Print : ISSN 0970-7662
Online : ISSN 2455-7129

Journal of Tree Sciences
online available at www.ists.in

Volume 38 No. 1 June, 2019

Performance of *Melia dubia* Under *Cymbopogon* spp. Based Agroforestry Systems

N S Thakur, Sumit Mohanty, H T Hegde, R S Chauhan, R P Gunaga and D C Bhuva

College of Forestry, Navsari Agricultural University, Navsari, Gujarat- 396 450, India
**Email: drnsthakur74@gmail.com*

DOI: 10.5958/2455-7129.2019.00005.0

ABSTRACT

The experiment was conducted in randomized block design with 15 treatments (land use systems). Maximum height (3.4 m) and diameter (4.06 cm), at intercrop planting was recorded in sole plantation of *M. dubia* at 4×4 m spacing and at final harvest, it was maximum (7.7 m) in *M. dubia* planted at 3×3 m spacing. However, maximum DBH (8.24 cm) was recorded in sole plantation spaced at 4×4 m. Height (4.6 m) and DBH (4.42 cm) increment was registered maximum under sole plantation of *M. dubia* at 3×3 m spacing. Maximum volume (41.25 m^3/ha) and biomass increment (17.41 Mg/ha) was recorded in *M. dubia* (3×3m) sole. The study indicated that there was significant difference in tree height due intercropping of *Cymbopogon* spp. (silvi-medicinal systems). The maximum height increment was attained under *M. dubia* (3×3 m) (either sole or silvi-medicinal system). There was significant effect of *Cymbopogon* intercropping on DBH of *M. dubia* trees as evident from the increment in height. Minimum growth attributes were in closer spacing of *M. dubia* (2×2 m). The increment (difference in volume or biomass/tree at intercrop planting and at harvest) in volume and biomass show that intercropping has significant effect on growth and yield of *M. dubia*.

Key Words:

Biomass, *Cymbopogon* spp., Growth, *Melia dubia*, Volume

INTRODUCTION

Melia dubia Cav. is a fast growing, short-rotation industrial species (Chauhan and Ritu 2005; Bhusara et al. 2018a & b; Thakur et al. 2019). It is indigenous to Western Ghats region in India, and is common in moist deciduous forests of the Indian state of Kerala, Katnataka, Gujarat etc. Worldwide, it is found in Bangladesh, Myanmar, Thailand, Mexico, Sri Lanka, Malaysia, Java, China, America, Philippines and Australia (Saravanan et al. 2013; Chauhan et al. 2018). It is valued for its high-quality termite and fungus resistant timber, used for furniture, agricultural implements and house construction, as an alternative pulp, plywood and fuel wood species (Suprapti et al. 2004; Vijayan et al. 2004; Parthiban et al. 2009). It also has many medicinal properties as well (Susheela et al. 2008; Malarvannan et al. 2009; Yasodha et al. 2011). The industrial and ecological importance of *M. dubia* has encouraged the farmers to take up large scale plantations either in block or in agroforestry systems (Chauhan and Ritu 2005; Parthiban et al. 2009; Nuthan et al. 2009; Thakur et al. 2018) with ephemeral or no allelopathic effect on under storey crops (Kumar et al. 2017, Thakur et al. 2017a&b; Parmar et al. 2018).

Agro-forestry and farm-forestry sectors remain the mainstay for wood production in India. Indian industrial demand for wood has been estimated at 150 million cum in the current year 2018 (Shrivastava and Saxena 2017). In the back drop of productivity potential Indian forests to meet out the ever increasing demand for timber for various purposes and to remove the tag of net importer of wood, the species available and their suitability in different land use systems, there is urgent need to identify more productive multipurpose tree species. Such species should have fast growth, wider adaptability to varied edapho-climatic conditions and more importantly species should be amenable agroforestry ideotype. Such fast emerging species, which is gaining popularity like poplar, eucalypts, casuarinas etc. It is notable that successful outreach and popularity of poplars and eucalypts in India and elsewhere in the world has been attributed to their amenable nature to agroforestry land use systems, which make their plantations remunerative at early stage (Chauhan and Mahey 2008; Luna et al. 2009&2011). Therefore, with this backdrop the present study intended to estimate the growth and productivity of *M dubia* plantations under agroforestry and sole plantations

