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Correlation, path analysis, heritability and genetic advance for morpho-physiological character on bread wheat (*Triticum aestivum* L.)

Rahul Singh Rajput

Abstract
The present investigation entitled "Correlation, path analysis, heritability and genetic advance for morpho-physiological characters in bread wheat (*Triticum aestivum* L.)" was undertaken to study the Correlation, path analysis, heritability and genetic advance for grain yield and its components in F_1 generation of wheat through Line X Tester analysis. Experiment was conducted with 2 replications and 54 genotypes consisting 10 lines *viz.*, 33rd ESWYT150, 20th HRWYT213, 20th HRWYT235, 45th IBWSN1021, 14th FHBSN6418, 36th SAWSN3065, PBW658, KB2013-03, KB2013, VW921 and 4 testers *viz.*, GW273, GW366, RVW 4106, SUJATA and their 40 crosses made in L X T mating fashion in randomized block design at experimental Research Farm, College of Agriculture, Gwalior, (M.P.) during 2014-2015. Genetic analysis revealed that Canopy temperature index and harvest index recorded high value of heritability and genetic advance. Genotypic path analysis revealed that test weight and weight of grain/spike exhibited positive and strong association with grain yield and highest positive direct effects on grain yield. The selection for yield contributing test weight and weight of grain/spike must be given preference along with grain yield for speedy improvement grain yield.

Keywords: PCV, GCV, heritability, genetic advance, correlation analysis, path analysis

Introduction
Wheat is the principal food crop in most areas of the world and also occupies prominent position in Indian agriculture after rice. It is nutritionally important cereal essential for the food security, poverty alleviation and for livelihoods. It is widely cultivated as staple food crop among the cereals and is contributing about 30% to the food basket of the country. India is the second largest producer of wheat in the world with the production around 75 million tonnes during the last decade and it is a major contributor to the food security system in India, occupying nearly 30.37 million hectares, producing 90.78 million tonnes and productivity 29.89 q/ha and in Madhya Pradesh, grown in 5.56 million hectares with production of 13.37 million tonnes and productivity of 24.05 q/ha (Anonymous 2014-2015). The substantial improvement in production is utmost necessary not only to meet ever increasing food requirement for domestic consumption, but also for export to earn foreign exchange. To feed the growing population, the country's wheat requirement by 2030 has been estimated at 100 million metric tonnes and to achieve this target, wheat production has to be increased at the rate of <1per annum (Sharma *et al.*, 2011) [20] and this can be achieved through horizontal approach i.e. by increasing area under cultivation or through vertical approach i.e. varietal / hybrid improvement, which is one of the strongest tool to take a quantum jump in production and productivity under various agro- climatic conditions. *Triticum aestivum* (bread wheat) (2n=6x=42) is an allohexaploid produced from two separate naturally occurring hybridization events. The initial hybridization, that occurred between the two grass species *Triticum urartu* (2n=2x=14) (the A genome donor), and *Triticum speltoides* (2n=2x=14) (B genome donor). This new species would have been tetraploid wheat (2n=4x=28) viz., *Triticum turgidum* var. durum (Durum wheat). Hexaploid wheat arose as a result of a second hybridization between the new tetraploid and a third diploid species (2n=2x=14) viz., *Triticum tauschii* (D genome donor). Again, doubling chromosome must have occurred in order to produce a fertile individual. This new species would then have 42 chromosomes; i.e. six complete genomes each of 7 chromosomes.

