



## Endomycorrhizal diversity analysis of forest plant species of Nongkhylllem Reserve Forest (NRF), Nongpoh, Meghalaya, India

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**Abstract:** The rhizospheric soil samples of Nongkhylllem Reserve Forest, Nongpoh, Meghalaya were screened for endomycorrhizal qualitative and quantitative analysis. Hyphal infection/colonization was present in all rhizospheric soil samples, whereas vesicular infection was found scarce and absent in most of the rhizospheric samples. It is observed that scrubs, herbs, and shrubs had high pH values than trees. Percent total colonization in roots was also low in scrubs and trees than herbs and shrubs whereas climbers were having high total endomycorrhizal colonization in roots. Shrubs and trees were having more AM spore numbers than scrubs. Percent colonization intensity and percent hyphal infection in roots in case of herbs, shrubs and climbers were high than trees and scrubs. Percent vesicular infection was also low in trees and shrubs than herbs. Percent arbuscular infection was again low in case of scrubs and trees than shrubs, herbs and climbers but trees were having more percent organic carbon than shrubs, herbs and climbers. The soil temperature in scrubs and trees was high than shrubs, climbers and herbs. But AM spore numbers increased with elevation. Total root colonization (%), hyphal infection (%), arbuscular infection (%) and colonization intensity (%) gradually decreased with elevation. At lowest elevation the organic carbon (%) was low. There was no any significant change in *pH* value, but little fluctuation was reported with elevation and it occurred in acidic range. The diversity index of Umtasor range was 0.036 and that of Nongpoh range was 0.049. The correlation coefficient (*r*) between species richness and diversity index was 0.54 (positive correlation) and it suggests that species richness is positively correlated with diversity index in the reserve forest.

**Keywords:** Colonization intensity; Diversity; Endomycorrhiza; Diversity index; Species richness.

### Introduction

The north-east Himalayan region in India has very rich forest flora. It has tremendous potential for cultivating and utilizing the plant resources in its diverse agro climatic zones. Meghalaya is one of the smallest states in this North-eastern part of India, (25° 5'-26° 10' N latitude, 89° 47'-92° 47' E longitude), covering an area of 22,429 km<sup>2</sup> and occupies the plateau and rolling hills between Assam state and neighboring country, Bangladesh (Gupta & Sharma, 2005). The word 'Meghalaya' means the abode of clouds. The tribals who inhabited here are

*Khasis, Jaintias, Garo, Mikirs* and the *Kacharis* (Ramirez, 2013). Meghalaya is a hilly strip in the eastern part of the country. It is mostly covered with lush forest area and rich orchid plantations. Meghalaya has a forest cover of 9,496 km<sup>2</sup> square, which is 42.34% of the total geographical area of the state (Gupta & Sharma, 2005). The Meghalayan subtropical forests have been considered among the richest botanical habitats of Asia. These forests receive abundant rainfall and support a vast variety of floral and faunal biodiversity. A small portion

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of the forest area in Meghalaya is under “sacred groves”. These are small pockets of the ancient forest that have been preserved by the communities for hundreds of years due to religious, cultural, and spiritual beliefs and are held in great veneration. These forests under sacred groves represent the ancient ecosystem of the world. These sacred groves harbour many rare plant and animal species. Meghalaya has three Wildlife Sanctuaries. These are Nongkhylllem Wildlife Sanctuary, the Siju Sanctuary, and the Bhagmara Sanctuary, which is also the home of the insectivorous ‘pitcher plant’, *Nepenthes khasiana* (Gupta & Sharma, 2005).

Nongkhylllem Reserve Forest (NRF) is located near Nongpoh, the district- headquarters of Ri-Bhoi district of Meghalaya and it is situated on Guahati-Shillong National Highway (NH-40). Nongkhylllem Reserve Forest, Nongpoh is having an area of 96 km<sup>2</sup> excluding the 29 km<sup>2</sup> area of Nongkhylllem Wildlife Sanctuary (Map 1 & Fig.1) (Parkash & Dhungana, 2011). Due to the diverse climatic and topographic conditions, Nongkhylllem Reserve Forest supports a vast floral diversity, including a large variety epiphytes, succulent plants and shrubs. The floral diversity is also supported by microbial diversity below the soil. Among microbial diversity, endomycorrhizal fungi constitute an important group of fungi that act as nutrient mobilizers in the forest ecosystem and play a vital role in ecosystem functioning.

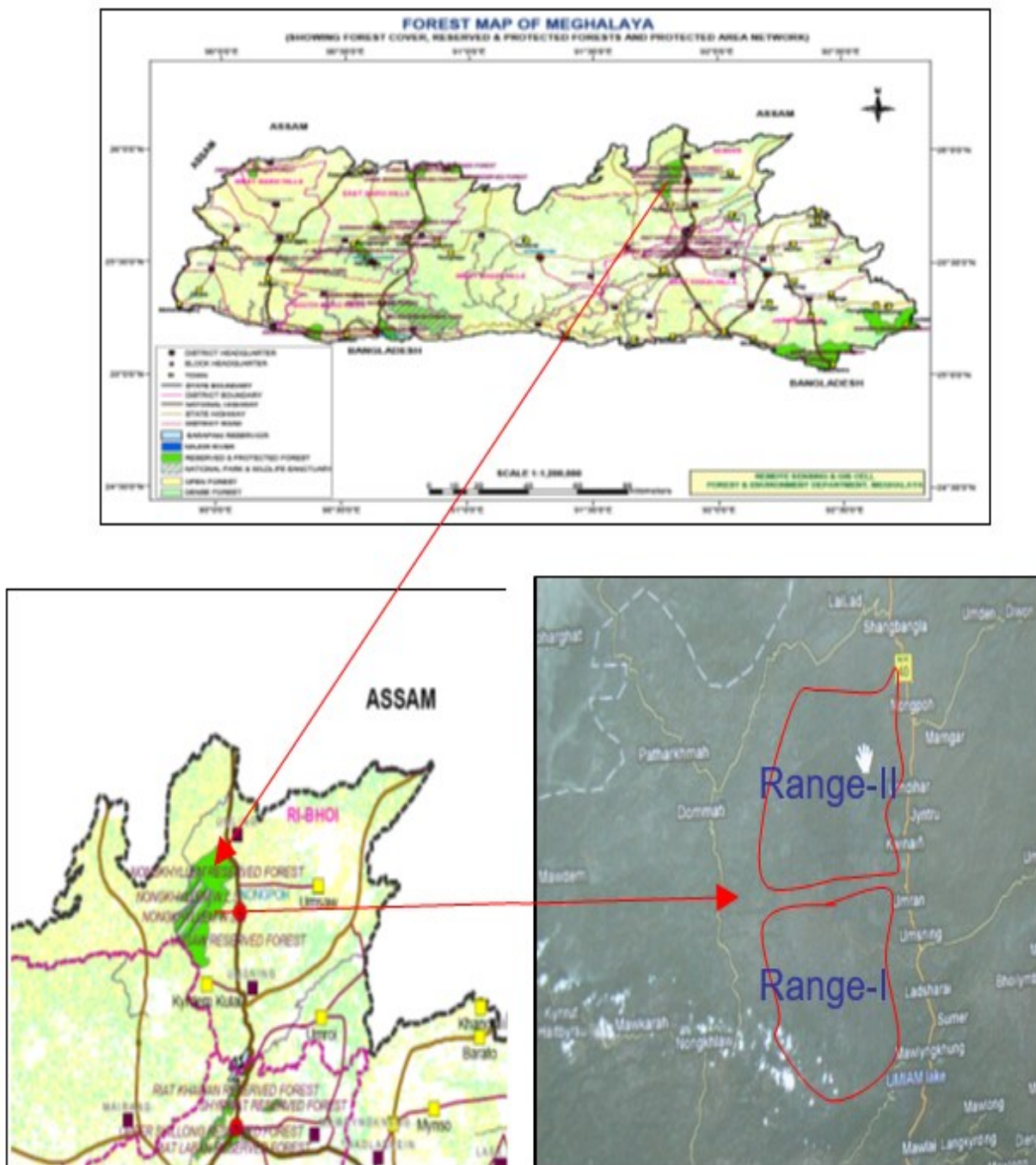
Vesicular Arbuscular Mycorrhizal (VAM=AM) fungi constitute an important component of the soil microbial community and are extremely successful fungi that form mutualistic symbioses with about two thirds of all plant species (Trappe, 1987). They improve plant nutrition and promote plant diversity, help to control pests and fungal pathogens, and affect the fitness of plants in polluted environments (Hildebrandt *et al.*, 1999). In nutrient-poor soil

of the humid tropics, many plants are obligatory or ecologically dependent on AM fungi (Gemma *et al.*, 2002). Therefore, it is important to study the biodiversity of arbuscular mycorrhizal fungi as this can improve understanding of tropical forest functioning, plant succession, and reforestation in disturbed areas (Zhao *et al.*, 2003). There are some important research studies where workers have done a study on mycorrhizal fungi on important plants. During last decade, Aggarwal *et al.*, (2005) and Parkash *et al.*, (2009) had surveyed ethno-medicinal plants of Himachal Pradesh and Haryana. They had listed AM fungi associated with them and they further reported that the rhizospheres were dominated by *Glomus mosseae*. Raj and Chandrashekar (2003) studied the association of mycorrhizal fungi with endemic dipterocarps of Sharavathi valley forest, Karnataka region. They isolated thirty-six species of mycorrhizal fungi and *Glomus* species was represented by twenty species, *Acaulospora* by eight, *Scutellospora* by four, *Gigaspora*, and *Entrophospora* by only two species each, and the root colonization by mycorrhizal fungi ranged from 84% to 92%. In another study by Uniyal (2003), he had isolated ten species of *Glomus*, three species of *Acaulospora*, *Scutellospora*, and *Sclerocystis* and two species of *Gigaspora* from the rhizosphere of *Populus deltoides* plantations in New Forest, Dehradun.

