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Variability, heritability, correlation and path analysis in wheat (Triticum aestivum L.)

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Abstract

The genetic analysis of wheat (Triticum aestivum L.) was carried out twenty five 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 Nidhariya Agriculture Farm, S.M.M. Town P.G. College, Ballia, U.P. The data was recorded on thirteen characters viz, days to 50% heading, number of productive tillers per plant, plant height(cm), flag leaf area (cm^2), peduncle length (cm), spike length (cm), days to maturity, number of grains per spike, biological yield (g), test weight(g), harvest index (%), grain yield per plant and protein content (%). The result of analysis of variance (ANOVA) of present investigation reveals that, the highly significant variation among genotypes for all the 12 characters. On the basis of mean data observation HTWYT-31, HTWYT-26, SAWYT-316, HTWYT-31, New CB-31, SAWYT338, SAWYT-339, SAWYT- 333, SAWYT-334, SAWYT-339 and Black wheat are the superior for most of the character. High PCV and GCV were observed for biological yield per plant, grain yield per plant. Moderate PCV and GCV observed for number of days to maturity, number of tillers per plant, flag leaf area, number of grains per spike, protein content. High heritability was observed for all the traits except number of tillers per plant. High heritability coupled with moderate genetic advance was exhibited by flag leaf area, harvest-index, test weight and biological yield.Plant height, tillers per plant, biological yield and protein content showed positive and significant correlation with grain yield per plant.

Keywords-Wheat (Triticum aestivum L.), mean, viability, heritability, genetic advance and correlation.

Introduction

Wheat (*Triticum aestivum* L.) belongs to the genus Triticum of the Poaceae (Gramineae) family originally from the Levant region of the Near East and Ethiopian Highlands and now cultivated worldwide.

The three species of wheat namely, Triticum aestivum 2n=6x=42 (Bread wheat), Triticum durum 2n=4x=28 (macaroni or Pasta wheat) and Triticum dicoccum 2n=4x=28 (Emmer or Khapli wheat) grown on commercial basisin the Indian subcontinent from pre-historic times. Cereals are generally considered as the "staff oflife" Wheat, rice and maize are the major cereals constituting the staplediet of the majority of the world population. Cereal crops serve as the majorsource of calories, carbohydrates, and some proteins for the human population in developing countries (Tiwari and Shoran, 2010). Wheat is mainly grown during Rabi season and has wideadaptability. It can be grown not only in the tropical and sub-tropical zones,but also in the temperate zone The most favourableclimatic condition for wheat cultivation is cool and moist weather duringthe vegetative growth period followed by dry, warm weather for the grainto mature and ripening. The optimum temperature range for ideal germination of wheat seed is 20-25°C. It is also used for preparation of bread, biscuits, cookies, cracks, noodles, dalia, maida, vermicelli, etc. Wheat straw is also used for the animal feed as fodder and for packaging materials. The Wheat grain contains carbohydrates 70%, protein 12%, fat 1.7%, minerals 2.7%, and fiber 2%. India wheat production has touched the landmark figure of 112.18 million tons from 31.76 million hectares (13.43% of global area) registering an all-time highest crop productivity of 3424 kg/ha. (Annual report 2022-23, IIWBR, Karnal). The total area under production in Uttar Pradesh is 9.85 million ha. and production is 35.4 million tonnes and productivity is 36.64 quintal/ha. Total area of cultivation for Ballia district is 147.717 thousand ha and production is 514.646 thousand metric tons and productivity is 34.84 quintal/ha. The five phases of a wheat breeding program are: (1) defining the problem and setting the objective, (2) identifying and incorporating useful genetic variation, (3) inbreeding and selection among the resulting variants, (4) evaluation of selected elite lines, and (5) cultivar release. These five phases are explained using the unique biology and genetic diversity of wheat. As described, wheat breeding has five phases; defining an objective, identifying and incorporating useful genetic variation, inbreeding and selecting among the variants, evaluating the selected lines, and releasing a new cultivar. New technologies will change wheat breeding if they can affect one of these five processes.

