Eco. Env. & Cons. 30 (July Suppl. Issue) : 2024; pp. (S124-S130)
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ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2024.v30i04s.022

Soil Characteristics of Casuarina, Eucalyptus, Melia and Teak Plantations in Tamil Nadu, India

A.C. Surya Prabha[1*], A. Rajkamal[2], M. Senthivelu[3] and S. Pragadeesh[4]

[1*,2,4]Scientist-D, Silviculture and Forest Management Division, ICFRE-Institute of Forest Genetics and Tree Breeding, Coimbatore 641 002, Tamil Nadu, India
[3]Department of Oilseeds, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India

(Received 22 October, 2023; Accepted 29 December, 2023)

ABSTRACT

Soil is the major source of nutrients for the growth of plants and determining the degree of soil physico-chemical characteristics are very necessary to evaluate the soil fertility. The present investigation was conducted to study the soil properties of important plantations in the Cauvery delta zone of Tamil Nadu. The tree species selected for the study were Casuarina, Eucalyptus, Melia and Teak. Composite soil samples were collected from the selected plantations at three different depths; i.e., 0-15, 15-30 and 30-45 cm. The maximum OC (0.69 %) was recorded in *Casuarina* clonal plantation (CH-5) of > 5 years at 0-15 cm depth. The mean soil pH in selected plantations of the Cauvery delta zone varied from 5.96 ± 0.08 to 7.40 ± 0.08. Nitrogen availability (307.57 kg ha^{-1}) and potassium availability (339.57 kg ha^{-1}) was maximum in >5 years of *Casuarina* clonal plantation (CH-5). The available phosphorus content was high in the surface soils (0-15 cm) of >6 years of *E. camaldulensis* (26.31 kg ha^{-1}). The study has contributed to the understanding of the soil properties in different plantation species of clonal and seedling origin in Tamil Nadu.

Key words: *Soil pH, Organic carbon, Available nutrients, Plantations*

Introduction

A nation's life support systems and the socioeconomic development of its population are greatly influenced by its soils. Soils are the most significant natural resources for society. It provides for the fundamental necessities of humanity by producing food, fibre, and wood. Thus, it is essential for the sustainable use of this unique natural resource to have a thorough grasp of the distribution and range of different soil types as well as their traits, potential, and restrictions. The ecosystem of the forest depends on the soil. It is a complex and diverse medium made up of living things, water, mineral particles, and organic stuff. The characteristics of the soil heavily influence the kinds of plants and animals that sustain the planet's terrestrial biodiversity and its potential for productivity. Geology, geography, and climate all have an impact on the many different types of soil that exist, many of which differ across relatively small areas.

Soil properties vary spatially from a field to a larger regional scale affected by both intrinsic (soil forming factors) and extrinsic factors (soil management practices, fertilization, and crop rotation) (Camberdella and Karlen, 1999). Soil pH, a function of parent material, time of weathering, vegetation and climate, is considered as one of the dominant chemical indicators of soil health, identifying trends in change for a range of soil biological and chemical

([1]*Scientist-D, [2]Project Assistant, [3]Associate Professor, [4]Technical Assistant) functions including acidification, salinisation, crop performance, nutrient availability and cycling and biological activity (Dalal and Moloney, 2000).

Information on distribution, potential and constraints of planted forest soils are essential to design most appropriate soil management systems in order to increase productivity of planted forests. Soil quality is the most important factor in planted forest management decisions. Soils will determine productivity of a particular forest and management strategy. Knowing about soils of planted forests can serve as a basis for forest management decisions, including land acquisition, species selection for planting, site preparation requirements, watershed development, fertilization prescriptions, stand density/composition, and harvest timing, as well as decisions affecting land ownership and use.

In order to assess the soil fertility, it is critical to ascertain the degree of the physico-chemical features of the soil, which is the main source of nutrients for plant growth. pH, clay minerals, cation and anion exchange capacity all affect how nutrients are transformed and made available in soils (Reddy and Reddy, 2010). The rooting and litter fall characteristics of perennial vegetation on roughly the same soil material cause soils to differ spatially from one another in terms of their qualities in relation to changes in vegetation (Balagopalan and Jose, 1993). Plantation forestry enhances soil health by maintaining soil fertility through its extensive and varied organic input into the soil (Kumar *et al.,* 2014; Chaudhari *et al.,* 2015b). It is also known to bring about changes in edaphic, microclimatic, floral, faunal, and other ecosystem components through the bio-recycling of mineral elements, environmental modifications, and changes in floral and faunal composition (Shukla, 2009).

