Research Article

Contribution of yield and yield related traits toward grain yield in maize F₁ hybrids

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Abstract

Knowledge of correlation between grain yield and its contributing components enhances the effectiveness of breeding programs through the use of appropriate breeding method. Twenty seven maize Genotypes including 20 F₁ hybrids, 5 parental inbred lines and two checks were evaluated in a randomized complete block design with three replications under the environmental conditions of Cereal Crops Research Institute (CCRI), Pirsabak - Nowshera, KPK, Pakistan during spring 2011. Correlation among all measured parameters has been calculated. Grain yield revealed negative genotypic and phenotypic correlations with earliness traits i.e. days to 50% tasseling, pollen shedding and silking. Although, genotypic and phenotypic correlations of grain yield were significantly positive with yield contributing traits.

Keywords: Correlation; Genotypic; Maize F₁ Hybrids; Phenotypic; Yield; Yield related traits

Introduction

Maize (*Zea mays* L.) is an important cereal crop of the world grown in irrigated and rainfed areas, and ranks third after wheat and rice [1]. Maize utilizes solar radiations more efficiently than other cereals. It is an annual short day plant and belongs to family poaceae and tribe Maydeae. It is grown at an altitude from sea level to 3300 meters above sea level and from 50° N to 40°S latitude in temperate, sub-tropical and tropical regions of the world [2]. It can be grown on all types of soils ranging from sandy loam to clay loam. However, medium textured soil of pH 6.5 to

7.5 is the most suitable for its successful cultivation. Maize plant is monoecious and protandrous, and hot dry weather usually accelerates pollen shedding [3].

Maize is a multipurpose crop and is mainly grown for human consumption as an available source of oil, carbohydrate and slightly for protein and as well as for livestock feed (gluten feed, maize oil meal and distillers dried grains). As vegetable, it consumed as green maize. It has achieved a remarkable place in agricultural industry due to its wide utilization. Worldwide maize yields are estimated to be 4000 industrial

products [4]. Due to its wide utilization and huge potential, maize conquers the exclusive place as queen of cereals.

In Pakistan, maize is also third important cereal crop after wheat and rice [5]. In Pakistan, maize is also cultivated as multipurpose crop for food, feed and fodder by the farming community, who largely lives in rural area. Maize use in Pakistan as direct human food is decreasing; however, its industrial use is increasing at a much faster rate [6]. Currently in Pakistan, maize is grown on an area of 1130 thousand hectares and total production was 6695 thousand tones with average seed yield of 4155 kg ha⁻¹ [7].

In Khyber Pakhtunkhwa, after wheat, the maize is the second important summer cereal with an area of 440.60 thousand hectares and production of 833.56 thousand tons with average seed yield of 1892 kg ha⁻¹ [8]. In Khyber Pakhtunkhwa, more than 27% of the total cultivated area is occupied by maize, which is second to wheat with total cropped area of 42% [9]. In the mountainous areas of Khyber Pakhtunkhwa, maize is utilized as an important staple food by the farming community as well as source of green and dry fodder for livestock [9, 10].

Information about nature and magnitude of genotypic and phenotypic correlations among earliness, morphological and yield traits is of immense importance for plant breeding program to select and breed different maize cultivars with increased yield potential. Correlation among various traits showed the extent to which various plant traits are correlated with economic yield [11]. According to Vencovsky and Barriga [11] association between various traits is an important aspect to deal with breeding programs because genetic change due to selection for a given trait may change positively or negatively the other traits. In addition, in most breeding programs the strategy is based on selection for various traits simultaneously and, therefore,

knowledge about the genotypic association between traits is inevitably helpful to make useful selection. Pleiotropy and linkage disequilibrium are the basic causes of genotypic correlation [13]. Hallauer, and Miranda [14], findings revealed that if heritability estimates of the secondary traits are greater than that of primary one, then indirect selection would be more effective. In Pakistan, average maize yield is low because of sub-optimal plant density, weed infestation, insect pest attack, inadequate water supply and fertilizer application and last but not the least unsuitable cultivar selection under a given set of environments [15]. Therefore, in light of these considerations, the present research was conducted with the objectives to estimate genotypic and phenotypic correlations among various traits.

