Assessment of Drumstick Tree (M. deifera)
Accessions for Genetic Diversity in the Southern guinea Region of Nigeria

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Abstract—An experiment was conducted to analyze the genetic diversity among 9 drumstick tree (Moringa oleifera) accessions in the Teaching and Research Farm of the University of Agriculture Makurdi. The experiment was laid out in a Randomized Complete Block Design (RCBD) replicated three times. Data were recorded on growth and yield characteristics before and after pruning. The result obtained showed that at 18 weeks after transplanting, accession UAM-NI had the tallest plants (3.63m) while UAM-BE had the shortest mean plant height (2.84m) under no pruning. Other parameters that showed significant differences were number of leaves per tree and stem diameter. Although accession UAM-OY recorded highest fresh (220.22g), dry (113.42g) and leaf powder (82.60g) weights, it was not significantly different from other accessions. However, at 18 weeks after pruning, there was a significant difference among the accessions with regard to leaf length. Although accession UAM-NA recorded highest fresh leaf weight (286.60g), dry leaf weight (90.67g) and leaf powder weight (85.60g), it was not statistically different from other accessions. For the pruned accessions, significant differences were recorded in leaf length, number of flowers/tree, days to podding and fifty percent podding, pod length, pod girth, pod weight, number of seeds/pod, number of seeds/tree and 100 seed weight. The result also indicated that the pruned accessions recorded higher leaf yield than the unpruned. The result of the cluster analysis grouped the accessions into two clusters and an outlier both for the pruned and unpruned accessions irrespective of area of collection.

Keywords—Drumstick, accession, cluster, pruned, unpruned, outlier.

I. INTRODUCTION

Drumstick (Moringa oleifera L.) is believed to have originated from Northern India and has been distributed worldwide in the tropics and sub-tropics (Olson, 2002). It is one of the thirteen species belonging to the family moringaceae with only one genus, moringa. In West Africa, the family is represented by 10 species while in Nigeria, the plant is represented by the only species of Moringa oleifera (Keay, 1989). Drumstick (Moringa oleifera) is commonly named horse-radish tree, drumstick tree, mothers best friend, Indian ben among others. It is a fast growing drought resistant tree that is widely adaptable to the tropics and subtropics (Olson, 2002). Its fast growing attributes coupled with its ability to grow on marginal soils has particularly made drumstick an invaluable vegetable and fodder crop especially during the dry season (Price, 2007; Rajangam et al., 2001; Foidl et al., 2001). Moringa oleifera is considered one of the world’s most useful trees as almost every part of the plant is useful in one way or the other. It is a multipurpose plant with a tremendous variety of potential uses and recently attracted the attention of several authors (Abubakare et al., 2011). Thus Moringa oleifera could be useful in alley farming, animal forage, vegetable, biogas, dye, medicinal, water purification, edible oil (Foidl et al., 2001, Rajangam et al., 2001). The leaf of this plant is known to be rich in micro-nutrients and vitamins such as zinc, iron and vitamin A and thus, has been used in the treatment of malnutrition in children and in the improvement of the diets of lactating mothers in some African countries. The oil extracted from the seeds is used in lubricating delicate machines, cosmetics, perfume and pharmaceutical industries. Foidl et al., (2001) has reported on the possibility of using the ben oil as a biofuel considering the high cost of crude oil in the international market. However, in the aspect of water purification, Aho and Agumba (2010), Foidl et al. (2001) had
reported that up to 99% of colloids can be removed from dirty (turbid) water and works more effectively than the imported alum (aluminiumsulphate). It has been documented that the drumstick plant have a lot of pharmaceutical properties for the control of terminal ailments such as high blood pressure, diabetes, typhoid, rheumatism and asthma due to the presence of antioxidants (Rajangam et al., 2001; Foidl et al., 2001).

