International Journal of Research in Agronomy 2025; 8(2): 159-165

E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2025; 8(2): 159-165
Received: 14-11-2024
Accepted: 18-12-2024

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Dissection of selection parameters of various yield and yield attributing traits of bread wheat (*Triticum aestivum* L.)

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DOI: https://doi.org/10.33545/2618060X.2025.v8.i2c.2546

Abstract
A study was undertaken to Dissection of Selection parameters *viz*., genetic variability, correlation and path coefficient analysis of yield and yield contributing traits in forty wheat genotypes grown at Section of Rabi Cereals, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur during Rabi season of 2020-21. All genotypes were showed wide genetic variations for all the traits under study. High GCV and PCV was observed for productive tillers per plant and spike length, whereas, low GCV and PCV was observed for days to maturity and days to flowering. High heritability with high genetic advance in per cent of mean was expressed by plant height, weight of 1000 grains, number of grains per spike and ear length per plant which reflected involvement of additive gene action for the expression of these character and selection for such trait might be useful. Plant height and chlorophyll content had high positive and significant correlation with grain yield per plant. Days of 50% flowering, productive tillers per plant, plant height, number of spikelets per spike, number of grains per spike, weight of 1000 grains had positive direct effect on grain yield per plant.

Keywords: Bread wheat, yield, path-coefficient, heritability, genetic advance and correlation analysis

Introduction
Wheat (*Triticum aestivum* L.) is a crop that is cultivated in diverse ecologies and is considered to be of worldwide and predominant cereal crop globally in term of acreage and production. Wheat consumption is projected to increase by 60% by 2050, but production is estimated to decline by 30% due to severe weather conditions (Alam *et al*., 2022) [1]. India's wheat production was estimated 112.92 million tonnes in the 2023-24 from an area of 31.78 million ha with average productivity of 36.15 quintals per ha. Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, and Rajasthan are the principal wheat-producing states for both area and yield. Uttar Pradesh is the foremost wheat producer among these states, yielding 35.43 million tonnes from an area of 9.31 million ha (ICAR-IIWBR, 2024) [16]. The present research was conducted to assess the nature and degree of genetic variability, heritability, and genetic improvements among several yield and their contributing traits in wheat. Genetic parameters such as the Phenotypic Coefficient of Variation, Genetic Coefficient of Variation (GCV), heritability, and Genetic Advance (GA) for different traits of interest play very significant role in crop improvement. Understanding heritability and genetic progress enables breeders to predict the traits of future generations, make appropriate choices, and assess the degree of genetic enhancement achieved by selection. (Tuhina - Khatun *et al*., 2015) [40]. Genetic advance offers insights into the expected genetic gain from selecting better individuals. Path analysis approach effectively distinguishes correlation coefficients into direct and indirect effects, clarifying the genetic relationship more appropriately.

Materials and Methods
The experiment was executed during Rabi season of 2020-21 at crop Research Farm, Nawabganj, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.),

India in Randomised Complete block design (RCBD) with three replications. Each genotype was sown in two rows in 5.0 m. long and 45 cm. broad plots with a spacing of 22.5 x 5 cm. between row to row and plant to plant distance respectively. Recommended agronomic package and practices were applied to raise a healthy crop. Data were recorded on ten characters to estimate mean, range and coefficient of variation (CV) and, Genotypic and phenotypic coefficients of variation (PCV). Heritability in broad sense (h^2bs) as per Burton and Devane (1953) [9]; genetic advance (GA) and genetic advance as per cent of meanby Johnson *et al*. (1955) [20], correlation coefficient analysis by Robinson *et al.*, (1951) [35] and path coefficient analysis by Dewey and Lu (1959) [12] were work out following INDOSTAT software, Hyderabad.

Results and Discussion

Analysis of variance for yield and yield attributing traits

The mean sum of squares for 10 characters namely, Days to flowering (50%), Days to maturity, Number of productive tillers per plant, Plant height(cm), Ear length per plant(cm.), Number of spikelets per spike, Number of grains per spike, Weight of 1000 grains (gm), Chlorophyll content, and Grain yield per plant (gm) were revealed highly significant difference between the treatments (Table1)which reflected the presence of large variability in the materials for successfully exploitation in future breeding programme for evolving high yielding new plant type varieties. Result is in conformity with the findings of Singh *et al*. (2018) [37], Tiwari *et al*. (2017) [39], Kumar *et al*. (2013) [23].

