Journal of Experimental Agriculture International

Volume 46, Issue 6, Page 389-397, 2024; Article no.JEAI.116493
ISSN: 2457-0591
(Past name: American Journal of Experimental Agriculture, Past ISSN: 2231-0606)

Studies on Genetic Variability, Correlation and Path Coefficient Analysis for Yield and Yield Contributing Traits in Bread Wheat (*Triticum aestivum* L.)

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Authors' contributions

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

Article Information

DOI: 10.9734/JEAI/2024/v46i62490

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/116493

Original Research Article

Received: 29/02/2024
Accepted: 03/05/2024
Published: 09/05/2024

ABSTRACT

A study was undertaken to analyse the genetic variability, correlation and estimates path coefficient analysis of yield and yield contributing traits in twenty-eight wheat genotypes grown at BAU Agricultural Farm, ranchi during Rabi season of 2019-2020 in three different dates of sowing with an interval of 15 days which is considered as three environments E1, E2, E3. In this investigation the pooled analysis of variance revealed that the treatments were highly significant for all the

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characters. Wide genetic variation was observed among genotypes for plant height, number of grains per spike, 1000 kernel weight, days to maturity and flag leaf area. Considering genetic parameters, high genotypic co-efficient of variation (GCV), was observed for 1000 kernel weight (11.95), no of grains per spike (12.73), flag leaf area (13.74), spike length (15.83), grain yield per plant (17.64), no of effective tillers (18.38) Whereas, low GCV was observed for plant height (3.49), days to 50% flowering (1.46), days to maturity (2.54) and harvest index (6.90). In most of the cases, phenotypic variances were higher than the genotypic variances. Environmental variance is much higher in harvest index (35.64), days to 50% flowering (33.47). low environmental variance was observed in plant height (16.75), flag leaf area (10.29), days to maturity (13.93), no of grains per spike (14.07), spike length (0.49) and biological yield (35.64). High heritability with low genetic advance in per cent of mean was observed for plant height, days to maturity, days to 50% flowering & harvest index which indicated the involvement of non-additive gene action for the expression of this character and selection for such trait might not be rewarding. High heritability with high genetic advance in per cent of mean was observed for grain yield per plant (27.73), no of grains per spike (20.93), 1000 kernel weight (23.58) and no of effective tillers (27.91) indicating that these traits were under additive gene control and selection for genetic improvement for these traits would be effective. Biological yield had high positive and significant correlation with plant height, number of effective tillers and number of grains per spike. Path coefficient analysis revealed maximum direct contribution towards yield per plot with sheath length followed by grains per spike.

Keywords: Wheat (Triticum aestivum L.); correlation; path-coefficient; heritability.

1. INTRODUCTION

Wheat (*Triticum aestivum. L*) 2n=42 is a crop of global significance. It is grown in diversified environments. It is a staple food of millions of people. Approximately one-sixth of the total arable land in the world is cultivated with wheat. Whereas paddy is mainly cultivated in Asia, wheat is grown in all the continents of the world. It supplies about 20 per cent of the food calories for the world's growing population. Global wheat production touched 763.93 million tons in 2019-20. India is the second largest producer of wheat after China. Wheat has a distinct place among the food grain crops. Carbohydrate and protein are two main constituents of wheat. On average wheat contains 11-12% protein. Wheat is grown mainly in two seasons in the world *viz*. winter and spring. Winter wheat is grown in cold countries like Europe, U.S.A., Australia, Russian federation *etc*. While spring wheat is grown in Asia and a part of U.S.A. spring wheat matures in 120-130 days while winter wheat takes 240-300 days for maturity. Due to this reason productivity of winter wheat is higher in comparison to spring wheat Neeraj Singh *et al*. (2018). Considering the quality wheat has been divided into two categories (1) Soft wheat and (2) Hard wheat. *Triticum aestivum* (Bread wheat) is known as soft wheat and *Triticum durum* is known as hard wheat. Therefore, there is need to exploit the existing genetic variability in wheat for developing high yielding varieties that can be adjusting and highly productive under changing climatic scenario. Grain yield, being a complex trait, depends upon component variables and their interaction. Correlations and path coefficient analysis provide knowledge on trait interrelationships and potential for simultaneous, direct, or indirect selection in plant breeding N.W Mbumba *et al.* [1]. Degree and direction of relationship between two or more variables lead to estimation of correlation. Correlation studies provide better understanding of yield component which helps the plant breeder during selection. Path coefficient analysis measures the direct and indirect contribution of independent variables on dependent variables and thus helps breeder in determining the yield components and understanding cause of association between two variables. The information obtains by path coefficient analysis helps in indirect selection for genetic improvement of yield because direct selection is not effective for low heritable trait like yield. Thus, the estimation of heritability and genetic advance is essential for a breeder which helps in understanding the magnitude, nature and interaction of genotype and environmental variation of the traits. With the above reference the present experiment was conducted to study the extent of genotypic and phenotypic variability among the genotypes and to estimate genetic advance, correlation coefficient among the selected characters and direct and indirect effects of component characters on yield of wheat to screen out the suitable parental groups for future- breeding program.