Materials and Methods: The experimental material consisted 54 genotypes consisting 10 lines *viz.*, 33rdESWYT150, 20thHRWYT213, 20thHRWYT235, 45thIBWSN1021, 14thFHBSN6418, 36thSAWSN3065, PBW658, KB2013-03, KB2013, VW921 and 4 testers *viz.*, GW273, GW366, RVW 4106, Sujata and their 40 crosses made in L X T mating

fashion in randomized block design at experimental Research Farm, College of Agriculture, Gwalior, (M.P.) during 2014-2015. Observations were recorded on randomly selected 5 tagged plants for grain yield per plant and different yield contributing traits *viz.*, days to heading, days to maturity, plant height, tillers per plant, spike length, 1st internodes length, weight of spikes per plant, weight of grains per spike, grains per spike, test weight, canopy temperature index, biological yield and harvest index. Standard statistical procedures were followed for estimating genetic constants i.e. phenotypic and genotypic coefficients of variation (Burton, 1952), heritability in broad sense (Hanson *et al*, 1956) and genetic advance (Johnson *et al*., 1955). Genotypic and phenotypic correlation coefficients were calculated following the formula suggested by Searle (1971) and path analysis following Dewey and Lu (1959). In path analysis, grain yield used as dependent variable, and the other studied traits were use as predictor variables. The stepwise regression analysis was also carried out for the data obtained to test the significance of the independent variables affecting the grain yield.

Results and Discussion

Phenotypic and genotypic coefficient of variation (PCV and GCV): PCV and GCV have been presented in Table 1.1. Phenotypic coefficient of variation (PCV) were recorded highest for canopy temperature index (13.93%) followed by harvest index (10.78%), spike length (9.30%), grain/spike (8.58%), tillers/plant (8.06%), test weight (7.62%), grain yield/plant (7.56%), weight of grains/spike (7.45%), 1st inter-node length (7.00%), weight of spike/plant (6.42%), biological yield (5.71%) and plant height (5.09%) whereas, comparatively lower in days to maturity (1.23%) and days to heading (1.66%). The highest genotypic coefficient of variation (GCV) were observed for the canopy temperature index (13.21%) followed by harvest index (10.37%), spike length (9.26%), grain/spike (8.42%), test weight (7.55%), grain yield/plant (7.51%), tillers/plant (6.95%), 1st inter-node length (6.44), weight of grain/spike (6.40%), weight of spike/plant (6.15%), biological yield (5.52%) and plant height (5.03%) whereas, comparatively lower in days to maturity (1.11%) and days to heading (1.49%).

Heritability (broad- sense heritability): The estimates of broad-sense heritability % have been presented in Table 1.1. the Higher heritability were observed for spike length (99.11%), grain yield per plant (98.58%), test weight (98.07%), plant height (97.68%), grains per spike (96.39%), biological yield (93.45%), harvest index (92.52%), weight of spikes per plant (91.61%), canopy temperature index (89.91%), 1st inter-node length (84.56%), days to maturity (82.55), days to heading (80.64%), tillers per plant (74.34%), weight of grains per spike (73.88%).

Genetic advance: The estimates of genetic advance in Table 1.1. revealed that the higher genetic advance as per cent were observed for canopy temperature index (25.80%), harvest index (20.54%). the moderate genetic advance were observed for spike length (18.99%), grains per spike (17.03%), test weight (15.40%), grain yield per plant (15.36%), tillers per plant (12.35%), 1st inter-node length (12.19%), weight of spike per plant (12.12%), weight of grains per spike (11.33%), biological yield (11.00%), plant height (10.25%).

Correlation analysis: Phenotypic and genotypic correlation coefficient among grain yield per plant and its contributing characters are presented below:-

