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RESEARCH ARTICLE

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Studies on different flora, physico-chemical, microbiological properties of rhizospheric and non rhizospheric soils in compartment No. 792 of Gorewada Forest

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ABSTRACT

Study of Gorewada forest was carried out to find out the various types of flora and the soil properties like physicochemical properties, available total nutrient status as well as soil microbiological properties. It was revealed from the data that the forest present in 792 compartment is of dry deciduous type like tree, shrubs, herbs, climbers and grasses. Soil of the different plant species had clayey texture, porosity and WHC was high. The EC, organic carbon and CEC of pit soil was somewhat high compared to barren soil; however, levels of these chemical properties were lower as compared to the rhizospheric soil samples of dominant plant species. Total and available nutrient content was high in rhizosperic soil as compared to the pit soil and barren. The bacteria, fungi, actinomycetes and nitrogen fixer namely *Rhizobium* and *Azotobacter* and vesicular arbuscular mycorrhizae (VAM) spores were found to be high in pit soil as compared to barren soil. However, the rhizospheric soil samples had comparatively high counts of tested microorganisms. Findings of this particular study will formed a basis for developing future plans required for development of forest cover with a diversed variety of plants of high economic value like timber, medicinal and ornamental including even the exotic and rare species by using the biotechnological approach of bioaugmentation.

KEY WORDS : Gorewada forest, Flora, Soil and plant analysis, Chemical and microbiological properties

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INTRODUCTION

Many parts of country are facing problem of forest resources depletion, due to lack of proper physico-chemical and microbiological status of forest soils. This problem can be alleviated by site-specific soil augmentation process which has now been accepted as a tool for the sustainable management of forest resources. Sustainable management of forest practices are many. In forest management practices, high scientific skills are required. However, important steps are proposed herein as preliminary study is based on following aims and objectives. One of the main aims of the proposed study is to study native plant species in and around Gorewada forest. Another aim is to characterize rhizospheric soil of native plant species with respect to its physico-chemical and microbiological properties. This study will help to generate the basic data required for developing an appropriate bioaugmentation process that can be used to resolve the low nutrient status and less counts of useful micro flora present in forest soil for proper functioning of biogeochemical cycle. Project also aims to isolate site specfic biofertilizer strains of *Rhizobium, Azotobacter* and Vesicular Arbuscular Mycorrhiza (VAM) and to select a suitable organic amendment for improving the physico-chemical and microbiological properties of soil. Results of above mentioned study will form a platform for future studies in order to define the most supportive and nutritive rhizosphere for the sustainable development of the forest canopy by using bioaugmentation process.

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MATERIALS AND METHODS

The study was carried out on the project entitled, "Studies on different flora, physico-chemical, microbiological properties of rhizospheric and non rhizospheric soils in Compartment No. 792 of Gorewada Forest" by Sevadal Mahila Mahavidyalaya and Research Academy, Nagpur. During the study it was observed that

the parent material dominant in this area is basalt rock. The climate of the area is mainly characterized as dry sub humid climate with hot summer and mild winter. The Gorewada forest is located in Nagpur at 21^0 45'N latitude and 78^0 15'E longitude. The annual rainfall is 750 to 1000 mm. Site surveys were conducted at Gorewada forest during December-2007 to March-2008 by the college team of microbiologist, botanist and soil scientist. During every visit, as many specimens as possible and were collected were brought to the college laboratory to identify all plants by using reference of floras by Hooker's (1872-1897), Ugemuge (1986), Almeida (1990), Joshi (2000) and Singh *et al.* (2001). Beside this representative soil samples from minimum five rhizospheres of same plant species were collected from each compartment with the help of hand auger, and were mixed in equal proportions to get a composite sample on dry weight basis, air dried, homogenized, sieved through 2.0 mm mesh and stored in polythene bags. Analysis of composite barren, pit and rhizospheric soil samples of dominant plant species available in experimental site were conducted for different physico – chemical and microbiological properties to know the fertility status of the soil. Particle size analysis of soil samples was done by international pipette method (Piper, 1966), bulk density was determined by using clod method as described by Black (1965a), particle density was determined by a pycnometer method as described by Black *et al.* (1965), water holding capacity was determined by using Keen- Roozkowski brass boxes as described by Piper (1965), The pH of soil was determined by using 1:2.5 soil water suspension ratio as described by (Jackson; 1967), electrical conductivity was determined with the help of conductivity meter using 1: 2.5 soil water suspension ratios, (Jackson, 1967), organic carbon was determined by following Walkly and Black wet digestion method, (Black *et al.,* 1965), available N (was determined by following alkaline permanganate (0.31% $KMnO_4$) method (Subbaih and Asija, 1956), available P_2O_5 determined colorimetrically by following Bray's II method at 660 nm wavelength, (Black *et al.,* 1965), available K_2O determined air dried soil with 50.0 ml neutral N NH_4OAc. (Jackson, 1967). Total N: Samples were digested using conc. H_2SO_4 (wet digestion) and taken for nitrogen distillation by micro Kjeldahl method using Kjel Plus instrument (Tondon, 1993). Total phosphorous was estimated by digesting the soil with mixture of nitric acid and perchloric acid (9:4) and determines the phosphate by ammonium vanadomolybdate as described by Jackson (1967). Total potassium is estimated by digesting the soil with mixture of nitric acid and perchloric acid (9:4) and determines the potassium by using flame photometer. (Hesse, 1971). Microbes such as bacteria, fungi, actinomycetes and nitrogen fixing strains of *Rhizobium* and *Azotobacter* were analyzed by following standard procedure for soil microbial populations and were expressed in terms of colony forming units cfu/g (Black *et al.*, 1965 and Page *et al.*, 1982). Vesicular Arbuscular Mycorrhizal (VAM) spores were enumerated by Wet Sieving and decanting technique (Gerdmann and Nicolson, 1963).

