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Character association and path co-efficient analysis for various traits in grain amaranth (*Amaranthus* spp.)

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One hundred genotypes of grain amaranth were used to estimate correlation and path co-efficients among 10 quantitative traits including grain yield in grain amaranth. At the phenotypic level, stem girth, number of leaves per plant, plant height, panicle length and seed weight exhibited significant positive correlation with grain yield. While, its association with panicle width was negative and significant. Path co-efficient analysis revealed maximum positive direct effect of number of leaves per plant (0.575) on grain yield followed by seed weight (0.234), panicle length (0.221) and plant height (0.124). The study suggests that selection of varieties with higher number of leaves per plant, seed weight, panicle length and plant height will help the breeder to select the genotypes which can give better grain yield.

Key words : Grain amaranth, Grain protein, Character association, Path co-efficient analysis

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INTRODUCTION

Grain amaranth of the genus *Amaranthus* is the most important subsidiary food crop of the people inhabiting to the tropical and subtropical highlands of Central and South America (Sauer, 1967). The genus contains more than 60 species (Kalac and Moudry, 2000) of which there are four cultivated species. Amaranthus are native to new world and it is widely distributed throughout the old and new world. In India, these are cultivated both in hills as well as plains covering states of Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Chattisgarh, Maharastra, Gujarat, Orissa, Karnataka, Kerala and Tamil Nadu. It is a potential nutritional crop as the grain contains 14-16 per cent protein which other commonly used cereals like rice, wheat and maize do not contain this much of protein (Sauer, 1967). The protein is of higher quality due to the presence of higher lysine content (5.0 to 6.0 %) and also rich in the sulphur-containing amino acids confirms its high potential for use in both human and animal nutrition and also shows high promise for supplementing nutritive food and amelioration of protein deficiency strictly in the vegetarian diet of people (Downton, 1973; Senft, 1980; Vietmeyer, 1980; Bressani *et al*., 1987a; Bressani *et al.*, 1987b and Andrasofszky *et al*., 1998). Grain yield in any crop depends on many component characters which influence yield either jointly or singly and either directly or indirectly through other related characters. Selection for yield on the basis of *per se* performance alone may not be effective as that based on component characters associated with it, which is biometrically determined by correlation co-efficient and path analysis. Understanding of the nature and extent of association of the component characters with grain yield and amongst themselves is an essential pre-requisite for formulating selection indices while selecting higher grain yield and grain protein content in breeding programmes. Knowledge of interrelationship between economic yield and its components is obvious for efficient selection of desirable segregants in plant breeding. Unlike the correlation co-efficient values which measure the extent of relationship, path co-efficient (Wright, 1921; Dewey and Lu, 1959) measure the

magnitude of direct and indirect effects of characters on complex dependent characters like yield and thus enable the breeders to judge best about the important component characters during selection.

RESEARCH METHODOLOGY

Field experiment for the present study on grain amaranth was conducted at the field unit of All India Co-ordinated Research Network on Underutilized Crops, Main Research Station, Hebbal, University of Agricultural Sciences, Bangalore during *Kharif* 2011-12 under protective irrigation. The experimental material used in the present study comprised of hundred genotypes of grain amaranth of which fifty germplasm lines were obtained from Sardarkrushinagar Dantiwada Agricultural University, Gujarat and fifty from National Bureau of Plant genetic Resources (NBPGR) Regional Station, Akola (Maharastra). Three varieties *viz*., Suvarna, BGA-2 and GA-2 were used as check varieties. The experiment was laid out in an Augmented design with 10 compact blocks. Each block was comprised of 10 genotypes and three checks. All the checks were repeated in all the blocks, while the genotypes were unreplicated. Each genotype was sown in two rows of three meters length, each with a spacing of 45 centimeters between the rows. Thinning of seedlings was done after 25-30 days after sowing and plant to plant distance of 15 centimeters was maintained. All the normal recommended agronomic practices and plant protection measures were followed for raising a good and healthy crop. Five plants were randomly selected and the observations were recorded in respect of various characters in each genotype. The average values of observations on these five plants were used as treatment mean in all statistical analysis. The observations included days to 50 per cent flowering, days to maturity, stem girth (cm), number of leaves per plant, plant height (cm), panicle length (cm), panicle width (cm), seed weight (g/10 ml), grain protein content (%) and grain yield per plant (g). Correlation co-efficient was computed from variance and covariance components as suggested by Narasimharao and Rachie(1964). The correlation co-efficient was partitioned into direct and indirect causes according to Dewey and Lu (1959).

