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Original Research

Correlation and Path Analysis for Grain Yield and Yield Related Traits of Barley (*Hordeum vulgare L.)* Landraces from Southern Ethiopia

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Abstract

Knowledge of genetic and phenotypic association among economic traits helps plant breeders in designing efficient breeding strategies for development of high yielding barley cultivars. Accordingly, a study was conducted to investigate the interrelationship among yield and yield related characters and extent of their contribution to grain yield on barley landraces. Thirty six barley landraces were collected from three barley growing districts of Gamo Gofa Zone, Ethiopia. The landraces were sown in the first week of June, 2014 in Chencha experimental field in a randomized complete block design with three replications. Based on phenotypic level, grain yield was positively and highly significantly correlated with number of grain per spike, biomass per plant and harvest index. Significant and positive phenotypic correlation between grain yield and harvest index, indicated that genotypes that have higher harvest index able to use most of photosynthetic materials. Grain yield was positively correlated with grain filling period (0.026,, 0.029), maturity days (0.024, 0.026), harvest index (0.763, 0.912), peduncle length(0.045, 0.076), plant height(0.197, 0.211), number of grain per spike(0.705, 0.778), biomass per plant (0.679, 0.597) and thousand seed weight (0.480, 0.830) at both phenotypic and genotypic level, respectively. Path coefficient analysis based on grain yield as dependent variable revealed that days to heading, days to maturity, number of tillers per plant, peduncle length, plant height and biomass per plant showed positive direct effects on grain yield. Therefore, these characters could be considered as major components of selection in a breeding program for obtaining higher grain yield.

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INTRODUCTION

Barley (*Hordeum vulgare* L.) is the most widely grown cereal crop in a wide range of climatic conditions. At present, barley is the world's fourth most produced and marketed cereal (Mohammed *et al.,* 2011). Because of its use in malt production, barley is grown in many areas of the world for cultural as well as economic reasons. Most recent reports showed that, the quantity of barley produced worldwide is declining (Mohtashami, 2015). In Ethiopia, barley is a major traditional cereal crop, together with teff (*Eragrostis tef (Zucc.)* Trotter), maize (*Zea mays* L.), wheat (*Triticum ssp.)* and sorghum (*Sorghum bicolour* (L.) Moench), and it represents about 13% of the total national cereal production, with an average yield of 1.7 t ha-1 (FAO, 2008). It is a low input crop that is produced mainly in marginal areas with low soil fertility and varied agro ecological conditions. With few exceptions, barley is grown in all regions in Ethiopia. Lack of improved varieties, disease, insect, pest problem, weed competition and poor soil fertility has been indicated as major constraints in barley improvement (Berhane *et al*. 1997). Therefore, to meet the self-sufficiency, increasing barley production is important to the economic stability and food security of Ethiopia.

Grain yield and its quality are the principal characters of a cereal crop (Quan, 2015). They are complex quantitative characters, which are influenced by a number of yield contributing characters. Hence, selection for desirable barley landraces genotypes should not only be based on yield alone, and the other yield components should also be considered. Direct selection for yield is often misleading in barley because barley yield is polygenically controlled. The correlation coefficients between yield and yield components usually show a complex chain of interacting relationship. Path coefficient analysis partitions the components of correlation coefficient into direct and indirect effects and illuminates the relationship in a more meaningful way (Majumder *et al.,* 2008). Therefore, the purpose of this research is to estimate the magnitude of correlation between barley grain yield and yield contributing characters, and to partition the correlation coefficients of yield with its related traits into direct and indirect effects through path analysis.

MATERIALS AND METHODS

The study was conducted in Southern Nations, Nationalities and People's Regional State, Gamo Gofa Zone, Chencha District. Chencha is one of the districts in the highlands of Gamo Gofa Zone having two agro-ecological zones, *Dega* and *Woina Dega*, accounting for about 82 and 18% the total area respectively. Altitude of the district varies from 1800 m.a.s.l to 3500 m.a.s.l. The area has bimodal rainfall. The first is from March to April and the second from June to October helping to grow *meher (*long rainy season) *and belg* (short rainy season) respectively. The annual rainfall ranges between 1201mm to 1600mm. The site is selected based on its barley crop production potential, along rainy season which covers from June to October.

