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Genotypic variability and correlations among morpho-physiological traits affecting grain yield in barley (*Hordeum vulgare L.*)

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Abstract

Genotypic variability analysis is an important aspect of barley yield improvement. The study was conducted to analyze genotypic variability for yield its component traits and some physiological characters along with analysis of correlations among different traits under normal and late sown conditions. The material of the present investigation consisted of 25 barley genotypes comprising two row and six row types. The experiment was laid out in randomized block design with 25 treatments and replicated thrice in blocks under normal and late-sown conditions in the field. The data revealed significant genotypic variation for all the characters studied viz., grain yield, grain weight, days to heading, biological yield, days to maturity, harvest index, tillers per meter, grains per spike and grain growth rate after 20,27 and 34 days of anthesis, canopy temperature depression(CTD), membrane thermo stability(MTS) and chlorophyll fluorescence. The characters, biological yield, grain weight, days to heading, tillers per meter, harvest index, canopy temperature depression (CTD) were having high mean, wide range, high GCV, PCV, heritability and genetic advance. Correlation coefficients revealed significant positive association of grain yield with harvest index, biological yield and days to maturity in normal sown condition and for biological yield and harvest index in late sown condition. 1000 grain weight had positive and significant correlation with grain growth rate after anthesis. The rate of grain filling is an important trait affecting grain yield.

Keywords: Barley, yield components, variability, Correlations, Membrane Thermo Stability (MTS), Chlorophyllfluorescence, Grain growth.

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Introduction

Grain yield is complex character governed by polygenes with great genetic, physio-morphological, ecological and pathological dependencies, particularly the knowledge of morpho-physiological components which contribute to seed yield are helpful for enhancing the productivity. In order to achieve this goal, it is to gather information on the genetic variability of yield contributing characters along with nature and their magnitude of relationship with grain yield. In many cereals relationships have been observed between grain yield and duration of the areas of total canopy and of specific leaves. The effects of environmental factors in general and, temperature and photoperiod components in particular are genotypic specific. Thus, genotypes with differential photo thermo response are influenced by temperature and photoperiod at different growth stages, i.e. vegetative, spike development and stem elongation phase (Kirby and Appelyard, 1981). In most of the studies dealing with temperature response, days to ear emergence or anthesis has been regarded as key diagnostic character as it represents liaison between vegetative and reproductive stages. High temperature stress during the grain filling period is a major constraint to increase productivity of barley in the ongoing weather scenario. Current efforts using evaluations are frequently inefficient because heat stress conditions during grain filling are too inconsistent to permit selection.

Since barley is an industrial crop, the malt quality is also affected. Therefore, improving grain filling capacity under heat stress is an important breeding target. The studies on genetic variability in morpho-physiological traits associated with yield under normal as well late sown conditions can be used to increase selection efficiency.

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Materials and Methods

The research work was carried out in the Department of Genetics and Plant Breeding CCS HAU, Hisar during the rabi season of 2009-10. 25 barley genotypes viz. BH902, BH07-14, BH07–18, BH07-34, BH08-5, BH08-18, BH08–19, BH08–20, BH08–24, BH08–34, BH08–36, BH393, BH885, DWRUB52, RD2552, K551, RD2801, RD2800, RD2799, RD2798, DWR87, DWR88, DWR89, DWR90, DWR91 comprising two row as well as six row types were grown in a plot size of 5m X 1.38m with 3 replication in a randomized block design under normal as well as late sown conditions. The normal sown experiment was sown on 13.11.2009 and late sown on 15.12.2009.

The data were recorded for timely as well late sown crop for the characters viz. Number of days to heading, Number of days to maturity, Plant height (cm), Ear length (cm), No. of tillers/meter, No. of grains/spike, 1000-grain weight (g), Biological yield per meter (g), Grain yield per meter (g) and Harvest index (%) as yield component characters. Plant canopy temperature depression (^{0}C), Chlorophyll flouroscence, Membrane thermal stability (%), Grain weight was recorded after 20 days of anthesis, 27 days of anthesis and 34 days of anthesis as physiological characters.

The experimental data was subjected to statistical analyses as following standard statistical procedures described by Panse and Sukhatme (1967). Correlation coefficient between different characters were calculated as per Al-Jouberi *et.al* (1958).

Results and Discussion

The data pertaining to range, mean, GCV, PCV, heritability and genetic advance for 16 characters in 25 genotypes are presented in Table 1 for normal sown and in Table 2 for late sown conditions. Significant difference was observed for all traits studied indicating considerable amount of variation among genotypes for each characters under normal and late sown conditions. (Riaz-ud-din *et al.*, 2010). Wide range high coefficients of variation, heritability and genetic advance as percent of mean were recorded for grain yield, tillers per meter, biological yield, number of grains per spike, grain yield, and CTD under normal and late sown conditions revealed the possibility of their further improvement under both the dates of sowings.

