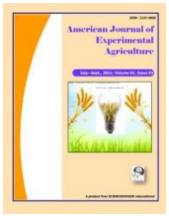

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Media Effects on Emergence and Growth of Moringa (*Moringa oleifera Lam*) Seedlings in the Nursery

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Authors' contributions

This work was carried out in collaboration between all authors. Authors UMN and KPB designed the study. Author UMN wrote the protocol and the first draft of the manuscript. Author UMN reviewed the experimental design and all drafts of the manuscript. Author AEE performed the statistical analysis. All the authors managed the analyses of the study, identified the plants, read and approved the final manuscript.

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ABSTRACT

This study was carried out in the Teaching and Research Farm of the Department of Crop Science, University of Nigeria, Nsukka to determine the effects of different sowing media on emergence and growth of moringa (*Moringa oleifera* Lam) seedlings in the nursery. The moringa seeds used for the study were collected from different parts of Nigeria; Nsukka (Eastern Nigeria), Ibadan (Western Nigeria) and Jos (Northern Nigeria). The sowing media were weathered sawdust (100%), top soil (100%), weathered sawdust plus cured poultry manure in the ratio of 2:1(volume by volume; v/v), and top soil plus cured poultry manure plus river sand in the ratio of 3:2:1(v/v/v). Perforated black polythene bags were used as potting media. The experiment was a 3 x 4 factorial trial in completely randomized design with three replications. The seeds sown in the 100% topsoil took average of 8.2

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and 9.0 days to have first and 50% seedling emergence. Weathered sawdust medium gave the highest mean percentage seedling emergence (84%) followed by the sawdust plus cured poultry manure (82%). The topsoil (control), 100% sawdust and weathered sawdust plus cured poultry manure had similar coefficient velocity of seedling emergence (11%). The topsoil medium (control) had the highest values of plant height and stem girth while sawdust plus poultry manure gave the highest number of leaves in the seedlings. There were no significant differences (P = .05) in the morphological traits of the seedlings in the different sowing media. The three accessions of *Moringa oleifera* also had no significant differences (P = .05) in their morphological growth. Sawdust and sawdust plus poultry manure encouraged early seedling emergence in moringa and sustained their growth in the nursery for four weeks. The media can, therefore, be used as good substitutes for topsoil in nursery establishment of crops with short nursery lives.

Keywords: Moringa; morphological growth; seedling emergence; sowing media.

1. INTRODUCTION

Moringa plants are easily established either by cuttings or seeds. Seeds are either sown directly in the field at the onset of the rainy season or planted in nurseries. Nursery operations involve raising seedlings in different media. Nursery potting media influence quality of seedlings produced thereof [1,2] which subsequently influences their establishment and productivity in the field [3]. The traditional nursery potting medium in Nigeria is topsoil dug from farmland and amended with poultry manure. Digging agricultural soils not only renders the land unproductive for cropping, but also makes it prone to erosion and other forms of degradation [4]. The quality of seedlings obtained is influenced by the composition of media used [5,6]. Ekwu and Mbah [6] reported on the relative importance of soiless media for growing potted ornamental plants in Nigeria. Baiyeri [7] evaluated three soiless media for weaning banana plantlets and showed that most of the genotypes produced vigorous seedlings when grown in rice hull (RH) composted with poultry manure (PM). Percentage germination, seedling emergence and growth in different sowing media are affected by the physical and chemical compositions of the media. Use of coarse materials in a sowing medium ensured greater aeration and drainage of the medium and also enhanced germination and seedling emergence [8].

Moringa is a fast-growing, deep-rooted dicotyledonous plant with tuberous taproot system. It is drought-tolerant and can thrive well in poor soils with little or no fertilization. There are 13 species of moringa which include *Moringa oleifera* Lam, *M. arborea* Verdc, *M. borziana* Mattei, *M. concanensis* Nimmo, *M. drouhardii* Jum, etc. *Moringa oleifera* is the most widely cultivated because of its high nutritional, medicinal, agricultural, domestic and environmental purposes. *Moringa oleifera* plants can be irrigated during the dry season but should not be water-logged to avoid root rot. The trees can grow up to a height of 15 m. The leaves are tri-pinnate, usually 25-60 cm long. The plants flower about three times a year and produce average of 17 tonnes of seeds/ha/annum in Nigeria [9]. The flowers are pollinated by bees. The seeds have very short dormancy period and can germinate promptly immediately after harvest. The seeds germinate within five to ten days of planting and the seedlings have short nursery life span (four to eight weeks) because of the fast growing nature of the plants [10]. The seeds lose their viability within one year of storage. Moringa can also be propagated using mature stem cuttings. The cuttings produce roots within two weeks of planting without any rooting hormone. The leaves are good sources of protein, minerals, vitamins, beta-carotene, amino acids and various phenolic compounds [11]. Moringa is widely cultivated in Nigeria. It is environmental-friendly because of its ability to absorb a lot of the atmospheric carbondioxide for its all-year-round leaf production (evergreen plant). It is a native of India but widely grown in parts of Afghanistan, Israel, Iran, Nepal, Bangladesh, China, Taiwan, Sri Lanka, Malaysia, Philippines, Thailand, Vietnam, Indonesia and Papua New Guinea [12]. Moringa plant does not perform well in intercrop with maize and cassava but can be used as alley crop in arable crop farming.

