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GENETIC VARIABILITY STUDIES OF LOCAL DRUMSTICK (*MORINGA OLEIFERA* L.) GENOTYPES FOR LEAF YIELD

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ABSTRACT

Moringa oleifera L., commonly known as drumstick, is a highly valued, multi-purpose tree widely cultivated in tropical and subtropical regions for its nutritional and medicinal properties. Despite its versatile use, the development of high-yielding varieties for leaf production remains unexplored. In this study, thirty-three genotypes of *Moringa oleifera* collected from various regions in India were evaluated at the College of Horticulture, Bagalkot, using a Randomized Complete Block Design (RCBD) across four harvesting seasons. Significant genetic variability was observed, with traits such as the number of leaflets per rachis, fresh leaf yield, dry leaf yield, and leaf powder yield showing high genotypic and phenotypic coefficients of variation, heritability, and genetic advance, indicating strong genetic control and the predominance of additive gene action. These traits are promising candidates for genetic improvement through selection. The findings emphasize the importance of genetic variability in enhancing leaf yield and provide a foundation for breeding high-yielding moringa cultivars.
***Keywords* :** *Moringa oleifera* L., Genetic variability

Introduction

Drumstick (*Moringa oleifera L.*), is a medium-sized evergreen tree that belongs to the Moringaceae family. This perennial plant is widely cultivated in tropical and subtropical climates across the world and known for its excellent nutritional and therapeutic qualities. *Moringa oleifera* is a flexible plant that can be grown in both humid and desert environments. It is also referred to as a multi-purpose tree since the entire plant roots, leaves, blooms, mature pods, and seeds serves several functions. It is well known that drumstick leaves are abundant in health-promoting antioxidant chemicals, especially phenolic compounds like flavonoids. Numerous epidemiological studies indicate that diets high in antioxidants are associated with a reduced risk of degenerative diseases like cancer, cardiovascular issues and neurological disorders (Kashaninejad *et al*., 2021).

The Moringa tree has a wide, umbrella-shaped crown, a grey cork-like trunk, and fragile, drooping branches with delicate, hairy foliage. Its tripinnate leaves bear small elliptical leaflets, and it produces fragrant white to cream flowers in spreading panicles. The tree's long, green pods mature into brown capsules containing winged, oil-rich seeds.

Moringa leaves, pods, roots, and flowers are consumed as vegetables, with leaves being a vital source of nutrition. Leaves are especially valued for their high levels of vitamins A and C, minerals, calcium, potassium, Iron and protein, making them an important element in diets designed to fight malnutrition.

Currently, there is no distinct variety for greater leaf yield purposes. Developing cultivars with superior leaf yield in Moringa requires genetic variability, which serves as the foundation for yield improvement. Understanding this variability is essential for identifying sources of variation, enabling effective parental selection in breeding programs. It also facilitates long-term selection gains and the exploitation of heterosis, ensuring efficient crop improvement (Verma *et al*., 2019).

Materials and Methods

Thirty-three genotypes of drumstick (*Moringa oleifera* L.) were utilized in the study, which are collected from the various eco-geographical locations across different states of India. The experiment was conducted at College of Horticulture, Bagalkot, Karnataka, India. COH Bagalkot belongs to the northern dry zone of Karnataka. The experimental design is Randomized Complete Block Design (RCBD) with three replications. The morphological observations were recorded as the leaf crop is harvested frequently for its young leaves. In each season, leaf harvesting was done two months after pruning the trees (specifically at 90 days after transplanting (DAT), 150 DAT, 210 DAT, and 270 DAT). To assess the genetic potential for leaf yield across four seasons, data was collected for morphological characters, including growth traits such as plant height (cm), number of primary branches, number of rachis per plant, number of pinnae per rachis, number of leaflets per rachis, fresh leaf yield (g), dry leaf yield (g), and leaf powder yield (g).

Statistical analysis: The data were analysed for analysis of variance suggested by Panse and Sukhatme (1967), genotypic (GCV) and phenotypic coefficient of variation (PCV) as per Burton and De-vane (1953). Heritability was estimated according to Falconer (1981) and classified based on Johnson *et al.* (1955). Genetic advance was calculated according to Robinson *et al.* (1949) and genetic advance as per mean was calculated according to Johnson *et al.* (1955).