Material and methods

The experiment was conducted at Agriculture Farm Nidharia of Shri Murli Manohar Town P.G. College Ballia (U.P.) during winter season in November 20222 - 2023. The experiment was conducted to evaluate twenty five lines of wheat under irrigated normal soil condition in Randomized Block Design (RBD). The entire experimental field was divided into 3 blocks of equal size and each block had twenty five entries. The row to row spacing was 20 cm, plant to plant distance was 10 cm. All cultural practices essential for the good crop of wheat (Triticum aestivum L.) were applied for obtaining healthy and competitive crop stand. Five plants from each plot were randomly selected for recording observations for all the quantitative characters except days to 50% flowering and days to maturity, which were recorded on line basis. Average of these five plants in respect of different plant characters were used for statistical analysis. Observations of twelve data were compiled by computing the mean of each treatment was subjected to the statistical analysis: Analysis of Variance (ANOVA) by Fisher and Yate (1938), heritability (In broad sense) is calculated by the formula suggested by Allard (1960) and genetic advance was calculated by the formula suggested by Johnson *et. al.(*1955).

Results and Discussion

The present investigation estimated for Analysis of variance (ANOVA) to obtain the nature and magnitude of variation. Highly significant differences were observed for all the treatments that indicate the presence of genetic variation in the population. Similar findings were reported by Kotal *et al.* (2010), Bhusan *et al*. (2013), It may be easily exploited through selection with suitable breeding programme.

The estimation of heritable and non-heritable component for assessment of a suitable breeding programme is necessary. The magnitude and nature of variation estimated using Genetic Coefficient of variation (GCV) and phenotypic Coefficient of variation (PCV). It may be exploited through a suitable breeding programme. Phenotypic coefficient of variation (PCV) was found higher than Genotypic Coefficient of variation (GCV) for all the traits. It revealed that the influence of environment factors. Similar findings were reported by Kotal *et al*. (2010), Ashfaq *et al.* (2014)**.** The differences between PCV and GCVwere very low for all traits. It indicated that least influence of environmental factors. High PCV and GCV were observed for biological yield per plant, grain yield per plant. Moderate PCV and GCV observed for number of days to maturity, number of tillers per plant, flag leaf area, number of grains per spike, protein content and low PCV and GCV obtained for days to 50% heading, plant height, peduncle length, spike length, test weight and harvest index days. Genotypic coefficient of variation (GCV) does not provide full scope to access the characters is heritable or non-heritable to measure the heritability components, genetic parameter is used. It is an important genetic parameter (the ratio of Vg/Vp) that measured the heritable components. Heritability is only measured in a broad sense.

High heritability was observed for all the traits except number of tillers per plant. It means the traits are governed by additive gene action. It means these traits are highly heritable in offspring hence these traits should be taken into consideration during selection for development of elite genotypes. Similar findings were reported by Nukasanin et al. (2013)for Plant height, spike length, number of grains per spike and 1000 grain weight Singh et al. (2022)for peduncle length (97.12),biological yield per plant, flag leaf area, harvest index, days to 50% flowering, and spike length, Bhushan et al. (2013).Moderate heritability observed for number of tillers per plant it is not govern by additive gene action and provides fair chance for improvement of genotypes hence it should be taken into consideration. Days to maturity showed discouraging result due to low heritability. It should not take into breeding programme.

The grain yield or economic yield in most of crops is a complex character which manifests from multiplicative interaction of several characters that are termed as yield components. The genetics of grain yield in wheat as well as other crops is based on the balance or overall effect produced by various yield components directly or indirectly by interacting with one another. Therefore, selection for yield per se alone would not matter much as such unless accompanied by the selection for various component characters responsible for conditioning it. Thus, identification of important component characters and information about their association with yield and also with each other are very useful for developing efficient breeding strategy for evolving high yielding varieties. The correlation coefficient is the measure of degree of linear association between two variables or characters and helps us in understanding the nature and magnitude of association among yield and yield components. Plant height showed positive and highly significant correlation with grain yield per plant. It indicates that selection of this trait for breeding programme can help in development of elite genotypes. Few other characters Harvest Index and Spike length may also improve due to positive and highly significant correlation hence breeders should be taken into consideration during selection of traits. Similar findings were reported by Singh et al. (2023).A positive and highly significant correlation observed between tillers per plant and grain yield per plant. It

indicates that to selection this trait will also increase grain yield hence breeders should take into consideration for adoption of suitable breeding programme. Biological yield showed positive and highly significant correlation with grain yield per plant hence this trait should be taken into consideration for development of elite genotypes while adopting a suitable breeding programme. Few other traits/variables like test weight will also improve due to positive and highly significant correlation with biological yield.

