Correlation Analysis of Grain Yield and Important Agronomic Traits in Six Rowed Barley (*HORDEUM VULGARE* L.) in Agra Region

Dr. Rajiv Kumar Singh Rathore[1], Dr. Yashasvita Chauhan[2]

[1]Department of Botany, Ch. Suraj Singh (P.G.) College Jagir, Mainpuri , U.P. India

[2]Department of Biotechnology, Agra College, Agra, U.P. India

Abstract: ***The investigation was conducted to evaluate the genotypic and phenotypic correlation analysis of grain yield and other contributing traits of cultivars and breeding line of barley in K.V.K. Research Farm Mathura. The results of correlation coefficient revealed thatthe genotypic correlations in general were higher than phenotypic correlations.The seed yield expressed significant and positive correlation at genotypic and phenotypic levels with tillers per plant (r= 0.382G, r= 0.358P), seeds per spike (r= 0.583G, r= 0.519P), 1000 seed weight (r= 0.364G, r=0.297P), biological yield per plant (r= 0.921G, r= 0.862P) and harvest index (r= 0.498G, r= 0.439P).Seed yield exhibited positive but non-significant association with days to flower (r= 0.058G, r= 0.029P) and strongly significant negative association with days to maturity (r= -0.634G, r= -0.487P) and plant height (r= -0.083G, r= -0.075P).***

Keywords: Genotypic correlation, phenotypic correlation, six rowed-barley

1. Introduction

Barley (Hordeumvulgare L.) is one of the most widespread cereals and currently ranks fourth in crop production throughout the world after wheat, maize and rice (Bengsston 1992, Asare *et al* 2011, FAOSTAT2017).

The greatest share of the worlds barley grain is used for animal feed, alcohol; production and human food barley is adapted to dry condition and can withstand environmental stress. The principal focus of most barley breeding programs has been improving yield by developing new cultivars with higher yield to meet the rising demand (Arpaili and Yagmur, 2015).

In the crop improvement process determining the genetic basis of agronomic traits has been a scientific principle (Pasam *et al*., 2012)

Correlation coefficient studied by Tofiq *et al.* (2015)provides necessary information to select the suitable parents for a hybridizing program.

There for the present study was undertaken to analyze the genotypic and phenotypic correlation coefficient for yield and yield contributing traits in six rowed barley (*Hordeum vulgare* L.)

2. Material and Methods

The present experiment was performed at K.V.K. Research Farm, Mathura (Uttar Pradesh), India during the rabi season. Mathura has semi-arid and tropical climate with hot and dry summers and severe winter.

3. Experimental Material

The experimental material for the present investigation was generated by crossing ten genetically diverse genotype of *Hordeum vulgare* following diallel mating design, n (n-1)/2 excluding reciprocals. In all the 45 crosses were made from the parents JYOTI, K603 (NARMADA), AZAD, K560 (HARITIMA), MANJULA, K551 (RITAMBHARA), K1149 (GEETANJALI), K226 (LAKHAN), K508 (PRAJAPATI), JAGRATI.

The 45 F_1 hybrids along with their 10 parents were evaluated for their performance in randomized block design (RBD) with three replications. Each treatment comprised of two rows of 3m length with the agronomicaly recommended (20*10 cm.) spacing between and within rows. Each treatment comprised of two rows of F_1 and four rows of parents and five competitive plants in each treatment in F_1 and parents were randomly selected for recording observations on following characters understudy.

Characters Studied

1. Days to flower, 2.Days to maturity, 3.Plant height (cm), 4.Number of tillers per plant, 5. Spike length (cm), 6. Number of seeds per spike, 7. 1000 seed weight (g), 8. Grain yield per pant, 9. Biological yield per plant, 10.Harvest index (%).

Estimation and Correlation Coffient

The inter-relationship between various characters were studied by using the phenotypic and genotypic correlation coefficients as suggested by Croxton and Cowden (1968).