Descriptive statistics of the accessions

The mean performance of days to 50% flowering ranged from 70.33 days to 81.66 days. The earliest flowering was shown by genotype IC-290186 and late flowering was observed for genotypes IC-406521, IC-335683, EC-27051, EC-478017 with grand mean (77.71). Days to maturity varied from 109.67 days to 119.00 days. Early maturity was observed for the genotype IC-402042 and late maturity was observed for the genotype IC-443633 respectively, with grand mean of 113.61 days. Number of productive tillers per plantranged from 6.00 to 17.67. The lowest number of tillers at maturity was recorded in the genotype IC-335683 and the highest tillers were observed for the genotype EC-578134 with grand mean (10.50). Plant height ranged from 59.67 to 101.00 cm. The lowest plant height was observed for the genotype BW11 and highest plant height was observed for the genotype VWFW2024 with a grand mean (82.72).Ear length ranged from 5.33 to 14.50 cm. The lowest value for spike length was exhibited by genotype EC-478017 and the highest value for the genotype VWFW2024 with grand mean (9.30 cm). Spikelets per spike ranged from 12.00 to 22.33. The lowestspikelets per spike was exhibited by genotype IC-542076 and the highest was shown by the genotype NINGMAI with grand mean (17.17). Number of grains per spike varied from 37.33 to 88.00 with minimum for the genotype IC-290186 and maximum for the genotype VWFW2024 with grand mean (55.54).1000- grain weight ranged from 23.33 to 42.67 gm. The minimum 1000- grain weight was recorded for genotype RAJ 164 while maximum was recorded for genotype IC-113734 with grand mean of 36.20. Chlorophyll content was ranged from 32.10 to 52.03 with grand mean of 44.86. The minimum content recorded for genotype IC-401927 and the maximum for the genotype IC-402042.Grain yield per plant ranged from 9.6 gm to 49.43 gm. The minimum exhibited by genotype EC-577050 and maximum by genotype EC-576930 with grand mean of 14.06 gm.The coefficient of Variation ranged from 1.35 to 72.62%. This indicated the presence of substantial amount of variation among the yield attributing traits of the genotypes. (Table-2)

Variability studies in genotypic accessions

Genotypic coefficient of variation was maximum for number of productive tillers per plant (26.25) followed by Spike Length (21.89). Similar result of high GCV were also reported by Arya *et al.* (2017) [3] and Yadav *et al.* (2014) [41]. Grain yield per Plant (9.68), Chlorophyll content (5.48), days to 50% flowering (3.78) and days to maturity (1.72) expressed low value of GCV, which also reported by Karla *et al. (*2023) [21]. High phenotypic coefficient of variation (PCV) was exhibited by grain yield per plant (73.27%) followed by number of productive tillers per plant (34.06), these were in conformity with Arya *et al., (*2017) [3] and Kumar *et al*. (2013) [25]. Days to 50% flowering (4.35) and Days of Maturity (2.18) exhibited low value of PCV, it also reported by Karla *et al. (*2023) [21] and Bhushan *et al*. (2013) [6].

Heritability and Genetic advance

The broad-sense heritability and genetic advance were calculated and presented in Table 3. High heritability value was noted for the traits *viz*., plant height (0.92), followed by weight of 1000 grains (0.88), number of grains per spike (0.84), and days to 50% flowering (0.75). Comparable findings of elevated heritability were shown by Nagar *et al*. (2018) [30] and Gaur *et al*. (2020) [14] in wheat. Chlorophyll content (0.23) and grain yield per plant (0.02) exhibited low heritability. Fellahi *et al*. (2013) [13] found a similar outcome of low heritability. Genetic advance, expressed as a percentage of the mean, was observed for the traits under investigation from high to low magnitude. High genetic advance was observed in Productive Tiller per plant (41.69), while a moderate genetic advance was noted for Number of Grains per Spike (41.43), Ear Length per Plant (30.62), Plant Height (29.13) and Weight of 1000 Grains (21.00). The low estimates of genetic advance were noted for Day to 50% Flowering (6.76), Chlorophyll content (5.41), days to maturity (2.78), and Grain Yield per Plant (2.63). These findings are conformed with the results of Payal *et al*. (2007) [32], Maurya *et al*. (2014) [29], Devesh *et al*. (2018) [11], and Sohail *et al*. (2018) [38]. The grain yield per plant exhibited high heritability and significant genetic advance, indicating the presence of additive genetic variance. Consequently, selection for these traits would be highly effective, allowing for the development of a superior genotype, as environmental factors minimally influenced the expression of these traits.