Pandey *et al.*, (2020) studied the AM and dark septate endophytic fungal associations from ginger species of Northeast India whereas bamboo species has been explored for the diversity of AM fungi by Parkash *et al.*, (2019), but no endomycorrhizal studies has been done in NRF. Considering the importance of forest plant species, the present investigation was carried out to study the endomycorrhizal association and scan out the AM fungal population from the rhizospheres of the

selected important forest plant species. These selected plant species were of multipurpose uses, economically important and frequently which are used for timber, fuel wood, fodder, sources of tannins, gums, dying agents and agro-forestry species and traditional medicinal purposes by the local tribals. Information on the status of AM fungal association with the forest plant species in NRF, Nongpoh,

Meghalaya is very little. Therefore, in the present study, surveys were carried out to investigate the endomycorrhizal status of important forest plant species and further to identify the most predominant AM fungi from the rhizospheric soils so that the germplasm of these predominant AM fungi can be conserved and preserved with trap hosts.



**Map 1.** The study site of Nongkhylllem Reserve Forest, Nongpoh, Meghalaya

## Materials and Methods

### Survey and collection of soil samples

Surveys of different remote sites and areas of study region were done for the collection of rhizospheric soil samples and plant specimens of some economically important tree/s. The plant specimens were preserved in herbarium sheets for identification. Rhizospheric soil samples (at least three samples) were taken by digging out a small amount of soil (500 g) close to plant roots up to the depth of 15-30 cm and these samples were kept in sterilized polythene bags at 10 °C for further processing in the laboratory for physicochemical analysis of soil, mycorrhizal colonization and quantification to see the dominance of AM fungi. Carbon estimation was done with help of Walkley and Black's Method (1934) and soil temperature and pH were measured with the help of soil thermometer and pH meter, Eutech makes, Japan. Colour of collected rhizospheric soil samples were given according to Munsell Soil Colour Code (Munsell, 2000).

### Isolation, quantification and root colonization by AM spores

Isolation of AM spores was done by using wet sieving and decanting techniques of Gerdemann and Nicolson (1963) and Singh and Tiwari (2001). For the quantitative estimation of AM spores, Gaur and Adholeya's modified method (1994) was used.

### Identification of AM fungi

For identification of AM spores/chlamydo-spores, the following criteria like conventional morphological characters *i.e.* colour, size, shape, wall structure, surface, the ornamentation of spores, nature, and size of the subtending hyphae, bulbous suspensor, the number and arrangement of the spores in the sporocarps were used. These AM spores were identified by using the keys of Trappe (1982), Walker (1992), Schenck and Perez (1990), Morton and Benny (1990) and Mukerji (1996) and Enet websites.

### Colonization of VA Mycorrhizae

It was studied by rapid clearing and staining method of Phillips and Hayman (1970). The percentage mycorrhizal root colonization was studied by following formula.

$$\text{Percentage mycorrhizal root colonization} = \frac{\text{Total no. of infected root segments}}{\text{Total no. of root segments examined}} \times 100$$

**Mycorrhizal Diversity analysis:** Analysis of the following diversity parameters were computed based on the methods used by Miller *et al.*, (1987).

**Species richness:** After identification, the total number of species recovered (T) and AM fungal species richness were determined. Species richness was computed by the following formula Miller *et al.*, (1987).

$$S = n + \left(\frac{n-1}{n}\right)^k$$

where:  $S$  = Species richness;  $n$  = Total number of species present in the sample population;  $k$  = Number of "unique" species (of which only one organism was found in sample population)

**Diversity index:** Diversity index was computed by the following formula (Miller *et al.*, 1987)

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

where:  $D$  = Diversity Index;  $N$  = Total number of organisms of all species found;  $n$  = Number of individuals of a particular species

**Pearson's coefficient of correlation:** Pearson's coefficient of correlation was computed by the following formula with the help of SPSS Statistics for Windows, ver. x. software.

$$r = \frac{\text{Covariance of X and Y}}{\sqrt{(\text{Variance of X})(\text{Variance of Y})}} = \frac{\text{Cov}(X, Y)}{\sqrt{(V(X))(V(Y))}}$$

where:  $\text{Cov}(X, Y) = \frac{1}{n} \left( \sum_{i=1}^n x_i y_i - \frac{\sum_{i=1}^n x_i \sum_{i=1}^n y_i}{n} \right)$ ;  
 $V(X) = \frac{1}{n} \left( \sum_{i=1}^n x_i^2 - \frac{(\sum_{i=1}^n x_i)^2}{n} \right)$ ;  $V(Y) = \frac{1}{n} \left( \sum_{i=1}^n y_i^2 - \frac{(\sum_{i=1}^n y_i)^2}{n} \right)$

### Similarity and Dissimilarity indices

Indices of similarity and dissimilarity were calculated by using formula as per Misra (1989) and Sorensen (1948) as follows.

$$\text{Index of similarity (S)} = \frac{2C}{A + B}$$

where: A = Number of Species in the range A

B = Number of Species in the range B

C = Number of common Species in both the ranges

Index of dissimilarity = 1 - S

where: S = Index of similarity

**Quantitative Analysis:** The quantitative analysis such as density, frequency, and abundance of Endomycorrhizal species were determined as per Curtis and McIntosh (1950).

**Density:** Density is an expression of the numerical strength of a species where the total number of individuals of each species in all the compartments is divided by the total number of compartments studied and calculated using this equation:

$$\text{Density} = \frac{\text{Total number of individuals of a species in all compartments}}{\text{Total number of compartments studied}}$$

**Frequency (%):** Frequency refers to the degree of dispersion of individual species in an area and usually expressed in terms of percentage occurrence. It was studied by sampling the study area at several places at random and recorded the name of the species that occurred in each sampling units and calculated by the equation:

$$\begin{aligned} \text{Frequency (\%):} \\ &= \frac{\text{Total number of compartments in which the species occurred}}{\text{Total number of compartments studied}} \times 100 \end{aligned}$$

**Abundance:** Abundance is the study of the number of individuals of different species in the community per unit area. By compartments method, samplings are made at random at several places and the number of individuals of each species was summed up for all the

compartments divided by the total number of compartments in which the species occurred. It is represented by the equation:

$$\begin{aligned} \text{Abundance :} \\ &= \frac{\text{Total number of individuals of a species in all compartments}}{\text{Number of compartments in which the species occurred}} \end{aligned}$$

**Percentage of occurrence (%):** The density and distribution of AM fungi in the rhizosphere soil sample were expressed in terms of percentage of occurrence.

$$\begin{aligned} \text{Occurrence (\%):} \\ &= \frac{\text{Total number of spores of individual AM fungus}}{\text{Total number of spores of AM fungi}} \times 100 \end{aligned}$$

## Results and Discussion

About 117 rhizospheric soil samples of economically important forest plant species were screened for endomycorrhizal qualitative and quantitative analysis as per methods as described in Methodology part earlier. Data of physico-chemical analysis of all collected rhizospheric soil samples of Nongkhylllem Reserve Forest (NRF), Nongpoh is given in Table 1 and Figs. 2(a) to 2(i). The parameters analyzed for physico-chemical properties were pH, E-conductivity, Temperature, percent organic carbon and colour/type of soil. The range of pH in collected rhizospheric soil samples was varying from 4.89 (lowest in *Amorphophallus* species) to 8.89 (highest in *Centella asiatica*). The low E-conductivity (6.66 Sm<sup>-1</sup>) in rhizospheric soil sample was observed in *Eryngium foetidum* whereas the high E-conductivity (199.7 Sm<sup>-1</sup>) was observed in *Trevesia palmata*. The intact soil temperature in the rhizospheric soil samples was ranging from 20.5°C (lowest in *Centella asiatica*) to 36.9 °C (highest in *Peperomia pellucida*). Analysis of percent organic carbon of rhizospheric soil samples showed the range from 0.09% (lowest in *Macaranga denticulata*) to 3.48% (highest in *Aquilaria agallocha*). The colour

of collected rhizospheric soil samples from NRF, Nongpoh was varying from reddish-brown to blackish-brown (Table 1). Different types of root colonizations in rhizospheric roots are shown in Table 2. All the three types of root infection/colonization namely Hyphal, Vesicular and Arbuscular were observed in varying degree of occurrence. Hyphal infection/colonization was present in all the collected rhizospheric soil samples, whereas Vesicular infection was found scarce and absent in most of the samples (Table 2 & Figure 1A).