Phenotypic and genotypic correlation coefficients were calculated by using variances and co-variances of the respective pairs of character combinations as:
Where,

$$Genotiptpypic\ correlation\ coefficient\ (rg) = \frac{Cov.XYg}{\sqrt{Var\ Xg\ Var\ Yg}}$$

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Where
$CovXY_p$ = Phenotypic covariance of character X and Y

$VarX_p$ = Phenotypic variance of character X
$VarY_p$ = Phenotypic variance of character Y
$CovXY_g$ = Genotypic covariance of character X and Y
$VarX_g$ = Genotypic variance of character X
$VarY_g$ = Genotypic variance of character Y

The significance of correlation coefficient was tested against 'r' values from 'r' table of Fisher and Yates (1967) for (t-2) degrees of freedom at 5 percent and 1 percent.

Values of significance, where, 't' is the number of genotype.

4. Observations and Results

The experimental data recorded for two consecutive years in the present investigations were statistically analyzed and the results obtained from the diallel set of ten parents and their 45 F1s are presented here.

The correlation coefficients between different characters in55 genotypes including 45 F_1's and their 10 parents of barley (*Hordeum vulgare*) for two years and there pooled analysis at genotypic and phenotypic level are presented table 1, 2 and 3.

The genotype correlations in general were higher than phenotypic correlations. The directions of genotypic and phenotypic correlations were almost same for most of the character combinations.

A perusal of table3 revealed that **days to flower** exhibited highly significant and positive correlation at both the genotypic and phenotypic level with days to maturity (r= 0.450G, r= 0.310P); and non-significant positive with plant height (r= 0.065G, r=0.033P); seeds per spike (r= 0.095G, r 0.055P); biological yield per plant (r= 0.088G, r= 0.056P) and seed yield per plant (r= 0.058G, r=0.029P). However, but negative correlation of this character was noted with tillers per plant (r- -0. 185G, r= -0. 179P); spike length (r= -0.067G, r= 0.073P); 1000 seed weight (r -0. 164G, r= -0.11 1P) and harvest index (r= -0.016G, r= -0.013P).

Days to maturity : Days to maturity manifested negative and highly significant genotypic and phenotypic correlations with tillers per plant (r-0.445G, r - 0.372P); seeds per spike (r= -0.437G, r= -0.33 1P); 1000 seeds weight (r= -0.5 16G, r= -0.232P); biological yield (r= -0.3 12G, r= -0.239P); harvest index (r= -0.970G, r= -0.671P) and seed yield per plant (r= -0.634G, r -0.487P). The only positive but non-significant correlation was noted days to maturity and plant height (r=0.142G, r= 0.184P).

Plant height : The character plant height exhibited highly significant and positive correlation at genotypic and phenotypic level with tillers per plant (r0.580G, r 0.435P) and 1000 seed weight (r= 0.237G, r= 0.21 1P). However, non-significant positive association of this character was noted with seeds per spike (r= 0.036G, r= 0.034P) and with spike length (r= 0.018P) at phenotypic level only. Negative but non-significant association of this character was noted with biological yield per plant (r= -0.018G, r= -0.017P); harvest index (r -0.074G, r= -0.057P) and seed yield per plant (r = -0.083G, r = -0.075P) at both genotypic and phenotypic level and with spike length (r= -0.003G) at genotypic level only.

Tillers per plant: The pooled estimates of correlation coefficient at genotypic and phenotypic level for this character were noted to be positive with all the remaining characters. However, it exhibited highly significant correlation with harvest index (r= 0.38 1G, r= 0.308P) and seed yield per plant (r= 0.382 G, r= 0.358P) at both the levels and significant positive with spike length (r 0.263G); seeds per spike (R= 0.221G) and 1000 seed weight (r= 0.236G) at genotypic level only.

