The Pharma Innovation Journal 2023; 12(5): 2559-2563

www.ThePharmaJournal.com

The Pharma Innovation

**ISSN (E): 2277-7695**
**ISSN (P): 2349-8242**
**NAAS Rating: 5.23**
TPI 2023; 12(5): 2559-2563

www.thepharmajournal.com
Received: 19-03-2023
Accepted: 24-04-2023

**P Hemalatha**
Associate Professor (Horticulture), Forest College and Research Institute, Mettupalayam, Tamil Nadu, India

**P Rajendran**
Professor (Forestry), Forest College and Research Institute, Mettupalayam, Tamil Nadu, India

**R Ravi**
Assistant Professor (Forestry), Forest College and Research Institute, Mettupalayam, Tamil Nadu, India

**M Vijayabhama**
Associate Professor (Statistics), Department of Physical Sciences and Information Technology, TNAU, Coimbatore

**I Sekar**
Professor (Forestry), Forest College and Research Institute, Mettupalayam, Tamil Nadu, India

**Corresponding Author:**
**P Hemalatha**
Associate Professor (Horticulture), Forest College and Research Institute, Mettupalayam, Tamil Nadu, India

# Assessment of suitability of vegetable cluster bean genotypes for *Melia dubia* based agroforestry system

**P Hemalatha, P Rajendran, R Ravi, M Vijayabhama and I Sekar**

**Abstract**
The main objective of the project is to explore the possibilities of integrating cluster bean under *Melia dubia* based agroforestry model to provide small and marginal farmers a new potential vegetable crop to diversify cropping and achieve sustainability. The experiment was carried out at Department of Agroforestry, Forest College and Research Institute, Mettupalayam during 2019-2022 with three vegetable cluster bean varieties *viz.*, MDU 1, Pusa Navbahar and Sonali under three different ecosystems *viz.*, open field conditions, under 3 years old *Melia dubia* and 6 years old *Melia dubia.* The morphological parameters *viz.*, plant height (107.3%) and leaf area index (1.53) were registered highest in cluster bean variety MDU 1 under open condition. The pod yield (11.58 t/ha) and quality parameters *viz.*, crude protein (16.94%), ash (3.40%) and dry matter (20.10%) content were recorded higher in MDU 1 variety under open condition. Under all the ecosystems, the soil nutrient status was stable after the harvest of cluster bean. In addition, the cost benefit ratio was comparatively higher in MDU 1 cluster bean variety raised under 3 years old *Melia dubia* ecosystem (1.73) which indicates the amenability for cultivating MDU 1 cluster bean variety as intercrop under Melia dubia ecosystems upto 3 years of planting of the perennial crop.

**Keywords:** Cluster bean, varieties, ecosystems, intercrop, yield

## Introduction
Agroforestry involves woody and non woody components simultaneously or sequentially on the same land management unit. The success towards ecologically and economically sound agroforestry systems lies in identification of compatible tree-crop units under varying spatial arrangements and limited solar energy available underneath. Further, adoption and outreach of such practices depends on the multi-purpose outputs provided and their market potential. Agroforestry can reduce vulnerability, enhance the resilience of farming systems and also can buffer household activities against climate-related risks (Dhyani 2014) [7]. The choice of intercrop depends on characteristics of particular woody component like root system, canopy architecture, allelopathic effect of litter along with edapho-climatic conditions (Batish *et al.*, 2007) [3]. The interaction of cropping between woody and non-woody components is a success key of agroforestry systems (Rao *et al.*, 1998) [22]. *Melia dubia* is one such species, commonly known as Malabar neem or Burma neem. Planting *Melia dubia* which fetch a handsome price in the market, assured buyback, and require low maintenance expenditure may help in this regard. In addition, the trees also aid the planet by preventing temperature rise and checking gas emission into the atmosphere. *Melia dubia* is a fast growing, indigenous and economically important multipurpose tree species that grows naturally in certain parts of the Western Ghats of South India. The species has been reported to have transient or null allelopathic effect on understorey crops hence could be a promising agroforestry ideotype. The industrial and ecological importance of Melia has allowed farmers to take large scale plantations with different intercrops (Parthiban *et al.*, 2009) [18]. It has been reported that *M. dubia* based agroforestry systems are profitable than that of monocropping systems (Anusha, 2012 [2], Jilariya *et al.*, 2019 [10]; Mohanty *et al.*, 2017 [14]).
Cluster bean (*Cyamopsis tetragonoloba* L.) commonly known as guar, is cultivated mainly as rainfed crop in arid and semi-arid regions during rainy season. It is used as vegetable, forage, green manure and also for the water soluble gum. It is a rich source of protein, fats, carotenes, P, Ca and mineral salts needed in foods for human beings, feeds and fodder for animals, which contains 42% crude protein as well as seeds contain 29 to 31.4 per cent gum (Kumar and Rodge, 2012) [13]. India is one of the main producers of cluster bean accounting 82% of the total production of the world.