RESULTS AND DISCUSSION

The results obtained from the present study have been presented under following heads :

Type of flora present:

There were about 42 different plant species classified as trees, shrubs, herbs, climbers and grasses in compartment number 792 (Table 1). Among the tree species dominant type were *Acacia catechu, A. leucophloea. A. nilotica, Albizia odoratissima, Butea monosperma, Cassia siamea, Mitragyna perbifolia, and Ziziphus mauritiana.*

Textural classification:

The textural classification *i.e.* sand, silt and clay percentages of soils collected from 792 compartment of Gorewada forest is presented in the Table 2 and results show that the textural class of all the soil samples analyzed were clayey in texture. The rhizospheric soil of the *Albizia odoratissima* had highest clay content of 62.12 per cent and very low content of sand (17.57%) and silts (20.31%). Due to clayey textural class, the clay content was high in all the rhizospheric soils of different species as compared to the sand and silt percentages. It was in this compartment reported that the majority of the soils have high amount of clay as compared to sand and silt. As basalt (rock) being the parent material for formation of these soils, therefore, it is known to impart higher amount of clay to the soil.

Physical properties:

Results of different physical properties of the soils collected from compartment number 792 of Gorewada forest are presented in the Table 3 and results show that the barren soil was although clayey in texture, the porosity and WHC was very low (51.32% and 50.45%, respectively) and the bulk density was very high (1.29 Mg m^{-3}). Due presence of vegetation in the soil the rhizospheric soil showed increase in porosity and WHC percentages. This phenomenon was observed in case of rhizospheric soil of *Albizia odoratissima* which reported the highest WHC (61.45%) and porosity (65.34%) with

