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# Fodder Leaves and Wood Mass Productivity Assessment of *Moringa oleifera* in Semi-arid Central India

**P. N. Dwivedi[1], P. K. Pathak[2], S.K. Singh[2] and Amit Kumar Patil[3*]**

***[1]ICAR- Indian Grassland and Fodder Research Institute, Jhansi 284 003, U.P., India***

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**ABSTRACT**

Good quality feed resources are very important component to achieve the production potential from livestock business. Supplementation of protein rich fodder tree leaves or its leaf meal could be a potential alternative for increasing the quality of livestock diet. A study was conducted to assess *Moringa* foliage plantation with respect to leaves and wood leaves and wood production per unit area to quantify precise biomass production. The relationship between plant base diameter to leaf biomass and wood mass yield were established and observed high correlation coefficients ($R^2$) ranges from 0.80 to 0.87. Mean fodder leaves yield of 227q/ha, woodmass yield of 984q /ha with leaf stem ratio of 18.8:81.2 were observed on fresh harvesting basis. Dried leaf and wood mass production were recorded 66q/ha and 659 q/ha, respectively. The crude protein yield from Moringa leaves was assessed as 12.9 q on dry matter basis from one hectare Moringa field. A process methodology has also been developed for the preparation of Moringa leaf meal.

***Key words:*** *Biomass,Leaf meal, Moringa, Productivity, Tree leaves, Wood mass*

## Introduction

Low quality feed is one of the limiting factors in productivity of ruminants which can hardly meet the maintenance requirement of these animals. The non-availability of green fodder in dry period is well known and farmers fed their animals with crop residues and hay which are having high lignocelluloses and low in protein, minerals and vitamins. These feed resources cannot provide required level of nutrients to the animals and resulting poor growth, poor reproductive performance and low milk yield (Gebregiorgis *et al.,* 2012). In another study Farmers fed green and dry fodder to the milch animals, however, majority did not supply the green fodder and concentrate in required quantity (Satbir Singh and Bharat Singh, 2020). The non-availability and high price of concentrate particularly of protein sources is a serious concern faced by livestock sector. It was observed that depending on the feeding management there was a difference in milk yield obtained (Sharma *et al.* 2020). Supplementation of protein rich fodder tree leaves or its leaf meal is a potential alternative for increasing the quality of livestock diet and achieve their potential productivity during dry period, Forage trees are an important part of agroforestry systems, especially when it comes to livestock fodder and fuel wood production. In comparison to agricultural annual fodder crops, tree species are easier to establish and maintain at later

([1]Principal Scientist (Animal Nutrition), [2]Principal Scientist (Agri. Structure & Process Engineering), [3]Scientist (Farm Machinery and Power)

stages since they require less post planting care and protection. Forage trees are capable of generating more foliage with high levels of digestible protein and other vital elements in their leaves, allowing them to provide high-quality biomass for cattle (Nouman *et al.,* 2013).

*Moringa oleifera* belonging to the family Moringaceae is a softwood tree, native of India occurring wild in the sub Himalayan region of north India and now grown wide in the topics and sub topics (Ramachandran *et al.*, 1980). The moringa tree belongs to the Moringaceae family and can reach a height of 10 metres with a trunk diameter of 20 to 40 centimetres (Kautkar *et al.,* 2020). Moringa is also known as a fast growing tree, draught tolerant, easily adapted to varied ecosystem and farming system. Leaf meal is good source of protein, vitamins and minerals and can be stored safely (Dwivedi and Pathak, 2010). Improved processing especially drying methods can play a significant role for enhancing shelf life and nutrients availability of these products. (Singh *et al.,* 2022 and Singh *et al.,* 2017). Sun drying leads to considerable reduction of drying time and maintains product quality in terms of color, flavor and nutrient retention.

