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Effect of different nitrogen fixing tree species on soil chemical properties and primary nutrients in lateritic soil

V.V. Dalvi, P.R. Pawar, S.S. More and A.S. Shigwan

Dr. Balasaheb Sawant Konkan Krishi Vidhyapeeth, Dapoli- 415 712. Maharashtra, India

Corresponding authors Email: vjy_dlv@yahoo.co.in

ABSTRACT: The study was conducted to know the effect of different nitrogen fixing tree species on soil chemical properties and primary nutrients in lateritic soil. Twenty one year old experiment of nitrogen fixing species was selected for the research. Ten different species viz., T_1 (*Acacia auriculiformis*), T_2 (*Acacia catechu*), T_3 (*Acacia mangium*), T_4 (*Acacia holosericea*), T_5 (*Albizia lebbeck*), T_6 (*Casuarina equisetifolia*), T_7 (*Pterocarpus marsupium*), T_8 (*Gliricidia sepium*), T_9 (*Dalbergia sissoo*), T_{10} (*Cassia siamea*) and T_{11} (Control) were planted in the experiment. During the course of investigation the soil samples were collected at 1m, 2m and 3m distances from the plant and at two depths viz., 0-15 cm and 15-30 cm. The soil was analysed for soil pH, soil electrical conductivity, organic carbon, organic matter, available nitrogen, available phosphorus and available potassium by standard methods. It was revealed that there was no much variation for pH and EC among the ten species. However, some of the NFT species showed higher organic carbon, organic matter, available nitrogen, phosphorous and potassium as compared to control. There were differences in values of above parameters even among NFT species. It was revealed from the study that use of nitrogen fixing trees species showed beneficial effect on available nutrient content in soil and improves organic carbon in soil. NFT species increases nitrogen content in soil and also phosphorous and potassium content showed noticeable increment.

***Key words*:** Aavailable nitrogen, phosphorous and potassium, electrical conductivity, organic carbon and pH

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1. INTRODUCTION

Nitrogen fixing trees (NFTs) are often considered to be critical components of sustainable agroforestry systems. Symbiotic nitrogen fixation is an important source of N and various legume crops and pastures often fix as 200-300 kg N ha^{-1} yr^{1} (Peoples *et al.,* 1995). It is widely accepted that the N fixed by NFTs can be used to improve production of trees, crops and animals and to improve soil fertility. Agroforestry has been in practice in semi-arid zone of southern region of Tamil Nadu since ages. Farmers retain local trees like *Acacia nilotica, Albigia lebbeck, Sesbania grandiflora* in their farm land in rainfed conditions because legumes are rich in protein and make good feed for cattle. Collection of pods from the trees can be economically viable if the yield is high. These species can boost the productivity of the pastures not only by contributing feed, but also improve soil physical properties, organic matter and conserving soil, moisture, and promote nutrient cycling. Traditional rainfed crops like sorghum and maize are cultivated with scattered trees. As irrigation facilities are increasing, people are retaining exotic species like *Casuarina, Leucaena leucocephala, Sesbania grandiflora* and other trees on the bunds only. In many parts of southern part of India, poles harvested from 3-4 years old trees are widely used for housing in rural areas and hence fetch a premium price even in rural markets. As these species grow straight with very few side branches, the trees planted in rows on field bunds serve as windbreaks for protecting arable crops from wind and hot weather without competing for sunlight and moisture. By understanding the important of agroforestry plants and plant parts utilized by people traditionally for various products available in the market and the raw material required for it, we can evaluate a system to grow them in farm lands at large scale, in turn this will reduce the pressure on the natural forest and thereby conserve the bio-diversity and improve the socio-economics of the rural poor. Hence, the present investigation was carried out to identify and document the nitrogen fixing multipurpose trees adopted by farmers in agroforestry systems in lateritic soil of *konkan* region.