However, despite the numerous economic significance of this crop, there is no evidence that it has benefited from adequate research and agronomic management attention that would promote its cultivation among the local farmers for increase yield. At present, its production in Nigeria is still in the hands of peasant farmers who cultivate it in home gardens and the few accessions under cultivation in Nigeria have not been fully characterized. Therefore, to wean its production from hands of the resource-poor farmers and integrate it into the commercial scale agriculture, knowledge of the extent of genetic variability in the population and the magnitude of genetic diversity in the accessions is extremely important. Similarly, Christopher (2010) had earlier reported that moringa trees should be trimmed in order to promote branching, increase yield and facilitates harvesting. If left to grow without pruning, the plants will grow straight and tall producing leaves and pods only on the primary stem. According to Palada and Chang (2003), pinching of drumstick trees at 1.0 – 2.0m height enhances production, controlled tree height and takes only three (3) weeks for the tree to be ready for a leaf harvest after the pruning. Thus, the present study was aimed at assessing the yield (leaf) performance of the moringa accessions under pruned and unpruned in order to ascertain the degree of similarity among the different accessions so as to establish their breeding potentials.

II. MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research Farm of the Federal University of Agriculture Makurdi, Benue State. Makurdi is located on latitude 07º 41’N, Longitude 08º 37’E and altitude of 106.4 m above sea level. The experiment consisted of 9 accessions of drumstick seeds collected from different states of the country including Nasarawa, Benue, Kogi, Oyo, Kebbi, Niger, Adamawa, Abuja and Akwa-Ibom States. For the sake of identification, acronyms were used (Table 1).

The treatments were laid out in a Randomize Complete Block Design (RCBD) with three replicates in a 3m x 3m spacing as described by Patricio et al.(2011). Six weeks old seedlings were transplanted to the field according to Palada and Chang(2003). Data were taken from two plants randomly selected and tagged in each plot on a weekly basis as follows.

**Plant height (cm):** Heights of two plants from each plot randomly selected were measured with a measuring tape from the base of the plant at soil level to the apical tip.

**Number of branches/plant:** These were taken by counting the number of branches in the selected plants on weekly bases.

**Stem diameter (cm):** The stems of the selected plants were measured at soil level using verniercalliper on weekly bases.

**Number of leaves/plant:** The numbers of leaves of selected plants were counted on weekly bases.

**Leaf Length (cm):** Lengths of the leaves selected on each plot were measured and the means were determined in centimeter on weekly bases.

**Forty percent (40%)** of total number of leaves on each selected plant were harvested at 18 weeks after transplanting and pruning respectively as described by Freer,(2006) and the fresh, dried and leaf powder weights were recorded. Pods were equally harvested from the selected plants as they dried and turned brown.

After trimming the trees at 2m height, data were equally collected on number of branches/tree, stem diameter, number of leaves/tree, leaf length, number of flowers/tree, number of pods/tree, pod length, pod girth, pod weight,

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**Table 1:** Locations of M. oleifera accessions collected for yield performance

| S/No | Accession Code | State | Location | Latitude | Longitude |
|------|----------------|-------|----------|----------|-----------|
| 1    | UAM-NA         | Nasarawa | Kolo     | 8º 48’ N | 7º 33’ E  |
| 2    | UAM-BE         | Benue   | Makurdi  | 7º 41’ N | 8º 37’ E  |
| 3    | UAM-KO         | Kogi    | Ankpa    | 7º 30’ N | 6º 42’ E  |
| 4    | UAM-OY         | Oyo     | Idere    | 7º 23’ N | 3º 55’ E  |
| 5    | UAM-NI         | Niger   | Kontagora| 10º 24’ N| 5º 28’ E  |
| 6    | UAM-KE         | Kebbi   | Zuru     | 11º 26’ N| 5º 13’ E  |
| 7    | UAM-AD         | Adamawa | Yola     | 9º 14’ N | 12º 18’ E |
| 8    | UAM-AB         | Abuja   | Kuje     | 9º 28’ N | 7º 25’ E  |
| 9    | UAM-AK         | Akwalbom| Uyo      | 5º 05’ N | 7º 39’ E  |
number of seeds/pod, number of seeds/tree and 100-seed weight.
The data collected were subjected to Analysis of variance (ANOVA) and Duncan Multiple Range Test (DMRT) was used to separate between significant treatments means (Singh and Chaudhary, 1979). Test of significance was at 5% probability level. Cluster Analysis was also computed according to Singh and Chaudhary (1979) using SAS 2000.