Tree species like Eucalyptus, Casuarina, Teak, and Melia were chosen for the study as they are widely cultivated in India, particularly in Tamil Nadu, for the production of pulpwood, timber, plywood veneer, and other end uses, as well as because tree growers readily accept them as plantation species. Studies on soil characteristics of different plantations *viz,* Eucalyptus, Casuarina, Melia and Teak in the Cauvery delta zone of Tamil Nadu, India are limited. The present study therefore aimed to study the soil characteristics of selected plantations in Tamil Nadu, India.

Materials and Methods

Location and site description

The present study was carried out in the Cauvery delta agro climatic zone of Tamil Nadu. The Cauvery Delta Zone (CDZ) is located in Tamil Nadu's eastern region between latitudes 10°00' and 11°30' north and 78°15' and 79°45' east. Thanjavur, Nagapattinam, Tiruvarur, Tiruchirapalli, Ariyalur, Perambalur, and Pudukkottai are the major districts included in the Cauvery Delta Zone (Fig. 1). At the base of the Cauvery river basin sits this region. The Cauvery delta zone has a total area of 24,943 sq. km. The average annual rainfall in this zone is 1129 mm. The average maximum temperature is 38.6 degrees Celsius in May, and the average low is 21 degrees Celsius in December. Both red loamy and alluvium soils are prevalent in this area. The plantations selected for the study were Eucalyptus (Seedling origin and clone-EC-4), Casuarina (Seedling origin and clone-CH 5), Melia (Seedling origin) and Teak (Seedling origin).

Soil sampling

From among the plantations that were present on

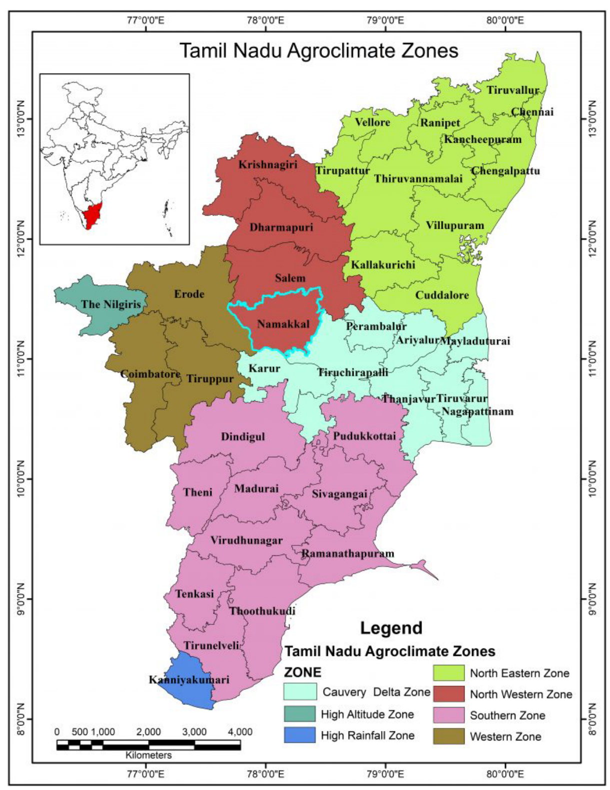

Fig. 1. Map showing the study area

farmlands, the existing stands of three various ages of tree plantations such as Eucalyptus, Casuarina, Melia, and Teak were chosen. Composite soil samples were taken in all the plantations at three distinct depths: 0–15, 15–30, and 30-45 cm. To create a composite sample for each stratum, soil samples were taken in each of the four cardinal directions surrounding the tree. A trench that was 50 cm wide, 50 cm long, and 45 cm deep was excavated at each sampling location, covering an area measuring 0.5 m by 0.5 m. With the aid of a kurpee at each depth, the soil was scraped off of its three sides. The soil was completely mixed before being transferred to a polythene bag and properly labelled. Each sampling point's latitude, longitude, and altitude were recorded via GPS.

