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Genetic variability, heritability, genetic advance and correlation analysis in wheat (*Triticum aestivum* L.)

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Abstract

The genetic analysis was carried out twenty two germplasm lines under irrigated normal soil condition to determine mode of inheritance of yield and its contributing traits. The experiment was conducted to evaluate in Randomized Block Design (RBD) with three replication at Nidharia Agriculture Farm S.M.M. Town P.G. College, Ballia, U.P. Data were recorded in respect of days to 50% germination, days to 50% flowering, tillers per plant, plant height, flag leaf area, peduncle length, spike length, days to maturity, number of grain per spike, biological yield, 100 seed weight, harvest index and seed yield per plant for their analysis and interpretation to determine the genetic variability, correlation coefficient,, heritability and genetic advance analysis. All the 22 genotypes showed vastrange of variation for all the13 characters under consideration. .The analysis of variance showed highly significant differences between the treatments for all the characters under study. Genotypes such as New CB, NEW CB- 7, NEW CB- 3 and NEW CB- 45 produce highest seed yield .Thus genotypes can be used as donor parents in breeding programmes and can be beneficial for transferring the desired gene.The highest amount of genotypic and phenotypic coefficients of variation were observed for biological yield per plant, grain yield per plant, followed by harvest index , tillers per plant, peduncle length and number of grain per spike. The heritability in broad sense for thirteen characters studied which ranged from 98% to 52%, maximum for days to 50% germination, followed by days to maturity, biological yield, harvest index, days to 50% flowering, number of grain per spike, peduncle length, grain yield per plant and test weight showed high heritability. Maximum genetic advancement was reported for the trait like harvest index, days to maturity, biological yield, and number of grain per spike. The grain yield per plant exhibited highly significant and positive correlation with tillers per plant, plant height, flag leaf area, and biological yield.The result revealed that these traits may serve as effective selection attributes during selection in breeding program for yield improvement.

Key words- Wheat (*Triticum aestivum* L.), mean, viability, heritability, genetic advance, correlation.