Phenotypic correlation coefficient

1. **Grain yield:** Correlation analysis presented in Table 1.2 revealed that grain yield exhibited significant positive association with test weight (0.9895), weight of spike/plant (0.8565), weight of grains/spike (0.7921) and harvest index (0.7667), whereas, spike length (-0.4579), grains/spike (-0.3757) and days to maturity (-0.3077) exhibited negative but significant association with grain yield.
2. **Days to maturity:** It exhibited significant negative correlation with plant height (-0.5237), weight of grain/spike (-0.3009), harvest index (-0.3355), test weight (-0.2849).
3. **Spike length:** It showed significant positive correlation with grains/spike and significant negative correlation with test weight (-0.4618), weight of spike/plant (-0.3865), weight of grains/spike (-0.3163) and 1st inter-node length (-0.2499).
4. **Grain/spike:** It showed significant negative correlation with test weight (-0.3849), plant height (-0.3010), weight of spike/plant (-0.2857) and significant positively correlated with spike length (0.8640).
5. **Weight of grain/spike:** It exhibited significant positive correlation with test weight (0.8094), weight of spike/plant (0.7115), harvest index (0.7232) and canopy temperature index (0.2768), significantly negatively correlated with spike length (-0.3163) and days to maturity (-0.3009).
6. **Test weight:** It exhibited significant positive correlation with weight of grains/spike (0.8094), weight of spike/plant (0.7115) and harvest index (0.7323) significantly negatively correlated with spike length (-0.4618), grains/spike (-0.3849) and days to maturity (-0.2849).
7. **Harvest index:** It exhibited the significant positive correlation with weight of grains/spike (0.7232), test weight (0.7795), weight of spike/plant (0.6948) and canopy temperature index (0.5617) significantly negatively correlated with biological yield (-0.6739), days to maturity (-0.3355).
8. **Weight of spike/plant:** It exhibited the significant positive correlation with test weight (0.8531), weight of grain/spike (0.7115) and harvest index (0.6948) significantly negatively correlated with spike length (-0.3868) and grains/spike (-0.2857).

Genotypic correlation coefficient

1. **Grain yield:** Correlation analysis presented in Table 1.3 revealed that grain yield exhibited significant positive association with test weight (0.9992); weight of grains/spike (0.9217); weight of spike/plant (0.8985); and harvest index (0.7966), whereas, spike length (-0.4632), days to maturity (-0.3385) and grains/spike (-0.3855) and exhibited negative but significant association between yield.
2. **Test weight:** It showed significant positive correlation with weight of grains/spike (0.9198), weight of spike/plant (0.8941) and harvest index (0.8076). Significantly negatively correlated with spike length (-0.4684), grains/spike (-0.3894) and days to maturity (-0.3174).

3. **Weight of grain/spike:** It showed significant positive correlation with test weight (0.9198), weight of spike/plant (0.8730), harvest index (0.8367) and canopy temperature index (0.3177), significantly negatively correlated with spike length (-0.3696), days to maturity (-0.3690) and biological yield (-0.2872).
4. **Weight of spike/plant:** It exhibited the significant positive correlation with test weight (0.8941), weight of grain/spike (0.8730) and harvest index (0.7513) significantly negatively correlated with spike length (-0.4056), grains/spike (-0.3098) and days to maturity (-0.2911).
5. **Harvest index:** It showed significant positive correlation with weight of grains/spike (0.8367), test weight (0.8076), weight of spike/plant (0.7513) and canopy temperature index (0.6279) significantly negatively correlated with biological yield (-0.6876), days to maturity (-0.3511).
6. **Spike length:** It exhibited significant positive correlation with grains/spike and significant negative correlation with test weight (-0.4684), weight of spike/plant (-0.4056), weight of grains/spike (-0.3696) and 1st inter-node length (-0.2735).
7. **Days to maturity:** It recorded significant negative correlation with plant height (-0.5804), weight of grain/spike (-0.3639), harvest index (-0.3511), test weight (-0.3174) and weight of spike/plant (-0.2911).
8. **Grain/spike:** It recorded significant negative correlation with test weight (-0.3894), plant height (-0.3120), weight of spike / plant (-0.3098) and significant positively correlated with spike length (0.8840).

Phenotypic path analysis: Direct and indirect effect of various traits on grain yield presented in table: 1.4.