2. MATERIALS AND METHODS

Ten different nitrogen fixing trees species planted in 1992-93 were taken for the study during 2014-15. Three soil samples were taken from the plot of each tree species and these samples were analyzed for available nutrients and chemical properties like pH, EC and organic carbon with the recommended methodology. Two depths were considered while soil sampling 0-15 and 15-30 cm and from every tree species from three different distances 1, 2 and 3m from tree soil samples were taken. The pH of soil was determined using pH meter having glass and calomel electrode using 1:2.5 soil: water suspension ratio Jackson, 1967. Electrical conductivity of soil was determined with the help of Systronic Conductivity Meter-306 using 1: 2.5 soil: water suspension ratio Jackson, 1973. Organic carbon was determined by Walkley and Black, wet oxidation method by oxidizing the organic matter in soil (passed through 70 mesh sieve) with chromic acid as described by Black, 1965. Available nitrogen was determined by alkaline permanganet (0.32% $KMnO_4$) method (Subbiah and Asija, 1956). Available phosphorus was determined by Brays No. 1 method of extracting the soil P with 0.03 NH_4F in 0.025 N HCl. Phosphorus in the extractant was determined colorimetrically by using spectrophotometer at 660 nm wavelength as outlined by Bray and Kurtz, 1945. Available potassium was determined by using neutral normal ammonium acetate as an extractant on Systronics Flame Photometer as described by Jackson 1973.

3. RESULTS AND DISCUSSION

The soil samples from each treatment were analyzed in the laboratory to estimate soil pH, electrical conductivity, organic carbon, available N, P_2O_5 and K_2O content. Results obtained are presented in Table 1. The soil pH at 1 m distance from various tree species at the depth of 0-15 cm was ranged from 5.51 to 5.94. At 2 m distance from each tree species, it ranged from 5.43 to 5.84. Similarly, at 3 m distance, the pH varied from 5.44 to 5.76. The maximum pH (5.94) was recorded in a control at 1 m distance from tree species, at 2 m distance from tree species the maximum pH (5.84) was recorded in a treatment with *Acacia catechu* and at 3 m it was recorded highest in *Cassia siamea* (5.76). The soil reaction was observed acidic in nature with in all the treatments. The electrical conductivity at 1 m distance from various tree species at the depth of 0-15 ranged from 0.08 to 0.46 dS m^{-1}. At 2 m distance, it ranged from 0.09 to 0.23 dS m^{-1}. Similarly, at 3 m distance, the conductivity varied from 0.09 to 0.44 dS m^{-1}. The maximum EC (0.46 dS m^{-1}) was recorded in a treatment with *Acacia auriculiformis at* 1 m distance from tree species, *at* 2 m distance from tree species the maximum electrical conductivity of soil (0.23 dS m^{-1}) was recorded in a treatment with *Pterocarpus marsupium* and at 3 m it was recorded highest (0.44 dS m^{-1}) in *Acacia mangium*. The electrical conductivity was observed normal in all the treatments. The organic carbon content of the soil at 1 m distance from various tree species at the depth of 0-15 cm ranged from 1.30 to 2.94 per cent. At 2 m distance, it ranged from 1.47 to 3.64 per cent. Similarly, at 3 m distance, the soil organic carbon varied from 1.68 to 4.48 per cent. The soil of these nitrogen fixing trees are high in organic carbon content. And the highest organic carbon was observed in treatment *Casuarina equisetifolia* at 1 m distance, while at 2 m and 3 m distance it was recorded with treatment *Acacia holosericea*. The available nitrogen at 1 m from various tree species at the depth of 0-15 cm ranged from 282.24 kg/ha to 501.76 kg/ha. At 2 m distance from various species at the depth of 0-15 cm it ranged from 282.24 to 439.04 kg/ha and at 3 m distance from tree species the available N varied from 313.60 to 439.04 kg/ha. The maximum available nitrogen (501.76 kg/ha) content was observed with treatment *Gliricidia sepium* which was followed by *Acacia mangium (*439.04 kg/ha) at depth of 0-15 cm. The available phosphorous at 1 m from various tree species at the depth of 0-15 cm ranged from 9.16 kg/ha to 18.57 kg/ha. While at 2 m distance from various species it ranged from 8.91 to 20.55 kg/ha and at 3 m distance from tree species the available phosphorous varied from 7.43 to 17.58 kg/ha. The maximum available phosphorous (18.57 kg/ha) content at depth 0-15 cm was observed with treatment *Pterocarpus marsupium* in both the distances 1 m and 2 m from tree species which was followed by *Cassia siamea* (17.58 kg/ha). The available potassium at 1 m distance from various tree species at the depth of 0-15 cm ranged from 291.65 kg/ha to 396.48 kg/ha. While at 2 m distance from various species it ranged from 305.09 to 401.86 kg/ha and at 3 m distance from tree species and at the same depth of 0-15 cm the available potassium varied from 306.43 to 411.26 kg/ha. The maximum available