Experimental Materials and Design

Thirty six barley landraces were collected from three barley growing districts of Gamo Gofa Zone (Table 1, which covers an altitudinal range from 2,000 to 3, 000 m.a.s.l. The landraces were collected from farmers' fields, by use of random sampling technique (Hawkes, 1976). The landraces were sown in the first week of June, 2014 in Chencha experimental field in a randomized complete block design with three replications. The experimental plots consisted of 6 rows of 2.5 m length with 30 cm spaces and seed were sown by hand. The plant density of 300 plants per m^2 and recommended dose of fertilizer (100:70:50, NPK) kg per ha were applied. Weeds were removed by hand prior to flowering stage.

Table 1: List of barley landraces used in the experiment and their collection site

No.	Local name	Collection site	Altitude (m.a.s.l)	No.	Local name	Collection site	Altitude(m.a.s.l)
1.	Duhe I	Chencha	2983	19	Solga II	Dita	2764
2.	Locha I	Chencha	2992	20	Morka	Dita	2771
3.	Maleno I	Chencha	2986	21	Chega IV	Dita	2867
4.	Locha II	Chencha	2984	22	Osaha	Dita	2870
5.	Chega I	Chencha	2968	23	NK 1	Dita	2871
6.	Chentic	Chencha	2971	24	Maleno III	Dita	2888
7.	Wolate	Chencha	2932	25	Locha II	Dita	2948
8.	Kawbanga I	Chencha	2931	26	Losha	Dita	2950
9.	Bote I	Chencha	2939	27	Bote II	Dita	2950
10.	Maleno II	Chencha	2872	28	Kaobanga II	Dita	2904
11.	Bote 2	Chencha	2886	29	Chega V	Dita	2762
12.	Ye gibirina	Chencha	2885	30	Murka	Bonke	2384
13.	Karsa Ocho	Chencha	2895	31	Shilash	Bonke	2365
14.	Giso	Chencha	2810	32	Geze Banga	Bonke	2559
15.	Bote 3	Chencha	2809	33	Wolkiie	Bonke	2557
16.	Chega II	Dita	2536	34	Lealo	Bonke	2372
17.	Solga I	Dita	2542	35	Mirichicho	Bonke	2379
18.	Chega III	Dita	2636	36	NK II	Bonke	2354

Data Collection Methods

Data were collected on thirteen quantitative character's such as days to heading , grain filling period, days to maturity, number of tiller per plant, harvest Index, peduncle length, plant height, spike length, number of spikelet's per spike, number of grains per spike, biomass per plant, thousand seed weight(gm), grain yield per plant .

Statistical Analysis

Association of characters and path coefficient analysis

A. **Correlation coefficient (r):**

Genotypic and phenotypic coefficients of correlation between two characters were determined by using variance and covariance components as suggested by Dewey & Lu (1995).

$$r_g(xy) = \frac{\text{cov}_g(xy)}{\sigma^{\frac{1}{2}}{}_g(x) \times \sigma_p{}^{\frac{1}{2(y)}}}$$

$$r_p = \frac{\text{cov}_p(xy)}{\sigma^{\frac{1}{2}}{}_g(x) \times \sigma_p{}^{\frac{1}{2(y)}}}$$

Where: $r_g(xy)$ and $r_p(xy)$ are genotypic and phenotypiccorrelation coefficients, respectively. Cov_g (xy) and Cov (xy) are genotypic and phenotypic covariance of xy

$$\sigma^{\frac{1}{2}}{}_g(x), \sigma^{\frac{1}{2}}{}_p(x) and \sigma^{\frac{1}{2}}{}_g(y), \sigma^{\frac{1}{2}}{}_p(y)$$

are genotypic and phenotypic standard deviations of x and y, respectively.

