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Short communication

Association and path coefficient analysis for growth, pod and oil characters in moringa (*Moringa oleifera* Lam.) genotypes

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ABSTRACT

The correlation studies in 34 moringa genotypes indicated strong association of number of pods/ tree, number of seeds /pod, pod length, seed yield/ tree, 100-seed weight and seed oil content with oil yield/ tree. Genotypic and phenotypic correlation coefficients estimated for various traits indicated higher magnitude of genotypic correlations than phenotypic correlations. The difference between genotypic and phenotypic correlations was in general low, indicating the least influence of environment on these traits. The highest positive direct effect was recorded by seed yield/ tree, followed by seed oil content, number of pods/ tree, 100-seed weight, tree height and pod length indicating their relationship and selection based on these traits would be highly desirable. Among the traits, negative direct effect was recorded by seeds/ pod. Positive indirect effects of seed yield/ tree *via* number of pods/ tree, number of seeds/pod, tree height, 100-seed weight and seed oil content were found to be high and indirect selection through seed yield/ tree is expected lead to oil yield improvement.

Key words: Moringa, correlation coefficients, path analysis, oil yield, selection.

Moringa (*Moringa oleifera* Lam.), popularly known as drumstick is a medium sized (about 10 m high) tree belonging to the family Moringaceae. The Moringaceae is a single genus family with 13 known species, of these only *M. oleifera* (syn. *M. pterygosperma* Gaertn.) is the most widely known species and is planted in the whole tropical belt. The tree is indigenous to northern India and Pakistan. Moringa is known for its wide variety of uses and nutritional values. Almost every part of the plant is used: leaves, flowers and pods as vegetables, roots, bark and leaves in traditional medicine. Seeds of moringa are one of the best natural coagulants and possess antimicrobial properties.

The seed oil content of de-hulled seed (kernel) is approximately 42 per cent, brilliant yellow, used as a lubricant for fine machinery such as time pieces because it has little tendency to deteriorate and become rancid and sticky (Ramachandran *et al.*, 7). It is also useful as vegetable cooking oil. It is high in oleic acid and similar in composition to olive oil. Oil production is one of the promising areas for moringa economic exploitation. Moringa oil produced in India is sold between $150 and 550 per litre (Saint Sauveur, 9). The suitability of *M. oleifera* seed oil as biodiesel source has been tested and recommended by Da Silva *et al.* (2) who reported that the oil could be used as pure biodiesel or petrodiesel mixture in engine.

Thirty four moringa genotypes were planted in October, 2009 in randomized block design with two replications. Observations were recorded on five randomly selected plants for eight quantitative characters, namely, tree height, number of pods / tree, pod length, number of seeds / pod, 100-seed weight, seed yield / tree, seed oil content and oil yield / tree. The seed oil content was estimated by Soxhlet apparatus method. The data were statistically analyzed to estimate phenotypic and genotypic correlations (Allard, 1). Path analysis as suggested by Dewey and Lu (3) was used to partition the genotypic correlation coefficients of oil yield into direct and indirect effects.

Genotypic and phenotypic correlation coefficients estimated for various traits in moringa (Table 1) indicated higher magnitude of genotypic correlations than phenotypic correlations. In general, values of correlations coefficient at the genotypic levels were higher than the phenotypic correlation coefficient indicates an inherent association among various characters and the genotypic superiority but its expression is lessened under the influence of environment (Dey *et al.*, 4). The difference between genotypic and phenotypic correlations was in general low, indicating the least influence of environment on these characters. Tree height showed non-significant positive correlation with number of pods/ tree, number of seeds/ pod, 100-seed weight and oil yield/ tree at both genotypic and phenotypic levels. However, strong positive significant correlation was found between tree height and pod length at genotypic and phenotypic levels. Seed oil content showed negative significant correlation with tree height at both the levels. Positive

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Table 1. Genotypic and phenotypic correlation coefficients of eight quantitative traits in moringa.

Trait	No. of pods /tree	Pod length	No. of seeds/ pod	Seed yield /tree	100-seed weight	Seed oil content	Oil yield/ tree
Tree height	0.212	0.326*	0.232	0.331*	0.293	-0.348*	0.256
	(0.194)	(0.299*)	(0.196)	(0.3)	(0.273)	(-0.307*)	(0.232)
No. of pods/ tree		-0.216	0.039	0.919**	0.087	0.079	0.896**
		(-0.22)	(0.021)	(0.91**)	(0.088)	(0.061)	(0.883**
Pod length			0.428**	-0.031	0.269	-0.185	-0.067
			(0.465**)	(-0.013)	(0.265)	(-0.169)	(-0.048)
No. of seeds/ pod				0.365*	0.257	0.118	0.352*
				(0.366*)	(0.242)	(0.111)	(0.354*)
Seed yield/ tree					0.322*	0.123	0.978**
					(0.327*)	(0.106)	(0.973**)
100-seed weight						0.234	0.363*
						(0.219)	(0.364*)
Seed oil content							0.309*
							(0.307*)

Values in parenthesis are phenotypic values; *, ** significant at 5 and 1% probability levels

significant correlation was found between tree height and seed yield/ tree. Number of pods/ tree was positively and significantly correlated with the seed yield /tree and oil yield/ tree at both the levels. Kader Mohideen and Shanmugavelu (5) reported positive correlation for fruit yield with number of fruits per plant.