Introduction

Wheat (*Triticum aestivum* L.), a self-pollinated crop originated from West Asia, is considered as the second most important cereal crop in the world. It belongs to genes *Triticum* of poaceae family and there are seventeen different species out of which only three species are cultivated throughout the world, including *Triticum aestivum,* (bread wheat) in 95% *Triticum durum* (macaroni wheat)in 4% and *Triticum dicocum* (emmer Wheat) in 1% area. In India bread wheat, *Triticum aestivum* (2n=6x = 42 AA BB DD) belongs to the tribe triticeae in the family poaceae. Wheat is classified based on the three primary characteristics; agronomic, kernel color and endosperm quality. There are two seed coat colors red and white, red colour conditioned by three dominant genes while the true whites comprise recessive alleles of the three genes. Kernel hardness is classified into two *i.e.* hard and soft upon milling, hard wheat yields coarse flour while the white wheat lacks this. Starch protein complexes produce a higher yield of fine flour upon milling. Hard wheat is used for bread making because its gluten protein is cohesive and elastic. Ethiopia is the center of diversity for durum wheat. It is one of the major cereal crops grown at an altitude ranging from 1500 to 3000 meters above sea level. It is grown over a wide range of environment, which are different in soil fertility. In the marketing year of 2019-2020 the global production of wheat amounted to over 765 million metric tonnes this was an increase of over 30 million tonnes compared to the previous marketing year. In the year 2020- 2021 the production increased by 772.62 million metric tonnes (according to statista.com https://www.statista.com). India is the world's second largest wheat producer with an area of 29.55 Million hectare, with production of 108.21 million tonnes and an average national productivity of 3424 kg/hectare (2020-2021). China is the top country by wheat production in the world as of 2020, wheat production in China was 134,259 thousand tonnes that account for 20.65% of the world's wheat production. The top 5 countries other than India, Russian federation, The United States of America and Canada account for 63.43%of it. (ICAR-DRMR - 2021). Uttar Pradesh was the 3rd state to produce largest wheat in year (2020- 2021) which is 24.5 million tonnes with an average cultivated area of 9.2 million hectare with the productivity of 33 qt per hectare, in year 2020- 2021 Punjab is the largest wheat producer in India, wheat recorded the highest productivity at 38.50 quintal per hectare with record of 56.41 lakh metric tonnes procurement of wheat has been done during Rabi Marketing Season 2021-22 in Uttar Pradesh. Wheat may be compared well with other cereals in nutritive value. It has a good nutrition profile with 12% protein, 1.8 % lipid, 1.8% ash, 2.0 % reducing sugar, 6.7% pentose, 59.2% starch, 70% of total carbohydrate and provides 314 cal/100g of food. It is also a good source of minerals and vitamins *viz.,* calcium (37 mg/100g), iron (4.1mg/100g) thiamine (0.45 mg/100g), riboflavin (0.13 mg/100g) and nicotinic acid (5.4mg/100g).Unlike other cereals wheat contains a unique property having a storage protein called "gluten", which has visco-elastic nature, necessary for excellent quality of "Roti". Hard wheat is high in protein (10-17%) and yields a flour rich in gluten, making it particularly suitable for yeast bread. The low protein (6- 10%) softer type yields flour lower in gluten better suited for tender baked products, such as biscuits and cakes. Wheat is generally grown intended for food humans, but lesser quality wheat and also nutrient - dense by-products of flour refining are used for animal feed. *Triticum durum* wheat, although high in gluten, is not suitable for baking, but suitable for "semolina", the basis for excellent "pasta" such as "spaghetti and macaroni" preparation. There is much scope to bread wheat variety for higher yield coupled with acceptable quality. For genetic improvement of yield in crop plant selection and hybridization techniques are utilized frequently. Selection and hybridization techniques are used for improving the genetic constitution of a genotype. Selection is usually practiced for pooling favorable genes while hybridization is predominantly utilized to accumulate favourable genes in a variety for obtaining better performance for this purpose donor can be sorted out from available germplasm, because germplasm serves as a valuable natural reservoir providing several better attributes. The identification of donor parents for important character

through assessment of genetic variation in the available germplasm and the information about character association are required to devise a successful breeding program.

Yield being the complex character is a function of several components' character and their interactions with the environment. Genotypic and phenotypic correlation reveals the degree of Association between different characters and thus aids in selection to improve the yield and yield attributing character simultaneously. Further path coefficient analysis helps in partitioning of correlation coefficient into direct and indirect effects and in the assessment of relative contribution of each component character to the yield. Keeping the fact in view the present investigation entitled "Genetic variability, heritability, genetic advance and correlation coefficient analysis in wheat (*Triticum aestivum* L.) has been studied.

Materials and methods

The investigation was carried out during *Rabi 2020-2021* at the Nidharia Agriculture Farm of Shri Murli Manohar Town Post Graduate College, Ballia. The soil of experimental field was sandy loamy. During Rabi 2020-21 a trial comprising 22 strains/varieties were laid out in Randomized Block Design (R.B.D.) with 3 replications dated 13th December, 2020 at Nidharia Agriculture Farm, S.M.M. Town P.G. College, Ballia. Each treatment was sown in a plot with a distance of cm between rows and 15 cm between the plants. All the recommended packages of practices were adopted to raise the crop.The data were recorded on the five randomly tagged plant in respect of days to 50% germination, days to 50% flowering, tillers per plant, plant height, flag leaf area, peduncle length, spike length, days to maturity, number of grain per spike, biological yield, 100 seed weight, harvest index and seed yield per plant for their analysis and interpretation to determine the genetic variability, correlation coefficient,, heritability, genetic advance.