Result and Discussion

Analysis of variance (ANOVA) showed highly significant differences (P<0.01) among the genotypes (Table 1) indicating highly heterogeneous nature of thirty-three moringa genotypes for all the traits. Higher genotypic coefficient of variation (GCV) coupled with high phenotypic coefficient of variation (PCV) was observed in traits like number of leaflet per rachis at 90 DAT (40.88 %, 44.25 %), number of leaflet per rachis at 150 DAT (41.63 %, 42.9 %), number of leaflet per rachis at 210 DAT (44.23 %, 44.75 %), number of leaflet per rachis at 270 DAT (43.69 %, 44.32 %), fresh leaf yield at 90 DAT (22.89 %, 30.94 %), fresh leaf yield at 270 DAT (22.4 %, 23.2 %), dry leaf yield at 90 DAT (26.8 %, 28.23 %), dry leaf yield at 150 DAT (20.74 %, 21.67 %), dry leaf yield at 270 DAT (22.95 %, 22.97 %), leaf powder yield at 90 DAT (27.09 %. 28.44 %), leaf powder yield at 150 DAT (21.28 %. 22.24 %), leaf powder yield at 270 DAT (21.54 %. 23.68 %). While the rest of the characters recorded the moderate to low-level variance (Table 2).

The GCV and PCV analysis highlights genetic and environmental contributions to moringa traits, identifying traits with high genetic control and minimal environmental influence, like plant height at 90 DAT, plant height at 270 DAT and number of leaflets per rachis at 270 DAT, which are stable candidates for selection. Traits with larger GCV and PCV differences, such as plant height at 150 DAT and primary branches at 90 DAT, suggest stronger environmental influence, indicating the need for controlled conditions to achieve reliable results. This analysis emphasizes traits with high genetic influence as ideal for selection, while those more impacted by the environment may benefit from environmental management. This showed similarity with the studies of Raja and Bagle (2005), Selvakumari and Ponnuswami (2017), Avinash (2022).

The range of heritability was categorized by following method of Johnson *et al*. (1955) such as high (>60%), moderate (31–60%) and low (0–30%) heritability. Heritability was recorded for several traits, with the number of leaflets per rachis at 210 DAT showing the highest heritability (97.69%), followed by the number of leaflet per rachis at 270 DAT (97.17%), plant height (96.3 %), number of pinna per rachis at 270 DAT (94.89%), number of leaflet per rachis at 150 DAT (94.16 %), number of pinna per rachis 90 DAT (93.23 %), fresh leaf yield at 270 DAT (93.2 %), number of pinna per rachis 150 DAT (92.94 %), fresh leaf yield at 210 DAT (92.68 %), number of rachis per plant 90 DAT (91.88 %), dry leaf yield at 150 DAT (91.63%), leaf powder yield at 150 DAT (91.61 %), number of rachis per plant 150 DAT (90.88 %), number of pinna per rachis 210 DAT (90.81 %), leaf powder yield 90 DAT (90.76 %), dry leaf yield 90 DAT (90.12 %), fresh leaf yield 150 DAT (89.22 %), plant height 210 DAT (89.08 %), number of leaflet per rachis 90 DAT (85.36 %), dry leaf yield 270 DAT (83.19 %), leaf powder yield 270 DAT (82.74 %), dry leaf yield 210 DAT (81.74 %), leaf powder yield 210 DAT (81.62 %). Traits, number of rachis per plant 210 DAT (76.94 %), plant height 270 DAT (73.31 %), number of rachis per plant 270 DAT (72.23 %), number of primary branches 150 DAT (71.32 %) also exhibited high heritability, indicating strong genetic control. The rest of the characters recorded the moderate to low-level variance (Table 2).

The heritability findings from this study highlight the degree of genetic control and environmental influence on various traits, which is essential for effective breeding strategies. High heritability was observed for traits like the number of leaflets per rachis at 210 DAT and 270 DAT, the number of pinnae per rachis at 270 DAT and fresh leaf yield at 150 DAT. These findings align with the research conducted by Raja and Bagle (2005), Selvakumari and Ponnuswami (2017), Nair (2021).

Genetic advance as a percentage of mean (GAM) varied widely across the traits. The range of genetic advance as per cent of mean was classified using method developed by Johnson *et al*. (1955) as high (>20%), moderate (11–20%) and low (1–10%). High genetic advance was observed for traits like the number of leaflets per rachis at 210 DAT (90.06%), 270 DAT (88.72%) and 150 DAT (83.23%), number of leaflets per rachis 90 DAT (77.81 %), leaf powder yield 90 DAT (53.17 %), dry leaf yield at 90 DAT (52.41%), fresh leaf yield at 270 DAT (44.5 %), leaf powder yield 150 DAT (41.96 %), dry leaf yield 150 DAT (40.9 %), leaf powder yield 270 DAT (40.36 %), dry leaf yield 270 DAT (39.37 %), fresh leaf yield 210 DAT (39.09 %), leaf powder yield 210 DAT (36.74 %), dry leaf yield 210 DAT (35.91 %), fresh leaf yield 150 DAT (35.24 %), fresh leaf yield 90 DAT (34.87 %), number of rachis per plant 90 DAT (34.53 %). The rest of the characters recorded the moderate to low-level variance (Table 2). This finding clearly indicated that most of these traits are governed by additive gene and thus, selection approach will be helpful for improvement of these characters. Hence, estimation of genetic advance and genetic gain has an added advantage over heritability as a guiding factor in a selection program to improve any particular desired traits (Xu *et al*. 2017, Li *et al*. 2018). Traits with both high GCV and genetic advance, such as the number of leaflets per rachis and fresh and dry leaf yield, are particularly promising for genetic improvement through selection. These results are consistent with previous studies by Raja and Bagle (2005), Selvakumari and Ponnuswami (2017), Verma *et al.* (2019).