The range of percentage Hyphal infection / colonization was from 10% (lowest in *Cinnamomum, tamala*) to 100% (highest in 16 root samples namely *Dioscorea* sp., *Asplenium* sp., *Polypodium* sp., *Thysanoleana maxima*, *Hyptis suaveolens*, *Biden pilosa*, *Dicliptera* sp., *Houttuynia cordata*, *Abroma augusta*, *Melastoma malabathricum*, *Solanum toroum*, *Alpinia allughas*, *Euphorbia* sp., *Grewia* sp., *Callicarpa arborea*, *Ficus glomerata*). The percentage Vesicular infection / colonization was ranging from 5% (lowest in 12 samples namely *Smilax aspera*, *Pteridium* sp., *Richardia scabra*, *Biden pilosa*, *Hypoestes*, *Victiptera* sp., *Manihot esculanta*, *Leea indica*, *Elaeocarpus florifundus*, *Eheretia* sp., *Cassia occidentalis*, *Artocarpus chaplasha*, *Caryota urens*) to 60% (highest in *Mussaenda frondosa*). The percentage of Arbuscular infection was ranging from 5% (lowest in 8 root samples namely *Dicliptera* sp., *Crassocephalum crepidioides*, *Carissa* sp., *Eheretia* sp., *Cassia occidentalis*, *Aquilaria agallocha*, *Emblica officinalis*, *Albizia chinensis*) to 90% (highest in 2 root samples namely *Hyptis suaveolens*, *Callicarpa arborea* respectively). The percentage colonization intensity in roots showed a range from 25% (lowest) in *Pteris cretica*, *Amorphophallus* sp., *Bridelia retusa*, *Zanthoxylum armatum*, *Carissa* sp., *Bauhinia purpurea*, *Emblica officinalis*, *Salix daphnoides*, *Toona ciliata*, *Cinnamomum tamala* to 94.74% (highest) in *Costos speciosus*. The quantification of AM spore numbers

showed the range from 7 (lowest) in *Caryota urens* to 903 (highest) in *Solanum khasianum*.

The habit wise variation (based on an average data of all collected samples) on different parameters such as pH, percentage colonization in roots, AM spore number, percentage colonization intensity, hyphal infection (%), vesicular infection (%), arbuscular infection (%), carbon and temperature are shown in Figs. 2(a) to 2(i). In general, it is observed that scrubs, herbs and shrubs had high pH values, and trees with low pH values. Percent endomycorrhizal colonization in roots was also low in scrubs and trees than herbs and shrubs whereas climbers were having the high total colonization in roots. Shrubs and trees were having more AM spore numbers than scrubs and trees. Percent endomycorrhizal colonization intensity and percent hyphal infection in roots in case of herbs, shrubs and climbers were high than trees and scrubs. Percent vesicular infection was also low in trees and shrubs than herbs. Percent arbuscular infection was again low in case of scrubs and trees than shrubs, herbs and climbers but trees were having more percent soil organic carbon than shrubs, herbs and climbers. The soil temperature in scrubs and trees was high than shrubs, climbers and herbs (Figs. 2(a) to 2(i)).

The lowest elevation was 432 amsl observed in Diphu sydang compartment of Nongpoh range while the highest elevation 628 amsl was recorded in Mawdkhar compartment of Umtasoar range. The elevation wise variation (based on an average data) on different parameters i.e. AM spore number, percentage colonization in roots, hyphal infection (%), vesicular infection (%), arbuscular infection (%), percent colonization intensity, pH, temperature and organic carbon (%) are shown in Figs. 3(a) to 3(i). Generally, it is observed that AM spore numbers were increased with elevation.



**Figure 1:** A: study/Habitat view, B-C: Collection and datum recording of rhizospheric samples, D: *Abroma augusta*, E: *Elephantopus scaber*, F: *Indigofera hebeptala*, G: *Castanopsis indica*, H: *Holmskioldia sanguinea*, I: Arbuscules, J: Vesicles, K: *Glomus macrocarpum*, L: *Glomus clavisorum*, M: *Glomus mosseae*, N: *Acaulospora foveata* (Scale bar = 20  $\mu$ m at 200 X for images I-J & 400 X for images K-N)

Total root colonization (%), hyphal infection (%), arbuscular infection (%) and colonization intensity (%) were decreased gradually with elevation. However, vesicular infection (%) abruptly decreased to zero at elevation 569 to 570 amsl and it started increasing from 576 to 616 amsl range of elevation, but again it decreased at 628 amsl and beyond. There was no any significant change in pH value, but little fluctuation was reported with elevation and it occurred in acidic range. Temperature at lowest elevation was 27.3 °C. At elevation 536 amsl, the temperature of the soil abruptly increased to 29.2 °C and then gradually decreased with elevation. However, at highest elevation, the temperature was recorded 28.3 °C. At lowest elevation, the organic carbon (%) was low. As the organic Carbon (%) increased in middle range of elevation but at higher elevation, it again decreased (Fig. 3(a) to 3(i)). (based on analysis on an average data).

The natural occurrence and diversity of *Acaulospora*, *Gigaspora*, *Entrophospora*, *Scutellospora*, *Sclerocystis* sp. is shown in Table 3. There were 14 *Acaulospora* species, 5 *Gigaspora* species and only one *Entrophospora*, *Scutellospora*, *Sclerocystis* species each had been identified from the collected rhizospheric soil samples of Nongkhyllem Reserve Forest (NRF), Nongpoh. While 45 *Glomus* species were isolated and identified with the help of available literatures, flora and manuals in the laboratory. Natural occurrence of AM fungi in NRF showed highest frequency in case of *Glomus* species (64%) followed by *Acaulospora* species (33%), *Entrophospora* species (2%), *Gigaspora* species (1%) and *Scutellospora* & *Sclerocystis* species approximately negligible (almost 0%) each. Among the *Acaulospora* sp., *Acaulospora laevis* had the highest frequency of occurrence (27%) and *Acaulospora trappei* and *Acaulospora capsicula* had negligible frequency of occurrence (almost 0%) each. In case of natural occurrence of different species of

*Gigaspora*, *Gigaspora rosea* were having maximum natural occurrence (43%) followed by *Gigaspora nigra* (15%) and *Gigaspora gregaria* and *Gigaspora margarita* (14%) each respectively, whereas *Entrophospora* species had 14% natural occurrence. The natural occurrence of different *Glomus* species showed that *Glomus clavosporum* (27%), *Glomus mosseae* (19%) and *Glomus macrocarpum* (19%) had maximum natural occurrence whereas *Glomus callosum*, *Glomus diaphanum*, *Gl. formasanum*, *Gl. verruculosum*, *Gl. maculosum*, *Gl. pansihalos*, *Gl. microcarpum* had lowest/ negligible natural occurrence (0.1 to 2.45%) respectively each (Table 3 & Figure 1A).

The endomycorrhizal diversity analysis for species richness and diversity index (compartment wise) of Nongkhyllem Reserve Forest (NRF), Nongpoh is shown in Figure 4. The species richness (unique) in Umtasoor range was ranging from 3 (lowest in Kyrdemkulia compartment) to 249.89 (highest in Umsaw compartment), while the species richness (unique) in Nongpoh range was ranging from 14 (lowest in Umsiling compartment) to 133.93 (highest in Leprosy Colony compartment). The diversity index (compartment wise) of Kyrdemkulia and Pen-Point was found with lowest value (0) while maximum was found in Ben-Point and Zero-Point (0.039) each respectively of the Umtasoor Forest Range. The diversity index of Umsiling compartment was found lowest (approximately 0) while highest diversity index was found in Towar-Point (0.059) of the Nongpoh Forest Range. The diversity index of Umtasoor range was 0.036 and that of Nongpoh range was 0.049 (Fig. 4(a) to 4(b)). The correlation coefficient (r) between Species richness and Diversity index was 0.54 (positive correlation) and it was expressed by a scatter diagram in Fig. 4(c). It suggests that species richness is positively correlated with diversity index. The Covariance (Species richness, Diversity index) was 0.78034 whereas V (Species

richness) was 5208.891 and V (Diversity index) was 0.000402. Therefore, Correlation Coefficient (r) value was 0.54 which is having Positive correlation between species richness and diversity index (Fig. 4(c)).

