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Association of characters and path coefficient analysis for yield and its components in finger millet (*Eleusine coracana* (L.) Gaertn.) genotypes

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Abstract
The association of characters and path coefficient analysis were studied in the present investigation for identifying the characters depending upon which the selection would be effective in improvement of finger millet (*Eleusine coracana* (L.) Gaertn) genotypes. The experiment were conducted during *kharif*, 2018 at Botany Farm, College of Agriculture, Pune, (M.S.), comprised of 50 diverse genotypes of finger millet and studied thirteen quantitative and biochemical characters. The character grain yield per plant showed positive and significant correlation with fodder yield per plant followed by ear weight per plant, fertile tillers per plant, plant height, 1000-seed weight and harvest index showed highly positive correlation among themselves. Days to 50 per cent flowering showed positive and significant correlation with days to maturity and protein content. Fertile tillers per plant showed positive and significant correlation with 1000-seed weight, ear weight per plant, fodder per plant and harvest index. Considering the overall effect of all characters *viz.*, days to 50 per cent flowering, days to maturity, fertile tillers per plant, plant height, length of finger, 1000-seed weight, ear weight per plant, fingers per ear, fodder yield per plant and harvest index contributed indirectly towards grain yield per plant. Characters like days to maturity and finger per ear exhibited low positive direct effect on grain yield per plant. Traits like length of finger, 1000-seed weight, harvest index and protein content exhibited high negative direct effect on grain yield per plant.

Keywords: Finger millet, correlation coefficient, path analysis, yield components

Introduction
Finger Millet (*Eleusine coracana* (L.) Gaertn) is an annual herbaceous cereal crop widely grown and consumed by poor people in Africa and Asia. It is also known as *Ragi* or *Nachani* and common name 'Finger millet' is derived from the finger-like branching of the panicle.. The major Finger millet producing countries are Uganda, India, Nepal and China. India is the major producer in Asia and in India, it is widely grown in the states of Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, Orissa, Gujarat, Jharkhand, Uttar Pradesh, Madhya Pradesh and Uttarakhand. In Maharashtra, *bhakri* (in Marathi), a type of flat bread is prepared using finger millet (ragi) flour. In Mumbai and Navi Mumbai areas, the biscuits prepared with ragi flour are also available in some bakeries. Normally due to high calcium and iron content nachni is nutritionally important in diet of Maharashtra people. Finger millet is highly nutritious as its grain contains the high quality protein (7-10%). It is the richest source of calcium (344 mg/100 g), iron and other minerals. It is also rich in phosphorus (283 mg/100 g) and potassium (408 mg/100 g). The carbohydrates present in finger millet have the unique property of slower digestibility and regarded as food for long sustenance. It is an ideal grain for people with diabetes, because of its low glycemic index. It also contains amino acids, lecithin and methionine, which help in bringing down cholesterol level. The achievement in plant breeding programme largely depends upon the genetic variability available in breeding population and the efficiency of selection technique. Seed yield is quantitative character with highly variable expression, which depends on numerous independent characters. Correlation analysis describes the mutual relationship between the variables and estimation of such association at both genotypic and phenotypic level shows not only the inherent relation but also indicates the level of environmental influence. Estimation of correlation coefficient provides a measure of association between characters. The correlation coefficient provides the basic information to the breeders to identify characters that have little or no importance in the selection programme. Path analysis provides the exact picture of the direct and indirect causes of such associations, which can be had through path analysis (Wright, 1921) [13]. Dewey and Lu (1959) [5] gave the detailed procedure for path analysis.

Therefore, the present study was conducted in finger millet to study the genetic parameters like variability, correlation and path coefficient effects of different yield components on grain yield.