MATERIAL AND METHODS

This investigation was carried out in College of Forestry, ACHF, Navsari Agricultural University, Navsari, Gujarat, India, during 2016-2017. Navsari is situated at 20.95 N latitude, 75.90E longitude at an altitude of 10 m above the mean sea level. The experiment was conducted in randomized block design with 10 treatments (land use systems) *viz.*, *M. dubia* (2×2 m)-*C. flexuosus*/*C. martinii*, *M. dubia* (3×3 m)-*C. flexuosus*/*C. martinii*, *M. dubia* (3×2 m)-*C. flexuosus*/*C. martinii*, *M. dubia* (4×4 m)-*C. flexuosus*/*C. martinii*, *M. dubia* (4×2 m)-*C. flexuosus*/*C. martinii*, *M. dubia* (2×2 m) sole, *M. dubia* (3×3 m) sole, *M. dubia* (3×2 m) sole, *M. dubia* (4×4 m) sole, *M. dubia* (4×2 m) sole.

Growth, biomass and volume of *M. dubia* was assessed at the age of 2 years [both under agroforestry (intercrops taken during 2016-17) and sole plantations established in 2014]. *M. dubia* tree height and diameter at breast height (DBH, at 1.37 cm above ground) were recorded following standard methods by randomly selecting 5 trees from each replication under all land use systems. Standing tree volume was estimated by Smalian's formula (Volume= $(S_1+S_2)/2 \times L$, where S_1&S_2= $\pi \times D^2/10000$, D= DBH in cm and L=Length of log in m). Biomass (per tree) was estimated by formula: Biomass= wood specific gravity × per tree volume. The individual tree volume and biomass was converted to per hectare basis considering number of trees/ha in each system land use system assuming 10% mortality.

The experimental data generated were subjected to the statistical analysis following completely randomized design (RBD) and ANOVA was constructed following Sheoran et al. (1998). Treatment means were compared at $P \leq 0.05$. Further, Duncan's multiple range test (DMRT) was used to compare the sets of means of each treatment.

RESULTS AND DISCUSSION

Height growth and increment

The tree height of *M. dubia*, and *Cymbopogon.* spp. planting, varied significantly either kept for *M. dubia-Cymbopogon* spp. silvi-medicinal systems or sole plantations (Table 1). The maximum height (3.4 m) of *M. dubia* (at planting of *Cymbopogon* spp.), was recorded in sole plantation of *M. dubia* at 4×4 m spacing (T_{14}), which was at par with T_7 [*M. dubia* (3×3 m)-*C. martinii*]. Minimum initial height (1.9 m) was recorded under T_1 [*M. dubia* (2×2 m)-*C. flexuosus*]. At *Cymbopogon* spp. final harvest, height of *M. dubia*, differed significantly. Maximum height (7.73 m) was recorded in *M. dubia* planted at 3×3 m spacing. Minimum tree height (4.68 m) was recorded under *M. dubia* (2×2 m)-*C. martinii* silvi-medicinal system.

The height increment (height at *Cymbopogon* spp. final harvesting - height at *Cymbopogon* spp. planting) of *M. dubia* showed significant difference either in silvi-medicinal systems and sole plantations (Table 1). The maximum height increment (4.60 m) was registered under sole plantation of *M. dubia* at 3×3 m spacing (T_{12}). Minimum height increment (2.59 m) was recorded in silvi-medicinal systems *viz*., T_4 and T_6 *M. dubia* (4×4 m)-*C. flexuosus* and [*M. dubia* (2×2 m)-*C. martinii*.

Diameter at breast height (DBH) (cm) and increment

The DBH of *M. dubia*, at *Cymbopogon* spp. planting, varied significantly either under silvi-medicinal systems or sole plantations (Table 1). The maximum DBH of *M. dubia* (4.06 cm) was recorded in sole plantation at 4×4 m spacing (T_{14}). Minimum initial DBH (1.94 cm) was recorded in treatment T_1 [*M. dubia* (2×2 m)-*C. flexuosus*]. At *Cymbopogon* spp. final harvest, DBH of *M. dubia* differed significantly. Maximum DBH of *M. dubia* (8.24 cm) was recorded in sole plantation spaced at 4×4 m (T_{14}). Minimum DBH (3.90 cm) was recorded under sole *M. dubia* grown at 2×2 m spacing (T_{11}).

