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ASSESSMENT OF TRAIT RELATIONSHIP IN WHEAT (*TRITICUM AESTIVUM* L.) USING CORRELATION AND PATH COEFFICIENT ANALYSIS

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ABSTRACT

The present study was conducted during *Rabi* 2024–25 at C.S. Azad University of Agriculture and Technology, Kanpur, to identify key traits influencing seed yield in wheat crop. The experimental material comprised 157 treatments (21 parents, 68 F_1s, and 68 F_2s) evaluated in a randomized block design with three replications. Sixteen morphological and physiological traits were recorded, and correlation and path coefficient analysis were done to identify the association between seed yield and yield attributing traits. Correlation analysis showed that seed yield per plant had significant positive associations with biological yield, harvest index, and chlorophyll content in parents; with productive tillers, number of grains per spike, and harvest index in F_1s; and with harvest index in F_2s. Path analysis revealed that harvest index and biological yield exerted the strongest direct effects on seed yield across all generations, followed by number of grains per spike, productive tillers, and 1000-seed weight. Biological yield and chlorophyll content also contributed indirectly to yield through harvest index and other traits. The findings suggested that traits *viz.,* harvest index, biological yield per plant, number of grains per spike, and productive tillers were the most important as they are positively associated as well as directly affecting seed yield. Therefore, focus should be given on selection of genotypes based on these characters for the development of superior wheat genotypes with more seed yield and improved productivity.

***Keywords*:** Wheat, Correlation coefficient, Path coefficient, Seed yield, Chlorophyll content.

Introduction

Wheat (*Triticum aestivum* L) is one of the most important self-pollinating crop belongs to the Poaceae family and having chromosome number 2n=6x=42. About 55-70% of the world's culinary calories and 20% of its protein comes from wheat, which also contains 1.7% fat, 2.7% minerals, 2% fiber, and 12% moisture (Breiman and Graur., 1995; Sharma *et al.,* 2021). Additionally, it contains a number of vitamins and minerals, including riboflavin (0.13 mg 100 g^{-1}), calcium (37 mg 100 g^{-1}), nicotinic acid (5.4 mg 100 g^{-1}), iron (4.1 mg 100 g^{-1}), and thiamine (0.45 mg 100 g^{-1}) (Lorenz and Kulp, 1991). Due to Its significance, it is known as the “King of cereals”.

Being a major cereal crop, wheat accounts for about 30% of the world’s cereal area to provide food for about 36% of the global population. In India wheat is cultivated around 31.86 million hectares area with

production of 112.19 million and crop productivity of 3484 kg/ha (Anonymous, 2022-23). Uttar Pradesh holds the top position in both land area and wheat production among Indian states. The state achieves an impressive wheat yield of 38.07 million tonnes from a cultivated area of 10.19 million hectares, resulting in a productivity rate of 3,730 kg per hectare (Anonymous, 2022-23).

As the population of the world is increasing rapidly day-by-day, the risks of food crisis are also increasing. According to an estimate by Singh *et al.* (2019), with the ongoing expansion of population in the nation, there will be a requirement of more than 140 million tons of wheat grain to be produced by 2050 and local production is insufficient to fulfil current demand.

Wheat production can increase either through increasing yield per unit land, or by expanding the cultivated area. Since, crop land expansion is a very difficult option because land is a finite resource and expansion of cultivated land causes human residential, livestock grazing and some other problems (Semahegn *et al.*, 2020). Therefore, there is a need of development of genotypes which have high yield.

According to Chhibber and Jain (2014) there is need to identify traits related with yield and more focus should be given on those traits which are closely associated with grain yield. While correlation analysis is widely used to study the relationship between yield and its components, it alone is insufficient to determine their relative importance (Ali and Shakor, 2012; Anwar *et al*., 2009; Bhutta *et al*., 2005). Therefore, there is need of path coefficient analysis which provides more information by partitioning correlations into direct and indirect effects of yield components on grain yield (Del Moral *et al*., 2003).

Keeping above points in mind present investigation was conducted to identify those traits which are closely associated and directly or indirectly influencing the seed yield.

