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Correlation and path analysis in bread wheat (*Triticum aestivum* L.) for yield and yield contributing traits

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Abstract
The present investigation was conducted to examine the 10 Bread Wheat genotypes along with 2 checks to study the genetic parameters, correlation and genetic diversity. The experiment was carried out in main experimental station of Agricultural Research Farm, Rama University (U.P), Mandhana, Kanpur during Rabi Season, 2020-21 in Randomized Block Design (RBD) with three replications. Analysis of variance showed highly significant differences among 10 Bread Wheat for 11 characters studied. On the basis of mean performance, Analysis of variance showed highly significant differences among 10 Bread Wheat for 11 characters studied. On the basis of mean performance, genotype DBW187 exhibited high grain yield per plant over the check. Genotypic coefficient of variation (GCV) was recorded highest for Harvest index (17.58%). Phenotypic Coefficient of Variation (PCV) was recorded highest for Harvest index (54.72%). Environmental coefficient of variation (ECV) was recorded highest for Harvest index (99.56%). High heritability was observed for most of the traits and it was noted highest for Biological yield per plant (34.2%). Genetic advancement was recorded highest for Biological yield per plant (346.21%). The high Genetic advance as per cent of mean was recorded for Biological yield per plant (16.97%). Grain yield per plant shows Significant Positive Correlation with Spike length (1.06**) genotypic level. Grain yield per plant shows Significant Negative Correlation with Harvest index (0.92**) phenotypic level.

Keywords: Bread wheat, genetic parameters and correlation

Introduction
Wheat (*Triticum aestivum* L.) is one of the most important cereal crops of the world and falls under family Poaceae. Among major cereals, wheat ranks first in area and production at the global level and it is the staple food of nearly 35 per cent of the world population. In India wheat is the second most important cereal crop and plays an important role in the food and nutritional security of the country. It is the leading source of protein in human food, having higher protein content than either maize (corn) or rice and the other major cereals. In terms of total production used for food, it is currently second to rice, as the main human food.
Correlation studies provide information about yield contributing characters. This information is useful to plant breeder in selection of elite genotypes from diverse genetic populations (Robinson *et al.* 1951, Jhonson *et al.* 1955) [4, 5]. Mass selection has been used to improve grain yield in several crops through indirect selection of highly heritable traits which are associated with yield. Path coefficient analysis helps in indirect selection for genetic improvement of yield. Selection for a component trait for yield improvement is called indirect selection. While, straight selection for is termed as direct selection.

Materials and Methods
The present investigation entitled "Study of screening for tolerance to terminal heat stress in bread wheat (*Triticum aestivum* L. em. Thell)" was carried out during Rabi 2020-21 at Agricultural Research Farm, Rama University, Kanpur (U.P.).
The experimental material comprised of 10 bread wheat genotypes were evaluated in Randomized Block Design (RBD), with 3 Replications. The observations were recorded on 5 randomly selective competitive plants for each genotype for plant height, effective tiller per plant, spikelet's per spike, spike length, grain per spike, 1000 seed weight, days to maturity, days to 50% flowering, biological yield per plant, harvest index, grain yield per plant observations were recorded on whole plot basis. The data so, obtained were subjected to analysis of variance, estimate the magnitude of genetic variability, heritability and genetic advance, correlation coefficient and genetic divergence.

Result

Correlation coefficient analysis

Correlation coefficient at phenotypic and genotypic levels were estimated using 11 characters in 10 genotypes of bread wheat to study the degree of mutual relationship between yields and its component traits. Perusal of the results revealed that the estimates of genotypic correlation coefficients were higher in magnitude than their corresponding correlation coefficient.

Grain yield per plant shows Significant Positive Correlation with Spike length (1.0648**). Significant Negative Correlation with Days to maturity (-2.0627**), Harvest index (-1.8910**), Plant height (-0.8175**), Days to 50% flowering (-0.7742**) Non-Significant Positive Correlation with Spikelets per spike (0.3733), Grain per spike (0.3060), Thousand seed weight (0.0995). Non-Significant Negative Correlation with Effective tiller per plant (-2993), Biological yield per plant (-0.0399). Rajpoot *et al.* (2013) [16], Sulaiman *et al.* (2014) [17], Kaddem *et al.* (2014) [18], Rahman *et al.* (2016) [19], Sabit *et al.* (2017) [10] also agreed with the similar finding.

