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Short communication

The importance of *Butea monosperma* for the restoration of degraded lands

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ABSTRACT

The present study emphasized the importance of *Butea monosperma* (native tree species), not only as an ideal economic investment that can be utilized in many different manners but also as an species of enormous potential for restoration of degraded lands. Here, we evaluate the changes in chemical, microbial and enzymatic activities of rhizosphere soils (RS) of Butea and compared with bare lands (disturbed lands) to assess its ecological suitability for recovery. We collected 50 soil samples from Butea rhizosphere as well as from bare land soil. Soil pH and electrical conductivity (EC) were significantly lower in rhizospheric soils in comparison to bare land soils, while water holding capacity (WHC), organic carbon (OC), total nitrogen (N), available phosphorus (P), microbial biomass carbon (MBC), dehydrogenase, β-glucosidase and alkaline phosphatase activities were significantly higher in rhizospheric soil. Decrease in soil pH, EC and increases in soil nutrients, microbial biomass and soil enzyme activities suggests that Butea can be potential species to restore and enhance the biological activities of degraded lands and further to facilitate the vegetation establishment. However, further extensive research is required for better insights in this aspect.

1. Introduction

Land degradation is defined as a loss of ecosystem function and productivity caused by the disturbances induced directly or indirectly by the human activities from which the land cannot recover unaided (Bai et al., 2008; Acharya and Kafle, 2009). It is the net result of derivative processes regulated by natural and anthropogenic factors. The degree of soil degradation depends on duration of degradative land use, susceptibility of soil to the degradative processes and the management processes (Mishra et al., 2014). The crucial factor recognized in degradation of soils is the deforestation, allowing increased erosion and salinization processes to occur (Sinha et al., 2009). Land degradation has raised one of the serious debates, as it has become an important issue in the modern era due to decrease in the agriculture and forest area. Hence, due to the decrease in the productive area, encroachment of humans is increasing in forest and agricultural lands to ensure food security. Therefore, ecological restoration of degraded lands has a paramount importance.

There are so many approaches for the eco-restoration of degraded lands like mechanical and biological approach, soil amendments for enhancing productivity, proper land use planning, natural plantation and agroforestry (Mishra et al., 2014). However, ecological restoration performed through natural forest (Mukhopadhyay et al., 2013) is a potential approach in renewing damaged and degraded lands caused due to the active human interferences (Chazdon et al., 2009; Singh et al., 2012a). Presence of vegetation is important in such areas since it enhances soil water holding capacity and soil fertility which increases the physical protection and contributes in soil organic matter (Garcia et al., 1994). The role of plantation on degraded lands can have multiple functions in terms of ecosystem services such as carbon sequestration, substrate improvement, rehabilitation and pollutants remediation (Singh et al., 2004; Tormo et al., 2007; Singh et al., 2012b). Additionally, the roots of growing plant help in increasing the water holding capacity and in controlling the process of evapotranspiration (Hussain, 1995). The region around the plant roots is known as a rhizospheric region and is a biologically active zone due to higher microbial growth and activities (Singh et al., 2013). The

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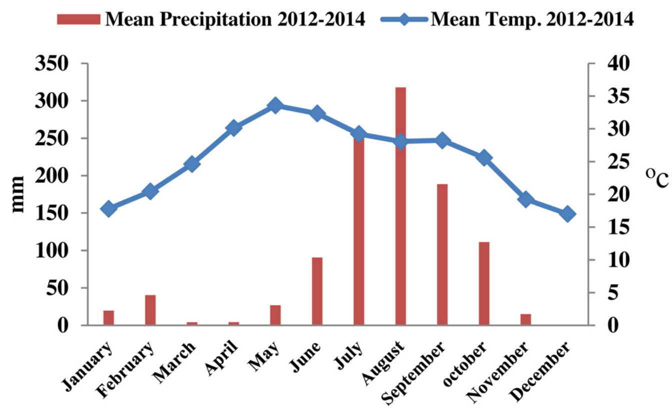

Fig. 1. Mean temperature and mean precipitation for the study site.

rhizosphere microbial processes of the tree species are one of the very important factors in deciding their survival and sustainable growth. Soil microorganisms play a fundamental role in establishing biogeochemical cycles and facilitate the development of plant cover. Apart from this, the growth of plantation enriches the biodiversity and improves the livelihood of the local communities (Pandey and Singh, 2014).

