

Original Research Article

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Acacia mearnsii Invasion on Soil Microbial Population of Shola Forests in the Western Ghats

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ABSTRACT

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The Australian Black Wattle (*A. mearnsii*), an invasive alien species introduced in the upper altitudes of the Palani hills threatens the high altitude ecosystem. The present investigation was undertaken to study the soil microbial population in shola forests invaded by *A. mearnsii* plantations in the Western Ghats covering the Kodaikanal. Soil samples were collected from shola forests invaded by *A. mearnsii* in three forest ranges viz, Kodaikanal, Berijam and Poombarai of the Kodaikanal Forest Division. For comparison purpose, soil samples were collected from shola forest, pure *A. mearnsii* plantation, grass land and pine plantations. The study showed a significant variation in the microbial population in the different study plots with the highest bacterial (29.3×10^8 cfu g⁻¹), fungal (15.0×10^4 cfu g⁻¹) and actinomycetes (3.0×10^3 cfu g⁻¹) population in shola forest in all the three ranges of Kodaikanal Forest Division. The population of soil microbes in Berijam and Poombarai forest range was also high under shola forests. This study has contributed to the understanding of soil microbial population in *A. mearnsii* invaded shola forests.

Introduction

Tropical Montane, evergreen forests locally known as sholas, situated in the higher mountain tracts of the Western Ghats, at an altitude above 1500m is interspersed with rolling grasslands. Sholas stay in restricted boundaries, in small pockets and the grasslands dominate. These bio diverse forests and grasslands were converted into commercially valuable plantation to serve fuel wood need of tea industry during British period. Some of the introduced species like *A.*

mearnsii have become invasive alien species in this ecosystem and became a serious threat to this high altitude ecosystem (Myers *et al.*, 2000).

The Australian Black Wattle (*A. mearnsii*) was introduced during the 1960s in State Forest lands located in the upper altitudes of the Palani hills - an eastern offshoot of the Western Ghats, a mountain range that runs parallel to the southwest coast of Peninsular India near the hill station of Kodaikanal (Mitchell, 1972; Mathew *et al.*, 1975). The

tree species is well established in the upper Palani hills between 1800 and 2400m both within State Forest plantations and in areas near towns and rural settlements (Rangan *et al.*, 2010). Mass of leaf litter in areas invaded by *A. mearnsii* was reported to be greater than that of un-invaded area, thereby the dense layer inhibits the establishment of native seedlings. Between 1849 and 1992, the sholas decreased from 8600ha to 4225 ha and grasslands from 29875 ha to 4700 ha. This non-regenerating and fast-receding shola forest is a dying community, more appropriately called a 'living fossil' community. Soil microbial communities have important role in organic matter decomposition, nutrient cycling, soil structural formation, and even plant interactions (Wardle *et al.*, 2004). The abundance, size and activity of the microbial populations depend on the quantity and quality of organic matter, texture and other environmental factors (Insam *et al.*, 1989; Kaiser *et al.*, 1992) as well as limited carbon content (Lynch and Whipps, 1990; Wardle, 1992). Soil biological health is also an important indicator of soil quality. Soil microbial communities are extremely diverse in their composition and play an important role in nutrient cycling functions such as organic matter decomposition and mineralization, nutrient mobilization and carbon sequestration (Strickland and Rousk, 2010).

Studies on the soil microbial properties in invaded shola forests are required for proper management of the forests and utilization of resources. Comparative studies on the assessment of soil microbes under shola forests invaded by *A. mearnsii* in the Western Ghats of Kodaikanal are sparse. Hence, the present study was proposed with an aim to study the soil microbial population of shola forests invaded by *A. mearnsii* plantations in the Western Ghats.

Materials and Methods

The present study was carried out in the Western Ghats of Tamil Nadu covering three forest ranges of the Kodaikanal Forest Division *viz*, Kodaikanal, Berijam and Poombarai. Kodaikanal Forest Division lies within 10°6' and 10°21' North latitudes and 77°16' and 77°42' East longitudes and is surrounded by Kerala state in West, Indira Gandhi Wild life sanctuary, Pollachi in North-west, Dindigul forest division on the North-east and Theni revenue district in South. The altitude varies from 300 to 2654 m and this area experiences an average yearly rainfall of 165 cm. The minimum temperature of Kodaikanal varies between 8 to 13 °C and the maximum temperature varies between 11.3 to 19.8 °C.

