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## Analysis of yield components and their association for enhancing grain yield in bread wheat (*Triticum aestivum* L. em *Thell.*) under sodic soil

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### Abstract

Experiment was conducted to assess direction, magnitude of association of different characters and contribution of various traits on yield for 96 (72 crosses+ 22 parents+ 2 standard checks)wheat genotypes in which grain yield was assumed as dependent character. The variation due to checks was significant for all the character. Highly significant and positive correlations were exerted in case of biological yield followed by harvest index while significant and positive association was observed for chlorophyll content, tillers per plant, plant height, flag leaf area. Path-coefficient analysis revealed that biological yield has high order of direct positive effect followed by test weight and chlorophyll content while other traits exhibited very low or negative direct effect on grain yield. The characters identified above can be practiced for obtaining high yielding cultivar.

**Keywords:** Components, association, enhancing, *Triticum aestivum* L.

### Introduction

Wheat (*Triticum aestivum* L. em. Thell., 2n=42) is a self-pollinated crop of the member of *Poaceae* family and one of the most leading cereal of many countries of the world including India. It has been described as the 'King of cereals' because of the acreage it occupies, high productivity and the prominent position it holds in the International food grain trade. It is the most important food crop of India and is a main source of protein and energy. In India, wheat is the second most important food crop after rice both in terms of area and production. Wheat is consumed in a variety of ways such as *bread*, *chapatti*, *porridge*, *flour*, *suji* etc. Wheat has relatively high content of niacin and thiamin which are principally concerned in providing the special protein called 'Gluten'. Wheat proteins are of special significance because *Gluten* provides the framework of spongy cellular texture of bread and baked products. In India, wheat covered about 29.72 mha during the recent past 2017-18 *Rabi* season and accounts for about 37 percent of the country's total food grains production as per the recent 3<sup>rd</sup> Advance Estimates from Directorate of Economics and Statistics (DES), Ministry of Agriculture and Farmers Welfare (MoA&FW), India. In India, during 2017-18 *Rabi* season the production of wheat 98.61million tonnes and average productivity was 33.18 q/ha, with the area of 29.72 million ha. During the year 2017-18 in Uttar Pradesh, the total wheat production was 31.98 million tonnes and average productivity was 32.69 q/ha., with the area of 9.786 million ha. Wheat production in 2017-18 has made another record and hallmark level output of 98.61 mt with an average national all time highest productivity of 3318 kg/ha. The perusal of state wise production indicated that Uttar Pradesh tops the list with 31.99 mt, followed by Punjab (17.61mt), Madhya Pradesh (15.91 mt), Haryana (11.31 mt), Rajasthan (9.53 mt) and Bihar (4.58 mt). These top six states together contributed about 92 per cent of the total production (Anonymous 2018).

### Materials and Methods

The was carried out during *Rabi* 2015-16 and 2016-17 at Main Experiment Station Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.). This place is located between 24° 47' and 26° 56' N latitude, 82° 12' and 83° 98' E longitude and at an altitude of 113 m above mean sea level. This area falls in sub-tropical climatic zone. The soil type is sandy loam. The annual rainfall is about 1270 mm. The climate of district Ayodhya is semi-arid with hot summer and cold winter.

The experimental materials of the study comprised of 96 treatments of wheat. These materials included 72 F<sub>1</sub>'s, 22 parental lines (18 females + 4 males) and two standard variety. Eighteen lines were crossed with 4 testers following Line x Tester mating design during 2015-16 at Main Experiment Station (MES), Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.). Half of seed of 72 F<sub>1</sub>'s crosses made among 18 lines and 4 testers during year, 2016-17 were sowed in timely town and half of seed sowed in late sown. The experimental materials consisting of 96 genotypes (72 F<sub>1</sub>'s + 22 parents and 2 checks) were sown at Main Experiment Station of Department of Genetics & Plant Breeding in Randomized Block Design with three replications in a single row (F<sub>1</sub>'s), and 2 rows (parents) in plot of 3 m length with inter and intra-row spacing of 23 cm and 10 cm, respectively.

