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Original Research Article

Phenotypic Correlation and Path Coefficient Analysis of Yield and Yield Component in Rice (*Oryza Sativa*)

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ABSTRACT

Rice is among one of the three major food crops of the world and also a stable food for majority of African countries. In Ethiopia rice is becoming more popular and considered as a strategic crop and believed to assure food security. Rice research in Ethiopia is focused on evaluating the rice genotypes based on their growing ecosystems in relation to biotic and abiotic factors and hence more upland rice varieties have been generated than for lowland ecosystem. Additionally, the rice genotypes have been evaluated based on their growing ecosystems and not so far the upland rice genotypes were studied under lowland condition. Hence, the objective of the study was to show phenotypic correlation and direct and indirect cause of yield and yield components of upland rice genotypes under lowland condition. Ten different upland rice genotypes were evaluated under lowland condition at Assosa and Woreta Agricultural research centers in 2014. Correlation of traits revealed that grain yield exhibited significant and positive correlation with plant height (r =0.430) and harvest index (r =0.390). Days to heading (r=0.760), days to maturity (r= 0.680), and plant height (r=0.660) exhibited positive and highly significant association with above ground biomass. Panicle length (r=0.500) exhibited significant and positive correlation with above ground biomass. Days to heading (r=0.765) showed positive and significant associations with days to maturity. Harvest index (r=-0.600) had negative and significant correlation with above ground biomass. Days to heading (r=-0.510) and plant height (r=-0.388) exhibited negative and significant associations with harvest index. Path coefficient analysis revealed that the highest and positive direct effect on grain yield exhibited by harvest index (0.667) followed by panicle length (0.466), above ground biomass (0.381), plant height (0.356) and thousand grain weight (0.025). Negative direct effect exhibited by days to heading (-0.170), days to maturity (-0.192) and number of filled grain (-0.194). Days to heading (+0.289) exhibited highest positive indirect effect followed by days to maturity (+0.259), plant height (+0.251), panicle length (+0.190), and thousand grain weight (+0.129) on grain yield via above ground biomass. So that the above mentioned traits were identified and they are the most contributing factors for the improvement of rice grain yield. Hence, those traits have to be taken in to consideration in rice breeding program for further improvement of rice production and productivity.

Key words: Ecosystem, grain yield, path coefficient, phenotypic correlation, upland, lowland and yield components.

INTRODUCTION

Rice (*Oryza sativa* L.) is a plant belonging to the family of grasses, *Poaceae* (formerly known as *Gramineae*). It is one among of the second three major food crops of the world (Rice, Maize and Wheat) and forms the staple diet of about half of the world's population. In Africa, rice is becoming increasingly popular, important stable food crop and it is grown over 75% of the countries (FAO, 2013). The crop is recognized in Ethiopia, as a food security crop and also a source of income and employment opportunities. It is estimated that about 30 million hectares are suitable for rice production (MoARD, 2010). The rice research has focused mainly on the introduction of improved varieties from a range of different sources, including the International Rice Research Institute (IRRI), the Africa Rice Center (WARDA), Guinea, and Madagascar.

Rice can grow at different agro ecological zones and the main types of ecosystems are rain fed upland; rain fed low land and flooded prone areas (Bambaradeniya and Amarasinghe, 2003). They are further categorized in to five distinct ecosystems which include irrigated rice ecosystems, flooded prone rice ecosystems and deep water, floating rice along river beds / banks (Prasad *et al.*, 2001). Rain fed upland, lowland and irrigated rice ecosystems are the most known ecologies of rice in Ethiopia.

Even though, rice research in Ethiopian is in progress, within a few years promising varieties have been released and extended to end users. Relatively, more upland rice varieties were recommended than lowland rice varieties. The research is also focused on increasing the yield potential in relation to biotic and a biotic factor based on their growing ecosystems. Since the genetic makeup of upland and lowland rice genotypes are different, the research is also focused on evaluating rice genotypes based on their growing ecosystems. Adaptation and performance of the released upland rice genotypes were evaluated in upland ecosystems and hence their genetic performances have not been yet studied under lowland ecosystems. This study therefore, is focused on evaluating the upland rice genotypes under lowland condition. Hence, ten upland rice genotypes were evaluated under lowland conditions to generate information on the genetic architecture of grain yield and yield attributing components.

As yield is a complex trait it is necessary to indicate the contribution of various traits by conducting correlation and path coefficient analysis. Path analysis has an advantage for partitioning of the correlation coefficients (Dewey and Lu, 1959). Based on this, correlation and path coefficient analysis of ten rice genotypes were studied for nine characters to evaluate the contribution of traits for grain yield and yield components. Correlation provides information on how two traits are associated. Direct and indirect influences of the traits on grain yield and yield components were also estimated.