Analysis of Correlation Coefficient

The phenotypic correlation coefficient exhibited a highly significant and positive relationship between yield per plant and chlorophyll content (0.983), plant height (0.936), number of productive tillers per plant (0.468), number of spikelets per spike (0.434), weight of 1000 grains (0.274), and number of grains per spike (0.251). A strong and very significant association was identified among component parameters for the number of spikelets per plant with days to flowering and Ear length per plant. The thousand grain weight exhibited a substantial negative phenotypic association with both days to flowering and the number of spikelets per spike. The Ear length per plant (cm) exhibited a strong and statistically significant positive link with plant height, while demonstrating a substantial negative phenotypic correlate with days to maturity. Plant height exhibited a strong and very significant positive relation with the number of productive tillers per plant, while demonstrating a substantial negative phenotypic correlate with days to maturity.

(Table-4). These findings were also reported by Javed *et al*. (2022) [19], Jaisi *et al.* (2021) [17], and Khaliq *et al*. (2004) [22].

The genotypic correlation coefficient exhibited a highly significant positive relationship between yield per plant and chlorophyll content, plant height, number of productive tillers per plant, number of spikelets per spike, number of grains per spike, and weight of 1000 grains (g), alongside a significant negative correlation with days to maturity. The number of grains per spike had a very significant positive correlation with Ear length per plant and the number of spikelets per spike. The thousand grain weight had a very significant positive association with the number of productive tillers per plant, whereas it showed a substantial negative genotypic correlation with days to flowering and the number of spikelets per spike. The Ear length per plant (cm) exhibited a positive and highly significant correlation with the number of productive tillers per plant and plant height, but it had a substantial negative genotypic correlation with days to maturity. Plant height exhibited a strong and very significant positive relationship with the number of productive tillers per plant, but it had a substantial negative genotypic correlation with days to 50% flowering and days to maturity. The number of productive tillers per plant had a strong negative genotypic connection with the days to 50% flowering. Days to maturity shown a substantial beneficial association with days to 50% flowering. (Table-4) Same pattern of genetic association were also showed by Hama *et al*. (2016) [15], Jaiswal *et al*. (2022) [18], and Bishwas and Singh (2024) [7] in wheat.

