Growth and Yield of Tree Borne Oilseed Crops Based Agroforestry System

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Abstract: Experiment was carried out to study the growth and yield pattern of tree borne oilseed crops based agroforestry system for the Eastern dry zone of Karnataka conducted in GKVK, University of Agricultural Sciences, Bengaluru. The soil of experimental site was neutral in pH and medium in available Nitrogen, Phosphorus and Potassium. The experiment was laid out in Randomized Block Design with seven treatments and replicated thrice. The growth parameter of 11 year old TBO's revealed that, *Melia dubia* recorded significantly higher tree height (12.54 m,13.22 m and 12.88, respectively), Girth at breast height (113.28 cm, 114.84 cm and 114.06cm, respectively), bole height (4.85 m, 5.13 m and 4.99 m, respectively), collar diameter (139.29 cm, 116.82 cm and 114.06 cm, respectively), Canopy spread towards N-S (14.37 m, 14.79 m and 14.58 m, repectively) and E-W (11.83 m, 11.93 m and 11.87 m, respectively) directions and wood volume (0.389 m^3, 1.8410 m^3 and 1.115 m^3, respectively) during 2019, 2020 and pooled respectively. It was followed by *Melia azedarach*, *Simarouba glauca, Azadiractha indica*, *Madhuca latifolia, Pongamia pinnata* and least growth parameters were observed with *Callophyllum inophyllum.* Thus, it clearly indicated that *Melia dubia* found to be one of the fast growing TBO's among the seven tree borne oilseed crops. Further, higher tree carbon stock (40.93 t ha^{-1}, 42.73 t ha^{-1} and 41.83 t ha^{-1}, respectively) and soil carbon stock (29.16 t ha^{-1}, 30.41 t ha^{-1} and 29.78 t ha^{-1}, respectively) during 2019, 2020 and pooled respectively was recorded by *Melia dubia* based agroforestry system.

Keywords: Carbon stock, Collar diameter, GBH, Tree borne oilseed, Wood volume

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1. Introduction

As India struggling to grapple with its growing imports for vegetable oil, over 67 per cent of our current demand is met by imports, a hidden source of unlimited potential lies untapped. As per the third assessment of IPCC, the global oil demand will rise by 1.68 % from 75 MB/day in the year 2002 to 120 MB/day in 2030 *i.e*. a tenfold increase. In order to meet this demand, Tree borne oilseeds (TBO's) play key role. Tree borne oilseeds, a minor forest produce, can significantly contribute to avert this situation. Most of these TBOs are abundantly found in forest and non-forest areas but are scattered and are not properly collected, what so ever collected is of poor quality due to the lack of awareness. Tree Borne Oilseeds as potential value, the major source of bio-diesel and renewable liquid fuels in India is non-edible oil seeds and the technology for its production is indigenously available and have proven to be good substitutes for oil (21 to 73 %) in the energy sector, a solution for problems like environmental degradation, restricting imports, rural employment and agricultural economy. India has about 10 TBO varieties, which include Simarouba (*Simarouba glauca*), Melia (*Melia azedarach* and *Melia dubia*), Sal (*Shorea robusta*), Neem (*Azadirachta indica*), Mahua (*Madhuca longifolia* and *Madhuca latifolia*), Calophyllum (*Calophyllum inophyllum*), Karanj(*Pongamia pinnata*) and Kokum (*Garcinia indica*). The production potential for bio-diesel is nearly 20 mt per annum. Only a few million tonnes have been utilized (due to lack of demand).

Tree borne oilseeds (TBO's) are gaining importance as a supplementary source of oil for food, fodder,fuel and industrial applications. All products of forests excluding timber have been traditionally classified as Non Timber Forest Produce (NTFP) or Minor Forest Produce (MFP). In addition to sources of oils and fats, the products fall into various categories *viz.,* medicinal plants, essential oils, spices, gums, resins, fibers, dyes etc. which may be used locally by the tribal's / forest dwellers. Tree borne oilseeds which form an important NTFP are region specific depending on the species supported in the particular agro-climatic zone. In order to prevent over exploitation and ensure sustainable supply, the alternative is to additionally raise them as plantations or in various agroforestry systems.