The data were recorded on 5 randomly selected plants from each plot for twelve characters *viz.* Days to 50% flowering, Days to maturity, Plant height (cm), Number of tillers per plant, Spike length (cm), Peduncle length (cm), flag leaf area, 1000-grain weight (g), Biological yield (g), Grain yield per plant (g), Harvest index, Chlorophyll content (mg / 100g). Data recorded on the above characters were subjected to estimate the correlation coefficient (Searle, 1961) and path coefficient analysis (Dewey and Lu, 1959).

## Results and Discussion

The genotypic and phenotypic correlation coefficient was worked out to measure the association among the characters in E<sub>1</sub> and E<sub>2</sub> conditions.

Grain yield per plant exhibited highly positive phenotypic correlation with biological yield per plant (0.9603), harvest index (0.3997), chlorophyll content (0.3531), tillers per plant (0.2824), plant height (0.2401), flag leaf area (0.1957), peduncle length (0.1817) and days to 50% flowering (0.1813) in E<sub>1</sub> respectively; while spike length (-0.1490) shows negatively significant in E<sub>1</sub>. In E<sub>2</sub> grain yield per plant exhibited highly positive phenotypic correlation with biological yield per plant (0.9690), harvest index (0.5652), test weight (0.5096), peduncle length (0.3835), plant height (0.3269) respectively; while tillers per plant (-0.2988) shows negatively significant in E<sub>2</sub>. Days to 50% flowering showed highly positive correlation with days to maturity (0.7942) and grain yield per plant (0.1813) in E<sub>1</sub>; while in E<sub>2</sub> days to maturity (0.8465) showed high positive correlation and tillers per plant (-0.2403) showed negative correlation for this character. Days to maturity showed positive correlation with plant height (0.1710) and peduncle length (0.1300); while tillers per plant (-0.1390) showed negatively significant in E<sub>1</sub>. In E<sub>2</sub> days to maturity showed negatively high significant for tillers per plant (-0.1823) and rest of all characters are non-significant. Flag leaf area showed highly positive correlation with peduncle length (0.4760), tillers per plant (0.4452), spike length (0.2717), chlorophyll content (0.2698), test weight (0.2279), plant height (0.2230), biological yield per plant (0.2177) and grain yield per plant (0.1957) in E<sub>1</sub>; while in E<sub>2</sub> Flag leaf area showed highly positive correlation with peduncle length (0.4186), plant height (0.3382), test weight (0.2606), spike length (0.2337), tillers per plant (0.2216) and chlorophyll content (0.2018). Plant height showed highly positive association with peduncle length (0.5736), biological yield per plant (0.2957) and grain yield per plant (0.2401) in E<sub>1</sub>; whereas, with rest of the characters either very less or negative correlation exhibited; while for Plant height showed

