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Original Article

Determination of major traits responsible for the expressed variation among 31 accessions of *Moringa oleifera* Lam. in Nigeria

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ABSTRACT

In the pursuit of creating a repository for breeding activities to determine *Moringa oleifera* accessions for future genetic improvement, this study was undertaken at the Forestry Research Institute of Nigeria (FRIN), Jericho Ibadan arboretum from 2013 to 2016. The experiment was laid out in a randomized complete block design with three replications. The morphological data were subjected to analysis of variance and rank summation index (RSI) to determine their pattern of variation, identify major traits responsible for the variation, and suggest appropriate accessions for breeding. Significant ($P < 0.05$) variation was observed among the accessions for surviving ability, pod diameter, and number of seed/pod and highly significant ($P < 0.01$) differences for days to flowering, days to fruiting, pod length, plant height, and secondary branches (Sbr). Positive significant ($P < 0.05$) correlations were observed between survival ability and vegetative characters, as well as between survival ability and yield-related characters. Negative significant correlations were observed between early flowering and yield-related characters; likewise between early flowering and vegetative characters. Based on RSI, Accessions FRINMOR12-17, FRINMOR12-22, and FRINMOR12-6 were the best materials in terms of total number of pods, total number of seeds, the seed yield, 100 seed weight, pod weight, number of seeds per pod, Sbr, and flowering branches. Thus, it can be considered the best potential materials for the improvement of *Moringa* among the collected accessions in Nigeria.

Keywords: Morphological characters, survival ability, vegetative characters and rank summation, yield related characters

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INTRODUCTION

Moringa oleifera Lam commonly known as drumstick is the most widely cultivated species of the monogenetic family, *Moringaceae*.[1] Drumstick is a fast growing deciduous perennial tree, native to India in Asia and was introduced in 1920s to the lower part of China, South-east to the Philippines, westward to Africa and America.[2] The tree comprises of four different edible parts: leaves, pod, stem, and root.[3] Different parts of Moringa tree such as the leaves, fruits, flowers, and immature pods are highly nutritious and have been used as a source of food in many countries such as India, Pakistan, Philippines, Hawaii, and several countries in Africa.[4] *M. oleifera* leaves have been reported to be a rich sources of β-carotene, protein, Vitamin C, calcium, and potassium. In the Philippines, in addition to food uses, *M. oleifera* is used for animal feed.[5] When supplemented in the diet of dairy animals, the leaves improve dry matter intake, digestion, and milk production without affecting the smell, taste, or color of milk produced by the animal.[5] It has also been reported as a natural coagulant for treatment of turbid water[6,7] as well as a source of phytomedical compounds.[8] The medicinal uses, safety, and efficacy of *M. oleifera* have been widely reported by several authors.[8-11] Information on diversity and population structure is expected to assist plant breeders in the selection of parents for crossing, thereby providing a more rational basis for expanding the gene pool and for identifying material that harbors alleles of value for plant improvement.[12] *M. oleifera* is being underutilized, as available germplasms are scarcely represented in *ex situ* collections and *in situ* collections are poorly managed and conserved.[9,13] According to,[14] analysis of the association between various plant traits would help in identifying traits that are useful for production and breeding. This study, therefore, aimed

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at evaluating diversity among 31 accessions of *M. oleifera* using morphological means with minimal descriptors for drumstick[15] and descriptors for legumes[16] as used and referenced by.[9]

MATERIALS AND METHODS

Source of Materials

Seedlings from 31 provenances that were able to make the required number of 30 seedlings needed for the field establishment were selected out of the 52 provenances from different locations in Nigeria and three from outside Nigeria, namely: Mali, Israel, and India were used in this study.