The similarity index of NRF, Nongpoh was found 0.77 while dissimilarity index was 0.23. The scatter diagrams of different colonization in roots of rhizospheric samples of Nogkhyllem Reserve Forest had revealed that there is a positive variation between total colonization (%) and hyphal infection (%) in roots with a regression value of 0.86 and also between total colonization (%) and colonization intensity (%) in roots with regression value of 0.55. It reveals that if hyphal infection (%) and colonization intensity (%) in roots increases then total colonization (%) in root will also be increased. However, a negative variation was observed between total colonization (%) and arbuscular infection (%) in roots with regression value of 0.36 and also between total colonization (%) and vesicular infection (%) in roots with a regression value of 0.14 (Fig. 5 (a) to 5 (d)).

The natural occurrence and diversity of *Acaulospora*, *Gigaspora*, *Entrophospora*, *Scutellospora*, *Sclerocystis* species and *Glomus* species were sustaining in the study area. It is found in this study that no any host specificity is there and different AM species are colonizing the plant species. Many factors could affect spore density and species richness in a given host rhizosphere. Values for arbuscular mycorrhizal fungal spore density associated with different plants at different sites have varied greatly in previous reports (Koske, 1987).

Seasonality, edaphic factors, host-dependence, age of the host plants, the sporulation abilities of arbuscular mycorrhizal fungi, and the dormancy and the distribution patterns of arbuscular mycorrhizal fungal spores in the soils, have been reported previously (Mangan *et al.*, 2004).

Guadarrama and Alvarez-Sanchez (1999) reported that disturbance, but not seasonality, affects the abundance and richness of mycorrhizal spores in a tropical wet forest in Mexico. The results in this research support the previous suggestions (Zhao *et al.*, 2001) that the uneven spatial distribution (clumped distribution) of arbuscular mycorrhizal fungal spores and the complex below-ground structure of tropical rainforests are major factors that affect the spore density. Similarly, Koske (1987) found 8 to 14 different VAM species in the roots of *Ammophila reiligulata*, *Solidago sempervirens* and *Uniola paniculata* along transect on the barrier dunes of the United States. Also, Rosendahl *et al.*, (1989) were able to identify four different mycorrhizal types in the roots of several coexisting plants, while Sanders and Fitter (1992) found that different AM fungal species sporulated when several coexisting grassland plant species were grown either as seedlings in sterilized soil or from seeds in field soil. These were evidences of no host specificity, either in fungal distribution or in the ability of one fungal species to infect a restricted range of hosts. The unspecificity in AM fungi also has been proofed (Johnson *et al.*, 1997).

In this study, all the three types of root infection/colonization namely hyphal, vesicular and arbuscular were observed in varying degree of occurrence. Hyphal infection/colonization was present in all the collected rhizospheric soil samples, whereas Vesicular infection was found scarce and absent in most of the samples. Percent total colonization in roots was also low in scrubs and trees than herbs and shrubs whereas climbers were having the high total colonization in roots. Shrubs and trees were having more AM spore numbers than scrubs and trees. Percent colonization intensity and percent hyphal infection in roots in case of herbs, shrubs and climbers were high than trees and scrubs. Percent vesicular infection was also

low in trees and shrubs than herbs. Percent Arbuscular infection was again low in case of scrubs and trees than shrubs, herbs and climbers but trees were having more percent organic carbon than shrubs, herbs and climbers. The soil temperature in scrubs and trees was high than shrubs, climbers and herbs.

The variation in AM fungal colonization pattern within the same species in a different location was earlier noticed by (Lakshmipathy *et al.*, 2003) in their study with medicinal plants in Karnataka. The variation of AM fungal root colonization in different locations could be due to the change in the habitat, environmental factors, soil fertility and acclimatization of a particular AM fungal genus/species to a particular location (Brundrett, 1991). This study also reveals that AM fungal colonization pattern is related to soil pH and available phosphorous in the soil. AM fungal colonization was high in slightly acidic soils as compared to the neutral and alkaline soils. According to Sumana (1998), acid phosphatase activity increases with increased colonization by AM fungi. AMF colonization is known to alter the inherent phosphorous supply by increasing the phosphatase activity in the rhizosphere (Allen *et al.*, 1995). In this study, it was observed that there were variations in AM fungal spore density. Picone (2000) also recorded more sporulation by AM fungi in pastures compared to forests. Further, spore densities in pastures were found to be more compared to secondary forests (Fischer *et al.*, 1994). Sieverding and Leihner (1984) reported that combination of graminaceous and leguminous crops generally increases mycorrhizal population. In this study also, the genus, *Glomus* was more abundant as compared to *Acaulospora* and *Scutellospora* among these three genera. The variation in spore abundance of different AM fungi in different locations was observed in earlier studies also. Schenk and Kinloch (1980) observed the

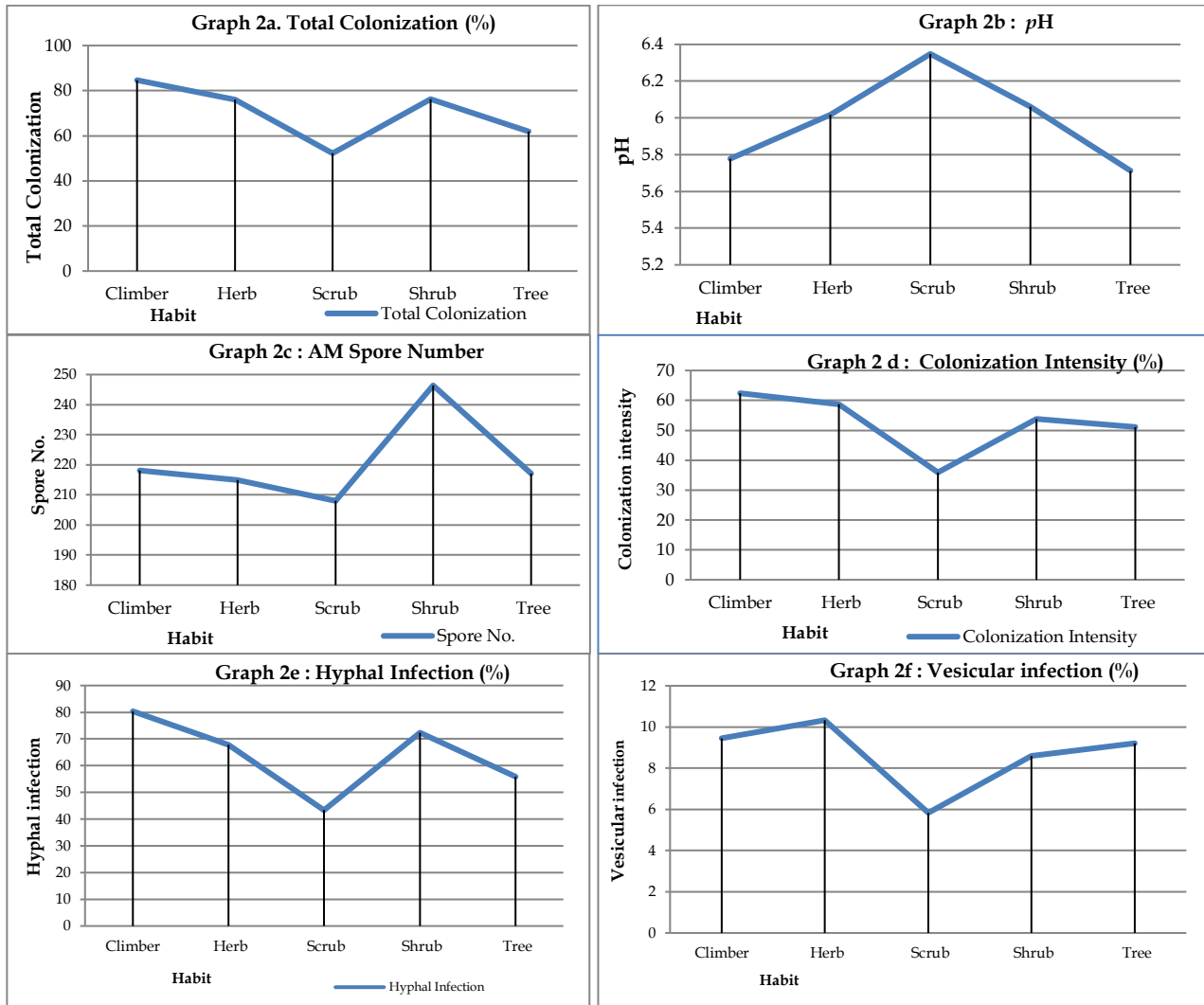
dominance of species in *Gigaspora margarita*, *Gigaspora gigantea* and *Gigaspora gregaria* in soyabean fields while *Glomus fasciculatum* and *Glomus clarum* in bahia grass and *Acaulospora* in cotton and peanut fields. The same results were obtained by Lakshmipathy *et al.*, (2004) in cashew plantations where *Glomus etunicatum* was most abundant. Vijayalakshmi and Rao (1988) while working with mycorrhizal association in ten members of Asteraceae and seven Amaranthaceae growing in different locations having different soil types observed variation in mycorrhizal association and they found that *Glomus mosseae* and *Glomus macrocarpum* were dominant.