1. **Days to heading:** Days to heading exhibited negative direct effect on grain yield (-0.0527) and its positive indirect effect on grain yield via. canopy temperature index (0.1217) and tillers/plant (0.0196)
2. **Days to maturity:** Days to maturity recorded negative direct effect on grain yield (-0.0715) and its positive indirect effect on grain yield via biological yield (0.0532), plant height (0.0521) and weight of grain/spike (0.0299)**.**
3. **Plant height:** Plant height exhibited negative direct effect on grain yield (-0.0995) and its positive indirect effect on grain yield via canopy temperature index (0.0943), weight of spike/plant (0.0766) and spike length (0.0191)
4. **Tiller / plant:** Tillers / plant exhibited negative direct effect on grain yield (-0.1365) but positive indirect effect via spike weight /plant (0.2093), canopy temperature index (0.1493) and test weight (0.0291).
5. **1st inter-node length:** It recorded positive direct effect on grain yield (0.0460) and showed positive indirect effect via spike length (0.0216) and weight of spike/plant (0.0070)
6. **Spike length:** Spike length showed negative direct effect on grain yield (-0.0863) and positive indirect effect on grain yield via grains/spike (0.0589), canopy temperature index (0.0480) and weight of grain/spike (0.0314)
7. **Grains / spikes:** Grain/spike exhibited positive direct effect on grain yield (0.0682) and positive indirect effect on grain yield via plant height (0.0299), weight of grains/spike (0.0236) and days to heading (0.0104)
8. **Weight of grain/spike:** Weight of grain/spike recorded negative direct effect on grain yield (-0.0994) and its positive indirect effect on grain yield via weight of spike/plant (0.7002), canopy temperature index (0.1366) and test weight (0.1101).
9. **Test weight:** Test weight had exhibited positive direct effect on grain yield (0.1360) and also showed positive indirect effect on grain yield via weight of spike/plant (0.08397), canopy temperature index (0.1181), spike length (0.0399) and harvest index (0.0240)
10. **Biological yield:** Grain/spike exhibited positive direct effect on grain yield (0.3583) and positive indirect effect on grain yield via weight of grains/spike (0.0252), spike length (0.0166) and tillers/plant (0.0110)
11. **Harvest index:** Harvest index exhibited positive direct effect on grain yield (0.0308) and also showed positive indirect effect on grain yield via weight of spike/plant (0.6836), canopy temperature index (0.2771), test weight (0.1060) and days to maturity (0.0240)
12. **Canopy temperature index:** It exhibited positive direct effect on grain yield (0.4933) and showed positive indirect effect via test weight (0.0326) and harvest index (0.0173)
13. **Weight of spike/plant:** Weight of spike/plant exhibited positive direct effect on grain yield (0.9842) and showed positive indirect effect via spike length (0.0334) and harvest index (0.0214) The residual path effect value found to be 0.1233

Genotypic path analysis: Direct and indirect effect of various traits on grain yield is presented in Table: 1.5.

1. **Days to heading:** Days to heading showed positive direct effect on grain yield (0.0065) and its indirect effect on grain yield via grains/spike (0.0245) and biological yield (0.0121)
2. **Days to maturity**: Days to maturity recorded meagre negative direct effect on grain yield (-0.0065) and high positive indirect effect on grain yield via harvest index (0.0448), canopy temperature index (0.0213) and weight of spike/plant (0.0109)
3. **Plant height**: Plant height exhibited positive direct effect on grain yield (0.0171) and its indirect effect on grain yield via test weight (0.0609), grains/spike (0.0323) and biological yield (0.0185)
4. **Tillers / plant**: it recorded positive direct effect on grain yield (0.0791) and its positive indirect effect on grain yield via test weight (0.2596)
5. **1st inter-node length**: It exhibited negative direct effect on grain yield (-0.0230) and it has indirect positive effect on grain yield via grain/spike (0.0189) and canopy temperature index (0.0145)
6. **Spike length**: Spike length exhibited positive direct effect on grain yield (0.1065) and showed positive indirect effect via biological yield (0.0242), harvest index (0.0235), weight of spike/plant (0.0152), 1st inter-node length (0.0051) and days to heading (0.0004)
7. **Grains/spikes**: Grain/spike exhibited negative direct effect on grain yield (-0.1037) but it indirectly contributed via spike length (0.0942), biological yield (0.0268), harvest index (0.0147), weight of spike/plant (0.0116)
8. **Weight of grain/spike**: Weight of grain/spike exhibited positive direct effect on grain yield (01081) and showed positive indirect effect via test weight (0.9506), biological yield (0.0347), grains/spike (0.0280),

tillers/plant (0.0128), plant height (0.0011) and days to maturity (0.0083)