III. RESULTS AND DISCUSSION
Choice of parents for developing base population is a crucial step in plant breeding since it largely predetermines the outcome of subsequent selection steps in breeding programmes. The analysis of genetic diversity and the relationships among germplasm therefore, facilitates the selection of parents with diverse genetic background (Subramanian and Subbaraman, 2010). The result of this study showed that significant variations exists among the accessions in many of the characters studied. For the unprune, accessions, UAM-NI produced the tallest (3.63m) plants while UAM-BE(2.84m) produced the least. Accession UAM-OY recorded the highest (96) number of leaves/tree as UAM-NA had the least (37). On number of branches/tree, Accession UAM-OY recorded the highest (12.33) as the least (4) was recorded by UAM-NA. Other parameters which equally exhibited significant differences were stem diameter, days to flowering and days to fifty percent flowering (Table2). The result of the scatter plot analysis for the unpruned drumstick accessions therefore, classified the nine accessions into two broad groups, cluster I and cluster II and an outlier with distinct genetic potentials (Figure 1). The result further revealed that cluster I comprised of two accessions, UAM-NI and UAM-KE while cluster II consisted of six accessions including UAM-AK, UAM-AD, UAM-AB, UAM-KO, UAM-BE and UAM-NA (Figure 1) while the outlier, UAM-OY alienated from the other accessions because of its genetic dissimilarity and uniqueness. The accessions in cluster I are characterized by tall plants and highly profused branching habit which also translated into higher number of leaves per tree (71) as indicated by cluster mean (Table 3). However, cluster II comprised of accessions that had intermediate performances while the outlier was quite unique, indicating its distinct identity. It is comparatively short, and also gave the least number of branches and leaves. Consequently, it recorded the least fresh, dry and leaf powder weights.
Eighteen weeks (18weeks) after pruning, the result of the study showed that accession UAM-BE (66.07cm) recorded the longest leaf lengths while UAM-AB recorded the least(41.13cm). On number of flowers/ tree, accession UAM-OY had the highest(350) UAM-KO had the least(91).Similarly, accession UAM-OY recorded the least number of days(189days and 206days) to podding and fifty percent podding respectively. Other parameters which exhibited significant differences were pod length, pod girth, pod weight, number of seeds/pod, number of seeds/tree and 100-seed (Table4). The result also revealed that the pattern of grouping of the accessions were similar to that observed in the unpruned data. The cluster analysis revealed that the 9 accessions were classified into two clusters, I and II and an outlier with the same members both in number and in kind. The cluster mean (Table 4) showed that cluster I was characterized by least number of leaves and branches, least values for fresh, dry and leaf powder weights were also obtained in this cluster. Cluster II showed intermediate performances in the characters studied while the outlier (UAM-OY) produced the highest number of leaves, highly branched and consequently produced the highest fresh, dry and leaf powder weights contrary to when it was unpruned. On the general note, the accessions exhibited increased in fresh, dry and leaf powder weights pruned (Table 4 ) than unpruned (Table 2). This finding supports the report of Palada and Chang (2003) who reported that trimming of drumstick trees promotes branching and increases leaf yield. However, the data for the unpruned and the pruned drumstick accessions were pooled together, but the clustering pattern was still consistent for the unpruned, pruned and when these results were pooled together. In all these situations, accession UAM-OY (outlier) from Oyo State maintained its distinctiveness and uniqueness. However, the clustering of two accessions UAM-NI from Niger State (guinea savanna) and UAM-KE from Kebbi State (sahel agro-ecological zone) into cluster I is indicative of the fact that regional boundary was not a criteria for genotype differentiation (Figure 1). Similarly, the accessions comprised in cluster II were also collected from across different agro-climatic areas. For instance, UAM-AK from Akwa-Ibom State in the rainforest zone, UAM-AB from Federal Capital Territory Abuja, UAM-KO from Kogi State, UAM-BE from Benue State and UAM-NA from Nasarawa State in the guinea savanna zone, UAM-AD from Adamawa State in the sudan savanna zone. Thus, it is evident that clustering of accessions was based on similarity irrespective of their place of collection; Hence, regional boundary was not a criterion for genotype differentiation. This result agrees with the report of Thulet et al. (2009) who reported four clusters and two outliers from...
a collection of Capsicum species studied irrespective of area of collection

Abubakaret al. (2011) also reported six clusters from the 21 accessions of Moringaoleifera studied irrespective of where the accessions were collected. This appears to mean that factors other than regional boundaries are responsible for divergence in drumstick trees studied. Thus, the growth and vegetative characters differentiated the accessions into different groups from which superior hybrids can be derived. Based on the level of divergence among the clusters as revealed by the scatter plot analysis and mean cluster distance, cluster II and the outlier are highly dissimilar, suggesting that accessions from these two groups could be evaluated for their combining ability for possible utilization as parents in the heterosis breeding programme in drumstick as suggested in maize (Betran et al., 2003) and Brassica (Mahmuda et al., 2008) crops.