Material and Methods

The present experiment comprised of 157 treatments (21 parents + 68 F_1s + 68 F_2s) was conducted at Nawabganj Farm of C. S. Azad University of Agriculture and Technology, Kanpur-208002 (U.P.) during *Rabi*, 2024-25. All the parents along with crosses were grown in randomized block design with three replications each and spacing of 20 x 10 cm. Observations were recorded for 16 metric traits namely, days to 50% heading, days to maturity, plant height (cm), number of total tillers per plant, number of productive tillers per plant, flag leaf area (cm^2), spike length (cm), number of spikelets per spike, number of grains per spike, biological yield per plant (gm), 1000-seed weight (gm), harvest index (%), seed yield per plant (gm), protein content (%), chlorophyll content ($\mu mol\ m^{-2}$) and canopy temperature depression (°C).

Statistical analysis was done by using MS Excel 2021. The correlations between characters were determined by using the Pearson correlation coefficient method and "metan" package (Olivoto and Lúcio, 2020) in R software. The direct and indirect effects of each trait were assessed by using path analysis (Dewey and Lu., 1959) and R software.

Results and Discussion

(A) Correlation coefficient

The genetic architecture of seed yield is based on the balance or overall net effect of various yield components which are directly or indirectly interacting with each another. Therefore, selection for yield *per se* alone would not be effective unless selection for various yield component characters responsible also done. Therefore, identification of yield components and information regarding their relationship with seed yield and with each other are very important for developing high yielding varieties. The correlation between yield and contributing traits among parents, F_1s and F_2s are depicted in Table 1, 2 & 3 respectively.

In present investigation, among parents, seed yield per plant showed significant and positive association with biological yield per plant (0.83**), harvest index (0.88*) and chlorophyll content (0.60**), while with number of productive tillers per plant (0.28*), number of grains per spike (0.46**) and harvest index (0.55**) in F_1s and with harvest index (0.57**) in F_2 generation. Similar reports were given for number of productive tillers per plant by Baranwal *et al*. (2012), Kamani *et al*. (2017) and Singh *et al.* (2023), for biological yield per plant by Tripathi *et al.* (2011), Bhushan *et al*. (2013), Avinashe *et al*. (2015), Kamani *et al*. (2017), Dvivedi *et al.* (2023) and Kumar *et al*. (2025), for number of grains per spike by Tripathi *et al.* (2011), Kumar *et al*. (2014) and Kumar *et al*. (2025), for harvest index by Kumar *et al*. (2014), Avinashe *et al*. (2015), Kamani *et al*. (2017), Dvivedi *et al.* (2023), Singh *et al.* (2023) and Kumar *et al*. (2025) and for chlorophyll content by Fellahi *et al*. (2013) and Karla *et al.* (2024).

The traits *viz.,* days to maturity (-0.07), plant height (-0.12), spike length (-0.13), number of spikelets per spike (-0.10) and number of grains per spike (-

0.28) among parents, plant height (F_1 = -0.11, F_2 -0.10), flag leaf area (F_1 = -0.09, F_2 = -0.10), spike length (F_1 = -0.07, F_2 = -0.06), biological yield per plant (F_1 = -0.03, F_2 = -0.12) and protein content (F_1 = -0.03, F_2 = -0.05) among F_1 and F_2 exhibited negative but non-significant correlation with seed yield per plant. This finding also supported by Bhushan *et al*. (2013) and Mahparaa *et al.* (2024) for days to maturity, Bhushan *et al*. (2013) and Mahparaa *et al.* (2024) for plant height, Dvivedi *et al.* (2023), Maurya *et al.* (2023) and Singh *et al.* (2023) for flag leaf area, Maurya *et al*. (2023) and Singh *et al.* (2023) spike length, Singh *et al.* (2020) for number of spikelets per spike, Singh *et al.* (2020) and Singh *et al.* (2023) for biological yield per plant and Kumari *et al.* (2020) for protein content.