Spike length: A perusal of Table 3 consisting pooled estimates of correlations at genotypic and phenotypic level revealed that spike length was found to be positively associated with seeds per spike, harvest index and seed yield per plant. It exhibited significant and positive association with seeds per spike (r= 0.242P) at phenotypic level and with harvest index (r= 0.252G) at genotypic level spike length exhibited non-significant negative association with 1000 seed weight (r - 0.06 1G, r= -0.080P) and biological yield per plant (r= -0.200G, r= -0. 124P) at both the level.

Seeds per spike: Highly significant and positive correlation of this character was noted with biological yield per plant (r= 0.362G, r= 0.334P); harvest index (r=687G, r=0.572P); and seed yield per plant (r 0.583G, r= 0.519P) at both the levels and non-significant positive with 1000 seed weight (r= 0.040G, 0.018P).

1000 seed weight: The character 1000 seed weight exhibited highly significant and positive association with harvest index (r= 0.332G, r= 0.247P) and seed yield per plant (r= 0.364G, r= 0.297P) at genotypic and phenotypic level both. However, it exhibited significant and positive association with biological yield per plant (r= 0.228G) at genotypic level and non-significant positive association (r= 0. 190P) at phenotypic level.

Biological yield per plant: A perusal of Table 29 revealed that biological yield per plant exhibited highly significant and positive correlation with seed yield per plant (r= 0.921G, r= 0.862P) at genotypic and phenotypic levels whereas it exhibited non significant and positive correlation with harvest index (r= 0.10 G, r= 0.061P).

Harvest index: At both genotypic and phenotypic levels harvest index expressed highly significant and positive association with seed yield per plant (r= 0.498G, r=0.439P).

5. Discussions and Conclusion

Since, yield is a polygenically controlled complex character. It is being expressed due to simultaneous contribution of its many associated characters that doesn't change or change a little from one environment to another. If there is no significant correlation between these characters, then their effect on yields are direct. The nature of correlation between yield and its contributing characters provide more efficient selection tools for the crop breeders because the complexity and preponderance of environment on seed yield, further restricts direct selection for this trait. Acknowledged of interrelationships between seed yield and its component characters is of tremendous significance in developing an efficient breeding program to manipulate the yield contributing characters simultaneously in order to manipulate genetic architecture essential for tailoring of genotypes to get new plant types (NPT) as advocated by Donald (1978) in wheat and rice.

The correlation studies supply more reliable information about the nature, extent and direction of selection. The knowledge of genetic correlation between yield and its contributing characters become pre-requisite when a breeder takes the target of introducing a character into some otherwise agronomicaly accepted superior cultivar from an uneconomic genotype.

The knowledge of correlation between desirable and undesirable gene and/or genes restrains the breeder from applying exhaustive unidirectional selection as it will lead to drastic and disastrous consequence. Thus, the knowledge of correlations is very useful in plant breeding for indirect selection of characters that show low heritability and/or difficult to measure.

The overall results of the present study on this parameter indicate that genotypic correlations in general were higher than phenotypic correlations. The direction and magnitude of genotypic correlation was almost same for most of the character combinations.

The seed yield expressed significant and positive correlation at genotypic and phenotypic levels with tillers per plant, seeds per spike, 1000 seed weight, biological yield per plant and harvest index. Similar results were also reported by Aghaei (1994) and Melomirka et al., (2005). The magnitude of correlations between seed yield and biological yield was higher than other traits. Thus the role in biological yield in the high expression of seed yield was higher than other traits. Significant and positive correlation between seed yield and harvest index indicated that genotypes that have higher harvest index are able to use most of photosynthate. This result was in agreement with those reported by Yazadan Sepas (1998).

Many workers have also reported similar positive and significant association of seed yield with tillers per plant (Yadav and Josi, 1992; Ataei, 2005), with spike length " (Bist and Ghalin, 2009; Drikvand et al., 2011 and Tas and Celik, 2011), with seeds per spike (Dogan 2009; Drikvand et al., 2011; Khagavi et al., 2013), with 1000 seed weight (Tar and Celik, 2011; Khajavi et al., 2014, Kumar et al., 2014), with biological yield (Shimia et al., 2005;Dogan et a!., 2009; Tas and celek 2011; Drikvand et al., 2012), with harvest index (Carpici and Celik 2012; Khajavi et al., 2014, Kumar et al., 2014).