Path coefficients Analysis

Phenotypic path coefficient analysis effectively identifies direct and indirect origins of correlations. The data presented in (Table-6, Figure-1) indicate that plant height had the most significant positive direct effect, followed by the number of productive tillers per plant and the number of spikelets per spike. All the characteristics had minimal indirect influence via other traits on grain yield. Consequently, simultaneous selection for many qualities would be futile. The direct effect of Ear length was negative and modest. Given that the direct effect was negative, direct selection for this characteristic to enhance yield will be inadvisable. The indirect effect of Ear length on plant height and the number of productive tillers per plant was negative and insignificant. The selection for this characteristic will be ineffective. The number of productive tillers per plant had a positive direct effect and a positive correlation coefficient with grain yield per plant, showing a genuine association; hence, direct selection based on this characteristic will be useful for yield enhancement. The indirect effect of this characteristic through plant height was positive however insignificant. Consequently, concurrent selection for both characteristics to enhance grain production will be ineffectual. The direct effect was negative and minimal, but the correlation coefficient between days to maturity and grain production per plant was positive. The most significant positive effect and correlation coefficient were observed between plant height and grain yield per plant. The straight selection for this characteristic will be efficacious. Thousand grain weight demonstrated a positive direct effect with negligible association. Selection for this feature will not produce benefits for yield enhancement. Plant height had a favourable effect on grain yield per plant, a finding consistent with the reports of Aycicek and Yildirim (2006) [4] and Salahuddin *et al*. (2016) [36]. The number of grains per spike yielded results consistent with those of Lad *et al.* (2003) [26], Kumar *et al*. (2019) [24], and Rathod *et al.* (2019) [33], whereas the days to 50% flowering were conformity with the results of Degewione *et al*. (2013) [10] and Rathod *et al*. (2019) [33]. Genotypic path coefficient analysis effectively identifies direct and indirect origins of correlations. (Table-5, Figure-2) presents findings indicating that plant height had the most significant positive direct influence, followed by chlorophyll content and the number of grains per spike. A moderate positive direct effect was seen for days to maturity. This suggests that selecting for these traits may improve the grain production per plant. The direct effect of Ear length was significantly negative. The direct effect of days to maturity was modest, and its association with grain yield per plant was negative and very significant. The number of productive tillers per plant, days to 50% blooming, and spikelet count per spike had a negative direct effect on grain yield per plant; hence, selecting for these characteristics may not be advantageous for improving grain yield. The weight of 1000 grains had a negative direct effect on grain yield per plant, indicating that selection for these qualities may not be beneficial for improving grain output. The indirect effect of days to 50% flowering on productive tillers per plant and chlorophyll content was substantial and beneficial. A negative high indirect effect on days to 50% flowering was detected via plant height. The indirect influence of days to maturity via ear length was substantial and beneficial. A negative high indirect effect on days to maturity was detected via plant height and chlorophyll content. The indirect effect of productive tillers per plant on chlorophyll content and days to 50% flowering was substantial and beneficial. A negative high indirect influence on productive tillers per plant was detected via Ear length. The indirect effect of Ear length on plant height, grain count per spike, and chlorophyll content was substantial and beneficial. A negative high indirect effect on Ear length was found via the number of spikelets per spike. The indirect influence of the number of spikelets per spike on chlorophyll content, number of grains per spike, and plant height was substantial and beneficial. A negative high indirect effect on the number of spikelets per spike was established via Ear length. The indirect effect of the number of grains per spike on chlorophyll concentration was significant and beneficial. A negative high indirect effect was found on the number of grains per spike via Ear length and the number of spikelets per spike. The indirect impact of chlorophyll content through plant height and the number of grains per spike was significant and beneficial. A negative high indirect effect for chlorophyll content was identified via the number of spikelets per spike, Ear length, and productive tillers per plant. Same findings were also reported by Malbhage *et al.* (2020) [28], Regar *et al.* (2023) [34], Ayer *et al*. (2017) [5], and Arya *et al*. (2017) [3].

Table 1: Analysis of variance (ANOVA) for ten characters in 40 wheat genotypes.

Source of variation	DF	D50F	DM	PTPP	PH	ELP	NSPP	NGPS	TGW	CC	GYP
Replication	2	2.63	6.46	13.98	4.03	0.91	0.13	86.41	16.51	23.70	127.43
Genotypes	39	28.64	13.76	27.98	460.26	10.22	16.31	471.07	48.64	38.47	109.80
Error	78	2.80	2.35	5.19	13.26	1.51	2.93	27.40	2.13	20.31	104.25

DF-Degree of freedom, D50F-days to 50% flowering, DM-days to maturity, PTPP-productive tillers per plant, PH- plant height, ELP-Ear length per plant, NSPP- number of spike per plant, NGPS- number of grains per spike, TGW-1000 grain weight, CC- chlorophyll content, GYP- grain yield per plant