In India, it is mainly grown in Rajasthan, Haryana, Gujarat, Tamil Nadu, Andhra Pradesh, Maharashtra and Punjab. India becomes the leading producer of gaur with 60 pe rcent of the world production followed by Pakistan with 35 per cent (Rao, 2001) [21].

Intercropping of cluster bean with tree species is one of the sustainable practices in agro-forestry. Intercropping of legumes helps to maintain soil fertility status. Agroforestry systems get abundant nutrient stock litter decomposition and mineralization supplies which subsequently increases crop yields. The legumes with their ability to fix atmospheric nitrogen increase the pool of nitrogen available to the crop and usually increase the nitrogen content of the soil for perennial tree crops. Intercropping provides additional income to farmers and prevents soil erosion in alley spaces of tree crops. Intercropping increases efficient use of natural resource as well as applied inputs Collection and evaluation of cluster bean genotypes under *Melia dubia* ecosystems is essential to identify the varieties suitable for partial shade. However, such intercropping studies with Melia are lacking. Considering the above fact, this study is proposed to explore the possibilities of integrating Cluster bean under *Melia dubia* based system which could be a viable option for Melia growing farmers.

## Materials and Method

*Melia dubia* is a fairly large, deciduous and fast growing tree, 20-25 m height and 1.2-1.5 m in girth, with a straight cylindrical bole of about 9-12 m. The tree is leafless for a short period between December to February and new leaves appear during February - March. It is a multipurpose industrial wood species suitable for packing cases, cigar boxes, ceiling planks, building and construction materials, agricultural implements, pencils, matchboxes, splints, catamarans, musical instruments, tea boxes and ply board. It is also a good fuelwood (calorific value: 5,043 - 5,176 cal.). The species has been identified as one of the alternate pulpwood species (Parthiban *et al*. 2009) [18]. Cluster bean grows upright, reaching a maximum height of 2-3m. It has a main single stem with either basal branching or fine branching along the stem. It is relatively tolerant to saline, alkaline, drought condition, gives higher yield under adverse climatic conditions and therefore, preferred by small and marginal farmers.

The seeds of cluster bean varieties *viz.*, Pusa Navbahar (IARI, New Delhi), TNAU MDU 1 and Sonali (Mangaldev Agritech Pvt. Ltd, Agra) were sown as intercrop in 3 years old, 6 years old *Melia dubia* and open field conditions. The trial was conducted at Agroforestry field station, Department of Agroforestry, Forest College and Research Institute, Mettupalayam from 2019 to 2022 to identify the best cluster bean genotype for intercropping under *Melia dubia* plantations. The field experiment was conducted at 'K' block of Forest College and Research Institute, Mettupalayam lying at the foothills of the Nilgiris between 11° 19' and 11°20' N latitude, 76°56' and 76°57' E longitude and at an altitude of 300 m above MSL. The soil of experimental site belongs to Inceptisol (Typic Ustropept), Irugur soil series, sandy loam in texture, red, non calcareous, neutral in reaction, non saline, low in available N and organic carbon and medium in available P and K.

The trail was laid out in factorial randomized block design with three replications. The soil samples were collected before sowing and after harvest of the intercrops and subjected to analysis by following standard procedures.

