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Research Article

Genetic Variability and Path Analysis Studies in Barley (*Hordeum vulgare* L.)

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Abstract

The present study was carried out to investigate the correlation coefficient, path analysis and genetic variability among some barley varieties for nine characters in a Randomize Block Design (RBD) with three replications in three environments of Bangladesh. High genotypic coefficient of variation (GCV) was obtained from grain/ spike (29.89 %), yield/ plant (28.72%) and effective tiller/plant (21.86 %) and spike length (13.56 %). The characters with high GCV indicated high potential for selection. The highest heritability (Hb) was observed for 1000 seed weight (95.09) followed by yield/ plant (93.98), grain/ spike (92.09) and spike length (69.93), days to heading (72.65) but the lowest Hb was identified for effective tiller/plant (22.41) followed by the plant height (34.21). Those traits with higher heritability may be considered for selection. Grain/ spike had the highest positive direct effect (5.65) on yield followed by 1000 seed weight (4.65), spike length (1.26), yield/ plant (0.66), days to heading (0.55) and days to maturity (0.34). These parameters were identified as direct selection. Direct negative effect on yield was shown by plant height (-0.32) and effective tiller/plant (-0.74). This was an indication of indirect selection.

Keywords: Genetic Variability; Path Co-Efficient; Barley

Introduction

Barley (*Hordeum vulgare* L., 2n=2x=14) is a cereal grain that was domesticated 10,000 years ago in the fertile crescent indicated by different archaeological evidence. Among the cereals, barley currently ranks fourth after wheat, maize and rice in terms of total production which has an early maturation and a high level of adaptability to stress environment. It serves as a major animal fodder, as base malt for beer and certain distilled beverages and as a component of various healthy foods.

In many countries of the world it is grown with less care and input in stress environment due to its hardiness. The degree of association between yield and other metric traits is considered for improving yield in breeding programme.

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As yield is complex and dependent character, and influenced by many independent characters so, improvement in yield depends upon the improvement of its component characters. The correlation coefficient ensures the degree of association, genetic or non-genetic relationship between two or more characters that forms the basis for selection (Shrimali *et al*., 2017).

The nature of complex interrelationships among yield components determined by path coefficient and correlation analyses and widely used by plant breeders. Knowledge derived in this way could be used to develop selection criteria to improve crop yield in relation to agricultural practices (Board *et al*., 1997; Finne *et al*., 2000; Gravois and McNew, 1993; Samonte *et al*., 1998 and Sinebo, 2002). Considering the above importance, the present study was conducted to assess the relationship between grain yield and other morphological traits and also identifying the direct and indirect effects on yield.

Materials and Method

The experiment was conducted at three locations of Bangladesh namely Gazipur, Jamalpur and Ishurdi during *rabi* 2016-17. Four hull-less barley lines *viz.* INBONL-21/15, INBONL-40/15, Esmaradla M-104/12 and Atabapha12 along with one check variety BARI Barley -7 were evaluated in this study. The trials were laid out in RCB design with three replications. Seeds of each entry were sown in 5m × 2m plot with 25 cm row spacing and continuous sowing. Seeds were sown at Gazipur on 9 December, Jamalpur on 19 December and Ishurdi on 1st December. Thinning was done three weeks after date of sowing. Fertilizers were applied at the rate of 100, 60 and 40 kg of N, P, and K per hectare respectively. All intercultural operations were done in time to raise the crop uniformly. Ten plants from each plot were selected randomly to record data of days to heading, days to maturity, plant height, effective tiller per plant, spike length, grain per spike, 1000 seed weight, grain yield per plant and yield per plot. All the data were processed and analyzed according to Sheoran *et al*. (1998).

Results and Discussion

Mean sum of squares from pooled analysis revealed significant effects for yield. Most of the characters showed significant treatment effects indicating that the genotypes were differed for those characters indicating the sufficient variability among them (Table 1).

The highest σ^2g (686.38) and σ^2p (706.04) variance were found for grain/ spike (G/S) (Table 2). The lowest magnitude σ^2g (0.04), σ^2p (0.07) variance were observed in plot/yield (kg). High genotypic coefficient of variation (GCV) were obtained from grain/ spike (29.89 %), yield/ plant (28.72%) and effective tiller/plant (21.86 %) and spike length (13.56 %). The characters with high GCV indicated higher potential for selection. Some traits with high GCV observed in *B juncea* for selection (Alam *et al*., 1988).

The highest phenotypic coefficient of variation (PCV) were observed in effective tiller/plant (46.18%) followed by grain/ spike (31.14%) and yield/ plant (29.62%) the lowest in days to maturity (1.90%).

The difference between GCV and PCV of yield indicating the influence of environment on it. Most of the traits showed high heritability which revealed lower influence of environment also observed in the study of Begum *et al*. (2016).