Material and Methods

The experimental material for the present investigation comprised of 50 indigenous genotypes of finger millet [*Eleusine coracana* (L.) Gaertn.], collected from All India Co-ordinated Research Project on small millets ZARS, Kolhapur. The experiment was conducted in a Randomized Block Design with three replications at Agricultural Botany Farm, College of Agriculture, Pune (Maharashtra) during *kharif*, 2018. All the recommended agronomic and cultural practices were followed for raising a healthy crop. A piece of land selected for experiment was brought to fine tilth by ploughing followed by harrowing. Sowing was carried by following dibbling method. Each entry was represented by single rows of 5.0 meter length. The spacing of 30 cm between the rows and 10 cm between plants *i.e.* 30 x 10 cm spacing. Two border rows along the length of each replication were grown to avoid the border effects. Sowing was carried on 28th June, 2018. The recommended dose of 50:40:25 NPK (kg/ha) was applied at the time of sowing. Experimental plot was kept weed free. All the crop management and plant protection operations were carried out as per recommended package of practices. The observations were recorded on five randomly selected plants from each treatment in each replication for thirteen quantitative and biochemical characters *viz.*, days to 50 per cent flowering, days to maturity, number of fertile tillers per plant, plant height, length of finger, grain yield per plant, 1000-seed weight, ear weight per plant, number of fingers per ear, fodder yield per plant, harvest index, protein content, iron content and grain yield per plant. The data for different characters were statistically analyzed for significance by using analysis of variance technique described by Panse and Sukhatme (1985) [12]. To understand the association among the different characters, genotypic and phenotypic correlation coefficient were worked out by adopting the method described by Johnson *et al*. (1955) [7]. To establish a cause and effect relationship the first step used was to partition genotypic and phenotypic correlation coefficient into direct and indirect effects by path analysis as suggested by Dewey and Lu (1959) [5].

Result and Discussion

The efficiency of selection for yield mainly depends on the direction and magnitude of association between yield and its component characters and also among themselves. Characters association provides information on the nature and extent of association between pairs of metric traits and helps in selection for the improvement of the character. The yield is a complex character and the result of interaction between various yield components. The success of any breeding programme depends on the efficiency of selection. Thus, it helps a breeder in selection of characters for future breeding programme. In the present study, various quantitative and biochemical characters were studied and their relation with yield as well as among themselves was examined using correlation analysis. The grain yield per plant showed highly significant positive association with fodder yield per plant (0.9873), followed by ear weight per plant (0.9845), harvest index (0.8623), number of fertile tillers (0.6612), 1000-seed weight (0.4419) and plant height (0.2134) (Table 1.). Days to 50 per cent flowering and protein content have positive but non-significant effect on grain yield per plant. Number of fingers per ear has positive non-significant effect on grain yield per plant. Similar, results were reported for highly significant and positive correlation with grain yield by Muduli *et al*. (2012) [11] for ear weight per plant; Das. (2013) [4] for number of fertile tillers per plant; Bothikar *et al*. (2014) [3] for harvest index and fertile tillers per plant and Kumar *et al*. (2014) [8] for fodder yield per plant. Manayasa *et al.* (2016) [10] also reported similar results for fertile tillers per plant and 1000 seed weight.

The present studies revealed highly significant differences among fifty genotypes for thirteen quantitative characters, indicating presence of wider genetic variability. The genotypic correlations were higher in magnitude than the phenotypic correlation. Genotypic correlation coefficients between yield and its related components are presented in Table 1.

Inter relationship between component character at genotypic level revealed that, days to 50 per cent flowering exhibited highly significant and positive correlation with days to maturity (0.8467) and protein content (0.2341). It showed negative and highly significant correlation with plant height (-0.2762) and length of finger (-0.2226). Number of fertile tillers per plant exhibited highly significant and positive correlation with harvest index (0.6834), grain yield per plant (0.6612), fodder yield per plant (0.6055), ear weight per plant (0.5277) and 1000-seed weight (0.4066), while it showed positive and non-significant correlation with iron content (0.0307) and length of finger (0.0044). Plant height was highly significant and positively correlated with length of finger (0.6753), number of fingers per ear (0.2859), ear weight per plant (0.2720), fodder yield per plant (0.2294), iron content (0.2254) and grain yield per plant (0.2134). Length of finger showed positive and significant correlation with fingers per ear and fodder yield per plant. 1000- seed weight showed positive and significant correlation with ear weight per plant, fodder yield per plant, iron content and harvest index. Ear weight per plant showed positive and significant correlation with harvest index and fodder yield. Fodder yield per plant showed positive and significant correlation with harvest index. Jadhav *et al*. (2015) [6] reported that, traits like 1000 seed weight, number of fingers per ear, finger length, days to maturity, productive tillers per plant, days to 50 per cent flowering and plant height were found to possess significant positive association with seed yield per plant. Mahanthesha *et al*. (2018) [9] observed that grain yield per plant has exhibited significant positive association with total no. of basal tillers per plant, productive tillers per plant, total fingers on the main ear, finger length and finger width The results obtained indicate that, yield was increased whenever there was increase in effective total no. fertile tillers, harvest index and ear weight per plant. These characters can be considered as criteria for selection for higher yield, as these are mutually and directly associated with grain yield. The study of correlations provides the inter relationships among the quantitative traits, which is useful in the choice of breeding method for crop improvement. The genetic correlation coefficient provides close measure of association between characters, which is useful in overall crop improvement.

