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Genetic Variability and Associations of Selected Wheat (*Triticum aestivum* L.) Genotypes under Early and Late Sown Rainfed Conditions

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ABSTRACT: The present study was conducted during rabi season 2019-20 to find variability, correlations and path coefficient analysis. Two experiments were conducted in α –RBD design on 66 genotypes for recording observations under duly sown and late sown unirrigated conditions. Examination of variations showed critical genotypic contrasts among all the characters which shown that the genotypes had adequate level of differences. Under both the situations high heritability together with high genetic advance for peduncle length and biological yield per plant were observed. So, selection can be compelling for these characters for further change of the genotypes beneath conditions of stress. It is indicated by correlations and path coefficient analysis that biological yield per plant, harvest index were important traits under both conditions, because they had a significant correlation with grain yield and high direct effect and indirect effects on grain yield per plant. This appeared genuine relationship between these characters and grain yield and so consideration ought to be given on such characterstics in breeding program to create drought resistant genotypes. Therefore, this study suggests that biological yield per plant and harvest index can both be used in breeding studies in order to improve high yielding and drought resistant wheat genotypes.

Keywords: Correlation coefficient, path coefficient, heritability and genetic advance.

INTRODUCTION

Wheat is one of the driving cereal and staple crop for a noteworthy extent of worlds populace. It is inspected as the ruler of cereals and it gives nourishment to around 36% of the worldwide populace, which contribute around 20% of the nourishment calories (Kumar *et al.*, 2013). Together many species of wheat make up the genus Triticum, and the mostly grown is the common wheat (Triticum aestivum 2n=6x=42). It requires moderate rainfall and temperature should be low during sowing time but during the harvesting time it should be higher for proper ripening of the crop.

Ahmadizadeh *et al.*, (2011) reported that there was a mean loss of around 17 to 70 percent in grain yield due to drought stress conditions. That is why the productivity of wheat under drought environment is one of the major concern. The criteria for the determination based on physiological and morphological traits have been proposed for the screening of dry season resilience in wheat. Choice based on one character don't offer chance for the victory of advancement of other character. So, more then one character should be considered for the selection success. The selection of morphological and physiological drought adaptable attributes is very important for next generations. Different hereditary parameters *i.e.* heritability, genotypic and phenotypic coefficient of variation and hereditary progresses are surveyed for morphological and physiological characteristics that can be utilized in determination of strong dry season tolerant assortments (Rahman *et al.*, 2016).

High heritability beside high genetic dvance considered as alluring criteria for the purpose of selection (Johnson *et al.*, 1955). Grain yield of wheat is the complex trait as the yield fluctuates in the association with the environment and its also multiple of numerous yield components influencing yield directly, indirectly. Yield can be evaluated by examining its related traits, such as number of productive tillers, spike length, 1000 grain weight and number of spikelets per spike (Li *et al.*, 2020). So, in the context, correlation helps to study how strongly pairs of variables are related. Whereas path coefficient investigation offer assistance to ponder the direct and indirect impact of free variable upon its subordinate variable (Dewey and Lu, 1959).

MATERIAL AND METHODS

A. Experimental material and the site

At the research farm at the Rice and Wheat Research Centre, Malan (elevation of around 950 m a.m.s.l. with 32°1′ latitude and 76°2′ longitude), sixty-six wheat genotypes were studied.The experiment conducted in α-randomized block design using 66 genotypes of wheat which included induced mutants and landraces of wheat with three replications and the plot size was kept 1.5 × 0.4 m^2 with row-to-row spacing as 20 cm. The experiment conducted under timely and late sown rainfedconditions. The genotypes were raised as per package of practices under rainfed conditions. The minimum temperature ranged between 4.82°C and 16.4°C and the maximum temperature ranged between 22.71°C and 34.1°C. We selected five plants randomly from each replication and recorded the following traits: days to 50 percent flowering, flag leaf area, plant height, number of tillers per plant, peduncle length, days to 75 percent maturity, number of seeds per spike, biological yield per plant, seed yield per plant, 1000-seed weight, and harvest index.