The establishment of a successful agroforestry system with tree borne oilseeds as a component begins with the selection of the tree species. Around 300 tree species bearing oleaginous seeds have been reported in literature (Tyagi and Kakkar, 1991; Bringi, 1987). Popular species grown in agroforestry are economically important for timber and related products primarily to meet various farm requirements or supplement income in case of surplus production. In contrast to species raised for firewood, fodder *etc*., where coppicing and lopping of trees is practiced, tree borne oilseeds need to be allowed to grow undisturbed to allow for timely flowering and fruiting. In recent years, the focus of research has been on evaluating and propagating tree borne oilseeds for biofuels with emphasis on species like Pongamia, Neem, Mahua, Callophyllum, Simarouba and Melia with suitability for agroforestry primarily as border or sole plantations (Sudhakara Babu *et al.*, 2008).

2. Material and Methods

The experiment was conducted at Agroforestry unit, ZARS, GKVK, University of Agricultural Sciences, Bengaluru situated in the Eastern Dry Zone (Zone – 5) of Karnataka. The soil of the experimental site was red sandy clay loam with neutral pH, medium in available nitrogen, phosphorus and potassium. The experiment was laid out in completely randomized block design with seven treatments which are replicated thrice. The tree borne oilseeds (TBO) like *Simarouba glauca*, *Melia azedarach, Melia dubia*, *Azadirachta indica*, *Madhuca latifolia*, *Calophyllum inophyllum* and *Pongamia pinnata* are planted during 2008. Observations on various silvicultural parameters to assess the growth and yield of TBOs were recorded from five randomly selected trees from each replication. Observations were taken at two directions *i.e*. towards north and south and of tree rows and at a distance of 0 to 2.5 m from the base of each tree. The total height of the tree was measured using Ravi's multimeter. The diameter at breast height was measured with steel calliper at 1.37 m above the base of the tree. Bole height was taken from base of the tree till branching of the tree. Canopy spread was measured at east – west and north – south directions using measuring tape. Tree carbon stock was estimated by reducing the total biomass of the tree to 50 per cent (Pearson *et al*., 2005) or by multiplying the total biomass of tree with 0.5 (Mac Dicken, 1997). Soil organic carbon stock (Broos and Baldock, 2008) and total wood volume (by using quarter girth formula) was calculated by using the following equation.

Soil organic carbon (t ha^{-1}) = Depth (cm) x Bulk Density (g cm^{-3}) x Organic Carbon (%)

Total wood Volume (m^3) = (Girth of log at the middle/4)^2 x Length of log

The experimental data was subjected to Fisher's method of "Analysis of Variance" (ANOVA) as outlined by Panse and Sukhatme (1954). All the data were analysed and the results were presented and discussed at a probability level of 5 per cent.

3. Results and Discussion

The results showed that, the significantly higher tree height was observed in *Melia dubia* (12.54 m, 13.22 m and 12.88 m, respectively) followed by *Melia azedarach* (10.33 m, 10.98 m and 10.65 m, respectively) and *Azadirachta indica* (9.24 m, 10.32 m and 9.78 m, respectively). With respect to bole height, *Melia dubia* (4.85 m, 5.13 m and 4.99 m, respectively) recorded significantly higher bole height followed by *Melia azedarach* (4.07 m, 4.16 m and 4.11 m, respectively) and *Simarouba glauca* (3.43 m, 3.98 m and 3.70 m, respectively) during 2019, 2020 and pooled, respectively (Table. 1). The significant difference observed in tree height of different species was ascribed to growth habit and their aptness to local agro-ecological conditions and the results are in accordance with the findings of Kaushik *et al*, (2015) and Vaidya and Naik (2018).

In case of girth at breast height (GBH), significantly higher data was recorded under *Melia dubia* based agroforestry system (113.28 cm, 114.84 cm and 114.06 cm, respectively) followed by *Simarouba glauca* (87.38 cm, 88.34 cm and 87.83 cm, respectively) and *Pongamia pinnata* (75.54 cm, 76.41 cm and 75.97 cm, respectively). Significantly higher collar diameter recorded with *Melia dubia* (116.82 cm, 139.29 cm and 128.05 cm, respectively) followed by *Simarouba glauca* (92.10 cm, 94.84 cm and 93.47 cm, respectively) and *Melia azedarach* (63.58 cm, 89.23 cm and 76.40 cm, respectively) during 2019, 2020 and pooled, respectively (Table 1). The considerable difference observed in GBH of different tree species was attributed to the existing agro-ecological conditions and species specificity.

