Comparative Soil Nutrient Status and Microbiota Associated in the Rhizosphere of Oroxylum indicum growing in Different Natural Habitat in North East India

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A B S T R A C T

The rhizospheric soil samples were collected from five different sites of Northeast India where Oroxylum indicum was naturally growing in its ecological habitat and were analysed. A total of 25 fungal species and four bacterial isolates were found to be associated in the rhizosphere of O.indicum. The fungal microbiota comprised mainly of Trichoderma harzianum, Penicillium sp., Aspergillus sp., Trichoderma viride, Fusarium sp., Penicillium funiculosum, Penicillium capsulatum, Penicillium citrinum, Pachybasium sp., Trichoderma hamatum, Mucor sp., Verticillium sp., Curvularia sp., Rhizomucor sp., Pythium sp., Rhizoctonia sp., Colletotrichum sp. etc. While the bacterial isolates mainly comprised of Four bacterial isolates Pseudomonas putida, Pseudomonas sp., Streptobacillus sp., Bacillus sp. The overall analysis of soil nutrient status showed that pH status was higher in roadside and riverside, while minimum pH was found in forest fringe and hillslope. The % Organic Carbon was found to be highest in agricultural farmland and lowest in hillslope. Available Nitrogen was highest in agricultural farmland, while it was minimum in forest fringe. Available Phosphorus was again highest in agricultural farmland while it was lowest along riverside. Available Potassium was highest in hillslopes and agricultural farmland while it was lowest along riverside.

Introduction

The rhizosphere is a densely populated area in which the roots must compete with the invading root systems of neighboring plant species for space, water and mineral nutrients, and with soil-borne microorganisms, including bacteria, fungi, and insects feeding on an abundant source of organic material (Ryan and Delhaize 2001). Soil acts as a habitat for diverse group of microorganisms. Plant root exudates enrich rhizosphere region of the soil and attracts a variety of micro-organisms. Plant growth is influenced by the presence of bacteria and fungi and their interactions are common in the rhizospheres of plants with high relative densities of microbes (Berg and Smalla, 2009). Rhizosphere interactions are not solely driven by roots but are highly integrated with and influenced by residing organisms and local edaphic factors. Soil-inhabiting mutualists and parasites, both prokaryotic and eukaryotic, are actively involved in signaling
with a host plant. Microbial populations react to the exudates released by plant roots making the rhizosphere interactions very dynamic which are altered by addition or loss of any microbe (Badri et al., 2009). A strong interaction prevails between the group of microorganisms colonising the rhizosphere region and plant roots. Microorganisms and their products also affect the roots in a variety of positive, negative and neutral ways (Broeckling et al., 2008).

Plant growth-promoting bacteria occupy the rhizosphere of many plant species and have beneficial effects on the host plant. They may influence the plant in a direct or indirect manner. A direct mechanism would be to increase plant growth by supplying the plant with nutrients and hormones. The release of carbon compounds from plants into the rhizosphere increases microbial biomass and activity. Pseudomonas sp. comprises a genus of ubiquitous Gram-negative bacteria that can live in several environmental niches in the rhizosphere. Although, a few Pseudomonas spp. are studied for their role as plant pathogens i.e., Pseudomonas syringae but there are many species such as P. fluorescens, P. putida, P. aeaureofasciens and P. chloraphis, which may act as plant beneficial bacteria by antagonizing plant pathogens and through the production of traits that directly influence plant disease resistance and growth (Venturi 2006).

Plant Growth Promoting Rhizobacteria (PGPR=PGPB) are natural rhizosphere-inhabiting bacteria, which belong to diverse genera such as Pseudomonas and Bacillus species. These microorganisms have been isolated from a wide variety of wild and cultivated plant species such as Arabidopsis, barley, rice, canola and bean (Persello-Cartieaux et al., 2003). PGPR are used as inoculants for biofertilization, phytoestimulation and biocontrol. The general effect of PGPR is an increased growth and productivity of plants. Their contribution can be exerted through different mechanisms including root system architecture modulation and increased shoot growth by production of phytohormones such as auxins and cytokinins. Free-living microbes including filamentous fungi of the genus Trichoderma sp. and a variety of plant growth-promoting rhizobacteria (PGPR) are able to suppress soil-borne plant pathogens and to stimulate plant growth by different direct or indirect mechanisms, such as production of phytohormones, mycoparasitism and competence with plant pathogens, decomposition and mineralization of organic matter and enhancing the bioavailability of mineral nutrients such as phosphorus and iron (Valencia et al., 2007).

