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Effect of eucalyptus plantations on soil properties in different land use patterns in central Telangana zone

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Abstract
The effect of Eucalyptus on soil properties in two land use practices i.e., TSFDC managed Eucalyptus plantations and farmland raised Eucalyptus plantations were assessed in the current study. There results depicted that there was an improvement in properties along with increment in age gradations. With regard to soil pH, there was an increment along the age gradations in both the land use practices i.e., 6.00-7.11 in TSFDC managed plantations and 5.98-6.53 in farmland Eucalyptus plantations. EC of the Eucalyptus plantations was also enhanced in the both the land use practices. However, both soil pH and electrical conductivity were found to be significant over the age gradations. The organic carbon was enhanced in both the land use patterns due to the addition and decomposition of litterfall and ranged from 0.59% - 0.88% in TSFDC plantations whereas 0.42% - 0.85% in farmland plantations. The results also showed that there was an increasing trend in soil available N along the age gradations. Similar trend was also observed in phosphorus and potassium. From the present study, it is found that the Eucalyptus plantations have positive effect on soil properties.

Keywords: Eucalyptus, pH, nitrogen, phosphorus, potassium

Introduction
Eucalyptus is a genus of tree that is native to Australia but is widely grown around the world. It is a dominant and potential tree species in the Myrtaceae family, which includes three genera: Eucalyptus, Corymbia, and Angophora (Mengistu *et al.*, 2020) [15]. Along with Pinus and Cunninghamia, it is one of the most widely planted woody species on the planet (FAO, 2006; Oballa *et al.*, 2010) [10, 16]. Eucalyptus grows in the tropics, subtropics, and temperate regions and accounts for 0.5 percent of the global surface forest area (Grupo, 2009) [11]. Because of its potential and fast-growing nature, the species provides a living for the majority of the country's rural and urban populations. This species was used to meet the country's demand for pulpwood and industrial wood.

Many controversies have been raised in the area of Eucalyptus plantation from various parts of the world, and many concerns have been reported about the negative ecological effects of Eucalyptus species. According to various studies, Eucalyptus spp. plantations have disastrous effects on soil physicochemical properties, depleting soil organic matter content, and negatively impacting soil hydrology (Tererai *et al.*, 2014) [22]. Lane *et al*. (2004) [14] discovered that the expansion of Eucalyptus spp. plantation lowers water tables and reduces water availability in China because of its deep and dense root network. According to Wen *et al.*, (2009) [24, 25] and Zhu *et al.*, (2009) [25], Eucalyptus spp. plantation has a negative impact on soil physical and chemical properties as well as plant community. The negative effects of Eucalyptus on neighbouring food crops due to competition for soil moisture and nutrients, as well as the shade effect, have been reported in Ethiopia's Amhara regional state (Alebachew *et al.*, 2015) [2]. According to various studies, the impacts of Eucalyptus tree species are studied by various scholars. The main impact of Eucalyptus tree species is on water resources, soil nutrient resources, allelopathic effect on other species, agrobiodiversity, and human nutrition security (Aklilu *et al.*, 2019) [1].

Recent studies, on the other hand, suggest that if Eucalyptus is properly planted and managed, it supports and improves soil nutrients. Eucalyptus species have the potential to improve soil physicochemical properties. Recent research suggests that eucalyptus may not always have a negative impact on topsoil retention and soil nutrient availability. If Eucalyptus species are planted correctly, they can be used as crop shelterbelts (Beinart, 2003; Oballa *et al.*, 2010) [3, 16]. It is also used in dry areas to protect the soil from wind erosion through its lateral roots by

holding the top soil in place (Oballa *et al.*, 2010) [16].

The effects of Eucalyptus spp. plantations on soil properties and nutrient depletion remain unknown (EI-Amin *et al.*, 2001) [9], and conventional scientific reports are scarce (Oballa *et al.*, 2010) [16]. There have also been numerous controversies in Eucalyptus plantations from around the world. Many concerns have been raised about the effects of Eucalyptus plantation on the physicochemical properties of soil. According to various studies, such issues are debunked by various scholars. As a result, the effects of Eucalyptus spp. plantations on soil properties and soil nutrient depletion remain unknown. Hence, the following study was formulated to study the effect of Eucalyptus on soil properties in two different land use practices.