B. Statistical analysis

Our study used Parsad *et al.*, (2007) to analyse the variance. Genetic parameters such as variability, heritability, and genetic advancement were examined by following Burton and DeVane's (1953); Johnson *et al.*, (1955) conclusions. In accordance with Al-Jibouri *et al.*, (1958); Dewey and Lu (1959), correlations and paths were analyzed.

RESULTS AND DISCUSSION

A. Variability Studies

All characters were analyzed by variance, or mean sum of squares, under both timely and late sown rainfed conditions (Table 1). For all the traits, the analysis of variances or mean sum of squares was significant. The genotypes under both conditions exhibited enough variability. According to Ashfaq *et al.*, (2014), the means of the squares showed significant differences for days to heading, flag leaf area, peduncle length, tiller number per plant, plant height, ear length, number of spikelets per ear, seed weight per plant, and 1000-seed weight. Based on the present study, we observed that all PCVs are higher in magnitude than GCVs (Table 2).

Table 1: ANOVA under timely and late sown rainfed conditions.

	Mean sum of squares				
Traits/source	**Environment**	**Replication**	**Blocks with In replication**	**Genotypes**	**Error**
D.F.		2	27	59	91
Days to 50 percent flowering	E_1	5.33	1.49	52.20*	2.87
	E_2	25.31	2.27	42.21*	2.72
Flag leaf area(cm^2)	E_1	19.81	1.28	33.76*	1.97
	E_2	72.67	3.68	38.43*	5.42
Peduncle length (cm)	E_1	7.84	1.53	25.18*	1.48
	E_2	21.03	0.61	24.00*	1.06
Plant height (cm)	E_1	51.03	11.83	258.55*	21.31
	E_2	78.00	12.84	248.62*	24.23
Tiller per plant	E_1	2.03	0.324	0.90*	0.16
	E_2	0.008	0.125	0.29*	0.076
Days to 75 percent maturity	E_1	2.81	1.36	33.76*	1.97
	E_2	8.17	3.64	38.43*	2.31
Number of grains per spike	E_1	137.81	10.83	146.94*	8.25
	E_2	5.45	4.70	87.62*	4.07
Biological yield per plant (g)	E_1	43.37	0.69	18.67*	0.70
	E_2	23.41	0.28	10.99*	0.36
Grain yield per plant (g)	E_1	4.46	0.057	3.31*	0.057
	E_2	3.11	0.058	1.10*	0.082
Harvest index (%)	E_1	19.38	2.81	143.36*	3.20
	E_2	2.30	2.75	55.35*	2.48
1000-grain weight (g)	E_1	25.06	7.90	131.68*	4.66
	E_2	131.48	3.94	69.64*	2.48
***Significant at 0.005**					

Table 2: Range, mean and variability parameters for different traits under timely (E_1) and late (E_2) rainfed conditions.