Oroxylum indicum is a medicinally important forest tree species. This species is categorized as vulnerable due to over exploitation of whole plant for medicinal uses (Ravikumar and Ved 2000; Saraf et al., 2013). Das et al., 2013 reported that O. indicum is categorized under endangered status in North east India. Very little information is available on the soil nutrient status and rhizospheric micro biota associated with this medicinal plant species. Quiang (2006) reported that O. indicum lives in relationship with the actinomycete-Pseudonocardia oroxyli present in the soil surrounding the roots. Rashidi and Deokule, (2013) isolated 14 fungal species in the rhizosphere of O. indicum which comprised mainly of Fusarium solani, F. reticulatum, F. equiseti, F oxysporum, F. semitectum, F. acuminatum, Rhizopus oryzae, A. niger, A. parasiticus, Cunningamella elegans, Syncephalestrum racemosum, Chaetomium indicum, Trichoderma sp. and Papulaspora immerse. In the present study the fungal as well as bacterial microbiota present in the rhizospheric soil sample of O. indicum was analysed with respect to the soil nutrient
status of the tree growing in different natural habitat in North East India. The determination of the soil fungal as well as bacterial community composition along with physicochemical properties of soil is essential in order to evaluate above- and below-ground plant ecosystem health and functioning. It is also a prospective to exploit micro-biota for future conservation strategies.

Materials and Methods

Collection of the rhizospheric soil, root and plant samples

The rhizospheric soil and plant samples were collected from five different sites of Northeast India where Oroxylum indicum was naturally growing in its ecological habitat. The rhizospheric soil and root samples and pods were collected from Jorhat, Nalbari, Guwahati, Itanagar and North Lakhimpur. The samples of O. indicum were collected from trees showing fruiting from five different collection sites of a single eco-region (Brahmaputra Valley semi-evergreen forests), i.e. Jorhat, Nalbari, Guwahati, Itanagar and North Lakhimpur. Rhizospheric soil samples along with root segments were taken by digging out a small amount of soil (500g) close to the plant roots up to a depth 15-30 cm and these samples were kept in sterilized polythene bags for further processing in the laboratory for physicochemical analysis of soil, mycorrhizal colonization and spore quantification etc. Samples from the selected plant species were collected from the plant growing along riverside in Nalbari. From Guwahati, samples were collected from the tree growing in forest fringe area. Samples from hill slope were collected from Itanagar, while, sample from agricultural farmland were collected from North Lakhimpur. The samples were collected from healthy trees which overall represented the region.

Isolation of fungal isolates

The rhizospheric soil samples were collected from five different study sites in polyethene bags and was further analysed in the laboratory. Soil Dilution Plate Method (Waksman 1927) was used for the isolation of fungal species. Soil dilutions were made by suspending 1g of soil of each sample in 10ml of sterile distilled water. Dilutions of $10^{-2}$, $10^{-3}$ and $10^{-4}$ were used to isolate fungi in order to avoid over-crowding of the fungal colonies. 1ml of the suspension of each concentration was added to sterile Petri dishes, in triplicates of each dilution, containing sterile Potato Dextrose Agar (PDA) medium. 1% streptomycin solution was added to the medium for preventing bacterial growth, before pouring into Petri plates. The plates were then incubated at 28±2°C for 4-7 days. Fungi easily isolated because they formed surface colonies that were well dispersed particularly at higher dilutions. The pure colonies were preserved in PDA slants and stored at 3-4°C for further analysis.

Identification of the soil fungi

Identification of the fungal species is based on morphological characteristics of the colony and microscopic examinations (Diba et al., 2007). The fungi were identified by the help of various taxonomic keys available (Gilman 1957; Subramanian, 1971; Watanabe 1993; Domsch et al., 2007; Singh et al., 1991).