Table.2: Performance of some vegetative and phenological characters of unpruned Moringa accessions evaluated in Makurdi.

Means within column followed by same letter are not significantly different by Duncan at 5%.

| TRAITS             | UAM-NA | UAM-BE | UAM-KO | UAM-OY | UAM-NI | UAM-KE | UAM-AD | UAM-AB | UAM-AK | MEAN  |
|--------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|
| Plant height (cm)  | 3.11abc| 2.84c  | 3.19abc| 3.60a  | 3.63a  | 3.54ab | 3.30abc| 3.02bc | 3.15abc| 3.26  |
| Number of leaves   | 37c    | 44c    | 46bc   | 96a    | 60bc   | 81ba   | 50bc   | 56bc   | 57bc   | 58.55 |
| Number of branches | 4c     | 6.33bc | 7.17bc | 12.33a | 8.33abc| 10.00ab| 6.00bc | 7.66bc | 8.00bc | 7.76  |
| Leaf length (cm)   | 74.10  | 76.27  | 74.60  | 76.73  | 70.07  | 72.67  | 67.67  | 72.50  | 62.57  | 71.91 |
| Stem diameter(cm)  | 21.17ab| 19.07bc| 17.60bc| 12.33a | 8.33abc| 10.00ab| 6.00bc | 7.66bc | 8.00bc | 7.76  |
| Fresh leaf weight (g)| 118.10| 121.60 | 134.85 | 220.22 | 157.17 | 162.90 | 133.37 | 135.48 | 146.33 |
| Dry leaf weight (g) | 52.25  | 53.78  | 56.53  | 113.42 | 74.70  | 77.02  | 59.70  | 66.42  | 62.97  | 68.53 |
| Leaf powder weight (g)| 40.22| 41.70  | 45.70  | 82.60  | 53.25  | 54.25  | 43.03  | 44.28  | 46.12  | 50.13 |
| Days to flowering  | 152c   | 176a   | 179a   | 151c   | 153c   | 147c   | 159bc  | 154c   | 168ab  | 159.89|
| Days to 50% flowering | 157bc | 177a   | 180a   | 152c   | 155bc  | 148c   | 161bc  | 157bc  | 169ab  | 161.78|

Table.3: Cluster means for unpruned M. oleifera accessions evaluated in Makurdi in 2012.

| Trait                  | Cluster I   | Cluster II  | Outlier |
|------------------------|-------------|-------------|---------|
| Plant height (cm)      | 3.59        | 3.17cm      | 3.11    |
| Number of leaves per plant | 71.0       | 55.0        | 37.0    |
| Number of branches per plant | 9.0        | 7.0         | 4.0     |
| Leaf length (cm)       | 71.37       | 72.06       | 74.0    |
| Stem diameter (cm)     | 18.50       | 19.22       | 21.17   |
| Fresh leaf weight (g)  | 160.04      | 142.41      | 118.10  |
| Dry leaf weight (g)    | 75.86       | 66.44       | 52.25   |
| Leaf powder weight (g) | 53.75       | 49.09       | 40.22   |
| Days to flowering      | 150.0       | 163.0       | 152.0   |
| Days to 50% flowering  | 152.0       | 165.0       | 157.0   |