Some of the soiless materials used as sowing media, such as sawdust and rice husks, provide conducive environment for seed germination and seedling emergence as well as subsequent early seedling growth when mixed with manure [12]. High percentage seed loss has been observed in direct planting of moringa seeds in the field as many of them are destroyed by termites and

rodents [12]. There is, therefore, the need to plant moringa in the nursery before transplanting them to the field to reduce losses and ensure that healthy and vigorous seedlings are transplanted into the field. The objective of this study was to determine the effects of different sowing media on emergence and early growth of moringa seedlings in the nursery.

2. MATERIALS AND METHODS

2.1 The Experimental Site

The experiment was carried out in the Teaching and Research Farm of the Department of Crop Science, University of Nigeria, Nsukka. Nsukka, is located on latitude 06º 52'North, longitude 07º 24'East and altitude 447.26 meters above sea level (m.a.s.l). Rainfall distribution pattern in this region is bimodal with peaks in July and September and a short dry spell around mid-August. The soil of the experimental site is a reddish-brown clay loamy Ultisol (Oxicpaleustult) belonging to the Nsukka series. It consists of 78% sand, 14% clay and 8% silt. Nsukka has derived savanna vegetation with mean annual minimum and maximum temperatures of 25 and 32ºC respectively [13].

2.2 The Experimental Materials Used

The moringa seeds used for the study were collected from different parts of Nigeria; Nsukka (Eastern Nigeria), Ibadan (Western Nigeria) and Jos (Northern Nigeria) and they constituted the accessions. The sowing media were 100% weathered sawdust (SD), 100% top soil (TS), weathered sawdust (SD) plus cured poultry manure (PM) in the ratio of 2:1(volume by volume; v/v), and top soil plus cured poultry manure plus river sand (RS) in the ratio of 3:2:1(v/v/v). Perforated black polythene bags were used for potting the media.

2.3 Experimental Design and Cultural Practices in the Nursery

The experiment was a 3 x 4 factorial trial in completely randomized design with three replications. Seeds were collected from dry pods of the different moringa accessions and sown in the potted media at two centimeters depth. The seeds were unhulled (seed coat not removed) and not treated before planting. Ten seeds were planted per polythene bag. The nursery was not shaded but fenced round with one millimeter-mesh stainless wire gauze against rodents. The experiment was carried out during the dry season, so the plants were not rain-fed. The media were watered routinely every other day at the rate of 300 ml/pot. Weeding was done by hand rouging. There was no fertilizer or pesticide application throughout the nursery period.

2.4 Seedling Emergence and Morphological Data Collection

Seedling emergence was recorded daily when the first foliage leaf appeared. Percentage seedling emergence was determined using the formula:

$$E = \frac{Number\ of\ emerged\ seedlings}{total\ number\ of\ seeds\ planted} x \frac{100}{1}$$

Where %E = percentage seedling emergence
Coefficient velocity of seedling emergence (CVE) was calculated using Kotoski [14] formula stated as follows:

$$CVE = \frac{1}{N_1T_1 + N_1T_2 + \ldots N_xT_x} X \frac{100}{1}$$

Where N = Number of seeds emerging within the consecutive intervals of time. T = time between the beginning and end of a particular interval of measurement.

Days to first and 50% seedling emergence were recorded as the number of days from date of sowing to first and 50% seedling appearance.

The morphological growth parameters measured were plant height (cm), stem girth (cm) and number of leaves. The plant height was measured from the root/shoot junction to the shoot tip using a meter rule. The stem girth was determined by multiplying the stem diameter by 22/7 (π).