Result and discussion

Bread wheat (*Triticum aestivum* L.) is an important food crop for more than one third of the population. The demand of wheat is increasing day by day due to an increase in population. Ways to sustain increasing productivity should be explored. It is now realised that sustaining as well as increasing productivity may be essential. The knowledge of factors responsible for high yield has been rendered difficult as yield is a complex character (Singh *et al.,* 2010) and highly influenced by many genetic factors and environmental fluctuations. In plant breeding programmes successful selection depends on the information on the genetic variability of various character on yield and their diversity. The present research is based on thirteen characters namely day to 50% germination, days to 50% flowering, day to maturity, tillers per plant, plant height, flag leaf area, peduncle length, spike length, number of grain per spike, biological yield, test weight, harvest index, and grain yield per plant was taken to obtain sufficient information about character and thereby to make significant improvement in yield.

The analysis of variance (Table-1) showed highly significant differences between the treatments for all the characters under study. It basically represented the presence of large variability developing high yielding "new plant type varieties" according to Kumar and Mishra (2004).

Magnitude and nature of variability present in a population is a prerequisite for any crop improvement programme. Variation in variability is a result of its genotype and genotype x environment interaction. Only heritable components of variation are of prime importance from a

breeding point of view.

Present study revealed highly significant differences among the tested genotypes in respect to all the characters, so variability present in these genotypes will facilitate success of future wheat breeding programmes. Range and mean performance of genotype with respect to their thirteen quantitative characters has been given in Table-2. All the genotypes were vast range of variation for all the 13 characters under consideration.Genotypes such as New CB, NEW CB- 7, NEW CB- 3 and NEW CB- 45 produce highest seed yield .Thus genotypes can be used as donor parents in breeding programmes and can be beneficial for transferring the desired gene. Genotypes such as New CB, NEW CB- 7, NEW CB- 3 and NEW CB- 45 produce highest seed yield .Thus genotypes can be used as donor parents in breeding programmes and can be beneficial for transferring the desired gene.

In addition to the genotype mentioned above, some other indigenous lines exhibiting very high mean performance for other characters which may be utilized as donor for improving those character in a component breeding approach even if they had minimum and low grain yield. In view of the above consideration, the most deserving genotypes for minimum days to maturity were NEWCB - 49, NEW CB - 42, and NEW CB - 6. The genotypes for maximum number of grains per spike were NEW CB - 10, SRI SATNAM- 343 and NEW CB -3. The desirable genotypes for short plant height were NEW CB - 41, NEW CB - 42 and NEW CB - 5. For the maximum number of tillers per plant the desirable genotypes were NEW CB-10, NEW CB- 2 and NEW CB-9. For short Peduncle length the genotypes considered were NEWCB-41, NEW CB-43 and for tall peduncle length NEW CB - 2 NEW CB -7 were recorded. The genotype for maximum value for spike length NEW CB- 47, and NEW CB- 50 were recorded. The desirable genotypes with minimum days to maturity were NEW CB-3, NEW CB-1 and NEW CB-49, and the genotypes with maximum days to maturity NEW CB-5, NEW CB- 9 and NEW CB -4 were recorded.

The desirable genotypes for 1000grain weight NEW CB -3, NEW CB-7 and NEW CB- 6 were found. The genotypes with maximum mean performance for biological yield per plant NEW CB-9 were recorded, the most promising genotypes for harvest index were NEW CB- 47 and NEW CB -4 recorded respectively.(Kumar *et al*., 2010) (Asif *et al*., 2004) observed a wide range of variation for plant height, number of grains per spike and days to maturity.

It's a well-known fact that genetic coefficient of variation (GCV) is comparatively more important than phenotypic coefficient of variation (PCV) because high amounts of genetic variation helps in formation of effective breeding programmes for crop improvement.

The highest amount of genotypic and phenotypic coefficients of variation(Table-4) were observed for biological yield per plant , grain yield per plant, followed by harvest index , tillers per plant, peduncle length and number of grain per spike. These characteristics are taken into consideration for developing desirable and high yielding varieties.