Table 1 : List of various plant species present in compartment number 792

Sr. No.	Botanical name	Family	Local name
	Trees		
1.	*Acacia catechu*	Leguminosae	Khair
2.	*Acacia leucophloea*	Leguminosae	Hivar
3.	*Acacia nilotica*	Leguminosae	Babhul
4.	*Albizia odoratissima*	Leguminosae	Shiras
5.	*Andropogon pumilus*	Poaceae/Gramineae	Diwartan
6.	*Azadirachta indica*	Meliaceae	Kaduneem
7.	*Bauhinia racemosa*	Leguminosae	Apta
8.	*Butea monosperma*	Leguminosae	Palas
9.	*Cassia siamea*	Leguminosae	Cassia siamea
10.	*Dalbergia sissoo*	Leguminosae	Shisham
11.	*Dandrocalamus strictus*	Poaceae	Bamboo
12.	*Dolichandrone falcata*	Bignoniaceae	Mersing
13.	*Maytenus emarginata*	Celastraceae	Bharati
14.	*Mimosa hamata*	Leguminosae	Chilati
15.	*Mitragyna perbifolia*	Rubiaceae	Kalamb
16.	*Phoenix sylvestris*	Palmaceae	Sindi
17.	*Semicarpus anacardium*	Anacardiaceae	Biba
18.	*Tamarindus indica*	Leguminosae	Imli/Chinch
19.	*Tectona grandis*	Verbenaceae	Teak
20.	*Terminalia bellirica*	Combretaceae	Bihada
21.	*Ziziphus glaberrima*	Rhamnaceae	Guti
22.	*Ziziphus mauritiana*	Rhamnaceae	Bor
	Shrubs		
23.	*Lantana camera*	Verbenaceae	Ghaneri
24.	*Xanthium strumarium*	Asteraceae	Gokharu
	Climbers		
25.	*Cocculus hirsutus*	Menispermaceae	Vasanvel
26.	*Coix lacryma-jobi*	Poaceae/Gramineae	Kasai/Garu
27.	*Hemidesmus indicus*	Periplocaceae	Khobarvel/Anantvel
28.	*Ipomea quamoclit*	Convolvulaceae	Ganeshvell
	Herbs		
29.	*Ageratum conyzoides*	Asteraceae	Osadi
30.	*Alternanthera pungens*	Amaranthaceae	Galighosh
31.	*Blumea eriantha*	Asteraceae	Nirmudi
32.	*Cassia tora*	Leguminosae	Tarota
33.	*Hyptis suaveolens*	Lamiaceae/Labiatea	Rantulas
34.	*Parthenium*	Asteraceae	Gajarghas
35.	*Sida acuta*	Malvaceae	Chikana/Tupkadi
36.	*Sida cordata*	Malvaceae	Bhuichikana
37.	*Tridax procumbens*	Asteraceae	Kambarmodi
38.	*Vernonia cinerea*	Asteraceae	Sahadevi
39.	*Vicoa indica*	Asteraceae	Sankuli (Sonuli)
	Grasses		
40.	*Apluda mutica*	Poaceae/Gramineae	Ponai
41.	*Hackelochloa granularis*	Poaceae/Graminaeae	Phulwa
42.	*Iseilema laxum*	Poaceae/Gramineae	Mushan

Table 2 : Textural classification of barren and rhizospheric soils of dominant plant species available from compartment number 792 of Gorewada forest

Sr. No	Sample name	Sand (%)	Silt (%)	Clay (%)	Textural class
Compartment number 792					
1	Barren patch	19.29	28.61	52.10	Clayey
Rhizospheric soils of dominant plant species					
1	*Ziziphus mauritiana* (Bor)	22.34	26.29	51.37	Clayey
2	*Acacia catechu* (Khair)	28.39	27.45	44.16	Clayey
3	*Bauhinia racemosa* (Apta)	20.71	23.53	55.76	Clayey
4	*Acacia nilotica* (Babhul)	20.39	27.68	51.93	Clayey
5	*Albizia odoratissima* (Shiras)	17.57	20.31	62.12	Clayey
6	*Tamarindus indica* (Imli/ Chinch)	24.02	23.84	52.14	Clayey
7	*Mitragyna perbifolia* (Kalamb)	23.87	25.69	50.44	Clayey

Table 3 : Physical properties of barren and rhizospheric soils of dominant plant species available from compartment number 792 of Gorewada forest

S.N.	Sample name	BD (Mg m^{-3})	Porosity (%)	WHC (%)
Compartment number 792				
1.	Barren patch	1.29	51.32	50.45
Rhizospheric soils of dominant plant species				
1.	*Ziziphus mauritiana* (Bor)	1.14	58.92	56.39
2.	*Acacia catechu* (Khair)	1.15	56.60	52.65
3.	*Bauhinia racemosa* (Apta)	1.09	58.87	56.34
4.	*Acacia nilotica* (Babhul)	1.17	60.74	57.78
5.	*Albizia odoratissima* (Shiras)	1.10	65.34	61.45
6.	*Tamarindus indica* (Imli/Chinch)	1.13	57.36	54.45
7.	*Mitragyna perbifolia* (Kalamb)	1.10	58.59	55.34

Table 4 : The chemical properties of the barren and rhizospheric soils of dominant plant species available from compartment number 792 of Gorewada forest

Sr. No.	Name of sample	pH	EC dS m^{-1}	O.C (%)	CEC cmol (p^+) kg^{-1}
Compartment number 792					
1.	Barren soil	7.80	0.30	1.78	53.14
Rhizospheric soils of dominant plant species					
1.	*Ziziphus mauritiana* (Bor)	7.44	0.32	1.89	56.57
2.	*Acacia catechu* (Khair)	7.76	0.32	2.90	58.20
3.	*Bauhinia racemosa* (Apta)	7.67	0.22	2.21	56.66
4.	*Acacia nilotica* (Babhul)	7.12	0.29	2.22	55.34
5.	*Albizia odoratissima* (Shiras)	7.32	0.26	1.90	57.59
6.	*Tamarindus indica* (Imli/Chinch)	7.35	0.28	2.24	58.67
7.	*Mitragyna perbifolia* (Kalamb)	7.65	0.20	2.34	60.61

the lower BD of 1.10 Mg m^{-3}. Similar findings were observed in case of the rhizospheric soils of other plant species namely *Acacia nilotica*, *Mitragyna perbifolia*, *Acacia catechu*, *Ziziphus mauritiana* and *Bauhinia racemosa* where the WHC ranged from 52.65 per cent to 61.45 per cent.