Materials and Methods

Study area

The current study was carried out in Telangana State Forest Development Corporation Limited, Eucalyptus plantations and Farmland raised Eucalyptus plantations in Paloncha, Kothagudem, Sathupalli Divisions of Central Telangana zone during 2021-22. The area experiences hot and sub-humid climate with average rainfall of 900-1100 mm. of which major rainfall received in the rainy season (June-October) and the average no. of rainy days 80. Maximum temperature of 47 ^{0}C (May) and minimum temperature of 15 ^{0}C (December) with an average temperature of 30 ^{0}C have been recorded in the division and the relative humidity of the study area is about 80%.

Sampling techniques, data collection and analysis

During the study, the soil samples are taken from two land use patterns and different age gradations. The soil samples are collected based on the systematic approach covering all age gradation plantations in two land use practices. During soil sampling from each land uses the sample was collected from three depth (0–15 cm, 15–30 cm) of the soil for each system. A composite sample was made by mixing the samples from three depths. To get the accurate result and to minimize the error, the data collection was carried during the dry season at the month of January to February 2022.

Soil analysis

The samples were air-dried in the lab, ground with a wooden mortar, and sieved with a 2 mm nylon sieve before being packed in polythene bags and tagged for standard analysis. The soil sample was analysed based on the following procedure

Table 1: Table showing various methods used for soil analysis

Sl. No	Soil Parameter	Method for estimation
1.	Available Nitrogen (kg ha^{-1})	Black's method (Jackson, 1967) [27]
2.	Available Phosphorus (kg ha^{-1})	Bray's method (Tandon 1995) [28]
3.	Available Potassium (kg ha^{-1})	Flame Photometer Method (Jackson, 1973) [29]
4.	pH	Digital pH meter (Jackson, 1967) [27]
5.	EC (ds/m)	Conductometry (Jackson, 1967) [27]
6.	Organic carbon (%)	Walkley and Black (1934) [23]

Statistical analysis

Soil parameter for all land uses was analysed by using one way ANOVA. The statistically significant changes in physical and chemical properties of the soils under two land use practices were detected by multiple comparison of means for each class variable using the DMRT test at 0.05.

Results and Discussion

Soil Physico-chemical properties

To study the effect of Eucalyptus on soil properties, the parameters viz., pH, EC, Organic carbon (%), Available Nitrogen, Available phosphorus and Available potassium were analysed for both the land use patterns.

Soil pH

Because of age gradations in Eucalyptus plantations, the pH of the soil fluctuated. The soil pH of Telangana State Forest Development Corporation Eucalyptus plantations in three divisions, Paloncha, Sathupalli, and Kothagudem, increased from 1 year (6.00) to 7 years old plantations (7.11). In one-year-old plantations, soil pH was somewhat acidic, and soil acidity decreased as plantation age grew. The soil pH of three divisions of farmland Eucalyptus plantations, improved from one year (5.98) to four years old plantations (6.53). In one-year-old plantations, soil pH was moderately acidic, and soil acidity decreased as plantation age grew. Though there was a significant shift in soil pH, it was slow and increased with time. The impact of Eucalyptus plantation on soil pH is a major consideration because soil pH is recognised to be directly and indirectly responsible for the exposure of various properties. Pessaraki and Szabolcs (2019) [18] reported that the organic matter addition reduces the soil pH. The current research findings are in line with the findings of Horneck *et al*. (2011) [12], who have reported soil's pH value showed improvement from 5.2 (highly acidic) to 5.5–5.8 (moderately acidic) under *Eucalyptus camaldulensis* plantation providing the greatest reduction in soil acidity. The current study was consistent with Cao *et al*. (2010)'s [26] findings, which showed that soil pH beneath Eucalyptus spp. plantations in China decreased from 4.2 to 4.5.