Soil characteristics

For physico-chemical examination, the samples were sieved through a 2 mm mesh sieve after being air dried. The soil samples were analysed for the various properties such as pH, Electrical conductivity, organic carbon, Available N, Available P, Available K. The detailed methods are described below. The pH of soil was determined using an aqueous suspension of soil (soil and water in 1:2.5 ratio) using a pH meter (Jackson, 1973). The electrical conductivity of soil was determined using an aqueous suspension of soil (soil and water in 1:2.5 ratio) using a conductivity meter (Jackson, 1973). Soil organic carbon was estimated by standard Chromic acid wet oxidation method (Walkley and Black, 1934). The available nitrogen in the soil was estimated by the alkaline permanganate method. The amount of soil nitrogen released due to the oxidation of part of soil organic matter by $KMnO_4$ was estimated by distillation with NaOH (Subbiah and Asija, 1956). Available phosphorus was determined by the Olsen method. Blue colour was developed using ascorbic acid and the intensity of colour was measured using a spectrophotometer at 660 nm (Olsen *et al.*, 1954). In the Bray method, available P was commonly extracted using Bray No. 1 which consisted of 0.03 NH_4F and 0.025 HCl. The extracted phosphorus was measured colorimetrically based on the reaction with ammonium molybdate and development of the 'Molybdenum Blue' colour. The absorbance of the compound was measured at 882 nm in a spectrophotometer and is directly proportional to the amount of phosphorus extracted from the soil (Bray and Kurtz, 1945). Exchangeable potassium in the soil samples were extracted using 1N ammonium acetate and estimated using flame photometer (Standord and English, 1949). Bulk density was estimated using wax coating clod method. In the laboratory, the clods were tied with a thread and dipped in molten wax to coat the clod surface (Black, 1965). The wax coated clod was dipped in water and the bulk density was determined from the volume of water displaced.

Statistical analysis

SPSS® 19.0 version statistics software was used to run all statistical tests. The soil properties were evaluated using one-way analysis of variance (ANOVA). To separate means when differences were significant (P=0.05), Duncan's test was used.

Results and Discussion

Soil Bulk Density

The soil bulk density of plantations of the Cauvery Delta zone ranged from 1.26 ± 0.01 to 1.52 ± 0.00 (Table 1). The minimum bulk density (1.26 g/cc) was recorded in 0-15 cm of >6 years of Eucalyptus plantation of seedling origin. Bulk density was highest in 1 to 2 years of *Casuarina* clonal plantation (1.52 g/cc) followed by 1 to 2 years of Eucalyptus clonal plantation (1.48 g/cc), 2 to years of *M. dubia* (1.47 g/cc), >15 years of *T. grandis* (1.47 g/cc), 1 to 2 years of *E. camdldulensis* (1.39 g/cc), 3 to 5 years of *Casuarina equisetifolia* plantation (1.39 g/cc) at 30-45 cm depth. The measured bulk density significantly ($P \leq 0.05$) decreased with the increased age of plantations. However, in 3 to 5 years of *Casuarina* plantation of seedling origin and > 15 years of Teak, it was slightly increased over the age at 30-45 cm. The bulk density was lowest in the surface soil and increased with depth increment. The results of the current study make it abundantly evident that tree plantations have a significant impact on the characteristics of soil because they keep soil healthy and supply essential nutrients through the breakdown of organic matter. The results indicated that in the Cauvery delta zone, the measured bulk density significantly decreased with the increased age of plantations. A higher content of organic matter is responsible for decreasing the bulk density of soils (Balagopalan and Jose, 1993).