(B) Path coefficient

The technique of path coefficient was given by Wright (1921) and later applied to plant breeding by Dewey and Lu (1959), and now a days it is widely used in crop improvement program. It enables breeders to evaluate the contribution of different traits to yield, thereby assisting in the development of efficient selection strategies. Therefore, present investigation was also done to study the direct and indirect effects of different characters (independent) on seed yield per plant (dependent). The direct and indirect effect of studied traits towards seed yield per plants among parents, F_1s and F_2s are depicted in Table 4,5 & 6 respectively.

In present investigation, maximum positive direct effect on seed yield per plant was exhibited by harvest index (P = 0.6131, F_1 = 1.8203 & F_2 = 1.9219) in all three generations. The traits namely, biological yield per plant (P = 0.5382, F_1 = 1.5285 & F_2 = 1.6377), number of grains per spike (P = 0.0087, F_1 = 0.0481 & F_2 = 0.0004), protein content (P = 0.0095, F_1 = 0.0276 & F_2 = 0.0098), canopy temperature depression (P = 0.0013, F_1 = 0.0234 & F_2 = 0.0115), 1000-seed weight (P = 0.0031, F_1 = 0.0023 & F_2 = 0.0106) and number of productive tillers per plant (P = 0.0006, F_1 = 0.0348 & F_2 = 0.1341) also exhibited positive and direct effect on seed yield per plant across all three generations. This indicates that these characters emerged are most important direct yield contributors and emphasis should be given on these traits during selection of superior genotypes for seed yield in wheat. Previous workers *viz.,* Tripathi *et al.* (2011), Bhushan *et al*. (2013), Rathod *et al*. (2019), Alnajjar and Dawod (2020), Devesh *et al.* (2021), Maurya *et al.* (2023) and Singh *et al.* (2023) also found direct influence of these traits on seed yield per plant**.**

Biological yield per plant showed strong positive indirect effects on grain yield through harvest index, chlorophyll content, protein content, spike length, and number of grains per spike, while minor negative effects were recorded *via* plant height, total tillers, and canopy temperature depression. Harvest index consistently contributed positively across F_1 and F_2 generations, with notable indirect effects through biological yield and yield components, though some negative influence was observed *via* flag leaf area and protein content. Chlorophyll content also played an important role, enhancing yield indirectly through biological yield, harvest index, and grain number.

Through above paragraphs it was identified that harvest index, biological yield per plant were most important traits because they exhibited both direct as well as indirect positive effect on seed yield and its contributing traits. Therefore, emphasis should be given on these traits during selection for identifying superior genotypes with improved seed yield potential in wheat crop.

Conclusion

Effective selection is very crucial for improvement of seed yield and understanding of the interrelationships among yield-contributing traits helps in determining their importance. There are several traits which directly or indirectly influenced the seed yield in wheat. These traits also showed positive or negative association with seed yield. Therefore, evaluating both the performance of individual characters and their correlations is essential in genotype selection. Traits with strong direct effects and positive associations with yield, such as biological yield per plant, harvest index, number of grains per spike, and number of productive tillers per plant should be prioritized in future breeding programs in selection of superior genotypes for seed yield which ultimately enhance productivity in wheat crop.

Table 1 : Pearson's correlation coefficients among 16 characters of parents in wheat