Isolation of bacterial isolates

The isolation of soil bacteria was done by using dilution plate technique as given by Johnson and Curl (1972) at $10^{6}$ dilutions on Nutrient Agar (NA). The NA plates were incubated at 30±1°C for 48 hours. The pure cultures of bacteria were preserved at 4°C in NA slants after observing the abundance of bacterial growth and colony morphology. The
isolated bacteria were preserved in 15% (v/v) glycerol in nutrient broth (NB) at -20°C.

**Identification of bacterial isolates**

The identification of bacteria is based on external morphology as well as biochemical tests. The physiological and biochemical characteristics were examined according to Cappuccino and Sherman (2004) and Bergey’s Manual of Systematic Bacteriology, 1934. In order to differentiate Gram-positive and Gram-negative strain of bacteria, a modified method of Gram staining (Cruickshank, 1965) was followed.

The soil samples were analysed in the laboratory of Rain Forest Research Institute, Jorhat following standard methods. Soil pH was determined by the help of standard pH meter. The soil Organic Carbon Estimation was done by Walkley-Black’s method (1934). The estimation of Available Nitrogen in soil was done with the help of Kjeldahl (1883). The estimation of available Potassium in soil was done through Ammonium acetate extraction method by R.R. Simard (1993). Soil Available Phosphorus estimation was done according to Bray (1948).

Results of the various experiments were analyzed following appropriate statistical methods as per the procedure suggested by Panse and Sukhatme (1978). The results were further analysed using IBM SPSS Statistics 21. The ANOVA as well as DMRT was applied on the data sets.

**Results and Discussion**

The rhizospheric samples of *Oroxylum indicum* were collected from five different collection sites of a single eco-region of Northeast India (Brahmaputra Valley semi-evergreen forests), i.e. Jorhat, Nalbari, Guwahati, Itanagar and North Lakhimpur. In Jorhat the sampling was done along roadside, while, in Nalbari, the sampling was done along riverside. The samples were collected from forest fringe zone in Guwahati collection site, while, soil samples from hill slope were collected from Itanagar site. In North Lakhimpur site the soil samples were collected from agricultural farmland. The highest elevation was observed in Itanagar while lowest was found in Nalbari. Table 1 shows the pH and nutrient status of the soil under naturally growing *O. indicum* tree species. The organic carbon content %, available Nitrogen (kg/hac), available Potassium and available Phosphorus (P) in kg/hac was determined. The nutrient status of soil varied along different collection sites.

The soil status of the sample collected from Jorhat site has a pH value ranging between 5.89±0.11 to 6.2±0.03. The soil organic carbon percentage varied between 1.243±0.034 to 1.282±0.025, available Nitrogen (kg/hac) ranged between 242.69±0.001 to 301.27±0.001, and available Phosphorus (kg/hac) varied between 34.39±2.90 to 39±3.15, while available potassium (kg/hac) varied between 28.52±0.754 to 37.36±1.24. In Nalbari site the pH of the soil varied from 5.91±0.11 to 6.11±0.08. The organic carbon percentage was found to range between 1.320±0.033 to 1.397±0.034, the available nitrogen (kg/hac) varied between 326.37±0.002 to 359.85±0.002; available phosphorus (kg/hac) was between 40.78±3.15 to 43.61±0.81 and available potassium varied between 21.39±1.78 to 25.09±1.58. In Guwahati site the pH varied between 5.25±0.187 to 5.61±0.097, the organic carbon ranged between 1.760±0.050 to 1.808±0.033. The available nitrogen (kg/hac) varied between 175.74±0.0006 to 217.58±0.001; available phosphorus (kg/hac) was between 38.82±0.614 to 41.8±0.063 and available potassium varied between 29.37±1.24 to 36.22±1.02. The soil nutrient status of...
Itanagar site shows that the pH varied between 5.17±0.323 to 5.47±0.279. The organic carbon percentage was found to be 1.081±0.078, the available nitrogen (kg/hac) varied between 472.82±0.001 to 564.88±0.001, available phosphorus (kg/hac) was between 44.32±1.799 to 46.27±0.307 and available potassium varied between 42.49±1.50 to 45.34±1.48. In North Lakhimpur site the pH of the soil varied from 5.38±0.43 to 6.05±0.131. The organic carbon percentage was found to range between 1.808±0.033 to 1.865±0.049, the available nitrogen (kg/hac) varied between 594.17±0.003 to 648.56±0.004, available phosphorus (kg/hac) was between 48.22±0.639 to 50.17±0.639 and available potassium varied between 45.06 ± 1.99 to 49.34±1.50. The DMRT analysis of different parameters was done to segregate different parameters. The DMRT analysis of the pH status was higher in Jorhat and Nalbari, intermediate pH was found in North Lakhimpur site while minimum pH was found in Guwahati and Itanagar site. Overall, the pH of the soil under *O. indicum* is acidic. The % Organic Carbon was found to be highest in North Lakhimpur site while it was lowest in Itanagar site. Available Nitrogen was highest in North Lakhimpur, while it was minimum in Guwahati. Available Phosphorus was again highest in North Lakhimpur site while it was lowest in Nalbari and Guwahati site. Available Potassium was highest in Itanagar and North Lakhimpur sites while it was lowest in Nalbari site. Soil borne microorganisms are beneficial for plant growth.

