317	37.215	12.200	21.750	12.975	13.595
MP 3429	53.50	59.50	112.00	86.62	6.700	12.915	17.000	51.000	63.500	2.250	24.600	6.050	0.216	0.104	0.320	40.550	13.650	14.900	10.985	14.075
NIAW 2547	64.75	69.75	114.50	99.48	7.000	11.490	16.850	67.400	62.800	2.660	23.150	6.200	0.199	0.061	0.26	44.525	13.050	22.600	14.394	13.815
NW 6046	74.50	78.75	115.50	99.65	5.800	9.283	15.000	60.000	44.450	2.040	22.530	5.100	0.18	0.091	0.27	40.760	11.715	24.325	11.445	12.060
PBW 737	73.75	79.00	115.50	99.68	6.500	10.503	15.000	60.000	49.600	2.085	13.700	5.450	0.229	0.097	0.326	41.935	13.880	16.900	14.51	13.565
PBW 738	65.25	71.25	113.25	98.09	7.300	11.528	16.400	65.800	53.850	2.150	12.420	6.200	0.176	0.090	0.266	41.095	12.300	25.730	13.884	15.000
UAS 374	59.25	64.25	113.25	90.51	7.150	12.800	15.050	60.200	59.950	2.075	18.500	6.450	0.189	0.085	0.274	43.600	13.565	20.225	12.300	15.905
UAS 375	71.00	76.00	113.25	92.67	7.050	12.395	19.500	58.500	47.300	2.895	17.480	6.100	0.206	0.117	0.323	38.035	12.495	17.850	10.770	15.790
UP 2914	83.75	88.25	120.00	95.24	6.600	11.975	18.750	75.000	60.150	2.190	18.470	5.450	0.168	0.051	0.219	37.600	13.750	22.180	13.018	13.455
UP 2915	57.50	63.25	112.00	92.92	6.500	12.765	20.950	83.800	67.400	2.570	17.590	5.500	0.149	0.061	0.21	39.835	12.930	29.325	13.945	14.350
WH 1180	73.50	79.25	115.50	101.51	7.100	12.970	18.300	54.900	45.750	2.540	23.470	5.750	0.195	0.054	0.249	45.910	13.315	25.080	9.993	15.345
WH 1181	71.50	76.75	114.00	107.04	5.500	8.725	15.750	64.000	37.950	1.810	19.530	4.900	0.191	0.093	0.284	45.745	12.770	25.105	9.948	11.815
HD 2888©	76.25	81.50	119.00	124.10	5.450	8.095	15.400	46.200	34.150	1.570	21.440	5.400	0.214	0.078	0.295	49.030	12.815	29.700	10.490	12.085
MP 3288©	64.00	66.50	112.50	89.91	5.950	8.990	12.650	50.600	41.800	1.995	19.360	5.050	0.215	0.069	0.284	39.590	12.435	25.330	11.786	12.730
NI 5439©	65.00	70.75	119.25	110.98	7.500	12.765	18.100	54.150	48.050	2.240	17.530	7.350	0.204	0.082	0.286	41.035	14.175	21.745	13.620	15.440
WH 1080©	73.25	79.25	116.00	99.05	8.700	13.855	15.400	61.600	51.000	2.710	21.510	7.150	0.212	0.110	0.321	40.490	13.880	16.750	11.745	16.885
overall mean	69.56	74.90	115.88	101.24	6.943	11.569	17.304	63.659	52.642	2.209	20.976	5.990	0.197	0.082	0.279	40.813	12.804	23.272	12.098	14.442
SE $_{(m)}$	0.567	0.598	0.372	0.505	0.68	0.849	0.542	0.627	0.497	0.347	0.605	1.062	0.633	0.556	0.406	0.447	0.446	0.562	0.945	0.401
SE $_{(d)}$	0.801	0.846	0.526	0.715	0.961	1.201	0.766	0.887	0.704	0.491	0.855	1.503	0.896	0.786	0.574	0.632	0.631	0.795	1.336	0.567
CD (5%)	1.634	1.725	1.072	1.457	1.959	2.448	1.562	1.808	1.434	1.002	1.744	3.063	1.826	1.602	1.169	1.287	1.286	1.62	2.724	1.156