Table 1. Soil characteristics of different plantations in the Cauvery Delta zone

Plantation Type	Soil Depth	pH	EC (dS m^{-1})	OC (%)	BD (g/cc)	pH	EC (dS m^{-1})	OC (%)	BD (g/cc)	pH	EC (dS m^{-1})	OC (%)	BD (g/cc)
Eucalyptus		1 to 2 Years				4 to 5 Years				>6 Years			
	0-15	6.29±0.05^{cde}	0.16±0.00	0.38±0.00^{c}	1.30±0.01^{ab}	6.18±0.05^{bc}	0.10±0.00	0.56±0.00^{h}	1.29±0.01^{ab}	5.93±0.07^{a}	0.06±0.00	0.49±0.00^{f}	1.26±0.01^{a}
	15-30	6.47±0.05^{e}	0.19±0.00	0.36±0.00^{b}	1.37±0.01^{d}	6.41±0.05^{cde}	0.12±0.00	0.53±0.00^{g}	1.36±0.01^{cd}	6.03±0.06^{ab}	0.07±0.00	0.46±0.00^{e}	1.30±0.01^{ab}
	30-45	6.50±0.05^{e}	0.22±0.00	0.33±0.00^{a}	1.39±0.01^{d}	6.45±0.15^{de}	0.14±0.00	0.48±0.00^{f}	1.38±0.01^{d}	6.22±0.05^{bcdhihihih}	0.09±0.00	0.42±0.00^{d}	1.33±0.01^{bc}
Eucalyptus		1 to 2 Years				4 to 5 Years				>6 Years			
Clone	**0-15**	6.28±0.05^{bcd}	0.20±0.01^{de}	0.40±0.00^{cd}	1.37±0.01^{bc}	6.10±0.06^{ab}	0.16±0.01^{c}	0.45±0.00^{f}	1.34±0.01^{ab}	5.98±0.08^{a}	0.05±0.00^{a}	0.50±0.00^{h}	1.31±0.02^{a}
	15-30	6.35±0.05^{cd}	0.24±0.00^{f}	0.37±0.00^{b}	1.43±0.01^{de}	6.23±0.07^{bc}	0.17±0.00^{cd}	0.41±0.00^{d}	1.37±0.01^{bc}	6.18±0.05^{abc}	0.09±0.00^{b}	0.48±0.00^{g}	1.35±0.01^{ab}
	30-45	6.48±0.07^{d}	0.23±0.01^{f}	0.34±0.00^{a}	1.48±0.01^{e}	6.34±0.09^{cd}	0.21±0.01^{ef}	0.39±0.00^{c}	1.41±0.01^{cd}	6.24±0.06^{bc}	0.10±0.01^{b}	0.43±0.00^{e}	1.37±0.02^{bc}
Casuarina		1 to 2 Years				3 to 5 Years				>5 Years			
	0-15	6.68±0.13^{cde}	0.18±0.00^{f}	0.58±0.00^{cd}	1.31±0.01^{ab}	6.40±0.03^{ab}	0.14±0.00^{d}	0.64±0.00^{f}	1.29±0.01^{ab}	6.32±0.07^{a}	0.05±0.00^{a}	0.67±0.00^{g}	1.28±0.01^{a}
	15-30	6.86±0.06^{e}	0.22±0.00^{g}	0.55±0.00^{b}	1.36±0.01^{de}	6.53±0.05^{abcd}	0.16±0.00^{e}	0.61±0.00^{e}	1.35±0.01^{cd}	6.46±0.05^{abc}	0.06±0.00^{c}	0.64±0.00^{f}	1.32±0.01^{bc}
	30-45	6.89±0.06^{e}	0.24±0.00^{h}	0.53±0.00^{a}	1.38±0.01^{de}	6.70±0.05^{de}	0.18±0.00^{f}	0.57±0.00^{c}	1.39±0.01^{e}	6.58±0.05^{bcd}	0.07±0.00^{b}	0.59±0.00^{d}	1.36±0.01^{de}
Casuarina		1 to 2 Years				3 to 5 Years				>5 Years			
Clone	**0-15**	7.10±0.08^{bc}	0.16±0.00^{d}	0.58±0.00^{cd}	1.46±0.00^{de}	7.07±0.08^{bc}	0.10±0.00^{b}	0.64±0.00^{f}	1.41±0.00^{b}	6.70±0.09^{a}	0.08±0.00^{a}	0.69±0.00^{g}	1.38±0.00^{a}
	15-30	7.22±0.06^{c}	0.19±0.00^{f}	0.55±0.00^{b}	1.50±0.00^{f}	7.10±0.10^{bc}	0.18±0.00^{e}	0.61±0.00^{e}	1.44±0.01^{cd}	6.90±0.08^{ab}	0.10±0.00^{b}	0.64±0.00^{f}	1.43±0.00^{bc}
	30-45	7.26±0.06^{c}	0.21±0.00^{h}	0.53±0.00^{a}	1.52±0.00^{f}	7.18±0.06^{c}	0.20±0.00^{g}	0.57±0.00^{c}	1.47±0.00^{e}	6.99±0.08^{bc}	0.13±0.00^{c}	0.59±0.00^{d}	1.46±0.01^{de}
Melia		2 to 4 Years				5 to 7 Years				>7 Years			
	0-15	7.10±0.08^{c}	0.16±0.00^{f}	0.31±0.00^{c}	1.37±0.01^{abc}	6.98±0.08^{c}	0.06±0.00^{c}	0.47±0.00^{g}	1.35±0.01^{ab}	6.28±0.09^{a}	0.03±0.00^{a}	0.50±0.00^{h}	1.33±0.01^{a}
	15-30	7.23±0.06^{cd}	0.18±0.00^{h}	0.29±0.00^{b}	1.41±0.01^{bcde}	6.99±0.06^{c}	0.08±0.00^{d}	0.45±0.00^{f}	1.39±0.01^{abcd}	6.52±0.05^{b}	0.04±0.00^{b}	0.47±0.00^{g}	1.38±0.04^{abc}
	30-45	7.40±0.08^{d}	0.20±0.00^{i}	0.22±0.00^{a}	1.47±0.01^{e}	7.19±0.08^{cd}	0.17±0.00^{g}	0.40±0.00^{d}	1.45±0.01^{de}	6.70±0.09^{b}	0.09±0.00^{e}	0.43±0.00^{e}	1.42±0.01^{cde}
Teak		5 to 10 Years				11 to 15 Years				>15 Years			
	0-15	6.40±0.05^{cd}	0.17±0.00^{f}	0.39±0.00^{c}	1.39±0.01^{bc}	6.30±0.07^{bc}	0.11±0.00^{c}	0.45±0.00^{e}	1.37±0.01^{b}	5.96±0.08^{a}	0.07±0.00^{a}	0.52±0.00^{g}	1.29±0.02^{a}
	15-30	6.62±0.05^{de}	0.20±0.00^{g}	0.36±0.00^{b}	1.42±0.01^{bcd}	6.69±0.24^{de}	0.14±0.00^{e}	0.42±0.00^{d}	1.42±0.01^{bcd}	6.01±0.05^{ab}	0.09±0.00^{b}	0.49±0.01^{f}	1.39±0.01^{b}
	30-45	6.80±0.06^{e}	0.26±0.00^{h}	0.33±0.00^{a}	1.45±0.01^{de}	6.73±0.07^{e}	0.17±0.00^{f}	0.38±0.00^{bc}	1.44±0.01^{cde}	6.22±0.05^{abc}	0.12±0.00^{d}	0.45±0.00^{e}	1.47±0.02^{e}

