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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 thirty four 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. The genotypic correlation coefficients estimated for various traits were of higher magnitude than phenotypic correlations. The difference between genotypic and phenotypic correlations was in general low, indicating the least influence of environment on these characters. 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 will be highly desirable. Among the characters, 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 will lead to oil yield improvement.

Keywords: Moringa, correlation coefficients, path analysis, oil yield, selection

Introduction

Moringa (*Moringa oleifera* Lam.), popularly known as drumstick, is a medium sized (about 10 metres 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 grown in the 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 oil content of de-hulled seed (kernel) is approximately 42 per cent, brilliant yellow, used as a lubricant for fine machinery such as watches because it has little tendency to deteriorate and become rancid and sticky (Ramachandran *et al.,* 1980). It is also useful as vegetable cooking oil. The oil is known for its capacity to absorb and retain volatile substances and is therefore valuable in the perfume industry for stabilizing scents. The free fatty acid content varies from 0.5 to 3 per cent. The seed oil of moringa contains approximately 13 per cent saturated fatty acids and 82 per cent unsaturated fatty acids. It has a particularly high level of oleic acid (70%), and is similar in composition to olive oil. It has been documented by ancient cultures like Egyptian that moringa oil was placed in tombs as it possesses exceptional oxidative stability. Moringa oil is light and spreads easily on skin and is good for use in massage and aromatherapy applications. Moringa oil is used in creams, lotions, balms, scrubs, body oils and hair care formulations at 3-100 per cent composition. The seed cake contains a very high level of protein, which can therefore be used as a non - toxic natural polypeptide for sedimenting mineral particles and organics in the purification of drinking water, for cleaning vegetable oil or for sedimenting fibre in the juice and beer industries. Oil production is one of the promising areas for economic exploitation of moringa. Moringa oil produced in India is sold between $150 and $ 550 per litre (Saint Sauveur, 2001). The suitability of *M. oleifera* seed oil as biodiesel source has been tested and recommended by Da Silva *et al.* (2010), who reported that the oil could be used as pure biodiesel or petrodiesel mixture after converting it to fatty acid methyl esters through the process of transesterification in the presence of sodium hydroxide as catalyst.

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Material and Methods

Thirty four moringa genotypes were planted on 26.10.2009 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, 1960). Path analysis as suggested by Dewey and Lu (1959) was used to partition the genotypic correlation coefficients of oil yield into direct and indirect effects.

Results and Discussion

Genotypic and phenotypic correlation coefficients estimated for various traits in moringa (Table 1) indicated that the magnitude of genotypic correlations was higher than phenotypic correlations which indicated an inherent association among various characters and the genotypic superiority but its expression was lessened under the influence of environment (Dey *et al*., 2005). 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 significant correlation was found between tree height and seed yield/ tree. Number of pods/ tree was positively and significantly correlated with seed yield /tree and oil yield/ tree at both the levels. Kader Mohideen and Shanmugavelu (1983) also reported positive correlation of 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 were negatively correlated at both the levels. Pod length had highly significant positive correlation with number of seeds/pod, 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 (1995) also observed negative correlation of fruit length with yield. 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, (2008) also reported positive and significant correlation of fruit length and number of fruits per plant with yield per plant.

Complete information about a complex trait like oil yield that is controlled by several other traits either directly or indirectly cannot be given by the correlation coefficients. 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, 1959).

In path coefficient analysis, out of eight traits, six traits showed positive direct effects and one trait showed negative direct effect on oil yield/tree. The residual effect

Table 1: Genotypic and phenotypic correlation coefficients of eight quantitative characters in moringa

Particular	Number of pods/tree	Pod length	Number of seeds/pod	Seed yield/tree	100-seed weight	Seed oil content	Oil yield/tree
Tree height	0.212 (0.194)	0.326* (0.299*)	0.232 (0.196)	0.331* (0.3)	0.293 (0.273)	-0.348* (-0.307*)	0.256 (0.232)
Number of pods /tree		-0.216 (-0.22)	0.039 (0.021)	0.919** (0.91**)	0.087 (0.088)	0.079 (0.061)	0.896** (0.883**
Pod length			0.428** (0.465**)	-0.031 (-0.013)	0.269 (0.265)	-0.185 (-0.169)	-0.067 (-0.048)
Number of seeds/ pod				0.365* (0.366*)	0.257 (0.242)	0.118 (0.111)	0.352* (0.354*)
Seed yield/tree					0.322* (0.327*)	0.123 (0.106)	0.978** (0.973**)
100-seed weight						0.234 (0.219)	0.363* (0.364*)
Seed oil content							0.309* (0.307*)

(Values in parenthesis are phenotypic values) * significant at 5% probability level ** significant at 1% probability level

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

Particular	Tree height	Number of pods/tree	Pod length	Number of seeds/pod	Seed yield /tree	100-seed weight	Seed oil content	Correlation with oil yield/tree
Tree height	0.009	0.007	0.001	-0.004	0.305	0.005	-0.068	0.256
Number of pods /tree	0.002	0.033	-0.001	-0.001	0.846	0.002	0.015	0.896
Pod length	0.003	-0.007	0.004	-0.007	-0.029	0.005	-0.036	-0.067
Number of seeds/ pod	0.002	0.002	0.002	-0.017	0.336	0.005	0.023	0.352
Seed yield / tree	0.003	0.030	-0.001	-0.006	0.921	0.006	0.024	0.978
100-seed weight	0.003	0.003	0.001	-0.004	0.297	0.018	0.046	0.363
Seed oil content	-0.003	0.003	-0.001	-0.002	0.113	0.004	0.195	0.309

(Residual effect =0.08)

was low indicating the adequacy of the characters chosen. The highest positive direct effect was 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). Similar results were obtained by Raja and Bagle (2008) 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 showed positive indirect effect through seed yield per tree (0.846) and 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 (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 indirect contribution through number of pods/tree (0.03) and seed oil content (0.023). Negative indirect effects were observed through number of seeds/pod (-0.006) and pod length (-0.001). 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 (-0.007). 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.

सारांश

सह सम्बन्ध अध्ययनों मे चौतीस सहजन जीनोटाइप्स का सशक्त निम्बन्ध पाया गया, फली संख्या प्रति पौध, बीज/फली, फल लम्बाई, बीज की संख्या, उपज/पौधा, सौ बीज का वजन और बीज के तेल का पेड़ के साथ संकेत दिया। आनुवांशिक सहसंबंध गुणांक के लिए विभिन्न लक्षण का अनुमान प्ररूपी सहसंबंध की तुलना उच्च परिमाण के थे। आनुवांशिक और प्ररूपी सहसंबंध के बीच का अंतर कम था अर्थात् पर्यावरण का कम से कम प्रभाव का संकेत है। बीज उपज/पौधा, बीज तेल, फली की संख्या/पेड़, सौ बीज वजन, पौधे की ऊँचाई और फली लम्बाई द्वारा उच्चतम सकारात्मक प्रत्यक्ष प्रभाव दर्ज किया गया। इसका मतलब इन लक्षणों पर आधारित चयन उच्च वांछनीय हो जायेगा। वर्णों के बीच, नकारात्मक प्रत्यक्ष प्रभाव बीज/फली द्वारा दर्ज किया गया। सकारात्मक अप्रत्यक्ष प्रभावों के बीज उपज/पौधा के जरिए फली की संख्या/पौधा, बीज/फली, पौधे की ऊँचाई, सौ बीज वजन और बीज तेल सामग्री उच्च पाया गया था और बीज उपज/पौधा के माध्यम से अप्रत्यक्ष चयन करके तेल उपज में सुधार किया जा सकता है।

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