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## ORIGINAL ARTICLE

# Locational variability of Physico-chemical Properties of Rhizospheric soil and myco-biota associated with *Abroma augusta* L.

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**ABSTRACT**
*Abroma augusta L. is mainly used for the treatment of various disorders in the traditional system of medicine and whose overexploitation has predicted it as a plant of worthy conservation. The present study was an attempt to examine the association ecology of this an endangered plant species with rhizospheric myco-biota and their variability with respect to physico-chemical properties of soil. Rhizospheric soils and seeds were collected from 8 natural locations of Brahmaputra valley which are distributed in 4 districts of Assam, India. Through this study, it was observed that 26 species of fungi belonging to 14 families were present in the rhizospheric soil. The highest density (1.00) and natural occurrence frequency (0.63%) were observed in Aspergillus candidus and lowest density (0.2) and natural occurrence frequency (0.13%) in Alternaria alternata. The highest abundance value (2.0) was observed in Penicillium capsulatum and Rhizoctonia sp. and lowest value (1) in Alternaria alternata. The maximum species richness value (12.59) was observed in Amsoi whereas minimum species richness (1) was observed in Titabor. The highest diversity index value was in Jagiroad (0.14) while Titabor, Namrup, Kokilamukh and Kaziranga locations had almost meager diversity index value (0). Some fungal bio-agents like Trichoderma viride and Gliocladium sp. were also found associated with rhizosphere at low elevation and acedic pH range. The association between rhizospheric fungal biota including endomycorrhizae and abiotic soil properties can be exclusively advocated for a broader utilization as an ecological indicator for the conservation of target plant species.*
***Key words:*** *Abroma augusta, Diversity index, Myco-biota, Soil physico-chemical properties, Species richness.*

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## INTRODUCTION

The quality of soil is not only related with physical and chemical properties, but with microbiological processes also. Soil characteristics influence various basic soil functions such as moderating and partitioning water and solutes movement, nutrients redistribution and supply to plant, storing and cycling of nutrients, filtering, and buffering, immobilizing and detoxifying organic and inorganic materials, promoting root growth and providing resistance to erosion [1]. Several indicators have been suggested for assessing soil quality in agro-ecosystems, namely organic matter, topsoil depth, infiltration, aggregation, pH, electrical conductivity, suspected pollutants and soil respiration [2]. Measurements of the soil microbial community may certainly be used to determine biodiversity, ecological processes and structures [3, 4, 5]. Microbial biomass of C and N contribute a significant portion to the active pools of organic carbon and nitrogen and therefore provide better insights of soil organic carbon and nitrogen turnover [6]. The water availability and *p*H are also important factors affecting the numbers, activities and ecological relationships among microorganisms [7].

Physico-chemical characteristics of different soils vary in space and time due to variations in topography, climate, physical weathering processes, vegetation cover, microbial activities and several other biotic and

abiotic variables [8]. Inherent soil physico–chemical properties influence the behavior of soil and hence, knowledge of soil property is important [9]. Soil microbial activity is the overall quantification of soil functioning, including carbon and nitrogen biogeochemical cycles, organic matter decomposition [10]. Many soil chemical properties directly influence microbiological processes and these processes together with soil physical-chemical processes determine (1) the capacity of soils to hold, supply and cycle nutrients including carbon and (2) the movement and availability of water [11]. A narrow zone of soil affected by the presence of plant roots is defined as rhizosphere [12]. The rhizosphere is an environment that the plant itself helps to create and where pathogenic and beneficial microorganisms constitute a major influential force on plant growth and health [13]. Microbial groups and other bio-agents found in the rhizosphere include bacteria, fungi, nematodes, protozoa, algae and microarthropods [13, 14]. Microorganisms that adversely affect plant growth and health are the pathogenic fungi, oomycetes, bacteria and nematodes, whereas microorganisms that are beneficial include nitrogen-fixing bacteria, endo- and ecto-mycorrhizal fungi, Plant Growth-Promoting Rhizobacteria (PGPR) and fungi [15]. So keeping in mind all these biological and chemical processes, the study was undertaken on *Abroma augusta* L. which is a threatened important plant species in Bhramputra valley of Assam, India.

*Abroma augusta* L. belongs to Sterculiaceae family, commonly known as Devils's cotton, is a popular plant mainly used for the treatment of various types of disorder in the traditional system of medicine [16]. Its overexploitation has led to a decrease in its spread in forest areas, limiting it to the forest edges; so there is urgent need to conserve this plant species in *in situ* and *ex situ* conditions [17]. It is evergreen plant with spreading branches, quick-growing hairy shrub or a small tree with velvety branches, found in tropical Asia, South and eastern Africa and Australia [18]. The whole plant has been found to contain several alkaloids and secondary metabolites including steroids, triterpenes, flavonoids, megastigmanes, benzohydrofurans and their glycosides and phenylethanoid glycosides and very effective against a few bacteria and fungi [19]. It is found in both wild and cultivated areas, throughout the hot and moister parts of India ranging from Punjab and Uttar Pradesh eastwards to Arunachal Pradesh, Assam, Meghalaya and Tripura, ascending to 1,200 m, and southwards in peninsular India [19, 20]. Different parts of this plant are useful in treating diabetes, stomachache, dermatitis, leucorrhoea, scabies, gonorrhea, cough, leucoderma, jaundice, nerve stimulant, weakness, hypertension, uterine disorders, rheumatic pain of joints and headache with sinusitis [21]. It is also used in dermatitis, anti- inflammatory and analgesics [22]. The leaves of *A. augusta* contain octacosanol, taraxerol, ß-sitosterol acetate, lupeol, an aliphatic alcohol ($C_{32}H_{66}O$) and mixture of long chain fatty diols. Abromine, the active constituent of the *A. augusta* identified as betaine is mainly responsible for anti-hyperglycemic activity [23]. This important plant species particularly in Brahmaputra valley is nearing to its threshold due to overexploitation and needs conservation. Therefore, in this study an effort was made to analyze the relationship of myco-biota with physico-chemical properties of soil so that both can be exploited for its conservation as a future strategy of this study.