The DBH increment (difference in DBH at final harvest and intercrop planting) in *M. dubia* showed significant difference either in *M. dubia*-*Cymbopogon* spp. silvi-medicinal systems or sole plantations (Table 1). The maximum DBH increment (4.42 cm) was registered under sole plantation *M. dubia* (3×3 m spacing) (T_{12}) and minimum (1.88 cm) was recorded in *M. dubia* (2×2 m).

Volume production and increment

The volume (m^3/ha) of *M. dubia* with*Cymbopogon* spp. planting, showed no significant difference under *M. dubia*-*Cymbopogon* spp. silvi-medicinal systems and sole plantations (Table 2). *M. dubia*-*Cymbopogon* spp. based silvi-medicinal and sole crop system exhibited significant effect on volume of *M. dubia* at final harvest of intercrop. Maximum volume (45.60 m^3/ha) was recorded in treatment T_{12} [*M. dubia* (3×3m) sole], which was at par with T_3 [*M. dubia* (3×2 m)-*C. flexuosus*], T_7 [*M. dubia* (3×3 m)-*C. martinii*] and T_8 [*M. dubia* (3×2 m)-*C. martinii*]. Minimum volume (6.81 m^3/ha) was recorded for in treatment T_4 [*M. dubia* (4×4 m)-*C. flexuosus*], which was at par with T_5 [*M. dubia* (4×2 m)-*C. flexuosus*], T_9 [*M. dubia* (4×4 m)-*C. martinii*], T_{10} [*M. dubia* (4×2 m)-*C. martinii*] and T_{11} [*M. dubia* (2×2 m) sole].

The volume increment (m^3/ha) of *M. dubia* showed significant difference either in *M. dubia*-*Cymbopogon* spp. silvi-medicinal systems and sole plantations (Table 1). Maximum volume increment of *M. dubia* (41.25 m^3/ha) was recorded in treatment T_{12}[*M. dubia* (3×3m) sole], which was at par with T_3 [*M. dubia* (3×2 m)-*C. flexuosus*], T_7 [*M. dubia* (3×3 m)-*C. martinii*] and T_8 [*M. dubia* (3×2 m)-*C. martinii*]. Minimum volume increment of 5.77 m^3/tree was recorded in treatment T_4 [*M. dubia* (4×4 m)-*C. flexuosus*], which was at par with T_5 [*M. dubia* (4×2 m)-*C. flexuosus*], T_9 [*M. dubia* (4×4 m)-*C. martinii*], T_{10}[*M. dubia* (4×2 m)-*C. martinii*], T_{11}[*M. dubia* (2×2 m) sole] and T_{15}[*M. dubia* (4×2 m) sole].

Biomass production and increment (Mg ha^{-1})

The biomass (Mg/ha) of *M. dubia*, at intercrop planting, showed no significant difference under silvi-medicinal systems and sole plantations (Table 1). At harvest of intercrops, the *M. dubia*-*Cymbopogon* spp. based silvi-medicinal and sole crop system exhibited significant effect on biomass of *M. dubia*. Maximum biomass (19.15 Mg/ha) was recorded in treatment T_{12} [*M. dubia* (3×3m) sole], which was at par with T_3 [*M. dubia* (3×2 m)-*C. flexuosus*], T_7 [*M. dubia* (3×3 m)-*C. martinii*], and T_8 [*M. dubia* (3×2 m)-*C. martinii*]. Minimum biomass (2.86 Mg/ha) was recorded in *M. dubia* (4×4 m)-*C. flexuosus* silvi-medicinal system, which was at par with *M. dubia* (4×2 m)-*C. flexuosus*, *M. dubia* (4×4 m)-*C. martinii*, *M. dubia*

Table 1. Effect of different spatial arrangements and intercropping of *Cymbopogon* spp. (silvi-medicinal systems) on growth of *Melia dubia*.