2. MATERIALS AND METHODS

The experiment was conducted during Rabi season of 2019-20 at the at western section of research farm, BAU. Kanke during *rabi*-2019-20. Birsa Agricultural University (BAU), Kanke is located at an elevation of 634 meter above mean sea level with 85°18'48.3"East longitude and 23°25'47.3"North latitude.. The experimental material consisting 28 diverse wheat genotypes (Table 1) sown during Rabi 2019 in three different date of sowing mentioned in (Table 2) in Randomized Block Design (RBD) with two replications having a plot size of 0.6m x 4m. The distance maintained between row to row and between plant to plant were 23 cm and 10 cm, respectively The different date of sowing is considered as different environments E1 (Timely sown), E2 (Late sown), E3 (Very late sown) and every sowing is done with a gap period of fifteen days description of environment mentioned in (Table 2). Recommended agronomic package and practices were applied to raise a healthy crop. The Data were recorded as pre harvest observations are days to 50% flowering, chlorophyll content (%) (measured by SPAD device), flag leaf area (Flag leaf area was measured by multiplying the length and width of the flag leaf by a coefficient factor, 0.65 as suggested by R. lazarod [2] and data recorded as post harvest observations are Plant height (cm), Spike length (cm), number of Effective tiller per plant, Protein content % (measured by Granolyser device), number of Grains per spike, 1000 Kernel weight (g), grain yield per Plant (g), biological yield per plant (g), harvest index (%). Data from five plants of each genotype were averaged replication wise and mean data was used for statistical analysis. The statistical analysis was performed using R Programming software. Mean, range and coefficient of variation (CV) were also estimated. Genotypic coefficients of variation (GCV) and phenotypic coefficients of variation (PCV) were estimated according to Burton [3] heritability in broad sense (h2bs) was estimated according to Burton and Devane [4] genetic advance (GA) and genetic advance as per cent of mean (GAPM) were calculated by Johnson *et al*. [5] correlation coefficient analysis by Robinson *et al*. [6] and path coefficient analysis was accessed by Dewey and Lu [7].

3. RESULTS AND DISCUSSION

The pooled analysis of variance for overall Environment (E1, E2 & E3) has been presented in (Table 3). The table revealed highly significant difference for replication and treatment mean square at 1% level of significance for all the characters but for days to 50% flowering treatment mean sum of square is non-significant and for protein content replication mean sum of square is non-significant. The highest mean sum of squares due to error was observed for days to 50% flowering (1425.32), followed by harvest

Table 1. List of 28 wheat genotypes

(A)	Genotype	Origin	(B)	Genotype	Origin
1.	RW-5	Karnal (IIWBR)	15.	WH-1239	CCSHAU(HR)
2.	HI-1628	IARI, (Indore)	16.	HD-2932	Delhi (IARI)
3.	DBW-252	Karnal (IIWBR)	17.	HD-3237	Delhi (IARI)
4.	K-307(C)	Kanpur (U.P)	18.	LBP-2017-2	Karnal (Haryana)
5.	NIAW-3170	Niphad (M.H)	19.	DBW-14(C)	Karnal (IIWBR)
6.	RAJ-4529	Durgapura (Raj)	20.	PBW-773	Ludhiana (Punjab)
7.	NI-5439	Niphad (MH)	21.	MP-1331	Powarkheda (M.P)
8.	WH-1235	CCS HAU(HR)	22.	RIL-5138	Tata research
9.	DBW-273	Karnal (IIWBR)	23.	DBW-110	Karnal (IIWBR)
10.	BG-3(C)	Ranchi (B.A.U)	24.	M-516	AICRP (Wheat)
11.	RWP-2018-31	AICRP (Wheat)	25.	DBW-136	Karnal (IIWBR)
12.	DBW-233	Karnal (IIWBR)	26.	UP-2981	Pantnagar (U.K)
13.	MACS-6696	Pune, (ARI)	27.	HI-1621	IARI, (Indore)
14.	K-1317	Kanpur (U.P)	28.	WR-544(C)	Delhi (IARI)