Moringa foliage has been evaluated to a limited degree in terms of its potential to provide tree leaves and wood biomass productivity per unit land, thus limiting the precise quantification of biomass production.Some allometric equations for large trees to predict above ground biomass are available (Brown *et al.*, 1989; Chave *et al.*, 2005, and 2014) but, Species-specific equations for shrubs and small trees are relatively scarce (Ali *et al.,* 2015). Therefore, a study was undertaken to establish the relationships between leaf, wood and biomass yield with respect to plant base diameter and to assess the productivity potential for leaf meal and woodmass out of Moringa plants.

## Materials and Methods

A leaf meal block consist of *Moringa oleifera* and *Leucaena leucocephala* was established at central research farm at ICAR-Indian Grassland and Fodder Research Institute, Jhansi , India which is situated at 25° 27′ N, 78° 37′ E at an altitude of 275m above mean sea level. The climate is dry tropical with an annual rainfall of 880mm of which 90% falls between June-September. Mean maximum and mean minimum temperatures are 32.5 °C and 17.7 °C with as high as 48 °C and as low as 1.5 °C.

Five years old regenerated Moringa tree area of leaf meal block was investigated to assess the production of bio-mass, leaf and wood per hectare. Potential for production of leaf meal and wood mass out of Moringa plants was determined. Relationships between leaf, wood and biomass yield with plant base diameter were established. In leaf meal block six plots consist of moringa trees were identified randomly. Thirty Moringa plants in November (onset of winter) were randomly selected from these six plots, five trees from each plot and harvested for physical measurements of diameter and leaf, wood and total biomass of the plants. In this study the Moringa plantation was not irrigated artificially, and no fertilizers or pesticides were used.Branches of Moringa trees were harvested at breast height using serrated sickle and spread over threshing floor for picking the leaves from plants. Regenerated branches of Moringa plants were harvested at breast height for obtaining fodder leaves, so as to get fodder every year without destroying the plants from root level.

Leaf biomass was measured using weighing balance. Wood mass was measured after separating the leaves along with petiole from the harvested branches. Number of plants, number of branches, leaf stem ratio, were determined and analyzed for the assessment of Maringa productivity.

Dry matter (DM) was determined as described by the Association of Official Analytical Chemists (AOAC, 2000). Total nitrogen (N) in leaf samples was determined by Kjeltec Analyzer (AOAC, 2000). Acid detergent fibre (ADF) and Neutral Detergent Fibre (NDF) were analysed as per standard procedure (Van Soest *et al.,* 1991).

External caliper was used for measurement of the diameter, whereas, steel measuring tape was used for length and other measurements. Simple indicating type platform balance was used for weighting the plant samples and their leaf and wood components. The data was collectedfor two consequent years, i.e. 2019 and 2020 in post monsoon season (November-December).

Data on plant base diameter, leaf mass, wood mass and total biomass of thirty Moringa plants were collected, to establish mathematical relationships between various attributes of biomass as a function of plant base diameter during November 2019 and 2020. This study was important to see the difference in the yields of bio-mass especially the leaf because of its forage value.

Power relationships were established to predict the bio mass yield of Moringa plants if their base diameter is known (Rajput *et al.,* 2004)

$$Y = A D^B \quad \text{(1)}$$

Where,

Y =biomass yield of moringa plant, g

D =base diameter of moringa plant, cm.

A and B are regression coefficients.

Moringa leaves were processed for making leaf meal. Fresh Moringa leaves along with petiole were collected followed by shorting and removal of stone or other unwanted materials from the leaves. These leaves were kept in the layer under open sun for drying process. Initial moisture and final moisture content were measured. After three days sun drying the leaves shifted to a shed and drying process was carried out in shed until leaves were completely dried. Mathematical mean and statistical analysis were carried out by applying standard procedures.

## Results and Discussion

### Relationship between plant base diameter and biomass

Values of the regression coefficients (A and B) for leaf mass, wood mass and total biomass yield per plant and their correlation coefficients ($R^2$) for both the year 2019 and 2020 are given in Table 1 and the production potential from one hectare area is shown in Table 2 & 3.