Field Establishment

A 4-week-old seedlings were transplanted on May 29, 2013, to the arboretum in Forestry Research Institute of Nigeria (FRIN), Ibadan (South-west Nigeria), located on Latitude 7°23'15''–7° 24' 00''N and Longitude 3°51'00''N–3°52'15''E of the Greenwich Meridian, the climate is West African monsoon with dry and wet season. The location has a mean annual rainfall of approximately 1548.9 mm distributed within a period of 90 days. The mean maximum temperature is 31.9°C minimum 24.2°C. Mean daily relative humidity is about 71.9%.[17] Ten seedlings were planted per accession with three replicates in a two row plot 10 m long with intra and inter row spacing of 2.5 m × 2.5 m arranged in randomized complete block design.

Data Collection

Data on morphological traits were recorded as follows:

Surviving ability

Number of plants after 3 years of establishment; Regrowth potential: number of new sprouted shoots after abscission, Stem diameter: Taken at basal part 6 months after transplanting (mm), Plant height: taken 6 months after transplanting from the ground to the tip of the main stem (cm), Number of primary branches (Pbr): Total number of branches from the main bole at 24 months after transplanting, Number of secondary branches (Sbr): Total number of branches growing on Pbr 24 months after transplanting:, Number of flowering branches (Flbr): Total number of Flbr 30 months after transplanting**,** Number of days to first flowering (DFF): Number of days it takes a plot to produce a flower after transplanting, Number of days to first fruiting (DFFR): Number of days it take a flower to produce a fruit after transplanting, Number of pods per plot: Total number of pods (Tpods) harvested in a plot, Pod length (PL),: Distance between base to the tip of a pod (cm), Pod diameter (PD): Measured with veneer caliper at midpoint of the pod (mm): Pod weight (PW): Weight of harvested pods per plot during harvest (g), Number of seeds per plot: Total number of seeds from a plot, Seed yield: Total weight of seeds per plot (g), Hundred (100) seeds weight: Randomly counted hundred seeds weight (g) and Number of seeds per pod: Total number of seeds in a pod from a plot.

Data Analysis

The mean values of all data collected for each trait were analyzed using statistical analytical system (2002) package.

Analysis of variance was determined with model:

$$Y_{ijk} = \mu + \gamma_k + e_{ijk}$$

Where;
Y_{ijk} = the observed trait measured
μ = the grand mean of the character
γ_k = the genotypic effect
e_{ijk} = Environmental effect.

The form of analysis of variance calculated to get the expected mean squares is shown in Table 1:

Mean separation was done by least significance difference where significance exists. Coefficient of variation was computed to compare the variability existing within each studied character.

Rank Summation Index (RSI)

To identify superior accessions, an index, RSI according to[18], was generated from eight traits, namely: Tpods, total number of seeds, seed yield, 100 seed weight, PW, number of seeds per pod, Sbr, and Flbr.[18] described RSI as "parameter free" index. The index was formed by ranking each trait in descending order and then the values attached to each trait are added to obtain the sum of the ranks; this indicates the overall classification of the accessions.[19] Accessions with good Tpods, total number of seeds, the seed yield, 100 seed weight, PW, number of seeds per pod, Sbr, and Flbr ranked first, while the least performing ones ranked last. RSI computation by[18] is as follows:

$$RSI = \sum_{i-1}^{n} R_i = S$$

Where,
RSI = Aggregate performance of an accession using the ranking of each of the desired traits.
R_i = Rank of the mean of each of the desired traits.

RESULTS AND DISCUSSION

Mean Performance

The mean performances for the morphological characters of *M. oleifera* are presented in Table 2 survival of the plants

Table 1: Form of analysis of variance for morphological traits

Source of variation		DF	MS	EMS
Replication	2	*(r−1)*	MS_r	
Provenance	30	*(p−1)*	MS_p	$\sigma_e^2 + r\sigma_p^2$
Error	60	*(r−1) (p−1)*	MS_e	σ_e^2

Table 2: The mean performance for the morphological characters of *Moringa oleifera*

