Effect of Different Multipurpose Tree Species on Physico - Chemical Properties of Loamy Sand Soil Under Rainfed Conditions

ABSTRACT

Aims: To study the effect of MPTs on soil fertility

Study design: The experiment was laid out in Complete Randomized Block Design with four replications.

Place and Duration of Study:A field experiment was conducted during 2019-20at Agroforestry Research Station, SardarkrushinagarDantiwada Agricultural University, Sardarkrushinagar.

Methodology: An experimentconsisting of six years old Agroforestry tree plantation which consisted of five multipurpose tree species (MPTs) viz., *Tectona grandis, Eucalyptus camaldulensis, Gmelina arborea, Casurianaequstifolia* and *Melia azadiracht* were designed in CRD with four replications. The experiment consisting of 96 trees per species with a plot size of 24 m × 16 m under 4 m × 4 m tree spacing.

Results: Among the above six tree species significantly the lowest BD (1.56 Mg/m^3), higher WHC (27.87 per cent) and soil porosity (38.03 per cent) was recorded under *Casuarinas equisetifolia* tree species. Similarlythe maximum mean organic carbon (0.445 per cent), available N (165.17 kg/ha), available K_2O (196.26 kg/ha) and DTPA extractable iron (4.22 mg/kg) and copper(1.05 mg/kg)were noted under *Casuarina equisetifolia* tree species. Whereas, the mean maximum available P_2O_5 (57.92 kg/ha) was noted under *Tectona grandis.* The mean maximum DTPA extractable manganese(8.34 mg/kg) and zinc (0.925 mg/kg)was noted under*Eucalyptus camaldulensis* and*Melia azadiracht*tree species,respectively.

Conclusion: Multipurpose tree species under study significantly improved the physico- chemical properties of soil over open field. Among all the tree species *Casurianaequisetifolia* performed better for the improvement in physico-chemical properties of soil.

Keywords: Multipurpose tree species (MPTs), Organic Carbon (OC), Physico-chemical properties.

1. INTRODUCTION

"Trees provide food, fuel wood, fodder, fertilizer and timber, reduction in incidence of total crop failure and sustained productivity. Trees also provide the some more efficient recycling of nutrients by deep rooted trees on the site, reduction of surface run-off, nutrient leaching and soil erosion through impeding effect of tree roots and stems on these processes improvement of microclimate, such as lowering of soil surface temperature and reduction of evaporation of soil moisture through a combination of mulching and shading, increment in soil nutrients through addition and decomposition of litter fall and improvement of soil structure through the constant addition of organic matter from decomposed litter".

"The multipurpose trees help in the improvement of soil and ecosystem services. Trees with deep rooting system can improve ground water quality by serving as a 'safe net' where by excess nutrients that have been leached below the rooting zone of agronomic crops are taken-up by tree roots. The trees are able to maintain or improve soil health, the process by which trees improve soil fertility are photosynthesis, fixation of carbon and it's transfer to the soil via litter and root decay.Nitrogen fixation by leguminous trees, improve nutrient retrieval by tree roots and erosion control by a combination of ground cover and barrier effects, efficient uptake of nutrient from soil, soils under trees have a favorable structure and water holding capacity through organic matter stabilization and root action and exudation of growth promoting substances".

"Forest ecosystem contributes a lot of organic matter to the soil in the form of leaves, twigs, stems, flowers and fruits, which after decomposition result in the formation of organic carbon and release of different nutrients. There is an increase in soil organic matter by root growth especially in the instance of a permanent cover or the incorporation of vegetation such as green manure, which improves the physical and chemical properties of soil".

"Trees grown with agricultural crops in salt affected soils improve the physical properties of soil. For instance, tree minimizes the salt deposition in the upper layers of the soil, it prevents salt accumulation on the surface layer, it improves water permeability and it facilitate leaching of salts, it decreases the bicarbonate levels, it reduces soil pH and electrical conductivity (EC), it increases water holding capacity, as well as infiltration rate and hydraulic conductivity with soil fertility. Similarly, enhancing cation exchange capacity (CEC) reducing ESP and improvement in desolidification process all along the profile depth can be taken place through tree planning in salt affected soils. Tree species have different ability to overcome the problem of alkalinity (Behera *et al*., 2015)".Therefore, the relative efficiency of native and exotic tree species in terms of their Soil Fertility potential was undertaken to study the "**Effect of Different Multipurpose Tree Species on Physico - Chemical Properties of Loamy Sand Soil Under Rainfed Conditions**." The present investigation has been framed with the following Objectives:

Objectives:

- To study the effect of trees on soil fertility

2. MATERIALS AND METHODS

A field experiment was conducted at Agroforestry Research Station, SardarkrushinagarDantiwada Agricultural University, Sardarkrushinagar, Gujarat, India, during 2019-20 on six years old Agroforestry tree plantation which consisted of five multipurpose tree species (MPTs) viz., *Tectona grandis, Eucalyptus camaldulensis, Gmelina arborea, Casurianaequstifolia* and *Melia azadiracht* were designed in completely randomized block design with four replications. The experiment consisting of 96 trees per species with a plot size of 24 m × 16 m under 4 m × 4 m tree spacing.

COLLECTION AND ANALYSIS OF SOIL SAMPLES

Depth wise (0-30, 30-60 and 60-90 cm) soil samples were collected from each plantation as well as from control plot during 15th-18th May, 2020. The collected soil samples were air dried. The samples were powdered using a wooden mortar and pestle and passed through 2 mm plastic sieve to avoid metallic contamination. Soil moisture content was determined gravimetrically (Piper, 1966), bulk density in undisturbed core method (Cully, 1993). Soil pH was measured by Potentiometric method (Jackson, 1973), EC by Conductometric method (Jackson, 1973) organic carbon by Walkley and Black's method (Jackson, 1973), available nitrogen by alkaline permanganate method (Subbiah and Asija, 1959), available phosphorus by Olsen's method (Jackson, 1973), available potassium by using flame photometric Method (Jackson, 1973) and DTPA extractable iron, manganese, copper and zinc by Atomic absorption Spectrophotometric method (Lindsay and Norvell,1978).

3. RESULTS AND DISCUSSION

3.1 Effect of different MPTs on physical properties of soil

Data presented in Table 1 explicit that significantly lower BD was recorded under *Casurianaequisetifolia* tree species at all the soil depths over open field condition and remained at par with rest of the tree species,but at 60-90 cm soil depth it was remained at par with *Eucalyptus camaldulensis* and *Gmelina arborea*. The lower bulk density under tree species could be attributed to their larger and deeper root system and root biomass resulting from accumulation of higher organic matter, proliferation of rhizosphere and microbial activities and root exudation below ground which helps to bind soil particles into larger aggregates and thereby loosen the soil and decrease its bulk density. Similar results were obtained by Singh *et al*. (2011), Chauhan *et al*. (2018) and Kumar *et al.* (2019).

It is explicit from the data presented in Table 1 showed that significantly the higher WHC of soil were recorded under*Casurianaequisetifolia* at all the soil depths but it was remained at par with *Melia azadiracht* and *Tectona grandis* at 0-30 and 30-60 cm soil depths but at 60-90 cm soil depth it was remained at par with all the tree species. This might be due to the fact that soil under trees has a favourable structure and WHC through organic matter stabilization and conservation and root action. Similar results were obtained by Datta and Singh (2007) and Saha *et al*. (2010).

The data pertaining to soil porosity at varying soil depth are presented in Table 1 showed that significantly the higher soil porosity at 0-30 cm soil depth was noted in *Casurianaequisetifolia* (38.92 per cent) over rest of treatments except *Melia azadiracht* (38.81 per cent). Similarly, at 30-60 cm soil depth *Casurianaequisetifolia* (38.10 per cent) was also found significantly superior to rest of the treatments but remained at par with *Melia azadiracht* (37.53 per cent) and *Tectona grandis* (36.91 per cent) and at 60-90 cm soil depth significantly higher soil porosity was also observed under *Casurianaequisetifolia* (37.07 per cent) and remained at par with rest of tree species except open field (32.40 per cent). Higher soil porosity was noted under *Casurinaequisetifolia* might be attributed to better soil aggregation by the addition of large amount of organic matter which release organic acids during the organic matter decomposition. The lowest soil porosity was recorded under no tree cover at all the soil depth compared to tree species. Hence trees improve the soil physical properties and enhance the soil health. Similar results were obtained by Singh *et al*. (2011).