On the other hand, number of pods/ tree had positive but non-significant correlation with number of seeds/ pod, 100-seed weight and seed oil content at both the levels. Number of pods/ tree and pod length was negatively correlated at both the levels. Pod length had highly significant positive correlation with number of seeds/ pod at both the levels, while with 100-seed weight it had positive non-significant correlation. Pod length showed negative non-significant correlation with seed yield/ tree, seed oil content and oil yield/ tree. Sadasakthi (8) reported negative correlation with fruit length. Number of seeds/ pod showed positive significant correlation with seed yield/ tree and oil yield/ tree whereas it showed positive non significant correlation with 100-seed weight and seed oil content. Seed yield/ tree had highly significant correlation with oil yield/ tree and positive significant correlation with 100-seed weight. Seed yield/ tree had non-significant positive correlation with seed oil content. Hundred-seed weight had positive significant correlation with oil yield/ tree and positive correlation with seed oil content. Seed oil content had positive significant correlation with oil yield/ tree. Raja and Bagle (6) reported that yield per plant had positive and significant correlation with fruit length and number of fruits per plant. The genotypic correlation coefficients of oil yield/ tree with other characters were divided into direct and indirect effects. Complete information about a complex traits like oil yield that is controlled by several other traits either directly or indirectly. Hence, the path coefficient analysis would be quite useful as it permits the separation of direct effects from indirect effects through other related traits by partitioning the genotypic correlation coefficients (Dewey and Lu, 3).

Out of eight traits, six traits showed positive direct effects and one trait showed negative direct effects on oil yield/ tree. In the present study, the residual effect was low (Table 2) indicating the adequacy of the characters chosen. The highest positive direct effects were recorded by seed yield/ tree (0.921), followed by seed oil content (0.195) indicating their relationship and selection based on these traits will be highly desirable. Among the characters, negative direct effect was recorded by number of seeds/ pod (-0.017). However, this negative direct effect was compensated by the positive indirect effects. Similar results were obtained by Raja and Bagle (6) for number of fruits/ plant and plant height. Tree height had high positive indirect effect on oil yield through seed yield/ tree (0.305). Number of pods/ tree had the positive indirect effect through seed yield per tree (0.846), followed by seed oil content (0.015). Negative indirect effect was observed through pod length (-0.001) and number of seeds per pod (-0.001).

Pod length recorded high positive indirect effect through 100-seed weight (0.005) and tree height

Table 2. Direct and indirect effects of seven component traits on oil yield/ tree in moringa (genotypic path).

Trait	Tree height	No. of pods/ tree	Pod length	No. of seeds/ pod	Seed yield/ tree	100-seed weight	Seed oil content	Correlation with oil yield/ tree
Tree height	0.00883	0.007	0.00137	-0.00389	0.3048	0.0053	-0.06787	0.256
No. of pods/ tree	0.00187	0.03299	-0.00091	-0.00065	0.84591	0.00157	0.01531	0.896
Pod length	0.00288	-0.00714	0.0042	-0.00718	-0.02887	0.00488	-0.0361	-0.067
No. of seeds/ pod	0.00205	0.00128	0.0018	-0.01678	0.33593	0.00465	0.02309	0.352
Seed yield/ tree	0.00292	0.03031	-0.00013	-0.00612	0.92078	0.00584	0.02398	0.978
100-seed weight	0.00258	0.00286	0.00113	-0.00431	0.29653	0.01813	0.04565	0.363
Seed oil content	-0.00307	0.00259	-0.00078	-0.00199	0.1133	0.00425	0.19489	0.309

Residual effect = 0.08

(0.003). High negative indirect effect was recorded for seed oil content (-0.036) followed by seed yield / tree (-0.029), number of pods/ tree (-0.007) and number of seeds /pod (-0.007). Number of seeds/ pod exhibited high positive indirect effect through seed yield per tree (0.336), followed by seed oil content (0.023). Seed yield / tree had the indirect contribution through number of pods/ tree (0.03), seed oil content (0.023). Negative indirect effects were observed through number of seeds / pod (-0.006) and pod length (-0.0001).

Hundred-seed weight recorded high positive indirect effects through seed yield /tree (0.297) followed by seed oil content (0.046), number of pods / tree (0.002), tree height (0.002) and pod length (0.001). Negative indirect effect was recorded through number of seeds / pod (-0.004). Seed oil content exhibited high positive indirect effect through seed yield /tree (0.113), followed by 100-seed weight (0.004) and number of pods/ tree (0.003). Negative indirect effect was recorded for tree height (-0.003) followed by number of seeds / pod (-0.001) and pod length (-0.0007). Positive indirect effects of seed yield/ tree *via* number of pods /tree, number of seeds/ pod, tree height, 100-seed weight and seed oil content were found to be high and indirect selection through seed yield / tree will lead to oil yield improvement.

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