## MATERIALS AND METHODS

### *Survey and collection of seed and rhizospheric soil samples*

As *Abroma augusta* L. is scattered in its distribution, the survey of different locations in Assam was done for the collection of seeds and rhizospheric soil samples. Rhizospheric soil and seeds were collected from 8 natural locations/provenances of Brahmaputra valley, *viz*.- Titabor, Borholla, Namrup, Nagamati, Kokilamukh, Kaziranga, Amsoi and Jagiroad where *A. augusta* was naturally occurring in these geographic locations and distributed in 4 districts i.e. Jorhat, Dibrugarh, Golaghat and Nagaon of Assam state in India (latitude 24° 8′ to 24° 2′ N and longitude 89° 42′ to 96° 0′ E). The majority of rain fall (1800 mm to 3000 mm) in these regions occur during monsoon period i.e., March through May, the heaviest precipitation comes with the southwest monsoon, which arrives in June, stays through September, and often causes widespread and destructive flooding [24]. The ripe, mature fruits were collected from small trees which were tallest, straight; best shaped with well developed crowns and were free from pests and diseases. Ten ripe fruits per tree were collected at random from the selected trees for recording the seeds per 1 gram. The plant specimen were also collected, preserved in herbarium sheets for identification and deposited at herbaria of Rain Forest Research Institute, Jorhat, Assam. Rhizospheric soil samples (at least three samples) were taken by digging out a small amount of soil (500gms) close to plant roots up to the depth of 15-30cm and these samples were kept in sterilized polythene bags at 10ºC for further processing in the laboratory and physico-chemical analyses of soil.

### *Physico-chemical analysis of soil*

The *p*H and soil temperature were measured for all soil samples using electronic digital *p*H meter (Eutech Instruments, 2009) soil thermometer (Jainco, 1984). Moisture content was determined by oven dry technique [25]. Organic carbon (%) estimation was done by Walkley-Black's method [26].

***Isolation and identification of rhizospheric soil Myco-biota***

To ascertain the diversity of soil myco-biota, qualitative analysis involving Warcup's soil plate method [27] and Waksman's soil dilution method [28] was used. Identification of the fungal isolates was done using standard myco-taxonomic literature [29, 30]. The fungal isolates with their accession numbers are preserved and retained with Mycology and Soil microbiology Lab., Rain Forest Research Institute, Jorhat, Assam, India.

***Statistical analysis***

All data were analyzed statistically, Analysis of the diversity parameters with respect to soil myco-flora *viz*.- quantitative analysis such as density, frequency and abundance of rhizospheric soil myco-flora and diversity indices were computed based on standard methods and protocols [31, 32, 33]. Pearson's coefficient of correlation was calculated to study the relationship between number of seed gram$^{-1}$ and number of rhizospheric soil myco-biota; region-wise, habitat-wise and elevation-wise.

## RESULTS AND DISCUSSION

The physico-chemical data on *p*H, moisture content, soil temperature, electrical conductivity, humidity and organic carbon of all the locations where *Abroma augusta* was naturally found to occur are presented in Table 1. GPS coordinates of these sites along with their elevations were recorded. The highest elevation value (121amsl) was observed in Namrup while lowest (62.4 amsl) was reported in Jagiroad. The highest *p*H (8.2±0.24) was recorded in Kokilamukh and lowest (4.37±0.24) in Titabor. The highest (93.87±5.45 Sm$^{-1}$) and lowest (43.4±2.24 Sm$^{-1}$) values of electrical conductivity were observed in Borholla and Nagamati locations, respectively. The maximum soil temperature value (33°C, each sample) was reported in Titabor while minimum value (20 °C, each sample) was observed in Kokilamukh. The humidity was found to be highest (69±3.21) in Borholla and lowest in Namrup (34±4.71). Highest moisture content (%) (3.84±0.21) was reported in Namrup and lowest value (6±0.25) was observed in Borholla. The percent organic carbon was recorded highest (1.15±0) in Kaziranga location and lowest (0.06±0) in Titabor location, respectively (see Table 1).

The location-wise variation with respect to the height of plant, number of seeds/gm and number of fungal isolates are shown in Table 2. Maximum height (6.1±0.65) in naturally occurring *A. augusta* plants were observed in Jagiroad, while minimum height (2.77±0.12) was recorded in Nagamati. The number of seeds/gram was more (228±1.83) in Amsoi and minimum (156±3.91) in Titabor. The number of fungal isolates was maximum (12 isolates) in Amsoi and minimum (1) in Titabor location (see Table-2).

A total of 26 species of fungi belonging to 14 families were isolated from the rhizospheric soil of *A. augusta* as illustrated in Table 3. The highest density (1.00) was observed in case of *Aspergillus candidus* and lowest (0.2) in *Alternaria alternata*, *Aspergillus versicolor*, *Bispora* sp., *Chrysosporium* sp., *Fusarium* sp., *Gliocladium* sp., *Mucor racemosus*, *Nigrospora* sp., *Nigrospora sphaerica, Oidium* sp., *Pythium* sp., *Rhizoctonia solani*, *Rhizopus nigricans* and *Trichoderma viride* each. Natural occurrence of fungi showed highest (0.63%) location/region-wise frequency in case of *Aspergillus candidus* followed by *Alternaria alternata*, *Aspergillus versicolor*, *Bispora* sp., *Chrysosporium* sp., *Fusarium* sp., *Gliocladium* sp., *Mucor racemosus*, *Nigrospora* sp., *Nigrospora sphaerica*, *Oidium* sp., *Penicillium capsulatum*, *Pythium* sp., *Rhizoctonia solani*, *Rhizoctonia* sp., *Rhizopus nigricans* and *Trichoderma viride* (0.13%, each). The highest abundance value (2.0) was observed in *Penicillium capsulatum* and *Rhizoctonia* sp. and lowest value (1) in *Alternaria alternata*, *Aspergillus ochraceous*, *Aspergillus* sp., *Aspergillus versicolor*, *Bispora* sp., *Chrysosporium* sp., *Fusarium* sp., *Gliocladium* sp., *Monilinia* sp., *Mucor racemosus*, *Mucor* sp., *Nigrospora* sp., *Nigrospora sphaerica*, *Oidium* sp., *Penicillium citrinum*, *Pythium* sp., *Rhizoctonia solani*, *Rhizopus nigricans*, *Rhizopus* sp. and *Trichoderma viride* each respectively. In contrary to region wise frequency as cited above, the percent natural occurrence and species-wise frequency were highest (15.38%; 33.33%) for *Aspergillus candidus,* while lowest (1.92%; 4.17%) for *Alternaria alternata*, *Aspergillus versicolor*, *Bispora* sp., *Chrysosporium* sp., *Fusarium* sp., *Gliocladium* sp., *Mucor racemosus*, *Nigrospora* sp., *Nigrospora sphaerica*, *Oidium* sp., *Pythium* sp., *Rhizoctonia solani*, *Rhizopus nigricans* and *Trichoderma viride* each respectively (see Table 3).