9. **Test weight**: Test weight had exhibited highest positive direct effect on grain yield (1.0335) and showed positive indirect effect via weight of grain/spike (0.0994), grains/spike (0.0404), tillers/plant (0.0199), biological yield (0.0171), days to maturity (0.0071), 1st inter-node length (0.0015) and plant height (0.0010)
10. **Biological yield**: Grain/spike exhibited negative direct effect on grain yield (-0.1209) but it indirectly positive effect via harvest index (0.0878), canopy temperature index (0.0877) and grain/spike (0.0229)
11. **Harvest index**: Harvest index exhibited negative direct effect on grain yield (-0.1277) but it indirectly contributed via test weight (0.8346), biological yield (0.0832), weight of grain/spike (0.0905), tillers/plant (0.0205) and grains/spike (0.0119)
12. **Canopy temperature index**: It exhibited negative direct effect on grain yield (-0.1281) but it has indirect positive effect on grain yield via test weight (0.2710), biological yield (0.0828) and weight of grain/spike (0.0344)
13. **Weight of spike/plant**: Weight of spike/plant exhibited negative direct effect on grain yield (-0.0376). It had positive indirect effect through test weight (0.9240), weight of grains/spike (0.0944), grains/spike (0.0321), biological yield (0.0223) and tillers/plant (0.0166)

The residual path effect value found to be 0.0352

Table 1.1: Range, mean, phenotypic coefficients of variation (PCV) and genotypic coefficient of variation (GCV), heritability (broad sense) and genetic advance for different characters in wheat

S. No	Characters	Range	Mean	GV	PV	GCV	PCV	Broad sense heritability (%)	Genetic advance	Genetic advance as % of mean
1	Days to heading	83.50 - 90	86.35	1.66	2.06	1.49	1.66	80.64	2.39	2.76
2	Days to maturity	134.50 - 141	136.97	2.32	2.82	1.11	1.23	82.55	2.85	2.08
3	Plant height (cm)	88.70 - 110.10	104.45	27.62	28.28	5.03	5.09	97.68	10.70	10.25
4	Tillers / Plant	6 - 8.40	7.12	0.24	0.33	6.95	8.06	74.34	0.88	12.35
5	1st inter-node length (cm)	2.54 - 3.37	2.92	0.04	0.04	6.44	7.00	84.56	0.36	12.19
6	Spike length (cm)	8.35 - 12.07	10.25	0.90	0.91	9.26	9.30	99.11	1.95	18.99
7	Wt. of Spike/Plant (g)	20.09 - 24.58	22.06	1.84	2.01	6.15	6.42	91.61	2.67	12.12
8	Grains weight/Spike (g)	1.74 - 2.28	2.00	0.02	0.02	6.40	7.45	73.88	0.23	11.33
9	Grains/Spike	53.60 - 72.70	63.10	28.24	29.30	8.42	8.58	96.39	10.75	17.03
10	Test weight (g)	32.37 - 45.05	40.26	9.24	9.42	7.55	7.62	98.07	6.20	15.40
11	Grains yield/ Plant (g)	12.97 - 18.06	16.06	1.45	1.47	7.51	7.56	98.58	2.47	15.36
12	Canopy temperature index	0.25 - 0.41	0.27	0.00	0.00	13.21	13.93	89.91	0.07	25.80
13	Biological yield (g)	32.70 - 42.66	38.80	4.59	4.91	5.52	5.71	93.45	4.27	11.00
14	Harvest index (%)	34.13 - 54.75	42.52	19.42	21.00	10.37	10.78	92.52	8.73	20.54