The plant community composition is likely to affect mycorrhizal fungi (Kormanik *et al.*, 1980). This kind of diversity was also noticed earlier by Oehl *et al.*, (2003) in different land-use types, and they found a maximum diversity index being in grasslands compared to cultivated fields. However, Johnson and Wedin (1997) did not find any significant variation in diversity due to change in land-use types. The variation in AM fungal diversity in rhizosphere soil of a particular plant in different locations may be due to the influence of adjoining plants (Bagyaraj and Manjunath, 1980).

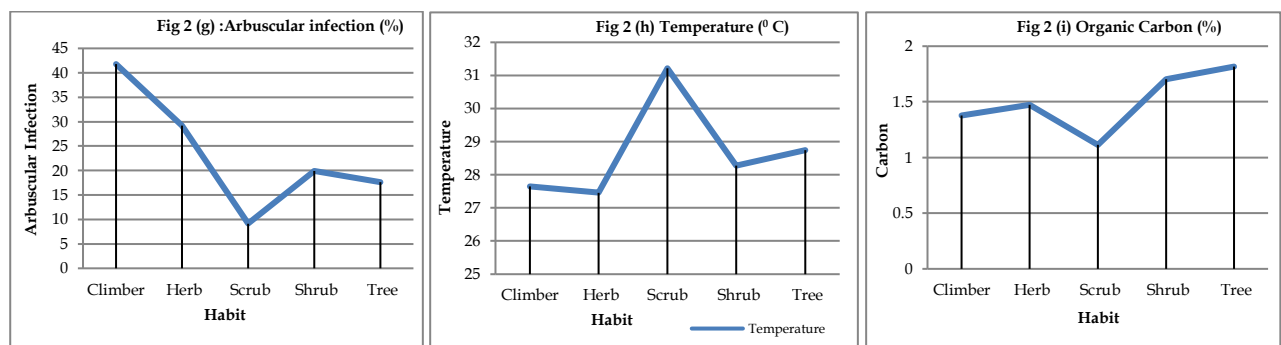
The variation in colonization could be related to the conclusion by other workers (Sander and Fitter, 1992) when they found a great range in AM infection density of the roots of coexisting species. The variation in AM infection could be a result of environmental pressures that determine the growth of plant roots or the fungus, the survival strategies that adaptive by the different plant species or the fungus distribution in space and time. At the other, the variation in AM infection could be a result of highly controlled phenomenon determined by plant, fungus or their interaction in response either to the flow of materials across the plant-fungus

interface or to some other benefit or cost being exchanged. These events are different by the different plant and fungus species that reflect the symbiotic association.

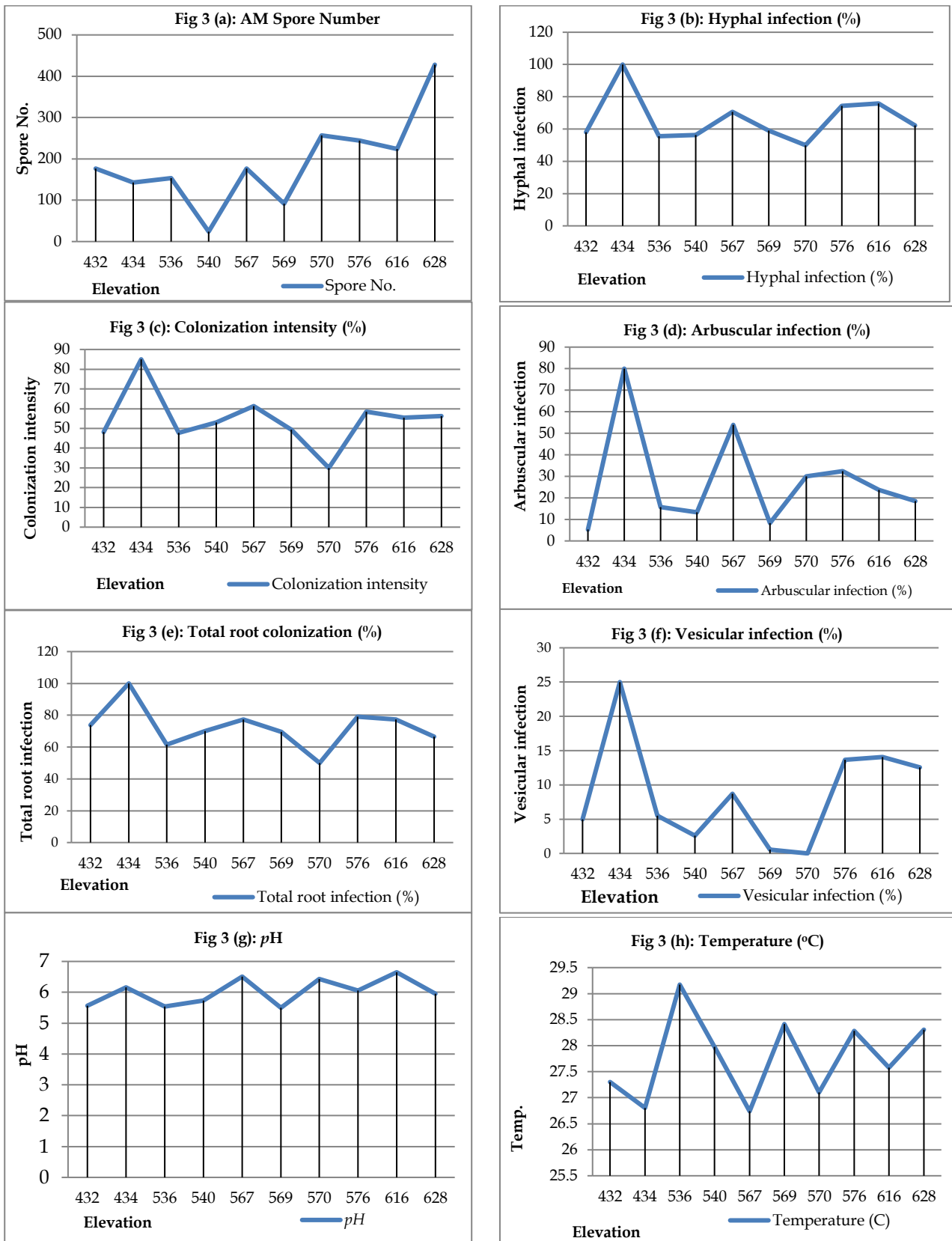
**Graphical analysis of parameters on different habits in NRF, Nongpoh (based on average data)**  
**Figures 2(a) - 2(f):** The graphs of total colonization, pH, AM spore number, colonization intensity, hypHal infection, and vesicular infection respectively on different plant habits (based on average data).

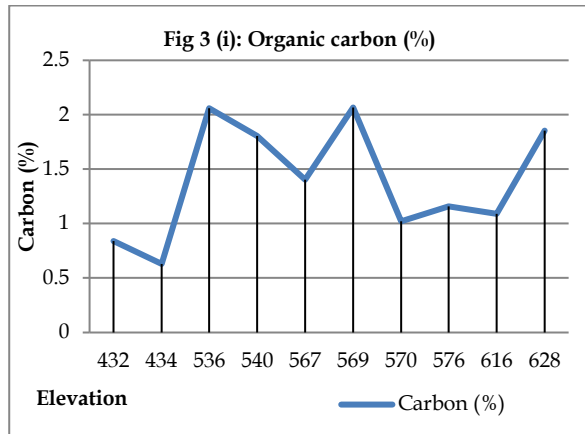


**Figures, 2 (g) - 2(i).** The graphs of arbuscular infection, carbon, and temperature respectively on different plant habits in NRF, Nongpoh ( based on average data).



**Figures, 3(a) - 3(i) :** Graphs of AM spore number, total colonization, hyphal infection, vesicular infection, arbuscular infection, colonization intensity, variation in pH, temperature, and carbon elevation wise respectively (based on average data).





Generally, it is seen during analysis in this study that AM spore numbers increased with elevation. Total root colonization (%), Hyphal infection (%), Arbuscular infection (%) and Colonization intensity (%) gradually decreased with elevation. However, Vesicular infection (%) abruptly decreased to zero at elevation 569 to 570 amsl and it started increasing from 576 to 616 amsl elevation, but again it decreased at 628amsl. There was no any significant change in pH value, but little fluctuation was reported with elevation and it occurred in acidic range. The temperature at lowest elevation was 27.3 °C. At elevation 536 amsl, the temperature of the soil abruptly increased to 29.2 °C and then gradually decreased with elevation. However, at highest elevation the temperature reached 28.3 °C. At the lowest elevation the organic Carbon (%) was low. As the organic Carbon (%) increased in middle range elevation but at higher elevation it again decreased. Mycorrhizal associations can be beneficial because colonized hosts have improved access to limited nutrients and water when compared to nonmycorrhizal plants. However, it must be noted that increased mycorrhizal colonization also may be due to the increase in the number of roots present in soils supporting several species.