The observations were recorded on growth parameters *viz*., plant height (cm), number of leaves and leaf area index, repeatedly from five trials to assess the morphological performance of the genotypes. The yield and other quality parameters *viz.*, number of pods per plant, length of pod (cm), width of pod (cm), pod yield per plant (kg), yield per hectare (tones), crude protein (%), ash (%) and dry matter (%) were also recorded. The data recorded during the research was analyzed statistically by the method given by Panse and Sukhatme (1985) [17].

## Results and Discussion

### I. Growth performance of cluster bean genotypes under *Melia dubia* ecosystems

#### i. Plant height (cm)

The morphological parameters *viz.*, plant height (cm), number of leaves and leaf area index of the cluster bean varieties were being observed at 30 Days after sowing (DAS) and 60 DAS. The cluster bean varieties exhibited significant difference in plant height at both 30 DAS and 60 DAS. Among the varieties, the maximum plant height was recorded in MDU 1 (44.89 cm and 84.11 cm) followed by Pusa Navbahar at 30 DAS and 60 DAS respectively (Table 1). Among the ecosystems, the highest plant height was observed under open condition (E1) at 30 DAS (45.02 cm) and 60 DAS (86.78 cm). Among the interaction, the MDU 1 variety raised under open condition has recorded the highest plant height both at 30 DAS (48.77 cm) and 60 DAS (91.83 cm). The probable reason might be due to the more accessibility of light under the open field conditions as compared to intercrops beneath the tree canopy of *Melia dubia*. Similar reduction in growth attributes of intercrops in agroforestry were already reported by Ummah (2012) [27], Habib *et al*. (2012) [9], Rani *et al*. (2015) [20] under Poplar based agroforestry system, Rajalingam *et al.* (2016) [19] and Bhusara *et al.* (2018) [6] for *A. esculentus* under different spacing of *M. composita*

Similar results have been obtained by Ajaykumar *et al*., (2022) [1] in blackgram intercropped with *Melia dubia* based Agroforestry trial. In this study, black gram var. VBN 6 under open condition has recorded the highest plant height (49.96 cm) than black gram var. CO 6.

**Table 1:** Effect of *Melia dubia* ecosystem on plant height of cluster bean genotypes

| Treatments | Plant height (cm) at 30 DAS | | | | Plant height (cm) at 60 DAS | | | |
|---|---|---|---|---|---|---|---|---|
| | MDU1 (V1) | Pusa Navbahar (V2) | Sonali (V3) | Mean | MDU1 (V1) | Pusa Navbahar (V2) | Sonali (V3) | Mean |
| Open Condition (E1) | 48.77 | 46.20 | 40.10 | 45.02 | 91.83 | 86.17 | 82.33 | 86.78 |
| Three years old *Melia dubia* (E2) | 46.73 | 45.30 | 40.87 | 44.30 | 88.83 | 79.50 | 73.97 | 80.77 |
| Six years old *Melia dubia* (E3) | 39.17 | 34.80 | 30.63 | 34.87 | 71.67 | 63.33 | 62.17 | 65.72 |
| Mean | 44.89 | 42.10 | 37.20 | 41.40 | 84.11 | 76.33 | 72.82 | 77.76 |

| | Plant height at 30 DAS | | | Plant height at 60 DAS | | |
|---|---|---|---|---|---|---|
| | E | V | E x V | E | V | E x V |
| SE(d) | 0.217 | 0.217 | 0.376 | 0.953 | 0.953 | 1.649 |
| CD(0.05%) | 0.461 | 0.461 | 0.798 | 2.019 | 2.019 | 3.497 |

**ii. Leaf Area Index (LAI)**

Significant difference among the cluster bean varieties was exhibited for leaf area index at both 30 and 60 DAS. Among the varieties, the maximum leaf area index (0.80) was observed in MDU 1 (V1). The LAI registered by MDU 1 was found on par with Pusa Navbahar (0.76) (V2). Among the ecosystems, the maximum number of leaves was observed under open condition (E1) at 30 days after sowing (10.44) and 60 DAS (13.44). The number of leaves in E1 at 30 DAS was found on par with E2 (10.22). The maximum LAI was recorded in MDU 1 variety raised under open condition (1.47) (Plate 1). The similar reduction in growth attributes of intercrops in agroforestry was recorded by Rani *et al.* (2015) [20] and Rajalingam *et al.* (2016) [19]. Thakur *et al.* (2020) [24] also obtained the similar result in lemon grass under *Melia dubia* based silvi-medicinal systems.