These, coefficient of correlation were tested for their statistical significance by using t test as:

$t = \frac{r\sqrt{(n-1)}}{\sqrt{(1-r^2)}}$ where n = number of treatments

The calculated value of t was compared with 't' table value at n-2 degrees of freedom at 1 and 5 percent level of significance.

B. Path coefficient analysis

Path coefficient analysis was estimated with the formula given by Dewey and Lu (1995).

$$r_{ij} = P_{ij} + \sum r_{ik} p_{jk}$$

Where: r_{ij} is association between independent variables (i) and dependent variable j as measured by phenotypic and genotypic correlation coefficient.

P_{ij} is component of direct effect of independent variable (j) as measured by the phenotypic and genotypic path coefficients and

$\sum r_{ik} p_{jk}$ is the summation of components of indirect effect of a given independent variable(i) on a given dependent variable(j) via all other independent variables.

For analyzing the above data Genstat and SPSS V. 16 software's were used. Moreover, PATH2 software was also used to analyze Path coefficient analysis.

RESULTS AND DISCUSSION

Association of grain yield per plant with yield related characters

It is evident from the result (Table 2) that magnitude of genotypic correlation coefficients is higher than that of phenotypic correlation coefficients which shows that the association between them is genotypic inheritance and not the environmental influence. Similar results were reported in barley by Bedassa (2014). Based on phenotypic level grain yield was positively and highly significantly correlated with harvest index (r = 0.763**), number of grain per spike (r = 0.705**) and biomass per plant (r = 0.679). There was also positive and significant correlation with thousand seed weight (0.480) at phenotypic levels. A positive value of r shows that the changes of two variables are in the same direction , that means high values of one variable are associated with high values of other and vice versa. This result was in agreement with those reported by (Madic, *et al*., 2005). Significant and positive phenotypic correlation between grain yield and harvest index, indicated that genotypes that have higher harvest index able to use most of photosynthetic materials. However, low and positive phenotypic correlations were observed between grain yield and grain filling period (0.026), days to maturity (0.024) and peduncle length (0.045), plant height (0.197) and number of spikelets per spike (0.001).

On the contrary, Mohammadi and Khodambashi (1997) reported negative correlation between plant height and grain yield. Grain yield showed positive and highly significant correlation with harvest index (0.912), thousand seed weight (0.830), number of grain per spike (0.778) and biomass per plant (0.597) at genotypic level. This result was in agreement with Mohtashami (2015), who reported that plant height, seed number spike, days to maturity and thousand kernel weight had the highest significant positive correlation with grain yield.

On the other hand grain yield was negatively correlated with days of heading (-0.015) and number of tillers per plant (-0.012). It also had highly significant ($p<0.01$) and negative correlation with spike length (-0.227^{**}) at phenotypic level. This is in agreement with the observation of Zaefizadeh *et al.* (2011), who reported a negative correlation between grain yield and days to heading, spike length and grain weight in spike. In contrary Mohtashami (2015), reported positive and significant correlation between grain yield and days of heading.

Generally, grain yield was positively correlated with grain filling period, maturity days, harvest index, peduncle length, plant height, number of spikelets per spike, number of grains per spike, biomass per plant and thousand seed weight at both phenotypic and genotypic level. In contrast, it was negatively correlated with days of heading, number of tiller per plant and spike length. Hence, making simultaneous increase for these characters with grain yield per plot is difficult.

Correlation among other characters

Correlation among yield and yield components and other quantitative traits help to identify characters needed by barley genotypes to grow successfully under certain ecological conditions and also to identify and avoid characters that have little or no importance and use of some traits in the selection program. Many interesting associations were observed among yield related characters (Table 2). Highly significant and positive correlation were observed between maturity days and grain filling period (0.692**, 0.744**), harvest index and number of grain per spike (0.892**, 0.764**), plant height and biomass per plant (0.263**, 0.268**), plant height and thousand seed weight (0.309**, 0.325**) at phenotypic and genotypic level, respectively. This was in agreement with Mohammed *et al.*(2011) , who reported that positive correlation between number of fertile tillers with days to heading, days to maturity with days to heading and thousand grain weight with days to maturity, plant height with number of grain per main spike, and thousand grain weight with harvest index.