In general, it is observed that scrubs, herbs and shrubs had high pH values than trees with low pH values. The pH value also affects the AM

colonization. Survival of VA mycorrhizal fungi and subsequent spore germination may depend on a species adaptation and on the influence of physical parameters of the soil such as pH (Green *et al.*, 1976). Powell and Bagyaraj (1984) concluded that pH can influence spore germination in AM fungal species, and that spore germination occurs within a range that is acceptable for plant growth. Friese and Koske (1991) found no significant correlation between VA mycorrhizal fungal spore clumping and soil pH. Bagyaraj (1992) pointed out that the interpretation of a pH effect on AM fungal spore germination is difficult because many chemical properties of soil vary with changes in pH. Soil pH over a range of 4.8-8.0 significantly influenced spores germination of *Glomus epigaeum* (Daniels and Trappe, 1980).

In ecosystem surveys, the degree of mycorrhizal colonization should be expressed as the proportion of susceptible roots that were mycorrhizal. This requires an understanding of root structure and phenology (Brundrett *et al.*, 1996). Mycorrhizas are three-way interactions of plants, fungi and soils (Brundrett, 1991). Consequently, descriptions of mycorrhiza types should include information about the soils and habitats where they occur which can be as valuable as information about the taxonomic identity of fungi (Brundrett, 1991).

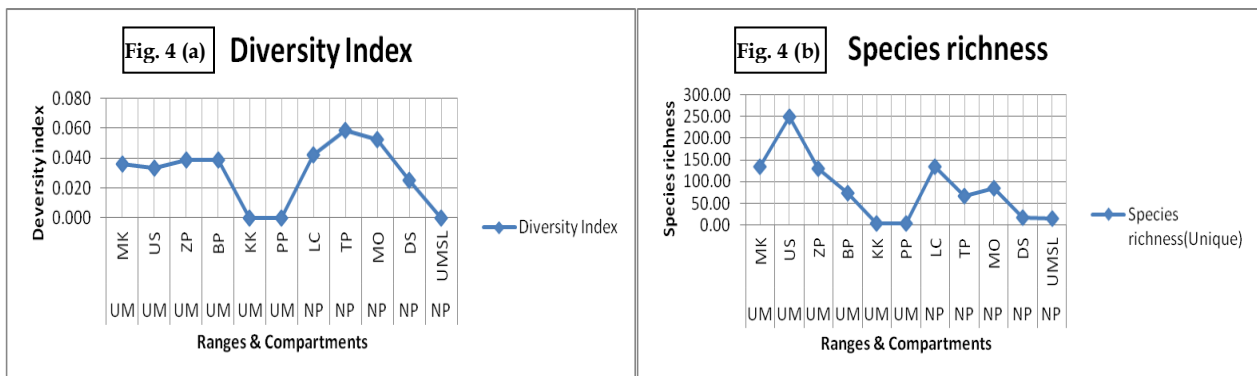
## Conclusion

Microbes including fungi constitute an important component of biodiversity and comprise one of the biggest kingdoms in the living world. The association of many plants with fungi has resulted in their use in agriculture as biological control agents against plant disease and as plant growth stimulants such as mycorrhizal inoculants. Conservation and utilization of endomycorrhizal diversity is important for sustainable plant productivity system point of view. There is hardly any plant

species of economic importance, that doesn't form mycorrhizal association in nature. For this fact, it is gaining more attention of forestry researchers. Knowledge of the biodiversity of natural resources like forest plant species and associated hypogaeal endomycorrhizae is important which can be utilized in the establishment of target seedlings/ plantlets with good and vigour health. On the other hand, apart from conservation of biodiversity and improvement of plant health, it can help in developing an improved technology with other rhizospheric

beneficial microbes that can be later on extended or transferred to the fields synergistically. Similarly, in the forestry sector, apart from quality seedling production and survival of plants on sub-marginal and degraded sites, mycorrhiza also regulates the composition and functioning of forests by enhancing beneficial biological interactions in nature. Therefore, their management, conservation and exploitation for the betterment of humankind are must.

**Graphs of species richness and diversity index of AM fungi in Nongkhylllem Reserve Forest**

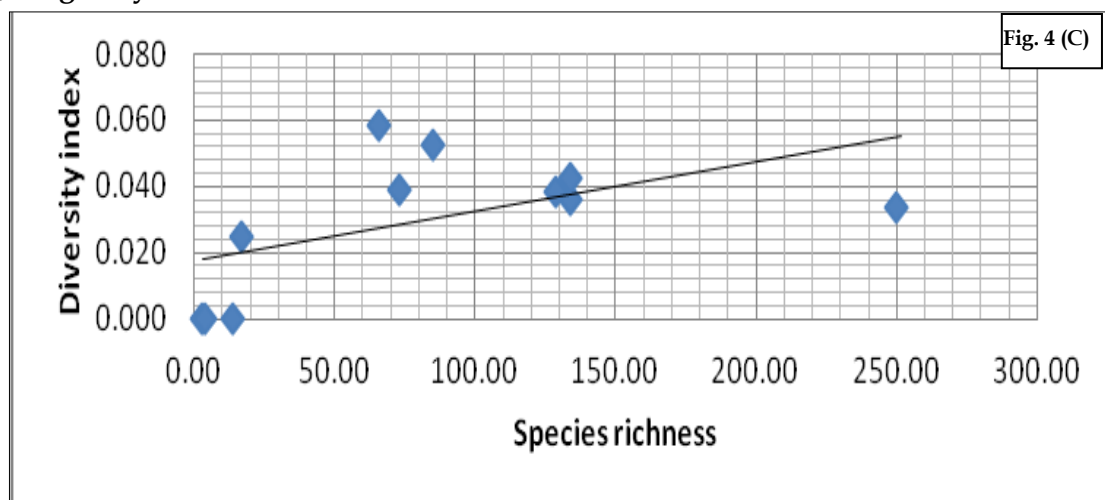


**Fig. 4(a).** Species richness of AM fungi in Nongkhylllem Reserve Forest, Meghalaya &

**Fig.4 (b).** Diversity index of AM in Nongkhylllem Reserve Forest, Meghalaya

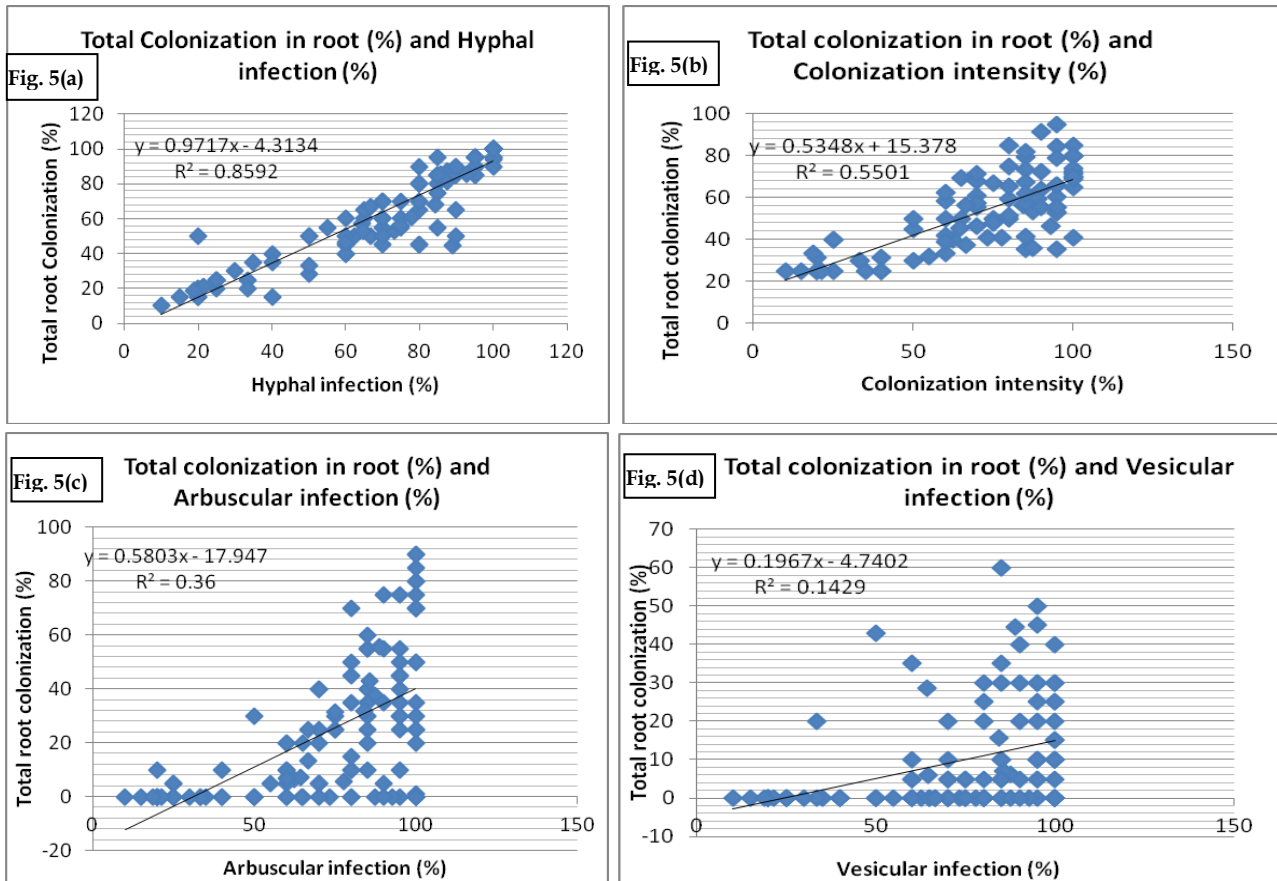
**N R F** = Nongkhylllem Reserve Forest, **UM** = Umtasoar, **NP**= Nongpoh, **MK** = Mowdkhar, **US**= Umsaw, **ZP**= Zero-Point, **BP**= Ben-Point, **KK**= Kyrdemkulia, **PP**= Pen-Point, **LC**= Leprosy Colony, **TP**= Tower Point, **MO**= Morok, **DS**= Diphu-Sydang and **UMSL**= Umsiling