Significantly higher canopy spread towards North-South and East-West direction was recorded with *Melia dubia* based agroforestry system (14.37 m, 11.81 m, 14.79 m, 11.93 m, 14.58 m and 11.87 m, respectively) followed by *Simarouba glauca* (8.76 m, 8.32 m, 8.84 m, 8.39 m, 8.80 m and 8.36 m, respectively) and *Pongamia pinnata* (7.62 m, 7.38 m, 7.87 m, 7.46 m, 7.75 m and 7.42 m, respectively) in 2019, 2020 and pooled. Least canopy spread was observed with *Canophyllum inophyllum* (2.96 m, 2.59 m, 3.59 m, 2.67 m, 3.28 m and 2.63 m, respectively). The difference noticed in canopy spread was ascribed to different growth pattern which depends on individual species and the influence of agro-ecological conditions.

The total tree volume differed significantly amidst different tree species. Higher wood volume was recorded with *Melia dubia* based agroforestry system in 2019, 2020 and pooled (217.84 m^3 ha^{-1}, 368.2 m^3 ha^{-1} and 293.02 m^3 ha^{-1}, respectively) followed by *Simouba glauca* and *Melia azedarach*. Least wood volume was recorded with *Calophyllum inophyllum* (9.58 m^3 ha^{-1}, 55.22 m^3 ha^{-1} and 32.40 m^3 ha^{-1}, respectively) (Table 2). The difference observed in average tree volume of different tree species was due to their different growth habit, internal vigour and the prevailing agro-ecological conditions (Kimaro *et al.*).

The above ground biomass of tree differed significantly among different tree species (Table 3). *Melia dubia* recorded significantly higher above ground biomass during 2019, 2020 and pooled respectively (65.07 t ha^{-1}, 67.84 t ha^{-1} and 66.45 t ha^{-1}, respectively). This was followed by *Azadirachta indica* (23.40 t ha^{-1}, 26.04 t ha^{-1} and 24.72 t ha^{-1}, respectively) and *Simarouba glauca* (21.57 t ha^{-1}, 24.79 t ha^{-1} and 23.18 t ha^{-1}, respectively) which were on par with each other. Significantly lower above ground biomass was noticed in *Calophyllum inophyllum* with (4.03 t ha^{-1}, 1.93 t $ha^{-1}$and 4.98 t ha^{-1}, respectively). The significant difference observed in above ground biomass of different tree species was ascribed to growth habit and their aptness to local agro-ecological conditions. The higher above ground biomass in *Melia dubia* agroforestry system was attributed to significantly higher GBH, wider canopy spread and vigorous growth. The results were in conformity with the findings of Subedi (2004) and Verma *et al*. (2006).

Significantly higher below ground biomass was recorded in *Melia dubia* based agroforestry system(15.42 t ha^{-1}, 17.63 t ha^{-1} and 16.52 t ha^{-1}, respectively) in 2019, 2020 and pooled respectively. Which was followed by *Azadirachta indica* (5.84 t ha^{-1}, 6.77 t ha^{-1}

and 6.31 t ha^{-1}, respectively) and *Simarouba glauca* (5.01 t ha^{-1}, 6.44 t ha^{-1}and 5.75 t ha^{-1}, respectively) which were on par with each other. Significantly lower below ground biomass was noticed in *Calophyllum inophyllum* (1.98 t ha^{-1}, 2.50 t ha^{-1}and 2.24 t ha^{-1}, respectively). The significant difference noticed in below ground biomass among different tree species was attributed to growth habit, above ground biomass, root system and suitability to agro-ecological conditions. The higher below ground biomass in *Melia dubia* was attributed to significantly higher above ground biomass, deep root system and vigorous growth. Similar results were observed by Woomer and Palm (1998).