Stem Girth = Stem Diameter x 22/7 (π)

Number of the leaves produced was obtained by counting. All the morphological parameters were measured forth nightly for four weeks after planting.

2.5 Soil and Data Analyses

Physical and chemical properties of the sowing media were determined through laboratory analyses before sowing the seeds. Data collected were subjected to analysis of variance (ANOVA) according to Obi [15]. Table 1 shows the ANOVA Table used. The significant means were separated using Fisher's least significant difference (FLSD) at 5% probability.

Table 1. Analysis of variance (ANOVA) table used for data analysis

Sources of variation	General d.f	Specific d.f
Block	r - 1	3 – 1 = 2
Accessions (a)	a - 1	3 – 1 = 2
Media (m)	m - 1	4 – 1 = 3
a x m	(a – 1)(m - 1)	(3 -1)(4 - 1) = 6
Error	(am - 1)(r - 1)	(12 - 1)(3 - 1) = 22
Total	(amr - 1)	(3 x 4x 3) – 1 = 35

3. RESULTS AND DISCUSSION

3.1 Physical and Chemical Properties of the Sowing Media

The weathered sawdust plus poultry manure had the highest total porosity (71%) and the least bulk density (0.7 gm/cm^3). The 100% topsoil had the highest bulk density (1.6 g/cm^3) and least porosity (41%). The topsoil plus cured poultry manure plus river sand had the highest water holding capacity (35%) and the 100% weathered sawdust the least (28%). There were significant differences (P = .05) in the porosity of the different media (Table 2). The 100% sawdust and sawdust plus poultry manure had the highest organic carbon and organic matter contents (20% for organic carbon and 34 for organic matter each). The sawdust plus poultry manure had the highest values of total nitrogen (1.1%), potassium (0.5%), phosphorus (0.21) and pH in water (7.2) while the 100% topsoil had the least values of all the chemical properties except the total nitrogen content. There were significant differences (P = .05) in the chemical compositions of the sowing media except the pH values (both in water and KCl) as shown in Table 2.

3.2 Effects of Sowing Media and *Moringa oleifera* Accessions on Seedling Emergence

The seeds sown in the 100% topsoil took average of 8.2 and 9.0 days to have first and 50% seedling emergence while the seedlings in the topsoil plus poultry manure plus river sand emerged within five days (Table 3). Sawdust medium gave the highest mean percentage seedling emergence (84%) followed by sawdust plus poultry manure (82%). The topsoil (control), 100% sawdust and sawdust plus poultry manure had siimilar coefficient velocity of seedling emergence (11%). The topsoil plus poultry manure plus river sand gave the least values of both total percentage (16%) and coefficient velocity of seedling emergence (2.9%). There were significant differences (P = .05) in the total percentage and coefficient velocity of seedling emergence in the different media (Table 3). Seedlings of Nsukka accession emerged most promptly with the least average number of days to first and 50% emergence (6.2 and 6.8 days respectively). Jos accession had the highest percentage and coefficient velocity of emergence followed by Nsukka and Ibadan accessions respectively. There were significant differences (P = .05) in the total percentage and coefficient velocity of seedling emergence among the different accessions (Table 4). There were no significant accession by media interaction effects on seedling emergence, total percentage and coefficient velocity of emergence (Table 5).

3.3 Effects of Sowing Media and *Moringa oleifera* Accessions on Morphological Growth Traits

After four weeks of planting, the seedlings grown in 100% topsoil had the highest values of plant height and stem girth followed by those grown in 100% sawdust, sawdust plus poultry manure and topsoil plus poultry manure plus river sand in that order. Sawdust plus poultry manure gave the highest number of leaves in the seedlings while the mixture of topsoil, poultry manure and river sand gave the least. There were no significant differences (P = .05) in the morphological traits of the seedlings in the different sowing media (Table 6). The Nsukka accession gave the highest plant height values in the second and fourth week of planting while the Jos accession had the highest stem girth values at both periods of growth. The Ibadan accession had the least values of all the morphological growth traits at both periods. However, there were no significant differences (P = .05) in the growth traits of the seedlings of the three accessions all through the period of observation (Table 7). The accession by media interaction effects on the morphological growth traits were also not significant (Table 8).