Table 1.2: Phenotypic correlation coefficient among 14 traits of wheat

Traits	DH	DM	PH	TP	FIN	SL	GS	WGS	TW	BY	HI	CTI	WSP	GYP
DH	1.0000	0.0312	0.1456	-0.1438	-0.0872	0.0699	-0.1980	-0.0629	-0.0531	-0.1089	0.0472	0.2467	-0.0841	-0.0730
DM		1.0000	-0.5237*	0.0195	0.1435	0.0736	0.0018	-0.3009*	-0.2849*	0.1485	-0.3355*	-0.1228	-0.2619	-0.3077*
PH			1.0000	-0.0313	0.2442	-0.2208	-0.3010*	0.0627	0.0561	-0.1444	0.1241	0.1912	0.0778	0.0688
TP				1.0000	0.0143	-0.0464	-0.0049	0.1409	0.2142	-0.0808	0.2395	0.3027*	0.2127	0.2294
FIN					1.0000	-0.2499	-0.1686	0.0601	-0.0602	-0.0525	-0.0378	-0.1150	0.0072	-0.0596
SL						1.0000	0.8640**	-0.3163*	-0.4618**	-0.1928	-0.1766	0.0973	-0.3865**	-0.4579**
GS							1.0000	-0.2379	-0.3849**	-0.2051	-0.1135	-0.0316	-0.2857*	-0.3757**
WGS								1.0000	0.8094**	-0.2539	0.7232**	0.2768*	0.7115**	0.7921**
TW									1.0000	-0.1329	0.7795**	0.2394	0.8531**	0.9895**
BY										1.0000	-0.6739**	-0.6393**	-0.1613	-0.1087
HI											1.0000	0.5617**	0.6948**	0.7667**
CTI												1.0000	0.0013	0.2075
WSP													1.0000	0.8565**

*, ** significant at 5 and 1 per cent level, respectively

DH: Days to heading, DM: Days to maturity, PH: Plant height, TP: Tillers/plant, FIN: 1st inter-node length, SL: Spike length, GS: Grains/spike, WGS: Weight of grains/spike, TW: Test weight, BY: biological yield, HI: harvest index, CTI: canopy temperature index, WSP: weight of spike/plant, GYP: grain yield/plant

Table 1.3: Genotypic correlation coefficient among 14 traits of wheat

Traits	DH	DM	PH	TP	FIN	SL	GS	WGS	TW	BY	HI	CTI	WSP	GYP
DH	1.000	0.0535	0.1661	-0.1926	-0.1375	0.0643	-0.2361	-0.0580	-0.0665	-0.0997	0.0535	0.3077*	-0.0884	-0.0785
DM		1.0000	-0.5804**	0.0390	0.1828	0.0796	0.0291	-0.3690**	-0.3174*	0.1654	-0.3511*	-0.1659	-0.2911	-0.3385*
PH			1.0000	-0.0490	0.2719	-0.2222	-0.3120*	0.0673	0.0590	-0.1529	0.1346	0.1968	0.0848	0.0708
TP				1.0000	0.0188	-0.0641	0.0024	0.1613	0.2512	-0.1028	0.2598	0.3954**	0.2104	0.2663
FIN					1.0000	-0.2735*	-0.1826	0.0791	-0.0664	-0.0354	-0.0584	-0.1132	0.0046	-0.0661
SL						1.0000	0.8840**	-0.3696**	-0.4684**	-0.2003	-0.1844	0.1030	-0.4056**	-0.4632**
GS							1.0000	-0.2704	-0.3894**	-0.2213	-0.1149	-0.0443	-0.3098*	-0.3855**
WGS								1.0000	0.9198**	-0.2872*	0.8367**	0.3177*	0.8730**	0.9217**
TW									1.0000	-0.1411	0.8076**	0.2622	0.8941**	0.9992**
BY										1.0000	-0.6876**	-0.6844**	-0.1846	-0.1281
HI											1.0000	0.6279**	0.7513**	0.7966**