Table 2. Description of environments

Environments	Date of sowing
1) Environment 1 (Timely sown- E_1)	27/11/2019
2) Environment 2 (Late sown-E_2)	12/12/2019
3) Environment 3 (Very late sown-E_3)	27/12/2019

Table 3. Analysis of variance for Pooled Environments (E1, E2 & E3)

		MEAN SQUARE												
SOV	**D.F**	**Plant Height (cm)**	**Spike Length (cm)**	**Flag Leaf Area (cm^2)**	**1000 kernel weight (g)**	**Days to 50% Flowering**	**Days to Maturity**	**Grain Yield/plant(g)**	**No of Grains /spike**	**No Effective Tillers**	**Chlorophyll Content (%)**	**Protein content (%)**	**Biological yield (g/plant)**	**Harvest Index (%)**
Replication	1	695.20	1.48	262.38	51.29	1425.32	84.10	8.55	65.60	6.94	67.92	0.03	261.04	416.43
Treatment	27	86.80**	11.86**	51.63**	164.09**	40.13	274.16**	8.77**	162.5**	5.0**	29.38**	13.59**	26.66* *	77.68**
Error	27	16.75	0.498	10.29	2.43	1425.32	13.93	0.93	14.07	0.61	10.32	0.05	8.05	35.64

*** = significant at 1%, * = significant at 5%*

Table 4. Range and mean of different characters in wheat (*Triticum aestivum* L.) genotypes over three Environments Timely sown (E_1), late (E_2) & very late (E_3) sown conditions

POOLED ENVIRONMENT					
Sl. No	**Characters**	**Range**	**General mean**	**SEm±**	**CD at 5%**
1	Plant Height(cm)	92.53-105.83	97.68	1.67	4.674
2	Spike Length(cm)	6.13-11.17	8.69	0.28	8.690
3	Flag leaf area (cm^2)	14.19-24.99	19.10	1.30	19.099
4	1000 kernel weight(g)	31-52.47	43.42	43.41	1.783
5	Days to 50% Flowering	67-78	71.89	2.36	6.606
6	Days to Maturity	128-142	134.19	1.52	4.262
7	Grain yield / plant (g)	4.64-8.41	6.48	0.39	1.104
8	No of grains/ spike	30.04 - 47.18	39.07	1.53	4.283
9	No. of Effective tillers	3.08-6.1	4.65	0.32	0.895
10	Chlorophyll Content (%)	38.61-46.8	43.69	1.31	3.669
11	Protein content (%)	10.23-15.48	13.47	0.09	0.272
12	Biological yield (g/plant)	13.58-20.73	17.25	1.15	3.240
13	Harvest index (%)	3.44 - 4.71	38.32	2.43	6.817

index (35.64) and plant height (16.75). The overall mean range, mean, standard error of mean along with C.D values for different characters over three environments (E1, E2 & E3) has been presented in (Table 4). The data revealed that the widest range of variability was observed for (1000 kernel weight) 31-52.47 with mean value 43.41, number of grains per spike (30.04-47.18) with mean value 39.08, (days to maturity) 128-142 with mean value 134.2, (plant height) range between 92-105 with mean value of 97.68 cm, (flag leaf area) range of variability between 14.19-24.99 with mean value of 19.09 cm^2. A perusal of the (Table 5) indicated that phenotypic variance was higher as compared to genotypic variance for all the characters studied. Highest phenotypic variance was observed in (harvest index) 42.65 followed by (no of grains spike) 38.82, (Days to 50% flowering) 34.58. The maximum value of genotypic variance was found for (1000 seed weight) 26.94, (no of grains spike) 24.74. moderate genotypic variance was observed in (plant height) 11.67, (flag leaf area) 6.89, (days to 50% flowering) 1.10, (days to maturity) 11.69, (biological yield) 3.10, (harvest index) 7.00. Environmental variance is much higher in (harvest index) 35.65, (days to 50% flowering) 33.47. Moderate environmental variance was observed in (plant height) 16.76, (flag leaf area) 10.29, (days to maturity) 13.94, (no. of grains spike) 14.07, (biological yield) 8.05.The estimates of PCV were found higher than GCV (Table 5) for spike length, flag leaf area, grain yield per plant, no of grains per spike, biological yield and no of effective tillers, this may be due to the non-genetic factor which played an important role in the manifestation of these characters. The characters with high phenotypic coefficient of variation indicated more influence of environmental factors. Therefore, caution has to be exercised during the selection programme, because the environmental variations are unpredictable in nature and may mislead the results similar results was observed by D. K. Baranwal *et al.,* [8] Sharma and Garg [9] and Kumar *et al*. [10]. Highest PCV was observed in no. of Effective tillers (24.94) followed by grain yield per plant (23.11), flag Leaf Area (21.70) similar results was also observed by similar with the studies of Mohammad *et al.* [11]. Highest GCV was observed in no of effective tillers (18.38) followed by grain yield per plant (17.64) and spike length (15.83) conformity with the findings of Panwar and Singh [12]. The highest ECV was observed in no of effective tillers (16.85), flag leaf area (16.79) and biological yield (16.44). The estimates of heritability (broad sense) and genetic advance expressed as per cent of mean have been presented in (Table 5). High heritability estimates was associated with high estimates of genetic advance (GA) for 1000 kernel weight, no of grains per spike, days to maturity and plant height which in fact demonstrate the presence of additive genes effect indicating effectiveness of selection for the improvement of these traits. Such a results showed similarity with findings of Atta *et al*. [13] and Bhoite *et al*. [14]. Broad sense heritability was highest for 1000 seed weight (91.70), spike length (79.1), no of grains per spike (63.75), grain yield per plant (58.25) similarity with findings of Atta *et al*. [13] and Bhoite *et al*. [14]. The estimate of genetic advance as % of mean was noticed for spike