Electrical Conductivity (dSm^{-1})

The electrical conductivity of Eucalyptus plantations varied related to age gradations. The EC of Telangana State Forest Development Corporations' Eucalyptus plantations of three divisions namely Paloncha, Sathupalli, and Kothagudem, improved from 1 year (0.03) to 7 years old (0.20). Electrical conductivity of farmland Eucalyptus plantings of three divisions, increased from 1 year (0.07) to 4 years old plantations (0.27). Electrical conductivity was found to be low in one-year-old plantations and rose as plantation age grew. Though there was significance in change in electrical conductivity, it was gradual in its increment along the age gradations. The current research findings are supported by Singh *et al*., (2019) [20], who have reported that EC of 11 years old Eucalyptus plantations ranged between 0.18 – 0.20 dSm^{-1} and also by Sirohi and Bangarwa (2017) [21] who reported that the EC of 8-year-old Poplar based agroforestry range from 0.08 – 0.14 dSm^{-1}.

Organic Carbon (%)

The organic carbon in Eucalyptus plantations differed related to age gradations. Telangana State Forest Development Corporation's Eucalyptus plantations of three divisions, Paloncha, Sathupalli, and Kothagudem, improved in organic carbon from 1 year (0.59%) to 7 years (0.88%). Organic carbon levels were found to be low in one-year-old plantations and rose with plantation age. Organic carbon of Farmland Eucalyptus plantations of three divisions, increased from 1 year (0.42%) to 4 years (0.85%). Organic carbon levels were found to be low in one-year-old plantations and rose with plantation age. Though there was significance in change in organic carbon, it was gradual in its increment along the age gradations.

In general, the organic carbon content of soil reflects the differences in soil quality and quantitate of leaf litter fall and the rate of decomposition. It is attributed to higher addition and incorporation of organic matter with advance in age of the plantations. There was an increment in organic carbon percentage from 1 year old (0.58%) to 7 years old (0.84%) TSFDC Eucalyptus plantations and also from 1 year old (0.42%) to 4-year-old (0.85%) farmland Eucalyptus plantations.

Available Nitrogen (kg ha^{-1})

The available nitrogen in Eucalyptus plants varied with age. Telangana State Forest Development Corporation's Eucalyptus plantations of three divisions, Paloncha, Sathupalli, and Kothagudem, improved in available nitrogen from 1 year (210 kg ha-1) to 7 years old plantations (290 kg ha-1). It was discovered that available nitrogen was low in one-year-old plantations and increased with plantation age. The available nitrogen of Farmland Eucalyptus plants of three divisions increased from one year (232.17 kg ha-1) to four years (301 kg ha-1). It was discovered that accessible nitrogen was low in one-year-old plantations and increased with plantation age. Though there was significance in change in available nitrogen, it was gradual in its increment along the age gradations. Similar results were reported by Divya *et al*., (2022) [8] where the available nitrogen of soil under Eucalyptus plantations increased along with increase in age of the plantations and ranged from 259 kg ha^{-1} to 301 kg ha^{-1} in 1 - 5 years old plantations. The study was also supported by Chauhan *et al*., (2018) [6] who have reported that the available nitrogen was 156.9 kg ha^{-1} in 10-year-old *Melia azedarach* plantation.

Available Phosphorus (kg ha^{-1})

The amount of phosphorus available varied according on the age of the Eucalyptus plantings. Telangana State Forest Development Corporation's Eucalyptus plantations of three divisions, Paloncha, Sathupalli, and Kothagudem, improved in available phosphorus from 1 year (4.89 kg ha^{-1}) to 7 years old plantations (14.55 kg ha^{-1}). It was discovered that accessible phosphorus was low in 1 year old plantations and rose with plantation age. Phosphorus availability varied due to age gradations in farmed Eucalyptus plants. The available phosphorus of Farmland Eucalyptus plants of three divisions increased from one year (14 kg ha^{-1}) to four years (20.94 kg ha-1). It was discovered that accessible phosphorus was low in 1 year old plantations and rose with plantation age. Though there was no significance in change in available phosphorus, it was gradual in its increment along the age gradations. The increase in available phosphorus might be through the improved soil fertility status by addition of more amount of organic matter in the form of litter fall and root biomass. There was a significant increment in available phosphorus from 1 year old (4.89 kg ha^{-1}) to 7 years old (14.55 kg ha^{-1}) TSFDC Eucalyptus plantations whereas there was a non-significant increment from 1 year old (14 kg ha^{-1}) to 4-year-old (20.94 kg ha^{-1}) farmland Eucalyptus plantations. The higher content of available phosphorus in farmland eucalyptus plantations as compared to TSFDC Eucalyptus plantations may be due to the application of phosphatic fertilizers as basal dressing during the time of planting.