Relationship between branch base diameter and leaf yield, wood mass and total biomass yield of Moringa plant for the year 2019 are graphically presented in Fig. 1, 2 and 3, separately. The study was

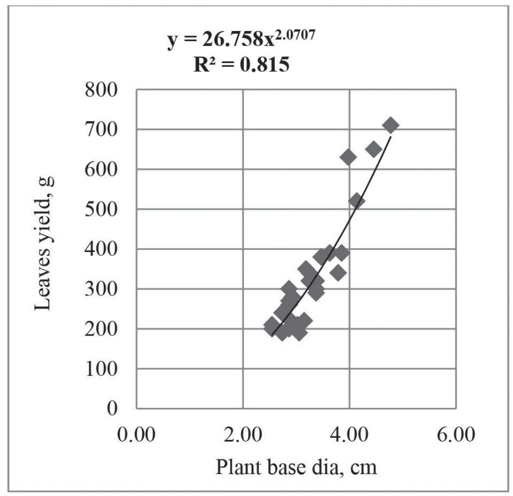


**Fig. 1**. Relationship between leaves yield and plant base diameter

**Table 1.** Values of regression and correlation coefficients for prediction of biomass of Moringa plants

| Season and year | Type of biomass | Regression coefficients A | B | Correlation coefficient ($R^2$) | Diameter range, cm |
|---|---|---|---|---|---|
| Post monsoon | Leaf mass | 26.75 | 2.07 | 0.82 | 2.55 - 4.77 (2.8) |
| November-December 2019 | Wood mass | 146.4 | 1.86 | 0.80 | - do - |
| | Total biomass | 66.37 | 2.61 | 0.81 | - do - |
| Post monsoon | Leaf mass | 68.45 | 1.18 | 0.81 | 2.86 - 4.77 (2.8) |
| November-December 2020 | Wood mass | 458.34 | 0.87 | 0.83 | - do - |
| | Total biomass | 522.79 | 0.92 | 0.87 | - do - |

**Table 2.** Leaf mass, wood mass and total biomass yield per plant in Moringa

| Average of 30 Plants | Year 2019-20 | Year 2020-21 | Mean | P<0.05 value |
|---|---|---|---|---|
| Average Base diameter, cm | 3.25 | 3.77 | 3.51 | NS |
| Leaf mass yield (fresh basis) | | | | |
| Observed value, g | 321 | 330 | 326 | NS |
| Predicted value, g | 317 | 329 | 323 | NS |
| Wood mass Yeild (fresh basis) | | | | |
| Observed value, g | 1360 | 1451 | 1406 | NS |
| Predicted value, g | 1347 | 1449 | 1398 | NS |
| Total biomass yield (fresh basis) | | | | |
| Observed value, g | 1682 | 1781 | 1732 | NS |
| Predicted value, g | 1520 | 1778 | 1649 | NS |