Enumeration of microorganisms from soil by the serial dilution-agar plating method (or viable plate count method)

Soil samples were collected from the rhizosphere at a depth of 0-20 cm layer of the top soil. Three replicate soil samples were collected from the selected plots of the shola forests invaded by *A. mearnsii* in the three forest ranges of Kodaikanal Forest Division *viz*, Kodaikanal Forest Range, Berijam Forest Range and Poombarai Forest Range. For comparison purpose, soil samples were also collected from shola forest, pure *A. mearnsii* plantation, grass land and pine plantations. Enumeration of Microorganisms (bacteria, fungus and actinomycetes) was carried out by standard serial dilution plate technique (Waksman, 1922). About 10 grams of soil was transferred to 90 ml sterile distilled water and agitated vigorously. Different aqueous dilutions, up to 10⁻⁹ of the suspensions were prepared and spread plated on soybean casein digest medium for bacteria and fungus and actinomycetes isolation agar for enumeration of actinomycetes. Inoculated plates were

incubated at 37°C for 24 – 44 hrs. After incubation microbial colonies were counted and the load was expressed as number of colony forming units (CFU) per gram of soil.

$$\text{No. of cells/ g} = \frac{\text{Number of colonies} \times \text{dilution factor}}{\text{Dry wt. of soil}}$$

All statistical tests were performed with SPSS ® 19.0 version statistical software. Wherever the treatment differences were found significant, the critical differences were worked out at 5 per cent probability and values were furnished. The treatment differences that are non-significant were indicated as Non-Significant (NS).

Results and Discussion

Microbial population in Kodaikanal range

Soil samples for microbial enumeration were collected from the different study plots and the population of microbes was expressed as colony forming units (cfu) per gram of soil. The microbial population varied significantly among the study plots (Table 1). The bacterial population ranged from 12.8 x10⁸ to 29.3 x10⁸ cfu g⁻¹. Among the different study plots, shola forest recorded the highest bacterial population (29.3 x10⁸ cfu g⁻¹) followed by *A. mearnsii* invaded shola (21.6 x10⁸ cfu g⁻¹). The lowest population of bacteria was recorded in pine forest (12.8 x10⁸ cfu g⁻¹). The

fungal population was highest in shola forests (15.0 x10⁴ cfu g⁻¹) and the lowest in grassland (7.8 x10⁵ cfu g⁻¹) (Fig.18). With respect to actinomycetes population, shola forest had the highest population (3.0 x10³ cfu g⁻¹) and it was lowest in pine forest.

The present study showed a significant variation with regard to the microbial population in the different study plots with the highest bacterial, fungal and actinomycetes population in shola forest of the Kodaikanal range. This variation in microbial population in soil can be ascribed to the difference in micro- and macro-climatic and edaphic factors prevalent at each site, which are known to influence the microbe population (Sankaran and Balasundaran, 2001).

Microbial population in Berijam range

In the Berijam range, the bacterial population ranged from 10.7 x10⁶ to 28.8 x10⁸ cfu g⁻¹ (Table 2). Among the different study plots, shola forest recorded the highest bacterial population (28.8 x10⁸ cfu g⁻¹) followed by *A. mearnsii* invaded shola (21.6 x10⁸ cfu g⁻¹) and *A. mearnsii* plantation (16.3 x10⁸). Pine forest registered the lowest population of bacteria (10.7 x10⁶ cfu g⁻¹). With respect to the fungal population, shola forests had the highest fungal load (16.3 x10⁴ cfu g⁻¹) and the lowest in grassland (9.1 x10⁵ cfu g⁻¹).