Seed yield exhibited positive but nonsignificant association with days to flower and strongly significant negative association with days to maturity. Similar results were reported by Selim et al., (1963); Jain (1968) and Tewari (1974). The difference may be due to various kinds of environmental stresses which considerably influenced the yield (Fuzicka, 1972, a). The selection studies of Fiuzat and Atkins (1963) and Rasmusson and Cannel (1972) for seed yield and its components also reveal that genetic as well as environmental factors were responsible for the observed phenotypic correlation between the components of seed yield.

Positive and significant association were also recorded between days to flower and days to maturity; plant height and tillers per plant and insignificant positive with seed yield per plant and 1000 seed weight. In this regard, findings of Maihotra and Jam (1972) are significantly important as they also reported that days to flower were positively associated with days to maturity.

In the present study plant height exhibited negative association with seed yield (Bilinsky et al., 1972; Mohammadi, 1997), biological yield and harvest index at genotypic and phenotypic level is also reported by Hamblian and Donald (1974) and khayatnezhad et al., 2010.Spike length had positive and significant correlation with seeds per spike and harvest index but negative but non-significant with 1000 seed weight and biological yield. Seeds per spike had weak positive association with 1000 seed weight but strong positive association with biological yield and harvest index. The expression of positive association between seeds per spike and 1000 seed weight provides a hope that segregants with higher number of well filled seeds (high test weight) can be isolated from the succeeding generations of the present investigation. The genotypic and phenotypic correlations of 1000 seed weight were positive and significant with biological yield and harvest index. Biological yield per plant was found to have strong positive association with harvest index at genotypic and phenotypic levels.

These correlations showed that selection for these traits plays an important role in improving grain yield in barley and to determine the influence of environment on productivity and yield potential.

6. Results and Observations

Table 1: Genotype correlation coefficients for yield and its contributing characters in of Barley (*Hordeum vulgare*) in the year 2009 – 2010 and 2010 – 2011

Characters	Years	Characters								
		Days To Maturity	Plant Height	Tillers/ Plant	Spike Length	Seeds / Spike	1000 Seed Weight	Biological Yield / Plant	Harvest Index	Correlation With Seed Yield/ Plant
Days To Flower	1	0.058**	0.128	-0.115	-0.213**	0.102	-0.334**	-0.098	-0.081	-0.182
	2	0.465**	0.062	0.098	-0.42**	0.293**	-0.067	0.658**	0.608**	0.756**
Days To Maturity	1		0.17	-0.295**	0.256*	-0.059	-0.497**	-0.158	0.587**	0.353**
	2		-0.4.00**	0.891**	0.475**	0.602**	-0.491**	-0.149	0.928**	0.686**
Plant Height	1			-0.381	0.098	0.326**	0.198	0.224*	0.078	0.198
	2			-0.582	0.602**	0.492**	0.258*	0.169	-0.178	0.139
Tillers / Plant	1				0.111	0.189	0.201	0.232*	0.227*	0.306*
	2				0.444*	0.523**	0.655**	0.08	0.530**	0.556**
Spike Length	1					0.181	0.005	-0.08	0.054	-0.082
	2					0.153	0.065	0.084	0.244**	0.027
Seeds / Spike	1						0.072	0.466**	0.429**	0.551**
	2						0.184	0.272**	0.026	0.417**
1000 Seed Weight	1							0.368**	0.308**	0.424**
	2							0.118	0.287**	0.168
Seed Yield/ Plant	1								0.261	0.928
	2								0.075	0.791**
Biological Yield	1									0.615**
	2									0.620**
* , ** = Significant at 5% and 1% level of significance										
1 = 20098 – 2010 and 2 = 2010 – 2011										