**Correlation between species richness and diversity index of AM fungi in Nongkhylllem Reserve Forest, Meghalaya**



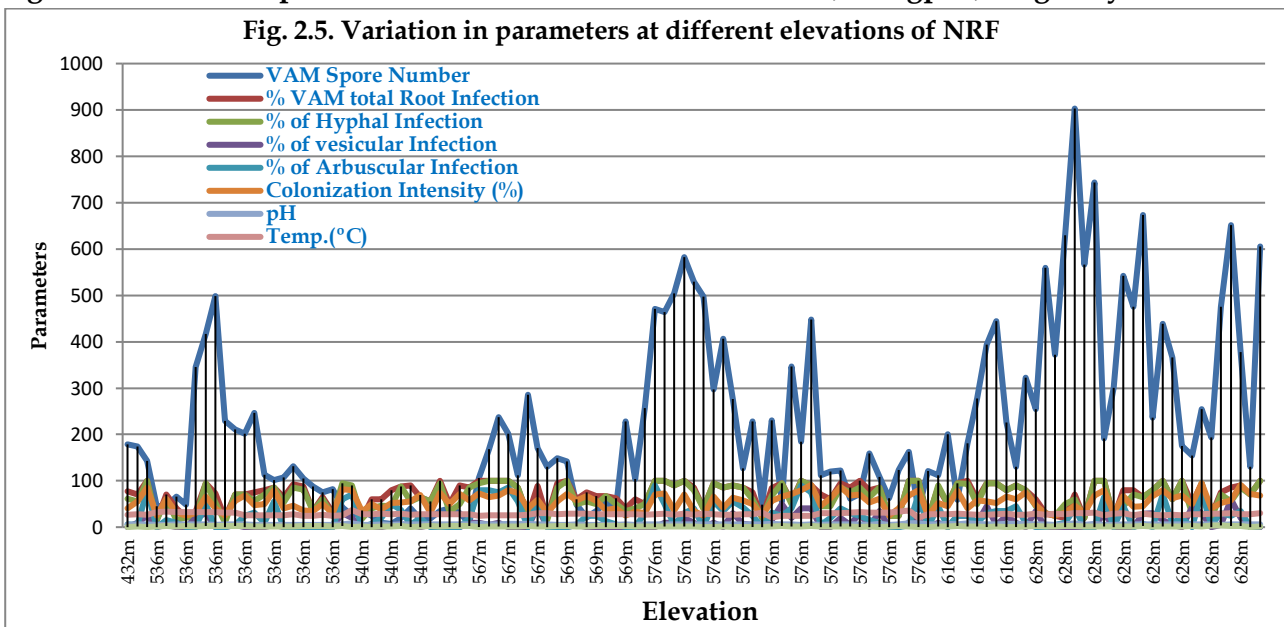
**Fig.4 (c).** Correlation between species richness and diversity index

**5(a-d). Correlation between different colonization in roots of collected rhizospheric samples in NRF (in Scatter diagrams)**



**Figs. 5(a-d).** Correlation between total colonization in root (%), hyphal infection (%), colonization intensity (%), arbuscular infection (%) and vesicular infection (%) of collected rhizospheric samples in NRF, Nongpoh, Meghalaya

**Fig. 2.5. Variation in parameters at different elevations of NRF, Nongpoh, Meghalaya**



**Table 1.** Physico-chemical properties of rhizospheric soil samples from NRF, Nongpoh, Meghalaya

Sl. No.	Botanical names	Habit	Family	pH	E. Conductivity (Sm <sup>-1</sup> )	Temp. (°C)	% of org. C	Soil colour (Munsell code)
1.	<i>Castanopsis indica</i> (Roxb.) DC.	Tree	Fagaceae	5.56±0.05	36.33±6.34	28.5±0	2.79±0	Brown (7.5YR 6/1)
2.	<i>Sterculia villosa</i> Roxb.	Tree	Sterculiaceae	5.69±0.055	39±1.41	29.3±0	3.03±0	Brown (7.5YR 6/1)
3.	<i>Melastoma malabathricum</i> L.	Shrub	Melastomaceae	6.00±0.086	12.66±0.471	30.1±0	1.98±0	Brown (7.5YR 6/1)
4.	<i>Curcuma pseudo-montana</i> Graham	Herb	Zingiberaceae	5.73±0.07	20.66±4.08	28.2±0	2.76±0	Black (10YR 2/1)
5.	<i>Aquilaria agallocha</i> Roxb.	Tree	Thymelaeaceae	5.92±0.04	11.66±0.94	29.4±0	3.48±0	Black (10YR 2/1)
6.	<i>Artocarpus chaplasha</i> Roxb.	Tree	Artocarpaceae	5.41±0	23.30±2.49	29±0	3.33±0	Black (10YR 2/1)
7.	<i>Mussaenda frondosa</i> Sensu G Forst., non L.	Shrub	Rubiaceae	6.00±0.04	17±1.41	30.6±0	2.64±0	Red (2.5YR 4/6)
8.	<i>Garcinia cova</i> L.	Tree	Clusiaceae	6.02±0.19	21.30±8.26	27.5±0	2.19±0	Brown (7.5YR 6/1)
9.	<i>Shorea robusta</i> C.F. Gaertn.	Tree	Dipterocarpaceae	5.88±0.04	7.00±0	28.3±0	0.33±0	Red (2.5YR 4/6)
10.	<i>Smilax hispida</i> Muhl.	Shrub	Smilacaceae	5.86±1.46	15±0	26.2±0	1.89±0	Red (2.5YR 4/6)
11.	<i>Emblia officinalis</i> Gaertn.	Tree	Euphorbiaceae	5.43±0.02	24.33±1.25	29.6±0	1.5±0	Red (2.5YR 4/6)
12.	<i>Lagerstroemia parviflora</i> Roxb.	Tree	Lythraceae	5.96±0.02	10.66±0.47	27.8±0	2.13±0	Red (2.5YR 4/6)
13.	<i>Solanum khasianum</i> C.B. Clarke	Shrub	Solanaceae	8.88±.04	41±0	29.7±0	2.13±0	Black (10YR 2/1)
14.	<i>Sida cordifolia</i> L.	Herb	Malvaceae	5.38±0.07	13.31±1.25	30.5±0	1.98±0	Red (2.5YR 4/6)
15.	<i>Solanum torvum</i> Sw.	Shrub	Solanaceae	6.70±0.09	14.66±2.49	30.8±0	1.53±0	Black (10YR 2/1)
16.	<i>Asplenium nidus</i> L.	Herb	Aspleniaceae	5.37±0.03	15±0.82	26.1±0	0.93±0	Red (2.5YR 4/6)
17.	<i>Mesua ferrea</i> L.	Tree	Clusiaceae	5.40±9.43	28.33±1.7	28.9±0	1.86±0	Red (2.5YR 4/6)
18.	<i>Spilanthes paniculata</i> L.	Herb	Asteraceae	5.99±0.03	66.33±3.77	29.8±0	1.08±0	Brown (7.5YR 6/1)
19.	<i>Eryngium foetidum</i> L.	Herb	Apiaceae	5.65±0.04	29±0.82	26.0±0	1.08±0	Brown (7.5YR 6/1)
20.	<i>Polystichium braunii</i> Spenner	Herb	Dryopteridaceae	5.85±0.08	6.66±0.47	26.2±0	1.08±0	Brown (7.5YR 6/1)
21.	<i>Polypodium vulgare</i> L.	Herb	Polypodiaceae	5.67±0.05	10±0.82	26.1±0	1.38±0	Black (10YR 2/1)
22.	<i>Pteridium aquilinum</i> (L.) Kuhn.	Herb	Dennstaedtiaceae	6.07±0.01	10.66±0.47	26.4±0	1.29±0	Brown (7.5YR 6/1)
23.	<i>Alpinia allughas</i> (Retz.) Rose	Shrub	Zingiberaceae	6.07±0.08	24±1.63	26.0±0	1.02±0	Black (10YR 2/1)