Table 2: Mean performance of different forty wheat genotypes for ten characters

SN No.	Genotypes	D50F	DM	PTPP	PH	ELP	NSPP	NGPS	TGW	CC	GYP
1	IC-574388	73.33	113.67	10.00	72.67	8.33	16.00	47.00	38.67	41.50	12.17
2	EC-577050	78.67	112.67	8.67	98.00	10.00	19.67	46.67	31.33	45.00	9.60
3	IC-116276	73.33	112.67	15.33	99.33	10.17	14.33	52.67	39.33	47.37	10.53
4	K9423	71.00	114.67	14.33	85.67	9.17	17.67	68.67	37.33	43.00	13.83
5	VWFW2024	76.33	111.33	9.67	101.00	14.50	19.67	88.00	37.33	48.20	13.00
6	IC-290186	70.33	111.67	16.33	99.33	9.17	14.33	37.33	39.00	46.97	12.87
7	IC-402042	77.67	109.67	9.67	90.33	10.33	16.33	66.33	37.00	52.03	11.73
8	IC-531183	78.33	111.67	9.67	73.00	11.50	19.67	66.67	31.67	47.33	14.47
9	IC-122126	72.00	111.33	16.67	89.67	10.33	16.33	62.67	40.00	45.33	15.07
10	IC-252794	78.00	116.67	7.00	62.00	8.50	16.67	57.33	39.83	42.23	13.90
11	IC-574476	78.33	114.33	8.00	64.00	8.67	18.67	65.00	33.00	47.13	13.33
12	IC-443633	81.00	119.00	7.67	68.67	8.67	14.00	41.00	32.83	44.13	10.77
13	IC-406521	81.67	114.67	8.67	95.33	7.17	17.33	47.00	30.33	43.93	12.07
14	IC-335683	81.67	113.33	6.00	80.00	9.83	17.67	63.00	37.67	45.20	14.80
15	EC-27051	81.67	118.67	8.33	62.67	6.67	16.67	57.33	38.67	46.37	12.03
16	IC-113734	77.67	113.00	9.67	88.67	10.67	15.67	41.33	42.67	42.43	15.17
17	BW11	72.67	112.33	7.33	59.67	8.00	15.67	48.67	35.33	40.17	12.03
18	EC-478017	81.67	114.33	8.33	67.00	5.33	17.00	48.33	42.33	48.97	13.67
19	IC-443766	72.67	112.67	9.67	68.00	6.00	12.67	45.00	41.00	39.93	11.37
20	IC-542076	79.33	111.67	8.33	73.67	6.83	12.00	45.33	38.50	44.80	13.43
21	RAJ164	76.67	111.67	9.00	80.33	7.83	15.33	42.33	23.33	43.37	11.00
22	UAS-415	80.33	114.33	13.33	77.00	7.50	19.00	49.33	34.17	50.07	15.93
23	EC-578134	80.67	113.00	17.67	76.00	11.17	15.00	48.67	34.67	47.43	10.80
24	IC-401927	76.67	115.33	11.33	83.67	11.00	17.33	52.00	34.33	32.10	12.57
25	IC-527448	77.00	115.00	11.00	87.00	8.17	15.33	56.67	37.00	43.93	11.00
26	MIYCSN22	78.00	113.67	12.67	98.33	7.17	17.00	41.67	33.67	42.43	11.00
27	IC-574387	76.67	113.67	8.00	83.67	11.17	18.00	72.33	36.67	48.93	13.53
28	EC-576930	77.33	113.33	12.67	97.33	7.67	17.00	57.00	35.00	46.00	49.43
29	IC-554661	78.67	114.67	17.00	98.00	11.33	20.67	57.00	38.83	46.97	15.07
30	EC-273814	81.33	116.33	8.67	93.33	9.17	18.67	47.00	27.67	43.53	12.30
31	EC-464070	78.33	112.67	10.67	89.00	10.17	16.33	38.33	38.83	44.90	16.03
32	IC-290195	80.33	112.00	7.33	66.33	10.33	21.00	85.67	30.00	40.07	10.03
33	IC-252429	77.67	110.33	9.67	94.00	9.17	17.33	50.33	37.33	41.97	12.83
34	IC-566636	79.67	113.33	11.67	86.33	8.83	15.67	49.33	39.67	45.13	16.40
35	NINGMAI	81.33	114.67	10.67	76.67	9.83	22.33	82.00	34.50	48.57	14.90
36	K-1006(Ch)	77.33	114.33	9.67	88.00	10.67	16.67	66.67	36.83	40.30	12.77
37	K-1317(ch)	78.33	112.00	8.00	71.00	10.00	15.67	64.00	40.83	44.47	14.70
38	PBW-373(ch)	81.00	115.00	6.67	75.00	7.83	18.00	49.00	38.17	45.33	13.87
39	K-9107(ch)	77.33	110.67	10.67	95.00	12.67	21.00	51.00	34.17	48.43	18.43
40	HD-2967(ch)	76.33	118.33	14.33	94.00	10.33	21.33	66.00	38.50	48.33	13.93
	Mean	77.71	113.61	10.50	82.72	9.30	17.17	55.54	36.20	44.86	14.06
	C.V.	2.16	1.35	21.69	4.40	13.22	9.97	9.42	4.03	10.05	72.62
	C.D. 5%	10.21	5.86	5.39	34.72	6.76	5.57	17.19	22.81	1.89	1.05