	DH	DM	PH	NTT	NPT	FLA	SL	NSS	NGS	BYP	TSW	HI	CC	CTD	PC	SYP
DH	1	0.82**	0.34	0.04	0.17	0.04	-0.30	0.59**	0.55	-0.13	-0.19	0.14	-0.09	-0.05	0.13	0.02
DM		1	0.54*	-0.1	0.20	0.13	-0.26	0.56**	0.29	-0.18	-0.18	0.04	0.15	-0.03	-0.12	-0.07
PH			1	-0.13	0.25	0.30	0.31	0.25	-0.15	-0.27	-0.28	0.05	-0.02	-0.38	-0.32	-0.12
NTT				1	0.67**	0.15	-0.03	-0.02	-0.16	0.28	0.12	0.26	0.25	0.27	0.11	0.30
NPT					1	0.32	0.03	0.18	-0.30	0.33	0.05	0.36	0.36	0.33	0.06	0.39
FLA						1	0.64**	-0.15	-0.32	0.16	0.11	0.25	0.03	0.37	-0.14	0.22
SL							1	-0.13	-0.36	-0.1	0.15	-0.08	-0.22	0.06	-0.13	-0.13
NSS								1	0.47*	-0.02	-0.11	-0.15	0.01	0.13	0.22	-0.10
NGS									1	-0.27	0.08	-0.23	-0.39	-0.27	0.32	-0.28
BYP										1	0.34	0.47*	0.43	0.45*	0.35	0.83**
TSW											1	0.12	0.20	0.23	0.45*	0.26
HI												1	0.57**	0.12	-0.04	0.88**
CC													1	0.39	-0.22	0.60**
CTD														1	0.16	0.32
PC															1	0.17
SYP																1

*, ** Significant at 5% and 1% probability level, respectively

DH = Days to 50% Heading, **DM** = Days to Maturity, **PH** = Plant Height (cm),
NTT = Number of Total Tillers per plant **NPT** = Number of Productive Tillers per plant, **FLA** = Flag Leaf Area (cm^2)
SL = Spike Length (cm) **NSS** = Number of Spikelet per Spike **NGS** = Number of Grains per Spike
BYP = Biological Yield Per Plant (g) **TSW** = 1000 Seed Weight (g) **HI** = Harvest index (%)
SYP = Seed Yield Per Plant (g), **CC** = Chlorophyll Content (µmol m^{-2}) **CTD** = Canopy Temperature Depression (°C)
PC = Protein Content (%)

Table 2 : Pearson's correlation coefficients among 16 characters of F_1 in wheat

	DH	DM	PH	NTT	NPT	FLA	SL	NSS	NGS	BYP	TSW	HI	CC	CTD	PC	SYP
DH	1	-0.02	0.01	0.09	0.12	0.21	-0.15	-0.02	0.08	0.02	-0.12	0.02	0.11	-0.09	0.14	0.05
DM		1	0.13	-0.07	-0.07	0.05	0.15	0.08	0.09	0.07	0.01	-0.01	-0.04	-0.19	0.08	0.11
PH			1	0.15	0.07	0.09	0.08	0.01	0.09	0.91**	0.01	-0.82**	0.03	-0.19	0.13	-0.11
NTT				1	0.85**	-0.09	-0.06	-0.01	0.23	0.14	0.09	-0.01	0.06	0.01	0.16	0.22
NPT					1	-0.1	-0.12	0.01	0.30*	0.10	-0.03	0.06	0.15	-0.06	0.10	0.28*
FLA						1	0.24	-0.13	-0.13	0.10	-0.07	-0.14	-0.04	0.03	-0.17	-0.09
SL							1	0.01	-0.28*	0.02	0.24*	-0.04	-0.05	0.15	0.10	-0.07
NSS								1	0.34**	-0.02	-0.06	0.13	0.04	0.14	0.10	0.19
NGS									1	0.08	-0.09	0.16	0.19	-0.03	0.11	0.46**
BYP										1	0.01	-0.85**	0.09	-0.15	0.11	-0.03
TSW											1	-0.09	-0.21	0.37**	0.27*	0.12
HI												1	0.03	0.13	-0.12	0.55**
CC													1	-0.20	-0.01	0.15
CTD														1	-0.05	0.04
PC															1	-0.03
SYP																1

*, ** Significant at 5% and 1% probability level, respectively

DH = Days to 50% Heading, **DM** = Days to Maturity, **PH** = Plant Height (cm),
NTT = Number of Total Tillers per plant **NPT** = Number of Productive Tillers per plant, **FLA** = Flag Leaf Area (cm^2)
SL = Spike Length (cm) **NSS** = Number of Spikelet per Spike **NGS** = Number of Grains per Spike
BYP = Biological Yield Per Plant (g) **TSW** = 1000 Seed Weight (g) **HI** = Harvest index (%)
SYP = Seed Yield Per Plant (g), **CC** = Chlorophyll Content (µmol m^{-2}) **CTD** = Canopy Temperature Depression (°C)
PC = Protein Content (%)