CTI												1.0000	0.1685	0.2320
WSP													1.0000	0.8985**

*, ** significant at 5 and 1 per cent level, respectively

DH: Days to heading, DM: Days to maturity, PH: Plant height, TP: Tillers/plant, FIN: 1st inter-node length, SL: Spike length, GS: Grains/spike, WGS: Weight of grains/spike, TW: Test weight, BY: biological yield, HI: harvest index, CTI: canopy temperature index, WSP: weight of spike/plant, GYP: grain yield/plant

Table 1.4: Phenotypic path analysis: Direct (diagonal) and indirect effect of 14 traits on Grains yield

Traits	DH	DM	PH	TP	FIN	SL	GS	WGS	TW	BY	HI	CTI	WSP	GYP
DH	-0.0527	-0.0022	-0.0145	0.0196	-0.0040	-0.0060	-0.0135	0.0063	-0.0072	-0.0390	0.0015	0.1217	-0.0828	-0.0730
DM	-0.0016	-0.0715	0.0521	-0.0027	0.0066	-0.0063	0.0001	0.0299	-0.0388	0.0532	-0.0103	-0.0606	-0.2578	-0.3077
PH	-0.0077	0.0375	-0.0995	0.0043	0.0112	0.0191	-0.0205	-0.0062	0.0076	-0.0517	0.0038	0.0943	0.0766	0.0688
TP	0.0076	-0.0014	0.0031	-0.1365	0.0007	0.0040	-0.0003	-0.0140	0.0291	-0.0290	0.0074	0.1493	0.2093	0.2294
FIN	0.0046	-0.0103	-0.0243	-0.0020	0.0460	0.0216	-0.0115	-0.0060	-0.0082	-0.0188	-0.0012	-0.0567	0.0070	-0.0596
SL	-0.0037	-0.0053	0.0220	0.0063	-0.0115	-0.0863	0.0589	0.0314	-0.0628	-0.0691	-0.0054	0.0480	-0.3804	-0.4579
GS	0.0104	-0.0001	0.0299	0.0007	-0.0078	-0.0746	0.0682	0.0236	-0.0524	-0.0735	-0.0035	-0.0156	-0.2812	-0.3757
WGS	0.0033	0.0215	-0.0062	-0.0192	0.0028	0.0273	-0.0162	-0.0994	0.1101	-0.0910	0.0223	0.1366	0.7002	0.7921
TW	0.0033	0.0204	-0.0056	-0.0292	-0.0028	0.0399	-0.0262	-0.0804	0.1360	-0.0476	0.0240	0.1181	0.8397	0.9895
BY	0.0057	-0.0106	0.0144	0.0110	-0.0024	0.0166	-0.0140	0.0252	-0.0181	0.3583	-0.0208	-0.3154	-0.1587	-0.1087
HI	-0.0025	0.0240	-0.0123	-0.0327	-0.0017	0.0152	-0.0077	-0.0719	0.1060	-0.2414	0.0308	0.2771	0.6838	0.7667
CTI	-0.0130	0.0088	-0.0190	-0.0413	-0.0053	-0.0084	-0.0022	-0.0275	0.0326	-0.2290	0.0173	0.4933	0.0013	0.2075
WSP	0.0044	0.0187	-0.0077	-0.0290	0.0003	0.0334	-0.0195	-0.0707	-0.0219	-0.0578	0.0214	0.0006	0.9842	0.8565

DH: Days to heading, DM: Days to maturity, PH: Plant height, TP: Tillers/plant, FIN: 1st inter-node length, SL: Spike length, GS: Grains/spike, WGS: Weight of grains/spike, TW: Test weight, BY: biological yield, HI: harvest index, CTI: canopy temperature index, WSP: weight of spike/plant, GYP: grain yield/plant

Table 1.5: Genotypic path analysis: Direct (diagonal) and indirect effect of 14 traits on Grains yield