highly positive association with peduncle length (0.5346), test weight (0.3631), biological yield per plant (0.3399), grain yield per plant (0.3269) and tillers per plant (0.2473) in E<sub>2</sub>; whereas, with rest of the characters either very less or non-significant. Tillers per plant showed positively correlated with chlorophyll content (0.3804), test weight (0.3361), peduncle length (0.3423), spike length (0.3243), biological yield per plant (0.2985) and grain yield per plant (0.2824) in E<sub>1</sub>. Tillers per plant showed positively correlated with spike length (0.2402) while grain yield (-0.2988) and biological yield (-0.2956) showed negatively highly significant in E<sub>2</sub>. Spike length showed positive association with spike length (0.3582) and peduncle length (0.2710), respectively; while negative correlation with grain yield per plant (-0.1490), harvest index (-0.1469) and biological yield per plant (-0.1223) was exhibited in E<sub>1</sub>. Spike length showed positive association with peduncle length (0.3014) and test weight (0.1994), respectively while rest of all the characters are non-significant in E<sub>2</sub>. Peduncle length showed positively correlated with biological yield per plant (0.2403) and grain yield per plant (0.1817), respectively; whereas with harvest index negative correlation was displayed in E<sub>1</sub>; while in E<sub>2</sub> Peduncle length showed positively correlated with biological yield per plant (0.4078), peduncle length (0.3864) and grain yield per plant (0.3855), respectively; whereas chlorophyll content showed negative correlation. Biological yield per plant showed positively associated with grain yield per plant (0.9603) and chlorophyll content (0.3474) in E<sub>1</sub>; while Biological yield per plant showed positively associated with grain yield per plant (0.9690), test weight (0.5133) and chlorophyll content (0.3852) in E<sub>2</sub>. Test weight showed positively associated with chlorophyll content (0.2040) in E<sub>1</sub>; while in E<sub>2</sub> Test weight showed positively associated with grain yield (0.5096) and harvest index (0.2977). Harvest index showed highly significant with grain yield per plant (0.3997) in E<sub>1</sub> and (0.5652) in E<sub>2</sub>. Chlorophyll content showed highly significant with grain yield per (0.3531) in E<sub>1</sub>; while in E<sub>2</sub> grain yield showed non-significant negative correlation.

The physiological trait biological yield per plant showed positively associated with grain yield per plant and chlorophyll content in E<sub>1</sub>; while Biological yield per plant showed positively associated with grain yield per plant, test weight and chlorophyll content in E<sub>2</sub>. Positive associations between these characters have also been reported by Prasad *et al.* (2006) [10], Payal *et al.* (2007), Yousaf *et al.* (2008), Nagireddy and Jyothula (2009), El-Mohsen *et al.* (2012), Bhutto *et al.*, (2015).

The path coefficient analysis using genotypic as well as phenotypic correlation coefficient estimated in E<sub>1</sub> and E<sub>2</sub> conditions were carried out to assess direct and indirect effects of twelve characters on the expression of grain yield per plant. The highest positive direct effect on grain yield per plant were exerted by biological yield per plant (0.9261) in E<sub>1</sub> and (0.8988) in E<sub>2</sub> followed by harvest index (0.2401) in E<sub>1</sub> and (0.2217) in E<sub>2</sub>. While remaining characters showed negative direct effect towards expression of flag leaf area (-0.0171), test weight (-0.0158), plant height (-0.0139) and chlorophyll content (-0.0130) in E<sub>1</sub> and test weight (-0.0385), tillers per plant (-0.0035), flag leaf area (-0.0095), days to 50% flowering in E<sub>2</sub>. The highest positive indirect effect on grain yield was exerted by harvest index (0.2013) via biological yield per plant, tillers per plant (0.2806) via biological yield per plant, plant height (0.2789) via biological yield per plant, chlorophyll content (0.3288) via biological yield per plant,

peduncle length (0.2390) via biological yield per plant, followed by test weight (0.1058) via biological yield per plant in E<sub>1</sub>. The highest positive indirect effect on grain yield was exerted by test weight (0.4556) via biological yield per plant followed by harvest index (0.3419) via biological yield per plant, peduncle length (0.3620) via biological yield per plant, flag leaf area (0.1367) via biological yield per plant in

E<sub>2</sub>. These characters have also been identified as major direct contributors towards seed yield by Singh, Bhuri and Upadhyay, P.K. (2013), Ayccek and Yldrm (2006), Sherif *et al.* (2005), Payal *et al.* (2007), Dharmendra and Singh (2010), Tripathi *et al.* (2011), El-Mohsen *et al.* (2012) and Bhutto *et al.*, (2015).