Table 3 : Pearson's correlation coefficients among 16 characters of F_2 in wheat

	DH	DM	PH	NTT	NPT	FLA	SL	NSS	NGS	BYP	TSW	HI	CC	CTD	PC	SYP
DH	1	-0.03	-0.01	0.04	-0.03	0.13	-0.20	-0.12	-0.06	-0.01	-0.05	0.03	-0.13	-0.02	0.04	0.06
DM		1	0.07	-0.12	-0.13	0.02	0.14	0.17	0.01	-0.01	0.04	0.03	-0.08	-0.15	0.12	0.06
PH			1	0.14	0.13	0.08	0.08	0.06	0.08	0.95**	0.03	-0.83**	0.05	-0.19	0.12	-0.10
NTT				1	0.80**	-0.09	-0.09	-0.19	-0.12	0.16	0.29*	-0.08	0.03	-0.02	0.14	0.10
NPT					1	-0.04	-0.09	-0.31*	-0.11	0.16	0.17	-0.22	-0.07	-0.1	0.04	0.23
FLA						1	0.23	0.01	-0.07	0.13	-0.16	-0.15	-0.04	0.04	-0.17	-0.10
SL							1	0.07	-0.15	0.05	0.14	-0.05	0.10	0.15	0.10	-0.06
NSS								1	0.06	0.01	-0.12	0.03	-0.03	0.15	-0.12	0.08
NGS									1	0.06	-0.01	0.06	0.11	-0.18	-0.12	0.21
BYP										1	0.04	-0.87**	0.06	-0.16	0.10	-0.12
TSW											1	0.03	-0.16	0.35**	0.18	0.12
HI												1	0.03	0.13	-0.12	0.57**
CC													1	-0.16	-0.02	0.15
CTD														1	-0.05	0.02
PC															1	-0.05
SYP																1

*, ** Significant at 5% and 1% probability level, respectively

DH = Days to 50% Heading, **DM** = Days to Maturity, **PH** = Plant Height (cm),
NTT = Number of Total Tillers per plant **NPT** = Number of Productive Tillers per plant, **FLA** = Flag Leaf Area (cm^2)
SL = Spike Length (cm) **NSS** = Number of Spikelet per Spike **NGS** = Number of Grains per Spike
BYP = Biological Yield Per Plant (g) **TSW** = 1000 Seed Weight (g) **HI** = Harvest index (%)
SYP = Seed Yield Per Plant (g), **CC** = Chlorophyll Content (µmol m^{-2}) **CTD** = Canopy Temperature Depression (°C)
PC = Protein Content (%)

Table 4 : Direct and indirect effect of 16 traits on seed yield per plant of 21 parents