Materials and methods

Five white kernel maize inbred lines with distinct genetic make-up were crossed in a complete diallel fashion during spring crop season 2011 at Cereal Crops Research Institute (CCRI), Pirsabak -Nowshera, Khyber Pakhtunkhwa, Pakistan (Table 1). The resulting 20 F₁ hybrids, five parental inbred lines and two check genotypes (OPV 'Jalal' and 'Pioneer hybrid 30K08') were evaluated during subsequent summer crop season 2011 through field experiment at Cereal Crops Research Institute (CCRI), Pirsabak - Nowshera, KPK, Pakistan. Rows and plants spacing were kept 75 and 25 cm, respectively with five meters length in all the experiments. Recommended cultural practices and inputs were uniformly applied to all the genotypes at all the locations. Ten plants were randomly selected and used for recording of the data of each variable in each treatment/replication/location, and data were recorded on the following 21 variables i.e. Days to 50% tasseling, Days to 50% pollen shedding, Days to 50% silking, Anthesis silking interval (ASI), Plant height (cm),

Primary leaf area (cm²), Days to physiological maturity, Fresh ear weight (kg), Prolificacy (%), Ear diameter (cm), Ear length (cm), Grain rows per ear, Grains per row, 1000-grain weight (g), Shelling percentage, Grain moisture content (%), Grain yield (kg ha⁻¹), Biological yield (kg ha⁻¹), Harvest index (%) and Grain yield efficiency. Genotypic and phenotypic correlations among various traits were estimated according to Kwon and Torrie [16].

Results and discussion

Correlation between various traits is one of

the important features in plant breeding. Correlation within crosses is used to find out the extent to which various characters of a plant are associated with economic yield. Moreover, knowledge about the extent and nature of association between yield and other traits is useful to device criterion for the selection of high yielding genotypes. The present research work was conducted on 5×5 diallel crosses of F₁ generation to find out the genotypic and phenotypic association between various traits under the agro climatic conditions Nowshers.

Table 1. Name and pedigree of parental inbred lines and their F₁diallel hybrids

S. No.	Name	Code	Pedigree
1.	FRHW-22(F2)-5	FRHW-1	Male Parental Single cross of Babar
2.	FRHW-22(F2)-4-7	FRHW-2	Male Parental Single cross of Babar
3.	FRHW-20-4	FRHW-3	Female Parental Single cross of Babar
4.	PSEV3-120-2-2-2	PSEV3	Derived from white maize population PSEV3 (base population of commercial OPV Jalal)
5.	SWAJK-6-6-3-6	SWAJK-1	Derived from open pollinated long duration variety Sarhad White
S. No.	F ₁ Crosses		S. No. F ₁ Crosses
1.	FRHW-1 × FRHW-2		11. FRHW-3 × PSEV3
2.	FRHW-1 × FRHW-3		12. FRHW-3 × SWAJK-1
3.	FRHW-1 × PSEV3		13. PSEV3 × FRHW-1
4.	FRHW-1 × SWAJK-1		14. PSEV3 × FRHW-2
5.	FRHW-2 × FRHW-1		15. PSEV3 × FRHW-3
6.	FRHW-2 × FRHW-3		16. PSEV3 × SWAJK-1
7.	FRHW-2 × PSEV3		17. SWAJK-1 × FRHW-1
8.	FRHW-2 × SWAJK-1		18. SWAJK-1 × FRHW-2
9.	FRHW-3 × FRHW-1		19. SWAJK-1 × FRHW-3
10.	FRHW-3 × FRHW-2		20. SWAJK-1 × PSEV3

Association between days to 50% tasseling and other characters

At CCRI (Table 2), days to 50% tasseling revealed positive and significant association with days to 50% pollen shedding, days to 50% silking and days to physiological maturity, while negative and non-significant association with plant height, ear height, primary leaf area, fresh ear weight, ear diameter, ear length, grains per row, grain

yield and grain yield efficiency both at genotypic and phenotypic levels. Biological yield and rows per ear showed positive but non-significant association with days to 50% tasseling at genotypic and phenotypic levels, but ASI and rows per ear revealed positive and non-significant association at genotypic level and negative and non-significant at phenotypic level with the said trait.