Conclusion

The study reveals significant genetic variability among Moringa genotypes, with traits like the number of leaflets per rachis, fresh and dry leaf yields, and leaf powder yield showing high genotypic and phenotypic variation, indicating strong genetic control. High heritability observed for traits such as the number of leaflets per rachis at 210 and 270 DAT, fresh leaf yield, and the number of pinnae per rachis underscores their potential for effective selection in breeding programs. Traits with both high GCV and genetic advance, including fresh and dry leaf yields, suggest the predominance of additive gene action, making them ideal for genetic improvement through direct selection. These findings emphasize prioritizing traits with high genetic influence for improvement while managing environmental impacts on moderately influenced traits.

Table 1 : Analysis of variance for growth, yield and quality parameters of moringa

SI. No.	Source of variation	M.S.S. (replications)	M.S.S. (treatments)	Error	F-Value
	Degrees of freedom	**2**	**32**	**64**	**(treatments)**
1	Plant height at 90 DAT (cm)	1901.60	33.39**	24.04	1.62
2	Plant height at 150 DAT (cm)	2797.19	354.68**	889.77	3.14
3	Plant height at 210 DAT (cm)	0.11	879.87**	34.55	20.47
4	Plant height at 270 DAT (cm)	251.27	508.57**	55.04	9.24
5	Number of primary branches at 90 DAT	0.96	0.49**	0.41	1.62
6	Number of primary branches at 150 DAT	0.01	0.45**	3.44	8.46
7	Number of primary branches at 210 DAT	0.38	19.35**	12.28	3.15
8	Number of primary branches at 270DAT	0.31	0.74**	0.26	2.83
9	Number of rachis per plant at 90 DAT	47.26	0.21**	1.35	34.96
10	Number of rachis per plant at 150 DAT	20.25	1.15**	0.66	30.91
11	Number of rachis per plant at 210 DAT	3.78	8.49**	0.77	11.01
12	Number of rachis per plant at 270 DAT	0.79	10.67**	1.21	8.80
13	Number of pinna per rachis at 90 DAT	6.88	0.41**	0.16	42.32
14	Number of pinna per rachis at 150 DAT	0.17	7.29**	0.18	40.47
15	Number of pinna per rachis at 210 DAT	1.35	7.45**	0.24	30.65
16	Number of pinna per rachis at 270 DAT	1.06	7.32**	0.13	56.66
17	Number of leaflets per rachis at 90 DAT	90927.02	4969.42**	4917.33	18.49
18	Number of leaflets per rachis at 150 DAT	1186.86	92209.07**	1866.25	49.41
19	Number of leaflets per rachis at 210 DAT	528.31	101181.42**	790.37	128.02
20	Number of leaflets per rachis at 270 DAT	382.87	96885.84**	932.60	103.89
21	Fresh leaf yield at 90 DAT (g)	47309.25	932.12**	10227.67	4.63

Sl. No.	Source of variation	M.S.S. (replications)	M.S.S. (treatments)	Error	F-Value
	Degrees of freedom	2	32	64	(treatments)
22	Fresh leaf yield at 150 DAT (g)	14824.63	88.40**	574.22	25.82
23	Fresh leaf yield at 210 DAT (g)	18901.29	11920.35**	305.81	38.98
24	Fresh leaf yield at 270 DAT (g)	11182.14	13546.28**	320.39	42.28
25	Dry leaf yield at 90 DAT (g)	2628.58	195.46**	92.69	28.36
26	Dry leaf yield at 150 DAT (g)	1075.03	8.65**	31.77	33.83
27	Dry leaf yield at 210 DAT (g)	2257.69	799.22**	55.38	14.43
28	Dry leaf yield at 270 DAT (g)	2468.32	826.09**	52.13	15.89
29	Leaf powder yield at 90 DAT (g)	2544.32	236.23**	83.49	30.48
30	Leaf powder yield at 150 DAT (g)	1076.18	8.03**	31.90	33.74
31	Leaf powder yield at 210 DAT (g)	2508	752.69**	52.54	14.33
32	Leaf powder yield at 270 DAT (g)	2413.93	291.45**	51.46	15.38
33	Protein (%)	0.27	11.99*	0.18	67.05
34	Iron (ppm)	0.27	3214.62*	23.69	135.70
35	Calcium (%)	0.01	1.36*	0.00	291.55
36	Vitamin-C (mg/100g)	1.21	3065.78*	21.19	144.66