Butea monosperma (Lam.) Taubert (henceforth referred as Butea) is a medium-sized deciduous tree belongs to family fabaceae and sub-family papilionaceae is a native tree of tropical and subtropical climate. It is considered as one of the largest families of flowering plants, numbering 630 genera and 18,000 species (Sindhia and Bairwa, 2010). It is found in drier parts, often gregarious in forests, open grasslands and wastelands. It can grow on poor soil such as swampy drained, water logged, black cotton soil, in high saline conditions and can even adapt into low availability of water (Jhade et al., 2009; Vaghela et al., 2010). Additionally, the fast turnover and decomposition of nutrient rich leaf litter of Butea increases the soil fertility by increasing the soil organic carbon (SOC) (Kumar et al., 2010). Butea forests have ecological and environmental functions in term of soil erosion control, land rehabilitation, water conservation and soil carbon sequestration (Kumari et al., 2005). The rapid increase in the rate of deforestation makes Butea an ideal investment or choice for plantation. Biological characteristics and growth habits of Butea make it more important in solving the problem of degraded lands, like for erosion control and carbon sequestration (Kumar et al., 2010; Rai et al., 2016). Hence, the present investigation was carried out to study the effect of *B. monosperma* on the soil quality with the emphasis on its role in eco-restoration of degraded lands so that policy makers may be encouraged to more actively conserve indigenous Butea trees and include Butea in sustainable land management strategies especially for dry tropics.

2. Materials and methods

2.1. Study site description

The study was conducted in the Vindhyan dry tropical region, Sonbhadra districts, Uttar Pradesh. This area experiences a tropical monsoon climate. The year is divisible into three seasons: rainy (mid-June to September), winter (November to February) and summer (April to mid-June). The months of March and October represent transitional periods, respectively between winter and summer and between rainy and winter. Approximately, 85% of annual rainfall is received during the rainy season (Jha and Singh, 1990). Mean precipitation and mean temperature of the study site is depicted in Fig. 1. The soils are residual ultisols in origin, sandy loam in texture and reddish to dark grey in colour and are extremely poor in nutrients (Singh et al., 1989). An experimental plot of 100 m × 50 m of Butea was established which included five replicate subplots of 50 m × 20 m (0.1 h).

2.2. Samples collection and analysis

Estimation of biomass was done by the method adopted in Southeast United States (www.forestdisturbance.net) . Soil samples were collected from the rhizosphere (RS) of Butea plot and from the bare land adjacent to the Butea plot. Composite soil samples (0–30 cm) were collected from each study site and sub-samples were brought to the laboratory. For RS soil, total 50 (10 from each subplot) soil samples were pooled to reduce the spatial heterogeneity of the soil, if any. After that five replicates from these pooled samples (composite samples) were taken to analyze the soil properties. It has been common practice to separate RS soil to assess the effect of growing plant roots on the microbial activities in the surrounding soils (Steer and Harris, 2000). Therefore, in this study we separated rhizosphere soil from Butea roots. Soil adhering to roots of Butea and within the space explored by the roots was considered as rhizosphere soil (Koranda et al., 2011) (Fig. 2A). Similarly, soil was collected from bare land (Fig. 2B). All the collected field soil samples were packed into plastic bags and taken back to the laboratory for further analysis. The soil samples were air dried and ground to pass through a sieve having a mesh size of 2.0 mm, homogenized and analyzed for chemical characteristics. The pH and electrical conductivity (EC) of rhizospheric and bare land soils were analyzed by using a pH meter and a conductivity meter (Singh et al., 2016), respectively. Organic carbon (OC) was estimated by Walkley and Black (1934) method. Available phosphorus (P) was analyzed by the method described by Olsen et al. (1954). Total nitrogen (N) was estimated by the Kjeldhal method through Kelplus nitrogenaceto-analyzer (Bremner and Mulvaney, 1982). Another portion of the soil sample was used for determining microbial biomass carbon (MBC) and enzyme activities. Microbial biomass carbon was estimated by the fumigation-extraction methods as described by Vance et al. (1987). Soil dehydrogenase activity was analyzed using 2, 3, 5-triphenyltetrazolium chloride as the substrate (Casida et al., 1964), soil β-glucosidase activities were determined using *p*-nitrophenyl-β-D-glucopyranoside as a substrate (Tabatabai, 1994) and alkaline phosphatase using *p*-nitrophenyl phosphate as substrate (Tabatabai, 1994). All reagents used in the present study were of analytical grade and Millipore quality distilled water was used for the preparation of all the solutions. Blanks and internal standards were included for quality assurance during the analysis of rhizospheric and bare land soil samples.

2.3. Statistical analysis

Duncans test was carried out to compare the means of bare land and rhizospheric soil of Butea at the significance level of 0.05 ($P < 0.05$). Observation on chemical parameters, microbial biomass carbon and enzyme activities were analyzed using SPSS software package. The results were expressed as mean ($n = 5$) ± standard deviation.

3. Results and discussion

3.1. Estimation of biomass

Forest of Butea shows higher biomass production of shoot in comparison to root. Shoot produces about 160 while root contributes to 40 t biomass ha^{-1}. The high production of shoot may be from the contribution of bole wood, branches, twigs and other reproductive parts which increase with age of the plant while