The region-wise variation related to the species richness and diversity index is shown in Table 4. The study of species richness and diversity index showed that maximum species richness value (12.59) was observed in Amsoi; whereas minimum species richness (1) was observed in Titabor location. Again the highest diversity index value was observed in Jagiroad (0.14); while Titabor, Namrup, Kokilamukh and Kaziranga had almost meager diversity index value (0).

The physico-chemical parameters *viz*.- elevation, plant height, *p*H, electrical conductivity, soil temperature, moisture content, humidity and organic carbon percent were categorized into high, medium and low ranges upon which further analysis was done. The number of seeds per gram and fungal isolates were maximum at low elevation (50-80 amsl), lower plant height (2-4 m), acidic *p*H value (4-6), medium soil temperature (22-24°C), medium organic Carbon (0.5-1.0%), medium moisture content (4-5%) and low humidity (30-50%). While minimum number of seeds per gram and fungal isolates were obtained at medium elevation (80-110 amsl), more plant height (6-8 m), alkaline *p*H value (8 m & above), maximum soil temperature (24°C & above), high organic Carbon (1.0 % & above), high moisture content (5 % & above) and high humidity (70% & above). The number of seeds per gram were maximum in low range of electrical conductivity (EC) (40-60 $Sm^{-1}$) and minimum in high range of EC (80 $Sm^{-1}$ & above) whereas fungal populations were observed highest in medium range of EC (60-80 $Sm^{-1}$) followed by high range EC (80 $Sm^{-1}$ & above) and lowest in low range of EC (40-60 $Sm^{-1}$) (see Table 1and Table 2).

**Table 1:** Physico-chemical properties of the rhizospheric soils of *Abroma augusta* L.

| Locations | GPS Coordinates | Elevation * (m) | pH* | Electrical Conductivity* (S $m^{-1}$) | Temp.* (ºC) | Org. Carbon* (%) | Humidity* (%) | Moisture Content* (%) |
|---|---|---|---|---|---|---|---|---|
| Titabor | N 25º 54' 38.6" E 93º 40' 55.9" | 78±0 | 4.37±0.24 | 80.8±4.71 | 33±0 | 0.06±0 | 55±2.36 | 4.44±0.11 |
| Borholla | N 24º 32' 39.3" E 94º 11' 12.3" | 83.67±0 | 4.9±0.26 | 93.87±5.45 | 33±0 | 0.48±0 | 69±3.21 | 6±0.25 |
| Namrup | N 27º 11.012' E 95º 21.999' | 121.33±0 | 5.22±0.21 | 55.4±2.83 | 22.33±0 | 1.21±0 | 34±4.71 | 3.84±0.21 |
| Nagamati | N 27º 12.027' E 95º 21.4' | 118±0 | 6.08±0.34 | 43.4±2.24 | 23±0 | 0.37±0 | 45±3.3 | 4.3±0.15 |
| Kokilamukh | N 26º 49' 52.7" E 94º 10' 45.1" | 63±0 | 8.2±0.24 | 91.4±4.41 | 20±0 | 0.81±0 | 50±2.4 | 4.6±0.28 |
| Kaziranga | N 26º 38' 6.2" E 93º 33' 16.1" | 65.33±0 | 5.25±0.11 | 76.1±1.89 | 22.67±0 | 1.15±0 | 53.67±1.91 | 5±0.38 |
| Amsoi | N 26º 07' 26.9" E 92º 16' 11.4" | 68.6±0 | 6.68±0.14 | 71.28±3.57 | 21. ±08 | 0.4±0 | 41.6±2.83 | 3.9±0.22 |
| Jagiroad | N 26º 06' 49.1" E 92º 10' 53.9" | 62.4±0 | 6.42±0.38 | 73.9±1.41 | 21.4±0 | 0.92±0 | 48.4±4.01 | 4.61±0.42 |

± SEm (Standard Error of mean), * Average of Three replications

**Table 2:** Location -wise variation in height of the plant (m), number of seeds/gm and number of fungal isolates in the rhizospheric soils of *Abroma augusta* L.

| Sl. No. | Locations | Height of plant* (m) | Number of seeds/gm* | Number of fungal isolates |
|---|---|---|---|---|
| 1 | Titabor | 3.15±0.47 | 156±3.91 | 1 |
| 2 | Borholla | 4.33±0.72 | 162±1.31 | 7 |
| 3 | Namrup | 5.5±0.84 | 190±2.47 | 5 |
| 4 | Nagamati | 2.77±0.12 | 183±4.18 | 7 |
| 5 | Kokilamukh | 6±0.58 | 201±2.51 | 3 |
| 6 | Kaziranga | 6±1.08 | 205±3.08 | 9 |
| 7 | Amsoi | 4.1±0.44 | 228±1.83 | 12 |
| 8 | Jagiroad | 6.1±0.65 | 163±2.25 | 8 |

± SEm (Standard Error of mean), * Average of Three replications

**Table 4:** Floristic indices of fungal flora associated with *Abroma augusta* L.

| Sl. No. | Locations | Species richness (Unique) | Diversity Index (Location-wise) |
|---|---|---|---|
| 1. | Titabor | 1 | 0 |
| 2. | Borholla | 7.46 | 0.05 |
| 3. | Namrup | 5.64 | 0 |
| 4. | Nagamati | 7.46 | 0.05 |
| 5. | Kokilamukh | 3.67 | 0 |
| 6. | Kaziranga | 9.62 | 0 |
| 7. | Amsoi | 12.59 | 0.05 |
| 8. | Jagiroad | 8.88 | 0.14 |

**Table 3:** Location-wise Natural occurrence and Diversity of Myco-flora in the collected soil samples of *Abroma augusta* L.