Plant height is also positively and non-significantly correlated with grain filling period (0.029, 0.032), number of tiller per plant (0.062, 0.079), harvest index (0.0.063, 0.073) at phenotypic and genotypic level, respectively. On the other hand, plant height had highly significant and negative correlation with days to heading and days to maturity. In contrast, Khayatnezhad et *al*. (2010), reported negative correlation between harvest index with plant height and plant height with grain yield.

	DH	*GFP*	*MD*	*NTPP*	*HI*	*PL*	*PH*	*SL*	*NSPS*	*NGPS*	*BPP*	*TSW*	*GY*
DH		-0.155	0.540*	0.005	0.056	-0.284**	-0.423**	0.088	0.137	0.034	-0.135	-0.065	-0.015
GFP	-0.178		0.692**	-0.292**	-0.032	-0.068	0.029	-0.263**	-0.107	-0.242**	0.123	0.399*	0.026
MD	0.606*	0.744**		-0.223*	0.040	-0.254**	-0.282**	-0.200*	0.004	-0.154	-0.005	0.286**	0.024
NTPP	0.006	-0.352	-0.265*		-0.005	-0.080	0.067	0.009	-0.001	0.124	-0.058	-0.224*	-0.012
HI	0.069	-0.039	-0.168	-0.007		0.014	0.063	-0.349**	0.013	0.892**	0.121	0.092	0.763**
PL	-0.496**	-0.115	-0.418*	-0.148	0.026		0.368	0.118	-0.217	-0.389*	0.061	0.068	0.045
PH	-0.469*	0.032	-0.295	0.079	0.073	0.596*		0.089	-0.138	0.041	0.263**	0.309**	0.197
SL	0.258	-0.732**	-0.549**	0.028	-0.057	0.502*	0.240		-0.058	-0.187*	-0.008	-0.200	-0.227**
NSPS	0.171	-0.128	0.005	-0.001	0.017	-0.394*	-0.160	-0.175		0.069	0.004	-0.048	0.001
NGPS	0.040	-0.266	-0.166	0.151	0.764**	-0.651**	0.043	-0.522	0.082		0.099	-0.187*	0.705**
BPP	-0.148	0.129	-0.005	-0.067	0.138	0.097	0.268**	-0.022	0.005	0.104		0.722	0.679**
TSW	-0.074	0.432*	0.305	-0.268*	0.109	0.112	0.325**	-0.551	-0.056	-0.203	-0.156		0.480*
GY	-0.017	0.029	0.026	-0.014	0.912**	0.076	0.211	-0.635	0.001	0.778**	0.597**	0.830**	

Table 2: Phenotypic (above diagonal) and genotypic (below diagonal) correlations coefficients among 13 traits in the 36 barley landraces grown at Chencha, 2014

DF-Days to heading (days); GFP -grain filling period (days); DM- Days to maturity (days); NTPP - Number of tiller per plant; HI-Harvest Index; PL- Peduncle length(cm) ; PH- Plant height(cm); SL- Spike length(cm); NSPS: Number of spikelet's per spike; NGPS: Number of grains per spike; BPP -Biomass per plant (gm); TSW: Thousand seed weight(gm);GY-Grain yield per plant (gm)

Path coefficient analysis

Correlations were further analyzed by path coefficient analysis technique, which involved partitioning of the correlation coefficient in to direct and indirect effects via alternative characters or path. Path coefficient analysis specifies the cause and measures the relative importance of characters, while correlation measures only mutual associations without considering causation (Dewey & Lu, 1995). Path analysis has proven useful in providing additional information that describes cause and effect relationships, such as between yield and yield components, it is therefore, essential to assess the importance as well as degree of association of various quantitative characters in order to initiate an effective selection program aimed at genetic improvement of crop yield.