The total biomass of tree differed significantly among different tree species. Significantly higher total biomass of tree was recorded by *Melia dubia* (80.49 t ha^{-1}, 85.47 t ha^{-1}and 82.98 t ha^{-1}, respectively). Next in the order was *Azadirachta indica* (29.24 t ha^{-1}, 32.81 t ha^{-1} and 30.61 t ha^{-1}, respectively) and *Simarouba glauca* (26.58 t ha^{-1}, 31.23 t ha^{-1}and 29.32 t ha^{-1}, respectively). Lower total biomass of tree was noticed in *Calophyllum inophyllum* (6.01 t ha^{-1}, 8.43 t ha^{-1} and 7.22 t ha^{-1}, respectively). The total biomass of tree differed significantly among different tree species due to their growth habit of species, age of trees and suitability to agro-ecological conditions. The higher total biomass in *Melia dubia* is attributed to significantly higher GBH, wider canopy spread, dense foliage and vigorous growth. The results were in similarity with the findings of Roy *et al*. (2006) and Ahmedin *et al*. (2013).

The tree carbon stock of different tree species differed significantly (Table 18). The above ground carbon stock was significantly higher in *Melia dubia* based agroforestry system (40.93 t ha^{-1}, 42.73 t ha^{-1} and 41.83 t ha^{-1}). This was followed by *Azadirachta indica* (15.43 t ha^{-1}, 16.40 t ha^{-1} and 15.91 t ha^{-1}, respectively) and *Simarouba glauca* (13.56 t ha^{-1}, 15.61 t ha^{-1} and 14.58 t ha^{-1}, respectively). Significantly lower tree carbon stock was witnessed in *Calophyllum inophyllum* (2.99 t ha^{-1}, 3.21 t ha^{-1} and 3.10 t ha^{-1}, respectively). The significant difference witnessed in tree carbon stock of different tree species depended on region, species, age of tree and previous land-use pattern. *Melia dubia* sequestered considerable quantity of atmospheric carbon because of more biomass accumulation and vigorous growth (Fig 11). Similar results were obtained by Oelbermann *et al.* (2004), Jana *et al*. (2009), Chavan and Rasal (2010), Hangarge *et al*. (2012), Mangalassery *et al.*(2014), Mitra *et al.* (2015) and Ganguly and Mukherjee (2016).

A significant difference was noticed in soil organic carbon stock among different tree species, *Pongamia pinnata* recorded significantly higher soil organic carbon stock (30.47 t ha^{-1}, 31.35 t ha^{-1} and 30.91 t ha^{-1}, respectively) followed by *Melia dubia* (29.16 t ha^{-1}, 30.41 t ha^{-1} and 29.78 t ha^{-1}, respectively) which was on par with *Pongamia pinnata.* Significantly lower soil organic carbon stock was found in *Calophyllum inophyllum* (21.68 t ha^{-1}, 22.33 t ha^{-1} and 22.0 t ha^{-1}, respectively). The total soil organic carbon stock varied significantly depending on region, species, soil quality and previous land-use pattern .*Pongamia pinnata* and *Melia dubia* accumulated considerable quantity of soil organic carbon because of litter fall, fast decomposition rate and vigorous growth. These results are in accordance with Makumba *et al*. (2007), Takimoto *et al*. (2008), Ahmedin *et al*. (2013) and Dhyani *et al.* (2016).

The economic seed yield is obtained after 8 years in *Melia dubia, Melia azedarach* and *Calophyllum inophyllum* with average yield of 13 kg tree^{-1}, 12 kg tree^{-1} and 45 kg tree^{-1} respectively (Table 4) with oil percentage of 21, 23 and 60 respectively. In case of *Pongamia pinnata* and *Azadirachta indica* economic seed yield is obtained after five years of planting with 28 kg and 18 kg average yield per tree and 28 and 22 per cent oil, respectively. Whereas, *Simarouba glauca* found to be early yielder with average seed yield of 45 kg tree^{-1} and 62 oil per cent and *Madhuca longifolia* is late bearer after ten years of planting with 25 kg tree^{-1} average seed yield and oil per cent of 33. The results are in accordance with the work of Dhyani *et al.* (2016).

4. Conclusions

Based on the TBO's growth traits analysis, *Melia dubia* recorded significantly higher tree height, GBH, wood volume and canopy spread as against other tree species. The performance of *Simarouba glauca, Azadirachta indica and Pongamia pinnata* were better compared to *Calophyllum inophyllum* and *Madhuca latifolia* whose growth and yield was poor. The higher oil per cent was recorded with *Simarouba glauca* and *Calophyllum inophyllum* over *Madhuca longifolia, Pongamia pinnata, Melia azedarach*, *Azadirachta indica* and *Melia dubia.*

References

[1].AHMEDIN, A. M., SURENDRA, B., SIRAJ, T. M., RAJU, A. J. S., 2013, Assessment of biomass and carbon sequestration potentials of standing *Pongamia pinnata* in Andhra University, Visakhapatnam, India. *Biosci. Disc*., **4**(2):143-148.