S. No.	Acce No	Surv	Reg	SD6M (mm)	H6M (cm)	Pbr	Sbr	Flbr	DFF	DFFR
1	FMOR12-1	2.0	2.0	13.24	67.53	10.40	5.33	6.93	102.0	172.7
2	FMOR12-2	7.0	4.0	13.23	98.87	3.25	1.00	2.42	141.0	243.0
3	FMOR12-3	5.0	4.0	22.34	126.21	7.16	9.94	12.27	144.0	305.3
4	FMOR12-4	4.3	2.3	23.61	134.12	5.40	5.69	7.10	174.3	234.3
5	FMOR12-5	4.0	3.0	17.91	130.83	5.58	9.00	8.63	205.0	267.0
6	FMOR12-6	5.0	2.0	25.10	145.73	5.69	15.11	12.97	136.5	274.0
7	FMOR12-7	2.0	1.0	16.10	109.37	3.89	13.67	11.78	122.0	192.0
8	FMOR12-8	2.0	1.0	9.62	59.83	5.52	10.55	7.54	192.5	299.5
9	FMOR12-9	4.0	4.0	20.70	127.23	15.00	15.31	19.67	197.0	222.3
10	FMOR12-10	1.0	1.0	9.55	68.57	4.67	0.00	5.00	162.0	231.0
11	FMOR12-11	2.0	1.0	22.85	102.06	11.17	27.17	18.00	183.5	274.0
12	FMOR12-12	3.0	2.0	15.59	114.08	8.89	10.78	12.17	194.5	166.0
13	FMOR12-13	3.0	2.0	15.99	101.30	8.53	7.75	12.77	136.3	221.7
14	FMOR12-14	5.0	3.0	15.40	103.70	5.50	13.00	9.81	188.0	257.3
15	FMOR12-15	5.0	3.0	15.89	128.31	6.39	8.56	5.30	154.0	231.3
16	FMOR12-16	3.0	1.0	17.77	107.93	8.50	13.83	21.22	133.0	253.7
17	FMOR12-17	5.0	3.0	19.09	116.09	9.11	22.33	16.92	160.3	264.0
18	FMOR12-18	3.0	2.0	18.43	111.40	5.83	8.03	2.25	184.0	255.0
19	FMOR12-19	3.0	1.0	14.84	120.00	2.19	7.20	3.44	117.5	227.0
20	FMOR12-20	2.0	1.0	9.09	81.00	4.52	2.80	1.79	434.5	491.5
21	FMOR12-21	3.0	2.0	8.45	65.88	2.33	7.70	3.70	358.0	419.0
22	FMOR12-22	5.0	3.0	24.37	257.30	6.87	21.67	15.00	107.0	187.0
23	FMOR 12-23	6.0	4.0	21.15	204.47	7.92	7.58	10.56	113.7	195.0
24	FMOR12-24	4.0	3.0	23.44	224.84	4.77	10.80	14.20	129.3	207.0
25	FMOR12-25	4.0	3.0	22.81	186.10	10.43	10.28	13.80	152.0	229.7
26	FMOR 12-26	5.0	3.0	22.96	183.73	10.69	6.56	8.57	123.0	194.5
27	FMOR12-27	2.0	1.0	17.59	114.87	4.89	4.00	5.33	124.5	256.5
28	FMOR12-28	4.0	3.0	13.97	133.49	5.43	17.42	10.93	112.0	177.0
29	FMOR12-29	3.0	2.0	18.34	210.54	8.57	17.78	14.75	110.0	176.0
30	FMOR12-30	2.0	2.0	11.58	113.89	5.33	10.70	10.20	105.0	179.0
31	FMOR12-31	5.0	5.0	29.37	231.43	8.72	12.33	9.85	132.5	200.0
	Std Error	1.18	0.94	4.29	33.54	2.62	4.27	4.76	16.11	25.01
	Mean	3.59	2.33	18.05	133.09	7.01	10.97	10.44	162.23	242.04
	C.V %	57.52	69.91	41.60	44.11	65.45	68.43	80.15	20.12	20.43
	LSD	3.30	2.66	11.51	93.00	6.81	11.83	12.96	52.48	77.92
	Significance	*	Ns	Ns	**	Ns	**	Ns	**	**

(*Contd...*)

Table 2: (*Continued*)