**Rhizospheric mycoflora associated with the rhizospheric soil samples of Oroxylum indicum (L.) Benth. ex Kurz**

The natural occurrence of the mycoflora associated in the rhizosphere of *O.indicum* was assessed in the laboratory of RFRI, Jorhat. The rhizospheric samples of *O. indicum* were collected from five different collection sites i.e. Jorhat, Nalbari, Guwahati, Itanagar and North Lakhimpur. 25 fungal species were isolated from the rhizosphere of *O. indicum* (Table 5). A total of 11 fungal species were isolated from the Jorhat collection site, which comprised mainly of *Trichoderma harzianum*, *Penicillium sp.*, *Aspergillus sp.*, *Trichoderma viride*, *Fusarium sp.*, *Penicillium funiculosum*, *Penicillium capsulatum*, *Penicillium citrinum*, *Pachybasium sp.*, *Trichoderma hamatum*, *Mucor sp.*. 12 fungal species were isolated from the rhizosphere of *O. indicum* from Nalbari collection site i.e. *Trichoderma harzianum*, *Penicillium sp.*, *Aspergillus sp.*, *Verticillium sp.*, *Fusarium sp.*, *Curvularia sp.*, *Penicillium capsulatum*, *Rhizomucor sp.*, *Pythium sp.*, *Penicillium citrinum*, *Pachybasium sp.*, *Penicillium sp.*. The Guwahati collection site showed occurrence of 14 fungal isolates i.e. *Rhizoctonia sp.*, *Trichoderma harzianum*, *Penicillium sp.*, *Colletrotrichum sp.*, *Geotrichum sp.*, *Trichoderma viride*, *Trichoderma hamatum*, *Penicillium capsulatum*, *Cunnighamella sp.*, *Pythium sp.*, *Penicillium citrinum*, *Pachybasium sp.*, *Pachybasium sp.*, *Mucor sp.*. 12 fungal species were isolated from the Itanagar collection site, which mainly comprised of *Rhizoctonia sp.*, *Trichoderma harzianum*, *Aspergillus sp.*, *Fusarium sp.*, *Colletrotrichum sp.*, *Curvularia sp.*, *Mucor sp.*, *Pythium sp.*, *Pachybasium sp.*. The North Lakhimpur collection site showed occurrence of 15 fungal isolates which mainly comprised of *Rhizoctonia sp.*, *Trichoderma harzianum*, *Aspergillus sp.*, *Trichoderma viride*, *Absidia sp.*, *Fusarium sp.*, *Colletrotrichum sp.*, *Curvularia sp.*, *Mucor sp.*, *Pythium sp.*, *Pachybasium sp.*. The North Lakhimpur collection site showed the occurrence of 15 fungal isolates which mainly comprised of *Rhizoctonia sp.*, *Trichoderma harzianum*, *Aspergillus sp.*, *Trichoderma viride*, *Absidia sp.*, *Fusarium sp.*, *Trichoderma hamatum*, *Gliocladium sp.*, *Colletrotrichum sp.*, *Rhizoctonia solani*, *Penicillium capsulatum*, *Rhizomucor sp.*, *Pythium sp.*, *Penicillium citrinum*, *Pachybasium sp.* only (Plate 1.1 and 1.2).
**Table 1** Soil status of different collection sites of *Oroxylum indicum* (L.) Benth. ex Kurz