Table.3 Genetic parameters for yield & its attributing characters of bread wheat estimated on pooled data

Characters	Mean	Range	Variance			C.V.	G.C.V.	P.C.V.	h^2(BS) %	G.A.	G.A. % of mean
			Genotypic varianc	Phenotypic varianc	Environmental varianc						
Days toheading	69.55	53.50-83.75	45.	46.15	0.70	2.387	9.692	9.767	98.482	13.782	**19.814**
Days toflowering	74.89	59.50-88.25	44.	46.288	1.80	2.466	8.905	9.084	96.09	13.467	**17.981**
Days to maturity	115.8	111.25-121	6.9	7.936	0.96	1.517	2.279	2.431	87.82	5.097	**4.399**
Plant height(cm)	101.2	86.615-124.095	72.	75.926	3.74	2.152	8.392	8.607	95.072	17.065	**16.856**
No. of tillersplant^{-1}	6.943	5.1-9.1	0.9	1.068	0.08	3.705	14.299	14.891	92.212	1.964	**28.286**
Spike length(cm)	11.5	7.715-14.405	3.3	3.514	0.16	3.357	15.829	16.204	95.419	3.685	**31.852**
No. of spikeletsspike^{-1}	17.3	12.15-21.6	6.5	6.685	0.09	2.184	14.833	14.942	98.553	5.249	**30.335**
No. of floretsspike^{-1}	63.6	46.2-83.8	125	126.7	1.21	2.662	17.598	17.683	99.037	22.966	**36.077**
No. ofgrains spike^{-1}	52.6	34.15-68.25	82.	83.784	1.64	2.013	17.217	17.388	98.049	18.488	**35.12**
Wt. of grains spike^{-1}(g)	2.20	1.54-2.9	0.1	0.125	0.00	1.84	15.653	16.048	95.135	0.695	**31.45**
Flag leaf area(cm^2)	20.9	12.42-26.53	12.	12.85	0.02	2.473	17.081	17.095	99.829	7.374	**35.156**
No. of spikesplant^{-1}	5.99	4.9-8.15	0.6	0.754	0.08	4.425	13.632	14.501	88.37	1.581	**26.398**
Chlorophyll a(mg/g)	0.19	0.142-0.229	0.0	0.000	0.00	2.667	11.702	11.991	95.235	0.046	**23.524**
Chlorophyll b(mg/g)	0.082	0.046-0.133	0.0	0.000	0.00	2.444	25.169	25.813	95.07	0.041	**50.553**
Total chlorophyll(mg/g)	0.279	0.194-0.337	0.0	0.0014	0.00	2.297	13.452	13.863	94.151	0.075	**26.888**
Test weight(g)	40.8	32.015-	18.	18.917	0.75	1.829	10.441	10.657	95.985	8.6	**21.072**
Grain protein (%)	12.80	11.655-14.85	0.5	0.591	0.00	1.806	5.976	6.008	98.912	1.568	**12.242**
Amylose(%)mg	23.2	14.63-36.05	26.	27.77	1.74	2.342	21.927	22.648	93.733	10.177	**43.73**
Dry gluten (%)	12.09	9.7-14.541	2.3	2.404	0.02	4.268	12.746	12.817	98.897	3.159	**26.112**
Yield plant^{-1}(g)	**14.4**	**10.92-17.895**	**2.8**	**3.139**	**0.31**	**2.213**	**11.637**	**12.268**	**89.979**	**3.284**	**22.739**

This outcome implies that there is greater variation among the genotypes for the above said traits. The character plant height and days to flowering were greatly influenced by environment having higher environmental variance.