Chemical properties:

The chemical properties of the different plant species found in compartment number 792 are presented in the Table 4. The result shows that pH and the EC of this site were observed to be high as compared to the other compartments. The organic carbon status was varied from 1.78 per cent in barren soil to the 2.34 per cent in the

Mitragyna perbifolia. The leguminous plant species like *Acacia catechu, Acacia nilotica, Mitragyna perbifolia* and *Tamarindus indica* were reported high organic carbon, *viz.,* 2.90, 2.22, 2.34 and 2.24 per cent. The CEC was obviously high in the rhizospheric soil of all the species of the compartment as compare to the barren soil. The rhizospheric soil exhibits biological nitrogen fixation in leguminous plants; hence, rhizosphere contains the higher level of nutrient availability and exchange of the cations and thus CEC is high in the rhizosphere. In this compartment the CEC was very high in the rhizospheric soil of the *Mitragyna perbifolia* (60.61CEC cmol (p^+) kg^{-1}) which was followed by the *Tamarindus indica* (58.67 cmol (p^+) kg $^{-1}$) and 58.20 cmol (p^+) kg^{-1} in the *Acacia catechu*.

Total nutrient status:

The total nutrient status of the 792 compartment is given in the Table 5. The highest N (0.26 %), K (0.57%) and S (0.067%) content was found in the rhizospheric soil of *Acacia catechu,* because the *Acacia catechu* is the leguminous plant which harbors *Rhizobium* in its root nodules and its growth is preferentially stimulated in the rhizosphere of legume than in that of non legumes. Moreover, legumes excrete a large number of substances into the rhizosphere principally sugars, amino acids and vitamins such as biotin and pantothenic acid therefore, the total N was high in the rhizosphere of this plant. The K and S content are high due to the rhizospheric effect of soil microorganisms residing in the root zone of *Acacia catechu*. In rhizospheric soils of other plant species the total N ranged from 0.12 to 0.25, P: 0.045 to 0.068; K: 0.27 to 0.45 and S: 0.043 to 0.063 per cent.

Available nutrient status:

The available nutrient status of the compartment number 792 is given in the Table 6. The nitrogen content of this site was low as compared to the other compartment. In all the rhizospheric soil of the different plant species of this compartment the highest N content was observed in

Table 5 : The Total nutrient status of barren and rhizospheric soils of dominant plant species available from compartment number 792 of Gorewada forest

Sr. No	Sample No.	Total nutrient status			
		Total N (%)	Total P (%)	Total K (%)	Total S (%)
Compartment number 792					
1.	Barren patch	0.22	0.045	0.35	0.050
Rhizospheric soils of dominant plant species					
1.	*Ziziphus mauritiana* (Bor)	0.12	0.067	0.45	0.055
2.	*Acacia catechu* (Khair)	0.26	0.056	0.57	0.067
3.	*Bauhinia racemosa* (Apta)	0.19	0.068	0.42	0.056
4.	*Acacia nilotica* (Babhul)	0.12	0.045	0.30	0.056
5.	*Albizia odoratissima* (Shiras)	0.25	0.050	0.27	0.047
6.	*Tamarindus indica* (Imli/Chinch)	0.12	0.054	0.32	0.063
7.	*Mitragyna perbifolia* (Kalamb)	0.24	0.057	0.34	0.043

Table 6 : The available nutrient status of barren and rhizospheric soils of dominant plant species available from compartment number 792 of Gorewada forest

Sr. No.	Name of sample	Available nutrient status		
		N (%)	P_2O_5 (%)	K_2O_5 (%)
Compartment number 792				
1.	Barren soil	0.012	0.00111	0.0224
Rhizospheric soils of dominant plant species				
1.	*Ziziphus mauritiana* (Bor)	0.022	0.00112	0.0345
2.	*Acacia catechu* (Khair)	0.016	0.00129	0.0435
3.	*Bauhinia racemosa* (Apta)	0.012	0.00063	0.0234
4.	*Acacia nilotica* (Babhul)	0.018	0.00110	0.0378
5.	*Albizia odoratissima* (Shiras)	0.016	0.00129	0.0443
6.	*Tamarindus indica* (Imli/ Chinch)	0.019	0.00122	0.0238
7.	*Mitragyna perbifolia* (Kalamb)	0.021	0.00120	0.0367