	DH	DM	PH	NTT	NPT	FLA	SL	NSS	NGS	BYP	TSW	HI	CC	CTD	PC	linear
DH	**0.0162**	-0.0132	0.0016	-0.0005	0.0001	-0.0002	0.0049	0.0015	-0.0048	-0.0702	-0.0006	0.0882	-0.0017	0.0002	0.0012	0.0227
DM	0.0133	**-0.0162**	0.0025	0.0012	0.0001	-0.0006	0.0042	0.0014	-0.0025	-0.0957	-0.0005	0.0227	0.0031	0.0001	-0.0011	-0.0679
PH	0.0055	-0.0088	**0.0047**	0.0016	0.0001	-0.0013	-0.0052	0.0006	0.0013	-0.1466	-0.0009	0.0306	-0.0003	0.0014	-0.0030	-0.1204
NTT	0.0007	0.0016	-0.0006	**-0.0129**	0.0004	-0.0007	0.0005	-0.0001	0.0014	0.1520	0.0004	0.1565	0.0050	-0.0010	0.0010	0.3041
NPT	0.0028	-0.0032	0.0012	-0.0086	**0.0006**	-0.0014	-0.0005	0.0005	0.0026	0.1753	0.0002	0.2182	0.0072	-0.0012	0.0006	0.3942
FLA	0.0006	-0.0020	0.0014	-0.0020	0.0002	**-0.0044**	-0.0106	-0.0004	0.0028	0.0851	0.0003	0.1523	0.0007	-0.0014	-0.0014	0.2212
SL	-0.0048	0.0041	0.0015	0.0004	0.0000	-0.0028	**-0.0166**	-0.0003	0.0031	-0.0552	0.0005	-0.0519	-0.0045	-0.0002	-0.0013	-0.1282
NSS	0.0096	-0.0091	0.0012	0.0003	0.0001	0.0007	0.0022	**0.0025**	-0.0041	-0.0132	-0.0003	-0.0926	0.0001	-0.0005	0.0021	-0.1011
NGS	-0.0090	-0.0047	-0.0007	0.0020	-0.0002	0.0014	0.0059	0.0012	**0.0087**	0.1435	0.0003	0.1400	-0.0079	0.0010	0.0030	0.2848
BYP	-0.0021	0.0029	-0.0013	-0.0036	0.0002	-0.0007	0.0017	-0.0001	0.0024	**0.5382**	0.0011	0.2855	0.0087	-0.0016	0.0033	0.8344**
TSW	-0.0031	0.0028	-0.0013	-0.0016	0.0000	-0.0005	-0.0025	-0.0003	-0.0007	0.1838	**0.0031**	0.0763	0.0040	-0.0009	0.0042	0.2635
HI	0.0023	-0.0006	0.0002	-0.0033	0.0002	-0.0011	0.0014	-0.0004	0.0020	0.2506	0.0004	**0.6131**	0.0115	-0.0004	-0.0004	0.8755**
CC	-0.0014	-0.0025	-0.0001	-0.0032	0.0002	-0.0001	0.0037	0.0001	0.0034	0.2324	0.0006	0.3495	**0.0201**	-0.0014	-0.0020	0.5992**
CTD	-0.0008	0.0004	-0.0018	-0.0035	0.0002	-0.0017	-0.0010	0.0003	0.0024	0.2432	0.0007	0.0707	0.0078	**0.0013**	0.0015	0.3198
PC	0.0021	0.0019	-0.0015	-0.0014	0.0000	0.0006	0.0022	0.0005	-0.0028	0.1886	0.0014	-0.0252	-0.0043	-0.0006	**0.0095**	0.1711

*, ** Significant at 5% and 1% probability level, respectively

DH = Days to 50% Heading, **DM** = Days to Maturity, **PH** = Plant Height (cm),
NTT = Number of Total Tillers per plant **NPT** = Number of Productive Tillers per plant, **FLA** = Flag Leaf Area (cm^2)
SL = Spike Length (cm) **NSS** = Number of Spikelet per Spike **NGS** = Number of Grains per Spike
BYP = Biological Yield Per Plant (g) **TSW** = 1000 Seed Weight (g) **HI** = Harvest index (%)
SYP = Seed Yield Per Plant (g), **CC** = Chlorophyll Content (µmol m^{-2}) **CTD** = Canopy Temperature Depression (°C)
PC = Protein Content (%)

Table 5 : Direct and indirect effect of 16 traits on seed yield per plant of 68 F_1s