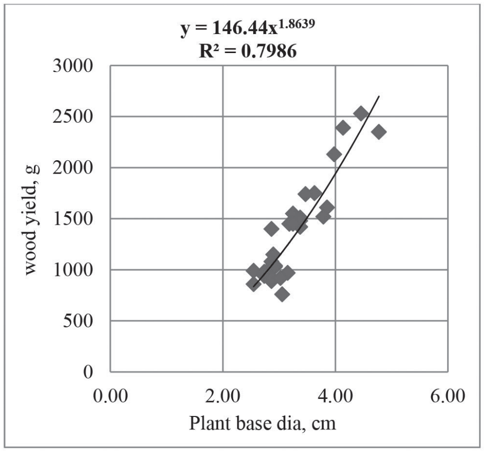


**Fig. 2.** Relationship between wood yield and plant base diameter

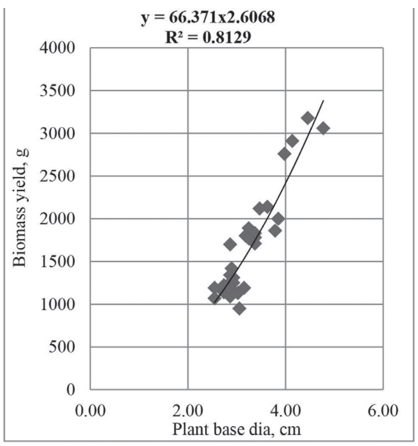


**Fig. 3.** Relationship between total biomass yield and plant base diameter

repeated in consequent year 2020 during same season in the same field to observe the variation, if any. Results of the study so obtained in year 2020 are also graphically presented as in Fig 4, 5 and 6 in terms of the relationship between plant base diameter and leaf, wood and total biomass yield on fresh basis.

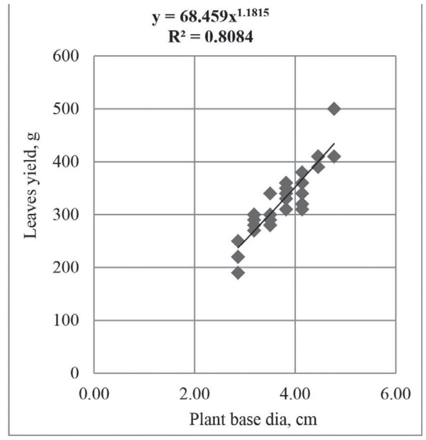


**Fig. 4.** Relationship between leaves yield and plant base diameter

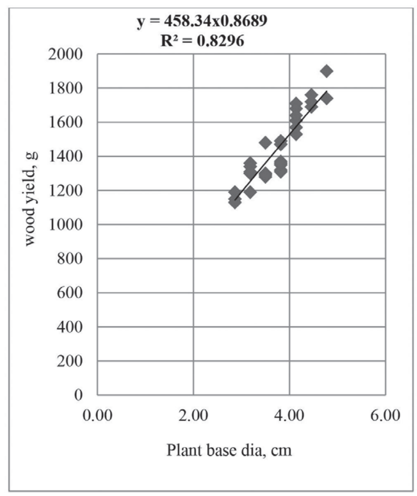


**Fig. 5.** Relationship between wood yield and plant base diameter

**Table 3.** Leaf mass, wood mass and total biomass yield per hactare in Moringa

| Prediction potential for 1 ha | Year 2019-20 | Year 2020-21 | Mean | P<0.05 value |
|---|---|---|---|---|
| No.of plant/ha(1mx1m) | 10,000 | 10,000 | 10,000 | |
| No. of branchs/plant, average | 7 | 7 | 7 | |
| Fresh leafmass Yield, kg/ha | 22493 | 23077 | 22785 | NS |
| Fresh wood mass kg/ha | 95223 | 101593 | 98408 | NS |
| Leaf- stem ratio (fresh basis) | 19.1 : 80.9 | 18.5 : 81.5 | 18.8 : 81.2 | |
| Dried leafmass, kg/ha | 6523 | 6692 | 6608 | NS |
| Dried wood mass, kg/ha | 63800 | 68068 | 65934 | NS |
| Leaf stem ratio (DM basis) | 9.3 : 90.7 | 9.0 : 91.0 | 9.1 : 90.9 | |
| Crude Protein (%) in leaves (DM basis) | 19.5 | 19.6 | 19.55 | NS |
| Crude Protein kg /ha (DM basis) | 1272 | 1312 | 1292 | NS |

DM= Dry Matter, NS= Non Significan

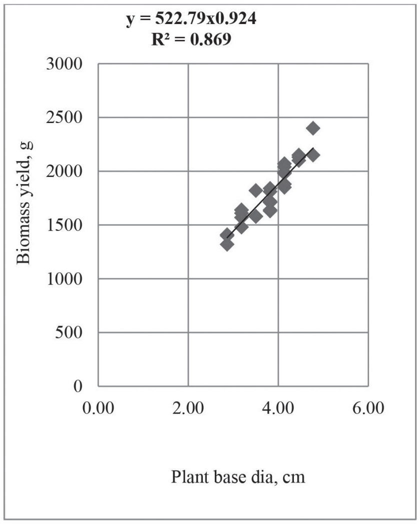


**Fig. 6.** Relationship between total biomass yield and plant base diameter

Results obtained from the study for leaves and wood mass yield during both years were statistically non-significant (Table 2 & 3) and repeated study supported the similar findings as obtained in previous year.