Land use systems	Height (m)		DBH (cm)		Increment	
	At *Cymbopogon* spp. planting	At *Cymbopogon* spp. final harvesting	At *Cymbopogon* spp. planting	At *Cymbopogon* spp. final harvesting	Height (m)	DBH (cm)
T_1[MD (2×2 m)-CF]	1.9^{c}	4.9^{fg}	1.94^{e}	4.48^{def}	2.95^{de}	2.54^{bcd}
T_2[MD (3×3 m)-CF]	2.4^{bc}	6.0^{bcde}	2.79^{bcde}	6.09^{bc}	3.63^{abcde}	3.29^{abc}
T_3[MD (3×2 m)-CF]	2.2^{c}	6.6^{abc}	2.39^{cde}	5.99^{bcd}	4.44^{ab}	3.59^{ab}
T_4[MD (4×4 m)-CF]	2.5^{bc}	5.1^{efg}	2.54^{cde}	4.97^{cdef}	2.59^{e}	2.43^{bcd}
T_5[MD (4×2 m)-CF]	2.5^{bc}	5.6^{cdefg}	2.53^{cde}	5.20^{cdef}	3.15^{cde}	2.67^{bcd}
T_6[MD (2×2 m)-CM]	2.0^{c}	4.6^{g}	2.24^{de}	4.33^{ef}	2.59^{e}	2.09^{cd}
T_7[MD (3×3 m)-CM]	3.1^{ab}	6.9^{ab}	3.66^{ab}	7.26^{ab}	3.82^{abcd}	3.6^{ab}
T_8[MD (3×2 m)-CM]	2.6^{abc}	6.7^{abc}	2.82^{bcde}	6.03^{bcd}	4.06^{abc}	3.22^{abc}
T_9[MD (4×4 m)-CM]	2.7^{abc}	5.6^{cdefg}	3.24^{abc}	5.99^{bcd}	2.97^{de}	2.75^{bcd}
T_{10}[MD (4×2 m)-CM]	2.0^{c}	5.2^{efg}	2.23^{de}	4.87^{cdef}	3.20^{cde}	2.63^{bcd}
T_{11}[MD (2×2 m) sole]	2.2^{c}	4.9^{fg}	2.02^{e}	3.90^{f}	2.69^{e}	1.88^{d}
T_{12}[MD (3×3 m) sole]	3.1^{ab}	7.7^{a}	3.63^{ab}	8.05^{a}	4.60^{a}	4.42^{a}
T_{13}[MD (3×2 m) sole]	2.1^{c}	5.5^{defg}	2.53^{cde}	5.34^{cdef}	3.41^{bcde}	2.81^{bcd}
T_{14}[MD (4×4 m) sole]	3.4^{a}	6.6^{abc}	4.06^{a}	8.24^{a}	3.24^{cde}	4.19^{a}
T_{15}[MD (4×2 m) sole]	2.6^{bc}	5.8^{cdef}	3.06^{bcd}	5.61^{cde}	3.20^{cde}	2.55^{bcd}

MD=*Melia dubia*; **CF=***Cymbopogon flexuosus*; **CM=***Cymbopogon martinii;* Mean values with different letter superscript in the same column indicate significant difference ($p<0.05$) according to Duncan's Multiple Range Test

Table 2. Effect of different spatial arrangements and intercropping of *Cymbopogon* spp. (silvi-medicinal systems) on volume (m^3/ha) and biomass (kg/ha) of *Melia dubia*.