Similar results were also reported by Divya *et al.*, (2022) [8] in their study that the available phosphorus in soil under Eucalyptus plantations of their study increased along with increase in age of the plantations i.e., the available phosphorus from 1 year to 5 years old plantations ranged from 11.39 kg ha^{-1} to 15.29 kg ha^{-1} respectively. Bhardwaj *et al*., (2017) [4] reported in their study that the amount of available phosphorus was high (15 kg ha^{-1}) when compared to control. These results were on line with the results of the present investigation.

Available potassium (kg ha^{-1})

The available potassium in Eucalyptus plants varied with age. Telangana State Forest Development Corporation's Eucalyptus plantations of three divisions, namely Paloncha, Sathupalli, and Kothagudem, improved in available potassium from 1 year (106.89 kg ha^{-1}) to 7 years old plantations (212 kg ha^{-1}). It was discovered that accessible potassium was low in one-year-old plantings and rose with plantation age. Farmland Eucalyptus plantations of three divisions improved in available potassium from 1 year (73.67 kg ha^{-1}) to 4 years old plantations (212.50 kg ha^{-1}). It was discovered that accessible potassium was low in one-year-old plantings and rose with plantation age. Though there was significance in change in available potassium, it was gradual in its increment along the age gradations. The increase in available potassium might be through the improved soil fertility status by addition of more amount of organic matter in the form of litter fall and root biomass. It is well known that addition of tree litter contains increased amount of Potassium. Similar results were also reported by Divya *et al.*, (2022) [8] in their study increased along with increase in age of the plantations i.e., the available potassium from 1 year to 5 years old plantations ranged from 187 kg ha^{-1}to 240.7 kg ha^{-1}respectively. The results were consistent with Singh *et al*. (1997) [19], who found a significant rise in soil available potassium status with the addition of Eucalyptus litter. The available potassium status in the soils under the cover of Eucalyptus planting increased in the current study, which was corroborated by Bhardwaj *et al* (2017) [4].

Table 2: Soil Chemical properties of TSFDC Eucalyptus plantations

Age of the plantation	pH	EC (dSm^{-1})	OC (%)	Avail. N (kg/ha)	Avail. P (kg/ha)	Avail. K (kg/ha)
1 Year	6.00	0.03	0.59	210.00	4.89	106.89
2 years	6.17	0.04	0.67	223.22	7.29	120.78
3 years	6.31	0.06	0.81	229.33	6.44	153.33
4 years	6.48	0.07	0.81	237.44	9.16	151.11
5 years	6.66	0.08	0.84	253.22	10.67	181.33
6 years	6.85	0.10	0.88	270.22	12.15	180.11
7 years	7.11	0.20	0.88	290.22	14.55	212.00
C.D (5%)	0.23	0.05	0.17	16.83	3.44	65.27
SE(m) ±	0.07	0.02	0.05	5.40	1.11	20.95

Table 3: Soil Chemical properties of Farmland Eucalyptus plantations

Age of the Plantation	pH	EC (dSm^{-1})	OC (%)	Avail. N (kg/ha)	Avail. P (kg/ha)	Avail. K (kg/ha)
1 Year	5.98	0.07	0.42	232.17	14.00	73.67
2 years	6.15	0.09	0.57	266.83	15.67	121.67
3 years	6.27	0.14	0.75	276.67	19.00	197.83
4 years	6.53	0.27	0.85	301.00	20.94	212.50
C.D (5%)	0.14	0.08	0.20	27.71	N/A	76.75
SE(m) ±	0.04	0.02	0.06	7.86	1.60	21.76

Conclusion

From this study the results showed that there was an increasing trend in all soil properties along with the increment in age gradation. Soil pH was improved from slightly acidic to neutral condition. The organic carbon of the soil has improved along with age gradation due to addition and decomposition of litter through leaf fall. The available nitrogen, available phosphorus and available potassium has also shown increment along with the age gradation. Finally, it was concluded from this study, the Eucalyptus plantations have positive effect on soil properties.

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