Path analysis is partial coefficient, which splits correlation coefficient into direct and indirect effects. In the present investigation, path analysis was done as per the procedure given by Dewey and Lu (1959) [5] to know the direct and

indirect effects of various characters. Correlation along with path analysis proves more reliable for use in breeding programme.

The path coefficient analysis indicated that the characters days to 50 per cent flowering, fertile tillers per plant, plant height, ear weight per plant, fodder yield per plant, iron content had high positive direct effect on seed yield per plant Table 2. Characters like days to maturity and finger per ear have low positive direct effect on grain yield per plant. Traits like length of finger, 1000-seed weight, harvest index and protein content have high negative direct effect on grain yield per plant. Days to 50 per cent flowering and grain yield per plant was positive and non-significant (0.0500). Its direct effect on grain yield per plant was positive and high (0.7541). The indirect effect of this trait *via* length of finger (0.2691) was positive and high on grain yield per plant. Days to maturity and grain yield per plant (-0.0037) was negative and non-significant. Its direct effect on grain yield per plant was positive and low (0.0247). The indirect effect of this trait *via* days to 50 per cent flowering (0.6385) and length of finger (0.2801) was positive and high on grain yield per plant, while its indirect effect *via* 1000- seed weight (0.0474) and harvest index (0.0117) was positive and low. Fertile tillers per plant and grain yield per plant was positive and highly significant (0.6612). Its direct effect on grain yield per plant was positive and high (1.0280). The traits ear weight per plant (1.2129) and fodder yield per plant (0.5161) showed positive and high indirect effect on grain yield per plant. The direct effect of plant height trait on grain yield per plant was positive and high (0.7843). The indirect effect of this trait *via* ear weight per plant (0.6250) was positive and high. Character 1000 - seed weight and grain yield per plant was positive and highly significant (0.4419). The direct effect of this trait on grain yield per plant was negative and high (-0.3625). The indirect effect of this trait *via* ear weight per plant (0.9874), number of fertile tillers per plant (0.4180) and fodder yield per plant (0.3184) was positive and high on grain yield per plant. The direct effect of ear weight per plant trait on grain yield per plant was positive and high (1.2974). The indirect effect of this trait *via* fodder yield per plant (0.9965), number of fertile tillers per plant (0.5425) and plant height (0.2134) was positive and high on grain yield per plant, while its indirect effect *via* number of fingers per ear (0.0019) was positive and negligible on grain yield per plant. Harvest index and grain yield per plant was positive and highly significant (0.8623). The direct effect of this trait on grain yield per plant was negative and high (-2.6853). Its indirect effect *via* ear weight per plant (0.9708), fodder yield per plant (0.7671) and number of fertile tillers per plant (0.7025) was positive and high on grain yield per plant. The direct effect of protein content on grain yield per plant was negative and high (-0.3019). Its indirect effect *via* days to 50 per cent flowering (0.1766) and length of finger (0.1218) was positive and moderate. Abraham *et al*. (1989) [1]. also observed direct effect of 50 per cent flowering on grain yield. Bhave *et al*. (2007) [2] also reported direct positive effect of plant height and days to 50 per cent flowering on grain yield.

Table 1: Genotypic correlation of 13 characters in 50 genotypes of finger millet

Observations	Days to maturity (No.)	Fertile tillers per plant (No.)	Plant height (cm)	Length of finger (cm)	1000 seed weight (g)	Ear weight per plant (g)	Fingers per ear (No.)	Fodder yield per plant (g)	Harvest index (%)	Protein content (%)	Iron content (ppm)	Grain yield per plant (g)
Days to 50% flowerin (No.)	0.8467**	-0.0747	-0.2762	-0.2226	-0.0184	-0.0971	-0.0073	0.0007	0.1378	0.2341**	-0.0653	0.0500
Days to maturity (No.)		-0.2207	-0.3314*	-0.2317	-0.1309	-0.1847	-0.0042	-0.0481	-0.0044	0.0868	-0.0854	-0.0337
Fertile tillers per plant (No.)			-0.1005	0.0044	0.4066**	0.5277**	-0.1362	0.6055**	0.6834**	-0.0539	0.0307	0.6612**
Plant height (cm)				0.6753**	0.1417	0.2720**	0.2859**	0.2294**	0.1486	-0.1152	0.2254**	0.2134**
Length of finger (cm)					0.0439	0.3566**	0.1842*	0.3242**	0.0385	-0.1007	0.0574	0.2026*
1000 seed weight (g)						0.4298**	-0.1139	0.3735**	0.3993**	-0.0208	0.1616*	0.4419**
Ear weight per plant (g)							0.0659	0.9815**	0.8578**	0.0367	-0.0945	0.9845**
Fingers per ear (No.)								0.0312	0.0261	0.0667	0.0142	0.0243
Fodder yield per plant (g)									0.8999**	0.1170	-0.1846	0.9873**
Harvest index (%)										0.0154	0.1216	0.8623**
Protein content (%)											0.0145	0.0149
Iron content (ppm)												-0.0013