Land use systems	Volume (m^3/ha)		Biomass (Mg/ha)		Increment	
	At *Cymbopogon* spp. planting	At *Cymbopogon* spp. final harvest	At *Cymbopogon* spp. planting	At *Cymbopogon* spp. final harvest	Volume (m^3 ha^{-1})	Biomass (Mg ha^{-1})
T_1[MD (2×2 m)-CF]	1.64^{a}	21.99^{bcde}	0.66^{a}	9.24^{bcde}	20.35^{bcde}	8.58^{bcde}
T_2[MD (3×3 m)-CF]	1.97^{a}	22.69^{bcde}	0.79^{a}	9.53^{bcde}	20.72^{bcde}	8.74^{bcde}
T_3[MD (3×2 m)-CF]	1.73^{a}	33.56^{abc}	0.69^{a}	14.10^{abc}	31.84^{ab}	13.41^{ab}
T_4[MD (4×4 m)-CF]	1.04^{a}	6.81^{f}	0.42^{a}	2.86^{f}	5.77^{f}	2.44^{f}
T_5[MD (4×2 m)-CF]	2.08^{a}	18.75^{def}	0.83^{a}	7.88^{def}	16.67^{cdef}	7.04^{cdef}
T_6[MD (2×2 m)-CM]	2.81^{a}	23.09^{bcde}	1.12^{a}	9.70^{bcde}	20.29^{bcde}	8.58^{bcde}
T_7[MD (3×3 m)-CM]	4.07^{a}	33.29^{abc}	1.63^{a}	13.98^{abc}	29.22^{abc}	12.36^{abc}
T_8[MD (3×2 m)-CM]	3.31^{a}	34.47^{ab}	1.32^{a}	14.48^{ab}	31.16^{ab}	13.15^{ab}
T_9[MD (4×4 m)-CM]	1.70^{a}	10.85^{ef}	0.68^{a}	4.56^{ef}	9.15^{ef}	3.88^{ef}
T_{10}[MD (4×2 m)-CM]	1.32^{a}	14.80^{def}	0.53^{a}	6.22^{def}	13.47^{def}	5.69^{def}
T_{11}[MD (2×2 m) sole]	1.97^{a}	17.06^{def}	0.79^{a}	7.16^{def}	15.08^{def}	6.37^{def}
T_{12}[MD (3×3 m) sole]	4.34^{a}	45.60^{a}	1.74^{a}	19.15^{a}	41.25^{a}	17.41^{a}
T_{13}[MD (3×2 m) sole]	2.69^{a}	25.17^{bcd}	1.08^{a}	10.57^{bcd}	22.48^{bcd}	9.50^{bcd}
T_{14}[MD (4×4 m) sole]	3.36^{a}	23.98^{bcde}	1.34^{a}	10.07^{bcde}	20.63^{bcde}	8.73^{bcde}
T_{15}[MD (4×2 m) sole]	3.30^{a}	20.46^{cde}	1.32^{a}	8.59^{cde}	17.16^{cdef}	7.27^{cdef}

MD=*Melia dubia*; **CF=***Cymbopogon flexuosus*; **CM=***Cymbopogon martinii;* Mean values with different letter superscript in the same column indicate significant difference ($p<0.05$) and superscript letter 'a' in same column indicate non-significant difference according to Duncan's Multiple Range Test

(4×2 m)-*C. martinii* and *M. dubia* (2×2 m) sole systems.

The biomass increment (Mg/tree) of *M. dubia* showed significant difference either in *M. dubia-Cymbopogon* spp. silvi-medicinal systems and sole plantations (Table 1). Maximum biomass increment (17.41 Mg/ha) was recorded in treatment T_{12}[*M. dubia* (3×3m) sole], which was at par with T_3 [*M. dubia* (3×2 m)-*C. flexuosus*], T_7[*M. dubia* (3×3 m)-*C. martinii*], and T_8[*M. dubia* (3×2 m)-*C. martinii*]. Minimum biomass of 2.44 Mg/ha was attained under *M. dubia* (4×4 m)-*C. flexuosus* silvi-medicinal system (T_4), which was at par with T_5 [*M. dubia* (4×2 m)-*C. flexuosus*], T_9 [*M. dubia* (4×4 m)-*C. martinii*], T_{10} [*M. dubia* (4×2 m)-*C. martinii*], T_{11} [*M. dubia* (2×2 m) sole] and T_{15} [*M. dubia* (4×2 m) sole].

The study indicated that there was significant difference in tree height due intercropping of *Cymbopogon* spp. (silvi-medicinal systems). The maximum height increment was attained under *M. dubia* (3×3 m) (either sole or silvi-medicinal system). There was significant effect of *Cymbopogon* intercropping on DBH of *M. dubia* trees as evident from the increment in height. Minimum growth attributes were in closer spacing of *M. dubia* (2×2 m). The increment (difference in volume or biomass/tree at intercrop planting and at harvest) in volume and biomass show that intercropping has significant effect on growth and yield of *M. dubia*.