Table 1. N, P_2O_5 and K_2O under nitrogen fixing tree Species at depth of 0-15 cm

S. No.	Species	Depth	pH			EC (dS m^{-1})			Organic carbon (%)			Organic matter (%)			Available nitrogen (kg ha^{-1})			Available P_2O_5 (kg ha^{-1})			Available K_2O (kg ha^{-1})		
			Distance			Distance			Distance			Distance			Distance			Distance			Distance		
			1m	2m	3m	1m	2m	3m	1m	2m	3m	1m	2m	3m	1m	2m	3m	1m	2m	3m	1m	2m	3m
1	*Cassia siamea* (Kashid)	0-15	5.68	5.71	5.76	0.08	0.11	0.18	2.17	2.08	1.68	3.74	3.58	2.89	376.32	376.32	376.32	13.12	13.86	17.58	333.31	380.35	370.94
2	*Dalbergia sissoo* (Shisso)	0-15	5.51	5.43	5.68	0.22	0.22	0.12	1.96	2.64	2.60	3.38	4.55	4.48	407.68	376.32	313.60	16.09	15.35	17.08	302.40	333.31	385.73
3	*Gliricidiasepium* (Giripushp)	0-15	5.64	5.55	5.51	0.29	0.10	0.24	2.15	1.47	2.60	3.70	2.53	4.48	501.76	439.04	344.96	15.85	13.12	13.37	391.10	331.97	368.26
4	*Pterocarpus marsupium* (Biwla)	0-15	5.72	5.84	5.69	0.25	0.23	0.32	2.04	1.87	1.97	3.51	3.22	3.39	344.96	313.60	313.60	18.57	20.55	11.88	291.65	345.41	411.26
5	*Acacia catechu* (Khair)	0-15	5.51	5.84	5.52	0.17	0.10	0.11	1.66	2.52	2.48	2.86	4.34	4.27	313.60	344.96	313.60	13.12	9.16	14.11	396.48	401.86	352.13
6	*Acacia auriculiformis* (Babhul)	0-15	5.73	5.69	5.55	0.46	0.21	0.13	2.10	2.20	1.96	3.62	3.79	3.38	376.32	376.32	313.60	11.88	16.84	9.90	377.66	385.73	350.78
7	*Acacia holosericea* (Holosericea)	0-15	5.56	5.71	5.44	0.11	0.12	0.23	2.73	3.64	4.48	4.70	6.27	7.72	313.60	282.24	344.96	15.10	11.64	7.43	348.10	325.25	344.06
8	*Acacia mangium* (Mangium)	0-15	5.63	5.46	5.51	0.20	0.09	0.44	2.52	2.31	2.66	4.34	3.98	4.58	407.68	376.32	439.04	10.40	12.38	10.65	319.87	305.09	364.22
9	*Casuarina equisetifolia* (Suru)	0-15	5.65	5.63	5.60	0.31	0.12	0.27	2.94	2.69	3.71	5.07	4.63	6.39	376.32	344.96	313.60	14.36	12.87	14.11	358.85	385.73	306.43
10	*Albizia lebbeck* (Shirish)	0-15	5.53	5.62	5.74	0.15	0.21	0.09	2.45	2.84	2.24	4.22	4.89	3.86	376.32	344.96	313.60	12.13	8.91	13.12	379.01	317.18	391.10
11	Control	0-15	5.94			0.13			1.30			2.24			282.24			9.16			314.50		
	Mean		5.65	5.65	5.60	0.21	0.15	0.21	2.18	2.43	2.64	3.76	4.18	4.55	370.62	357.50	338.69	13.62	13.47	12.92	346.63	351.19	364.49

potassium (411.26 kg/ha) content at depth 0-15 cm was observed with treatment *Pterocarpus marsupium* at 3 m distance from tree species which was followed by *Acacia catechu (*401.86 and 396.48 kg/ha) at depth of 0-15 cm and in both the distances 2 m and 1 m from tree species.

