Coppicing behaviour for clonal forestry in *Melia dubia* Cav.

The family Meliaceae has popularly been known for its multiple end-uses, primarily for quality timber. It includes 50 species and 550 genera, of which *Melia dubia* Cav. (syn. *Melia composita* Benth.) is one of the fast-growing deciduous tree species with great commercial importance[1]. The species is also known by the trade name Malabar Neem, Maha Neem or Gora Neem, and is indigenous to tropical moist deciduous forests of the Western Ghats, Khasi Hills, Odisha, Deccan region, North Bengal, Assam and parts of North East India up to 1500–1800 m amsl altitudes[2].

The versatile species attains a height of 30 m with spreading crown and a clear bole up to 9 m. The wood of the species has been reported to be moderately hard, light in weight, easy to saw and durable[3]. Therefore, it is promoted potentially as an excellent raw material for pulp and plywood industries; specifically brownish colour of the wood has ready acceptance as face veneer. *M. dubia* is recommended to be an important tree species for agroforestry systems as well as a potential alternative to exotics with high productivity[4]. Recently, 10 varieties of *M. dubia* have been released with average productivity of 34.53 m^3 ha^{-1} yr^{-1} for commercial cultivation in northern India[5]. The analysis revealed that wood is less susceptible to drying defects with density varying from 0.33 to 0.54 g/cm^3. Kumar[6] suggested *M. dubia* to be an important raw material for plywood industry as ply with higher glue-shear strength up to 200 $kg/inch^2$ could be manufactured with this wood, which is double the threshold level of 100 $kg/inch^2$.

Since tree improvement for *M. dubia* has recently been started, appropriate tools are needed to be made operational to supply sufficient quantity of planting stock for larger deployment. Moreover, limited availability of quality seeds enforces search of alternate routes of propagation. Clonal propagation therefore is one such technique that could easily play a complementary role and bridge the serious gap of demand and availability of quality planting stocks. In the making of clonal forestry operational, coppicing and coppicing behaviour become utmost essential and important aspects to attain sustainability. The emergence of new shoots/sprouts from the cut ends or felled stump is defined as coppice, and the operation of regenerating stands from coppices is known as coppicing[7]. Practice of coppicing could be economically efficient owing to the requirement of less management practices and significantly abundant production of shoot cuttings for clonal forestry. Moreover, it ensures passing of advantages of physiological age when compared to seed routes. It is nonetheless pertinent to highlight that clonal forestry is an important and viable tool for acquiring intermittent gains from long-term tree improvement strategies. However, little information is available in the public domain on the coppicing ability of *M. dubia* and clonal forestry. Thus the present study was conducted to analyse coppicing ability and impact of stump diameter on coppicing behaviour.

The experiment was conducted by the Division of Genetics and Tree Improvement, Forest Research Institute, Dehradun, Uttarakhand at Mehuwala (lat. N30°18′45.4″ and long. 77°59′20.8″E). A total of 45 trees, six years of age, were randomly felled at about 6–12 cm above ground level. The stump-bearing coppices were categorized into three different classes based on stump diameter, viz. (i) <20 cm, (ii) 20–30 cm and (iii) >30 cm. The stumps that sprouted were studied for stump diameter and coppicing behaviour in terms of number of coppices and coppice diameter. The data analysis was carried out for coppicing ability and collar area as well as basal stump area by establishing suitable correlation[8].

Out of 45 felled trees, 38 were found to bear coppices with coppicing ability of 84.43%, signifying that *M. dubia* is a strong coppice. Though the species has been considered and described as a good coppicer[9], no quantification on its coppicing ability is available in the public domain. Further perusal of analysis of stump diameter and its influence on coppicing behaviour connotes that the number of coppices/tree was maximum (13) with >30 cm stump diameter and minimum (4) with <20 cm diameter revealed a linear relationship between stump diameter and number of coppices (Table 1). Similar pattern was recorded for average basal collar area (Figure 1).

The present study revealed high positive correlation among stump diameter, number of coppices and basal collar area (Table 2). Stump diameter showed high positive significant correlation (P < 0.001) with number of coppices (0.590), basal collar area (0.678) and basal stump diameter (0.990). Similarly, number of coppices showed high positive significant correlation with basal collar area (0.687) and basal stump area (0.590).