| Sample      | Habitat       | pH       | % OC     | Available N (kg/hac) | Avl P (kg/hac) | Avl K (kg/hac) |
|-------------|---------------|----------|----------|----------------------|----------------|----------------|
| JORHAT      | Roadside      | 5.89±0.11| 1.282±0.025| 242.69±0.001         | 39±3.151       | 36.506±1.73   |
|             |               | 6.2±0.03 | 1.243±0.034| 251.05±0.002         | 34.39±2.90     | 28.52±0.754   |
|             |               | 5.74±0.141| 1.253±0.025| 301.27±0.001         | 34.75±5.22     | 37.36±1.24    |
| NALBARI     | Riverside     | 6±0.173  | 1.339±0.025| 330.56±0.001         | 40.78±3.15     | 21.39±1.78    |
|             |               | 6.11±0.08| 1.397±0.034| 326.37±0.002         | 41.48±1.91     | 24.81±1.30    |
|             |               | 5.91±0.11| 1.320±0.033| 359.85±0.002         | 43.61±0.81     | 23.09±1.58    |
| GUWAHATI    | Forest Fringe | 5.4±0.221| 1.760±0.050| 209.21±0.008         | 41.8±0.063     | 36.22±1.02    |
|             |               | 5.25±0.187| 1.760±0.074| 175.74±0.0006        | 39.71±0.987    | 29.37±1.24    |
|             |               | 5.61±0.097| 1.808±0.033| 217.58±0.001         | 38.82±0.614    | 34.79±1.99    |
| ITANAGAR    | Hill Slope    | 5.41±0.270| 1.081±0.050| 472.82±0.001         | 45.92±0.639    | 43.92±1.73    |
|             |               | 5.47±0.279| 1.081±0.078| 502.11±0.001         | 44.32±1.799    | 45.34±1.48    |
|             |               | 5.17±0.323| 1.081±0.058| 564.88±0.001         | 46.27±0.307    | 42.49±1.50    |
| NORTH       | Agricultural  | 5.65±0.174| 1.808±0.033| 594.17±0.003         | 48.22±0.639    | 49.34±1.50    |
| LAKHIMPUR   | Farmland      | 6.05±0.131| 1.846±0.041| 648.56±0.004         | 50.17±0.639    | 45.63±0.75    |
|             |               | 5.38±0.43 | 1.865±0.049| 623.46±0.001         | 48.58±0.639    | 45.06±1.99    |

**Table 2** Bacteria in rhizosphere of *Oroxylum indicum* (L.) Benth. ex Kurz

| Bacteria               | Jorhat | Nalbari | Guwahati | Itanagar | N. Lakhimpur |
|------------------------|--------|---------|----------|----------|--------------|
| *Pseudomonas putida*   | +      | +       | +        | -        | +            |
| *Pseudomonas sp.*      | +      | -       | +        | -        | +            |
| *Streptobacillus sp.*  | -      | +       | +        | +        | -            |
| *Bacillus sp.*         | +      | -       | +        | +        | +            |

+ denotes present, - denotes absent.

**Table 3** Classification of bacteria based on colony morphology

| Sl.No. | Biochemical test     | *Pseudomonas* species | *Bacillus* species |
|--------|----------------------|-----------------------|-------------------|
| 1      | Gram stain           | -                     | +                 |
| 2      | Shape                | Rod                   | Rod               |
| 3      | Agar plate character | White translucent (Kings B medium) | Dull white       |
| 4      | Methyl red test      | -                     | -                 |
| 5      | Catalase test        | +                     | +                 |
| 6      | Oxidase test         | +                     | +                 |
| 7      | Growth in NB         | +                     | +                 |
| 8      | Glucose fermentation test | -                  | +                 |
| 9      | Nitrate reduction test | -                  | NA                |