Note: At 5 per cent level of significance, MSS – Mean sum of squares, DAT- Days After Transplanting

Table 2 : Estimates of genetic parameters in moringa genotypes

Sl. No.	Characters	Mean	Range		GCV (%)	PCV (%)	h^2 (%)	GAM (%)
			Min.	Max.				
1	Plant height 90 DAT (cm)	155.35	109.86	219.81	16.1	16.41	96.3	32.55
2	Plant height 150 DAT (cm)	166.64	121.73	241.53	15.13	23.44	41.68	20.12
3	Plant height 210 DAT (cm)	150.4	114.34	187.22	11.16	11.83	89.08	21.7
4	Plant height 270 DAT (cm)	131.59	110.63	156	9.34	10.31	73.31	16.48
5	Number of primary branches 90 DAT	2.95	2	4.73	14.43	26.13	30.49	16.42
6	Number of primary branches 150 DAT	2.85	2.07	3.66	12.83	15.19	71.32	22.32
7	Number of primary branches 210 DAT	2.86	2	4	12.98	20.08	41.76	17.28
8	Number of primary branches 270 DAT	2.90	2	4	13.77	22.37	37.91	17.47
9	Number of rachis per plant 90 DAT	22.37	14.46	31.13	17.49	18.24	91.88	34.53
10	Number of rachis per plant 150 DAT	18.61	14.42	25.07	13.73	14.4	90.88	26.97
11	Number of rachis per plant 210 DAT	16	11.76	18.44	10.03	11.43	76.94	18.12
12	Number of rachis per plant 270 DAT	16.21	12.14	19.72	10.95	12.89	72.23	19.18
13	Number of pinna per rachis 90 DAT	11.98	9.44	15.1	12.5	12.94	93.23	24.86
14	Number of pinna per rachis 150 DAT	11.9	9.53	14.6	12.93	13.42	92.94	25.68
15	Number of pinna per rachis 210 DAT	11.55	9.5	14.92	13.42	14.08	90.81	26.34
16	Number of pinna per rachis 270 DAT	11.57	9.45	15.1	13.39	13.74	94.89	26.86
17	Number of leaflets per rachis 90 DAT	414.15	115.67	791.67	40.88	44.25	85.36	77.81
18	Number of leaflets per rachis 150 DAT	416.81	123.87	817.73	41.63	42.9	94.16	83.23
19	Number of leaflets per rachis 210 DAT	413.55	127.28	842.91	44.23	44.75	97.69	90.06
20	Number of leaflets per rachis 270 DAT	409.32	142.69	846.91	43.69	44.32	97.17	88.72
21	Fresh leaf yield 90 DAT (g)	485.8	303.16	862.26	22.89	30.94	54.72	34.87
22	Fresh leaf yield 150 DAT (g)	380.51	211.53	551.4	18.11	19.18	89.22	35.24
23	Fresh leaf yield 210 DAT (g)	315.65	195.61	433.73	19.71	20.48	92.68	39.09
24	Fresh leaf yield 270 DAT (g)	296.48	172.73	419.61	22.4	23.2	93.2	44.5
25	Dry leaf yield 90 DAT (g)	108.47	67.93	193.3	26.8	28.23	90.12	52.41
26	Dry leaf yield 150 DAT (g)	89.9	49.17	142.59	20.74	21.67	91.63	40.9
27	Dry leaf yield 210 DAT (g)	81.68	47.2	122.36	19.28	21.32	81.74	35.91
28	Dry leaf yield 270 DAT (g)	76.65	50.27	110.91	22.95	22.97	83.19	39.37
29	Leaf powder yield 90 DAT (g)	105.71	65.92	189.18	27.09	28.44	90.76	53.17
30	Leaf powder yield 150 DAT (g)	87.66	47.33	140.25	21.28	22.24	91.61	41.96
31	Leaf powder yield 210 DAT (g)	77.38	44.28	116.63	19.74	21.85	81.62	36.74
32	Leaf powder yield 270 DAT (g)	72.92	46.92	106.26	21.54	23.68	82.74	40.36

DAT –Days After Transplanting, GCV- Phenotypic coefficient of variation, PCV- Phenotypic coefficient of variation, h^2- Heritability (Broad sense), GAM- Genetic advance as percentage over mean

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