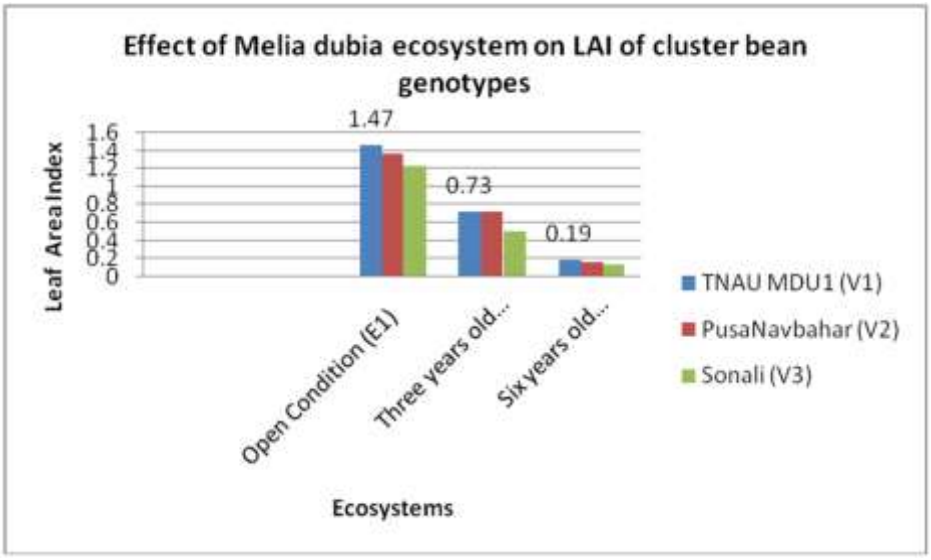


**Plate 1:** Effect of *Melia dubia* ecosystem on Leaf Area Index (LAI) of cluster bean genotypes

**II. Yield and Quality parameters of cluster bean genotypes under *Melia dubia* ecosystems**

**Yield parameters**

The yield characters exhibited significant difference among the treatments. The yield per plot (6 sq.m) (6.95 kg) and yield per heactare (11.58 tonnes) were recorded higher in MDU 1 variety under open condition (V1E1) (Table 2). The absence of interspecific competition for critical resources like moisture, nutrients and photosynthetically active radiation seems to favour better growth of solecrops relative to agroforestry (Thakur and Vaishnu Dutt, 2007) [25]. Similar reduction in growth and yield contributing attributes of intercrops in agroforestry were reported in past by Ummah (2012) [27], Habib *et al.* (2012) [9], Rani *et al.* (2015) [20] under Poplar based agroforestry system and Rajalingam *et al.* (2016) [19] and Bhusara *et al.* (2018) [6] for *A. esculentus* under different spacing of *M. composita*.

In addition, the yield reduction in pulses in intercropping with trees was also reported by Bhusara *et al.* (2018) [7], Pandey *et al.* (2019) [16] and Nandal and Hooda (2005) [15]. *Faidherbia albida* with pulses reported that grain yield is black gram in lower canopy density than the monocrops and higher canopy density, which support that if canopy is properly managed the yield reduction in intercropping with trees can be reduced (Korwar and Pratibha, 1999) [12].

However, the yield recorded under open condition was found on par with the yield obtained under 3 years old *Melia dubia* ecosystem. Dutt and Thakur (2004) [8] reported that net returns were comparatively more under agroforestry systems by combining *Ocimum sanctum* and *Tagetes minuta* with poplar at different spacing in comparison to mono-cropping.