DF-Degree of freedom, D50F-days to 50% flowering, DM-days to maturity, PTPP-productive tillers per plant, PH- plant height, ELP-Ear length per plant, NSPP- number of spike per plant, NGPS- number of grains per spike, TGW-1000 grain weight, CC- chlorophyll content, GYP- grain yield per plant

Table 3: Genetic parameters for yield and yield contributing characters in 40 wheat genotypes

Genetic parameters	GCV (%)	PCV (%)	H^2b.s (%)	GAM (%)
Day to 50% Flowering	3.776	4.348	0.754	6.756
Day of maturity	1.717	2.183	0.618	2.781
Productive tiller per plant	26.252	34.056	0.594	41.687
Plant height	14.757	15.400	0.918	29.132
Ear length per plant	18.329	22.601	0.658	30.622
No. of spikelets per plant	12.302	15.834	0.604	19.690
No of grain per spike	21.895	23.837	0.844	41.430
Weight of 1000 grain	10.876	11.600	0.879	21.007
Chlorophyll content	5.485	11.447	0.230	5.414
Grain yield per plant	9.676	73.266	0.017	2.633

PCV (percent) = Phenotypic coefficient of Variation, GCV (percent) = Genotypic coefficient of Variation, ECV (percent) = Environment coefficient of Variation, h^2b.s. (percent) = Heritability in broad sense, GAM = Genetic advance as per cent of mean and CV (percent) = coefficient of Variation

Table 4: Genotypic and phenotypic correlation coefficient for 10 characters in Wheat

Characters		D50F	DM	NPTPP	PH	ELPP	NSPP	NGPS	TH	CC	GYPP
D50F	G	1.000	0.282**	-0.484**	-0.232*	-0.119	0.345**	0.041	-0.285**	0.264**	-0.164
	P	1.000	0.398**	-0.338**	-0.173	-0.127	0.222*	0.040	-0.224*	0.172	0.044
DM	G		1.000	-0.134	-0.280**	-0.316**	0.116	-0.079	-0.014	-0.249**	-0.484**
	P		1.000	-0.025	-0.218*	-0.257**	0.101	-0.025	-0.003	-0.017	0.022
NPTPP	G			1.000	0.592**	0.277**	0.018	-0.095	0.191*	0.343**	0.468**
	P			1.000	0.396**	0.169	-0.029	-0.088	0.156	0.117	0.117
PH	G				1.000	0.452**	0.206*	-0.058	-0.037	0.272**	0.936**
	P				1.000	0.366**	0.162	-0.075	-0.062	0.114	0.113
ELPP	G					1.000	0.400**	0.573**	-0.042	0.249**	-0.106
	P					1.000	0.520**	0.371**	-0.027	0.067	-0.065
NSPS	G						1.000	0.663**	-0.332**	0.482**	0.434**
	P						1.000	0.449**	-0.250**	0.103	0.040
NGPS	G							1.000	-0.040	0.288**	0.251**
	P							1.000	0.022	0.160	0.005
TH	G								1.000	0.153	0.274**
	P								1.000	0.067	0.049
CC	G									1.000	0983**
	P									1.000	0.025
	G										1.000
	P										1.000

Selection intensity at 5%* & 1%** level of significance

Table 5: Genotypic path Analysis Matrix of direct and indirect effects of ten traits on grain yield of wheat genotypes