Table 2: Phenotype correlation coefficients for yield and its contributing characters in F1 Of barley (*Hordeum vulgare*) in the year 2009 – 2010 and 2010 – 2011

Characters	Years	Characters								
		Days To Maturity	Plant Height	Tillers/ Plant	Spike Length	Seeds / Spike	1000 Seed Weight	Biological Yield / Plant	Harvest Index	Correlation With Seed Yield/ Plant
Days To Flower	1	0.458**	0.107	-0.131	-0.139	0.092	-0.303**	-0.093	-0.07	-0.096
	2	0.097	0.059	0.05	-0.268	0.290*	-0.043	0.608**	0.553**	0.668**
Days To Maturity	1		0.193	-0.297	-0.113	-0.036	-0.378**	-0.147	-0.500**	-0.339
	2		0.02	-0.076	-0.124	-0.008	0.184	-0.024	0.104	0.024
Plant Height	1			-0.325**	-0.064	0.306**	0.18	0.196	0.031	0.152
	2			-0.387**	-0.353**	0.427**	-0.04	0.13	-0.044	0.075
Tillers / Plant	1				0.065	0.162	0.159	0.222*	0.203*	0.294*
	2				0.034	0.333**	0.236	0.078	0.410**	0.465**
Spike Length	1					-0.227*	0.052	-0.066	0.065	-0.045
	2					0.159	0.007	-0.058	-0.159	-0.09
Seeds / Spike	1						0.075	0.437**	0.382**	0.506**
	2						-0.149	0.269*	-0.043	0.391**
1000 Seed Weight	1							0.347**	0.297*	0.398**
	2							0.109	0.121	0.188
Seed Yield/ Plant	1								0.230*	0.887**
	2								0.069	0.757**
Biological Yield	1									0.580**
	2									0.559**

* , ** = Significant at 5% and 1% level of significance
1 = 20098 – 2010 and 2 = 2010 – 2011

Table 3: Pooled correlation coefficients for yield and its contributing characters in barley (*Hordeum vulgare*) in the year 2009 – 2010 and 2010 – 2011

Characters	Years	Characters								
		Days To Maturity	Plant Height	Tillers/ Plant	Spike Length	Seeds / Spike	1000 Seed Weight	Biological Yield / Plant	Harvest Index	Correlation With Seed Yield/ Plant
Days To Flower	G	0.450**	0.065	-0.186	-0.067	0.095	-0.164	0.088	-0.016	0.058
	P	0.310**	0.033	-0.179	-0.073	-0.055	-0.111	0.056	-0.013	0.029
Days To Maturity	G		0.142	0.445**	-0.068	-0.437**	-0.516**	-0.312**	-0.970**	-0.634**
	P		0.184	-0.372**	-0.028	-0.331**	-0.232*	-0.239	-0.671**	-0.487**
Plant Height	G			0.580**	-0.003	0.036	0.237*	-0.018	-0.074	-0.083
	P			0.435**	0.018	0.034	0.211*	-0.017	-0.057	-0.075
Tillers / Plant	G				0.263**	0.221**	0.236*	0.209	0.381**	0.382**
	P				0.156	0.193	0.125	0.197	0.308*	0.358**
Spike Length	G					0.159	-0.061	-0.200	0.252*	0.059
	P					0.242*	-0.08	-0.124	0.182	0.038
Seeds / Spike	G						0.040	0.362**	0.687**	0.583**
	P						0.018	0.334**	0.572**	0.519**
1000 Seed Weight	G							0.220*	0.332**	0.364**
	P							0.190	0.247*	0.297*
Seed Yield/ Plant	G								0.102	0921**
	P								0.001	0.862**
Biological Yield	G									0.498**
	P									0.439**
* , ** = Significant at 5% and 1% level of significance										
G = Genotypic Correlation P = Phenotypic Correlation										

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