**Table 2:** Effect of *Melia dubia* ecosystem on yield of cluster bean genotypes

| Treatments | Yield/ha (tonnes) | | | |
|---|---|---|---|---|
| | MDU 1 (V1) | Pusa Navbahar (V2) | Sonali (V3) | Mean |
| Open Condition (E1) | 11.58 | 10.61 | 9.34 | 10.51 |
| Three years old *Melia dubia* (E2) | 10.15 | 9.28 | 7.86 | 9.10 |
| Six years old *Melia dubia* (E3) | 7.10 | 6.89 | 6.09 | 6.70 |
| Mean | 9.61 | 8.93 | 7.77 | 8.77 |

| | Yield / ha (tonnes) | | |
|---|---|---|---|
| | E | V | E x V |
| SE(d) | 0.219 | 0.219 | 0.380 |
| CD (0.05%) | 0.465 | 0.465 | 0.805 |

**Quality parameters**

Significant difference among the treatments was exhibited for all the quality parameters. Among the varieties, the maximum crude protein, ash and dry matter contents were recorded in V1 (MDU 1) (16.15 %, 3.15 % and 19.90 % respectively). Among the interactions with the ecosystems, the treatment E1V1 (cluster bean raised under open condition) had registered the highest crude protein (16.94%), ash (3.40%) and dry matter (20.10%) contents (Table 3 and 4). The similar trend in reduction of dry matter content was observed in oots as intercrops under common vetch (Baxevanos *et al*., 2020) [4].

**Table 3:** Effect of *Melia dubia* ecosystem on pod quality of cluster bean genotypes

| Treatments | Crude Protein (%) | | | | Ash (%) | | | |
|---|---|---|---|---|---|---|---|---|
| | MDU1 (V1) | Pusa Navbahar (V2) | Sonali (V3) | Mean | MDU1 (V1) | Pusa Navbahar (V2) | Sonali (V3) | Mean |
| Open Condition (E1) | 16.94 | 16.71 | 16.20 | 16.62 | 3.40 | 3.10 | 2.84 | 3.11 |
| Three years old *Melia dubia* (E2) | 16.75 | 16.55 | 16.04 | 16.45 | 3.10 | 2.87 | 2.59 | 2.85 |
| Six years old *Melia dubia* (E3) | 14.75 | 14.66 | 14.35 | 14.59 | 2.95 | 2.55 | 2.24 | 2.58 |
| Mean | 16.15 | 15.97 | 15.53 | 15.88 | 3.15 | 2.84 | 2.56 | 2.85 |

| | Crude Protein (%) | | | Ash (%) | | |
|---|---|---|---|---|---|---|
| | E | V | E x V | E | V | E x V |
| **SE(d)** | 0.408 | 0.408 | 0.707 | 0.121 | 0.121 | 0.209 |
| **CD (0.05%)** | 0.865 | 0.865 | 1.499 | 0.256 | 0.256 | 0.444 |

**Table 4:** Effect of *Melia dubia* ecosystem on dry matter content of cluster bean genotypes

| Treatments | Dry matter (%) | | | |
|---|---|---|---|---|
| | MDU 1 (V1) | Pusa Navbahar (V2) | Sonali (V3) | Mean |
| Open Condition (E1) | 20.10 | 19.84 | 18.00 | 19.31 |
| Three years old *Melia dubia* (E2) | 19.90 | 19.55 | 17.20 | 18.88 |
| Six years old *Melia dubia* (E3) | 19.70 | 19.28 | 16.60 | 18.53 |
| Mean | 19.90 | 19.56 | 17.27 | 18.91 |

| | E | V | E x V |
|---|---|---|---|
| SE(d) | 0.802 | 0.802 | 1.390 |
| CD (0.05%) | 1.701 | 1.701 | 2.946 |

**III. Impact of intercropping of cluster bean on soil nutrient status under *Melia dubia* ecosystems.**

Regarding the impact of intercropping on soil nutrient status, the results revealed that after harvest of cluster bean, the available nitrogen content showed slight increasing trend both in the surface (from 212.21 kg/ha to 213.42 kg/ha) and sub-surface soils (207.23 kg/ha to 207.95 kg/ha), compared to the nitrogen level before sowing (Table 5). In all the systems, the soil nutrient status was almost stable after crop harvest; indicating the compatibility of intercrops and their role in maintaining the soil fertility. Similar results of improvement in the nutrient status of soil due to intercropping in an agroforestry have been reported earlier (Bhardwaj *et al.* 2017 [5]; Sirohi and Bangarwa 2017) [23].