Table 2. Physical and chemical properties of media used for raising *Moringa oleifera* seedlings in the nursery at University of Nigeria, Nsukka

Properties	Potting media			
	100% SD	2:1SD plus PM	100% (TS)	3:2:1TS plus PM Plus RS
Physical				
Total porosity (%)	70	71	41	47
Water holding capacity (%)	28	31	31	35
Bulk density (g/cm^3)	0.8	0.7	1.6	1.4
Chemical				
Organic carbon (%)	20	20	1.2	2.2
Organic matter (%)	35	35	2.0	3.7
Total nitrogen (%)	0.14	1.121	0.084	0.07
Potassium (%)	0.239	0.523	0.08	0.08
Phosphorus (%)	0.09	0.21	0.0029	0.0117
pH (H_2O)	6.7	7.2	6.2	6.8
pH (Kcl)	5.8	6.5	5.0	6.6

100% SD = Sawdust alone, SD plus PM = Sawdust plus poultry manure, TS plus PM plus RS = Topsoil plus poultry manure plus River sand, 100% TS = Topsoil alone

Table 3. Effects of media on the seedling emergence of *Moringa oleifera* plant in the nursery at University of Nigeria, Nsukka

Media	DE_1	DE_{50}	PE(%)	CVE(%)
TS	8.2	9.0	73	11
SD	8.0	8.4	84	11
SD plus PM	7.8	8.2	82	11
TS plus RS plus PM	5.1	5.1	8.9	4.2
$LSD_{(.05)}$	1.2	1.3	16	2.9

DE_1 = Days to first seedling emergence, DE_{50} = Days to 50% seedling emergence, PE = Percentage seedling emergence, CVE = Coefficient velocity of emergence, TS = Top soil, SD = Sawdust, PM = Poultry manure, RS = River sand, ns = Not significant, $LSD_{(.05)}$ = Least significant difference at 5% probability level

Table 4. Effects of accessions of *Moringa oleifera* on seedling emergence in the nursery at University of Nigeria, Nsukka

Accession	DE_1	DE_{50}	PE(%)	CVE(%)
Nsukka	6.2	6.8	68	10
Jos	7.9	8.2	70	10
Ibadan	7.8	8.2	48	8.3
$LSD_{(.05)}$	.2	.3	14	2.5

DE_1 = Days to first seedling emergence, DE_{50} = Days to 50% seedling emergence, PE = Percentage seedling emergence, CVE = Coefficient velocity of emergence, ns = Not significant, $LSD_{(.05)}$ = Least significance different at 5% probability level

Lower bulk densities and higher porosity of the 100% sawdust and the sawdust plus poultry manure (soiless) media might have aided prompt and higher coefficient velocity of emergence of the seedlings. Though the seedlings emerged most promptly in the topsoil plus poultry manure plus river sand medium, least percentage emergence and coefficient velocity of emergence were obtained in the medium. This was probably the reason for the poor morphological (vegetative) growth of the seedlings in the medium. The seedlings had relatively higher percentage and coefficient velocity of emergence in the 100% sawdust and sawdust plus poultry manure compared to the other media. The two soiless media also compared favorably with the topsoil medium (control) in promoting early nursery growth of the seedlings. All these attributes qualify the sawdust and sawdust plus poultry as good growth media for crop seedlings with short nursery lives. The sawdust and sawdust plus poultry manure media compared favorably with the control in terms of the plant height, stem girth and number of leaves probably because they contained reasonable amounts of organic matter, nitrogen, phosphorus and potassium. Ekwu and Mbah [13] reported the relative importance of soiless media for growing potted ornamental plants in Nigeria. In Nigeria, sawdust is regarded as waste from carpenters'

workshops and is often times burnt. Use of sawdust as nursery potting medium is a score in organic agriculture as a means of converting organic waste to useful agricultural material. It also reduces air pollution caused by smoke and greenhouse gases released in the process of burning, which deplete the ozone layer and result to global warming. The non-accessional differences obtained in the emergence and morphological growth of the seedlings suggest relative homogeneity in the genetic compositions of the seeds.