**Table 4** Biochemical test of bacteria

| Species         | Colony morphology                                           | Gram's reaction | Cell shape |
|-----------------|------------------------------------------------------------|-----------------|------------|
| *Streptobacillus sp.* | Pleomorphic, Fusiform; develop characteristic lateral bulbar swellings, filamentous rod | Gram -ve        | Rods       |
| *Pseudomonas putida* | Round, Translucent whitish, Bright, Button shaped Colonies | Gram -ve        | Rods       |
| *Bacillus sp. 1*   | Punctiform, Irregular, Opaque, Whitish, Raised             | Gram +ve        | Rods       |
| *Pseudomonas sp.*  | Irregular, whitish, raised colonies                       | Gram -ve        | Rods       |
**Table 5** Rhizospheric mycoflora associated with *Oroxylum indicum* (L.) Benth. ex Kurz

| Sl. No. | Fungal Species                      | Family              | Jorhat | Nalbari | Guwahati | Itanagar | N. Lakhimpur |
|---------|------------------------------------|---------------------|--------|---------|----------|----------|--------------|
| 1       | Absidia sp.                        | Cunninghamellaceae  | -      | -       | -        | +        | +            |
| 2       | Aspergillus sp.                    | Trichocomaceae      | +      | +       | -        | +        | +            |
| 3       | Colletrotrichum sp.                | Glomerellaceae      | -      | -       | +        | +        | +            |
| 4       | Cunninghamella sp.                 | Cunninghamellaceae  | -      | -       | +        | -        | -            |
| 5       | Curvularia sp.                     | Pleosporaceae       | -      | +       | -        | +        | -            |
| 6       | Fusarium sp.                       | Nectriaceae         | +      | +       | -        | +        | +            |
| 7       | Geotrichum sp.                     | Endomycetaceae      | -      | -       | -        | -        | -            |
| 8       | Gliocladium sp.                    | Hypocreaceae        | -      | -       | -        | -        | +            |
| 9       | Mucor sp.                          | Mucoraceae          | +      | -       | +        | +        | -            |
| 10      | Pachybasium sp.                    | Hypocreaceae        | +      | +       | +        | +        | +            |
| 11      | Penicillium capsulatum Raper and Fennell | Trichocomaceae | +      | +       | +        | -        | +            |
| 12      | Penicillium citrinum Thom           | Trichocomaceae      | +      | +       | +        | -        | -            |
| 13      | Penicillium funiculosum Thom        | Trichocomaceae      | +      | -       | -        | -        | -            |
| 14      | Penicillium sp. 1                  | Trichocomaceae      | +      | +       | +        | -        | +            |
| 15      | Penicillium sp. 2                  | Trichocomaceae      | -      | +       | -        | -        | -            |
| 16      | Pythium sp.                        | Pythiaceae          | -      | +       | +        | +        | +            |
| 17      | Rhizoctonia solani Kuhn.           | Ceratobasidiaceae   | -      | -       | -        | -        | +            |
| 18      | Rhizoctonia sp.                    | Ceratobasidiaceae   | -      | +       | +        | +        | +            |
| 19      | Rhizomucor sp.                     | Mucoraceae          | -      | +       | -        | -        | +            |
| 20      | Scedosporium sp.                   | Microascaceae       | -      | -       | -        | +        | -            |
| 21      | Trichoderma hamatum (Bonord.)      | Hypocreaceae        | +      | -       | +        | -        | +            |
| 22      | Trichoderma harzianum Pers.        | Hypocreaceae        | +      | +       | +        | +        | +            |
| 23      | Trichoderma sp.                    | Hypocreaceae        | -      | -       | +        | -        | -            |
| 24      | Trichoderma viridae Pers.          | Hypocreaceae        | +      | -       | +        | +        | +            |
| 25      | Verticillium sp.(Nees)             | Plectosphaerellaceae| -      | +       | -        | -        | -            |

+ denotes present, - denotes absent
Plate 1 A. Aspergillus ruber B. Trichoderma harzianum C. Penicillium citrinum D. Aspergillus sp. E. Absidia sp. F. Penicillium funiculosum G. Rhizoctonia solani H. Penicillium capsulatum I. Aspergillus sp. J. Cunninghamella sp. K. Mucor sp. L. Aspergillus sp.
Plate.2 Isolation of fungal species from rhizospheric soil samples A. Jorhat site B. and C. Nalbari site D. Guwahati site E. Itanagar site F. and G. North Lakhimpur site H., I., J. and K. Isolation of fungal species at different dilutions L. Pure culture of *Trichoderma harzianum*
Plate 3 A: *Pseudomonas* sp., B: *Pseudomonas putida* C: *Bacillus* sp. D: *Streptobacillus* sp. E-G: Culturing and subculturing of the bacterial species

Four bacterial isolates *Pseudomonas putida*, *Pseudomonas* sp., *Streptobacillus* sp., *Bacillus* sp. were found to be associated in the rhizosphere of *O. indicum*. Table 2, 3 and 4 shows the bacterial species associated in the rhizospheric soil samples of *O. indicum*, classification and biochemical test performed.