**Table 1:** Estimates of phenotypic and genotypic correlation coefficient between 12 characters under timely sown condition in wheat

Character		Days to 50% flowering	Flag leaf area (cm <sup>2</sup> )	Days to maturity	Plant height (cm)	Tillers/plant	Spike length (cm)	Peduncle length (cm)	Biological yield/plant (g)	Test weight (g)	Harvest index (%)	Chlorophyll content	Grain yield/plant (g)
Days to 50% flowering	P	1.0000	0.0953	0.7942**	0.1285*	-0.0750	-0.0410	0.1068	0.2156	0.0208	-0.0890	0.0605	0.1813**
	G	1.0000	0.1095	0.8597	0.1669	-0.0757	-0.0915	0.1284	0.2747	0.0364	-0.0753	0.0733	0.2370
Flag leaf area (cm <sup>2</sup> )	P		1.0000	0.0688	0.2230**	0.4452**	0.2717**	0.4760**	0.2177**	0.2279**	0.0143	0.2698**	0.1957**
	G		1.0000	0.0918	0.2281	0.4710	0.3092	0.5069	0.2276	0.2595	0.0144	0.2795	0.2028
Days to maturity	P			1.0000	0.1710**	-0.1390*	-0.1001	0.1300*	0.1040	-0.0181	-0.1046	-0.0518	0.0832
	G			1.0000	0.2177	-0.1677	-0.1738	0.1583	0.1402	-0.0325	-0.0991	-0.0653	0.1120
Plant height (cm)	P				1.0000	0.1492*	-0.0797	0.5736**	0.2957**	-0.0489	-0.1344*	-0.2462**	0.2401**
	G				1.0000	0.1561	-0.0993	0.6022	0.3012	-0.0631	-0.1556	-0.2528	0.2412
Tillers/plant	P					1.0000	0.3243**	0.3423**	0.2985**	0.3361**	0.0315	0.3804**	0.2824**
	G					1.0000	0.4002	0.3733	0.3030	0.3723	0.0355	0.4014	0.2896
Spike length (cm)	P						1.0000	0.2710**	-0.1223*	0.3582**	-0.1469*	0.1184*	-0.1490*
	G						1.0000	0.2866	-0.1259	0.3947	-0.2154	0.1499	-0.1704
Peduncle length (cm)	P							1.0000	0.2403**	0.1005	-0.1805**	0.0452	0.1817**
	G							1.0000	0.2581	0.0882	-0.2244	0.0507	0.1881
Biological yield/plant (g)	P								1.0000	0.1185*	0.1719	0.3474**	0.9603**
	G								1.0000	0.1143	0.2173	0.3550	0.9726*
Test weight (g)	P									1.0000	0.0674	0.2040**	0.1137
	G									1.0000	0.0500	0.2239	0.1031
Harvest index (%)	P										1.0000	0.1449*	0.3997**
	G										1.0000	0.1954	0.4364
Chlorophyll content	P											1.0000	0.3531**
	G											1.0000	0.3644

**Table 2:** Estimates of phenotypic and genotypic correlation coefficient between 12 characters under late sown condition in wheat