Number of grains per spike, test weight showed positive and highly significant correlation with grain yield. These traits are important from breeding point of view because increase in both number of grains per spike and test weight, grain yield also increase hence breeder should take into consideration for adoption of suitable breeding programme. Harvestindex will also increase due to positive and highly significant correlation with both traits**.** Protein content showed positive and highly significant correlation with grain yield so this trait should be taken into consideration. Similar findings were reported by Rathod *et al*.(2019). Rest of the traits are non- significant with grain yield hence these traits should not take into consideration from breeding point of view.

Table4.1:Analysis of variance (ANOVA) 13 quantitative traits in wheat (Triticum aestivum L.)

Sourceof variation	d.f.	Daysto 50% heading	Days to maturity	Plant height (cm)	No. of tillerper plant	Flagleaf area	Peduncle length	Spike length	No. of grainper spike	Biological yield per plant	Test weight	Harvest index	Protein content	Grain yieldper plant
Replication	2	10.573**	26.04**	8.545	19.990**	24.889**	9.296*	1.641*	28.478**	36.67**	11.454**	18.648*	0.070**	22.549**
Treatment	24	52.5**	517.06**	65.942**	7.173**	40.69**	13.176**	2.886**	137.237**	727.71**	32.461**	21.254**	12.177**	128.173**
Error	48	2.032	2.85	3.699	1.983	2.545	2.068	0.425	3.479	3.54	1.681	3.695	0.011	2.842

*Significantat5%levelofsignificant **Significantat1%levelofsignificance

Table4.2:-Mean value of 13 quantitative characters in wheat (Triticum aestivum L.)

Characters / Genotypes	Daysto50% heading	Daystomaturity	Planthieght(cm)	No.ofprodoctivetiller perplant	Flagleafarea(cm²)	Pedunclelength(cm)	Spikelength(cm)	Numberofgrainperspik e	Biologicalyield(g)	Testweight(g)	Harvestindex (%)	Proteincontent (%)	Grainyield/plant(g)
NEWCB-21	82.00	124.33	82.88	10.80	21.93	33.85	11.62	56.82	33.85	34.80	43.57	7.98	14.78

HTWYT-31	67.67	110.33	77.89	12.73	22.12	30.35	11.37	61.75	33.13	37.03	46.63	11.17	15.47
HTWYT-32	69.33	105.67	85.79	10.87	25.24	33.45	11.15	67.57	36.32	37.93	45.11	9.57	16.43
HTWYT-33	71.33	105.33	84.39	10.07	29.54	33.69	11.34	67.13	43.83	38.97	44.05	9.57	19.33
HTWYT-28	74.67	104.33	84.93	8.87	26.81	31.53	12.23	67.75	38.43	38.80	42.55	8.77	16.41
HTWYT-26	73.00	103.67	86.71	12.27	30.85	33.64	12.43	59.42	50.35	42.83	39.90	10.37	20.11
NEWCB-31	82.33	121.33	93.21	13.67	28.63	37.30	11.73	62.33	79.96	41.53	35.39	13.56	28.31
HTWYT-30	75.67	107.00	84.36	10.47	25.40	29.86	10.73	59.57	42.50	38.20	40.25	8.77	17.15
SAWYT-301	76.00	107.67	82.09	12.53	24.43	30.48	11.54	63.04	42.42	39.07	44.60	7.65	18.95
SAWYT-306	72.67	104.67	79.30	10.20	25.86	29.68	12.54	72.13	46.15	40.97	43.00	8.77	19.87
SAWYT-309	74.33	107.33	82.09	8.80	26.99	31.96	10.88	67.40	44.16	39.67	43.47	12.76	19.22
SAWYT-310	74.33	107.00	86.45	11.20	30.06	32.10	12.64	73.95	57.43	42.60	45.62	12.76	26.25
SAWYT-316	73.33	103.67	86.01	12.60	28.61	32.46	11.86	71.53	59.35	41.57	44.64	11.17	26.53
SAWYT-323	72.00	104.00	83.17	10.60	22.97	30.52	11.88	64.53	46.95	42.90	45.77	11.97	21.53
SAWYT-328	73.67	106.33	79.94	11.13	25.59	32.41	11.10	60.68	44.79	42.43	42.57	10.37	19.09
NEWCB-47	68.00	104.67	85.91	8.53	22.75	32.63	11.23	58.49	47.60	38.00	46.26	12.76	22.05
SAWYT-329	74.67	107.33	87.88	8.13	32.44	34.40	12.56	71.31	50.48	44.10	46.15	14.36	23.31
SAWYT-333	78.33	119.33	92.08	11.20	32.58	34.29	14.74	78.46	83.05	49.23	43.67	11.97	36.29
SAWYT-334	75.67	119.00	84.51	13.00	26.26	35.21	12.26	74.71	64.19	40.43	46.65	12.76	29.95
SAWYT-335	78.33	122.00	90.66	13.33	27.37	33.29	11.75	69.73	67.69	42.53	40.94	11.17	27.75
SAWYT-337	78.00	120.67	91.31	12.33	25.29	33.99	11.03	69.73	70.69	44.70	45.21	12.76	31.97
SAWYT-338	77.00	120.33	91.92	11.53	35.05	34.54	11.95	61.68	70.87	48.03	41.82	10.37	29.67
SAWYT-339	77.00	120.00	94.57	12.47	26.37	37.72	12.42	77.27	73.91	41.00	43.32	8.77	32.03
SAWYT-340	77.33	114.33	89.43	12.67	22.62	33.98	10.71	69.60	77.06	43.60	43.50	13.37	33.53
BlackWheat	85.00	124.67	94.07	11.13	20.33	35.29	9.34	51.22	35.08	39.10	39.33	14.36	13.83
Grand mean	75.27	114.20	86.46	11.25	26.64	33.14	11.72	66.31	53.61	41.20	43.36	11.11	23.19
Minimum	67.67	103.67	77.89	8.13	20.33	29.68	9.34	51.22	33.13	34.80	35.39	7.65	13.83
Maximum	85.00	124.67	94.57	13.67	35.05	37.72	14.74	78.46	83.05	49.23	46.65	14.36	36.29