Mean values with lower case superscript letters indicate significant difference between different aged plantations across different depths at (P d" 0.05). ± indicates standard error

Soil reaction (pH)

The mean soil reaction (pH) in plantations of the Cauvery delta zone is given in Table 1. The mean soil pH in selected plantations of the Cauvery delta zone varied from 5.96 ± 0.08 to 7.40 ± 0.08 and the samples were slightly acidic to neutral in range. Among the different plantations the minimum soil pH of 5.96 was recorded in >15 years of *T. grandis* plantation at 0-15 cm depth and the maximum of 7.40 was recorded in 2 to 4 years of *Melia* at 30-45 cm depth. Statistical analysis indicated that the samples were not significantly different and the pH decreased with the increasing age of the plantation. Lowest soil pH recorded might be due to the production of organic acids during the decomposition of organic litter and exudation from the root of the plantation (Srivatsava *et al.,* 2016).

Electrical conductivity (EC)

The mean soil electrical conductivity in plantations of the Cauvery Delta zone ranged from 0.03 ± 0.00 to 0.26 ± 0.00 and was non-saline (Table 1). Among the plantations, the minimum soil EC (0.03 dS m^{-1}) was observed under >7 years of *M. dubia* plantation at 0-15 cm and the highest (0.26 dS m^{-1}) was observed in 5-10 years of Teak plantation at 30-45 cm. The electrical conductivity (EC) significantly ($P \leq 0.05$) decreased with an increase in the age of the plantation and increased with depth increment.