3.2 Effect of different MPTs on chemical properties of soil

The data presented in Table 2 indicated that soil pH varied with soil depth, but it did not differed significantly under the influence of various tree species. But numerically the higher soil pH was observed under control i.e. 7.59, 7.60 and 7.79, while the minimum pH was recorded under *Casurianaequisetifolia* i.e. 7.31, 7.43 and 7.51 at 0-30 cm, 30-60 cm, 60-90 cm soil depth, respectively. The slight reduction in soil pH under tree cover was obtained, it might be dueto release of organic acids during decomposition of added litter fall from various tree species. Similar results were obtained by Singh *et al*. (2011).Similarly, EC of soil under different MPTs at various soil depths did not differed significantly but numerically higher soil EC value was recorded under the open field i.e. 0.057, 0.056 and 0.054 dS/m whereas minimum EC values were observed under *Eucalyptus camaldulensis* i.e. 0.051, 0.049 and 0.047 dS/m, at 0-30 cm, 30-60 cm and 60-90 cm soil depth, respectively.

Significantly higher organic carbon was found under *Casurianaequisetifolia* i.e. 0.472 per cent, 0.463 per cent and 0.400 per cent over rest of the treatments at 0-30 , 30-60 and 60-90 cm, respectivelyexcept *Melia azadiracht* (0.454 per cent) at 0-30 cm,*Melia azadiracht* (0.450 per cent) at 30-60 and *Melia azadiracht* (0.386 per cent) and *Tectona grandish* (0.382 per cent), at 60-90 cm soil depths. Significant improvement in organic carbon status in soil below the tree species compared to control may be due to addition of litter fall from the various tree species improved the organic carbon content of soil. These findings are in agreement with those of Behera *et al*. (2015) and Singh *et al*. (2018).

Significantly higher available N content in soil was noted under *Casurianaequisetifolia* (171.42kg N/ha),(164.05 kg/ha) and (160.04 kg/ha) at 0-30 cm, 30-60 cm and 60-90 cm , respectively over rest of the treatments and remained at par with*Melia azadiracht* (168.40 N kg/ha) and Teak (*Tectona grandis*) (165.80 N kg/ha) at 0-30 cm soil depth, *Eucalyptus camaldulensis* (156.70 kg/ha) at 30-60 cm soil depth andremained at par with rest of the tree species at 60-90 cm soil depths. The significant improvement in soil available N under different tree species was recorded compared to open field may be owing to the addition of organic matter by the different tree species in to soil which coupled with the presence of some of the nitrogen fixing tree species especially *Casurianaequisetifolia* have deeper root system and added nitrogen through atmospheric N fixation in root nodules.The activity of root symbionts such as nitrogen - fixing nodule could increase soil N level and as the suitable carbon substrate provide an energy source for bacterial mineralization and thereby enhance the availability of soil nitrogen which leads to higher accumulation of N in soil. Similar findings were obtained by Singh *et al.* 2009 and Chavan *et al*., 2018.

The data presented in Table 2 indicated that significantly the maximum available P_2O_5 content in soil was noted under *Tectona grandis* at all the soil depths i. e. 59.06 kg/ha, 58.37 kg/ha and 56.34 kg/ha at 0-30 cm, 30-60 cm and 60-90 cm soil depths, respectively and found significantly superior to rest of the treatments except *Eucalyptus camaldulensis* (58.96 kg/ha) at 0-30 cm, *Eucalyptus camaldulensis* (57.53 kg/ha) and *Eucalyptus camaldulensis* (55.80 kg/ha) at 30-60 cm and *Casurianaequisetifolia* (55.61 kg/ha) at 60-90 cm soil depths. Available P_2O_5 content of soil under different tree species was higher over open field might be due to the fact that organic acids released into the soil during the organic matter decompositionunder tree species which solubilize the native phosphorus and also add the phosphrous by the decomposition of litter fall obtained from the tree species.Similar results were obtained by Datta and Singh (2007).