Table 1: Genotypic correlation coefficients among 11 traits of wheat

Traits	DFF	DM	PH	ETP	SL	SPS	GPS	BYP	TSW	HI	GYP
DFF	1.0000	-6.0400**	0.5567**	0.0928	0.3993	-0.5973**	-1.3707**	0.5155**	0.4374	0.8078**	-0.7742**
DM		1.0000	8.2573**	7.7029**	5.572**	-6.554 7**	3.0997**	-4.9780**	-20.8379**	6.9498**	-2.0627**
PH			1.0000	1.2700**	0.1739	0.376	-1.2540**	-0.8862**	0.1221	0.0856	-0.8175**
ETP				1.0000	1.565**	1.6597**	2.7210**	-1.4790**	-1.5945**	3.0161**	-0.2993
SL					1.0000	0.3667**	-0.4686**	1.8619**	-2.9831**	-4.2639**	1.0648**
SPS						1.0000	-0.5792**	0.9935**	-1.4519**	-1.5333**	0.3733
GPS							1.0000	0.6895**	-0.2485	-2.2122**	0.3060
BYP								1.0000	-0.9542**	2.4331**	-0.0399
TSW									1.0000	0.2854	-0.0588
HI										1.0000	-1.8910**
GYP											1.0000

Phenotypic Correlation

Grain yield per plant shows Significant Negative Correlation with Harvest index (-0.9230**). Non-Significant Positive Correlation with Biological yield per plant (0.3708), plant height (0.3590), Grain per spike (0.3213), Spikelets per spike (0.2062), Thousand seed weight (0.2038), Days to maturity (0.1043), Spike length (0.0052).Non-Significant Negative Correlation with Effective tiller per plant (-0.1603), Days to 50% flowering (-0.0599). Shoaib Ur Rehman (2015) [6], Sherif *et al.* (2005) [7], Chaitali and Bini (2007) [8], Anwar *et al.* (2009) [11] and Poor *et al.* (2015) [12] also agreed with the similar results.

Table 2: Phenotypic correlation coefficients among 11 traits of wheat

Traits	DFF	DM	PH	ETP	SL	SPS	GPS	BYP	TSW	HI	GYP
DFF	1.0000	0.1600	-0.2374	-0.5077**	-0.1122	0.3422	-0.6448**	0.2144	-0.2440	0.1483	-0.0599
DM		1.0000	0.5202**	0.5938**	-0.3512	0.3289	-0.1557	-0. 841	-0.3350	-0.2463	0.1043
PH			1.0000	-0.3171	-0.2423	0.0574	0.1945	-0.4030	0.2951	-0.4638**	0.3590
ETP				1.0000	-0.1996	0.2305	0.2402	0.0432	0.1853	0.1211	-0.1603
SL					1.0000	-0.0509**	0.0577	-0.2646	0.5190**	0.0073	0.0052
SPS						1.0000	-0.2228	0.0047	-0.1560	-0.2526	0.2062
GPS							1.0000	0.1029	0.1685	-0.1260	0.3213
BYP								1.0000	0.052	-0.216	0.3708
TSW									1.0000	-0.252	0.2038
HI										1.0000	-0.92**
GYP											1.0000

Path analysis

Genotypic path analysis

Direct Path

The maximum direct positive genotypic path on grain yield per plant was observed in followed by Grain per spike (0.2375), Spikelet's per spike (0.1591), Biological yield per plant (0.0990), Plant height (0.0980), spike length (0.0065). Maximum direct negative effect on grain yield per plant was observed in followed by effective tiller per plant (-0.2708), Days to 50% flowering (-0.2033), Thousand seed weight (-0.0434), Harvest index (-0.3091), Days to maturity (-0.0058).

Indirect Path

The maximum indirect positive genotypic path in Days to 50% flowering observed through Days to maturity (1.2276) and followed by Grain per spike (0.2786), Spikelets per spike (0.1214). Maximum indirect negative genotypic path in Days to 50% flowering observed through Grain yield per plant (-0.7742), Harvest index (-0.1642), Plant height (-0.1132), Biological yield per plant (0.1048) and followed by Thousand seed weight (-0.0889), Spike length (-0.0812), Effective tiller per plant (0.0189).