Organic carbon (OC)

The organic carbon content in plantations of the Cauvery Delta zone ranged from 0.22 ± 0.00 to 0.69 ± 0.00 (Table 1) and was found between low to medium in range. The lowest soil OC (0.22 %) was recorded in *M. dubia* plantations of 1 to 5 years at 30-45cm. The maximum OC (0.69 %) was recorded in *Casuarina* clonal plantation (CH-5) of > 5 years at 0-15 cm depth, followed by >5 years of *Casuarina equisetifolia* plantation (0.67%), 4 to 5 years of Eucalyptus plantation of seedling origin (0.56), >15 years of Teak (0.52 %), >6 years of Eucalyptus clonal plantation (0.50%) and > 7 years of *Melia* plantation (0.50%) at 0-15 cm. The trend of changing SOC content in the different plantations with age significantly varied and increased with an increase in age, while in >6 years of *E. camaldulensis* plantation the SOC decreased in all depths. However, the OC decreased with depth increment. As mentioned earlier, soil organic carbon is an important determinant of soil quality. An integral constituent of the soil organic matter, it indicates the fertility status of the soil also. A lot of factors determine the amount of organic carbon present in the soil including climatic factors, land use types, different management practices etc. It was observed that, the higher organic carbon concentration in the Cauvery delta zone was observed in > 5 years of *Casuarina* clone at 0-15 cm depth. Similar results were reported in Acacia and Populus plantations (Osman *et al.,* 2002; Arora *et al.,* 2014).

Available Nitrogen

The available nitrogen content in plantations of the Cauvery delta zone ranged between 129.93 ± 1.57 to 307.57 ± 2.72 and was found between the low to medium range

Table 2. Available macronutrients status in different plantations of the Cauvery Delta zone