Kwon and Torrie[16] also found similar results of negative and significant magnitude between days to 50% tasseling and grain yield but contradictory results of positive and significant nature were observed by [17] between grain yield and days to 50% tasseling. Similar results were also observed by [18]. He also reported negative association of days to 50% tasseling with the all of the studied traits including grain yield except days to 50% silking and days to maturity.

Association between days to 50% pollen shedding and other characters

Days to 50% pollen shedding showed positive and significant association with days to 50% silking and days to physiological maturity, while negative but significant with thousand grain weight, shelling percentage and harvest index and negative non-significant association with plant height, ear height, primary leaf area, fresh ear weight, ear diameter, ear length, grains per row, grain yield, and grain yield efficiency both at genotypic and phenotypic levels. Days to 50% pollen shedding showed positive and non-significant association with biological yield, rows per ear and moisture content at both genotypic and phenotypic levels

Results of [19] are partially in line with the negative association of days to 50% pollen shedding with grain yield; however they observed significant negative association between these two traits. [19] Also observed negative association of days to 50% pollen shedding with ASI, plant height, ear height, moisture content and 100 grain weight.[17] also found positive association of days to 50% pollen shedding with days to 50% silking, ASI, plant height, ear height and ear weight, which were fully according to the results of Swat, however contradictory to the present research work, he observed positive association between days to 50% pollen shedding and grain yield.

Association between days to 50% silking and other characters

Days to 50% silking has positive significant genotypic and positive non-significant phenotypic correlation with days to physiological maturity at CCRI (Table 2), while negative significant association with thousand grain weight and shelling percentage at genotypic and phenotypic levels and negative significant association with grain yield and harvest index at genotypic level and negative non-significant at phenotypic level. Days to 50% silking has positive and non-significant association with ASI, biological yield, rows per ear and moisture content.

These results are similar to the findings revealed earlier by [20] who also found negative correlation of days to 50% silking with ear length, shelling percentage and grain yield. They also recorded positive association of rows per ear with the said trait. [21] had also manifested negative association of non-significant nature of days to 50% silking with fresh ear weight and grain yield while positive association with anthesis silking interval in their studies on maize. Results of [16, 18] agreed with the negative results of days to 50% silking with grain yield however they recorded significant association between these two traits.

Association between anthesis silking interval and other characters

Anthesis silking interval has positive and non-significant association with rows per ear and harvest index while negative and non-significant with plant height, ear height, primary leaf area, days to physiological maturity, biological yield, percent prolificacy, ear diameter, ear length, grains per row, thousand grain weight and shelling percentage and negative significant with fresh ear weight and grain yield both at genotypic and phenotypic levels at CCRI (Table 2).

These results were corroborated by the findings of [19]. They found negative association of ASI with grain yield, ear height, 100 grain weight, while positive association with plant height and moisture content. [21] reported negative genotypic and phenotypic association of ASI with ear height and positive significant genotypic and negative phenotypic association with plant height. They also observed positive significant genotypic and positive but non-significant phenotypic association with grain yield.

Association between plant height and other characters

Positive correlation of significant level of plant height with ear height, biological yield, fresh ear weight, ear length, grains per row, thousand grain weight, shelling percentage and grain yield was observed in both the models (genotypic and phenotypic), where the association of plant height with days to physiological maturity, ear diameter, moisture content and grain yield efficiency was of positive nature but did not reach the level of significance both at genotypic and phenotypic levels (Table 2). The association of plant height with percent prolificacy and harvest index was of non-significant level with negative sign.