Table4.3:-Variability parameters of various characters in wheat (Triticum aestivum L.)

Variability parameters / Characters	Allover mean	Range		Standard error of mean	Genotypic Coefficient of Variance (GCV) (%)	Phenotypic Coefficient of Variance (PCV) (%)	Heritability (h^2)	Genetic advance	Genetic advancei % ofmean
		Minimum	Maximum						
Days to50%heading	75.266	67.67	85.00	0.822	5.449	5.769	89.22	7.981	10.603
Daystomaturity	114.2	103.67	105.67	0.973	11.464	11.559	98.37	26.748	23.422
Plantheight(cm)	86.462	77.89	94.57	1.110	5.268	5.718	84.87	8.644	9.997
No.ofproductivetillersper plant	11.245	8.13	8.13	0.813	11.695	17.136	46.58	1.849	16.444
Fagleafarea	26.643	20.33	35.05	0.921	13.383	14.661	83.32	6.705	25.166
Pedunclelength	33.144	29.68	37.72	0.830	5.805	7.247	64.16	3.174	9.578
Spikelength	11.720	9.34	14.74	0.376	7.726	9.522	65.85	1.513	12.916
No.ofgrainperspike	66.311	51.22	78.46	1.076	10.069	10.455	92.76	13.248	19.978
Biologicalyieldperplant	53.609	33.13	83.05	1.086	28.981	29.193	98.55	31.773	59.268
Testweight	41.201	34.80	49.23	0.748	7.774	8.386	85.93	6.116	14.845
Harvestindex	43.358	35.39	46.65	1.109	5.579	7.126	61.30	3.901	8.999
Proteincontent	11.114	7.65	14.36	0.0615	18.118	18.144	99.72	4.142	37.272
Grainyieldperplant	23.191	13.83	36.29	0.973	27.869	28.802	93.63	12.883	55.553

Table4.4:-Genotypic and phenotypic correlation among 13 characters in wheat (Triticum aestivum L.)

Characters		Daysto 50%heading	Days to maturity	Plant height (cm)	Tillers per plant	Flag leaf area (cm²)	Peduncle length(cm)	Spike length (cm)	No.of grain per spike	Biological yield (g)	Test weight (g)	Harvest index (%)	Protein content (%)	Grain yieldper plant(g)
Daysto50%	rg	0.189	0.615**	0.294**	-0.052	0.528**	-0.166	-0.166	0.359**	0.164	-0.741**	0.19	0.226*
Heading	rp	0.211	0.625**	0.370**	0.06	0.558**	-0.012	-0.079	0.369**	0.230*	-0.392**	0.167	0.276*
Daystomaturity		Rg	0.345**	0.244*	-0.125	0.431**	-0.171	0.009	0.061	-0.091	-0.102	-0.18	0.033
		Rp	0.352**	0.234*	-0.076	0.399**	-0.093	0.035	0.073	-0.054	-0.021	-0.023	0.058
Plantheight			rg	0.234*	0.271*	0.806**	0.029	0.127	0.690**	0.489**	-0.554**	0.407**	0.604**
(cm)			rp	0.368**	0.345**	0.765**	0.14	0.194	0.668**	0.510**	-0.243*	0.359**	0.610**
Tillersper plant				Rg	-0.187	0.223	-0.125	0.052	0.550**	0.112	-0.545**	0.013	0.438**
				Rp	0.116	0.429**	0.147	0.172	0.447**	0.260*	0.015	-0.02	0.438**
Flagleafarea (cm²)					rg	0.201	0.648**	0.417**	0.468**	0.668**	-0.228*	0.06	0.431**
					rp	0.320**	0.626**	0.448**	0.464**	0.674**	0.015	0.039	0.464**