Table 5. Pooled Genetic estimate of Environments (E1, E2 & E3)

Source of variation	Plant Height(cm)	Spike Length(cm)	Flag Leaf Area(cm^2)	1000 kernel Weight (g)	Days to 50% Flowering	Days to Maturity	Grain yield / plant(g)	No. of grains/ spike	No. of Effective tillers	Biological yield (g/plant)	Harvest Index (%)
δ^2g	11.67	1.89	6.89	26.94	1.10	11.69	1.30	24.74	0.73	3.10	7.01
δ^2ph	28.43	2.39	17.18	29.38	34.58	25.63	2.24	38.81	1.34	11.15	42.65
δ^2e	16.75	0.49	10.29	2.43	33.47	13.93	0.93	14.07	0.61	8.05	35.64
GCV	3.49	15.83	13.74	11.95	1.46	2.54	17.64	12.73	18.38	10.20	6.90
PCV	5.45	17.80	21.70	12.48	8.18	3.77	23.11	15.94	24.94	19.35	17.03
ECV	4.19	8.12	16.79	3.59	8.04	2.78	14.93	9.60	16.85	16.44	15.57
h^2	41.0	79.1	40.10	91.70	3.20	45.62	58.25	63.75	54.34	27.8	16.43
GA	4.51	2.52	3.424	10.23	0.38	4.75	1.79	8.18	1.29	1.91	2.20
GA as % of mean	4.61	29.03	17.92	23.58	0.540	3.54	27.73	20.93	27.91	11.08	5.76

Table 6. Pooled Correlation analysis for ten characters of wheat (*Triticum aestivum* L.) genotypes for environments (E_1, E_2 & E_3)

Characters		Plant height(cm)	Spike length(cm)	Flag leaf area(cm^2)	1000-kernel weight(g)	Days to 50% flowering	Days to maturity	No. of grains/ spike	No. of Effective tillers	Biological yield (g/plant)	Harvest Index (%)	Grain yield / plant(g)
Plant height(cm)	G	1	-0.017	-0.278	0.465	-1.265	-0.548	1.002	1	1.027	0.841	0.953
	P	1	0.010	-0.050	0.282 **	-0.120	-0.188 *	0.570**	0.566 **	0.446 **	0.27 **	0.599 **
Spike length(cm)	G		1	-0.201	0.256	0.276	-0.125	0.124	0.104	0.184	0.165	0.161
	P		1	-0.116	0.209 **	0.103	-0.077	0.095	0.088	0.104	0.043	0.107
Flag leaf	G			1	-0.283	0.596	0.090	-0.232	-0.190	-0.284	-0.329	-0.253
area(cm^2)	P			1	-0.163 *	0.068	0.031	-0.214 **	-0.196*	-0.112	-0.048	-0.140
1000 kernel	G				1	-0.474	-0.267	0.544	0.531	0.402	0.709	0.493
weight(g)	P				1	-0.08	-0.176 *	0.417 **	0.377**	0.226**	0.245 **	0.358 **
Days to 50%	G					1	0.614	-0.831	-0.685 **	-1.029 **	-0.968 **	-0.861 **
flowering	P					1	0.229	-0.094	-0.013	-0.09	0.02	-0.058
Days to maturity	G						1	-0.535	-0.464	-0.514	-0.403	-0.517
	P						1	-0.247 **	-0.254 **	-0.238 **	-0.167 *	-0.323 **
No. of grains/	G							1	1.060	1.116	1.049	1.071
spike	P							1	0.751 **	0.449 **	0.326 **	0.637 **
No. of	G								1	1.072**	1.070**	1.053**
Effective tillers	P								1	0.484 **	0.395**	0.722 **
Biological yield	G									1	1.009	1.018
(g/plant)	P									1	-0.152 *	0.727 **
Harvest Index(%)	G										1	0.975
	P										1	0.519 **