	DH	DM	PH	NTT	NPT	FLA	SL	NSS	NGS	BYP	TSW	HI	CC	CTD	PC	linear
DH	**-0.0324**	-0.0006	0.0001	-0.0008	0.0040	0.0070	0.0051	0.0005	0.0040	0.0309	-0.0003	0.0406	-0.0049	-0.0022	0.0039	0.0549
DM	0.0005	**0.0358**	-0.0036	0.0006	-0.0023	0.0018	-0.0049	-0.0024	0.0043	0.1014	0.0001	-0.0182	0.0018	-0.0045	0.0021	0.1125
PH	0.0002	0.0045	**-0.0281**	-0.0013	0.0025	0.0030	-0.0027	0.0001	0.0043	1.3978	0.0002	-1.4864	-0.0012	-0.0045	0.0036	-0.1084
NTT	-0.0030	-0.0024	-0.0041	**-0.0086**	0.0296	-0.0029	0.0021	0.0002	0.0110	0.2133	0.0002	-0.0187	-0.0028	0.0003	0.0045	0.2186
NPT	-0.0037	-0.0023	-0.0020	-0.0073	**0.0348**	-0.0034	0.0040	-0.0002	0.0145	0.1468	-0.0001	0.1026	-0.0069	-0.0013	0.0029	0.2782*
FLA	-0.0067	0.0019	-0.0025	0.0007	-0.0035	**0.0337**	-0.0079	0.0039	-0.0060	0.1525	-0.0002	-0.2578	0.0016	0.0007	-0.0047	-0.0942
SL	0.0049	0.0053	-0.0023	0.0005	-0.0041	0.0080	**-0.0336**	0.0000	-0.0135	0.0270	0.0006	-0.0732	0.0021	0.0034	0.0028	-0.0721
NSS	0.0005	0.0028	0.0001	0.0001	0.0003	-0.0044	0.0001	**-0.0302**	0.0165	-0.0381	-0.0001	0.2343	-0.0016	0.0033	0.0029	0.1864
NGS	-0.0027	0.0032	-0.0025	-0.0020	0.0105	-0.0042	0.0094	-0.0104	**0.0481**	0.1238	-0.0002	0.2954	-0.0085	-0.0008	0.0030	0.4622**
BYP	-0.0007	0.0024	-0.0257	-0.0012	0.0033	0.0034	-0.0006	0.0008	0.0039	**1.5285**	0.0002	-1.5420	-0.0039	-0.0035	0.0029	-0.0324
TSW	0.0038	0.0002	-0.0003	-0.0008	-0.0011	-0.0022	-0.0080	0.0019	-0.0041	0.0137	**0.0023**	-0.1554	0.0094	0.0087	0.0075	-0.1246
HI	-0.0007	-0.0004	0.0230	0.0001	0.0020	-0.0048	0.0013	-0.0039	0.0078	-1.2948	-0.0002	**1.8203**	-0.0014	0.0031	-0.0032	0.5483**
CC	-0.0035	-0.0014	-0.0008	-0.0005	0.0054	-0.0012	0.0016	-0.0011	0.0091	0.1322	-0.0005	0.0555	**-0.0446**	-0.0046	-0.0003	0.1451
CTD	0.0030	-0.0069	0.0054	-0.0001	-0.0020	0.0010	-0.0049	-0.0043	-0.0016	-0.2276	0.0009	0.2447	0.0088	**0.0234**	-0.0013	0.0386
PC	-0.0045	0.0027	-0.0037	-0.0014	0.0036	-0.0057	-0.0034	-0.0032	0.0052	0.1615	0.0006	-0.2120	0.0005	-0.0011	**0.0276**	-0.0332

*, ** Significant at 5% and 1% probability level, respectively

DH = Days to 50% Heading, **DM** = Days to Maturity, **PH** = Plant Height (cm),
NTT = Number of Total Tillers per plant **NPT** = Number of Productive Tillers per plant, **FLA** = Flag Leaf Area (cm^2)
SL = Spike Length (cm) **NSS** = Number of Spikelet per Spike **NGS** = Number of Grains per Spike
BYP = Biological Yield Per Plant (g) **TSW** = 1000 Seed Weight (g) **HI** = Harvest index (%)
SYP = Seed Yield Per Plant (g), **CC** = Chlorophyll Content (µmol m^{-2}) **CTD** = Canopy Temperature Depression (°C)
PC = Protein Content (%)

Table 6 : Direct and indirect effect of 16 traits on seed yield per plant of 68 F_2s