Pedunclelength						Rg	-0.015	0.107	0.606**	0.229*	-0.526**	0.392**	0.510**
(cm)						Rp	0.199	0.212	0.540**	0.327**	-0.065	0.292**	0.513**
Spikelength (cm)							rg	0.681**	0.453**	0.512**	0.112	-0.125	0.488**
							rp	0.639**	0.405**	0.511**	0.275*	-0.117	0.468**
No.ofgrainper								rg	0.556**	0.441**	0.375**	0.061	0.661**
Spike								rp	0.560**	0.453**	0.414**	0.049	0.673**
Biologicalyield									rg	0.755**	-0.246*	0.352**	0.972**
(g)									rp	0.726**	-0.133	0.344**	0.962**
Testweight										rg	-0.137	0.382**	0.760**
(g)										rp	0.023	0.342**	0.744**
Harvestindex											rg	0.028	-0.022
(%)											rp	-0.002	0.129
Proteinconte nt (%)												rgrp	0.365** 0.342**

rg=Genotypic correlation coefficient **Significantat1%levelofsignificance

rg=Phenotypic correlation coefficient *Significant at 5% level of significance

Top Five Promising Lines

Characters	Germplasm Lines and their values	1	2	3	4	5
Daysto50%heading		HTWYT-31	NewCB-47	HTWYT-32	HTWYT-33	SAWYT-323
	Values	67.67	68.00	69.33	71.33	72.00
Daysto maturity		HTWYT-26,SAWYT-316	SAWYT-323	HTWYT-28	SAWYT-306,NewCB-47	HTWYT-33
	Values	103.67	104.00	104.33	104.67	105.33
Plantheight(cm)		HTWYT-31	SAWYT-306	SAWYT-328	SAWYT-301,SAWYT-309	NewCB-21
	Values	77.89	79.30	79.94	82.09	82.88
Numberoftillersperplant		NewCB-31	SAWYT-335	SAWYT-334	HTWYT-31	SAWYT-340
	Values	13.67	13.33	13.00	12.73	12.67
Flagleafarea(cm^2)		SAWYT-338	SAWYT-333	SAWYT-329	HTWYT-26	SAWYT-310
	Values	35.05	32.58	32.44	30.85	30.06
Pedunclelength(cm)		SAWYT-339	HTWYT-30	HTWYT-31	SAWYT-301	SAWYT-323
	Values	37.72	29.86	30.35	30.48	30.52
Spikelength(cm)		SAWYT-333	SAWYT-310	SAWYT-329	SAWYT-306	HTWYT-26
	Values	14.74	12.64	12.56	12.54	12.43
Numberofgrainsperspike		SAWYT-333	SAWYT-339	SAWYT-340	SAWYT-310	SAWYT-306
	Values	78.46	77.27	74.71	73.95	72.13
Biologicalyield(g)		SAWYT-333	NewCB-31	SAWYT-340	SAWYT-339	SAWYT-338
	Values	83.05	79.96	77.06	73.91	70.87
Testweight(g)		SAWYT-333	SAWYT-338	SAWYT-337	SAWYT-339	SAWYT-340
	Values	49.23	48.03	44.70	44.10	43.60
Harvestindex(%)		SAWYT-334	HTWYT-31	NewCB-47	SAWYT-339	SAWYT-323
	Values	46.65	46.63	46.26	46.15	47.77

Proteincontent(%)		SAWYT-339,Blackwheat	NewCB-31	SAWYT-340	SAWYT-309,NewCB-47,SAWYT-334,SAWYT-337	SAWYT-323, SAW-YT-333
	Values	14.36	13.56	13.37	12.76	11.97
Grainyieldperplant(g)		SAWYT-333	SAWYT-340	SAWYT-339	SAWYT-337	SAWYT-334
	Values	36.29	33.53	32.03	31.97	29.95

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