Table.4. Performance of some vegetative and phenological characters of pruned Moringa accessions evaluated in Makurdi
Table 4: Performance of some vegetative and phenological characters of pruned Moringa accessions evaluated in Makurdi

| Parameters                        | UAM-NA | UAM-BE | UAM-KO | UAM-OY | UAM-NI | UAM-KE | UAM-AD | UAM-AB | UAM-AK | Mean  |
|----------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|
| Number of branches/tree          | 24     | 21     | 17     | 27     | 16     | 20     | 19     | 22     | 21     | 20.78 |
| Number of leaves/tree            | 183    | 136    | 136    | 200    | 113    | 135    | 160    | 152    | 150    | 151.67|
| Stem diameter (cm)               | 36.87  | 34.47  | 32.97  | 39.10  | 32.37  | 34.20  | 31.07  | 32.77  | 33.27  | 34.12 |
| Leaf length (cm)                 | 45.23  | 66.07a | 52.50b | 52.07b | 44.00bc| 44.57bc| 42.30bc| 41.13c | 47.17bc| 48.34 |
| Fresh leaf weight/tree (g)       | 286.60 | 253.11 | 177.60 | 216.27 | 114.27 | 115.10 | 184.63 | 222.43 | 188.00 | 195.33|
| Dry leaf weight/tree (g)         | 90.67  | 82.93  | 67.60  | 70.80  | 36.73  | 42.67  | 64.53  | 73.10  | 68.32  | 66.38 |
| Leaf powder weight (g)           | 85.60  | 78.33  | 50.07  | 65.13  | 25.17  | 39.37  | 53.13  | 68.43  | 54.6   | 57.77 |
| Number of flowers/tree           | 279abc | 197abcd| 91d    | 350a   | 197abcd| 316ab  | 191abcd| 160bcd | 120cd  | 211.22|
| Days to podding                  | 250ab  | 274a   | 282a   | 189c   | 206c   | 193c   | 225bc  | 203c   | 283a   | 233.89|

NOB=Number of branches/tree, NOL=Number of leaves/tree, STD=Stem diameter (cm), LLGT=leaf length (cm), FLW/T=Fresh leaf weight/tree (g), DLW/T=Dry leaf weight/tree (g), LPW/T=Leaf powder weight/tree (g), NFL/T=Number of flowers/tree, DPD=Days to podding, D50%P=Days to 50% podding, NPD/T=Number of pods/tree, PDL=Pod length (cm), PDG=Pod girth (cm), PDW=Pod weight (g), NS/PD=Number of seeds/pod, NS/T=Number of seeds/tree, 100-SD=100-seed weight (g).
Means within row followed by same letter are not significantly different by Duncan at 5%.

Table 5: Cluster means of pruned Nine Moringa oleifera accessions evaluated in Makurdi in 2013.

| Trait                          | Cluster I | Cluster II | Outlier |
|-------------------------------|-----------|------------|---------|
| Number of branches per tree   | 18.0      | 22.0       | 27.0    |
| Number of leaves per tree     | 124.0     | 160.0      | 200.0   |
| Stem diameter (cm)             | 33.29     | 34.36      | 39.10   |
| Leaf length (cm)               | 44.29     | 49.50      | 52.07   |
| Fresh leaf weight (g)          | 114.69    | 189.80     | 216.27  |
| Dry leaf weight (g)            | 39.70     | 74.0       | 70.80   |
| Leaf powder weight (g)         | 32.27     | 65.05      | 65.13   |
| Number of flowers per tree     | 257.0     | 198.0      | 350.0   |
| Days to first podding          | 200.0     | 244.0      | 189.0   |
| Days to 50% podding            | 211.0     | 256.0      | 206.0   |
| Number of pods per tree        | 73.0      | 55.0       | 88.0    |
| Pod length (cm)                | 33.54     | 30.84      | 34.80   |
| Pod girth (cm)                 | 5.87      | 5.22       | 3.56    |
| Pod weight (g)                 | 12.44     | 8.79       | 11.78   |
| Number of seeds per pod        | 13.0      | 10.0       | 13.0    |
| Number of seeds per tree       | 924.0     | 600.0      | 1329    |
| 100-seed weight (g)            | 25.65     | 23.11      | 23.09   |

Fig. 1: Scatter plot analysis for pruned Moringa oleifera accessions evaluated in Makurdi.
IV. CONCLUSION

This study indicated that there is sufficient variability in the studied population to warrant the commencement of genetic improvement of drumstick through selection as revealed by the diversity analysis. It was also observed that the pruned accessions recorded higher fresh, dry and leaf powder weights than unpruned, with accession UAM-OY (outlier) expressing superiority over other accessions with regards to the fresh, dry and leaf powder weights and in most of the phenological characters studied.

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