Character		Days to 50% flowering	Flag leaf area (cm <sup>2</sup> )	Days to maturity	Plant height (cm)	Tillers/plant	Spike length (cm)	Peduncle length (cm)	Biological yield/plant (g)	Test weight (g)	Harvest index (%)	Chlorophyll content	Grain yield/plant (g)
Days to 50% flowering	P	1.0000	0.0585	0.8465**	0.0665	-0.2403**	0.0131	0.0466	0.0837	0.0443	0.1131	-0.0588	0.0954
	G	1.0000	0.0560	0.9305	0.0705	-0.3143	0.0196	0.0864	0.1048	0.0742	0.1501	-0.0823	0.1199
Flag leaf area (cm <sup>2</sup> )	P		1.0000	0.0885	0.3382**	0.2216**	0.2337**	0.4186**	0.1540*	0.2606**	0.0597	0.2018**	0.1511*
	G		1.0000	0.1165	0.3731	0.2408	0.2807	0.4469	0.1631	0.2787	0.0701	0.2310	0.1563
Days to maturity	P			1.0000	0.0770	-0.1823**	0.0776	0.0890	0.0287	0.0441	0.0748	-0.0117	0.0364
	G			1.0000	0.0803	-0.2105	0.1449	0.1633	0.0447	0.0718	0.0799	-0.0303	0.0527
Plant height (cm)	P				1.0000	0.2473**	0.0646	0.5346**	0.3399**	0.3631**	0.1514*	-0.1328*	0.3269**
	G				1.0000	0.2658	0.0722	0.5862	0.3475	0.3779	0.1840	-0.1709	0.3382
Tillers/plant	P					1.0000	0.2402**	0.0981	-0.2956**	-0.0158	-0.1249*	0.0395	-0.2988**
	G					1.0000	0.1978	0.0658	-0.3401	-0.0379	-0.1327	-0.0060	-0.3357
Spike length (cm)	P						1.0000	0.3014**	0.0688	0.1994**	-0.0986	0.0907	0.0369
	G						1.0000	0.3095	0.0775	0.2227	-0.1207	-0.0534	0.0377
Peduncle length (cm)	P							1.0000	0.4078**	0.3864**	0.1423*	-0.1296*	0.3835**
	G							1.0000	0.4277	0.3944	0.1843	-0.2360	0.4105
Biological yield/plant (g)	P								1.0000	0.5133**	0.3852**	-0.0864	0.9690**
	G								1.0000	0.5263	0.4553	-0.1221	0.9805
Test weight (g)	P									1.0000	0.2977**	0.1412*	0.5096**
	G									1.0000	0.3525	0.1449	0.5217
Harvest index (%)	P										1.0000	-0.0692	0.5652**
	G										1.0000	-0.0627	0.6164
Chlorophyll content	P											1.0000	-0.0770
	G											1.0000	-0.0990

**Table 3:** Estimation of direct and indirect effect of 12 characters on grain yield/ plant at phenotypic and genotypic level under timely sown condition in wheat.