Positive and significant genotypic and phenotypic association of plant height with ear height, ear length, grains per row, 100 grain weight and grain yield was also observed by [18]. Similarly [20] reported significant genotypic and phenotypic association of plant height with ear length, rows per ear, shelling percentage and grain yield while studying different maize crosses. [22] Reported positive association plant height with ear height, leaf area, rows per ear and grain yield. Corroborating results of positive and significant nature between plant height and grain yield were also reported by some other researchers [17, 19].

Association between ear height and other characters

Association between ear height and percent prolificacy was recorded to be significant and of positive nature at genotypic level and non-significant with positive nature at phenotypic level (Table 2). The association of ear height with fresh ear weight, , grains per row, thousand grain weight, shelling percentage, moisture content, grain yield, harvest index and grain yield efficiency was observed to be non-significant and of positive nature both at genotypic and phenotypic levels. Negative and non-significant association of ear height with primary leaf area, days to physiological maturity, biological yield, ear diameter and rows per ear was also revealed both at genotypic and phenotypic levels. The association between ear height and ear length was observed to be negative and non-significant at genotypic level and positive and non-significant at phenotypic level.

These results are in line with those reported by [22], while studying different maize genotypes and concluded positive genetic association of ear height with plant height, leaf area, fresh ear weight, grains per row, 100 grain weight and grain yield. The positive association is partially similar to the results of [23] who also observed positive association between ear height and grain yield, but with significant nature. Negative and non-significant association of ear height with percent prolificacy, fresh ear weight and grain yield was recorded by [21], which is in line with the present research findings at Swat. Partially corroborating results were also reported by [18], who stated that ear length was positively but significantly correlated with ear length, grains per row, shelling percentage and grain yield, while negative association of non-significant nature was observed with rows per ear.

Association between primary leaf area and other characters

Positive correlation of significant level of primary leaf area with biological yield, fresh ear weight, ear diameter, ear length, rows per ear, grains per row, thousand grain weight, shelling percentage and grain yield was manifested in both the models (genotypic and phenotypic), where the association of primary leaf area with days to physiological maturity, moisture content and grain yield efficiency was of positive nature but did not reach the level of significance both at genotypic and phenotypic levels (Table 2). The magnitude of association of primary leaf area with percent prolificacy and harvest index was of non-significant level with negative sign both at genotypic and phenotypic level.

These results are in line with the results of [24] who reported positive and significant association of leaf area with days to maturity, ear length, rows per ear, 100 grain weight and grain yield. Positive and significant association of leaf area with ear weight, grains per row and grain yield and non-significant but positive with rows per ear was also observed by [22]. Significant and positive genotypic and phenotypic association of leaf area and grain yield was also observed by [11, 20], while [25] manifested positive but non-significant association between these two parameters.

Association between days to physiological maturity and other characters

Genotypic and phenotypic correlation coefficient presented in (Table 2) revealed that correlation of days to physiological maturity with biological yield was significantly positive at both the levels, while its association with fresh ear weight, ear diameter, ear length, rows per ear, grains per row, thousand grain weight, moisture content, grain yield and grain yield efficiency was positive but non-significant both at genotypic and phenotypic levels. Days to

physiological maturity revealed negative and non-significant correlation with percent prolificacy and shelling percentage and negative significant with harvest index both at genotypic and phenotypic levels.

Positive association of days to maturity with grain yield will result in higher yield, as delay in maturity will provide more dry matter accumulation towards grain development for extended period of time. [26] found similar results of positive nature between grain yield and days to physiological maturity. Partially corroborating results were reported by [27] who found positive but significant association between days to physiological maturity and grain yield. Partially similar results were also reported by [18] who found positive but significant correlation of days to physiological maturity with ear length, 100 grain weight and grain yield, while only positive with plant height, ear height, rows per ear and grains per row.

Association between biological yield and other characters

Positive association with significant magnitude at both the genotypic and phenotypic levels was manifested by biological yield with fresh ear weight, ear diameter, ear length, rows per ear, grains per row, thousand grain weight, shelling percentage, grain yield and grain yield efficiency (Table 2), while its association with moisture content was non-significant and of positive nature at both the levels. Biological yield was negatively correlated with non-significant nature with the prolificacy and its correlation with harvest index was significantly negative at both genotypic and phenotypic levels.