Traits		Mean	Range	% reduction	PCV (%)	GCV (%)	Heritability (%)	GA (%) of mean
Days to 50 percent flowering	E_1	116.66±0.92	105.00-123.00	9.97	3.74	3.49	**86.60**	6.68
	E_2	105.03±0.82	92.00-114.33		5.27	5.09	93.28	10.13
Flag leaf area (cm^2)	E_1	25.63±0.79	17.03-33.08	14.00	14.47	13.46	**86.44**	25.77
	E_2	21.83±1.29	15.24-26.94		16.07	12.36	59.18	19.59
Peduncle length(cm)	E_1	15.06±0.71	10.50-22.03	6.35	20.35	18.66	**84.10**	35.24
	E_2	13.89±0.57	9.14-20.23		21.16	19.95	88.88	38.75
Plant height(cm)	E_1	93.69±2.53	75.70-119.30	12.98	10.62	9.53	**80.65**	17.64
	E_2	81.57±2.69	65.92-105.57		12.09	10.66	77.77	19.37
Number of tillers per plant	E_1	3.29±0.26	1.97-4.40	20.84	20.01	14.66	**53.69**	22.13
	E_2	2.52±0.17	1.88-3.31		15.69	10.38	43.79	14.16
Days to 75 percent maturity	E_1	158.77±0.78	150.33-166.00	8.05	2.18	2.01	**84.78**	3.81
	E_2	145.97±0.95	135.67-154.67		3.43	3.19	86.52	6.12
Number of grains per spike	E_1	50.64±1.71	36.57-63.03	29.09	14.62	13.40	**83.98**	25.30
	E_2	35.54±1.19	23.67-45.60		15.92	14.83	86.84	28.45
Biological yield per plant (g)	E_1	14.98±0.48	9.34-20.07	18.90	17.26	16.34	**89.64**	31.87
	E_2	12.01±0.34	8.59-15.47		16.42	15.68	91.25	30.86
Grain yield per plant (g)	E_1	5.74±0.20	3.80-7.93	33.50	17.75	17.25	**94.39**	34.52
	E_2	3.74±0.16	2.63-5.30		17.34	15.67	81.65	29.17
Harvest index(%)	E_1	38.90±1.02	25.08-53.13	16.70	18.15	17.58	**93.76**	35.06
	E_2	31.52±0.92	21.11-43.17		14.24	13.31	87.34	25.62
1000-grain weight	E_1	46.48±1.34	34.87-57.27	18.95	14.83	13.96	**88.62**	27.07
	E_2	37.36±1.20	29.40-47.70		13.67	12.49	83.53	23.52

There was moderate PCV and GCV (10-20%) under both conditions for biological yield per plant, harvest index, flag leaf area, number of seeds per spike, seed yield per plant and 1000 seed weight. Both timely and late sown conditions showed low PCV and GCV (*10 %) for days to 50 percent flowering and days to 75 percent maturity. In a study by Singh et al. (2014), PCV was observed for traits such as flag leaf area, number of tillers per plant, seed yield per plant, 1000-seed weight, and harvest index, showing their value for improving seed yield. The analysis by Paudel *et al.*, (2021) reveals that the GCV is lower than the PCV under both the conditions. Heritability estimation helps in deciding which traits to consider during selection, but selection solely on the basis of this factor may limit progress because it is prone to environmental changes. (Johnson *et al.,* 1955). The heritability in conjunction with the genetic advance as the percent mean plays a critical role in determining the effectiveness of selection for a character.

Both conditions showed high heritability for peduncle length and biological yield per plant as well as high genetic advance as percent mean. Hence, these characters can be selected directly for the future improvement of genotypes under stress; For number of grains per spike and 1000-grain weight, high heritability and moderate genetic advance indicate sufficient scope for selection in rainfed conditions; however, for days to 50 percent flowering, days to 75 percent maturity, and plant height, high heritability combined with low genetic advance revealed limited scope of selection. According to Naik *et al.,* (2015), traits that affect seed yield under rainfed conditions are highly heritable. In their study, Singh *et al.,* (2014) concluded that under drought stress conditions, high to moderate heritability and genetic advance were observed for seed yield, effective tillers per plant, spear leaf area, harvest index, and 1000- kernel weight, indicating their value for increasing seed yield.

B. Correlation

Genotypic correlations were stronger than their phenotypic counterparts in both conditions and in the same direction, suggesting the selection performed on the phenotypic correlations will be effective in the current study. (Table 3 and 4). A timely sown rainfed system exhibited positive and significant correlations with number of tillers per plant, grains per spike, biological yield per plant, harvest index, and 1000-grain weight at the phenotypic level.. According to Ahmadi *et al.*, (2012), biological yield, harvest index, spikes per m^2 and thousand grain weight correlate significantly with grain yield under stress conditions.Varsha *et al.*, (2019) found considerable positive correlations between grain yield and the number of grains per spike, the number of tillers per m^2 harvest index, and the spike length.