RESEARCH FINDINGS AND ANALYSIS

The phenotypic correlation co-efficients were computed among the ten characters including grain yield to know the nature of association existing among them. The correlation values are presented in Table 1. The grain yield was positively and significantly associated with stem girth, number of leaves per plant, plant height, panicle length and seed weight. The results suggest that selection for above mentioned characters would likely to improve the grain yield in grain amaranth. Similar results were also reported by Hiremath (2005), Lohitaswa (1992), PushpaRekha (1986), Yashwant Kumar (2009), Mathai and Ramachandra (1981). The correlation studies carried out suggest that for obtaining higher grain yields in grain amaranth through selection of the traits such as stem girth, number of leaves per plant, plant height, panicle length, seed weight may be more beneficial. The phenotypic association of grain yield per plant showed negative significant associations with panicle width, while non-significant association with days to fifty per cent flowering. These results are supported by Maruthi (1987), Kulakow and Jain (1985) and Yashwant Kumar (2009). Though, information on this in the past is lacking in grain amaranth, reports in Quinoa a related species of grain amaranth by Espindola and Gandarillas (1985) are contrary by showing positive association of panicle width with grain yield. In any food crop improvement programme increase in the yield is not only an ultimate aim of the plant breeder but the quality is also equally important. Hence, higher yield coupled with high quality is always desirable. Grain amaranth has already endowed with high protein content and further improvement in protein content without hampering the grain yield would be an

Table 1: Phenotypic correlation co-efficients among different traits in grain amaranth

Characters	Days to 50 % flowering	Days to maturity	Stem girth (cm)	No. of leaves per plant	Plant height (cm)	Panicle length (cm)	Panicle width (cm)	Seed weight (g/10 ml)	Grain protein (%)	Grain yield per plant (g)
Days to 50 % flowering	1	0.116	-0.055	-0.046	0.022	-0.158	0.134	0.033	0.06	-0.112
Days to maturity		1	-0.072	0.066	0.139	-0.003	0.031	0.093	0.054	0.025
Stem girth (cm)			1	0.414**	0.484**	0.411**	-0.338**	0.235**	-0.035	0.455**
No. of leaves per plant				1	0.318**	0.290**	-0.451**	0.433**	-0.036	0.760**
Plant height (cm)					1	0.598**	-0.170*	0.462**	0.044	0.531**
Panicle length (cm)						1	-0.455**	0.378**	0.187*	0.525**
Panicle width (cm)							1	-0.297**	0.108	-0.397**
Seed weight (g/10 ml)								1	0.004	0.612**
Grain protein (%)									1	0.127
Grain yield per plant (g)										1

important breeding objective. In the present study, the association of grain protein content with all the characters except panicle length showed non-significant correlation. As the length of the panicle was also positively associated with grain yield, there might be scope for improving both grain yield and grain protein content by selecting for panicle length.

In the present study, the major yield contributing characters such as plant height, panicle length, number of leaves per plant, stem girth and seed weight exhibited positive and significant associations among themselves, implying that tall plants comprising longer panicle accommodate more number of leaves with thicker stem are better yielders in grain amaranth. As panicle length supported by plant height provided with thick stem girth, provides better standablity and more number of leaves, which may facilitate increase in the photosynthetic activity due to increase in green biomass.