Values of correlation coefficient ($R^2$) ranged from 0.80 to 0.87 for different biomass components confirming the high correlation between plant base diameter andbiomass yield attributes (leaf, wood and total biomass) in *Moringa oliefera*. Rajput *et al.,* (2004) also reported positive and high correlation between plant base diameter and leaf, wood and total biomass yield in *Leucaenaleucocephala* and predicted yield per hectare. Similarly, Dwivedi *et al.,* (2007) established the relationship between plant base diameter and biomass yield in Zizyphuszylopyrus insemi arid region.The relation between total biomass and diameter at breast height (DBH) was linear one and for predicting standing tree biomass or estimation of aboveground biomass the allometric/power model proved to be the best one with DBH (Deb *et al.,* 2017).

**Leaves and wood mass productivity potential**

Fodder leaves production from Moringa plants per hectare land is an important outcome from the study and it was found thattotal 10,000 Moringa plants population per hectare with normal plant to plant distance as 1mx 1m interval. The average number of regenerated branches wasobservedseven with base diameter range of 2.5 to 5.0 cm suitable for harvesting, in five years old moringa field. Higher number of regenerated branches of moringa ensures the more availability of green foliage. The average value of moringa fodder leaves yield was found 227.85 q/ha on fresh basis. The average leaf to stem ratio was observed as 18.8:81.2 on fresh basis in harvested branches of moringa plants. Fresh moringa leaves were processed as leafmeal for feeding to the livestock during the period of green fodder scarcity.

The leaves samples were dried from initial moisture content of 64.7% to final moisture content of 10.2 to 11.5 to observe the drying characteristics. The change in moisture content with drying time for the samples exhibited a nonlinear decrease of moisture with drying time. Initially, the moisture decreased slowly because of low temperature in the morning followed by rapid decrease of moisture after 1pm afternoon. similar results were observed by Singh *et al.,* (2017). Total drying time varied from four to five days.

The mean yield of dried leafmeal production was 66.08 q/ha in climatic condition of central India. In laboratory analysis, it was found that Moringa leaves contained 19.6% crude protein, 30.6% Acid Detergent Fibre (ADF), 43.9% Neutral Detergent Fibre (NDF) and 9.8% Ash content on dry matter basis. Moringa leaves are fed mainly as a protein sourceto the livestock. Leaf meal added crop residue based feed block enhance the digestibility of nutrients in ruminants (Dwivedi and Pathak, 2012). The mean crude protein yield was assessed as 12.92 q/ha from the selected Moringa field of leaf meal block. After assessing Moringa leaves production as protein rich fodder source its wood mass wasdetermined which wassuitable for utilizing as fuel wood energy or cellulose resource in pulp and paper industry. The mean dried wood mass yield for both consecutive years was 659 q/ha with leaf to wood ratio 9.1:90.9 on dry matter basis. Though, Moringa leaves are rich source of protein but its narrow leaf to stem ratio is a factor for lower foliage productivity which limits the availability of moringa leaves for utilization as livestock ration.

## Conclusion

*Moringa* foliage was evaluated for consequent two years in terms of its potential to provide tree leaves and wood biomass production per unit land to precise quantification of biomass productivity of Moringa field. The relationship between plant base diameter and leaf, wood mass yield was established and observed high correlation. Mean fodder leaves, woodmass yield with leaf stem ratio were determined on fresh harvest basis. Dried leaf and wood mass production was also assessed. The crude protein yield from moringa leaves were assessed as 12.9 q on dry matter basis from one hectare Moringa field. The findings will be helpful in assessing different biomass production from Moringa field and quantity needed for future plantation planning.

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