The maximum indirect positive genotypic path in Days to maturity observed through Thousand seed weight (0.1219) followed by Spikelets per spike (0.0383), Days to 50% flowering (0.0353), Biological yield per plant (0.0291). Maximum indirect negative genotypic path in Days to maturity observed through Grain yield per plant (-2.0627) followed by Plant height (-0.0483), Effective tiller per plant (-0.0451), Harvest index (-0.0407), Spike length (-0.0326), Grain per spike (-0.0181). The maximum indirect positive genotypic path in Plant height observed through Days to maturity (0.8093) followed by Effective tiller per plant (0.1245), Days to 50% flowering (0.0546), Spike length

(0.0170), Thousand seed weight (0.0120), Harvest index (0.0084), Spikelets per spike (0.0037). Maximum indirect negative genotypic path in Plant height observed through Grain yield per plant (-0.8175) followed by Grain per spike (-0.1229), Biological yield per plant (-0.0869).

The maximum indirect positive genotypic path in Effective tiller per plant observed through Thousand seed weight (0.4318), followed by Biological yield per plant (0.4005).

Maximum indirect negative genotypic path in Effective tiller per plant observed through Days to maturity (-2.0858) followed by Harvest index (-0.8167), Grain per spike (0.7368), Spikelets per spike (-0.4494), Spike length (-0.4238), Plant height (-0.3439), Grain yield per plant (-0.2993) and Days to 50% flowering (-0.0251).

The maximum indirect positive genotypic path in Spike length observed through Grain yield per plant (1.0648) followed by Days to maturity (0.0363), Biological yield per plant (0.0121), Effective tiller per plant (0.0102), Days to 50% flowering (0.0026), Spikelets per spike (0.0024), Plant height (0.0011).Maximum indirect negative genotypic path in Spike length observed through Harvest index (-0.0278) followed by Thousand seed weight (-0.0194), Grain per spike (-0.0031). The maximum indirect positive genotypic path in Spikelets per spike observed through Grain yield per plant (0.3733) followed by Effective tiller per plant (0.2641), Biological yield per plant (0.1581), Spike length (0.0584), Plant height (0.0060). Maximum indirect negative genotypic path in Spikelets per spike observed through Days to maturity (-1.0430) followed by Harvest index (-0.2440), Thousand seed weight (-0.2310), Days to 50% flowering (-0.0951), Grain per spike (-0.0922).

The maximum indirect positive genotypic path in Grain per spike observed through Days to maturity (0.7362), followed by Effective tiller per plant (0.6463), Grain yield per plant (0.3060), Biological yield per plant (0.1638). Maximum indirect negative genotypic path in Grain per spike observed through Harvest index (-0.5254), followed by Days to 50% flowering (-0.3256), Plant height (-0.2979), Spikelets per spike (-0.1376), Spike length (-0.1113), Thousand seed weight (-0.0590).

The maximum indirect positive genotypic path in Biological yield per plant observed through Harvest index (0.2408), followed by Spike length (0.1843), Spikelets per spike (0.0983), Grain per spike (0.0682), Days to 50% flowering (0.0510). Maximum indirect negative genotypic path in Biological yield per plant observed through Days to maturity (-0.4927) followed by Effective tiller per plant (-0.1464), Thousand seed weight (-0.0944), Plant height (-0.0877), Grain yield per plant (-0.0399). The maximum indirect positive genotypic path in Thousand seed weight observed through Days to maturity (0.9037), followed by Spike length (0.1294), Effective tiller per plant (0.0691), Spikelets per spike (0.0630), Biological yield per plant (0.0414), Grain per spike (0.0108). Maximum indirect negative genotypic path in Thousand seed weight observed through Grain yield per plant (-0.0588) followed by Days to 50% flowering (-0.0190), Harvest index (-0.0124), Plant height (-0.0053).

The observed maximum indirect positive genotypic path in Harvest index through Spike length (1.3181), followed by Grain per spike (0.6839), Spikelets per spike (0.4740).

Maximum indirect negative genotypic path in Harvest index through Days to maturity (-2.1485) followed by Grain yield per plant (-1.8910), Effective tiller per plant (-0.9324), Biological yield per plant (-0.7522), Thousand seed weight (-0.0882), Days to 50% flowering (-0.2497), Plant height (-0.0265). Phougat *et al.* (2017) [13], Subhani *et al.* (2000) [14], Bhushan *et al.* (2013) [9], Chimdesa *et al.* (2017) [15] also agreed with the similar finding.