Table 1 Mean, range, PCV, GCV, heritability and genetic advance for different characters under timely sown conditions

S. No.	Characters	Mean	Range	Coefficient of variations (%)		Heritability	Genetic
				PCV	GCV		Advance(%)
1	Grain yield/m(g)	113.68±3.7	85.67 –138.33	12.96	11.69	0.81	21.74
2	1000grain weight (g)	44.69±0.50	32.67 – 59.87	16.33	16.21	0.98	33.17
3	Biological yield (g)	298.96±12.7	236.67 -366.67	12.06	9.56	0.62	15.61
4	Ear length (cm)	8.02±0.47	6.67 – 9.33	12.03	6.20	0.26	6.58
5	Grain per spike	37.68±0.85	25.27 – 58.80	34.71	34.49	0.98	70.60
6	No. of days to Heading	90.00±0.52	77.00 –100.33	6.18	6.10	0.97	12.41
7	No of days to Maturity	130.80±0.73	119.00 -145.00	5.91	5.83	0.97	11.86
8	Plant height (cm)	100.03±2.97	80.67 – 129.00	13.27	12.23	0.84	23.21
9	Tillers/m	154.24±2.05	113.33 – 235.67	20.23	20.10	0.98	41.14
10	Harvest index (%)	38.32±2.14	30.58 – 46.52	13.32	9.15	0.47	12.97
11	GGR 1	0.29±0.02	0.20 – 0.40	22.68	18.65	0.67	30.37
12	GGR2	0.40±0.02	0.27 – 0.57	21.90	19.66	0.80	35.54
13	GGR3	0.45±0.03	0.35 – 0.58	18.97	14.31	0.56	21.79
14	CTD (°C)	1.85±0.15	1.08 – 2.55	29.08	25.22	0.75	45.05
15	Chlorophyll Fluorescence	0.731±0.01	0.684 – 0.772	4.62	2.94	0.40	4.19

GGR1 : Grain growth rate after 20 days of anthesis , GGR2 : Grain growth rate after 27 days of anthesis , GGR3 : Grain growth rate after 34 days of anthesis, CTD:Canopy Temperature depression (°C)

Days to heading, however, showed more chances of improvement under normal sown as compared to the late sown conditions. These results are encouraging for a barley breeder who is interested to develop improved genotypes particularly for late sown conditions because most of the relevant traits like total grain growth rate after anthesis and days to heading have huge variation, high heritability, and large genetic gains. Earlier studies conducted in Bangladesh have also revealed almost similar findings in cereals (Barma *et al.,* 2002). Physiological parameter like membrane thermal stability (MTS) under late sown condition and chlorophyll fluorescence under normal and late sown condition show moderate range of variation, heritability and genetic advance as percent of mean. It was inferred that genotypes with less relative injury possessed greater thermo tolerance positively through maintaining their cell membrane integrity under high temperature conditions. Similar findings have also been reported by Munjal *et al.* (2004) and Singh *et al.(*2005) in wheat.

Grain growth rate after anthesis also show high coefficient of variation in both late and normal sown while show moderate heritability as well as moderate genetic advance as percent of mean in both sowing season respectively. High heritability estimates along with expected genetic gain and coefficient of variation are more useful than heritability value alone because phenotypic standard deviation is another component of genetic advance.

Among 25 genotypes studied 5 were early maturing and 20 were in medium maturity group. Two genotypes BH902 and RD2552 were still standing green whereas as other genotypes had turned yellow (matured) and the temperature was very high. This stay green character can carry out photosynthesis for a longer period and enhancing yield by preventing forced maturity that is why BH902 varied drastically in certain morphological and productivity features, from the other barley cultivars. This showed higher values for the mean performance for biological yield, grain yield and tillers per meter. However, the chlorophyll fluorescence were low in these genotypes under normal as well as late sown conditions but higher mean for component traits results in high mean yield than other genotypes. The finding of Thakur and Sethi (1985) and EI- Hennawy (1997) have same results in matter of morphological yield components.