Coefficient of variation (CV) had greater value in number of spikes plant^{-1}, dry gluten content and number of tillers plant^{-1} than other characters under study. Number of spikelets spike^{-1}, total chlorophyll content, amylose content and yield plant^{-1} was observed to have moderate to high CV than other characters. The magnitude of PCV was higher than GCV for all the characters suggesting the influences of the environment forces on the expression of these characters. The magnitude of PCV's was higher than the corresponding GCV's values for the characters viz., number of spikes plant^{-1}, amylose content, yield plant^{-1}, weight of grains spike^{-1}, spike length and weight of grains spike^{-1}indicating the influence of environment on the expression of these characters. A closer PCV & GCV was observed for the characters viz., flag leaf area, grain protein, dry gluten content, days to heading, number of florets spike^{-1}, number of spikelet spike^{-1}, days to maturity, number of grains spike^{-1}, days to flowering, plant height, test weight, chlorophyll a, spike length, weight of grains spike^{-1}, total chlorophyll content and number of tillers plant^{-1} showing little environment effect on the expression of these characters. Therefore, there is a large scope of genetic improvement of those traits under rainfed condition. High value of GCV & PCV was recorded in chlorophyll b, amylose content, number of florets spike^{-1}, number of grains spike^{-1} and flag leaf area. This finding was in conformity with Kalimullah *et al.,* (2012) for flag leaf area. There was little variability and scope for selection in the materials for days to maturity, grain protein content, plant height, days to flowering and days to heading having lower GCV and PCV. This result was in partially agreement with Mishra and Marker (2013).

High heritability was observed for all of the characters viz. days to heading, days to flowering, days to maturity, plant height, flag leaf area, total chlorophyll, number of tillers plant^{-1}, number of spikes plant^{-1}, no of spikelets spike^{-1},chlorophyll a, number of florets spike^{-1}, number of grains spike-$^{-1}$, chlorophyll b, weight of grains spike^{-1}, test weight, spike length, protein content, amylose content, yield plant^{-1} and dry gluten content. High estimate of heritability for spike length was supported by Shukla *et al.,* (2005). Days to heading, days to flowering, plant height, number of florets spike^{-1}, number of grains spike^{-1} and amylose content indicated high heritability coupled with high genetic advance. This finding is partially similar with that of Badole *et al.,* (2010), Laghari *et al.,* (2010), and Kalimullah *et al.,* (2012). High heritability coupled with genetic advance for number of grains spike^{-1} was also reported by Jedynski (2001) and Kumar *et al.,* (2003). Chlorophyll b, chlorophyll a, total chlorophyll, number of spikes plant^{-1}, no of tillers plant^{-1}, grain protein content, dry gluten content, yield plant^{-1}, spike length, days to maturity and no of spikelets spike^{-1} showed high heritability combined with low genetic advance. High heritability for number of spikelets spike^{-1} was reported by Kumar *et al.,* (2003). The characters viz. chlorophyll-b, amylose content, number of florets spike^{-1}, flag leaf area and number of grains spike^{-1} showed high heritability with high GA % of mean. These traits are controlled by both additive and non-additive genes. Disruptive selection may be followed which maintains polymorphism in the population. Spike length, weight of grains spike^{-1}, number of spikelet spike^{-1}, number of tillers plant^{-1} and total chlorophyll indicated high heritability accompanied with greater GA % of mean. These characters are controlled by additive genes and direct selection for these

characters may be effective under rainfed situation. As wheat is a self-pollinated crop pure line selection, mass selection, progeny selection or hybridization followed by next generation selection is effective for genetic improvement. High PCV, GCV, heritability, GA, GA % of mean was observed in the characters viz., number of grains spike^{-1}, amylose content, flag leaf area, number of florets spike^{-1}and test weight under rainfed condition in 36 genotypes of wheat. It implies that, these characters showed predominance of additive gene action. Therefore stabilizing selection should be followed for accumulation of alleles exhibiting additive gene action.

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