	DH	DM	PH	NTT	NPT	FLA	SL	NSS	NGS	BYP	TSW	HI	CC	CTD	PC	linear
DH	**0.0020**	-0.0011	0.0007	0.0039	0.0040	0.0003	0.0068	0.0002	0.0000	-0.0199	0.0005	0.0563	0.0027	-0.0003	0.0004	0.0564
DM	-0.0001	**0.0330**	-0.0050	-0.0118	0.0183	0.0000	-0.0047	-0.0002	0.0000	-0.0227	-0.0004	0.0490	0.0017	-0.0017	0.0012	0.0566
PH	0.0000	0.0024	**-0.0684**	0.0139	-0.0186	0.0002	-0.0029	-0.0001	0.0000	1.5622	-0.0003	-1.5866	-0.0011	-0.0021	0.0012	-0.1002
NTT	0.0001	-0.0038	-0.0093	**0.1025**	-0.1151	-0.0002	0.0031	0.0002	0.0000	0.2697	-0.0031	-0.1472	-0.0007	-0.0003	0.0014	0.0973
NPT	-0.0003	-0.0042	-0.0188	-0.0819	**0.1341**	-0.0002	0.0023	-0.0003	0.0001	0.1763	-0.0018	0.0228	0.0015	-0.0011	-0.0004	0.2278
FLA	0.0003	0.0007	-0.0053	-0.0093	0.0053	**0.0024**	-0.0081	0.0000	0.0000	0.2057	0.0017	-0.2958	0.0009	0.0004	-0.0017	-0.1027
SL	-0.0004	0.0045	-0.0057	-0.0092	0.0135	0.0006	**-0.0347**	-0.0001	-0.0001	0.0771	-0.0014	-0.1015	-0.0022	0.0017	0.0010	-0.0568
NSS	-0.0002	0.0056	-0.0043	-0.0192	0.0442	0.0000	-0.0025	**-0.0013**	0.0000	0.0002	0.0013	0.0523	0.0006	0.0017	-0.0011	0.0772
NGS	-0.0001	0.0004	-0.0057	-0.0123	0.0159	-0.0002	0.0053	-0.0001	**0.0004**	0.0959	0.0001	0.1194	-0.0024	-0.0021	-0.0011	0.2134
BYP	0.0000	-0.0005	-0.0652	0.0169	-0.0236	0.0003	-0.0016	0.0000	0.0000	**1.6377**	-0.0004	-1.6794	-0.0013	-0.0018	0.0010	-0.1179
TSW	-0.0001	0.0012	-0.0022	0.0299	-0.0244	-0.0004	-0.0047	0.0002	0.0000	0.0470	**0.0106**	0.0501	0.0035	0.0040	0.0018	0.1164
HI	0.0001	0.0008	0.0564	-0.0078	0.0317	-0.0004	0.0018	0.0000	0.0000	-1.4310	-0.0003	**1.9219**	-0.0007	0.0015	-0.0012	0.5730**
CC	-0.0003	-0.0026	-0.0035	0.0033	0.0101	-0.0001	-0.0036	0.0000	0.0000	0.0989	0.0017	0.0658	**-0.0215**	-0.0018	-0.0002	0.1463
CTD	0.0000	-0.0050	0.0128	-0.0023	0.0141	0.0001	-0.0051	-0.0002	-0.0001	-0.2611	-0.0037	0.2561	0.0034	**0.0115**	-0.0005	0.0198
PC	0.0001	0.0041	-0.0082	0.0142	-0.0056	-0.0004	-0.0035	0.0002	0.0000	0.1687	-0.0019	-0.2268	0.0005	-0.0006	**0.0098**	-0.0496

*, ** Significant at 5% and 1% probability level, respectively

DH = Days to 50% Heading, **DM** = Days to Maturity, **PH** = Plant Height (cm),
NTT = Number of Total Tillers per plant **NPT** = Number of Productive Tillers per plant, **FLA** = Flag Leaf Area (cm^2)
SL = Spike Length (cm) **NSS** = Number of Spikelet per Spike **NGS** = Number of Grains per Spike
BYP = Biological Yield Per Plant (g) **TSW** = 1000 Seed Weight (g) **HI** = Harvest index (%)
SYP = Seed Yield Per Plant (g), **CC** = Chlorophyll Content (µmol m^{-2}) **CTD** = Canopy Temperature Depression (°C)
PC = Protein Content (%)

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