Further, there was significant difference in per tree volume and biomass [higher for trees in 3×3 m either 3×3 m sole *M. dubia* or *M. dubia* (3×3 m)-*C. martinii*]. Similarly, volume and biomass yield per hectare varied significantly. The height, DBH, volume and biomass were more in *M. dubia* planted at 3×3 m in sole plantations as well as silvi-medicinal systems. The greater DBH and increased height may be attributed to wider spacings and more availability of light, water and nutrients resulting in increase in crown size, leaf area and synthesis of carbohydrates and hormonal growth regulators (Nissen et al. 2001; Jilariya 2017; Thakur et al. 2018).

There was significant variation in volume and biomass per tree and per hectare. This may be attributed to number trees per hectare which in the present study were in precedence *M. dubia* (2×2 m)>*M. dubia* (3×2 m)> *M. dubia* (3×3 m)> *M. dubia* (4×2 m)>*M. dubia* (4×4 m). This reveals that growth is function of age, spacing and site quality (Nissen et al. 2001). Similar inferences have been drawn by Khan and Chaudhary (2007) and Jilariya (2017).

CONCLUSION

There was significant difference in tree height due intercropping of *Cymbopogon* spp. (silvi-medicinal systems). The maximum height and DBH increment were attained under *M. composita* (3×3 m) (either sole or silvi-medicinal system). Minimum was found in closer spacing of *M. composita* (2×2 m). The increment (difference in volume or biomass/tree at *Cymbopogon* spp. planting and at harvest) in volume and biomass show that intercropping has significant effect on growth and yield of *M. composita*. Further, there was significant difference in per tree volume and biomass [higher for trees in 3×3 m either 3×3 m sole *M. composita* or *M. composita* (3×3 m)-*C. martinii*]. Similarly, difference in volume and biomass yield per hectare was significant. The height, DBH, volume and biomass of *M. composita* were more in close (3×2 and 3×3 m) spaced *M. composita* sole plantations as well as silvi-medicinal systems.

REFERENCES

Bhusara J.B., Dobriyal M.J., Thakur N.S., Gunaga R.P. and Tandel M.B. 2018a. Performance of okra (*Abelmoschus esculentus* L. Moench) under different spatial arrangements of *Melia composita* based agroforestry system. International Journal of Current Microbiology and Applied Sciences 7(5): 3533-3542.

Bhusara J.B., Dobriyal M.J., Thakur N.S., Sondarva R.L. and Prajapati D.H. 2018b.

Growth and yield performance of green gram under *Melia composita* plantations. Journal of Pharmacognosy and Phytochemistry 7(3): 1490-1494.

Chauhan R.S., Jadeja D.B., Thakur N.S., Jha S.K., and Sankanur M.S. 2018. Selection of Candidate plus trees (CPTs) of Malabar Neem (*Melia dubia* Cav.) for enhancement of farm productivity in south Gujarat. International Journal of Current Microbiology and Applied Sciences 7(5): 3582-3592.

Chauhan R.S., Jadeja D.B., Thakur N.S., Jha S.K., Sankanur M.S. 2018. Selection of candidate plus trees (CPTs) of malabar neem (*Melia dubia* Cav) for enhancement of farm productivity in south Gujarat. International Journal of Current Microbiology and Applied Sciences 7: 3582-3592.

Chauhan S.K. and Ritu. 2005. Towards agroecological health: diversifying traditional crop rotation through agroforestry in Punjab, India. APA News 27: 3-4

Chauhan S.K. and Mahey R.K. 2008. Poplar Cultivation (Revised Edition). Punjab Agricultural University, Ludhiana, 36 p.

Jilariya D.J., Thakur N.S. and Gunaga R.P. 2017. Quantitative and qualitative attributes of *Aloe vera* Linn. grown under *Melia composita* Willd. and sole cropping systems. Indian Journal of Ecology, 44 (Special Issue-5): 451-455.

Khan G.S. and Chaudhry A.K. 2007. Effect of spacing and plant density on the growth of poplar (*Populus deltoides*) trees under agroforestry system. Pakistan Journal of Agricultural Sciences, 44(2): 321-327.

Kumar D., Thakur N.S. and Gunaga R.P. 2017. Effects of leaf aqueous extract and leaf litter of *Melia composita* Willd. on black gram [*Vigna mungo* (L.) Hepper]. Allelopathy Jornal 41 (1): 127-140.