MATERIALS AND METHODS

The study conducted in northern and western parts of Ethiopia in Amhara and Benishangul Gumuze regions which are the most potential rice growing areas. The specific locations were Woreta and Assosa both of which are also potential areas for rice production in the regions and are located at altitude of 1812 m and 1850 m a.s.l with annual rainfall of 1376.9 mm and 1133.1 mm respectively The tested materials were obtained from the national rice research coordinator center and a total of ten upland improved rice varieties were evaluated for their genotypic performance at two locations under low land conditions (Table 1). The trial conducted during the rainy season and all recommended agronomic practices applied at both sites which are starting from land preparation to till harvesting. The field management activities such as plowing, weeding and others intercultural operations were done as per recommendation. Data per plots and per plants were collected and recorded. Totally nine characters or traits were studied which includes days to heading (DH), Days to 75 % physiological maturity, (DPM), Plant height (cm) (PH), The length of panicle (PL), The number of fertile (NFT) and non fertile tillers (NNFT), were identified and recorded by considering fertile and non fertile tillers. The number of filled (NFG) and unfilled grains NUFG) were recorded from each ten sampled panicles, filled and unfilled grains were separated by immersing the seeds in water. The floated and submerged seeds were separately collected and exposed for sun drying. The grain yield (GY) in (gm) was determined by harvesting all plants from the central four rows of each plot. Seeds were also adjusted to a moisture level of 14% using moisture content tester and then converted into kg ha-^{1}. The weight of thousand grains (TGW) from the grain yield of each plot was determined using a sensitive balance machine. The whole data were recorded from the same ten pre tagged sampled plants and from the middle of four rows of each plot. Harvest index (HI) was calculated based on the scientific procedure (Singa, 1977). Above ground biomass (AGBM) recorded by weighing the total above ground biomass harvested for each experimental plots. The data recorded were subjected to the phenotypic Pearson correlation analysis (Searle, 1961) and path coefficient analysis (Dewey and Lu, 1959). The phenotypic correlation coefficient among different characters was carried out as per procedure suggested by Searle (1961). The path coefficient analysis was carried out as suggested by Dewey and Lu (1959).

Table 1: Description of 10 evaluated Ethiopian upland rice varieties studied under lowland condition

No	Variety name	Line code
1	NERICA-3	WAB-450-IBP-28-HB
2	NERICA-4	WAB-450-IBP-91-HB
3	NERICA-12	WAB 880-1-38-20-17-P1-HB
4	NERICA-13	WAB 880-1-38-20-28-P1-HB
5	Kokit	IRAT-2009
6	SUPERICA- 1	WAB-4507
7	Getachew	AD-01
8	Andassa	AD-012
9	Tana	AD-048
10	Hedase	WAB-515-B-16A1-2

RESULTS AND DISCUSSION

The phenotypic correlation and path coefficient analysis of ten rice genotypes were estimated among the nine traits under lowland rice ecology. Associations of traits as well as direct and indirect effects for some quantitative traits are presented in Tables 2 and 3 respectively.

Phenotypic correlation for some quantitative traits

Correlation of traits revealed that grain yield exhibited significant and positive correlation with plant height (+0.430) and harvest index (+0.390). Highly significant and positive correlation was reported by Halil and Necmi (2002) between traits of grain yield and harvest index. Positive and highly significant correlation of grain yield with harvest index was reported by Dwivedi *et al*, (2012). Days to heading (0.760), days to maturity (0.680), and plant height (0.660) exhibited positive and highly significant association with above ground biomass. Panicle length (+0.500) exhibited significant and positive correlation with above ground biomass. Among the characters studied, days to heading (DTH) showed highly significant and positive correlation with days to physiological maturity (DTM) (+0.765). Days to heading (+0.765) showed positive and significant association with days to maturity. Days to maturity (0.389) exhibited significant and positive association with thousand grain weight. Panicle length (+0.457) had positive and significant correlation with number of filled grain. Plant height (+0.547) exhibited positive and significant association with panicle length. Days to maturity (+0.478) exhibited positive and significant correlation with plant height. Harvest index (-0.600) had negative and significant correlation with above ground biomass. Days to heading (-0.510) and plant height (-0.388) were exhibited negative and significant associations with harvest index. Traits of days to heading, days to maturity, panicle length, number of filled grain and thousand grain weights showed positive and non significant correlation. Thousand grain weight showed positive and non significant association with above ground biomass. Panicle length and number of filled grain also showed positive and non significant correlation with harvest index. Days to heading and plant height had positive and non significant associations with thousand grain weight. At the same time positive and non significant correlation were observed between days to maturity and panicle length. With regard to other traits showed negative and non significant associations as indicated in Table 2.