The data presented in Table 2 explicit that significantly the highest available K_2O content in soil was noted under *Casurianaequisetifolia* over open field at all the soil depthandremained at par with rest of the tree species at 0-30 and 30-60 cm soil depths. But at 60-90 cm soil depth it was remained at par with rest of the tree species except *Eucalyptus camaldulensis* and *Gmelina arborea*. The improvement in K_2O content in soil under tree plantation may be due to the addition of litter fall through the various tree species increase the O.M. content of soil which in turn increases the CEC of soil which is directly responsible for the conversion of non-exchangeable and exchangeable form of potassium into available potassium content, there by significant potassium improvement was noted under tree plantation compared to open field. The results are in close conformity with the finding of Singh *et al*. (2009), Chavan *et al*. (2018) and Singh *et al*. (2018).

It is explicit from the data presented in Table 2 revealed that the maximum DTPA extractable ironwas observed under *Casurianaequisetifolia*i. e. 4.40 mg/kg, 4.18 mg/kg and 4.09 mg/kg at 0-30 cm, 30-60 cm and 60-90 cm soil depths, respectively and found significantly superior to rest of the treatments at all the soil depths except *Gmelina arborea* (4.29 mg/kg) at 0 -30 cm soil depth .

Significantly higher DTPA extractable Mn content in soil was obtained under *Eucalyptus camaldulensis*at all the soil depths over rest of the treatments except *Gmelina arborea* at 0-30 cm soil depth, *Casurianaequisetifolia*, *Gmelina arborea* and *Tectona grandis* at 30-60 cm and at 60-90 cm soil depth it was found at par with *Gmelina arborea*, *Casurianaequisetifolia* and *Melia azadiracht*. Significantly higher DTPA extractable copper in soil was recorded under *Casurianaequisetifolia* over rest of the treatments at all the soil depths except *Melia azadiracht* at 60-90 cm soil depth.

The DTPA extractable zinc content in soil was significantly higher under *Melia azadiracht* i.e. 0.946 mg/kg, 0.929 mg/kg and 0.902 mg/kg at 0-30, 30-60 and 60-90 cm soil depths, respectively over rest of the treatments except *Eucalyptus camaldulensis* at all the soildepths. The increased in availability of micronutrient under different tree species might be due to drop in soil pH by the release of various organic acids during the decomposition of litter fall received from the various trees. Similar results were obtained by Datta and singh (2007).

4. CONCLUSION

Multipurpose tree species under study significantly improved the physico- chemical properties of soil i.e. BD, WHC, porosity, organic carbon, available N, P_2O_5 and K_2O and DTPA extractable Fe, Mn, Zn and Cu content in soil over open field. Among all the tree species *Casurianaequisetifolia* performed better for the improvement in physico-chemical properties of soil.

TABLE 1. EFFECT OF DIFFERENT MULTIPURPOSE TREE SPECIES (MPTS) ON PHYSICAL PROPERTIES OF SOIL

Soil Physical properties	Depth (cm)	*Tectona grandis*	*Eucalyptus camaldulensis*	*Gmelina arborea*	*Casuriana equisetifolia*	*Melia azadiracht*	Open field Control	S.Em. ±	C.D. (5%)
BD (Mg/m^3)	0-30	1.57	1.59	1.58	1.55	1.56	1.62	0.013	0.040
	30-60	1.59	1.60	1.59	1.56	1.57	1.63	0.014	0.041
	60-90	1.59	1.62	1.61	1.57	1.58	1.63	0.013	0.036
	Mean	1.58	1.60	1.59	1.56	1.57	1.63	-	-
WHC (%)	0-30	27.47	25.21	26.60	28.70	28.38	23.43	0.431	1.28
	30-60	27.41	25.10	26.50	28.13	27.96	23.14	0.607	1.80
	60-90	26.18	25.04	25.20	26.80	26.50	22.14	0.598	1.77
	Mean	27.01	25.1	26.10	27.87	27.61	23.23	-	-
Porosity (%)	0-30	37.53	36.38	36.76	38.92	38.81	34.19	0.441	1.311
	30-60	36.91	36.20	36.44	38.10	37.53	33.86	0.408	1.213
	60-90	36.51	36.00	36.37	37.07	36.32	32.40	0.495	1.476
	Mean	36.98	36.19	36.52	38.03	37.55	33.48	-	-