However with the help of genetic coefficient of variation (GCV) alone we cannot determine the heritable variation. It can be determinedby heritability and genetic advance. Varying

Table -1 Analysis of variance in thirteen characters in wheat (*Triticum aestivum* L.)

source of variation	d.f.	Days to 50% germina-tion	Days to 50% Flowering	Days To Ma-turity	Tillers/ plant	Plant height (cm)	Flag leaf area cm sq)	Peduncle Length cm)	Spike length (cm)	No. of grain / spike	Biologi-cal yiel d (g)	test weight(100 0 seeds)	Harvest in-dex (%)	Grain yield / Plan t
Replica-tion	2	0.3182	6.1061	22.6818	0.0274	45.0792	0.0752	2.4231	0.0420	2.7408	2.5764	0.0279	2.0858	5.0022
Treatment	21	62.7272**	93.4725**	248.1471**	5.8705**	199.5242**	4.3882**	68.5597**	2.0895**	178.0034**	223.238**	64.83874**	285.8976**	25.2272**
Error	42	0.4134	2.1696	1.9199	0.5682	21.8713	1.0456	2.0987	0.2651	5.0814	2.4620	4.5374	5.1320	0.9274

* Significant at 5% level of significance **significant at 1% level of significance

Table - 2 Mean value of thirteen character in Wheat (*Triticum aestivum* L.)

	Days to 50% germination	Days to 50% flowering	Days To Maturity	Tillers/ plant	Plant height (cm)	Flag leaf area (cm sq)	Peduncle Length cm)	Spike length (cm)	No. Of grain / spike	Biological yield (g)	test weight(100 seeds)	Harvest index (%)	Grain yield / Plant
NEW CB - 41	13.3333	71.0000	102.6667	6.6667	61.3663	18.4467	24.5310	9.1373	43.0333	19.8933	35.8333	34.7515	8.0533
NEW CB - 46	13.6667	71.0000	101.6667	6.4000	64.5560	19.7567	28.3850	9.7517	46.5633	29.1333	41.1667	40.9838	9.6400
NEW CB - 47	14.6667	72.6667	101.3333	6.1000	71.4533	19.9167	30.5943	11.4887	53.1000	13.3900	40.5667	83.0415	5.6333
NEW CB - 48	14.0000	76.0000	102.6667	6.7000	82.8667	20.3333	40.5600	10.5780	57.4000	17.5533	44.3733	42.9297	5.9667
NEW CB - 45	16.0000	72.0000	100.0000	8.1000	75.8240	21.7000	32.3370	9.6867	57.2667	21.4067	36.6333	43.0179	14.2267
NEW CB - 49	13.3333	66.0000	97.3333	5.2333	79.0163	18.5200	36.2830	10.3687	43.8667	26.1067	38.5033	43.2554	12.4833
NEW CB - 50	13.3333	72.3333	102.3333	8.4000	81.3233	19.1533	33.0877	11.0400	57.3667	34.6267	35.8000	41.2002	8.8900
NEW CB - 43	14.0000	71.0000	102.6667	5.4333	69.8963	18.2567	24.8463	10.4710	52.1333	18.3467	34.6000	41.8975	7.9800
NEW CB - 42	14.6667	70.6667	103.3333	6.7333	62.6647	19.5833	32.6567	8.0357	56.9333	8.3867	34.3667	43.5658	8.3233
NEW CB - 1	15.0000	73.6667	97.0000	8.4667	66.1367	19.1133	28.3277	8.2610	38.4667	25.9533	44.9333	38.8065	8.2733
NEW CB - 2	16.6667	71.0000	98.3333	9.3000	66.0303	21.1467	37.7707	10.1607	44.4000	20.7800	39.1733	43.9956	10.0267
NEW CB - 3	13.6667	71.3333	96.6667	8.5000	72.3320	19.6800	28.1927	9.5480	59.2000	14.3100	47.1833	39.0442	14.2800