| S. no. | Name of rhizospheric fungi | Family | Locations | | | | | | | | Density | Region-wise Frequency (%) | Abundance | % of Occurrence | Species-wise Frequency (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Titabor | Borhola | Namrup | Nagamati | Kokilamukh | Kaziranga | Amsoi | Jagiroad | | | | | |
| 1. | *Alternaria alternata* (Fr.) Keissl. | Pleosporaceae | | | + | | | | | | 0.13 | 0.13 | 1.0 | 1.92 | 4.17 |
| 2. | *Aspergillus candidus* Link. | Trichocomaceae | | + | | | + | + | + | + | 1.00 | 0.63 | 1.6 | 15.38 | 33.33 |
| 3. | *Aspergillus ochraceous* Wilhelm | Trichocomaceae | | + | | | | + | + | + | 0.50 | 0.50 | 1.0 | 7.69 | 16.67 |
| 4. | *Aspergillus* sp. Micheli | Trichocomaceae | | | | + | + | | + | | 0.38 | 0.38 | 1.0 | 5.77 | 12.50 |
| 5. | *Aspergillus versicolor* (Vuill.) Tiraboschi | Trichocomaceae | | | | | | + | | | 0.13 | 0.13 | 1.0 | 1.92 | 4.17 |
| 6. | *Bispora* sp. Fuckel | mitosporic Ascomycota | | | | | | + | | | 0.13 | 0.13 | 1.0 | 1.92 | 4.17 |
| 7. | *Chrysosporium* sp. Corda | Onygenaceae | | + | | | | | | | 0.13 | 0.13 | 1.0 | 1.92 | 4.17 |
| 8. | *Fusarium* sp. Link ex Gray | Nectriaceae | | | | | | + | | | 0.13 | 0.13 | 1.0 | 1.92 | 4.17 |
| 9. | *Geotrichum* sp. Link ex Persoon | Endomycetaceae | | + | | | | | + | | 0.38 | 0.25 | 1.5 | 5.77 | 12.50 |
| 10. | *Gliocladium* sp. Corda | Hypocreaceae | | | | | | | + | | 0.13 | 0.13 | 1.0 | 1.92 | 4.17 |
| 11. | *Monilinia* sp. Honey | Sclerotiniaceae | | | | | | + | + | | 0.25 | 0.25 | 1.0 | 3.85 | 8.33 |
| 12. | *Mucor racemosus* Bull. | Mucoraceae | | | | | | + | | | 0.13 | 0.13 | 1.0 | 1.92 | 4.17 |
| 13. | *Mucor* sp. Fresen | Mucoraceae | | | + | + | | | | | 0.25 | 0.25 | 1.0 | 3.85 | 8.33 |
| 14. | *Nigrospora* sp. Zimm. | Trichosphaeriaceae | + | | | | | | | | 0.13 | 0.13 | 1.0 | 1.92 | 4.17 |
| 15. | *Nigrospora sphaerica* (Sacc.) E.W. Mason | Sordariomycetes | | | + | | | | | | 0.13 | 0.13 | 1.0 | 1.92 | 4.17 |
| 16. | *Oidium* sp. Link. | Erysiphaceae | | + | | | | | | | 0.13 | 0.13 | 1.0 | 1.92 | 4.17 |
| 17. | *Penicillium capsulatum* Raper & Fennell | Trichocomaceae | | | | | | | | + | 0.25 | 0.13 | 2.0 | 3.85 | 8.33 |
| 18. | *Penicillium citrinum* Thom | Trichocomaceae | | | | + | + | | | + | 0.38 | 0.38 | 1.0 | 5.77 | 12.50 |
| 19. | *Penicillium* sp. Link. | Trichocomaceae | | + | | + | | + | | | 0.50 | 0.38 | 1.33 | 7.69 | 16.67 |
| 20. | *Pythium* sp. Pring. | Pythiaceae | | | | | | | | + | 0.13 | 0.13 | 1.0 | 1.92 | 4.17 |
| 21. | *Rhizoctonia solani* Kuhn. | Ceratobasidiaceae | | | | + | | | | | 0.13 | 0.13 | 1.0 | 1.92 | 4.17 |
| 22. | *Rhizoctonia* sp. DC | Ceratobasidiaceae | | | | + | | | | | 0.25 | 0.13 | 2.0 | 3.85 | 8.33 |
| 23. | *Rhizopus nigricans* Ehrenb. | Mucoraceae | | | | | | | + | | 0.13 | 0.13 | 1.0 | 1.92 | 4.17 |
| 24. | *Rhizopus* sp. Ehrenb. | Mucoraceae | | | + | | | | + | | 0.25 | 0.25 | 1.0 | 3.85 | 8.33 |
| 25. | *Rhizopus stolonifer* (Ehrenb. Fr.) Vuill. | Mucoraceae | | | | | | + | + | | 0.38 | 0.25 | 1.5 | 5.77 | 12.50 |
| 26. | *Trichoderma viride* Pers. | Hypocreaceae | | | + | | | | | | 0.13 | 0.13 | 1.0 | 1.92 | 4.17 |
| | | Total isolates | 1 | 7 | 5 | 7 | 3 | 9 | 12 | 8 | | | | | |

The relationship analysis illustrates that the Pearson's correlation coefficient values for variables like number of seeds per gram versus number of fungal isolates, species richness versus diversity index and number of seeds per gram versus organic carbon (%) were 0.56, 0.45 and 0.28 respectively and these are positively correlated (see Figure 1, 2 & 6). Thus, these studied variables positively affect each other i.e.

increase in one variable might lead to an increase in the other variable. On the contrary, elevation versus species richness (-0.17), elevation versus diversity Index (-0.21), number of seeds per gram versus elevation (-0.14) along with number of seeds per gram versus humidity (%) (-0.49) were found to be negatively correlated (see Figure 3, 4, 5 & 7). This infers that increase in one variable might lead to a decrease in the other variable.