These results are in harmony with those of [28, 29], who also revealed positive and significant association between biological yield and grain yield, while [30], also revealed positive but non-significant relationship between biological and grain yield.

Association between fresh ear weight and other characters

Association of fresh ear weight with ear diameter, ear length, grains per row, thousand grain weight, shelling percentage, grain yield and grain yield efficiency was highly significant and positive at the genotypic and phenotypic levels as shown in Table 2. The association of fresh ear weight with percent prolificacy, rows per ear, moisture content and harvest index was also found to be of positive nature but with non-significant magnitude at both the genotypic and phenotypic levels.

These results are in close conformity with those of [31], who concluded also the positive and significant association of fresh ear weight with Ear length, shelling percentage, ear diameter and grain yield. [21] Also found significant genotypic and phenotypic association of ear weight with 100 grain weight and grain yield. [32] While studying different maize genotypes concluded corroborating results of positive and significant genotypic and phenotypic association of fresh ear weight with rows per ear, grains per row, 100 grain weight and grain yield.

Association between percent prolificacy and other characters

Prolificacy (%) exhibited significant and positive association with moisture content at genotypic level while the association between these two at phenotypic level was also of positive nature but with non-significant magnitude (Table 2). It is obvious from the said table that the associations of percent prolificacy with grain yield, harvest index and grain yield efficiency was positive but non-significant at genotypic and phenotypic levels. Its association with ear diameter, ear length and grains per row was of negative nature with non-significant magnitude at genotypic and phenotypic levels, whereas its association with 1000

grain weight was negative and non-significant at genotypic level but positive and non-significant at phenotypic level. The association between percent prolificacy and rows per ear was negatively significant at both the genotypic and phenotypic levels. These results are in line with the findings of [22, 25] who also reported positive genotypic and phenotypic association between these two parameters.

Association between ear diameter and other characters

The association of ear diameter with ear length, rows per ear, grains per row, 1000 grain weight, shelling percentage, grain yield and grain yield efficiency was positive as well as significant at the genotypic and phenotypic levels and its association with grain yield efficiency was also positive but non-significant at both the genotypic and phenotypic levels (Table 2). The correlation of ear diameter with moisture content and harvest index was negative and non-significant. Similar results of positive and significant association of ear diameter with ear length, 1000 grain weight and grain yield was reported by [23, 33]. Corroborating results were also reported by [32] who also found significant genotypic and phenotypic association of ear diameter with ear length, rows per ear, grains per row, 100 grain weight and grain yield.

Association between ear length and other characters

The association of ear length with rows per ear, grains per row, 1000 grain weight, shelling percentage, grain yield and grain yield efficiency was positive and significant at both genotypic and phenotypic levels (Table 2) however, its association with harvest index was non-significant and negative at both the levels. The relationship among ear length and moisture content at the genotypic and phenotypic levels was positive but non-significant.

These results are in line with the finding of [33] who also reported positive and significant association of ear length with 1000 grain weight and grain yield. Fully corroborating results of positive and significant genotypic and phenotypic relationship of ear length with fresh ear weight, grains per row, 100 grain weight and grain yield was revealed by [32].

Association between rows per ear and other characters

Significant association of rows per ear with shelling percentage of positive nature at both the genotypic and phenotypic levels was recorded, while its association with grains per row and grain yield was positive and significant at genotypic level and positive but non-significant at phenotypic level (Table 2). The association of rows per ear with 1000 grain weight and grain yield efficiency was non-significant but positive at both the genotypic and phenotypic levels. Rows per ear were non-significantly as well as negatively correlated with moisture content and harvest index at genotypic and phenotypic levels. Similar results of positive and significant association between rows per ear and grain yield were reported by [16, 23, 34, 35] in their studies on maize. Positive but non-significant genotypic and phenotypic association between rows per ear and grain yield was reported by [18].