Table 2: Phenotypic correlation coefficient of important yield and yield components in 10 Ethiopian upland rice varieties under lowland condition

No	Traits	DTH	DTM	PH	PL	NFG	TGW	HI	AGBM	GYLD
1	DTH	1	0.765**	0.580*	0.388*	-0.127	0.213	-0.510*	0.760**	0.05
2	DTM		1	0.478*	0.317	-0.131	0.389*	-0.21	0.680**	0.15
3	PH			1	0.547*	-0.044	0.335	-0.388*	0.660**	0.430*
4	PL				1	0.457*	-0.111	0.04	0.500*	0.66
5	NFG					1	-0.293	0.288	-0.04	0.22
6	TGW						1	-0.026	0.34	0.15
7	HI							1	-0.600*	0.390*
8	AGBM								1	0.2
9	GYLD									1

DTH = Days to 50 % heading, DTM = Days to 75 % maturity, PH = Plant height (cm), PL = Panicle length (cm), NFG = Number of filled grain, TGW = Thousand grain weight (g), HI = Harvest index, AGBM = above ground biomass (kg), and GY = Grain Yield (kg).

Table 3: Direct (bold) and indirect effects of important studied traits on grain yield in Path Coefficient analysis of 10 Ethiopian upland rice varieties under lowland condition

Traits	DTH	DTM	PH	PL	NFG	TGW	HI	AGBM	Correlation with GY
DTH	**-0.170**	-0.147	0.206	0.181	0.025	0.005	-0.340	0.289	0.050
DTM	-0.130	**-0.192**	0.170	0.148	0.025	0.010	-0.140	0.259	0.150
PH	-0.098	-0.092	**0.356**	0.255	0.008	0.008	-0.259	0.251	0.43*
PL	-0.066	-0.061	0.195	**0.466**	-0.088	-0.003	0.027	0.190	0.660**
NFG	0.022	0.025	-0.016	0.213	**-0.194**	-0.007	0.192	-0.015	0.220
TGW	-0.036	-0.075	0.119	-0.052	0.057	**0.025**	-0.017	0.129	0.150
HI	0.087	0.040	-0.138	0.019	-0.056	-0.001	**0.667**	-0.228	0.390*
AGBM	-0.129	-0.131	0.235	0.231	0.008	0.008	-0.404	**0.381**	0.200
Residual effect		**0.528**							

Note: Bold diagonal figures indicate the direct effect. Here DTM = Days to 75 % maturity, PH = Plant height (cm), PL = Panicle length (cm), NFG = Number of filled grain, TGW = Thousand grain weight (g), HI = Harvest index, AGBM = above ground biomass (kg), and GY = Grain Yield (kg).

Path coefficient analysis

Path coefficient analysis revealed that the highest and positive direct effect on grain yield was exhibited by harvest index (0.667) followed by panicle length (0.466), above ground biomass (0.381), plant height (0.356) and thousand grain weight (0.025). Highest and positive direct effect of harvest index on yield was reported by Dwivedi, (2012 A) in the study of rice path analysis. This finding indicated that for the grain yield increment harvest index had positive and highest direct effect. Gopikannan and Ganesh (2013) found that positive and direct effect of panicle length. Panicle length had a direct and positive effect for grain yield. The study conducted by Ghaffar and Ghorbanali (2012) revealed that plant height had direct and positive effect on grain yield. Negative direct effect was exhibited by days to heading (-0.170), days to maturity (-0.192) and number of filled grain (-0.194). It was also reported by Ravindra *et al* (2012) number of filled grain had direct and negative effect.

Days to heading (0.289) exhibited highest positive indirect effect followed by days to maturity (0.259), plant height (0.251), panicle length (0.190), and thousand grain weight (0.129) on grain yield via above ground biomass. The highest negative indirect effect of above ground biomass (-0.404), followed by days to heading (-0.340), plant height (-0.259), days to maturity (-0.140) and thousand grain weight (-0.017) were recorded on grain yield per plant via harvest index. The residual effect was 0.528 indicated that the traits that was considered in the study contributed 47.2% of grain yield where as the rest 52.8% was the contribution of other factors, such as traits not studied.

CONCLUSION

The phenotypic correlation of harvest index showed positive and significant association with grain yield. Days to heading and maturity including plant height were exhibited positive and highly significant association with above ground biomass. From the result of correlations harvest index had a positive association with grain yield and hence it is the most important trait for the improvement rice. For grain yield harvest index showed highest and positive direct effect followed by panicle length, above ground biomass, plant height and thousand grain weight. Again harvest index had positive and direct effect for grain yield and hence this trait is highly important for the improvement of grain yield in rice breeding program. The highest negative indirect effect of above ground biomass was recorded on grain yield per plant via harvest index. So that the above mentioned traits were identified and they are the most contributing factors for the improvement of rice grain yield. Hence, those traits have to be taken in to consideration in rice breeding program for the improvement of grain yield.

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