The soil samples at depth of 15-30 cm from each treatment were also analyzed in the laboratory to estimate soil pH, electrical conductivity, organic carbon, available N, available P_2O_5 and available K_2O content. Results obtained are presented in Table 2. The pH of the soil at 1 m distance from various tree species at the depth of 15-30 cm ranged from 5.27 to 5.72. At 2 m distance from each tree species, it ranged from 5.15 to 5.71. Similarly at 3 m distance, the soil pH varied from 5.24 to 5.68. The soil of these nitrogen fixing trees are acidic in nature. The highest pH was observed in a treatment control at 1 m distance, while at 2 m distance highest pH was recorded with treatment *Pterocarpus marsupium* and at 3 m distance highest pH was recorded with treatment *Albizia lebbeck*. The electrical conductivity at 1 m distance from various tree species at the depth of 15-30 cm ranged from 0.09 to 0.25 dS m^{-1}. At 2 m distance from each tree species, it ranged from 0.08 to 0.47 dS m^{-1}. Similarly, at 3 m distance, the conductivity varied from 0.09 to 0.63 dS m^{-1}. The maximum EC (0.25 dS m^{-1}) was recorded in a treatment with *Casuarina equisetifolia* at 1 m distance from tree species, at 2 m distance from tree species the maximum electrical conductivity of soil (0.47 dS m^{-1}) was recorded in a treatment with *Acacia mangium* and at 3 m it was recorded highest (0.63 dS m^{-1}) in *Casuarina equisetifolia*. The electrical conductivity was observed normal in all the treatments. The organic carbon content of the soil at 1 m distance from various tree species at the depth of 15-30 cm ranged from 0.73 to 2.45. At 2 m distance from each tree species it was ranged from 1.40 to 2.48. Similarly at 3 m distance, the soil organic carbon varied from 1.03 to 3.08. The soil of these nitrogen fixing trees are high in organic carbon content. The highest organic carbon was observed in a treatment *Acacia holosericea* at 1 m distance, while at 2 m highest organic carbon was observed with in treatment *Acacia catechu* and 3 m distance it was recorded with treatment *Casuarina equisetifolia*. The available nitrogen at 1 m from various tree species at the depth of 15-30 cm ranged from 219.52 to 313.60 kg/ha. While at 2 m distance from various species at the depth of 15-30 cm it ranged from 219.52 to 313.60 kg/ha, similarly, at 3 m distance from tree species and at the same depth of 15-30 cm, the available N varied from 219.52 to 313.60 kg/ha. The maximum available nitrogen (313.60 kg/ha) content was observed with treatment *Gliricidia sepium* (3 m) C. *equisetifolia* and *Albizia lebbeck* (1 m) which was similar to *Acacia mangium* at depth of 15-30 cm. The available phosphorous at 1 m from various tree species at the depth of 15-30 cm ranged from 5.94 to 15.10 kg/ha. While at 2 m distance from various species at the

Table 2. N, P_2O_5 and K_2O under nitrogen fixing tree Species at depth of 15-30 cm

S. No.	Species		pH			EC (dS m^{-1})			Organic carbon (%)			Organic matter (%)			Available nitrogen (kg ha^{-1})			Available P_2O_5 (kg ha^{-1})			Available K_2O (kg ha^{-1})		
			Distance			Distance			Distance			Distance			Distance			Distance			Distance		
			1m	2m	3m	1m	2m	3m	1m	2m	3m	1m	2m	3m	1m	2m	3m	1m	2m	3m	1m	2m	3m
1	*Cassia siamea* (Kashid)	15-30	5.33	5.36	5.64	0.11	0.35	0.24	1.63	1.63	1.58	2.81	2.81	2.72	250.88	282.24	219.52	9.16	7.68	13.86	278.21	288.96	268.80
2	*Dalbergia sissoo* (Shisso)	15-30	5.47	5.39	5.67	0.21	0.13	0.09	1.47	1.55	1.71	2.53	2.67	2.95	313.60	282.24	282.24	11.39	10.15	9.41	228.48	267.46	284.93
3	*Gliricidiasepium* (Giripushp)	15-30	5.60	5.15	5.24	0.17	0.24	0.21	1.52	1.40	2.54	2.62	2.41	4.38	313.60	282.24	313.60	11.88	6.93	7.43	259.39	325.25	259.39
4	*Pterocarpus marsupium* (Biwla)	15-30	5.62	5.71	5.54	0.14	0.27	0.29	1.50	1.58	1.03	2.58	2.72	1.77	219.52	219.52	250.88	15.10	11.14	9.16	252.67	306.43	272.83
5	*Acacia catechu* (Khair)	15-30	5.46	5.71	5.48	0.13	0.11	0.36	0.73	2.48	1.08	1.26	4.27	1.86	282.24	282.24	250.88	10.15	5.45	9.66	276.86	302.40	252.67
6	*Acacia auriculiformis* (Babhul)	15-30	5.64	5.50	5.31	0.09	0.08	0.12	0.73	1.47	1.54	1.26	2.55	2.65	313.60	282.24	282.24	5.94	11.14	5.94	284.93	271.49	279.55
7	*Acacia holosericea* (Holosericea)	15-30	5.27	5.52	5.40	0.12	0.23	0.15	2.45	1.40	3 .04	4.22	2.41	5.24	250.88	250.88	282.24	8.42	7.68	5.69	325.25	268.80	288.96
8	*Acacia mangium* (Mangium)	15-30	5.51	5.41	5.42	0.09	0.47	0.10	1.61	1.51	1.40	2.77	2.60	2.41	282.24	313.60	313.60	8.17	8.67	6.68	254.02	267.46	287.62
9	*Casuarina equisetifolia* (Suru)	15-30	5.28	5.40	5.54	0.25	0.12	0.63	1.19	2.31	3.08	2.05	3.98	5.31	313.60	282.24	282.24	7.43	8.42	9.16	276.86	282.24	227.14
10	*Albizia lebbeck* (Shirish)	15-30	5.33	5.50	5.68	0.14	0.14	0.10	1.61	1.99	2.10	2.77	3.43	3.62	313.60	282.24	250.88	9.41	5.69	7.18	282.24	249.98	305.09
11	Control	15-30	5.72			0.15			1.00			1.72			250.88			6.96			282.24		
		Mean	5.48	5.47	5.49	0.15	0.21	0.23	1.40	1.65	1.81	2.42	2.83	3.11	282.24	275.97	272.83	9.46	8.29	8.42	272.83	283.05	272.70