Association between grains per row and other characters

Grains per row was positively and significantly correlated with 1000 grain weight, shelling percentage, grain yield and grain yield efficiency at the genotypic and phenotypic levels (Table 2). Grains per row was non-significantly correlated with moisture content and harvest index at the genotypic and phenotypic levels, however the magnitude of moisture content was positive and that of harvest index was negative at both the levels.

The association of grains per row with 1000 grain weight, shelling percentage and grain yield was highly significant and positive at genotypic and phenotypic levels at CCRI. Parallel positive and significant relationship between grains per row and grain yield was also reported by [16, 22]. These results are also similar to those reported earlier by [18], who observed positive significant genotypic and phenotypic association of grains per row with 100 grain weight, shelling percentage and grain yield. Positive significant genotypic and phenotypic association between grain per row and grain yield was also reported by [32].

Association between 1000 grain weight and other characters

Association of 1000 grain weight with shelling percentage, grain yield and grain yield efficiency was highly significant and positive at both genotypic and phenotypic levels (Table 2) but its association with harvest index was negative and non-significant at both the genotypic and phenotypic levels. The relationship between 1000 grain weight and moisture content was positive but non-significant at genotypic as well as phenotypic levels.

This significant and positive association indicated that increase in 1000 grain weight will increase shelling percentage and grain yield by using these materials. [16, 18, 20, 23, 24, 34] Reported positive and significant relationship between grain weight and grain yield. [18] Also observed positive significant genotypic and phenotypic association between 100 grain weight and shelling percentage.

Association between grain yield and other characters

The association of grain yield with grain yield efficiency was highly significant and positive and with harvest index was non-significant and positive at the genotypic and phenotypic levels (Table 2).

Table 2. Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients between various traits in 5×5 F₁diallel maize hybrids at CCRI