Luna R.K., Thakur N.S. and Vijay Kumar. 2009. Performance of clonal Eucalyptus in different agro-climatic zones in Punjab, India. Indian Forester, 135(11): 1455-1464.

Luna R.K., Thakur N.S. and Kumar V. 2011. Growth performance of twelve new clones of poplar in Punjab, India. Indian Journal of Ecology 38(Special Issue): 107-109.

Malarvannan S., Giridharan R., Sekar S., Prabavathy V.R. and Sudha N. 2009. Ovicidal activity of crude extracts of few traditional plants against *Helicoverpa armigera* (Hubner) (Noctuidae: Lepidoptera). Journal of Biopesticides 2 (1): 64-71.

Nissen T.M., Midmore D.J. and Keeler A.G. 2001. Biophysical and economic tradeoffs of intercropping timber with food crops in the Philippine uplands. Agricultural Systems 67: 49-69.

Nuthan D., Reddy K.M.C., Kumar S.P., Vajranabhaiah S.N., Yogeesha T.D. 2009. Cultivation of *Melia dubia* on farmlands of Kanakapura taluka Ramanagara district of Karnataka-A success story Pbli No 224, National Afforestation and Eco-development Board (NAEB) Ministry of Environment and Forests Goveronment of India University of Agricultural Sciences, GKVK Campus Banglore India, RC, NAEB.

Parmar A.G., Thakur N.S. and Gunaga R.P. 2019 *Melia dubia* Cav. leaf litter allelochemicals have ephemeral allelopathic proclivity. Agroforestry Systems 93(4):1347-1360.

Parthiban K.T., Bharathi A.K., Seenivasan R., Kamala K. and Rao M.G. 2009 Integrating *Melia dubia* in agroforestry farms as an alternate pulpwood species. APA News 34: 3-4.

Saravanan V., Parthiban K.T., Kumar P., Marimuthu P. 2013. Wood characterization studies on *Melia dubia* Cav for pulp and paper industry at different age gradation. Research Journal of Recent Sciences 2: 183-188.

Sheoran O.P., Tonk D.S., Kaushik L.S, Hasija R.C. and Pannu R.S. 1998 Statistical Software Package for Agricultural Research Workers. In: Hooda DS, Hasija RC (Eds) Recent Advances in information theory, Statistics & Computer Applications by Department of Mathematics Statistics, CCS HAU, Hisar, India, Pp. 139-143.

Shrivastava S. and Saxena A.K. 2017. Wood is Good: But, is India doing enough to meet its present and future needs? Centre for Science and Environment, New Delhi, India, pp 45.

Suprapti S., Djarwant and Hudiansyah. 2007. The resistance of five wood species against thirteen wood destroying fungi. Journal of Forest Product Research 25: 75-83.

Susheela T., Padma B., Theophilus J., Reddy T.N. and Reddy P.U.M. 2008. Evaluation of hypoglycaemic and antidiabetic effect of *Melia dubia* Cav fruits in mice. Current Science 94: 1191-1195.

Thakur N.S., Jilariya D.J., Gunaga R.P. and Singh S. 2018. Positive allelospoly of *Melia dubia* Cav. spatial geometry improve quantitative and qualitative attributes of *Aloe vera* L. Industrial Crops and Products 119:162-171.

Thakur N.S., Kumar D., Gunaga R.P. and Singh S. 2017b. Allelopathic propensity of the aqueous leaf extract and leaf litter of *Melia dubia* Cav. on pulse crops. Journal of Experimental Biology and Agricultural Sciences 5(5): 644-655.

Thakur N.S., Kumar D. and Gunaga R.P. 2017a. Transient allelopathic propensity of *Melia composita* Willd. leaf litter on chickpea (*Cicer arietinum* L.). Indian Journal of Ecology 44 (Special Issue-5): 443-450.

Vijayan P., Raghu C., Ashok G., Dhanaraj S. and Suresh B. 2004. Antiviral activity of medicinal plants of nilgiris including *Melia dubia.* Indian J. Med. Res. 120 (1): 24-29.

Yasodha D.M., Manimegalai Kumari, Binu S., Vijayakumar K. 2011. Larvicidal effect of *Melia dubia* seed extract against the malarial fever mosquito, *Culex quinquefasciatus.* Current Biotica, 5: 102-106.