**Figure 1:** Scatter diagram between number of fungal isolates versus number of seeds per gram

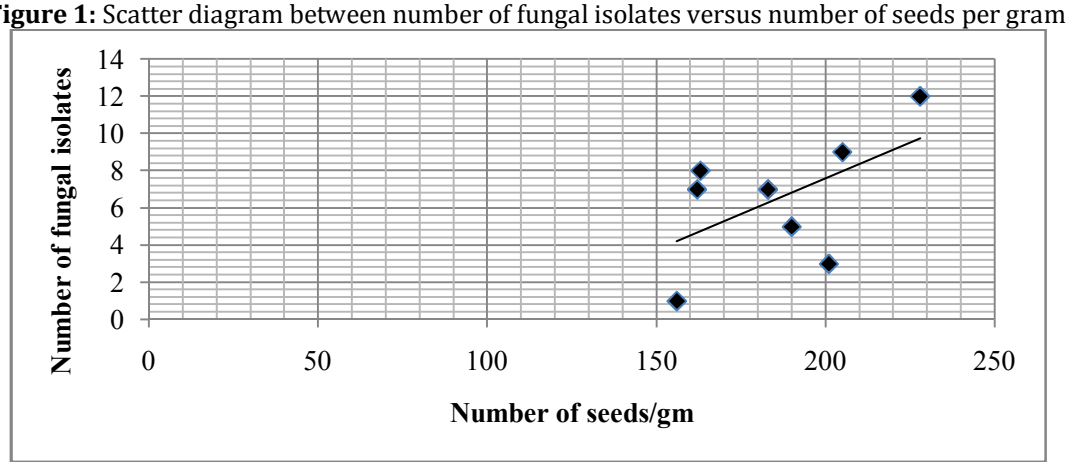



**Figure 2:** Scatter diagram between Species richness versus Diversity index

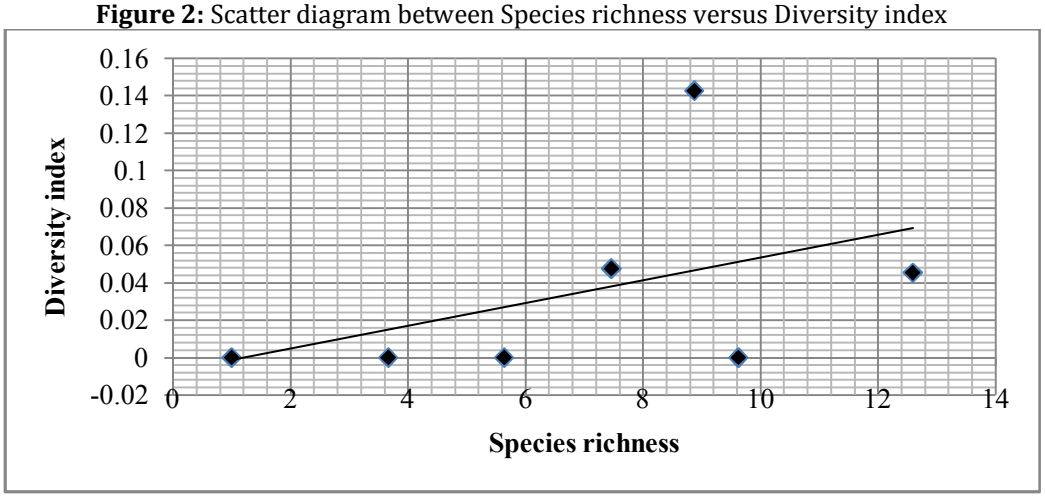



**Figure 3:** Scatter diagram between Species richness versus elevation

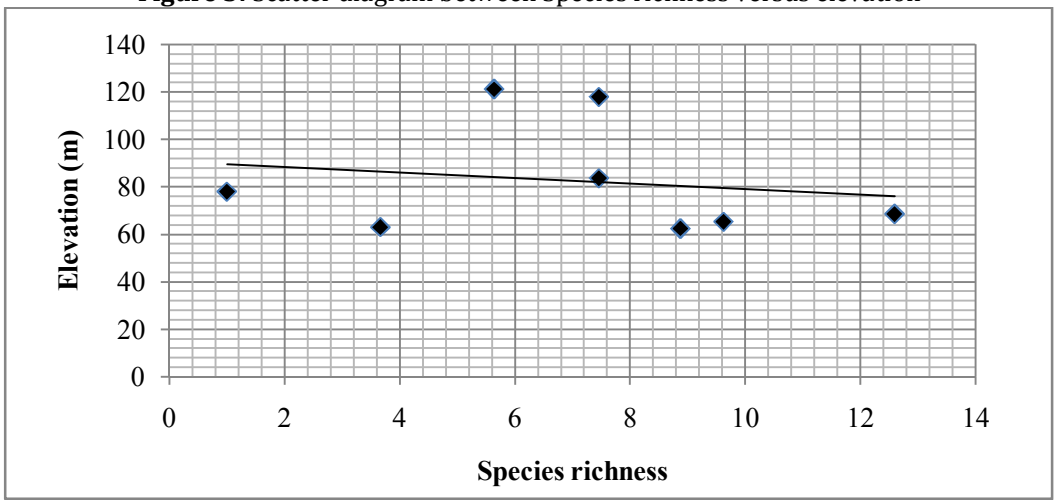


**Figure 4:** Scatter diagram between elevation versus Diversity index

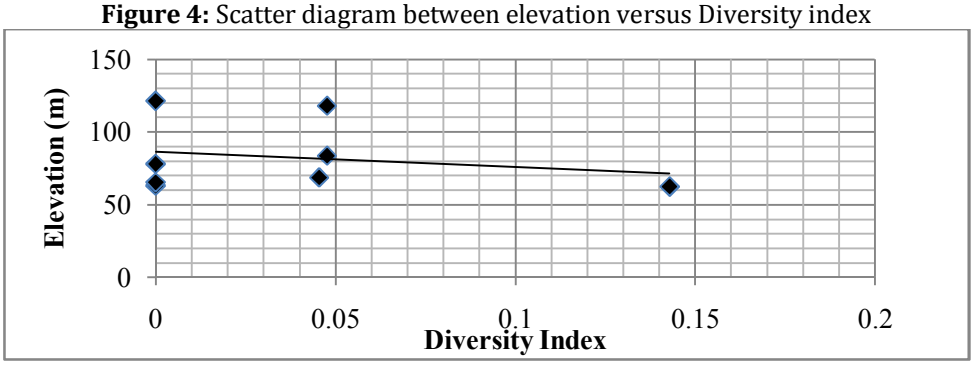



**Figure 5:** Scatter diagram between elevations versus number of seeds per gram

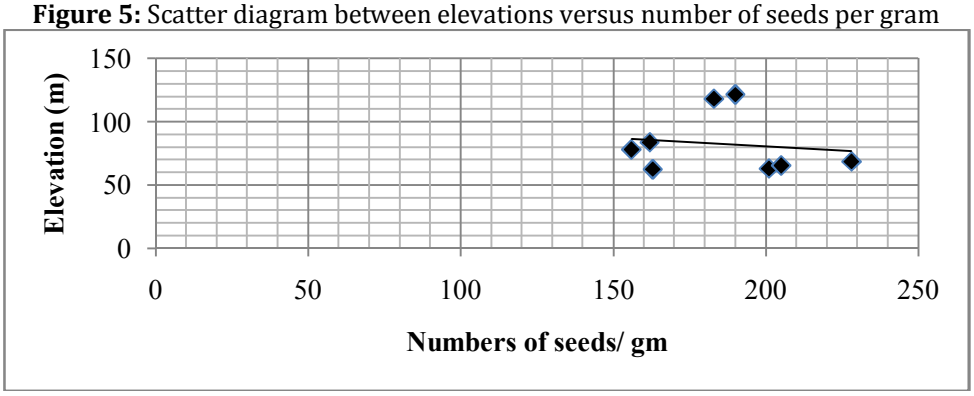



**Figure 6:** Scatter diagram between organic Carbon (%) versus number of seeds per gram

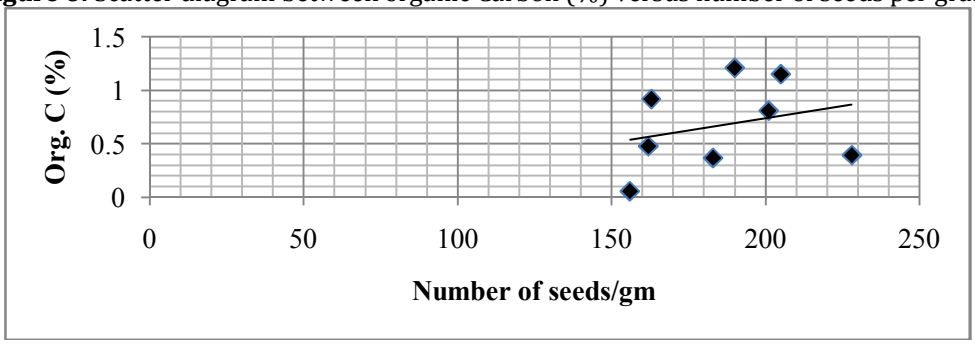
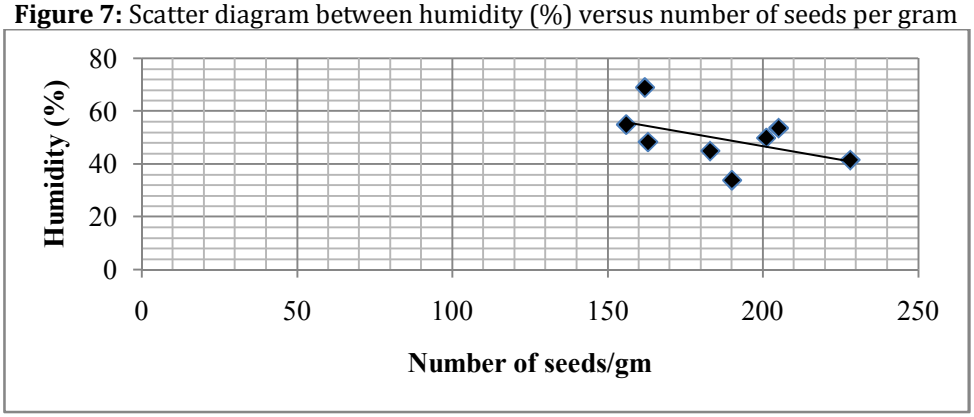



**Figure 7:** Scatter diagram between humidity (%) versus number of seeds per gram




Microbial communities are key drivers in ecosystem functioning and sustainability because they are the main source of necessary enzymes capable of decomposing plant-derived compounds [34]. Microbial communities associated with rhizosphere, defined as the volume of soil adjacent to and influenced by plant root, are important to plant health and soil fertility [35]. The rhizosphere of most crops or plants can exert an influence on the soil microbial communities within the soil [36]. Root exudates from different plants can stimulate the growth of unique bacterial and fungal populations in the vicinity of roots [37]. Many members of this community have a neutral effect on the plant, but are part of the complex food web that utilizes the large amount of carbon that is fixed by the plant and released into the

rhizosphere i.e. rhizodeposits. The microbial community in the rhizosphere also harbours other agents that exert both deleterious and beneficial effects on the plant [15]. In other words, the rhizosphere is the playground and colonization and infection court where soil-borne pathogens and bio-agents establish a parasitic or symbiotic relationship with the plant. However, the rhizosphere is also a battlefield where the complex rhizosphere community, both microflora and microfauna, interact with soilborne pathogens and influence the outcome of pathogen infection. The growth or activity of soil borne pathogenic fungi, oomycetes, bacteria, and/ or nematodes can be inhibited by several beneficial rhizosphere microorganisms [38, 39].