Plantation Type	Soil Depth	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
Eucalypts			1 to 2 Years			4 to 5 Years			>6 Years	
	0-15	199.93 ± 1.77^{efg}	20.73 ± 0.19^{f}	195.74 ± 1.73^{c}	213.99 ± 1.89^{i}	23.52 ± 0.21^{h}	263.92 ± 2.12^{f}	219.87 ± 1.95^{i}	26.31 ± 0.23	239.50 ± 2.34^{g}
	15-30	181.20 ± 1.59^{d}	17.30 ± 0.15^{c}	174.58 ± 1.53^{b}	201.40 ± 2.33^{efgh}	20.10 ± 0.23^{e}	240.90 ± 2.55^{e}	207.60 ± 1.84^{h}	23.52 ± 0.21^{h}	220.30 ± 2.13^{f}
	30-45	159.67 ± 1.4^{a}	14.15 ± 0.12^{a}	159.67 ± 1.41^{a}	174.02 ± 1.54^{bc}	16.24 ± 0.14^{b}	220.66 ± 1.77^{c}	179.80 ± 1.59^{cd}	19.33 ± 0.17^{d}	199.73 ± 1.95^{e}
Eucalypts Clone			1 to 2 Years			4 to 5 Years			>6 Years	
	0-15	203.68 ± 1.79^{fgh}	19.17 ± 0.23^{d}	221.26 ± 1.96^{e}	206.00 ± 2.38^{gh}	20.60 ± 0.24^{f}	239.20 ± 2.12^{f}	219.66 ± 1.94^{i}	21.93 ± 0.32^{g}	283.36 ± 10.24^{h}
	15-30	195.69 ± 2.37^{e}	15.95 ± 0.14^{b}	209.59 ± 2.54^{d}	198.70 ± 2.29^{ef}	16.94 ± 0.15^{c}	218.00 ± 2.52^{de}	202.32 ± 1.95^{efgh}	18.94 ± 0.17^{d}	263.12 ± 3.84^{g}
	30-45	169.46 ± 2.05^{b}	13.91 ± 0.17^{a}	178.80 ± 2.16^{b}	172.40 ± 1.99^{b}	14.00 ± 0.16^{a}	194.00 ± 2.24^{c}	195.65 ± 2.85^{e}	16.14 ± 0.24^{b}	233.22 ± 3.40^{f}
Casuarina			1 to 2 Years			3 to 5 Years			>5 Years	
	0-15	297.40 ± 2.63^{f}	21.73 ± 0.19^{h}	311.36 ± 2.75^{de}	299.40 ± 2.65^{f}	22.63 ± 0.20^{i}	325.71 ± 2.88^{f}	306.56 ± 2.72^{g}	25.21 ± 0.22^{j}	338.53 ± 3.00^{g}
	15-30	263.92 ± 2.34^{cd}	18.44 ± 0.16^{d}	297.61 ± 2.63^{c}	269.50 ± 2.38^{d}	20.23 ± 0.18^{f}	303.09 ± 2.68^{cd}	279.96 ± 2.48^{e}	22.72 ± 0.20^{i}	319.63 ± 2.83^{ef}
	30-45	239.80 ± 2.12^{a}	15.15 ± 0.13^{a}	269.40 ± 2.38^{a}	250.56 ± 2.22^{b}	16.34 ± 0.14^{b}	280.56 ± 2.48^{b}	259.83 ± 2.30^{c}	17.94 ± 0.16^{d}	299.90 ± 2.65^{c}
Casuarina Clone			1 to 2 Years			3 to 5 Years			>5 Years	
	0-15	297.40 ± 2.63^{f}	20.93 ± 0.19^{g}	311.36 ± 2.75^{de}	299.40 ± 2.65^{f}	21.53 ± 0.19^{h}	325.71 ± 2.88^{f}	307.57 ± 2.72^{g}	21.66 ± 0.26^{h}	339.57 ± 3.00^{g}
	15-30	269.50 ± 2.38^{d}	17.94 ± 0.199^{d}	297.61 ± 2.63^{c}	269.50 ± 2.38^{d}	19.14 ± 0.17^{e}	303.09 ± 2.68^{cd}	279.96 ± 2.48^{e}	19.33 ± 0.17^{e}	319.63 ± 2.83^{ef}
	30-45	239.80 ± 2.12^{a}	15.00 ± 0.18^{a}	269.10 ± 2.38^{a}	250.56 ± 2.22^{b}	17.20 ± 0.20^{c}	280.56 ± 2.48^{b}	259.83 ± 2.30^{c}	16.35 ± 0.24^{b}	299.90 ± 2.65^{c}
Melia			2 to 4 Years			5 to 7 Years			>7 Years	
	0-15	196.08 ± 2.37^{c}	18.08 ± 0.22^{d}	213.27 ± 2.58^{d}	230.40 ± 2.66^{e}	20.30 ± 0.24^{e}	234.90 ± 2.71^{e}	260.93 ± 3.80^{g}	21.33 ± 0.31^{f}	264.81 ± 3.86^{f}
	15-30	164.15 ± 1.45^{b}	15.35 ± 0.14^{b}	198.54 ± 1.76^{c}	213.89 ± 1.89^{d}	16.65 ± 0.15^{c}	200.73 ± 1.78^{c}	240.00 ± 2.13^{f}	18.54 ± 0.16^{d}	230.03 ± 2.04^{e}
	30-45	129.93 ± 1.57^{a}	13.11 ± 0.16^{a}	163.70 ± 1.98^{a}	198.40 ± 2.29^{c}	14.80 ± 0.17^{b}	182.40 ± 2.11^{b}	220.86 ± 3.22^{d}	14.95 ± 0.22^{b}	210.80 ± 3.07^{d}
Teak			5 to 10 Years			11 to 15 Years			>15 Years	
	0-15	249.56 ± 2.21^{c}	20.33 ± 0.18^{d}	239.80 ± 2.12^{c}	269.70 ± 2.39^{d}	22.43 ± 0.20^{e}	275.48 ± 2.44^{d}	288.46 ± 3.49^{e}	23.54 ± 0.29^{f}	296.01 ± 3.59^{e}
	15-30	219.87 ± 1.95^{b}	17.14 ± 0.15^{b}	219.56 ± 1.94^{b}	250.56 ± 2.22^{c}	18.34 ± 0.16^{c}	249.77 ± 2.21^{c}	277.71 ± 10.04^{de}	21.05 ± 0.76^{d}	277.61 ± 10.03^{d}
	30-45	200.03 ± 1.77^{a}	14.25 ± 0.13^{a}	202.72 ± 1.79^{a}	229.73 ± 2.03^{b}	13.46 ± 0.12^{a}	225.64 ± 2.00^{b}	244.16 ± 2.95^{c}	16.29 ± 0.20^{b}	242.18 ± 2.93^{c}

Mean values with lower case superscript letters indicate significant difference between different aged plantations across different depths at (P d" 0.05). ± indicates standard error