Table 1. Coppicing behaviour at different diameter classes

Stump diameter (cm)	Number of trees bearing coppices	Average number of coppices/tree	Average basal collar area (cm^2)	Coppicing ability (%)
>30	11	13	9.339	28.95
20–30	22	7	4.043	57.90
<20	5	4	2.995	13.16

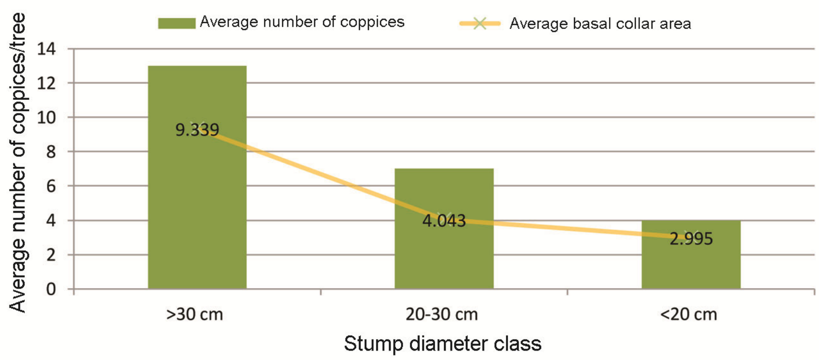

Figure 1. Stump diameter and its influence on the number of coppices/tree and basal collar area.

Table 2. Correlation matrix for diameter class and coppicing behaviour

	Stump diameter	Number of coppices	Basal collar area
Stump diameter	1		
Number of coppices	0.590*	1	
Basal collar area	0.678*	0.687*	1
Basal stump area	0.990*	0.590*	0.685*

*Highly significant ($P < 0.001$).

Basal collar area also showed high positive correlation with basal stump area (0.685). The findings of the present experiment reveal that increasing stump diameter leads to increase in the number of coppices and basal collar area, and the results are in agreement with those of Shackleton[10] for *Terminalia sericea*. The stump diameter has a positive relationship with the number of coppices, and thereby provides high coppice effectiveness.

Coppicing becomes an important and effective tool for reaping intermittent gains of long-term tree improvement and breeding strategies through clonal forestry. The technique is extremely useful in transferring traits with less heritability and ensures transfer of both additive and non-additive gene impacts. It is an essential tool for operational clonal forestry and deployment of promising clones commercially. This study reveals that *M. dubia* is a strong coppicer and can be promoted under clonal forestry to harvest maximum gains under agroforestry by multiplying desired clones.

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Quality enhancement of nutri-cereal browntop millet through agronomic practices

In the recent past, there has been an increasing recognition of the importance of millets as a substitute for major cereals owing to their inherent health benefits apart from climate resilience. Among the small millets, browntop millet (*Brachiaria ramosa* (L.) Stapf., *Panicum ramosum* L., *Urochola ramosa*), is one of the rarest crops commonly known as Dixie signal grass and locally as korale in Kannada and andukorralu in Telugu. It is drought-tolerant, early maturing and harvested in about 75–80 days. This millet is well suited for drylands[1], grown under a variety of soils and climates[2] and can fit into different cropping systems as a catch crop. It grows well in the dryland regions of Tumkur, Chitradurga and Chikkaballapura districts of Karnataka and Ananthapur district of Andhra Pradesh.

Browntop millet is gluten-free, rich in essential nutrients, a good source of zinc, iron, fibre and provides 338 kcal of energy. The mineral composition constitutes 28 mg of calcium, 7.72 mg of iron, 276 mg of phosphorus, 60 mg of potassium, 94.5 mg of magnesium, 1.99 mg of manganese, 7.60 mg of sodium, 2.5 mg of zinc, 1.23 mg of copper and a rich source of natural fibre (8.5%) due to which it serves as an excellent option for dealing with lifestyle diseases[3]. Lower incidence of cardiovascular diseases, duodenal ulcer and hyperglycaemia (diabetes) is reported among those who regularly consume millets. Agronomists have generated a wealth of information on good agricultural practices for millet crops, but meagre information is available with regard to the agronomic practices of browntop millet.

The present field experiment was carried out during *kharif*, 2019 at the College Farm, PJTSAU, Hyderabad. The farm is geographically situated at 17°32′N lat., 78°41′E long. and at an altitude of 541.6 m msl. The experimental soil was sandy loam in texture, moderately neutral in pH (7.1), non-saline in electrical conductivity (EC) (0.31 dS m^{-1}), low in organic carbon (0.47%), and available N (143 kg ha^{-1}), medium in available P (75 kg ha^{-1}) and high in available K (313 kg ha^{-1}). Treatments consisted of four dates of sowing and four levels of nitrogen (Table 1). Grain yield, quality parameters, viz. crude fibre[4], nitrogen[5], protein[6] and zinc content[7] were estimated using standard procedures. Crop (variety VZM-1) was sown according to the treatments at a spacing of 30 cm × 10 cm