The number of days to 50% flowering correlates positively with the number of days to 75% maturity. In relation to days to maturity of 75 percent, the area of flag leaves showed a significant and positive correlation. Plant height and peduncle length showed a significant and positive correlation, and days to 75 percent maturity showed a significant and negative correlation.. There were significant and positive correlations between the number of tillers per plant, the number of grains per spike, the biological yield per plant, and the 1000-grain weight. There was a significant negative correlation between the harvest index and the number of tillers per plant. There was a significant positive correlation between the number of grains per spike and the plant's biological yield. There was significant and positive correlation between biological yield per plant and 1000-grain weight, but a significant negative correlation between harvest index and biological yield per plant. With respect to the 1000-grain weight, harvest index exhibited a significant positive correlation.

A comparison of grain yield per plant under late-sown rainfed conditions showed a positive correlation between biological yield per plant, harvest index and 1000-grain weight, and a negative correlation with days to 50 percent flowering. Among the phenotypic and genotypic correlations observed between grain yield and biological yield, thousand grain weight, and harvest index by Alemu *et al.*, (2020), significant and positive correlations were highly present. According to Bilgin *et al.*, (2011), days to flowering were negatively correlated with grain yield in 27 wheat genotypes.

Table 3: Estimates of correlation coefficient at phenotypic levels among different traits under timely sown rainfed conditions.

Traits		Flag leaf area (cm^2)	Peduncle length (cm)	Plant height (cm)	Number of tillers per plant	Day to 75 percent maturity	Number of grains per spike	Biological yield per plant(g)	Harvest index (%)	1000-grain weight (g)	Grain yield per plant (g)
Days to 50 percent flowering	**E_1**	0.225**	-0.037	-0.114	-0.049	0.342**	0.134	-0.115	0.100	-0.050	0.017
	E_2	-0.012	-0.063	-0.164*	0.091	0.201*	-0.039	-0.180*	0.051	-0.098	-0.147*
Flag leaf area (cm^2)	**E_1**		0.119	0.099	0.115	0.358**	0.112	0.095	-0.048	-0.082	0.024
	E_2		0.018	0.109	-0.059	0.181*	0.064	0.081	-0.066	-0.147*	0.012
Peduncle length (cm)	**E_1**			0.205**	0.025	-0.160*	-0.118	0.013	-0.084	0.122	-0.043
	E_2			0.402**	0.084	0.136	0.272**	-0.045	0.174*	0.184*	0.129
Plant height (cm)	**E_1**				-0.110	-0.029	0.178*	-0.019	0.107	0.133	0.113
	E_2				0.057	-0.047	0.493**	0.051	-0.025	0.040	0.067
Number of tillers per plant	**E_1**					-0.090	0.152*	0.548**	-0.319*	0.164*	0.251**
	E_2					-0.010	0.089	-0.041	0.027	0.107	0.015
Day to 75 percent maturity	**E_1**						0.035	-0.085	0.127	-0.062	0.018
	E_2						0.026	-0.061	0.236**	0.238**	0.117
Number of grains per spike	**E_1**							0.213**	0.143	0.106	0.406**
	E_2							0.010	-0.026	0.083	0.030
Biological yield per plant (g)	**E_1**								-0.524**	0.179*	0.453**
	E_2								-0.416**	0.273**	0.609**
Harvest index (%)	**E_1**									0.304**	0.492**
	E_2									0.307**	0.426**
1000-grain weight (g)	**E_1**										0.515**
	E_2										0.550**

Table 4: Estimates of correlation coefficient at phenotypic and genotypic levels among different traits under late sown rainfed environment.