(Table 2). The lowest available nitrogen 129.93 kg ha^{-1} was recorded in 2 to 4 years of *M. dubia* plantation at 30-45 cm depth and the maximum 307.57 kg ha^{-1} was recorded in >5 years of *Casuarina* clonal plantation (CH-5) at 0-15 cm depth. Among the plantations, the available nitrogen was medium in the surface layer (0-15 cm) of > 5 years *Casuarina* clonal plantation (307.57 kg ha^{-1}), >5 years of *Casuarina equisetifolia* plantation (306.56 kg ha^{-1}), and > 15 years of Teak (288.46 kg ha$^{-1)}$, while it was low in seedling origin Eucalyptus, Eucalyptus clonal plantation and *Melia* plantations. The available nitrogen concentration found in the soil under plantation forest was significantly different (P ≤ 0.05) and increased with the increase in age of the plantation. The available nitrogen decreased with soil depth increment. Higher availability of nutrients on surface layers under different plantations might be due to accumulation and decomposition of litterfall on the soil surface as well as its incorporation in the soil surface layers. It assists in the mineralization of organic N and P from the litter and its release into the soil (Singh and Sharma, 2007; Bala *et al.*, 2017).

Available Phosphorus

The available phosphorus content in plantations of the Cauvery Delta zone ranged from 13.11 ± 0.16 to 26.31 ± 0.23 (Table 2) and was found between medium to high in range. The minimum available phosphorus of 13.11 kg ha^{-1} was recorded under 2 to 4 years of *M. dubia* at 30-45 cm depth and the maximum 26.31 kg ha^{-1} was recorded in >6 years of Eucalyptus plantation at 0-15 cm depth. Similar findings were reported by (Singh and Sharma, 2007; Bala *et al.*, 2017; Kumar *et al.*, 2018) who stated that the concentration of soil chemical parameters was higher in 0-20 cm soil depth and decreased with increase in soil depth. The available phosphorus content was high in the surface soils (0-15 cm) of >6 years of *E. camaldulensis* (26.31 kg ha^{-1}) followed by >5 years of *Casuarina equisetifolia* plantation (25.21 kg ha^{-1}), >15 years of *T. grandis* (23.54 kg ha^{-1}), while it was medium in >6 years of Eucalyptus clonal plantation (21.93 kg ha^{-1}), >5 years of *Casuarina* clonal plantation (21.66 kg ha^{-1}) and >7 years of *M. dubia* (21.33 kg ha^{-1}) plantation. However, the available phosphorus concentration found in the soil under different plantation forests was significantly varied (P ≤ 0.05) and it increased with an increase in age of plantation, while it was slightly decreased in >5 years of *Casuarina* clonal plantation at 30-45 cm and 11 to 15 years of Teak plantation at15-30 cm. However, the phosphorus concentration decreased with depth increment.

Available Potassium

The available potassium content in plantations of the Cauvery Delta zone ranged between 159.67 ± 1.41 to 339.57 ± 3.00 and was found between medium to high in range (Table 2). The minimum available potassium 159.67 kg ha^{-1} was recorded under 1 to 2 years of *E. camaldulensis* at 30-45 cm and the maximum 339.57 kg ha^{-1} was recorded in >5 years of *Casuarina* clonal plantation (CH-5) at 0-15 cm depth. Among the plantations, the available potassium was high in surface soils (0-15 cm) of >5 years *Casuarina* clonal plantation (339.57 kg ha^{-1}), >5 years *Casuarina equisetifolia* plantation (338.53 kg ha^{-1}), >15 years of Teak (296.01 kg ha^{-1}) and >6 years of Eucalyptus clonal plantation (283.36 kg ha^{-1}), while it was medium in >7 years of *M. dubia* (264.81 kg ha^{-1}) and 4 to 5 years of Eucalyptus (263.92 kg ha^{-1}) plantation. The available potassium in the different plantations was significantly varied (P ≤ 0.05) and it increased with an increase in the age of the plantation. Conversely, in >6 years of *E. camaldulensis* plantation, the available potassium decreased at all depths. However, with increasing soil depth the potassium content decreased. Higher availability of potassium at surface layers under plantations is attributed to liberation of K by decomposition process of litterfall as well as solubilization of insoluble forms of K present in soil due to organic decomposition products (Chauhan *et al.*, 2018). The results are similar to the findings of (Somasundaram *et al.*, 2009) who stated that leaf litters and their decomposition under perennial vegetation of Eucalyptus favour nutrients enrichment compared to regular crop removal in mono cropping system.

Acknowledgements

The authors are grateful to the Director General, Indian Council of Forestry Research and Education, Dehradun for providing financial support to undertake the project work.

Conflict of interest

The authors do not have any conflict of interest to declare.

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