		Days to 50% flowering	Flag leaf area (cm <sup>2</sup> )	Days to maturity	Plant height (cm)	Tillers/plant	Spike length (cm)	Peduncle length (cm)	Biological yield/plant (g)	Test weight (g)	Harvest index (%)	Chlorophyll content	Grain yield/plant (g)
Days to 50% flowering	P	-0.0141	-0.0014	0.0211	-0.0007	-0.0007	-0.0002	0.0011	0.1983	-0.0003	-0.0218	0.0001	0.1813
	G	-0.0102	-0.0019	0.0164	-0.0023	-0.0014	-0.0001	0.0017	0.2544	-0.0006	-0.0181	-0.0010	0.2370
Flag leaf area (cm <sup>2</sup> )	P	-0.0013	-0.0146	0.0018	-0.0013	0.0042	0.0011	0.0049	0.2002	-0.0032	0.0035	0.0003	0.1957
	G	-0.0011	-0.0171	0.0018	-0.0032	0.0089	0.0003	0.0066	0.2108	-0.0041	0.0035	-0.0036	0.2028
Days to maturity	P	-0.0112	-0.0010	0.0266	-0.0010	-0.0013	-0.0004	0.0014	0.0956	0.0003	-0.0257	-0.0001	0.0832
	G	-0.0087	-0.0016	0.0191	-0.0030	-0.0032	-0.0002	0.0021	0.1299	0.0005	-0.0238	0.0008	0.1120
Plant height (cm)	P	-0.0018	-0.0033	0.0045	-0.0058	0.0014	-0.0003	0.0060	0.2719	0.0007	-0.0330	-0.0002	0.2401
	G	-0.0017	-0.0039	0.0042	-0.0139	0.0029	-0.0001	0.0078	0.2789	0.0010	-0.0374	0.0033	0.2412
Tillers/plant	P	0.0011	-0.0065	-0.0037	-0.0009	0.0094	0.0013	0.0036	0.2746	-0.0047	0.0077	0.0004	0.2824
	G	0.0008	-0.0080	-0.0032	-0.0022	0.0189	0.0005	0.0049	0.2806	-0.0059	0.0085	-0.0052	0.2896
Spike length (cm)	P	0.0006	-0.0040	-0.0027	0.0005	0.0031	0.0041	0.0028	-0.1125	-0.0050	-0.0361	0.0001	-0.1490
	G	0.0009	-0.0053	-0.0033	0.0014	0.0076	0.0011	0.0037	-0.1166	-0.0062	-0.0517	-0.0019	-0.1704
Peduncle length (cm)	P	-0.0015	-0.0069	0.0035	-0.0033	0.0032	0.0011	0.0104	0.2210	-0.0014	-0.0443	0.0000	0.1817
	G	-0.0013	-0.0087	0.0030	-0.0084	0.0070	0.0003	0.0130	0.2390	-0.0014	-0.0539	-0.0007	0.1881
Biological yield/plant (g)	P	-0.0030	-0.0032	0.0028	-0.0017	0.0028	-0.0005	0.0025	0.9197	-0.0016	0.0422	0.0003	0.9603
	G	-0.0028	-0.0039	0.0027	-0.0042	0.0057	-0.0001	0.0034	0.9261	-0.0018	0.0522	-0.0046	0.9726
Test weight (g)	P	-0.0003	-0.0033	-0.0005	0.0003	0.0032	0.0015	0.0010	0.1090	-0.0139	0.0166	0.0002	0.1137
	G	-0.0004	-0.0044	-0.0006	0.0009	0.0070	0.0004	0.0011	0.1058	-0.0158	0.0120	-0.0029	0.1031
Harvest index (%)	P	0.0013	-0.0002	-0.0028	0.0008	0.0003	-0.0006	-0.0019	0.1581	-0.0009	0.2456	0.0001	0.3997
	G	0.0008	-0.0002	-0.0019	0.0022	0.0007	-0.0002	-0.0029	0.2013	-0.0008	0.2401	-0.0025	0.4364
Chlorophyll content	P	-0.0009	-0.0039	-0.0014	0.0014	0.0036	0.0005	0.0005	0.3195	-0.0028	0.0356	0.0010	0.3531
	G	-0.0007	-0.0048	-0.0012	0.0035	0.0076	0.0002	0.0007	0.3288	-0.0035	0.0469	-0.0130	0.3644

**Table 4:** Estimates of direct and indirect effect of 12 characters on grain yield per plant at phenotypic and genotypic level under late sown condition in wheat.