NEW CB - 4	25.3333	86.0000	123.3333	6.4667	79.2340	19.0500	31.7353	9.3407	42.1333	17.7733	42.7000	60.2932	6.6833
NEW CB - 5	26.3333	86.6667	124.0000	5.7667	63.4267	19.2233	29.6783	9.4207	47.1667	19.1033	34.8667	41.4318	6.9267
NEW CB- 6	14.0000	70.6667	100.6667	6.7000	72.6353	21.2200	35.8633	10.3587	43.3000	21.7333	45.0500	46.2621	10.1567
NEW CB - 7	14.6667	70.0000	100.0000	9.6667	82.4627	21.2167	36.5780	10.3707	49.9000	21.7067	46.6000	46.6384	14.9200
NEW CB - 8	15.0000	71.0000	101.3333	8.5667	74.4237	20.5333	30.7187	10.5257	48.6000	20.2600	35.3000	44.8700	9.4400
NEW CB - 9	26.3333	85.6667	123.6667	9.0667	92.8493	21.5467	40.7637	9.6500	46.4000	51.4933	41.4333	39.0813	15.0400
NEW CB -10	25.6667	80.0000	121.6667	9.3667	73.4187	21.2867	30.0880	10.3540	66.1667	29.1167	30.0833	44.8396	13.4767
SRI SATNAM-303	14.6667	73.0000	101.3333	6.2000	65.0273	18.5500	28.9117	10.7393	56.1000	21.3767	35.9000	45.4088	10.3033
SRI SATNAM-343	15.6667	73.0000	101.3333	6.3333	73.7395	22.2833	25.1093	10.5260	65.8667	21.0800	35.2000	45.9826	11.1600
MALVIYA-234	16.0000	71.0000	100.6667	6.2000	63.5080	19.1067	26.7480	10.4903	46.0333	18.3267	39.7667	51.4015	9.7167
Mean	**16.6364**	**73.8939**	**104.7273**	**7.2894**	**72.4633**	**19.9829**	**31.5348**	**10.0138**	**50.9726**	**22.3571**	**39.0924**	**45.5772**	**10.0727**

Table -3 The Range, Grand mean, SE and CD of thirteen Character of Wheat (*Triticum aestivum* L.)

Sr. No	Character	Range		Grand Mean	Coefficient of variation (cv)	Critical difference between two mean (CD)
		Minimum	Maximum			
1	Days to 50% germination	13.33	26.33	16.64	3.86	1.06
2	Days to 50% flowering	66.00	86.67	73.89	1.99	2.43
3	Days To Maturity	96.67	124.00	104.73	1.32	2.28
4	Tillers/ plant	5.23	9.67	7.29	10.34	1.24
5	Plant height (cm)	61.37	92.85	72.46	6.45	7.71
6	Flag leaf area (cm sq)	18.26	22.28	19.98	5.12	1.68
7	Peduncle Length (cm)	24.53	40.76	31.53	4.59	2.39
8	Spike length (cm)	8.04	11.49	10.01	5.14	0.85
9	No. Of grain /spike	38.47	66.17	50.97	4.42	3.71
10	Biological yield (g)	8.39	51.49	22.36	7.02	2.59
11	test weight (1000 seeds)	30.08	47.18	39.09	5.45	3.51
12	Harvest index (%)	34.75	83.04	45.58	4.97	3.73
13	Grain yield / Plant	5.63	15.04	10.07	9.56	1.59

Table - 4 Estimates of phenotypic variance, genotypic variance and environmental variance along with their phenotypic coefficient of variance (PCV) and genotypic coefficient of variance (GCV) and heritability, genetic advance and genetic advance as percent of (5%) mean for thirteen characters in Wheat (*Triticum aestivum* L.)