Traits	Days of 50% flowering	Days to maturity	Productive tillers per plant	Plant height (cm.)	Ear length (Cm.)	No. of spikelets per spike	No. of grains per spike	wt. of 1000 grains (gm.)	chlorophyll content	Grain yield per plant
Days of 50% flowering	-0.7323	-0.2062	0.3548	0.1698	0.0874	-0.2529	-0.0297	0.2086	-0.1936	-0.1636
Days to maturity	0.0701	0.2490	-0.0333	-0.0698	-0.0786	0.0288	-0.0196	-0.0034	-0.0621	-0.4841
Productive tillers per plant	0.4535	0.1253	-0.9361	-0.5537	-0.2589	-0.0167	0.0890	-0.1789	-0.3215	0.4683
Plant Height (cm.)	-0.4205	-0.5085	1.0726	1.8133	0.8198	0.3735	-0.1046	-0.0671	0.4927	0.9355
Ear Length (Cm.)	0.1756	0.4642	-0.4068	-0.6649	-1.4706	-0.5890	-0.8422	0.0621	-0.3657	-0.1064
No. of spikelets per spike	-0.2742	-0.0918	-0.0142	-0.1635	-0.3179	-0.7939	-0.5265	0.2633	-0.3827	0.4336
No. of grains per spike	0.0480	-0.0932	-0.1125	-0.0683	0.6779	0.7850	1.1838	-0.0437	0.3410	0.2514
wt. Of 1000 grains (gm.)	0.0642	0.0031	-0.0431	0.0083	0.0095	0.0748	0.0090	-0.2255	-0.0346	0.2739
chlorophyll content	0.4518	-0.4260	0.5869	0.4644	0.4250	0.8239	0.4923	0.2620	1.7092	1.1827

R SQUARE = 3.3269 RESIDUAL EFFECT =SQRT (1- 3.3269)
Bold values show direct and normal values shows indirect effects

Table 6: Phenotypic path Analysis Matrix of direct and indirect effects of ten traits on grain yield of wheat genotypes

Traits	Days of 50% flowering	Days to maturity	Productive tillers per plant	Plant Height (cm.)	Ear Length (Cm.)	No. of spikelets per spike	No. of grains per spike	wt. Of 1000 grains (gm.)	chlorophyll content	Grain yield per plant
Days of 50% flowering	0.103	-0.020	-0.044	-0.024	0.027	0.026	0.002	-0.019	-0.006	0.044
Days to maturity	0.041	-0.050	-0.003	-0.031	0.055	0.012	-0.001	0.000	0.001	0.022
Productive tillers per plant	-0.035	0.001	0.129	0.056	-0.036	-0.003	-0.005	0.013	-0.004	0.117
Plant Height (cm.)	-0.018	0.011	0.051	0.141	-0.078	0.019	-0.004	-0.005	-0.004	0.113
Ear Length (Cm.)	-0.013	0.013	0.022	0.052	-0.213	0.060	0.020	-0.002	-0.002	-0.065
No. of spikelets per spike	0.023	-0.005	-0.004	0.023	-0.111	0.115	0.024	-0.021	-0.004	0.040
No. of grains per spike	0.004	0.001	-0.011	-0.011	-0.079	0.052	0.053	0.002	-0.006	0.005
wt. Of 1000 grains (gm.)	-0.023	0.000	0.020	-0.009	0.006	-0.029	0.001	0.085	-0.002	0.049
chlorophyll content	0.018	0.001	0.015	0.016	-0.014	0.012	0.009	0.006	-0.036	0.025

R SQUARE =0.0563 RESIDUAL EFFECT = 0.9714
Bold values show direct and normal values shows indirect effects