[2].BRINGI, N.V. 1987. Non-Traditional Oilseeds and Oils in India. Oxford and IBH Pub Co.

[3].BROOS, K. AND BALDOCK, J., 2008, Building soil carbon for productivity and implications for carbon accounting, in 2008 South Australian GRDC Grains Research Update.

[4].CHAVAN, B, L. AND RASAL, G. B., 2010, Sequestered standing carbon stock in Selective tree species grown in University campus at Aurangabad, Maharashtra, India. *International Journal of Engineering Science and Technology*, **2**(7):3003-3007.

[5].DHYANI, S. K., 2014, National Agroforestry Policy 2014 and the need for area estimation under agroforestry. *Current Science,* **107**(1): 9–10.

[6].GANGULY, S. AND MUKHERJEE, A., 2016,A census of the tree species in the Golapbag campus of Burdwan university, West Bengal (India) with their IUCN red list status and carbon sequestration potential of some selected species. *Indian J.Sci.Res*.,**7**(1): 67-75.

[7].HANGARGE, L. M., KULKARNI,D. K., GAIKWAD,V. B., MAHAJAN, D. M. AND CHAUDHARI, N., 2012, Carbon Sequestration potential of tree species in Somjaichi Rai (Sacred grove) at Nandghur village, in Bhor region of Pune District, Maharashtra State, India. *Annals of Biological Research,* (7): 3426-3429.

[8].JANA, K. R., BISWAS, S., MAJUMDAR, M.,PANKAJ, K. R., ROY AND MAZUMDAR, A., 2009, Carbon sequestration rate and above ground biomass carbon potential of four young species. *J. Eco & Environ*., 2: 15-24.

[9].KAUSHIK, N., DESWAL,R. P. S., KUMAR, K., MALIK, S., KUMARI, S., 2015, Performance of *Pongamia pinnata* Progenies under Semi-Arid Conditions. *Environment & Ecology*,**33**(2A): 943—945.

[10]. KIMARO, A. A., TIMMER, V. R., CHAMSHAMA, S. A. O., MUGASHA, A. G. AND KIMARO, D.A., 2008, Differential response to tree fallows in rotational woodlot systems in semi-arid Tanzania: Post-fallow maize yield, nutrient uptake AND soil nutrients. *Agric. Ecosyst. Envi*., 125: 73-83.

[11]. MAC DICKEN., 1997, A guide to monitoring carbon storage in forestry and agroforestry, forest carbon monitoring programme. Winrock publications., New York, pp: 1-87.

[12]. MAKUMBA, W., AKKINIFER,F.K., JANNSON, B. AND ONEMA,O., 2007, Long term impact of *glyricidia*- maize intercropping system on carbon sequestration in Southern Malawai. *Agric. Ecosyst. & Envi*., **118**(1-4): 237-243

[13]. MANGALASSERY, S., DAYAL, D., MEENA, S. L., RAM, B., 2014, Carbon sequestration in agroforestry in pasture systems in arid north-western India. *Curr. Sci.* 107:1290–1293.

[14]. MITRA, A.,BAGCHI, J., THAKUR, S., PARKHI, U. S., DEBNATH,

S.,PRAMANICK, P., ZAMAN, S., 2015, Carbon sequestration in Bhubaneswar City of Odisha, India. *International Journal of Innovative Research in Science, Engineering and Technology,***4**(8): 2347-6710.

[15]. OELBERMANN, M., VORONEY, K. P. AND GORDON, A. M., 2004, Carbon sequestration in tropical and temperate agroforestry system: a review with examples from Coasta Rica and Southern Canada. *Agric. Ecosyst. Envi*., 104: 359-377.

[16]. PANSE, V. G. AND SUKHATME, P. V., 1954, Statistical methods for agricultural workers. ICAR publication, New Delhi. Pp.359.

[17]. PEARSON, T. R. H., BROWN, S., RAVINDRANATH, N. H. 2005, Integrating carbon benefits estimates into GEF Projects: 1-56.