Traits	DT	DPS	DS	ASI	PH	EH	PLA	DM	FEW	Pro	ED	EL	GRPE	GPR	TGW	SP	MC	GY	BY	HI	GYE
DT		0.98**	0.39*	-0.10	-0.27	-0.02	0.10	0.27	-0.20	0.14	-0.42	-0.34	-0.30	-0.08	-0.38	-0.49	-0.16	-0.25	-0.25	0.10	-0.59
DPS	0.95**		0.43*	-0.15	-0.26	0.03	-0.56**	0.25	-0.22	0.16	-0.47*	-0.36	-0.26	-0.06	-0.45*	-0.53**	-0.10	-0.29	-0.30	0.13	0.07
DS	0.36	0.41*		0.10	-0.27	-0.003	-0.50**	0.35	-0.25	0.06	-0.41*	-0.33	-0.15	-0.05	-0.45*	-0.54**	-0.14	-0.31	-0.23	0.01	0.01
ASI	-0.08	-0.13	0.12		-0.03	-0.13	0.25	0.45	-0.12	-0.37	0.26	0.16	0.45*	0.08	-0.002	-0.01	-0.14	-0.09	0.27	-0.49**	-0.26
PH	-0.26	-0.24	-0.25	-0.04		0.39*	0.39*	0.31	0.54**	-0.05	0.36	0.48*	0.26	0.54**	0.57**	0.43*	0.33	0.53**	0.59**	-0.31	0.35
EH	-0.02	0.03	-0.001	-0.12	0.39*		-0.10	0.10	0.16	0.40*	-0.18	-0.003	-0.12	0.12	0.07	0.01	0.37	0.113	-0.03	0.09	0.25
PLA	0.11	-0.53**	-0.47*	0.24	0.38	-0.10		0.05	0.55**	-0.21	0.77**	0.57**	0.66**	0.47*	0.59**	0.68**	0.20	0.60**	0.61**	-0.25	0.06
DM	0.25	0.24	0.32	0.43	0.31	0.10	0.05		0.20	-0.14	0.07	0.004	0.28	0.26	0.04	-0.14	0.18	0.14	0.43*	-0.48	0.15
FEW	-0.19	-0.21	-0.24	-0.11	0.52**	0.15	0.53**	0.20		0.11	0.63**	0.70**	0.37	0.68**	0.82**	0.65**	0.38	0.99**	0.70**	0.002	0.83**
Pro	0.11	0.12	0.41	-0.31	-0.02	0.33	-0.16	-0.11	0.12		-0.52**	-0.36	-0.56**	-0.18	-0.01	-0.18	0.40*	0.04	-0.14	0.21	0.22
ED	-0.40	-0.44*	-0.39*	0.22	0.33	-0.19	0.73**	0.06	0.61**	-0.38		0.76**	0.82**	0.49**	0.78**	0.74**	-0.001	0.69**	0.70**	-0.28	0.33
EL	-0.31	-0.34	-0.30	0.15	0.46*	0.004	0.56**	-0.002	0.68**	-0.29	0.72**		0.46*	0.75**	0.77**	0.65**	0.05	0.74**	0.56**	-0.06	0.52**
GRPE	-0.25	-0.24	-0.15	0.35	0.24	-0.13	0.57**	0.25	0.32	-0.41	0.70**	0.40*		0.40*	0.34	0.45*	-0.12	0.42*	0.51**	-0.25	0.06
GPR	-0.09	-0.07	-0.05	0.07	0.53**	0.13	0.46*	0.25	0.66**	-0.13	0.46*	0.74**	0.34		0.43*	0.54**	0.15	0.69**	0.53**	-0.04	0.56**
TGW	-0.33	-0.39*	-0.39*	-0.003	0.49*	0.07	0.54**	0.03	0.73**	0.03	0.66**	0.70**	0.27	0.39*		0.78**	0.23	0.86**	0.70**	-0.16	0.65**
SP	-0.46	-0.50**	-0.50**	-0.01	0.42*	0.01	0.67**	-0.13	0.62**	-0.15	0.70**	0.64**	0.39*	0.53**	0.69**		0.09	0.76**	0.55**	-0.01	0.50*
MC	-0.14	-0.09	-0.12	-0.13	0.30	0.34	0.19	0.18	0.37	0.33	-0.01	0.05	-0.09	0.14	0.20	0.09		0.27	0.21	-0.08	0.25
GY	-0.24	-0.28	-0.30	-0.08	0.52**	0.11	0.58**	0.14	0.98**	0.05	0.67**	0.73**	0.37	0.68**	0.76**	0.74**	0.25		0.71**	0.01	0.82**
BY	-0.25	-0.28	-0.22	0.25	0.56**	-0.03	0.60**	0.42*	0.69**	-0.10	0.68**	0.55**	0.43*	0.52**	0.63**	0.54**	0.20	0.70**		-0.69**	0.41*
HI	0.11	0.12	0.01	-0.44*	-0.27	0.09	-0.24	-0.47	0.02	0.16	-0.27	-0.05	-0.21	-0.04	-0.14	-0.01	-0.07	0.02	-0.68**		0.22
GYE	-0.56	0.06	0.002	-0.25	0.35	0.24	0.05	0.14	0.83**	0.20	0.33	0.51**	0.06	0.55**	0.57**	0.48*	0.24	0.82**	0.41*	0.23	

[30] Reported positive but non-significant association between these two parameters, which is also in line with the present research study. Contrasting results of negative and non-significant association between grain yield and harvest index was reported by [28, 29] which might be due to different genetic makeup of the material used in the present research work.

Conclusions

Genotypic and phenotypic correlations were studied among various traits. Grain yield revealed negative genotypic and phenotypic correlations with earliness traits i.e. days to 50% tasseling, pollen shedding, silking. Although, genotypic and phenotypic correlations of grain yield were significantly positive with yield contributing traits i.e. primary leaf area, ear diameter, ear length, grain rows per ear, grains per row, 1000-grain weight, shelling percentage and biological yield.

Authors' contributions

Conceived and designed the experiments: S Ali, M Iqbal & NU Khan, Performed the experiments: S Ali, Analyzed the data: A Farid, A Khan, I Hussain, SM Khan & K Naveed, Contributed reagents/ materials/ analysis tools: N Ali, I Ali, S Akbar, Wrote the paper: S Ali.

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