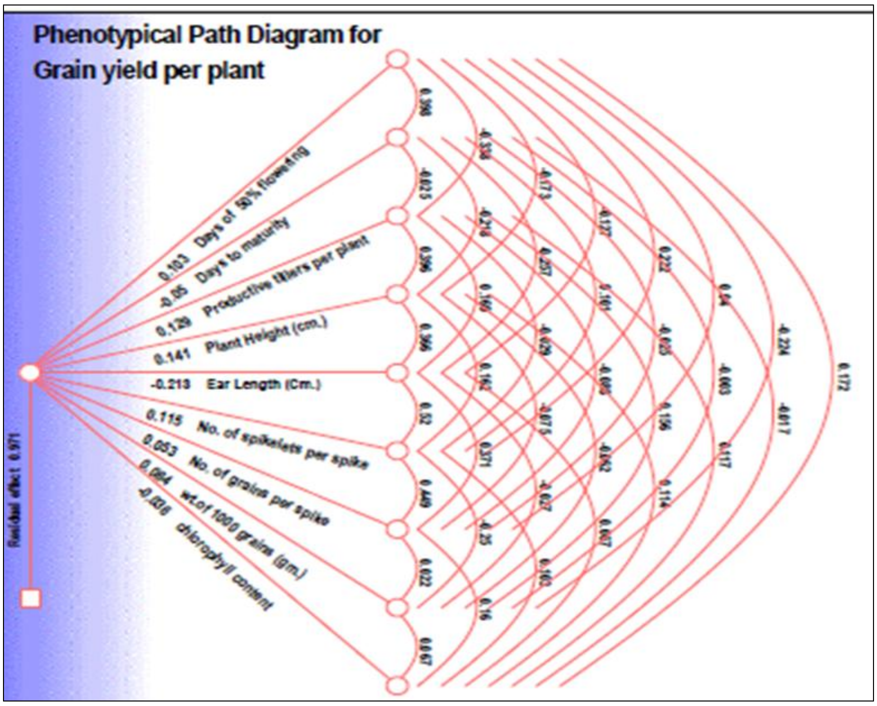

Fig 1: Phenotypic pathdiagram for grain yield per plant & effects of correlated traits

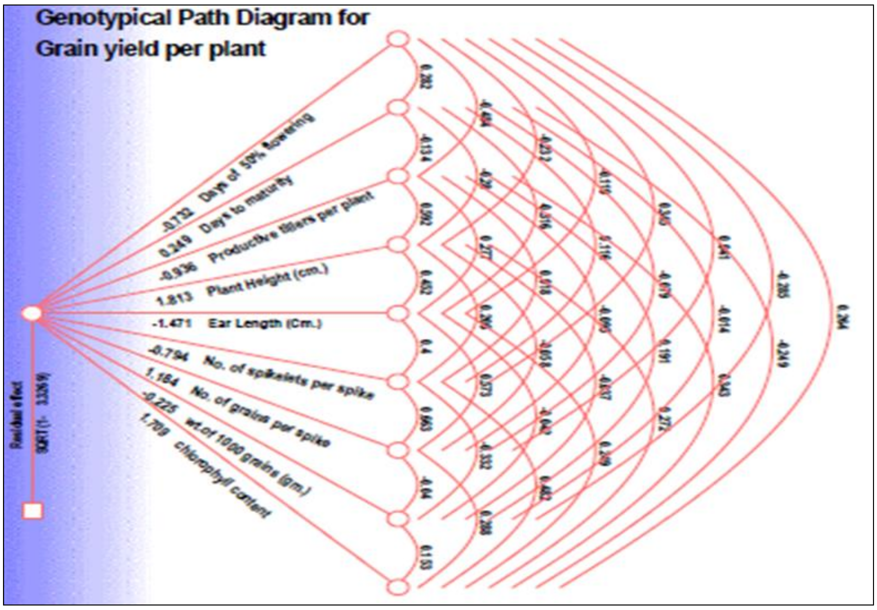

Fig 2: Genotypic path diagram for grain yield per plant & effects of correlated traits

Conclusion

As global demand for wheat continues to rise, leveraging genetic parameters of selection will be critical in breeding programs aimed at achieving sustainable productivity. Ultimately, the integration of these analyses into breeding practices not only fosters the development of superior wheat cultivars but also contributes significantly to food security. The significant genetic variability observed among the evaluated traits is useful for adapting to diverse environmental conditions and enhancing resilience against biotic and abiotic stresses. Moreover, strong associations identified that exhibit positive correlations with yield, breeders can implement strategies that promote overall improvement of wheat.

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