Traits		Flag leaf area (cm^2)	Peduncle length (cm)	Plant height (cm)	Number of tillers per plant	Day to 75 percent maturity	Number of grains per spike	Biological yield per plant(g)	Harvest index (%)	1000-grain weight (g)	Grain yield per plant (g)
Days to 50 percent flowering	E_1	0.258**	-0.048	-0.154*	-0.045	0.417**	0.195**	-0.121	0.118	-0.069	0.034
	E_2	-0.018	-0.068	-0.172*	0.188*	0.235**	-0.033	-0.185*	0.063	-0.104	-0.145
Flag leaf area (cm^2)	E_1		0.163*	0.128	0.166*	0.429**	0.199**	0.106	-0.060	-0.082	0.029
	E_2		0.020	0.120	-0.035	0.256**	0.096	0.147*	-0.135	-0.162*	0.017
Peduncle length (cm)	E_1			0.247**	-0.030	-0.225**	-0.142	0.013	-0.073	0.142	-0.038
	E_2			0.477**	0.147*	0.153*	0.304**	-0.059	0.192**	0.215**	0.149*
Plant height (cm)	E_1				-0.121	-0.016	0.207**	-0.011	0.111	0.186*	0.137
	E_2				0.092	-0.050	0.592**	0.057	-0.068	0.047	0.027
Number of tillers per plant	E_1					-0.145	0.233**	0.833**	-0.450**	0.183*	0.378**
	E_2					0.015	0.079	-0.077	0.094	0.252**	0.005
Day to 75 percent maturity	E_1						0.077	-0.090	0.146*	-0.070	0.028
	E_2						0.044	-0.086	0.262**	0.282**	0.125
Number of grains per spike	E_1							0.242**	0.161*	0.141	0.451**
	E_2							0.012	-0.045	0.086	0.026
Biological yield per plant (g)	E_1								-0.549**	0.204**	0.440**
	E_2								-0.453**	0.308**	0.623**
Harvest index (%)	E_1									0.330**	0.500**
	E_2									0.359**	0.400**
1000-grain weight (g)	E_1										0.564**
	E_2										0.649**

A significant positive correlation was found between days to 50 percent flowering and days to 75 percent flowering, while a significant negative correlation was found between biological yield per plant and days to 50 percent flowering. A significant correlation was observed between 1000-grain weight and the area of the flag leaves. Significantly positive correlations were observed with plant height, number of grains per spike, harvest index, as well as 1000 grain weight. Grain number per spike was positively correlated with plant height. It turned out that the biological yield per plant was positively correlated with the grain weight of 1000 grains and negatively correlated with the harvest index. The harvest index was also significantly correlated with 1000-grain weight. Due to their positive correlations with grain yield in timely rainfed conditions, increase in number of tillers per plant, grains per spike, harvest index and 1000-grain weight will result in increased grain yield. We found that harvest index and 1000-grain weight were significant yield-determining factors under late-sown rainfed conditions.

Rainfed conditions led the number of seeds per spike, the biomass per plant, the harvest index, the number of tillers per plant and the 1000-grain weight to show significant and positive correlations with seed per plant yield. It was found by Verma *et al.,* (2012) that there are positive and significant associations between phenotypic and genotypic attributes of seed yield, such as number of tillers per plant, harvest index, and test weight.

Days to 50 percent flowering showed positive significant association with flag leaf area, maturity days,number of grains per spikewhereas showed significant negative association with plant height. Flag leaf area showed positivesignificantassociation with number of tillers per plant,peduncle length, number of grains per spikeand days to maturity.Peduncle length showed positive significant correlation with plant height and significant negative correlation with maturity days. Plant height showed positive significant correlation with number of grains per spike and 1000-seed weight. Number of tillers per plant showed significant positive correlation with biological yield per plant, number of seeds per spike, 1000-seed weight whereas significant and negative correlation with harvest index. Days to 75 percent maturity showed significant positive correlation with harvest index. Number of seeds per spike showed positive significant correlation with biological yield per plant and harvest index. Biological yield per plant showed significant positive correlation with 1000-seed weight while negative significant association with harvest index. Harvest index showed a significant positive correlation with 1000-seed weight.

Under late sown rainfed conditions, at genotypic level seed yield per plant showed significant positive correlation with peduncle length, biological yield per plant, harvest index and 1000-kernel weight. Bogale *et al.,* (2011) found seed yield showed positive significant correlation with peduncle length.Avinashe *et al.,* (2015) revealed positive significantrelationof harvest index, biological yield per plant and test weight with grain yield per plant.