The increase in nitrogen content under agroforestry may be due to reason that a high moisture level associated with more moderate temperature in shade may result in a faster rate of mineralization, breakdown of litter, and turnover of N than occurs in full sunlight. Agroforestry provides an approach through which in a very little time organic content could be added by selection of proper nitrogen fixing and fast growing species (Tsufac *et al.*, 2021) [26]. The differential increase in soil OC and available nutrients under various tree species may be owing to variable addition and decomposition of litter fall as well as variable nutrient uptake by the intercrops and the trees (Kaur *et al*., 2017) [11].

**Table 5:** Impact of intercropping of cluster bean under *Melia dubia* ecosystems on soil nutrient status

| Sl. No. | Parameters | Surface soil (0-15 cm) | | Sub-surface soil (15-30 cm) | |
|---|---|---|---|---|---|
| | | Initial | Post-harvest | Initial | Post-harvest |
| 1. | Colour | Red | Red | Red | Red |
| 2. | Texture | Sandy loam | Sandy loam | Sandy loam | Sandy loam |
| 3. | Bulk density (mg/m$^3$) | 1.41 | 1.40 | 1.39 | 1.37 |
| 4. | pH | 8.21 | 8.19 | 8.19 | 8.16 |
| 5. | EC (dSm$^{-1}$) | 0.18 | 0.17 | 0.15 | 0.13 |
| 6. | Organic carbon (%) | 0.78 | 0.75 | 0.75 | 0.72 |
| 7. | Available Nitrogen (kg/ha) | 212.21 | 220.42 | 207.23 | 211.95 |
| 8. | Available Phosphorus (kg/ha) | 13.20 | 14.10 | 10.33 | 10.50 |
| 9. | Available Potassium (kg/ha) | 188.30 | 188.90 | 186.20 | 186.33 |

**Conclusion**

Cluster bean var. MDU 1 has recorded an average yield of 10.15 t/ha under 3 years old *Melia dubia* which is very closer to the yield of cluster bean var. MDU 1 recorded under open condition (11.58 t/ha). During the later stage of the tree growth *ie.*, under 6 years old *Melia dubia* trees, the yield of cluster bean got drastically reduced irrespective of the varieties. Hence, it can be concluded that Cluster bean var.

MDU 1 can be profitably cultivated as an intercrop under *Melia dubia* based Agroforestry system up to 3years of planting of the main crop.