The role of fungi in soil is extremely complex and is fundamental to the soil ecosystem [40]. Soil fungi play an important role in nutrient cycling, and plant health and development [40, 41, 42]. Some fungi cause a range of plant diseases [43, 44], while others antagonize plant pathogens, decompose plant residues, provide nutrients to plants, and stimulate plant growth [15]. 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 [15]. 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* [45]. Thus, determination of the soil fungal community composition along with physico-chemical properties of soil associated with rhizosphere of *A. augusta* is essential in order to evaluate above- and below-ground plant ecosystem health and functioning with a prospective to exploit myco-biota for future conservation strategies.

Many chemical reactions that influence nutrient availability e.g. adsorption, precipitation are influenced by the soil chemical environment and soil *p*H in particular [11]. In this study, acidic soil (low *p*H) harbours more fungal populations than higher *p*H retaining soils. Soil *p*H is simply a surrogate for this complex of potentially nutrient limiting processes, must be evaluated against the sensitivity of the target vegetation or crop and may in some instances not be the best measure of soil acidity and soil quality degradation [46]. On the other hand, electrical conductivity as a measure of ion concentration and the potentially negative effect of salinity on the osmotic potential *i.e.* water relations and nutrient imbalances (Na dominance in sodic soils) is primarily used in agricultural soils. Its application to forest soils is usually limited to very specific circumstances (e.g. reclamation of mine soils) where highly concentrated soil solutions are known or suspected to inhibit forest growth and productivity [47]. Soil temperature has a dominant influence on plant growth, both directly and indirectly [48]. It is also observed in this study that low temperature has more seeds per gram and fungal populations than high temperature. Soil organic matter (SOM) or soil organic carbon (SOC) is commonly recognized as one of the key chemical parameters of soil quality, yet quantitative assessment of its contribution to soil quality is often lacking. Corroborating to this fact, organic carbon percent in the present study also reveals that low and medium organic carbon percent ranges influence more seed yield and fungal populations. Soil organic carbon is a critical pool in the carbon cycle and a repository of nutrients and through its influence on many fundamental biological and chemical processes; it plays a pivotal role in nutrient release and availability [49, 50, 51, 52].