Table 1: Pooled analysis of variance using nine characters in barley

S.V.	d.f	DH	DM	PH	ET/P	SL	G/S	TSW	Y/P	Yld/plot
Replication	2	1.07	3.47	27.78	1.06	0.24	27.47	1.03	8.45	0.09
Treatment	4	30.50**	5.10	57.58	11.72	3.41**	706.04**	31.92**	30.24**	0.14*
Error	8	3.40	2.30	22.50	6.28	0.43	19.67	0.54	0.63	0.03

* indicates significant at 5% level and ** indicates significant at 1% level

Days to heading (DH), Days to maturity (DM), Plant height (PH)(cm), Effective tiller/plant (ET/P),Spike length (SL), (cm), Grain/ Spike (G/S), 1000 seed weight (TSW), Yield/ Plant (Y/P) (g), Plot yield (kg)

Table 2: Estimates of genetic parameters for nine characters in barley

Characters	σ^2g	σ^2p	GCV (%)	PCV (%)	Hb (%)	GA	GAPM
DH	9.03	12.43	5.74	6.74	72.65	5.28	10.08
DM	0.93	3.23	1.02	1.90	28.87	1.07	1.13
PH	11.70	34.19	3.94	6.74	34.21	4.12	4.75
ET/P	5.44	11.72	21.86	46.18	22.41	1.31	21.32
SL	0.94	1.42	13.56	16.21	69.93	1.72	23.36
G/S	686.38	706.04	29.89	31.14	92.09	29.90	59.08
TSW	31.38	31.92	7.81	8.01	95.09	6.50	15.69
Y/P	9.87	10.50	28.72	29.62	93.98	6.27	57.35
Yld/plot	0.04	0.07	7.42	10.02	54.79	0.29	11.31

σ^2g, σ^2p -Genotypic variance and phenotypic variance, GCV, PCV-Genotypic and phenotypic coefficient of variation, Hb- Heritability, GA- Genetic advance, GAPM- Genetic advance as percentage of mean

Days to heading (DH), Days to maturity (DM), Plant height (PH)(cm), Effective tiller/plant (ET/P),Spike length (SL), (cm), Grain/ Spike (G/S), 1000 grain weight (TSW), Yield/ Plant (Y/P) (g), Plot yield (kg)

The highest Hb was observed for 1000 seed weight (95.09) followed by yield/ plant (93.98), grain/ spike (92.09) and spike length (69.93), days to heading (72.65) but the lowest Hb identified for effective tiller/plant (22.41) followed by the plant height (34.21). The higher values of heritability of aforementioned traits were considered for selection, supported by Ali *et al*. (2012) and Moulin *et al*. (2009).

The highest GA was reported in grain/ spike (29.90) followed by 1000 seed weight (6.50), yield/plant (6.27), days to heading (5.28). The highest GA in grain/ spike resulted to the highest GAPM (59.08).

Five traits such as 1000 seed weight, yield/ plant, days to heading, spike length and yield/ plot showed higher heritability associated with low genetic advance indicated nonadditive gene action. It was also shown by Begum *et al*. (2016) and Matin *et al*. (2017). But the character grain/ spike had high Hb value along with high GA suggesting additive gene effects. It was also reported by Panse (1957).

Genotypic and Phenotypic Correlation Coefficients with Yield

The genotypic (upper diagonal) and phenotypic (lower diagonal) correlation coefficients for all nine traits were presented (Table 3). The yield had the highest positive genotypic (r_g) and phenotypic (r_p) correlation coefficient with grain/ spike ($r_{g=}0.84^{**}$, $r_p=0.68^{**}$). Grafius (1964) showed grains/spikes, spike number/m^2 and kernel weight /spike determined the yield of barley. Shrimali *et al*.(2017), Singh *et al*. (1987), Carpici and Celik (2012) mentioned spike length had positive correlation with yield. In many case, genotypic correlation recorded higher than phenotypic correlation which revealed that the association was due to genetic reason (strong coupling phase) (Sharma ,1988).

Negative significant correlation was found in plant height with yield ($r_{g=}$ -1.00**and r_p= -0.64**), yield/ plant ($r_{g=}$ -1.00**and r_p= -0.72**) and 1000 seed weight ($r_{g=}$ -0.92**and r_p= -0.64**) at both genotypic and phenotypic levels.

Table 3: Genotypic (upper diagonal) and phenotypic (lower diagonal) correlation with yield

	DH	DM	PH	ET/P	SL	G/S	TSW	Y/P	Y/plot
DH		1.00**	0.70**	0.65**	0.06^{NS}	-0.50*	0.39^{NS}	0.37^{NS}	-0.38^{NS}
DM	0.505*		0.66**	1.00**	0.79**	-0.37^{NS}	0.17^{NS}	0.19^{NS}	-0.09^{NS}
PH	0.48*	0.22^{NS}		1.00**	0.43^{NS}	-1.00**	1.00**	1.00**	-1.00**
ET/P	0.13^{NS}	-0.27^{NS}	0.46^{NS}		0.09^{NS}	-1.00**	1.00**	1.00**	-1.00**
SL	-0.07^{NS}	0.03^{NS}	0.10^{NS}	0.47^{NS}		-0.52*	0.27^{NS}	0.17^{NS}	-0.19^{NS}
G/S	-0.44^{NS}	-0.36^{NS}	-0.68**	-0.47^{NS}	-0.29^{NS}		-0.98**	-0.96**	0.84**
TSW	0.30^{NS}	0.13^{NS}	0.71**	0.62**	0.21^{NS}	-0.94**		1.00**	-0.92**
Y/P	0.36^{NS}	0.04^{NS}	0.61**	0.64**	0.14^{NS}	-0.89**	0.94**		-1.00**
Y/plot	-0.40^{NS}	-0.16^{NS}	-0.64**	-0.45^{NS}	0.09^{NS}	0.68**	-0.64**	-0.72**	