Plant height and biological yields per plant showed negative significant correlation with days to 50 percent flowering, as well as a significant correlation with days to 75 percent maturity and the number of tillers per plant. An area of flag leaves correlated positively with the days to maturity of 75 percent and biological yield per plant, whereas it correlated negatively with the weight of 1000 grains. In terms of plant height, number of tillers per plant, days to maturity 75 percent, number of grains per spike, harvest index and grain weight, peduncle length showed significant positive correlation. Number of tillers per plant showed a significant positive correlation with 1000-grain weight; plant height showed a significant positive correlation with number of grains per spike. The biological yield per plant was significantly positively related to 1000-grain weight, while the harvest index negatively related to 1000-grain weight. Harvest index was significantly positively related to 1000-grain weight. Therefore, under both conditions seeds produced per plant showed significant positive correlations with biological yield, harvest index, and 1000 seeds weight per plant.

C. Path Analysis

Correlation analysis is a method that determines what makes up a complex characteristic, such as grain yield. As the number of independent characters affecting a dependent character increases, interdependence among the traits increases as well. It is not possible to sort out the direct and indirect effects of the correlation by using correlation alone. In such situations, path analysis (Dewey and Lu, 1959) allows separating correlation studies into direct and indirect effects and also gives the degree of relationship between production and its related components. It is evident that the relationship between biological yield and harvest index and grain yield is highly positive directly and significantly positive in a rainfed environment. Number of tillers per plant significantly correlates positively with grain yield due to high indirect effects via biological yield and harvest index, while direct effects are low for the number of tillers per plant. A positive effect was also seen for number of grains per spike, but it was of a small magnitude, and an indirect effect could be observed for harvest index and biological yield per plant. It was found in Raina (2013) that grains per spike have a high indirect effect on grain yield via biological yield.

Harvest index and biological yield per plant also showed positive direct effects and negative indirect effects on grain yield per plant via harvest index and biological yield per plant. According to Ahmadizadeh *et al.,* (2011), biological yield per plant, grain number per spike, and harvest index traits showed a positive influence on yield under rainfed conditions. Under moisture stress conditions, grain number per spike showed a high positive direct impact on grain yield. In addition, 1000-grain weight showed significant positive correlation due to high indirect effects via biological yield and harvest index, a low magnitude direct effect, and negligible indirect effects via other traits.

A high positive direct effect and a significant positive correlation between biological yield and harvest index and grain yield were evident under late sown conditions, indicating a true relationship between these traits and grain yield. Biological yield per plant was significantly correlated with grain yield at both levels, mainly due to its high direct effects on grain yield, partially offset by negative indirect effects via harvest index on grain yield, while other indirect effects were of low magnitude. Harvest index's strong positive correlation with grain yield was caused by its strong direct effect on grain yield, which was partially offset by biological yield per plant's negative indirect effect on grain yield, but other indirect effects were of low magnitude at both levels. A significant positive correlation was also found in 1000-grain weight due to a high positive indirect effect via biological yield and harvest index, a low direct positive effect, and a negligible indirect effect via other traits. The results of Varsha *et al.*, (2019) showed that biological yield went hand-in-hand with harvest index in affecting grain yield in a maximum positive manner. Using 30 diverse genotypes and path analysis, Rahman *et al.*, (2016) concluded that 1000-grain weight has a high direct impact on yield.

A high direct effect of biological yield per plant and harvest index was evident under both environments, as well as their significant positive correlation with grain yield. Some other traits also resulted in indirect effects on grain yield, with 1000-grain weight showing a low direct effect under both conditions (Table 5 and 6).

Table 5: Estimates of path analysis at pheno levels among different traits under timely sown rainfed (E_1) environment.