Direct and indirect effects of various characters on grain yield

The path coefficient analysis based on grain yield as dependent variable revealed that, days to maturity (0.045), number of tillers per plant (0.018), harvest index (0.681), spike length (0.011) and biomass per plant (0.639) showed positive direct effects on grain yield (Table 3). Therefore, these characters could be considered as major components of selection in a breeding program for obtaining higher grain yield. Ignore characters with very small positive effect!!! They are not important for selection.

Path analysis of grain yield and its components showed that, biomass yield and harvest index showed the highest direct influence with values of 0.639 and 0.881, respectively. Similar results were reported by other researchers who conducted studies on grain yield and determined the direct effects of different yield components on grain yield (Khan *et al*., 1999; Moghaddam *et al*., 1998; Aycicek & Yıldırım, 2006).Furthermore, days to maturity, days to heading, plant height, number of tillers per plant, number of grains per plant, spike length and peduncle showed positive and moderate direct effects on grain yield, 0.045, 0.01, 0.009, 0.018,0.031, 0.011 and 0.001, respectively. In addition to its maximum direct effect on grain yield, biological yield exhibited positive indirect effects through harvest index

	DH	*GFP*	*MD*	*NTPP*	*HI*	*PL*	*PH*	*SL*	*NSPS*	*NGPS*	*BPP*	*TSW*
DH	**0.01**	0.005	0.025	0.000	0.039	0.000	-0.004	0.001	-0.003	0.001	-0.089	0.003
GFP	-0.002	**-0.033**	0.032	-0.005	-0.022	0.000	0.000	-0.003	0.002	-0.008	0.081	-0.016
MD	0.005	-0.023	**0.045**	-0.004	0.028	0.000	-0.003	-0.002	0.000	-0.005	-0.003	-0.012
NTPP	0.000	0.010	-0.010	**.018**	-0.004	0.000	0.001	0.000	0.000	0.004	-0.038	0.009
HI	0.001	0.001	0.002	0.000	**0.681**	0.000	0.001	-0.004	0.000	0.028	0.079	-0.004
PL	-0.003	0.002	-0.012	-0.001	0.010	**0.001**	0.003	0.001	0.005	0.001	0.040	-0.003
PH	-0.004	-0.001	-0.013	0.001	0.044	0.001	**0.009**	0.001	0.003	0.001	0.173	-0.013
SL	0.001	0.010	-0.010	0.000	-0.266	0.000	0.001	**0.011**	0.001	-0.006	-0.006	0.009
NSPS	0.001	0.004	0.000	0.000	0.009	0.000	-0.001	-0.001	**-0.021**	0.002	0.003	0.002
NGPS	0.000	0.008	-0.007	0.002	0.616	0.010	0.000	-0.002	-0.001	**0.031**	0.065	0.008
BPP	-0.001	-0.004	0.000	-0.001	0.084	0.000	0.002	0.000	0.000	0.003	**0.639**	-0.030
TSW	-0.001	-0.013	0.013	-0.004	0.064	0.001	0.003	-0.002	0.001	-0.006	0.473	**-0.040**

DF-Days to heading (days); GFP -grain filling period (days); DM- Days to maturity (days); NTPP - Number of tiller per plant; HI-Harvest Index; PL- Peduncle length(cm) ; PH- Plant height(cm); SL- Spike length(cm); NSPS: Number of spikelet's per spike; NGPS: Number of grains per spike; BPP -Biomass per plant (gm); TSW: Thousand seed weight(gm)

Besides its direct effect on grain yield, harvest index, exhibited maximum favorable indirect effects via biomass per plant (0.079), number of grain per spike (0.028), days to maturity (0.002), days to heading (0.001), grain filling period (0.01) and plant height (0.001). Negative indirect effect of harvest index was also observed on spike length and thousand seed weight (Table 3). This result was in agreement with Mohammod *et al.* (2011), who showed that most positive direct effect on yield by number of seeds per main spike and most negative direct effect were for number of spikletes per spike and also most indirect effects by fertile tillers on chaff weight. Negative direct effects on grain yield were recorded for grain filling period (-0.033), number of spikelets per spike (-0.021) and thousand seed weight (-0.040). Though, number of grains per spike was positively and highly significantly correlated with grain yield per plant (Table 3) , its positive direct effect was counterbalanced by negative indirect effect via days to maturity, spike length and number of spikelet's per spike.