* indicates significant at 5% level and ** indicates significant at 1% level

Days to heading (DH), Days to maturity (DM), Plant height (PH)(cm), Effective tiller/plant (ET/P),Spike length (SL), (cm), Grain/ Spike (G/S), 1000 grain weight (TSW), Yield/ Plant (Y/P) (g), Plot yield (kg)

Table 4: Direct (bold) and indirect effect of different traits at genotypic level on yield

Characters	DH	DM	PH	ET/P	SL	G/S	TSW	Y/P	r_g with Yield.
DH	**0.55**	0.46	-0.23	-0.48	0.07	-2.84	1.84	0.25	-0.38^{NS}
DM	0.73	**0.34**	-0.22	-0.75	1.01	-2.14	0.82	0.13	-0.09^{NS}
PH	0.38	0.23	**-0.32**	-1.39	0.54	-6.28	5.01	0.83	-1.00**
ET/P	0.36	0.35	-0.61	**-0.74**	0.50	-8.20	6.42	0.92	-1.00**
SL	0.03	0.28	-0.14	-0.07	**1.26**	-2.93	1.27	0.11	-0.19^{NS}
G/S	-0.28	-0.13	0.38	1.07	-0.65	**5.65**	-4.57	-0.63	0.84**
TSW	0.22	0.06	-0.35	-0.96	0.34	-5.55	**4.65**	0.66	-0.92**
Y/P	0.21	0.07	-0.41	-1.03	0.21	-5.40	4.69	**0.66**	-1.00**

Residual effect= 0.028

Path Coefficient Analysis

The determination of correlation co-efficient associated with characters may not always provide an exact picture of the relative importance of direct and indirect influence of each of yield components of yield. So to find out a clear picture of the inter-relationship between yield and other yield attributes, direct and indirect effects were worked out using path analysis both at genotypic and phenotypic level that also estimated relative importance of each components as well. The yield was considered as a resultant variable other characters estimated as causal or independent variable (Shahidul *et al*., 2015).

As yield is a complex trait and normally affected by several components and selection based primarily only on correlations escaping the cause and effect relationship might be misleading (Uddin *et al*., 2015).

A number of barley researchers sought to explain the relations of yield-related components by using path coefficient analysis. Those researchers obtained results that included some discrepancies. Some studies reported that grain yield was determined by three yield components, e.g., spike number per m2, kernel number per spike and kernel weight per spike (Grafius, 1964). Some studies concluded that spike number per m2 was the primary determinant of grain yield in barley (Dofing and Knight, 1994). On the other hand, Singh *et al*. (1987) found that grain yield in barley was significantly correlated with plant height and spike length and that these two components had high positive direct effects on yield.

So, the genotypic correlation coefficients (r_g) have been partitioned into direct and indirect effects through path coefficient analysis (Table 4) to find a clear picture. Grain/ spike had the highest positive direct effect (5.65) on yield followed by 1000 seed weight (4.65**)**, spike length (1.26**),** yield/ plant (0.66**),** days to heading (0.55**)** and days to maturity (0.34**).** These parameters were identified as direct selection. Grain/spike showed the maximum positive correlation with yield (0.84). Shrimali *et al*. (2017) also found that days to flowering, days to maturity, spike length, no. of effective tillers/plant and yield per plant had high positive direct effects on yield which was also in agreement with the studies of Mittal *et al*. (2009), Kundalia *et al*. (2006) and Najeeb *et al*. (2004). The rest of the traits exhibited negative correlation with yield. Direct negative effect on yield was shown by plant height (-0.32) and effective tiller/plant (-0.74). It was also supported by Shrimali *et al*. (2017) at phenotypic and genotypic level respectively. This was an indication of indirect selection. Direct negative effect on yield also mentioned in some parameters of maize in an study of Matin *et al*. (2017), which indicated the effectiveness of indirect selection.

The residual effect was recorded 0.028 indicating there might have some other parameters that have not been considered but influenced the grain yield.

Conclusion

High genotypic coefficient of variation (GCV) were obtained from grain/ spike, yield/ plant and effective tiller/plant and spike length. The characters with high GCV indicated high potential for selection. The highest heritability (Hb) was observed for 1000 seed weight followed by yield/ plant, grain/ spike and spike length, days to heading but the lowest Hb identified for effective tiller/plant followed by the plant height. The higher values of heritability of these traits were indicative for selection. Grain/ spike had the highest positive direct effect on yield followed by 1000 seed weight, spike length, yield/ plant, days to heading and days to maturity. These parameters were identified as direct selection. While direct negative effect on yield was shown by plant height and effective tiller/plant suggesting the indirect selection.

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