The ecology of microorganisms, however, cannot be considered solely in terms of their relationships with the abiotic environment, because their success in a given situation reflects their ability to co-exist with other microorganisms [53]. However, the link between rhizospheric fungal biota and abiotic soil properties can be exclusively advocated for a broader utilization as an ecological indicator for any plant species. Therefore, the present study was an attempt to determine the association ecology of an endangered plant species like *Abroma augusta* under threat due to anthropogenic pressure in the Brahmaputra valley of Assam, India. Through this study, it was observed that fungal bio-agents like *Trichoderma viride* and *Gliocladium* sp. were associated with rhizosphere of *A. augusta* growing in these regions characterized by low elevation and high *p*H ranges. Only the non-mycorrhizal myco-biota associated with rhizosphere of the target plant species is discussed in this paper hence, these beneficial fungi as cited above along with endomycorrhizal fungi on which work is going on in this laboratory can be synergistically exploited for having a formulation as a future propagation-conservation strategy of this plant species.

## REFERENCES

1. Karlen, D.L., Mausbach, M.J., Doran, J.W., Cline, R.G., Harris & R.F., Schuman, G.E. (1997). Soil quality: a concept, definition, and framework for evaluation. Soil Sci. Soc. Am. J., 61: 4–10.

2. Arshad, M.A. & Martin, S. (2002). Identifying critical limits for soil quality indicators in agro-ecosystems. Agriculture, Ecosystems, and Environment, 88: 153–160.
3. Society for Ecological Restoration. (2002). The SER Primer on Ecological Restoration. http://www.ser.org/.
4. Harris, J.A. & Birch, P. (1992). Land reclamation and restoration. (Eds. Fry, J.C., Gadd, G.M., Herbert, R.A., Jones, C.W. & Watson-Craik, I.) Microbial Control of Pollution. Society for General Microbiology, Symposium 48. Cambridge University Press, Cambridge. pp. 269–291.
5. Harris, J.A. (2003). Measurements of the soil microbial community for estimating the success of restoration. European Journal of Soil Science, 54: 801–808.
6. Sever H. & Makineci, E. (2009). Soil organic carbon and nitrogen accumulation on coal mine spoils reclaimed with maritime pine (*Pinus pinaster* Aiton) in Agacli–Istanbul. Environment Monitoring and Assessment, 155: 273-280.
7. Czaban, J., Wróblewska, B., Niedźwiecki, J. & Sułek, A. (2010). Relationships between Numbers of Microbial Communities in Polish Agricultural Soils and Properties of these Soils, paying Special Attention to Xerophilic/Xerotolerant Fungi. Polish J. of Environ. Stud., 19(6): 1171-1183.
8. Paudel, S. & Sah, J.P. (2003). Physiochemical characteristics of soil in tropical sal (*Shorea robusta* Gaertn.) forests in eastern Nepal. Himalayan J. Sci., 1(2): 107-110.
9. Sumithra, S., Ankalaiah, C., Rao, D. & Yamuna, R.T. (2013). A case study on physico - chemical characteristics of soil around industrial and agricultural area of yerraguntla, kadapa district, A. P, India. Int. J. Geo. Earth and Environ. Sci., 3(2): 28-34.
10. Bonilla, N., Gutiérrez-Barranquero, J.A., de Vicente, A. & Cazorla, F.M. (2012). Enhancing Soil Quality and Plant Health Through Suppressive Organic Amendments Diversity, 4: 475-491. doi:10.3390/d4040475
11. Schoenholtza, S.H., Miegroetb, H.V. & Burgerc, J.A. (2000). A review of chemical and physical properties as indicators of forest soil quality: challenges and opportunities. Forest Ecology and Management, 138: 335-356.
12. Hrynkiewicz, K. & Baum, C. (2011). The Potential of Rhizosphere Microorganisms to Promote the Plant Growth in Disturbed Soils. (Eds. Malik, A. & Grohmann, E.) Environmental Protection Strategies for Sustainable Development Strategies for Sustainability, Springer Science+Business Media, Netherlands. p. 35-64.
13. Lynch, J. (1990). The rhizosphere. Wiley, London, UK, pp. 458.
14. Raaijmakers, J.M. (2001). Rhizosphere and rhizosphere competence. (Eds. Maloy OC, Murray TD) Encyclopedia of Plant Pathology. Wiley, USA, pp. 859–860.
15. Raaijmakers, J.M., Paulitz, T.C., Steinberg, C., Alabouvette, C., Moënne-Loccoz, Y. (2009). The rhizosphere: a playground and battlefield for soilborne pathogens and beneficial microorganisms. Plant Soil, 321: 341–36.
16. Patel, D.K. & Dhanabal, S.P. (2013). Determination of bioanalytical parameters for the standardization of *Abroma augusta*. J. Acute Dis., 2(4): 292-295.
17. Parkash, V., Saikia, A.J., Dutta, R. & Borah, D. (2013). Wild medicinal plants of Umtasoar Range under Nonghkyllem Reserve Forest, Nongpoh, Meghalaya, India and their traditional usage by *Khasi* tribe –I. Journal of Ethnobiology and Traditional Medicine, 118: 228-237
18. Das, S., Datta, R. & Nandy, S. (2012). Phytochemical screening and evaluation of anti-inflammatory activity of methanolic extract of *Abroma augusta* Linn. Asian Pacific Journal of Tropical Disease 2(S1): 114-117.
19. Gupta, B., Nayak, S. & Solanki, S. (2011). *Abroma augusta* Linn. : A review. Der Pharmacia Sinica, 2(4): 253-26.
20. Anonymous. (2006). The Wealth of India. NISCAIR Press Publisher, New Delhi, pp. 222.
21. Rahmatullah, M., Sadeak, S.M.I., Bachar, S.C., Hossain, M.T., Abdullahal-Mamun, Montaha, et al. (2010). Brine Shrimp Toxicity Study of different Bangladeshi Medicinal Plants. Adv. in Nat. Appl. Sci., 4(2): 163-73.
22. Al-Bari, M.A.A., Sayeed, M.A., Rahman, M.S. (2006). Characterization and antimicrobial activities of a phenolic acid derivative produced by *Streptomyces bangladeshiensis*, a novel species collected in Bangladesh. Res. J. Med. and Med. Sci., 1: 77-81.
23. Mir, S.H., Darzi, M.M., Mir, M.S. (2013). Efficacy of *Abroma augusta* on biochemical and histomorphological features of alloxan-induced diabetic rabbits. Iranian J. Pathol., 8(3): 153-158.
24. Das, H. (2014). Assam (state, India). Encyclopædia Britannica. http://www. brittannica. com/E-Bchecked /topic/39101/Assam
25. Allen, S. E . (1974). Chemical Analysis of Ecological Materials. Wiley & Sons, New York. Pp. 565
26. Walkley, A. & Black, I.A. (1934). An examination of the Degtjareff method for determining organic carbon in soils: Effect of variations in digestion conditions and of inorganic soil constituents. Soil Sci., 63: 251-263.
27. Warcup, J. H. (1950). The soil pate method for isolation of fungi from soil. Nature, 166: 117-118.
28. Waksman, S. A. (1927) Principles of soil microbiology, Williams and Wilkins Co., Baltimore, Md. Pp. 897.
29. Barnett, H.L. & Hunter, B.B. (1987).Illustrated Genera of Imperfect Fungi. Macmillan Publishing Company, New York. Pp. 218.
30. Gilman, J.G. (1998). A Manual of Soil Fungi. Biotech Books, Delhi, India. Pp. 392.
31. Miller, R.I., Bratton, S.P. & White, P.S. (1987). A regional strategy for reserve design and placement based on an analysis of rare and endangered species' distribution patterns. Biol. Conserv., 39: 255-268.
32. Parkash, V. (2012). Utilization of Vesicular Arbuscular mycorrhizal diversity for the quality stock production of some useful forest plant/s species of Nongkhyllem Reserve forest, Nongpoh, Meghalaya, India. Project Completion Report (RFRI-12/2008-09/SFM). Rain Forest Research Institute, Jorhat, Assam, India.
33. Curtis, J.T. & McIntosh, R.P. (1950). The interrelations of certain analytic and synthetic phyto-sociological characters. Ecology, 31: 434-455.