S. No	Acce No	Tpod	PLt (cm)	PD (mm)	PW (g)	Tseeds	Syield (g)	HSW (g)	Seeds/p
1	FMOR12-1	34.00	13.11	5.58	4.42	51.00	13.67	9.00	6.38
2	FMOR12-2	7.33	27.14	13.34	7.43	58.67	11.33	0.00	14.66
3	FMOR12-3	64.00	34.48	13.37	9.67	602.00	130.00	21.33	16.10
4	FMOR12-4	37.33	33.69	13.70	8.20	413.00	82.00	15.33	15.73
5	FMOR12-5	20.00	43.91	15.08	12.40	354.00	90.33	22.27	17.10
6	FMOR12-6	89.67	34.12	14.57	11.37	548.00	116.33	16.19	14.92
7	FMOR12-7	44.33	20.70	4.95	4.90	284.33	56.33	6.67	6.10
8	FMOR12-8	11.00	9.98	5.37	2.60	46.33	12.00	9.33	4.10
9	FMOR12-9	56.67	20.48	10.39	6.33	66.67	21.00	17.27	9.13
10	FMOR12-10	6.67	8.50	3.87	2.20	53.67	10.00	6.00	6.00
11	FMOR12-11	34.00	29.92	11.20	9.73	237.33	35.33	8.19	14.10
12	FMOR12-12	36.33	26.42	9.42	7.67	255.33	53.67	15.67	11.53
13	FMOR12-13	36.67	31.95	13.30	8.40	346.67	77.00	21.33	15.37
14	FMOR12-14	25.00	46.80	13.12	9.18	303.67	55.67	21.67	15.43
15	FMOR12-15	59.67	33.82	15.75	10.60	222.67	57.00	15.00	13.50
16	FMOR12-16	32.33	35.92	14.88	10.32	194.00	52.33	11.67	14.13
17	FMOR12-17	88.33	43.36	16.60	14.20	661.67	201.33	28.33	18.33
18	FMOR12-18	7.00	28.18	15.36	7.19	59.33	14.33	0.00	9.43
19	FMOR12-19	8.67	26.27	12.44	6.25	20.67	5.67	8.09	8.50
20	FMOR12-20	2.00	7.53	5.23	2.33	4.00	0.67	5.93	4.00
21	FMOR12-21	4.33	7.67	3.49	1.43	25.00	3.67	6.60	2.77
22	FMOR12-22	127.00	31.99	14.34	9.17	2129.33	464.33	20.69	15.97
23	FMOR12-23	115.33	32.11	15.23	8.90	461.67	107.00	21.93	11.20
24	FMOR12-24	60.67	30.45	14.79	8.10	462.67	107.67	21.67	12.60
25	FMOR12-25	88.33	31.79	15.88	9.63	177.67	53.67	18.33	10.67
26	FMOR 12-26	61.00	29.42	14.06	7.93	374.00	77.33	21.67	13.73
27	FMOR12-27	21.00	9.27	4.09	2.03	97.33	19.00	7.00	3.40
28	FMOR12-28	72.33	18.46	10.59	6.33	356.67	83.33	7.67	8.47
29	FMOR12-29	58.67	30.67	14.52	8.63	241.33	56.33	23.00	13.97
30	FMOR12-30	12.33	21.43	9.87	6.70	50.67	10.00	6.19	7.47
31	FMOR12-31	60.67	20.46	10.29	6.17	623.33	132.67	15.33	8.03
	Std Error	31.40	7.97	3.11	2.53	386.42	84.32	6.11	3.41
	Mean	44.60	33.79	14.55	9.50	407.84	92.41	18.28	14.15
	C.V %	121.94	52.18	47.05	58.98	212.09	204.77	74.75	53.40
	LSD	88.83	10.58	2.68	4.37	1068.00	233.67	11.81	4.41
	Significance	Ns	**	*	Ns	*	Ns	Ns	*