*,** significant at 5% and 1% level respectively.

Table 2: Direct (diagonal) and Indirect (above and below diagonal) path effects of different characters towards seed yield at genotypic level in finger millet

Observations	Days to 50% flowering (No.)	Days to maturity (No.)	Fertile tillers per plant (No.)	Plant height (cm)	Length of finger (cm)	1000 seed weight (g)	Ear weight per plant (g)	Fingers per ear (No.)	Fodder yield per plant (g)	Harvest index (%)	Protein content (%)	Iron content (ppm)	Grain yield per plant (g)
Days to 50% flowering (No.)	0.7541	0.0209	-0.0768	-0.2166	0.2691	0.0067	-0.2231	-0.0002	0.0006	-0.3699	-0.0707	-0.0441	0.0500
Days to maturity (No.)	0.6385	0.0247	-0.2268	-0.2599	0.2801	0.0474	-0.4244	-0.0001	-0.0410	0.0117	-0.0262	-0.0576	-0.0337
Fertile tillers per plant (No.)	-0.0563	-0.0054	1.0280	-0.0788	-0.0053	-0.1474	1.2124	-0.0040	0.5161	-1.8350	0.0163	0.0207	0.6612**
Plant height (cm)	-0.2083	-0.0082	-0.1033	0.7843	-0.8164	-0.0513	0.6250	0.0084	0.1955	-0.3991	0.0348	0.1520	0.2134**
Length of finger (cm)	-0.1679	-0.0057	0.0045	0.5297	-1.2089	-0.0159	0.8193	0.0054	0.2763	-0.1033	0.0304	0.0387	0.2026*
1000 seed weight (g)	-0.0138	-0.0032	0.4180	0.1111	-0.0531	-0.3625	0.9874	-0.0034	0.3184	-1.0723	0.0063	0.1090	0.4419**
Ear weight per plant (g)	-0.0732	-0.0046	0.5425	0.2134	-0.4311	-0.1558	1.2974	0.0019	0.9965	-2.3035	-0.0111	-0.0637	0.9845**
Fingers per ear (No.)	-0.0055	-0.0001	-0.1400	0.2242	-0.2227	0.0413	0.1515	0.0295	0.0266	-0.0700	-0.0202	0.0096	0.0243
Fodder yield per plant (g)	0.0005	-0.0012	0.6224	0.1799	-0.3919	-0.1354	1.0685	0.0009	0.8524	-2.4166	-0.0353	-0.1245	0.9873**
Harvest index (%)	0.1039	-0.0001	0.7025	0.1166	-0.0465	-0.1448	0.9708	0.0008	0.7671	-2.6853	-0.0046	0.0820	0.8623**
Protein content (%)	0.1766	0.0021	-0.0554	-0.0903	0.1218	0.0076	0.0843	0.0020	0.0997	-0.0413	-0.3019	0.0098	0.0149
Iron content (ppm)	-0.0493	-0.0021	0.0316	0.1768	-0.0693	-0.0586	-0.2170	0.0004	-0.1574	-0.3265	-0.0044	0.6745	-0.0013

Conclusion

Based on the results of present investigation it could be concluded that grain yield per plant showed highly significant positive association with fodder yield per plant, followed by ear weight per plant, harvest index, number of fertile tillers, 1000-seed weight and plant height.

Moreover, characters days to 50 per cent flowering, fertile tillers per plant, plant height, ear weight per plant, fodder yield per plant and iron content had high positive direct effect on grain yield per plant. Thus, direct selection for these traits will be beneficial in yield improvement programme This investigation therefore, suggests that number of fertile tillers per plant, 1000-seed weight, ear weight per plant and harvest index should be given maximum consideration for total yield improvement as the appropriate selection criteria.

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