TRAITS		Days to 50 percent flowering	Flag leaf area (cm^2)	Peduncle length (cm)	Plant height (cm)	Number of tillers per plant	Day to 75 percent maturity	Number of grains per spike	Biological yield per plant (g)	Harvest index (%)	1000-grain weight (g)	Grain yield per plant (g)
Days to 50 percent flowering	E_1	**0.0396**	-0.0076	-0.0009	-0.0021	-0.0022	-0.0065	0.0078	-0.1067	0.0971	-0.0016	0.017
	E_2	**-0.0080**	0.0002	-0.0005	-0.0031	0.0021	-0.0054	-0.0009	-0.1668	0.0409	-0.0048	-0.147*
Flag leaf area (cm^2)	E_1	0.0089	**-0.0340**	0.0031	0.0019	0.0052	-0.0067	0.0065	0.0880	-0.0463	-0.0027	0.024
	E_2	0.0001	**-0.0015**	0.0001	-0.0021	-0.0013	0.0048	0.0016	0.0755	-0.0528	-0.0072	0.012
Peduncle length(cm)	E_1	-0.0015	-0.0040	**0.0263**	0.0039	0.0011	0.0030	-0.0069	0.0118	-0.0811	0.0040	-0.043
	E_2	0.0005	-0.0003	**0.0080**	0.0076	0.0019	-0.0034	0.0067	-0.0414	0.1394	0.0091	0.129
Plant height (cm)	E_1	-0.0045	-0.0034	0.0054	**0.0188**	-0.0050	0.0005	0.0104	-0.0176	0.1037	0.0044	0.113
	E_2	0.0013	-0.0001	0.0033	**0.0192**	0.0013	0.0013	0.0121	0.0472	-0.0201	0.0019	0.067
Number of tillers per plant	E_1	-0.0019	-0.0039	0.0006	-0.0021	**0.0454**	0.0017	0.0089	0.5059	-0.3089	0.0054	0.251**
	E_2	-0.0007	0.0001	0.0007	0.0011	**0.0230**	0.0002	0.0022	-0.0382	0.0218	0.0053	0.015
Day to 75 percent maturity	E_1	0.0135	-0.0122	-0.0042	-0.0006	-0.0041	**-0.0189**	0.0020	-0.0789	0.1231	-0.0020	0.018
	E_2	-0.0016	-0.0003	0.0011	-0.0010	-0.0001	**-0.0268**	0.0006	-0.0565	0.1893	0.0118	0.117
Number of grains per spike	E_1	0.0053	-0.0038	-0.0031	0.0033	0.0069	-0.0007	**0.1978**	0.0584	0.1389	0.0035	0.406**
	E_2	0.0003	-0.0001	0.0022	0.0094	0.0020	-0.0007	**0.0246**	0.0096	-0.0211	0.0041	0.030
Biological yield per plant (g)	E_1	0.0046	-0.0032	0.0003	-0.0004	0.0250	0.0016	0.0125	**0.9238**	-0.5079	0.0059	0.453**
	E_2	0.0015	-0.0001	-0.0003	0.0010	0.0009	0.0017	0.0002	**0.9268**	-0.3338	0.0135	0.609**
Harvest Index (%)	E_1	0.0040	0.0016	-0.0022	0.0020	-0.00145	-0.0024	0.0084	-0.4840	**0.9694**	0.0101	0.492**
	E_2	-0.0004	0.0001	0.0014	-0.0005	-0.0006	-0.0063	-0.0006	-0.3856	**0.8024**	0.0152	0.426**
1000- grain weight (g)	E_1	-0.0020	0.0028	0.0032	0.0025	0.0075	0.0012	0.0062	0.1656	0.2948	**0.0332**	0.515**
	E_2	0.0007	0.0002	0.0015	0.0007	0.0025	-0.0064	0.0020	0.2529	0.2463	**0.0496**	0.550**

Table 6: Estimates of pathanalysis genotypic levels among different traits under late sown rainfed (E_2) environment.