[18]. ROY, M. M., PATHAK, P. S., RAI, A. K. AND KUSHWAHA, D. 2006, Tree growth and biomass in *Melia azadirach* on farm boundaries in a semi-arid region. *Indian Forester*, **132**(1): 100-105.

[19]. SUDHAKARA BABU, S. N., SUJATHA, M. AND RAO, G. R. 2008. Non-edible oil-seed crops for biofuel production: Prospects and challenges In: J. Keith Syers, David Wood, and Pongmanee Thongbai (Eds) Proceedings of the International Technical Workshop on the Feasibility of Non-edible Oil Seed Crops for Biofuel Production May 25-27, 2007, Mae Fah Luang University, Chiang Rai, Thailand. Pp 24-38.

[20]. TAKIMOTO, A., NAIR, P, K, R. AND NAIR. V, D., 2008, Carbon stock and sequestration potential of traditional and improved agroforestry systems in West African Sahel. *Agric. Ecosyst. Envi*., 125: 159-166.

[21]. TYAGI, P. D. AND KAKKAR, K. K. 1991. Non conventional vegetable oils. Batra Book Service, New Delhi. Pp 94-211

[22]. VAIDYA, G. R. AND NAIK., 2018, Comparative Evaluation of Bioproductivity Studies of *Simarouba, Pongamia* and *Jatropha* for Biodiesel Parameters. *Int. J. Cur. Res. Rev*.,**10**(5): 2231-2196.

[23]. WOOMER, P. L., PALM, C. A., ALEGRE, J., CASTILLA, C., CORDEIRO, D. G., HAIRIAH, K., KOTTO-SAME, J., MOUKAM, A., RICSE, A., RODRIGUES, V., VAN NOORDWIJK, M., 2000, Slash-and-burn effects on carbon stocks in the humid tropics. Global Climate Change and Tropical Ecosystems. Advances in Soil Science, CRC Press, Boca Raton, FL, USA. pp. 99–115.

[24]. SUBEDI, M. 2004, Above ground biomass of *Quercus semecarpifolia* Sm. Forest surveyed on natural and seminatural stands in Nepal. *Indian. Forester*., **130**(8): 858-866.

[25]. VERMA, K. S., NAYAK, B. K., MISHRA, V.K. AND BHARADWAJ., 2006, High density energy plantations: A comparison of growth responses of three species at different planting densities. *Ann. For*., **14**(2): 206-212.

Table 1: Tree height, Bole height, Girth at breast height and Collar diameter of different tree borne oilseed species established under agroforestry system 2019 & 2020.

Tree species	Tree height (m)			Bole height (m)			GBH (cm)			Collar diameter (cm)		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
Simarouba glauca	9.3	9.51	9.40	3.43	3.98	3.70	87.32	88.34	87.83	92.11	94.84	93.47
Melia dubia	12.54	13.22	12.88	4.85	5.13	4.99	113.28	114.84	114.06	116.82	139.29	128.05
Azadirachta indica	9.24	10.32	9.78	3.29	3.78	3.53	67.08	68.16	67.62	72.92	78.99	75.95
Melia azedarach	10.33	10.98	10.65	4.07	4.16	4.11	61.16	62.14	61.65	63.58	89.23	76.40
Pongamia pinnata	6.08	6.97	6.52	2.53	2.84	2.68	75.54	76.41	75.97	79.57	72.14	75.85
Madhuca latifolia	5.88	6.54	6.21	3.14	3.25	3.19	62.94	63.87	63.40	79.14	77.28	78.21
Calophyllum inophyllum	4.88	5.49	5.18	2.58	2.64	2.61	32.52	33.47	32.99	48.09	41.55	44.82
S.Em±	**1.85**	**1.24**	**1.54**	**0.43**	**0.87**	**0.65**	**3.12**	**2.87**	**2.99**	**3.84**	**4.44**	**4.14**
CD at 5%	**5.52**	**3.59**	**4.55**	**1.28**	**2.52**	**1.9**	**9.36**	**8.61**	**8.98**	**6.19**	**13.32**	**9.75**

Table 2: Canopy spread and Wood volume of different tree borne oilseed species established under agroforestry system 2019 & 2020.