depth of 15-30 cm it ranged from 5.45 to 11.14 kg/ha, Similarly, at 3 m distance from tree species and at the same depth of 15-30 cm, the available phosphorous varied from 5.69 to 13.86 kg/ha. The maximum available phosphorous (15.10 and 11.14 kg/ha) content at depth 15-30 cm was observed with treatment *Pterocarpus marsupium* in both the distances 1 m and 2 m from tree species which was followed by *Cassia siamea* (13.86 kg/ha) at 3 m distance. The available potassium at 1 m distance from various tree species at the depth of 15-30 cm ranged from 228.48 to 325.25 kg/ha while at 2 m distance it ranged from 249.98 to 325.25 kg/ha, Similarly, at 3 m distance from tree species and at the same depth of 15-30 cm, the available potassium varied from 227.14 to 305.09 kg/ha. The maximum available potassium (325.25 kg/ha) content at depth 15-30 cm was observed with treatment *Acacia holosericea* and *Gliricidia sepium* at 1 m and 2 m distance from different tree species, respectively which was followed by *Albizia lebbeck* (305.09 kg/ha) at depth of 15-30 cm and 3 m distance from tree species, respectively. There are three main tree-mediated processes that determine nutrient cycling in agroforestry systems (Nair *et al.,* 1999). These includes, (i) increased input of N through BNF by NFTs; (ii) enhanced availability of nutrients resulting from production and decomposition of tree biomass; and (iii) greater uptake and utilization of nutrients from deeper soil layers by the trees. The NFTs have additional advantage over the other species because of their nitrogen fixing ability.

4. CONCLUSION

Many peoples of the world rely on multipurpose NFTs as a source of food, fodder, timber and fuel wood. There is a great significance of NFTs for their N inputs but also for their role in carbon cycle and the maintenance of soil organic matter. Trees on the field are the important component of the sustainable land use systems (agroforestry), which improves soil nutrient status by various processes, such as litter addition, decomposition, nutrient release, atmospheric N_2 fixation, nutrient pumping, etc. Among all these ten nitrogen fixing tree species maximum available nitrogen (501.76 kg ha^{-1}) content was observed with treatment *Gliricidia sepium* which was followed by *Acacia mangium* (439.04 kg ha^{-1}) at depth of 0-15 cm. In case of available phosphorous highest phosphorous (18.57 kg ha^{-1}) content at depth 0-15 cm was observed with treatment *Pterocarpus marsupium* in both the distances 1 m and 2 m from tree species. The nutrient loss through soil erosion is also controlled by tree species. The improved soil through agroforestry systems helps to meet increased food requirement and serve as an evergreen revolution. The belowground research in agroforestry is still lacking attention; therefore, it requires study at different land use systems.

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