Table 5. Effects of accession by media interaction on moringa seedling emergence, total percentage and coefficient velocity of emergence at University of Nigeria, Nsukka

Accession	Media	DE_1	DE_{50}	PE (%)	CVE (%)
Nsukka	TS	7.7	8.7	80	11
	SD	7.3	8.0	100	12
	SD + PM	7.0	7.7	87	12
	TS + RS + PM	2.7	2.7	6.7	4.2
	Mean	6.2	6.2	68	10
Jos	TS	8.0	8.7	93	11
	SD	8.0	8.3	87	12
	SD + PM	7.7	7.7	87	12
	TS + RS + PM	8.0	8.0	13	5.9
	Mean	7.9	8.2	70	10
Ibadan	TS	9.0	9.7	47	10
	SD	8.7	9.0	67	11
	SD + PM	8.7	9.3	73	9.8
	TS + RS + PM	4.7	4.7	6.7	2.4
	Mean	7.8	8.2	48	8.3
$FLSD_{.05}$ for two media (M) means		1.2	1.3	16	2.9
$FLSD_{.05}$ for two accessions (A) means		.2	.3	14	2.5
$FLSD_{.05}$ for two interaction (M x A) means		1.3	1.3	28	5.1

Table 6. Effects of media on morphological growth traits of *Moringa oleifera* at two and four weeks after planting in the nursery at University of Nigeria, Nsukka

Media	2 WAP			4 WAP		
	PHT(cm)	SG(cm)	NL	PHT(cm)	SG(cm)	NL
TS	7.9	0.71	3.7	14	0.95	6.0
SD	6.8	0.69	3.8	9.1	0.8	6.0
SD plus PM	6.1	0.60	3.9	10	0.81	6.4
TS plus RS plus PM	4.0	0.31	1.8	12	0.79	3.7
$LSD_{(.05)}$	1.1	.23	1.4	1.4	.54	2.8

TS = Topsoil, SD = Sawdust, SD plus PM = Sawdust plus poultry manure, TS plus RS plus PM = Topsoil plus River sand plus poultry manure, PHT = plant height, SG = stem girth, NL = Number of leaves, $LSD_{(.05)}$ = least significant difference at 5% probability level, ns = Not significant

Table 7. Effects of accessions on morphological growth traits of *Moringa oleifera* plants at two and four weeks after planting in the nursery at University of Nigeria, Nsukka

Accession	2 WAP			4 WAP		
	PHT(cm)	SG(cm)	NL	PHT(cm)	SG(cm)	NL
Nsukka	6.9	0.61	3.7	13	0.93	6.0
Jos	6.3	0.62	3.7	12	0.97	6.4
Ibadan	5.0	0.51	2.5	8.2	0.67	5.3
$LSD_{(.05)}$	1.4	.12	.58	2.3	.26	1.3

PHT = Plant height, SG = Stem girth, NL = Number of leaves, $LSD_{(.05)}$ = Least significant difference at 5% probability level, ns = not significant

Table 8. Accession by media interaction effects on morphological growth traits of *Moringa oleifera* at two and four weeks after planting

Accession		2 WAP			4WAP		
	Media	**PHT**	**SG**	**NL**	**PHT**	**SG**	**NL**
Nsukka	TS	8.3	0.72	4.0	15	1.03	8.7
	SD	7.9	0.71	4.0	11	0.79	5.7
	SD + PM	7.9	0.76	5.3	13	1.03	7.3
	TS + RS + PM	3.4	0.23	1.3	14	0.89	3.7
	Mean	4.2	0.61	3.7	11	0.94	6.3
Jos	TS	7.1	0.71	4.0	14	1.0	7.3
	SD	6.0	0.69	4.0	8.3	0.81	5.3
	SD + PM	6.7	0.62	4.0	12	0.85	7.7
	TS + RS + PM	5.4	0.47	2.7	15	1.2	5.3
	Mean	6.3	0.63	7.7	12	0.98	6.4
Ibadan	TS	6.7	0.70	3.0	14	0.81	8.0
	SD	6.5	0.68	3.3	8.4	0.82	7.0
	SD + PM	3.7	0.42	3.3	6.5	0.55	4.3
	TS + RS + PM	3.1	0.23	1.3	4.2	0.26	2.0
	Mean	5.0	0.51	2.8	8.2	0.61	5.3
$FLSD_{.05}$ for two media (M) means		1.1	0.23	1.4	1.4	.54	2.8
$FLSD_{.05}$ for two accessions (A) means		1.4	.12	.58	2.3	.26	1.3
$FLSD_{.05}$ for two interaction (M x A) means		2.2	.26	.89	3.2	.36	2.4

4. CONCLUSION

Weathered sawdust and sawdust plus poultry manure gave the highest total percentage emergence and compared favorably with the topsoil medium (control) in terms of coefficient velocity of seedling emergence, plant height, stem girth and number of leaves. They can, therefore, be used as suitable alternatives to topsoil for raising crop seedlings with short nursery life spans.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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