Four bacterial isolates *Pseudomonas putida*, *Pseudomonas* sp., *Streptobacillus* sp., *Bacillus* sp. were found to be associated in the rhizosphere of *O. indicum* (Plate 1.3). Soil microbes act as essential component of plant community variety and productivity (Wardle 2004). The environmental factors such as the
soil pH, moisture, temperature, organic carbon and nitrogen play an important role in the distribution of microorganisms (Gaddeyya, 2012). These are the main factors affecting the microbial population and diversity.

The role of fungi in soil is extremely complex and is fundamental to the soil ecosystem (Bridge and Spooner, 2001). Soil fungi play an important role in nutrient cycling, and plant health and development (Bridge and Spooner, 2001; Thorn, 1997; Martin et al., 2001). Some fungi cause a range of plant diseases (Jarosz and Davelos, 1995; Thorn, 1997), while others antagonize plant pathogens, decompose plant residues, provide nutrients to plants, and stimulate plant growth (Raaijmakers et al., 2009). Information on the knowledge of the diversity and structure of fungal communities in bulk and rhizosphere soils help in better understanding of their roles in soil ecosystem and in improving plant health. The activity and effects of beneficial rhizospheric myco-biota on plant growth and health are well documented for fungi under Deuteromycetes e.g. Trichoderma, Gliocladium and non-pathogenic Fusarium species (Raaijmakers et al., 2009).

Direct rhizospheric bio-control effects on soil-borne plant pathogens can result from hyperparasitism as is documented for Trichoderma and Gliocladium and it affects various fungal pathogens such as Rhizoctonia, Sclerotinia, Verticillium and Gaeumannomyces (Harman et al., 2004). Thus, determination of the microbiota along with physico-chemical properties of soil associated with rhizosphere of O. indicum is essential in order to evaluate above- and below-ground plant ecosystem health and functioning. It is also a prospective to exploit myco-biota for future conservation strategies.

Rashidi and Deokule (2013) isolated 14 fungal species in the rhizosphere of O. indicum which comprised mainly of Fusarium solani, F. reticulatum, F. equiseti, F. oxysporum, F. semitectum, F. acuminatum, Rhizopus oryzae, A. niger, A. parasiticus, Cunninghamella elegans, Syncephalestrum racemosum, Chaetomium indicum, Trichoderma sp. and Papulaspora immerse.

In the present study 25 fungal species were isolated from the rhizosphere of O. indicum growing under different natural habitat which comprised of Trichoderma sp., Fusarium sp., Cunninghamella sp., Aspergillus sp., Penicillium funiculosum, Penicillium capsulatum, Penicillium citrinum, Pachybasium sp., Trichoderma hamatum, Mucor sp., Pythium sp., Penicillium citrinum etc. Curvularia sp. was isolated from the seeds of O. indicum which might be the causative agent for fungal decay of seeds. Pande and Gupta (2011) also reported the presence of Curvularia lunata as seed mycoflora of O. indicum.

The study of rhizosphere bacteria from the important medicinal plants is very crucial, as they are known to have impact on plant growth and also produce industrially important metabolites and improve quality of medicinal product (Bafana and Lohiya, 2013). The rhizospheric soil samples of this plant species mainly comprised of Pseudomonas putida, Pseudomonas sp. and Bacillus sp and Streptobacillus sp. A significant number of bacteria produce the phytotherapeutic compounds (Koeberl et al., 2013) and increase the growth of the medicinal plants when they are associated with rhizosphere of plants.

The study revealed that rhizospheric soil of Oroxylum reflects the presence of diverse fungi and bacteria. Concerned study are to be taken up to conserve the target plant species by modern biotechnological eco-friendly methods and to produce healthy and quality stock of superior germplasm.
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