**significant at 0.01 level of probability, *significant at 0.05 level of probability, Ns: Non-significant difference, Surv: Surviving ability, Reg: Regrowth potential, SD6M: Stem diameter, H6M: Plant height, Pbr: Number of primary branches, Sbr: Number of secondary branches, flbr: Number of flowering branches, DFF: Days to first flowering, DFFR: Days to first fruiting

(Surv) in each accession for the period of 3 years under study ranged from 1 to 7 plants. Sixteen accessions performed well above the mean value of 3.59 for survival ability. Accessions FMOR12-2 and FMOR12-23 are the most stable in adaptation to the experimental area for the 3 years under study. The regrowth ability after abscission (Reg) ranged from 1 to 5 shoot count with a mean of 2.33. Accessions FMOR12-31 had the best regrowth potential with five shoots followed by accessions FMOR12-23, FMOR12-9, FMOR12-2, and FMOR12-3 having four shoots each. The plant stem diameter at 6 months after field establishment ranged from 8.45 mm to 29.37 mm, with a mean value of 18.05 mm. Accessions FMOR12-31 and FMOR12-6 had the thickest diameter of 29.37 mm and 25.10 mm, respectively. Plant height (H6M) at 6 months after establishment (MAE) ranged from 59.83 cm to 257.30 cm, with a mean of 133.09 cm. The accessions with the tallest plants are FMOR12-22 and FMOR12-31 with values of 257.30 cm and 231.43 cm, respectively. Number of Pbr ranged from 2 to 15 branches, with a mean value of 7.01. Twelve accessions performed above the mean value. Number of Sbr ranged from 0.00 to 27 branches with a mean value of 10.97 branches. While accessions FMOR12-11 and FMOR12-12-17 were the best performing accessions with 27 and 22 branches, respectively. Number of Flbr ranged from 2 to 21 branches, with a mean of 10.44 branches. Days to DFF ranged from 102 to 435 days, having an average of 162 days. FMOR12-1 and FMOR12-30 had early flowers with 102 and 105 days, respectively. FMOR12-21 and FMOR12-20 had delayed flowers of 358 and 435 days, respectively. DFFR ranged from 173 to 492 days, having an average of 242 days. Tpods harvested ranged from as low as 2.00 pods for accession FMOR12-20 to 127 pods for accession FMOR12-22 with a mean of 44.6 pods. Accessions FMOR12-22 and FMOR12-23 had the highest number of pods with 127 and 115 pods, respectively. The PL ranged from 7.53 cm to 46.80 cm with a mean of 33.79 cm. The PD ranged from 3.49 mm for accession FMOR12-21 to 16.60 mm for accession FMOR12-17 with a mean of 14.55 mm. The best performing accessions were FMOR12-17 and FMOR12-15 with diameter of 16.60 mm and 15.88 mm, respectively. The PW ranged from 1.43 g to 14.20 g with a mean of 9.50 g. Accessions FMOR12-17 and FMOR12-5 had the heaviest pods weight with values 14.20 g and 12.40 g, respectively. The total number of seeds (Tseeds) produced per plot ranged from 4.00 seeds to 2129.33 seeds with a mean of 407.84 seeds. Accessions FMOR12-22 and FMOR12-17 had the highest number of seeds, with 2129.33 seeds and 662 seeds, respectively. The seed yield per plot (Syield) ranged from 0.67 g to 464.33 g with a mean of 92.41 g. Accessions FMOR12-22 and FMOR12-17 had the highest yield with values 464.33 g and 201.33 g, respectively. The 100 seed weight (HSW) for the accessions ranged from 0.00 g to 28.33 g, with a mean of 18.28 g. Accessions FMOR12-17 and FMOR12-29 had the heaviest seeds density with 28.33 g and 23 g, respectively. The number of seeds per pod (S/pod) varied

Table 3: Mean squares from analysis of variance for Drumstick (*Moringa oleifera*)