Table 2 Mean, range, PCV, GCV, heritability and genetic advance for different characters under late sown conditions

S. No.	Characters	Mean	Range	Coefficient of variations (%)		Heritability	Genetic Advance (%)
				PCV	GCV		
1	Grain yield/m (g)	82.89±3.86	50.00–113.33	19.94	18.23	0.83	34.33
2	1000 grain weight (g)	45.26±0.43	33.93 – 61.00	13.88	13.76	0.98	28.10
3	Biological yield (g)	245.69±10.45	184.26-308.89	15.05	13.13	0.76	23.59
4	Ear length (cm)	7.96±0.41	6.33 – 9.57	13.32	9.75	0.53	14.72
5	Grain per spike	32.68±0.81	18.60 – 57.80	40.43	40.20	0.98	82.35
6	No. of days to Heading	83.0±0.38	74.33 – 89.33	5.26	5.20	0.97	10.60
7	No. of days to Maturity	114.65±0.51	108.33–122.00	3.52	3.43	0.95	6.91
8	Plant height (cm)	96.84±2.85	83.67 – 110.33	7.95	6.09	0.58	9.62
9	Tillers/m	128.79±3.06	89.00 – 218.67	26.07	25.75	0.97	52.38
10	Harvest index (%)	34.08±2.32	24.11 – 44.84	19.82	15.89	0.64	26.26
11	GGR 1	0.40±0.02	0.28 – 0.53	20.87	17.01	0.66	28.61
12	GGR2	0.42±0.03	0.29 – 0.58	20.70	13.49	0.42	17.85
13	GGR3	0.47±0.03	0.32 – 0.67	19.47	15.33	0.62	24.80
14	CTD (°C)	4.88±0.23	1.75 – 6.29	27.26	25.94	0.90	50.85
15	MTS (%)	81.46±1.54	73.19 – 89.41	5.49	4.40	0.64	7.26
16	Chlorophyll fluorescence	0.702±0.01	0.601 – 0.767	5.80	5.00	0.74	9.75

The increased days to heading or days to maturity led to a decrease in number of grains per spike, thousand grain weight, grain yield, biological yield and grain growth after anthesis under normal sown condition. However, under late sown condition, there was not a significant decrease in grain weight and grain yield but in number of grains per spike with the increased days to maturity. Under late sown experiment, 1000 grain weight and grain growth rates had higher mean values than the normal sown experiment. It showed that in late sown experiment under heat stress conditions the concentration of gradients has increased to mobilize more reserves to the sink. The yields are also decreased under late sown as a result of low number of grains per unit area. (Daniels and Alcock, 1982).

Character Association

Phenotypic correlation coefficients among different morpho-physiological characters are presented in Table 3 for normal sown and Table 4 for late sown condition. A significant positive correlation was observed between grain yield and biological yield under normal as well as late sown conditions. This was because the good grain filling for photosynthesis led to more reserves in the sink, resulting in higher grain weight. It was interesting to note that exhibited a significant positive correlation with grain growth rate after anthesis under late sown but not under the normal sown condition with 1000 grain weight. 1000- grain weight was found to be positively correlated with grain growth rate after anthesis under both environments. A positive correlation between 1000-grain weight and grain growth rate after anthesis has also been reported by Van Sanford (1985), Bruckner and frohberg (1981), Duguid and Brule (1994) and Mou *et al.* (1994) Harvest index also have significant and positive correlation with grain yield in normal and late sown.

Plant height was found to be having no correlation with number of grains per spike and under normal and late sown conditions. This means that here the photosynthetic translocates would no divert in the development of all the plant parts and thus no significant effect on the number of grains in the ear as compared to the dwarf genotypes to tall genotype for grain development. The similar results have seen observed in the finding of E-I-Hennawy (1997), Sajeda *et al.* (1997) and Sandeep *et al.* (2002).

It is worth mentioning here that the numbers of tillers per meter with grain yield in this study showed a non significant negative correlation with low magnitude. It had happened due to pooled analysis of 2–rowed and 6–rowed types of barley genotypes. The 2–row types had more number of tillers per meter than 6–row types but lesser in yield, so there was a cancellation effect and this type of result is obtained.

Among physiological characters 1000–grain weight had significant positive correlation with grain growth rate in normal and late sown conditions. This showed had there was a linear relationship of 1000-grain weight with grain growth rate in respect of days after anthesis. Grain growth rate itself

Table 3 Phenotypic Correlation Co-efficient between different Morpho-physiological characters in Barley genotypes under Normal Sown Conditions