Therefore, it is evident from the result of the study that high consideration should be placed on biological yield, harvest index, days to heading, days to maturity, peduncle length , plant height, and number of grain per spike to improve barley grain yield, since they showed positive direct effects; with special emphasis on biological yield and harvest index.

CONCLUSIONS AND RECOMMENDATIONS

Based on this study it can be concluded that grain yield could be effectively increased by maximum genetic expression of number of grain per spike, biomass per plant, plant height and thousand seed weight. The path coefficient analysis based on grain yield as dependent variable revealed that days to maturity, harvest index and biomass per plant showed positive direct effect on grain yield. Therefore, these characters could be considered as major components of selection in a breeding program for obtaining higher grain yield.

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REFERENCES

Aycıcek, M. & Yıldırım, T. (2006). Path coefficient analysis of yield and yield components in bread wheat (*Triticum aesiıvum* L.) genotypes*. Pak Journal of Botany*, *38:* 417-424.

Berhane L., Yitbarek S., Fekadu A., Gebre, H., Grando, S., van Leur, J.A.G. & Ceccarelli, S. (1997). Exploiting the diversity of barley landraces in Ethiopia. *Genetic Resources and Crop Evolution, 44:*109–116.

Dewey, D.R., & K.H. Lu. (1995). A correlation and path coefficient Analysis components of crested wheat grass production. *Journal of Agronomy, 51,* 515-518.

FAO. (2008). The state of food and agriculture. Conversion of agricultural feedstocks. Rome, Italy.

Khan, HA,, Shaik M., & Mohammad, S. (1999). Character association and path coefficient analysis of grain yield and yield components in wheat. *Crop Research Hisar, 17,* 229-233.

Khayatnezhad, M., M. Zaefizadeh, R., Gholamin S., & Somarein, J. (2010). Study of Genetic Diversity and Path Analysis for Yield in Durum Wheat Genotypes under Water and Dry Conditions. *World Applied Science Journal. 5,* 655-665.

Madic, M., Paunovic., A., A., Djurovic. D., & Knezevic, D. (2005). Correlation and Path Coefficient Analysis for Yield and Yield Components in Winter Barley. *Acta Agriculture Serbica., 20,* 3-9.

Majumder, D. A. N., Shamsuddin, A. K. M., Kabir, M. A. & Hassan, L. (2008). Genetic variability, correlated response and path analysis of yield and yield contributing traits of spring wheat. *Journal of Bangladesh Agricultural University, 6,* 227–234.

Moghaddam, M., Ehdaie, B., & Waines, J.G. (1998). Genetic variation for and ınterrelationships among agronomic traits in landraces of bread wheat from southwestern Iran. *Journal of Genetics Breed, 52*, 73-8.

Mohammed, Z., Marefat, G., Jafar, A., Majid, K.., & Babak. (2011). Correlation Analysis and Path. *Analysis for Yield and its Components in Hulless Barley. Advances in Environmental Biology*, *5,* 123-126.

Mohammadi, H., & Khodambashi-e-emami, M. (1997). Estimation of genetic parameters for yield and yield components of wheat diallel cross method. *Journal of Agricultural Research, 4,*12-15.

Mohtashami, R. (2015). The Correlation Study of important Barley agronomic traits and grain yield by Path Analysis. *Biological Forum – An International Journal, 7,*1211-1219.

Quan, X. (2015). Physiological and genetic determination of yield and yield components in a bread wheat × spelt mapping population (PhD Thesis), Plenum, London, UK.

Zaefizadeh, M., Ghasemi, M., Azimi, J., Khayatnezhad, M. & Ahadzadeh, B. (2011). Correlation Analysis and Path Analysis for Yield and its Components in Hulless Barley. *Advances in Environmental Biology, 5*,123-126.