TRAITS		Days to 50 percent flowering	Flag leaf area (cm^2)	Peduncle length (cm)	Plant height (cm)	Number of tillers per plant	Day to 75 percent maturity	Number of grains per spike	Biological yield per plant (g)	Harvest index (%)	1000-grain weight (g)	Grain yield/ plant
Days to 50 percent flowering	E_1	**0.0675**	-0.0061	-0.0008	-0.0056	-0.0007	-0.0186	0.0052	-0.1212	0.1240	0.0003	0.134
	E_2	**0.0008**	0.0006	-0.0028	0.0043	-0.0031	-0.0071	-0.0017	-0.1824	0.0521	-0.0049	-0.143
Flag leaf area (cm^2)	E_1	0.0148	**-0.0287**	0.0030	0.0045	0.0025	-0.0192	0.0032	0.10648	-0.0625	0.0003	0.029
	E_2	-0.0001	**-0.0032**	0.0008	-0.0030	0.0006	-0.0077	0.0050	0.1450	-0.1124	-0.0077	0.017
Peduncle length(cm)	E_1	-0.0028	-0.0039	**0.0191**	0.0087	-0.0004	0.0100	-0.0038	0.0129	0.0765	-0.0005	-0.038
	E_2	-0.0002	-0.0006	**0.0410**	-0.0019	-0.0024	-0.0046	0.0160	-0.0582	0.1594	0.0102	0.149*
Plant height (cm)	E_1	-0.0088	-0.0030	0.0045	**0.0355**	-0.0018	0.0007	0.0056	-0.0115	0.1166	-0.0007	0.137
	E_2	0.0005	-0.0004	0.0196	**-0.0348**	-0.0015	0.0015	0.0312	0.0558	-0.0567	0.0022	0.027
Number	E_1	-0.0026	-	-0.0005	-0.0043	**0.0148**	0.0065	0.0062	0.8357	-0.4728	-	0.348**

of tillers			0.0039								0.0007	
per plant	**E_2**	0.0000	0.0001	0.0060	-0.0023	**-0.0186**	-0.0004	0.0042	-0.0755	0.0777	0.0119	0.005
Day to 75 percent maturity	**E_1**	0.0239	-0.0102	-0.0041	-0.0006	-0.0021	**-0.0476**	0.0021	-0.0902	0.1538	-0.0003	0.028
	E_2	0.0007	-0.0008	0.0063	0.0012	-0.0002	**-0.0302**	0.0023	-0.0846	0.2173	0.0133	0.125
Number of grains per spike	**E_1**	0.0112	-0.0028	-0.0026	0.0073	0.0034	-0.0034	**0.2727**	0.0268	0.1688	-0.0005	0.541**
	E_2	-0.0001	-0.0031	0.0125	-0.0147	-0.0013	0.0013	**0.0526**	0.0119	-0.0371	0.0040	0.026
Biological yield per plant (g)	**E_1**	-0.0069	-0.0025	0.0023	-0.0004	0.0123	0.0040	0.0065	**1.0036**	-0.5761	-0.0078	0.540**
	E_2	0.0005	-0.0005	-0.0024	-0.0014	0.0013	0.0026	0.0064	**0.9447**	-0.3762	0.0146	0.723**
Harvest Index (%)	**E_1**	0.0068	0.0014	-0.0013	0.0040	-0.0068	-0.0065	0.0043	-0.5507	**1.0500**	-0.0013	0.480**
	E_2	0.0002	0.0004	0.0079	0.0017	-0.0015	-0.0079	-0.0023	-0.4460	**0.8206**	0.0170	0.370**
1000-grain weight (g)	**E_1**	-0.0039	0.0019	0.0026	0.0066	0.0027	0.0031	0.0038	0.20487	0.3464	**-0.0038**	0.554**
	E_2	0.0003	0.0005	0.0088	-0.0017	0.0042	-0.0085	0.0045	0.3033	0.2980	**0.0455**	0.639**

CONCLUSION

Characteristics such as peduncle length and biological yield per plant, as well as genetic advance, show high heritability as percent mean.Traits such as biological yield per plant, harvest index and 1000-grain weight showed highly significant and positive correlation with grain yield per plant, can be used as selection criteria in grain yield improvement under both the environments. By performing direct selection on traits such as biological yield per plant, harvest index, and 1000-grain weight in both environments, the path coefficient analysis revealed that selection results in high grain yield can be obtained by selecting for traits such as these, which have exhibited positive, significant correlations with grain yield as well as positive impacts on grain yield. It was also reported by (Dayem *et al.*, 2021) that grain yield was directly affected by harvest index, followed by biomass yield. So, selection based on these traits may prove effective in improving yield.

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