Considering the results of correlation in the presented study where number of leaves and seed yield exhibited positive and significant association as compared to other traits, number of leaves per plant may play more important role to improve grain yield in grain amaranth. Similar results were also reported by Ghosh *et al.* (1999), Hiremath (2005) and Yashwant Kumar (2009). Kusuma *et al.* (2007) observed positive and significant correlation between plant height and panicle length. Pushpa Rekha (1986) observed positive significant association between panicle length and plant height. Panicle length exhibited positive and significant association with grain protein content which is in agreement with Hiremath (2005) and indicated that by increasing in length of the panicle, there might be scope for increasing both grain yield and grain protein content. The associations of above said characters have registered non-significant association with the remaining characters on either direction, except with panicle width with which these exhibited negative and significant association. Association of panicle width was negative and significant with all the major yield contributing traits, which in turn positively correlated with grain yield indicating that wider the panicle, lesser will be the seed yield per plant hypothetically. However, if the wider panicle is accompanied with dense type of inflorescence compactness then it yields more seed yield per plant. Studies made by various workers on correlation, in several crop plants revealed that strength and direction of correlation in different character combinations depends on the nature of experimental material and environmental conditions in which they have studied (Falconer, 1960). However, in grain amaranth on the basis of results obtained in the present study, it is necessary to lay greater emphasis for improving grain yield by adopting selection based on the stem girth, number of leaves per plant, plant height and panicle length as these showed high positive and significant association with grain yield per plant.

Path co-efficient analysis permits a thorough understanding of contribution of various characters by partitioning the correlation co-efficient into components of direct and indirect effects. Among the characters studied, number of leaves per plant exhibited the highest direct and positive effect (0.575) on grain yield, followed by seed weight (0.234), panicle length (0.221) and plant height (0.124). The results of path analysis are summarized in the Table 2, depicting that, number of leaves per plant, seed weight, panicle length and plant height had higher magnitude of positive and direct effects on grain yield. Stem girth (0.015) and panicle width (0.037) showed low but positive direct effect on grain yield per plant. Highest positive direct effect was exerted by number of leaves per plant (0.575) on grain yield followed by seed weight (0.234), panicle length (0.221) and plant height (0.124) which is in conformity with the reports of PushpaRekha (1986) and Lohitashwa (1992) wherein they observed appreciable positive direct effect of inflorescence length. Direct selection for number of leaves per plant alone can bring about considerable improvement in the grain yield due to its high direct effect, positive and indirect effects through all the major yield contributing characters except panicle width on seed yield. The effect of all the major yield contributing characters except panicle width exhibited positive and direct as well as indirect effects on seed yield. Panicle width showed positive and direct effect on the seed yield, while its indirect effect through remaining characters on yield was negative. Positive direct effect of seed weight on yield per plant was noticed and this was supplemented by positive indirect effects through number of leaves per plant. reported high direct effect of hundred seed weight on seed yield. Hence, seed weight can

Table 2 : Direct and indirect effects of six characters on grain yield

Characters	Stem girth (cm)	No. of leaves per plant	Plant height (cm)	Panicle length (cm)	Panicle width (cm)	Seed weight (g/10 ml)	'r' value
Stem girth (cm)	0.015	0.230	0.029	0.049	-0.009	0.094	0.379**
No. of leaves per plant	0.006	0.575	0.039	0.064	-0.017	0.103	0.760**
Plant height (cm)	0.003	0.183	0.124	0.132	-0.007	0.102	0.531**
Panicle length (cm)	0.003	0.167	0.074	0.221	-0.018	0.084	0.525**
Panicle width (cm)	-0.004	-0.260	-0.024	-0.108	0.037	-0.075	-0.426**
Seed weight (g/10ml)	0.006	0.254	0.054	0.080	-0.012	0.234	0.604**

Residual effect= 0.511

also be considered during selection for improving yield in grain amaranth. In the present study, the characters like stem girth, number of leaves per plant, plant height, and panicle length and seed weight showed significantly positive association with grain yield. Therefore, these characters might be considered for improving grain yield in grain amaranth.

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