Table 3: Direct (diagonal) and indirect effects of eight traits on grain yield

TRAITS	DFF	DM	PH	ETP	SL	SPS	GPS	BYP	TSW	HI	GYP
DFF	-0.2033	1.2276**	-0.1132	-0.0189	-0.0812	0.1214	0.2786	-0.1048	0.0889	-0.1642	-0.7742**
DM	0.0353	-0.0058	-0.0483	-0.451	-0.0326	0.0383	-0.0181	0.0291	0.1219	-0.0407	-2.0627**
PH	0.0546	0.8093**	0.0980	0.1245	0,0170	0.0037	-0.1229	-0.0869	0.0120	0.0084	-0.8175**
ETP	-0.0251	-2.0858**	-0.3439	-0.02708	-04238	-0.4494**	-0.7368**	0.4005	0.4318	-0.8167**	-0.2993
SL	0.0026	0.0363	0.0011	0.0102	0.0065	0.0024	-0.0031	0.0121	-0.0194	-0.0278	1.0648**
SPS	-0.0951	-1.0430	0.0060	0.2641	0.0584	-0.1591	-0.0922	0.1581	-0.2310	0.2440	0.3733
GPS	-0.3256	0.7362**	-0.2979	0.6463**	-0.1113	-0.1376	-0.2375	0.1638	-0.0590	0.5254**	0.3060
BYP	-0.0510	-0.4927	-.08 7**	-0.1464	0.1843	0.0983	0.0682	0.0990	-0.0944	0.2408	-0.0399
TSW	0.0190	0.9037**	-0.0053	0.0691	0.1294	0.0630	0.0108	0.0414	-0.0434	0.124	-0.0588
HI	-0.22497	-2.1485**	-0.0265	-0.9324**	1.3181**	0.4740**	0.6839**	-0.7522**	-0.0882	-0.3091	-1.8910**

Phenotypic path analysis

Direct path

The maximum direct positive phenotypic path on grain yield per plant was observed in Spikelets per spike (0.9277) followed by Grain per spike (0.1620) Biological yield per plant (0.0448).Maximum direct negative effect on grain yield per plant was observed in Effective tiller per plant (-1.2878), followed by Days to maturity (-0.9526), Days to 50% flowering (-0.7315), Harvest index (-0.6978), Plant height (-0.1499), Spike length (-0.1349), Thousand seed weight (-0.0021).

Indirect path

The maximum indirect positive phenotypic path in Days to 50% flowering observed through Grain per spike (0.4717) followed by Effective tiller per plant (0.3713), thousand seed weight (0.1785), Plant height (0.1736), Spike length (0.0821).

Maximum indirect negative phenotypic path in Days to 50% flowering observed through Spikelets per spike (-0.2503), followed by Biological yield per plant (-0.1568), Days to maturity (-0.1170) and Harvest index (-

The maximum indirect positive phenotypic path in Days to maturity observed through Effective tiller per plant (0.5657), followed by Spike length (0.3345), Thousand seed weight (0.3191), Biological yield per plant (0.2707), Harvest index (0.2346), Grain per spike (0.1483), Grain yield per plant (0.1043).

Maximum indirect negative phenotypic path in Days to maturity observed through Plant height (-0.4955) followed by Spikelets per spike (-0.3133), Days to 50% flowering (-

0.1524). The maximum indirect positive phenotypic path in Plant height observed through Grain yield per plant (0.3590) followed by Harvest index (0.0695), Biological yield per plant (0.0604), Effective tiller per plant (0.0475), spike length (0.0363), Days to 50% flowering (0.0356)Maximum indirect negative phenotypic path in Plant height observed through Days to maturity (-0.0780), followed by Thousand seed weight (-0.0442), Grain per spike (-0.0291), Spikelets per spike (-0.0086).The maximum indirect positive phenotypic path in Effective tiller per plant observed through Days to maturity (0.7647) followed by Days to 50% flowering (0.6538), Plant height (0.4084).

Maximum indirect negative phenotypic path in Effective tiller per plant observed through Grain per spike (-0.3093) followed by Spikelets per spike (-0.2969), Spike length (-0.2570), Thousand seed weight (-0.2387), Grain yield per plant (-0.1603) Harvest index (-0.1559), Biological yield per plant (-0.0557). The maximum indirect positive phenotypic path in Spike length observed through Days to maturity (0.0474) followed by Biological yield per plant (0.0357), Plant height (0.0327),Days to 50% flowering (0.0151), Spikelets per spike (0.0069), Grain yield per plant (0.0052).Maximum indirect negative phenotypic path in Spike length observed through Thousand seed weight (-0.0700)followed by Effective tiller per plant (-0.0269), Grain per spike (-0.0078), Harvest index (-0.0010). The maximum indirect positive phenotypic path in Spikelets per spike observed through Days to 50% flowering (0.3174) followed by Days to maturity (0.3051), Effective tiller per plant (0.2138), Grain yield per plant (0.2062), Plant height (0.0533), Biological yield per plant (0.0044).