34. Kandeler, E., Kampichler, C. & Horak, O. (1996). Influence of heavy metals on the functional diversity of soil communities. Biol. Fertil. Soils, 23: 299–306.
35. Sørensen, J. (1997). Modern soil microbiology. Eds. van Elsas, J.D., Trevors, J.T. & Wellington, E.M.H.) The Rhizosphere as a Habitat for Soil Microorganisms. Marcel Dekker, Inc.: New York, NY, USA, 1997; pp. 21–45.
36. Gregory, P.J. (2006). Roots, rhizosphere and soil: The route to a better understanding of soil science? Eur. J. Soil Sci., 57: 2–12.
37. Rovira, A.D. (1965). Interactions between plant roots and soil micro-organisms. Annu. Rev. Microbiol., 18: 241–266.
38. Weller, D.M. (1988). Biological control of soilborne pathogens in the rhizosphere with bacteria. Ann. Rev. Phytopathol., 26: 379–407.
39. Raaijmakers, J.M., Leeman, M., Van Oorschot, M.M.P., Van der Sluis, I., Schippers, B., Bakker, P.A.H.M. (1995). Dose–response relationships in biological control of fusarium wilt of radish by *Pseudomonas* spp. Phytopathol., 85: 1075–1081.
40. Bridge, P. & Spooner, B.M. (2001). Soil fungi: diversity and detection. Plant and Soil, 232: 147–154.
41. Thorn, G. (1997). The fungi in soil. (Eds. van Elsas, J.D., Trevors, J.T., Wellington, E.M.H.) Modern Soil Microbiology. New York, Marcel Dekker, pp. 63–127.
42. Martin, F.M., Perotto, S., Bonfante, P. (2001) Mycorrhizal fungi. (Eds. Pinton, R., Varanini, Z., Nannipieri, P.) The Rhizosphere – a fungal community at the interphase between soil and roots. New York, Marcel Dekker. pp. 263–296.
43. Jarosz, A.M. & Davelos, A.L. (1995). Effects of disease in wild plant populations and the evolution of pathogen aggressiveness. New Phytologist, 129: 371–387.
44. Thorn, G. (1997). The fungi in soil. (Eds. van Elsas, J.D., Trevors, J.T., Wellington, E.M.H.) Modern Soil Microbiology. New York, Marcel Dekker, pp. 63–127.
45. Harman, G.E., Petzoldt, R., Comis, A., Chen, J. (2004), Interactions between Trichoderma harzianum strain T22 and maize inbred line Mo17 and effects of these interactions on diseases caused by *Pythium ultimum* and *Colletotrichum graminicola*. Phytopathol., 94: 147–153.
46. Aune, J.B. & Lal, R. (1997). The tropical soil productivity calculator Ð a model for assessing effects of soil management on productivity. (Eds. Lal, R. & Stewart, B.A.) Soil Management - Experimental Basis for Sustainability and Environmental Quality. Adv. Soil Sci., Lewis Publishers, London, UK, pp. 499-520.
47. Burger, J.A., Johnson, J.E., Andrews, J.A. & Torbert, J.L. (1994). Measuring mine soil productivity for forests. In: International Land Reclamation and Mine Drainage Conference on Reclamation and Revegetation, Vol. 3. USDOI Bureau of Mines, Special Publication SP 06C-94, pp. 48-56.
48. Willis, W.O. & Power, J.F. (1975). Soil temperature and plant growth in the northern Great Plains. http://www.nal.usda.gov.
49. Johnson, D.W. (1985). Forest nutrient cycles as affected by climate, species composition, stand age and intensive harvesting. IEA/ ENFOR Report No. 1, p. 15.
50. Henderson, G.S., Hammer, R.D. & Grigal, D.F. (1990). Can measurable soil properties be integrated into a framework for characterizing forest productivity? (Eds. Gessel, S.P., Lacate, D.S., Weetman, G.F. & Powers, R.F.) Proceedings of the 7th North American Forest Soils Conference on Sustained Productivity of Forest Soils. University of British Columbia, Faculty of Forestry, Vancouver, BC, pp. 137-154.
51. Henderson, G.S. (1995). Soil organic matter: a link between forest management and productivity. (Eds. McFee, W.W. & Kelly, J.M.) Proceedings of the 8th North American Forest Soils Conference on Carbon Forms and Functions in Forest Soils. Soil Science Society of America., Madison, WI, pp. 419-435.
52. Nambiar, E.K.S. (1997). Sustained productivity of forests as a continuing challenge to soil science. Soil Sci. Soc. Am. J., 60: 1629-1642.
53. Jha, D.K., Sharma, G.D. & Mishra, R.R. (1992). Ecology of soil microflora and mycorrhizal symbionts. Biol. Fertil. Soils, 12: 272-278.