Character	GY	GW	BY	EL	G/S	DH	DM	PH	T/M	HI	GGR 1	GGR 2	GGR 3	CTD	CF
GY	1.000	0.110	0.502*	0.081	0.303	0.185	0.546**	0.178	-0.281	0.533**	-0.156	0.075	0.069	-0.107	-0.109
GW		1.000	-0.067	0.126	0.621**	0.004	0.344	0.172	0.245	0.123	0.488*	0.684**	0.583**	-0.170	0.053
BY			1.000	-0.005	0.428*	0.492*	0.528**	0.383	-0.098	-0.448*	-0.299	-0.177	-0.062	0.071	0.042
EL				1.000	0.058	-0.085	0.169	0.380	-0.115	0.077	0.069	0.154	0.222	-0.024	-0.094
G/S					1.000	0.179	0.263	0.294	-0.441*	-0.062	-0.583**	-0.661**	-0.584**	0.071	-0.003
DH						1.000	0.524**	0.251	-0.155	-0.301	-0.330	-0.306	-0.057	-0.260	-0.031
DM							1.000	0.405*	-0.339	0.021	-0.157	-0.055	0.145	-0.035	-0.017
PH								1.000	-0.256	-0.203	-0.039	-0.030	0.053	-0.140	0.055
T/M									1.000	-0.186	0.202	0.346	0.188	-0.096	-0.073
HI										1.000	0.092	0.187	0.056	-0.144	-0.122
GGR 1											1.000	0.691**	0.430*	-0.035	0.053
GGR 2												1.000	0.687**	-0.197	-0.039
GGR 3													1.000	-0.187	0.063
CTD														1.000	-0.103
CF															1.000

GY = Grain yield per meter (g), GW = 1000-grain weight (g), BY = Biological yield (g), EL = Ear length, GY = Grain per spike, DH = No. of days to heading, DM = No. of days to maturity, PH = Plant height, T/M = No. of tiller per meter, HI = Harvest index(g), GGR1= Grain growth rate after 20 days of anthesis GGR2 = Grain growth rate after 27 days of anthesis, GGR3 = Grain growth rate after 34 days of anthesis, CTD = Canopy temperature depression (ºC), CF = Chlorophyll fluorescence

Table 4 Phenotypic Correlation Co-efficient between different Morpho-physiological characters in Barley genotypes under late Sown Condition

Character	GY	GW	BY	EL	G/S	DH	DM	PH	T/M	HI	GGR 1	GGR 2	GGR 3	CTD	MTS	CF
GY	1.000	0.012	0.428*	-0.099	0.443*	-0.155	-0.048	0.113	-0.300	0.693**	-0.214	-0.124	-0.049	0.018	-0.118	0.054
GW		1.000	-0.351	0.238	-0.649**	-0.156	-0.319	0.072	0.091	0.325	0.585**	0.529**	0.617**	-0.237	-0.382	-0.050
BY			1.000	-0.168	0.288	0.244	0.461*	0.110	-0.016	-0.343	-0.229	-0.142	-0.217	0.230	0.329	0.119
EL				1.000	-0.221	-0.056	-0.255	0.199	0.154	0.064	0.293	0.280	0.297	0.273	-0.108	0.166
G/S					1.000	-0.231	-0.012	0.069	-0.354	0.206	-0.616*	-0.535**	-0.584**	0.174	0.014	0.011
DH						1.000	0.552**	0.028	0.013	-0.365	0.039	-0.015	0.011	-0.043	0.441**	-0.033
DM							1.000	0.178	0.221	-0.422*	-0.159	-0.153	-0.229	0.176	0.233	-0.133
PH								1.000	0.126	0.014	-0.157	0.004	0.068	0.249	0.077	-0.053
T/M									1.000	-0.308	0.305	0.234	0.240	0.008	-0.237	-0.061
HI										1.000	-0.021	0.011	0.141	-0.143	-0.389	-0.032
GGR 1											1.000	0.599**	0.496*	-0.115	-0.233	-0.204
GGR 2												1.000	0.589**	-0.095	-0.103	0.002
GGR 3													1.000	-0.199	-0.195	0.001
CTD														1.000	0.068	-0.326
MTS															1.000	0.241
CF																1.000

GY = Grain yield per meter (g), GW = 1000-grain weight (g), BY = Biological yield (g), EL = Ear length, GY = Grain per spike, DH = No. of days to heading, DM = No. of days to maturity, PH = Plant height, T/M = No. of tiller per meter, HI = Harvest index(g), GGR1= Grain growth rate after 20 days of anthesis GGR2 = Grain growth rate after 27 days of anthesis, GGR3 = Grain growth rate after 34 days of anthesis, CTD = Canopy temperature depression (°C), CF = Chlorophyll fluorescence, MTS = Membrane thermo stability (%)

had significant correlation between them i.e. between grain growth rate after 20 days of anthesis and grain growth rate after 27 and 34 days of anthesis means as days to anthesis increases source to sink capacity increases in respect of grain filling. Membrane thermal stability (MTS) also had positive significant correlation with days to maturity. These physiological parameters can be used as a criteria of selection for grain weight and indirect selection for grain yield.

It is evident from the above discussion that rate of grain filling is one of the important trait affecting the grain weight and ultimately the grain yield in barley. This trait has high heritable component of variance and hence can be manipulated genetically through direct or indirect selection via the simply inherited correlated traits such as grain weight and days to 50% heading.

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