***=significant at 1%, * = significant at 5%*

Table 7. Pooled Path analysis for ten characters of wheat (*Triticum aestivum* L.) genotypes under three environments (E_1, E_2, E_3)

Characters		Plant height(cm)	Spike length(cm)	Flag leaf area(cm^2)	1000-Kernel weight(g)	Days to 50% flowering	Days to maturity	No. of grains/ spike	No. of Effective tillers	Biological yield (g/plant)	Harvest Index (%)
Plant height(cm)	P	**0.048**	-0.000	0.000	-0.002	-0.001	0.003	0.014	0.049	0.328	0.158
Spike length(cm)	P	0.000	**-0.008**	0.000	-0.002	0.001	0.001	0.002	0.007	0.076	0.024
Flag leaf area(cm^2)	P	-0.002	0.000	**-0.006**	0.001	0.000	-0.000	-0.005	-0.017	-0.082	-0.027
1000 kernel weight(g)	P	0.013	-0.001	0.001	**-0.010**	-0.001	0.003	0.010	0.033	0.166	0.139
Days to 50% flowering	P	-0.005	-0.000	-0.000	0.000	**0.013**	-0.004	-0.002	-0.001	-0.066	0.011
Days to maturity	P	-0.009	0.000	-0.000	0.001	0.003	**-0.017**	-0.006	-0.022	-0.175	-0.095
No. of grains/ spike	P	0.027	-0.000	0.001	-0.004	-0.001	0.004	**0.026**	0.065	0.331	0.185
No. of Effective tillers	P	0.027	-0.000	0.001	-0.003	-0.000	0.004	0.019	**0.087**	0.356	0.225
Biological yield (g/plant)	P	0.021	-0.000	0.000	-0.002	-0.001	0.004	0.011	0.042	**0.736**	-0.086
Harvest Index(%)	P	0.013	-0.000	0.000	-0.002	0.000	0.003	0.008	0.034	-0.111	**0.568**

length (29.03), no of effective tillers (27.91), grain yield per plant (27.73). The phenotypic correlation coefficient was highly significant (Table 6) and positive for grain yield per plant with no of effective tillers, no of grains per spike, 1000 kernel weight, plant height, biological yield and harvest index. Among component traits positive and highly significant correlation was observed between plant height and 1000 kernel weight, no of grains per spike, no of effective tillers, biological yield and harvest index. The 1000 kernel weight and no of grains per spike showed significant and positive correlation with yield envisages the use of these traits for yield improvement supported by earlier reports of Khan *et al*. [15] and Khokar *et al.* [16]. The grain yield showed highly significant positive correlation with no of grains per spike (0.637), no of effective tillers (0.722), 1000 kernel weight (0.358), the results showed conformity with the findings of Kara and Akman [17] and highly significant negative correlation with days to maturity (-0.323). Path analysis partitions correlation coefficient (Table 7) into direct and indirect effect which probes the cause and effect relationship. Maximum direct effect on yield was exhibited by biological yield (0.736) via harvest index (0.568), no of effective tillers (0.087) and plant height (0.048). The no of grains per spike had positive direct effect on grain yield per plant (0.026) and had relatively high and significant correlation with no effective tillers (0.751) and grain yield per plant (0.637) [18,19].

4. CONCLUSION

The correlation study revealed that grain yield had strong positive association with no of effective tillers (0.722), no of grains per spike (0.637) and 1000 seed weight (0.358). The association studies, indicated that grain yield of wheat can be improved by selecting genotypes having higher performances for the above characters. The selection for less days to maturity would ultimately be helpful for improving grain yield. Path-coefficient analysis revealed that the maximum positive direct effect on grain yield exhibited by biological yield (0.736), harvest index (0.568), no of effective tillers (0.087) and plant height (0.048)

CONFERENCE DISCLAIMER

Abstract of this manuscript was previously presented and published in the conference: Challenges, Opportunities and Strategies of Plant Science for Crop Improvement dated from 08-09 NOVEMBER, 2023 in BIRSA AGRICULTURAL UNIVERSITY, RANCHI-834006
JHARKHAND (INDIA), Web Link of the proceeding:
https://www.isgpb.org/documents/Abstract-National%20Seminar%20,%20ISGPB,%20Ranchi%20Chapter.pdf

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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