Table 7 : The microbiological count of the barren and rhizospheric soil of dominant plant species available in the compartment number 792 of Goreada forest

Sr. No.	Name of sample	Counts of different types of useful microorganisms					
		Bacteria Cfu g^{-1}	Fungi Cfu g^{-1}	Actinomycetes Cfu g^{-1}	*Rhizobium* Cfu g^{-1}	*Azotobacter* Cfu g^{-1}	VAM spores Cfu 10^{-1} g
Compartment number 792							
1.	Barren patch	14 X10^5	11 X 10^3	7 X 10^3	12 X 10^3	17 X 10^3	4
Rhizospheric soils of dominant plant species							
1.	*Ziziphus mauritiana* (Bor)	49 X 10^5	34 X 10^3	40 X 10^3	36 X 10^3	43 X 10^3	9
2.	*Acacia catechu* (Khair)	53 X 10^5	42 X 10^3	36 X 10^3	46 X 10^3	34 X 10^3	10
3.	*Bauhinia racemosa* (Apta)	52 X 10^5	37 X 10^3	41 X 10^3	39 X 10^3	24 X 10^3	12
4.	*Acacia nilotica* (Babhul)	43 X 10^5	40 X 10^3	39 X 10^3	48 X 10^3	27 X 10^3	10
5.	*Albizia odoratissima* (Shiras)	41 X 10^5	32 X 10^3	34 X 10^3	29 X 10^3	26 X 10^3	9
6.	*Tamarindus indica* (Imli/Chinch)	32 X 10^5	41 X 10^3	27 X 10^3	26 X 10^3	21 X 10^3	10
7.	*Mitragyna perbifolia* (Kalamb)	40 X 10^5	35 X 10^3	23 X 10^3	29 X 10^3	20 X 10^3	3

the *Ziziphus mauritiana* (0.022%) followed by the *Mitragyna perbifolia* (0.021%). The P_2O_5 and K_2O content were high in the *Albizia odoratissima* 0.00129 and 0.00443 per cent, respectively. The *Acacia catechu* also showed the high P_2O_5 and K_2O *viz.,* 0.00129 and 0.0435 per cent, respectively.

Microbiological count:

The microbiological count of the different plant species collected from the compartment number 792 is presented in the Table 7. The highest bacterial and fungal count was reported in the rhizospheric soil of *Acacia catechu* (53 x 10^5, 42 x 10^3 cfu g^{-1}, respectively) due to high organic carbon and CEC of the soil. The actinomycetes were highest in the *Bauhinia racemosa* (41 x 10^3 cfu g^{-1}) followed *Ziziphus Mauritiana*. The nitrogen fixing bacteria *i.e. Rhizobium* was high in the *Acacia nilotica* (48 x 10^3 cfu g^{-1}) closely followed by the *Acacia catechu* (46 x 10^3 cfu g^{-1}) being a leguminous plant. However, the non symbiotic nitrogen fixing bacteria *i.e. Azotobacter* was highest in the *Ziziphus Mauritiana*. The count of VAM spores was high in the rhizosphere of *Bauhinia racemosa* (12 cfu 10^{-1} g). In the barren soil, the microbiological counts of useful microorganisms was very low owing to low total and available nutrient status of barren soil in terms of contents of carbon, N, P and K levels.

Conclusion

Development of richness in the vegetation wealth and biodiversity of soil is of prime importance in the forest cover as well as on the non - forest area to conserve the bioresources and tree wealth. Many parts of country are facing problem of forest resources depletion, due to lack of proper physico-chemical and microbiological status of forests soils. Therefore, sustainable management of forest soil is required. This can be achieved by virtue of performing the proposed preliminary study of native plant species in and around Gorewada forest, characterization of rhizospheric soil of native plant species with respect to its physico-chemical and microbiological properties, isolation of site specific biofertilizer strains of *Rhizobium, Azotobacter* and Vesicular arbuscular mycorrhiza (VAM) and selection of a suitable organic amendment to improve the physico-chemical and microbiological properties of soil from Gorewada forest. Findings of this particular study will formed a basis for developing future plans required for development of forest cover with a diversed variety of plants of high economic value like timber, medicinal and ornamental including even the exotic and rare species by using the biotechnological approach of bioaugmentation. The bioaugmentation process can be used to resolve the low nutrient status and less counts of useful micro flora present in forest soil.

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