		Days to 50% flowering	Flag leaf area (cm <sup>2</sup> )	Days to maturity	Plant height (cm)	Tillers/plant	Spike length (cm)	Peduncle length (cm)	Biological yield/plant (g)	Test weight (g)	Harvest index (%)	Chlorophyll content	Grain yield/plant (g)
Days to 50% flowering	P	0.0017	0.0003	-0.0082	0.0003	0.0031	0.0001	-0.0003	0.0743	-0.0008	0.0259	-0.0010	0.0954
	G	-0.0016	-0.0001	-0.0015	-0.0001	0.0005	0.0000	-0.0001	-0.0002	-0.0001	-0.0002	0.0001	0.1199
Flag leaf area (cm <sup>2</sup> )	P	0.0001	0.0057	-0.0009	0.0013	-0.0029	0.0010	-0.0024	0.1367	-0.0047	0.0137	0.0034	0.1511
	G	-0.0005	-0.0095	-0.0011	-0.0035	-0.0023	-0.0027	-0.0042	-0.0016	-0.0026	-0.0007	-0.0022	0.1563
Days to maturity	P	0.0015	0.0005	-0.0096	0.0003	0.0023	0.0003	-0.0005	0.0255	-0.0008	0.0171	-0.0002	0.0364
	G	-0.0020	-0.0002	-0.0021	-0.0002	0.0004	-0.0003	-0.0003	-0.0001	-0.0002	-0.0002	0.0001	0.0527
Plant height (cm)	P	0.0001	0.0019	-0.0007	0.0039	-0.0032	0.0003	-0.0030	0.3017	-0.0065	0.0347	-0.0022	0.3269
	G	0.0003	0.0017	0.0004	0.0046	0.0012	0.0003	0.0027	0.0016	0.0017	0.0008	-0.0008	0.3382
Tillers/plant	P	-0.0004	0.0013	0.0018	0.0010	-0.0129	0.0011	-0.0006	-0.2623	0.0003	-0.0286	0.0007	-0.2988
	G	0.0011	-0.0008	0.0007	-0.0009	-0.0035	-0.0007	-0.0002	0.0012	0.0001	0.0005	0.0000	-0.3357
Spike length (cm)	P	0.0000	0.0013	-0.0007	0.0003	-0.0031	0.0044	-0.0017	0.0611	-0.0036	-0.0226	0.0015	0.0369
	G	0.0001	0.0016	0.0008	0.0004	0.0011	0.0058	0.0018	0.0004	0.0013	-0.0007	-0.0003	0.0377
Peduncle length (cm)	P	0.0001	0.0024	-0.0009	0.0021	-0.0013	0.0013	-0.0057	0.3620	-0.0070	0.0326	-0.0022	0.3835
	G	0.0008	0.0042	0.0015	0.0054	0.0006	0.0029	0.0093	0.0040	0.0037	0.0017	-0.0022	0.4105
Biological yield/plant (g)	P	0.0001	0.0009	-0.0003	0.0013	0.0038	0.0003	-0.0023	0.8876	-0.0092	0.0882	-0.0015	0.9690
	G	0.0942	0.1466	0.0401	0.3123	-0.3057	0.0696	0.3844	0.8988	0.4730	0.4092	0.0942	0.9805
Test weight (g)	P	0.0001	0.0015	-0.0004	0.0014	0.0002	0.0009	-0.0022	0.4556	-0.0180	0.0682	0.0024	0.5096
	G	-0.0029	-0.0107	-0.0028	-0.0145	0.0015	-0.0086	-0.0152	-0.0202	-0.0385	-0.0136	-0.0056	0.5217
Harvest index (%)	P	0.0002	0.0003	-0.0007	0.0006	0.0016	-0.0004	-0.0008	0.3419	-0.0054	0.2291	-0.0012	0.5652
	G	0.0333	0.0155	0.0177	0.0408	-0.0294	-0.0268	0.0409	0.1010	0.0782	0.2217	-0.0139	0.6164
Chlorophyll content	P	-0.0001	0.0012	0.0001	-0.0005	-0.0005	0.0004	0.0007	-0.0767	-0.0025	-0.0159	0.0168	-0.0770
	G	-0.0029	0.0082	-0.0011	-0.0061	-0.0002	-0.0019	-0.0084	-0.0043	0.0051	-0.0022	0.0354	-0.0990

## Conclusion

The high significant and positive correlations of grain yield per plant (at <1% level of significance) with biological yield per plant, harvest index, chlorophyll content, tillers per plant, plant height, flag leaf area, peduncle length and days to 50% flowering in E<sub>1</sub> while significantly but negatively associated with spike length. In E<sub>2</sub> grain yield per plant exhibited highly positive phenotypic correlation with biological yield per plant, harvest index, test weight, peduncle length, plant height respectively; while tillers per plant shows negatively significant in E<sub>2</sub>.

Grain yield per plant and chlorophyll content in E<sub>1</sub>; while Biological yield per plant showed positively associated with grain yield per plant, test weight and chlorophyll content in E<sub>2</sub> exhibited positive direct effects on grain yield per plant at both phenotypic and genotypic level in both conditions (E1

and E2), will help in improving grain yield through early generation selection. It is evident that genotypes developed might serve as good source of material for further breeding programme.

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