## References


1. Ajaykumar R, Prabakaran P, Sivasabari K. Growth and Yield Performance of Black Gram (*Vigna mungo* L.) under Malabar Neem (*Melia dubia*) Plantations in Western Zone of Tamil Nadu. Legume Research. 2022;45:182-188. DOI: 10.18805/LR-4658.
2. Anusha. Performance of finger millet and carbon sequestration in agroforestry system, M.Sc. Thesis, University of Agricultural Sciences, Bengaluru, 2012, 142.
3. Batish DR, Kohli RK, Jose S, Singh HP. eds., Ecological basis of agroforestry. CRC press; c2007. p. 400.
4. Baxevanos D, Tsialtas IT, Voulgari O, Pankou CI, Vlachostergios D, Lithourgidis AS. Oat genotypic requirement for intercropping with vetch under Mediterranean conditions. The Journal of Agricultural Science. 2020;158(8-9):695-706.
5. Bhardwaj KK, Dhillon RS, Kumari S, Johar V, Dalal V, Chavan SB. Effect of *Eucalyptus* Bund Plantation on Yield of Agricultural Crops and Soil Properties in Semi-Arid Region of India, International Journal of Current Microbiology and Applied Science. 2017;6(10):2059-2065.
6. Bhusara JB, Dobriyal MJ, Thakur NS, Sondarva RL, Prajapati DH. Growth and yield performance of green gram under *Melia composita* plantations. Journal of Pharmacognosy and Phytochemistry. 2018;7:1490-1494.
7. Dhyani SK. National Agroforestry Policy 2014 and the need for area estimation under agroforestry. Current Science. 2014;107(1):9-10.
8. Dutt V, Thakur PS. Bio-economics of cropping systems combining medicinal and aromatic herbs with commercial timber tree species. Indian Journal of Agroforestry. 2004;6:1-7.
9. Habib MA, Mondol MA, Alam Z, Hasan MR, Wadud MA. Interaction Effect of Four Years Old *Xylia dolabriformis* Tree on the Growth and Yield of Summer Vegetables. Journal of Agroforestry and Environment. 2012;6:19-22.
10. Jilariya DJ, Thakur NS Singh N, Gunaga RP. Economics of cultivation of *Melia dubia* Cav.–*Aloe vera* L. silvi-medicinal model. Indian Journal of Agroforestry. 2019;21(2):35-40.
11. Kaur N, Singh B, Gill RIS. Productivity and profitability of intercrops under four tree species throughout their rotation in north-western India. Indian Journal of Agronomy. 2017;62(2):160-169.
12. Korwar GR, Pratibha G. Performance of short duration pulses with African winter thorn (*Faidherbia albida*) in semi-arid regions. Indian Journal of Agricultural Sciences. 1999;69:560-562.
13. Kumar D, Rodge A. Status, scope and strategies of arid legumes research in India-A review. J Food Legum. 2012;25:255-272.
14. Mohanty S, Thakur NS, Gunaga RP, Dobriyal MJ, Desai BS. Value addition in *Cymbopogon* spp. to enhance the financial flows from *Cymbopogon* spp.-*Melia dubia* Cav. based silvimedicinal and sole cropping systems. Indian Journal of Ecology. 2017;44(6):812-816
15. Nandal DPS, Hooda MS. Production potential of some agricultural crops under different spacings of poplar. Indian Journal of Agroforestry. 2005;7(1):16-20.
16. Pandey AK, Gupta VK, Solanki KR. Productivity of neem-based agroforestry system in semi-arid region of India. Range Management and Agroforestry. 2019;31:144-149.
17. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, Publication and Information division; c1985, p. 359
18. Parthiban KT, Bharathi AK, Seenivasan R, Kamala K, Rao MG. Integrating *Melia dubia* in agroforestry farms as an alternate pulpwood species. APA News. 2009;34:3-4.
19. Rajalingam GV, Divya MP, Prabaharan C, Parthiban KT. Performance of vegetable crops under *Ailanthus excelsa* based agroforestry system. Indian Journal of Agroforestry. 2016;18:16-20.
20. Rani S, Rajasekaran A, Benbi DK, Chauhan SK. Cost benefits analysis and yield performance of agricultural crops under poplar and fruit crop in north western zone of Punjab, India. International journal of scientific research. 2015;4:791-793.
21. Rao AO. Status of underutilized crops in Pakistan. Dept. Bot. Univ. Agri, Faisalabad; c2001. p. 1-13.
22. Rao MR, Nair PKR, Ong CK. Biophysical interactions in tropical agroforestry systems. Agroforestry Systems. 1998;38:3-50.
23. Sirohi C, Bangarwa KS. Effect of different spacings of poplar based agroforestry system on soil chemical properties and nutrient status in Haryana, India. Current Science. 2017;113(7):1403-1407.
24. Thakur NS, Mohanty S, Gunaga RP, Gajbhiye NA. *Melia dubia* Cav. Spatial geometries influence the growth, yield and essential oil principles content of *Cymbopogon flexuosus* (Nees Ex Steud.) W. Watson. Agroforest Syst. 2020;94:985-995.
25. Thakur PS, Vaishnu Dutt. Cultivation of medicinal and aromatic plants in Agroforestry for diversification under submarine conditions of Western Himalayas. Ind. Jour. Agrofor. 2007;9(2):67-76.
26. Tsufac AR, Awazi NP, Yerima BPK. Characterization of agroforestry systems and their effectiveness in soil fertility enhancement in the south-west region of Cameroon. Current Research in Environmental Sustainability. 2021;3:100024.
27. Ummah E. Evaluation of the Performance of Bottle Gourd in the Crop Field having Boundary Platation of Mahogoni. M.Sc. Thesis. Department of Agroforestry. BAU. Mymensingh, Bangladesh. 2012, 85.