Character	Phenotypic variance	Genotypic variance	Environmental variance	PCV	GCV	Heritability (h^2) (%)	Genetic advance (5%)	Genetic advance in percent of (5%) mean
Days to 50% germination	21.185	20.771	0.413	21.666	27.395	98	9.296	55.881
Days to 50% flowering	32.604	30.434	2.17	7.727	7.466	93	10.98	14.859
Days to maturity	83.996	82.076	1.92	8.751	8.651	98	18.448	17.616
Tillers/ plant	2.336	1.767	0.568	20.966	18.238	76	2.382	32.683
Plant height (cm)	81.089	59.218	21.871	12.427	10.62	73	13.547	18.695
Flag leaf area (cm sq)	2.16	1.114	1.046	7.354	5.282	52	1.562	7.816
Peduncle Length (cm)	24.252	22.154	2.099	15.617	14.926	91	9.267	29.386
Spike length (cm)	0.873	0.608	0.265	9.332	7.787	70	1.34	13.387
No. of grain/spike	62.722	57.641	5.081	15.537	14.895	92	14.993	29.414
Biological yield (g)	76.054	73.592	2.462	39.007	38.371	97	17.386	77.745
test weight (1000 seeds)	24.638	20.1	4.537	12.697	11.469	82	8.342	21.339
Harvest index (%)	98.721	93.589	5.132	21.8	21.226	95	19.404	42.573
Grain yield /Plant	9.027	8.1	0.927	29.829	28.255	90	5.554	55.134

from one population to another for a given character (Bruton 1953) suggested the genetic variation along with ideas about the expected efficiency of selection, thus a character possessing high GCV along with high heritability will be valuable in the selection programme.

The heritability in broad sense for thirteen characters studied which ranged from 98% to 52%, maximum for days to 50% germination, followed by days to maturity, biological yield, harvest index, days to 50% flowering, number of grain per spike, peduncle length, grain yield per plant and test weight showed high heritability. Whereas tillers per plant, plant height, and spike length shows moderate heritability and the only character which shows low heritability was flag leaf area. It has discouraging results and will not be taken into consideration.

Heritability alone does not provide any indication of how much genetic change will come from choosing individual genotypes. Hence it is most important to learn about genetic development coupled with heritability. Genetic progress is an improvement over the base population in the mean of selected families (Lush 1949 and Johnson *et al*., 1955). It is expressed as the change in gene frequencies on the exercise of selection pressure towards the superior side.

A character with high heritability cannot automatically offer substantial genetic advancement (Johnson *et al.,* 1955) suggested that heritability and genetic advancement would prove more useful when computed together. Maximum genetic advancement was reported for the trait like harvest index, days to maturity, biological yield, and number of grain per spike. However for the biological yield days to 50% germination, grain yield per plant and harvest index a high estimate of genetic progress as per cent of mean was reported. According to *(Paul k et al., 2006)* high heritability along with high genetic advance were observed for grains per spike, plant height and productive tillers.

Conclusion

The sufficient variability exist in the present Wheat breeding material. Analysis of variance showed highly significant differences among all the genotypes under study. The phenotypic coefficient of variation was higher than the genotypic coefficient of variation for all the characters indicating the effect of environment on these characters. Maximum genetic variation was recorded for days to 50% flowering, days to maturity, plant height, biological yield. High heritability estimates were found for thirteen characters under study. The estimates of heritability (%) in broad sense for thirteen characters which ranged from 98% to 52% *i.e.,* days to 50% germination, day to maturity, biological yield followed by harvest index, days to 50% flowering, number of grain per spike, peduncle length, grain yield per plant, and test weight showed high heritability whereas tillers per plant, plant height, and spike length shows moderate heritability and the only character which shows the lowest heritability was flag leaf area. Studies on variability, heritability and genetic advance showed that harvest index, days to maturity, biological yield, number of grain per spike, followed by plant height grain yield per plant are of considerable importance to breeders for selection. Studies of variation indicated that considerable variation in plant height, number of pods per plant, seed yield per plant, biological yield per plant, harvest index and days to 50% germination would be used for bringing an improvement through the breeding programme. Studies on heritability and genetic advance indicated that the plant height, biological yield per plant, number of pods per plant, seed yield per plant, branches per plant and days to 50% germination bear considerable importance for supporting in crop improvement.

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