Source	DF	Sur	Rej	DFF	DFFr	Tpods	PL	PG	PW	Tseed	S/yield	100S	S/pods	SD6M	H6M	Pbr	Sbr	Flbr
REP	2	0.68	0.85	2128.6	7523.63	2242.01	443.94	142.72	36.03	382034	15989.6	284.305	73.99	21.93	1305.31	62.43	122.57	440.32
PROV	30	7.52*	3.38	14844.63**	14238.83**	3339.50	347.46**	52.14**	29.48	455010	22741.4	162.786	60.88*	81.39	7487.99**	24.15	112.27**	77.80
Error	60	4.17	2.66	32.13	47.71	2957.89	190.54	28.98	19.22	447961	21330.7	112.158	34.87	55.10	3374.45	20.55	54.64	67.98

Sur: Survival, Rej: Rejuvenation, DFF: Days to first flower, DFFr: Days to first fruiting, TPods: Total pods, PL: Pod length, PD: Pod diameter, PW: Pod weight, TSeed: Total seed, Syied: Seed yield, 100 S: 100 seed weight, S/pod: Seeds per pod, SD6m: Stem diameter at 6 months, H6M: Plant height at 6 months, Pbr: Primary branches, Sbr: Secondary branches, Flbr: Flowering branches, *5% level of probability, **1% level of probability

Table 4: Rank Summation Indices on eight morphological traits

S. No	Accessions	Tpod	Tseeds	Syield	HSW	podwgt	Seed/pod	Sec br	Flbr	Rank index
1	FRIN MOR12-17	4	2	2	1	1	1	2	4	17
2	FRIN MOR12-22	1	1	1	10	10	4	3	5	35
3	FRIN MOR12-6	3	5	5	13	3	8	7	9	53
4	FRIN MOR12-3	7	4	4	9	7	3	17	11	62
5	FRIN MOR12-24	9	6	6	6	15	15	12	7	76
6	FRIN MOR12-29	12	16	14	2	12	12	4	6	78
7	FRIN MOR12-5	23	11	8	3	2	2	18	19	86
8	FRIN MOR12-23	2	7	7	4	11	17	23	15	86
9	FRIN MOR12-11	19	17	20	21	6	11	1	3	98
10	FRIN MOR12-14	21	13	16	5	9	6	10	18	98
11	FRIN MOR12-13	16	12	12	8	13	7	21	10	99
12	FRIN MOR12-16	20	19	19	18	5	10	8	1	100
13	FRIN MOR12-25	5	20	18	11	8	18	16	8	104
14	FRIN MOR12-31	10	3	3	15	24	23	11	17	106
15	FRIN MOR12-26	8	9	11	7	16	13	25	20	109
16	FRIN MOR12-28	6	10	9	23	21	22	5	14	110
17	FRIN MOR12-4	15	8	10	16	14	5	26	22	116
18	FRIN MOR12-9	13	22	21	12	22	20	6	2	118
19	FRIN MOR12-12	17	15	17	14	17	16	13	12	121
20	FRIN MOR12-15	11	18	13	17	4	14	19	25	121
21	FRIN MOR12-7	14	14	15	25	25	26	9	13	141
22	FRIN MOR12-30	24	27	28	27	20	24	14	16	180
23	FRIN MOR12-8	25	28	25	19	27	28	15	21	188
24	FRIN MOR12-1	18	26	24	20	26	25	27	23	189
25	FRIN MOR12-18	28	23	23	30	19	19	20	30	192
26	FRIN MOR12-2	27	24	26	31	18	9	30	29	194
27	FRIN MOR12-27	22	21	22	24	30	30	28	24	201
28	FRIN MOR12-19	26	30	29	22	23	21	24	28	203
29	FRIN MOR12-10	29	25	27	28	29	27	31	26	222
30	FRIN MOR12-21	30	29	30	26	31	31	22	27	226
31	FRIN MOR12-20	31	31	31	29	28	29	29	31	239

Tpod: Total pod, Tseeds: Total number of seeds, Syield: Seed yield, HSW: 100 seed weight, podwgt: Pod weight, secbr: Secondary branches, flbr: Flowering

from 2.77 seeds to 18.33 seeds, with a mean of 11.06 seeds. The best performing accessions are FMOR12-17 closely followed by FMOR12- 5 with 18.33 and 17.10 seeds, respectively.