Tree species	Canopy spread (m)						Wood volume (m^3)			Wood volume (ha^{-1} m^3)		
	2019		2020		Pooled		2019	2020	Pooled	2019	2020	Pooled
	N-S	E-W	N-S	E-W	N-S	E-W						
Simarouba glauca	8.76	8.32	8.84	8.39	8.80	8.36	0.1635	1.0987	0.6311	91.56	219.74	155.65
Melia dubia	14.37	11.81	14.79	11.93	14.58	11.87	0.3890	1.8410	1.1150	217.84	368.2	293.02
Azadirachta indica	6.10	5.41	7.03	6.22	6.57	5.82	0.0925	0.8051	0.4488	51.80	161.02	106.41
Melia azedarach	6.83	6.14	7.94	6.25	7.39	6.20	0.0952	0.8078	0.4515	53.31	161.56	107.44
Pongamia pinnata	7.62	7.38	7.87	7.46	7.75	7.42	0.0902	0.6781	0.3842	50.51	135.62	93.07
Madhuca latifolia	3.80	3.90	4.57	4.11	4.19	4.01	0.0777	0.6487	0.3632	43.52	129.74	86.63
Calophyllum inophyllum	2.96	2.59	3.59	2.67	3.28	2.63	0.0171	0.2761	0.1466	9.58	55.22	32.40
S.Em±	**0.71**	**0.66**	**0.91**	**0.87**	**0.82**	**0.79**	-					
CD at 5%	**2.14**	**1.69**	**2.64**	**2.52**	**2.35**	**2.13**						

Table 3: Biomass of tree, Tree carbon stock and Soil organic carbon stock of different tree borne oilseed species established under agroforestry system 2019 & 2020.

Tree species	Above ground biomass (t ha^{-1})			Below ground biomass (t ha^{-1})			Total tree biomass (t ha^{-1})			Tree carbon stock (t ha^{-1})			Soil organic carbon stock (t ha^{-1})		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
Simarouba glauca	21.57	24.79	23.18	5.01	6.44	6.14	26.58	31.23	29.32	13.56	15.61	14.585	26.51	28.67	27.59
Melia dubia	65.07	67.84	66.455	15.42	17.63	16.525	80.49	85.47	82.98	40.93	42.73	41.83	29.16	30.41	29.785
Azadirachta indica	23.4	26.04	24.72	5.84	6.77	5.89	29.24	32.81	30.61	15.43	16.4	15.915	25.66	26.73	26.195
Melia azedarach	17.32	19.09	18.205	3.19	4.97	4.08	20.51	24.06	22.285	11.19	12.02	11.605	28.54	27.47	28.005
Pongamia pinnata	14.56	15.34	14.95	2.23	3.98	3.105	16.79	19.32	18.055	8.42	9.66	9.04	30.47	31.35	30.91
Madhuca latifolia	13.11	14.46	13.785	2.46	3.76	3.11	15.57	18.22	16.895	8.42	9.11	8.765	22.65	24.12	23.385
Calophyllum inophyllum	4.03	5.93	4.98	1.98	2.5	2.24	6.01	8.43	7.22	2.99	3.21	3.1	21.68	22.33	22.005
S.Em±	**0.66**	**0.72**	**0.68**	**0.28**	**0.19**	**0.27**	**0.69**	**0.91**	**0.78**	**0.63**	**0.46**	**0.52**	**0.61**	**0.72**	**0.64**
CD at 5%	**1.82**	**2.23**	**1.84**	**0.75**	**0.58**	**0.7**	**1.77**	**2.81**	**2.02**	**1.6**	**1.4**	**1.49**	**1.77**	**2.24**	**1.71**

Table 4: Flowering, harvesting season and yield parameters of Tree Borne oilseed crops

Plants	***Melia dubia***	***Melia azedarach***	***Pongamia pinnata***	***Azadirachta indica***	***Madhuca longifolia***	***Simarouba glauca***	***Calophyllum inophyllum***
Flowering season	March-April	March-April	March-May	March-May	March-April	December-February	April-September
Harvesting season	December-January	December-January	January-March	June-November	June-August	February-April	October-December
Yield starts from	8 years	8 years	5 years	5 years	10 years	4 years	7-8 years
Seed yield (kg tree^{-1})	13	12	28	18	25	25	45
Oil percent	21	23	28	22	33	62	60