Maximum indirect negative phenotypic path in Spikelets per spike observed through Harvest index (-0.2344), followed by Grain per spike (-0.2067), Thousand seed weight (-0.1447), Spike length (-0.0472).

The maximum indirect positive phenotypic path in Grain per spike observed through Grain yield per plant (0.3213) followed by Effective tiller per plant (0.0389),Plant height (0.0315), Thousand seed weight (0.0273), Biological yield per plant (0.0167), Spike length (0.0093).

Maximum indirect negative phenotypic path in Grain per spike observed through Days to 50% flowering (-0.1045), followed by Spikelets per spike (-0.0361), Days to maturity (-0.0252), Harvest index (-0.0204).

The maximum indirect positive phenotypic path in Biological yield per plant observed through Grain yield per plant (0.3708) followed by Days to 50% flowering (0.0096), Grain per spike (0.0046), Thousand seed weight (0.0023), Effective tiller per plant (0.0019), Spikelets per spike (0.0002).

Maximum indirect positive phenotypic path in Biological yield per plant observed through Plant height (-0.0181) followed by Days to maturity (-0.0127), Spike length (-0.0119), Harvest index (-0.0097).

The maximum indirect positive phenotypic path in thousand seed weight observed through Grain yield per plant (0.2038) followed by Days to maturity (0.0007), Days to 50% flowering and Harvest index (0.0005), Spikelets per spike (0.0003).

Maximum indirect negative phenotypic path in Thousand seed weight observed through spike length (-0.0011) followed by Plant height (-0.0006), Effective tiller per plant and Grain per spike (-0.0004), Biological yield per plant (-0.0001).

The maximum indirect positive phenotypic path in Harvest index observed through Plant height (0.3236), followed by Days to maturity (0.1719), Spikelets per spike and Thousand seed weight (0.1763), Biological yield per plant (0.1507), Grain per spike (0.0879). Maximum indirect negative phenotypic path in Harvest index observed through Days to 50% flowering (-0.1035) followed by Grain yield per plant (-0.9230), Effective tiller per plant (-0.0845), Spike Tsegaye *et al.* (2012) [1], Gelalcha and Hanchinal (2013) [3] also agreed with the similar finding.

Table 4: Direct (diagonal) and indirect effects of eight traits on grain yield

TRAITS	DFF	DM	PH	ETP	SL	SPS	GPS	BYP	TSW	HI	GYP
DFF	-0.7315**	-0.1170	0.1736	0.3713	0.0821	-0.2503	0.4717	-0.1568	0.1785	-0.1085	-0.0599
DM	-0.1524	-0.9526**	-0.4955**	0.5657**	0.3345	-0.3133	0.1483	0.2707	0.3191	0.2346	0.1043
PH	0.0356	-0.0780	-0.1499	0.0475	0.0363	-0.0086	-0.0291	0.0604	-0.0442	0.0695	0.3590
ETP	0.6538**	0.7647**	0.4084**	-1.2878**	-0.2570	-0.2969	-0.3093	-0.0557	-0.2387	-0.1559	-0.1603
SL	0.0151	0.0474	0.0327	-0.0269	-01349	0.0069	-0.0078	0.0357	-0.0700	-0.0010	0.0052
SPS	0.3174	0.3051	0.0533	0.2138	-0.0472	-0.9277	-0.2067	0.0044	-0.1447	-0.2344	0.2062
GPS	-0.1045	-0.0252	0.0315	0.0389	0.0093	-0.0361	0.1620	0.0167	0.0273	-0.0204	0.3213
BYP	0.0096	-0.0127	-0.0181	0.0019	-0.0119	0.0002	0.0046	0.0448	0.0023	-0.0097	0.3708
TSW	0.0005	0.0007	-0.0006	-0.0004	-0.0011	0.0003	-0.0004	-0.0001	-0.0021	0.0005	0.2038
HI	-0.1035	0.1719	0.3236	-0.0845	-0.0051	0.1763	0.0879	0.1507	0.1763	-0.6978	-0.9230

Conclusion

Based on the results, the present work is concluded that DBW 187 genotype showed high mean performance for grain yield per plant. The characters Days to maturity, Days to 50% flowering, Plant height, Grain per spike, Spikelets per spike should be given priority during selection.

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