The initial analysis of the accessions on the field brought out wide variation for all the 17 traits measured. This wide variation among the accessions can be ascribed to the different locations and sources of collection of the planting materials. Variation among the accessions had also been reported to result from genetic differences caused by the adaptation to diverse environmental conditions.[20] The observed variation in 100 seed weight in this result may partly be due to the different position of seed on mother plants or due to different environmental conditions to which the mother plants were subjected to during the growing season.[21] Earlier studies has reported variation among seed sources with respect to seed traits (length, width, thickness, and weight) in many forest species including *Faidherbia albida*,[22,23] *Acacia karroo*,[24] *Pinus roxbrughii*,[25] *Dalbergia melanoxylon*,[26] and *Celtis australis*,[27] A lower range of coefficients of variation (CV) usually implies low variability and it is an indication of uniformity among accessions. In this study, CV for all the characters evaluated had high values reflecting the existence of a high level of variability among the accessions suggesting their sensitivity to environmental factors as reported by[23] These patterns of high level differences or variability have been recorded by[13] in their study on 13 accession collected from Nigeria realized significant levels of intraspecific variations. Number of total seeds in this study is the most varied of the measured traits closely followed by seed yield and they gave negative variances and were regarded as zero following the suggestion by Chandra.[28] The negative variance had been attributed to the large differences among the data obtained from different replications of the trial.

Analysis of Variance

The results of the analysis of variance for the 17 traits evaluated are presented in Table 3. The mean squares for three of the characters surviving ability of the plant, PD, and seed/pod were significant at 95% level of probability ($P < 0.05$). Five traits DFF, DFFR, PL, plant height at MAE, and number of Sbr were highly significant at 99% level of probability ($P < 0.01$). The remaining nine characters did not reveal statistical difference among the accessions for the characters.

RSI

RSI on eight selected traits: Tpods, total number of seeds, the seed yield, 100 seed weight, PW, number of seeds per pod, Sbr, and Flbr is presented in Table 4, FRINMOR12-17, FRINMOR12-22, and FRINMOR12-6 ranked first, second, and third, respectively, with RSI of 17, 35, and 53, respectively, while FRINMOR12-20 ranked last with RSI of 239. Result from the RSI indicated that accessions FRINMOR12-17, FRINMOR12-22, and FRINMOR 12-6 from Kano, Sokoto, and Gombe states, respectively, all belonging to cluster 2 are the best materials in terms of Tpods, total number of seeds, the seed yield, 100 seed weight, PW, number of seeds per pod, secondary branches, and Flbr. These accessions are therefore considered the best potential materials for the improvement of *Moringa* in Nigeria

CONCLUSIONS AND RECOMMENDATIONS

M. oleifera has attracted several scholars resulting from diverse uses the different parts of the plant that has been subjected to which stretch from food and medicinal uses to water purification, bio-pesticide, and production of biodiesel. In this study, morphological traits have been used for evaluation of the variation among 31 accessions of drumstick. Data analysis results has shown the presence of wide genetic diversity among the accessions. The evaluation of the accessions using morphological traits depicted that the accessions possess sufficient genetic diversity and significant positive associations among most of the yield-related traits.

The computed RSI has ranked accessions FRINMOR12-17, FRINMOR12-22, and FRINMOR12-6 as superior materials with respect to Tpods, total number of seeds, the seed yield, hundred seed weight, PW, number of seeds per pod, Sbr, and Flbr and these can be used for further improvement on *Moringa* in Nigeria.

Recommendations from this Study are

1. Accessions FRINMOR12-14 and FRINMOR12-5 are recommended for superior performance relating to and number of seeds per pod, accession FRINMOR12-1 and FRINMOR12-9 had their first fruit earlier while accessions FRINMOR12-22 and FRINMOR12-17 performed best in yield-related traits
2. DFF and DFFR are the most varied traits and could be regarded as an important trait for evaluation in breeding program.

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