Traits	DH	DM	PH	TP	FIN	SL	GS	WGS	TW	BY	HI	CTI	WSP	GYP
DH	0.0065	-0.0012	0.0028	-0.0152	0.0032	0.0069	0.0245	-0.0063	-0.0688	0.0121	-0.0068	-0.0394	0.0033	-0.0785
DM	0.0003	-0.0224	-0.0099	0.0031	-0.0042	0.0085	-0.0030	-0.0399	-0.3280	-0.0200	0.0448	0.0213	0.0109	-0.3385
PH	0.0011	0.0130	0.0171	-0.0039	-0.0063	-0.0237	0.0323	0.0073	0.0609	0.0185	-0.0172	-0.0252	-0.0032	0.0708
TP	-0.0013	-0.0009	-0.0008	0.0791	-0.0004	-0.0068	-0.0002	0.0174	0.2596	0.0124	-0.0332	-0.0507	-0.0079	0.2663
FIN	-0.0009	-0.0041	0.0046	0.0015	-0.0230	-0.0291	0.0189	0.0086	-0.0686	0.0043	0.0075	0.0145	-0.0002	-0.0661
SL	0.0004	-0.0018	-0.0038	-0.0051	0.0063	0.1065	-0.0916	-0.0400	-0.4841	0.0242	0.0235	-0.0132	0.0152	-0.4632
GS	-0.0015	-0.0007	-0.0053	0.0002	0.0042	0.0942	-0.1037	-0.0292	-0.4024	0.0268	0.0147	0.0057	0.0116	-0.3855
WGS	-0.0004	0.0083	0.0011	0.0128	-0.0018	-0.0394	0.0280	0.1081	0.9506	0.0347	-0.1069	-0.0407	-0.0328	0.9217
TW	-0.0004	0.0071	0.0010	0.0199	0.0015	-0.0499	0.0404	0.0994	1.0335	0.0171	-0.1031	-0.0336	-0.0336	0.9992
BY	-0.0006	-0.0037	-0.0026	-0.0081	0.0008	-0.0213	0.0229	-0.0311	-0.1458	-0.1209	0.0878	0.0877	0.0069	-0.1281
HI	0.0003	0.0079	0.0023	0.0205	0.0013	-0.0196	0.0119	0.0905	0.8346	0.0832	-0.1277	-0.0804	-0.0063	0.8185
CTI	0.0020	0.0037	0.0034	0.0313	0.0026	0.0110	0.0046	0.0344	0.2710	0.0828	-0.0802	-0.1281	-0.0063	0.2320
WSP	-0.0006	0.0065	0.0014	0.0166	-0.0001	-0.0432	0.0321	0.0944	0.9240	0.0223	-0.0959	-0.0216	-0.0376	0.8985

DH: Days to heading, DM: Days to maturity, PH: Plant height, TP: Tillers/plant, FIN: 1st inter-node length, SL: Spike length, GS: Grains/spike, WGS: Weight of grains/spike, TW: Test weight, BY: biological yield, HI: harvest index, CTI: canopy temperature index, WSP: weight of spike/plant, GYP: grain yield/plant

Conclusion

The high heritability values coupled with high genetic advance were recorded for traits canopy temperature index, harvest index, spike length, grains per spike, test weight, grain yield per plant, tillers per plant, 1st inter-node length, weight of spike per plant, weight of grains per spike, biological yield and plant height, indicating that these characters are governed by additive gene effects and direct selection for these traits would be more effective for desired genetic improvement.

Correlation between grain yield/plant and four characters namely test weight (0.9895); weight of spike/plant (0.8565); weight of grains/spike (0.7921) and harvest index (0.7667) was found positive and significant and therefore selection for these characters can directly be followed for yield improvement in wheat. Path coefficient analysis revealed that some traits viz., test weight, weight of grain/spike and spike length exhibited highest positive direct effect and some traits have indirect positive effect on grain yield and each trait must be given preference in selecting the superior types.

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