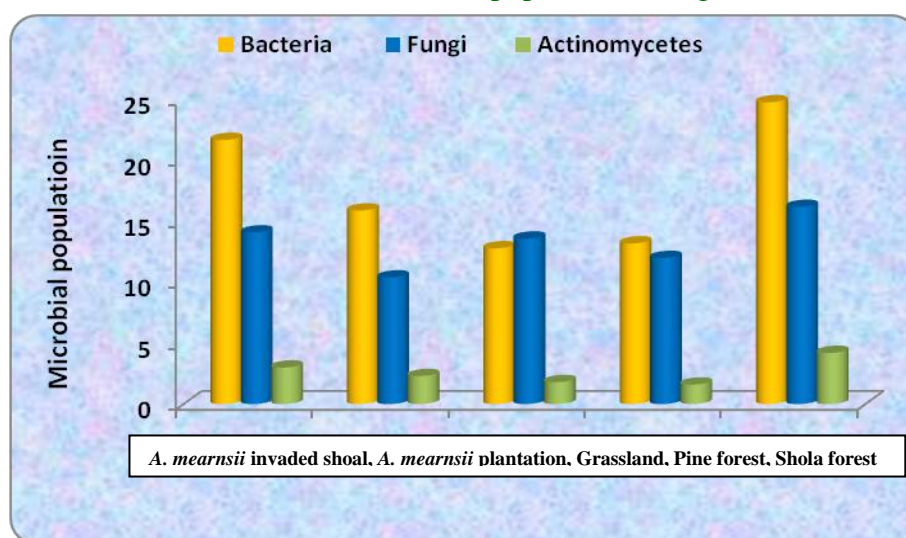
Table.1 Microbial population under different study plots in Kodaikanal range

Study plots	Bacteria (cfu g ⁻¹)	Fungi (cfu g ⁻¹)	Actinomycetes (cfu g ⁻¹)
<i>A. mearnsii</i> invaded shola	21.6x10 ⁸	13.6x10 ⁴	2.6x10 ³
<i>A. mearnsii</i> plantation	15.5 x10 ⁶	12.5 x10 ⁵	2.1x10 ³
Grassland	14.1 x10 ⁸	7.8 x10 ⁵	1.6 x10 ³
Pine forest	12.8 x10 ⁸	8.6 x10 ⁴	1.4x10 ³
Shola forest	29.3 x10 ⁸	15.0 x10 ⁴	3.0x10 ³
SE(d)	0.77	0.53	0.10
CD (0.05)	1.68	1.16	0.21

Table.2 Microbial population under different study plots in Berijam range

Study plots	Bacteria (cfu g ⁻¹)	Fungi (cfu g ⁻¹)	Actinomycetes (cfu g ⁻¹)
<i>A. mearnsii</i> invaded shola	24.4x10 ⁸	15.2x10 ⁴	3.8x10 ³
<i>A. mearnsii</i> plantation	16.3 x10 ⁸	12.0 x10 ⁴	2.6x10 ³
Grassland	14.4 x10 ⁸	11.6 x10 ⁵	1.4 x10 ³
Pine forest	10.7x10 ⁶	9.1 x10 ⁵	2.3x10 ³
Shola forest	28.8 x10 ⁸	16.3 x10 ⁴	5.6x10 ³
SE(d)	0.85	0.61	0.14
CD (0.05)	1.85	1.32	0.30

Fig.1 *A. mearnsii* invasion on soil microbial population (cfu/g) in Poombarai range



The actinomycetes population was highest in shola forest (5.6 x10³ cfu g⁻¹) and it was lowest in grassland. Silva *et al.*, (2005) reported that microbial population were significantly greater in forest soil than in field soil, which could also be related to the higher level of soil organic matter in the forest soil. The present study also revealed higher bacterial, fungal and actinomycetes population in shola forest of the Berijam range.

Microbial population in Poombarai range

The bacterial population in Poombarai range varied from 12.8 x10⁸ to 24.8 x10⁸ cfu g⁻¹. The population of bacteria was highest under shola forest (24.8 x10⁸ cfu g⁻¹) and lowest in

grassland (Fig.1). The fungal population was highest in shola forests (16.2 x10⁴ cfu g⁻¹) and the lowest in *A. mearnsii* plantation (10.4 x10⁵ cfu g⁻¹). With respect to actinomycetes population, shola forest had the highest population (4.2 x10³ cfu g⁻¹) and it was lowest in pine forest (1.6 x10³ cfu g⁻¹). As shown earlier, this higher number of microbial population in shola forest might be because of symbiotic relation of microorganism with tree species and microclimate developed in rhizosphere (root soil) soil by tree species (Sharma *et al.*, 2009; Golinska and Dahm, 2011).

The study has enabled generation of baseline data on the soil microbial population in the shola forests invaded by *Acacia mearnsii* in

Kodaikanal, Berijam and Poombarai ranges of the Kodaikanal Forest Division.

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