TABLE 2. EFFECT OF DIFFERENT MULTIPURPOSE TREE SPECIES (MPTS) ON CHEMICAL PROPERTIES OF SOIL

Soil Chemical property	Depth (cm)	*Tectona grandis*	*Eucalyptus camaldulensis*	*Gmelina arborea*	*Casuriana equisetifolia*	*Melia azadiracht*	Open field Control	S.Em. ±	C.D. (5%)
pH	0-30	7.42	7.51	7.49	7.31	7.39	7.59	0.186	NS
	30-60	7.51	7.59	7.55	7.43	7.47	7.60	0.150	NS
	60-90	7.63	7.78	7.64	7.51	7.54	7.79	0.156	NS

	Mean	7.52	7.62	7.55	7.41	7.46	7.65	-	-
EC (dS/m)	0-30	0.053	0.051	0.052	0.054	0.053	0.057	0.001	NS
	30-60	0.050	0.049	0.050	0.053	0.052	0.056	0.002	NS
	60-90	0.049	0.047	0.048	0.050	0.049	0.054	0.002	NS
	Mean	0.050	0.049	0.050	0.052	0.051	0.056	-	-
Organic carbon (%)	0-30	0.413	0.329	0.345	0.472	0.454	0.274	0.0068	0.018
	30-60	0.387	0.335	0.346	0.463	0.450	0.250	0.0074	0.022
	60-90	0.382	0.321	0.337	0.400	0.386	0.225	0.007	0.020
	Mean	0.394	0.328	0.342	0.445	0.429	0.249	-	-
Available N (kg/ha)	0-30	165.80	158.18	162.66	171.42	168.40	145.70	2.175	6.46
	30-60	161.61	156.70	159.30	164.05	162.45	142.99	2.031	6.03
	60-90	157.20	155.62	157.88	160.04	158.28	140.49	1.985	5.89
	Mean	161.53	156.83	159.94	165.17	163.04	146.00	--	-
Available P_2O_5 (kg/ha)	0-30	59.06	58.96	54.90	57.40	55.85	45.10	1.041	3.093
	30-60	58.37	57.53	53.40	56.12	55.15	42.91	0.470	1.397
	60-90	56.34	55.80	53.82	55.61	54.73	40.73	0.396	1.177
	Mean	57.92	57.43	54.04	56.37	55.24	42.91	-	-
Available K_2O (kg/ha)	0-30	195.06	193.91	194.17	198.29	196.38	179.91	3.152	9.366
	30-60	194.17	188.97	190.26	196.00	195.26	175.03	2.677	7.956
	60-90	190.74	186.09	188.04	194.50	193.87	173.84	1.927	5.726
	Mean	193.32	189.65	190.82	196.27	195.17	176.26	-	-
DTPA extractable Fe (mg/kg)	0-30	3.52	3.90	4.29	4.40	3.28	3.10	0.083	0.246
	30-60	3.20	3.79	3.90	4.18	3.02	2.90	0.053	0.156

	60-90	2.81	3.09	3.19	4.09	2.73	2.70	0.044	0.130
	Mean	3.18	3.59	3.79	4.22	3.01	2.90	-	-
DTPA extractable Mn (mg/kg)	0-30	8.07	8.56	8.39	8.22	7.93	7.26	0.096	0.286
	30-60	7.99	8.32	8.29	8.18	7.76	7.18	0.11	0.328
	60-90	7.80	8.14	8.07	8.05	7.79	7.09	0.095	0.283
	Mean	7.95	8.34	8.25	8.16	7.83	7.69	-	-
DTPA extractable Cu (mg/kg)	0-30	0.875	0.918	0.946	1.110	1.051	0.789	0.014	0.043
	30-60	0.839	0.860	0.919	1.025	0.961	0.780	0.012	0.035
	60-90	0.836	0.857	0.905	1.018	1.010	0.762	0.012	0.035
	Mean	0.850	0.878	0.923	1.05	1.000	0.760	-	-
DTPA extractable Zn (mg/kg)	0-30	0.873	0.924	0.859	0.840	0.946	0.803	0.011	0.033
	30-60	0.863	0.905	0.837	0.813	0.929	0.789	0.009	0.026
	60-90	0.849	0.884	0.827	0.804	0.902	0.774	0.008	0.023
	Mean	0.861	0.904	0.841	0.819	0.925	0.788	-	-

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