24.	<i>Callicarpa arborea</i> Roxb.	Tree	Verbenaceae	5.79±0.01	12±0	28.4±0	0.93±0	Brown (7.5YR 6/1)
25.	<i>Thysanoleana maxima</i> (Roxb.) O. Ktze	Herb	Poaceae	5.86±0.08	44.66±0.47	28.7±0	1.23±0	Red (2.5YR 4/6)
26.	<i>Manihot esculanta</i> Herm.	Scrub	Euphorbiaceae	5.63±0.05	18±0	27.3±0	1.08±0	Brown (7.5YR 6/1)
27.	<i>Ficus glomerata</i> L.	Tree	Moraceae	5.71±0.04	14.66±0.94	29.2±0	1.08±0	Red (2.5YR 4/6)
28.	<i>Pueraria tuberosa</i> (Roxb. ex Willd.) DC.	Climber	Papilionaceae	5.72±0.08	23.66±5.44	26.8±0	1.2±0	Red (2.5YR 4/6)
29.	<i>Pteris cretica</i> L.	Herb	Adiantaceae	6.26±0.02	12±0	28.5±0	0.87±0	Red (2.5YR 4/6)
30.	<i>Cocculus hirsutus</i> L.	Climber	Menispermaceae	5.61±0.02	13.33±0.47	27.6±0	0.87±0	Red (2.5YR 4/6)
31.	<i>Nephrodium hirsutum</i> C. Presl.	Herb	Dryopteridaceae	5.95±0.02	15±1.63	26.5±0	0.93±0	Red (2.5YR 4/6)
32.	<i>Adiantum tenerum</i> Sw.	Herb	Pteridaceae	5.96±0.47 1	26±0.27	26.3±0	0.51±0	Red (2.5YR 4/6)
33.	<i>Bridelia retusa</i> Spreng.	Scrub	Euphorbiaceae	6.17±0.26	16±9.99	28.2±0	0.27±0	Red (2.5YR 4/6)
34.	<i>Mimosa himalayensis</i> Gamble	Shrub	Mimosaceae	6.15±0.09	22.66±0.18	27.6±0	1.02±0	Red (2.5YR 4/6)
35.	<i>Crotolaria alata</i> Buch.-Ham. ex D. Don	Herb	Fabaceae	6.87±0.18	19.66±6.8	27.9±0	1.38±0	Brown (7.5YR 6/1)
36.	<i>Castanopsis concinna</i> (Champ. ex Benth.) A. DC.	Tree	Fagaceae	6.41±0.13	30.33±0.94	29.2±0	2.46±0	Brown (7.5YR 6/1)
37.	<i>Boechmeria macrophylla</i> Hornem	Shrub	Urticaceae	8.01±0.24	121±9.74	27.5±0	1.5±0	Brown (7.5YR 6/1)
38.	<i>Uncaria rhynchophylla</i> Schreb.	Climber	Rubiaceae	6.81±5.68	48.66±2.36	26.6±0	1.14±0	Black (10YR 2/1)
39.	<i>Festuca pratensis</i> Huds.	Herb	Poaceae	5.66±0.09	54.33±9.10	26.3±0	0.81±0	Black (10YR 2/1)
40.	<i>Leea indica</i> (Burm.) Merr.	Shrub	Lauraceae	6.51±0.05	19.33±2.62	27.7±0	1.26±0	Brown (7.5YR 6/1)
41.	<i>Duabanga grandiflora</i> Roxb. ex DC.	Tree	Sonneratiaceae	7.10±0.06	25.66±4.92	28.7±0	0.36±0	Black (10YR 2/1)
42.	<i>Boechmeria nivea</i> Hk. et Arn.	Shrub	Urticaceae	6.65±0.16	15.66±1.7	27.2±0	0.69±0	Black (10YR 2/1)
43.	<i>Begonia crenata</i> L.	Herb	Begoniaceae	6.80±0.07	22±0	26.5±0	1.08±0	Red (2.5YR 4/6)
44.	<i>Dioscorea bulbifera</i> L.	Climber	Dioscoriaceae	6.16±0.03	15±0	26.8±0	0.63±0	Brown (7.5YR 6/1)
45.	<i>Costos speciosa</i> (Koenig) Smith	Shrub	Costaceae	6.43±0.40	33.66±3.09	27.1±0	1.02±0	Red (2.5YR 4/6)
46.	<i>Crotolaria juncia</i> L.	Shrub	Leguminosae	6.29±0.10	18±2.45	28.3±0	1.08±0	Red (2.5YR 4/6)
47.	<i>Elephantopus scaber</i> L.	Herb	Asteraceae	5.88±0.09	13.66±0.94	27.8±0	0.63±0	Red (2.5YR 4/6)
48.	<i>Richardia scabra</i> L.	Herb	Rubiaceae	6.09±0.05	29.33±2.62	27.9±0	0.42±0	Brown (7.5YR 6/1)
49.	<i>Zanthoxylum armatum</i> DC	Scrub	Rutaceae	6.20±0.16	54.33±1.25	30.9±0	0.87±0	Brown (7.5YR 6/1)

50.	<i>Abrus fruticulosus</i> W.& A.	Shrub	Fabaceae	6.69±0.07	31.33±0.47	20.9±0	1.2±0	Brown (7.5YR 6/1)
51.	<i>Holmskioldia sanguinea</i> Retz	Shrub	Verbenaceae	5.95±0.04	14±0.82	24.33±0	2.1±0	Brown (7.5YR 6/1)
52.	<i>Semecarpus anacardium</i> L. f.	Tree	Anacardiaceae	6.34±0.05	12±0.82	24.3±0	1.71±0	Brown (7.5YR 6/1)
53.	<i>Hyptis suaveolens</i> (L.) Poit.	Herb	Lamiaceae	5.35±0.03	30.3±0	24.2±0	1.95±0	Brown (7.5YR 6/1)
54.	<i>Schima wallichii</i> (DC.) Korth.	Tree	Theaceae	6.22±0.13	17±0.42	24.63±0	2.07±0	Red (2.5YR 4/6)
55.	<i>Leucas cephalotes</i> (Roth) Spreng.	Herb	Lamiaceae	6.93±0.01	11±0.82	25.03±0	0.84±0	Brown (7.5YR 6/1)
56.	<i>Bidens pilosa</i> L.	Herb	Asteraceae	6.15±0.38	58.30±28.07	25.2±0	1.14±0	Dark brown (7.5YR 6/1)
57.	<i>Phyllanthus glaucus</i> Wall. Ex Mull.Arg.	Shrub	Phyllanthaceae	6.55±0.05	10.33±1.25	25.1±0	1.23±0	Reddish (2.5YR 4/6)
58.	<i>Dicliptera paniculata</i> Forssk.	Herb	Acanthaceae	6.75±0.05	18±4.24	25.9±0	1.68±0	Light brown (7.5YR 6/2)
59.	<i>Lepidagathis hyaline</i> Nees	Herb	Acanthaceae	6.71±0.04	14.00±1.41	26.13±0	1.71±0	Brown (7.5YR 6/1)
60.	<i>Achyranthes aspera</i> L.	Herb	Amaranthaceae	6.96±0.05	14.67±0.94	26.73±0	2.19±0	Blackish (10YR 2/1)
61.	<i>Urena picta</i> L.	Herb	Malvaceae	6.05±0.03	23.3±0.47	30.03±0	1.17±0	Dark brown (7.5YR 6/1)
62.	<i>Selaginella exalta</i> (Kunze) Spring.	Herb	Selaginellaceae	6.00±0.06	23.67±0.47	29.8±0	1.26±0	Brown (7.5YR 6/1)
63.	<i>Carissa spinarum</i> L.	Shrub	Apocynaceae	4.94±0.06	17±0.82	29.83±0	1.5±0	Dark brown (7.5YR 6/1)
64.	<i>Pteris umbrosa</i> R.Br.	Herb	Adiantaceae	6.10±0.02	40.5±1.41	30.63±0	1.26±0	Red (2.5YR 4/6)
65.	<i>Crepis japonica</i> (L.) Benth.	Herb	Asteraceae	5.71±0.02	51.67±1.7	30.4±0	1.29±0	Light brown (7.5YR 6/2)
66.	<i>Hypoestes aristata</i> (Vahl) Sol. ex R.Br.	Herb	Labiataea	5.79±0.07	63.67±1.7	30.87±0	1.29±0	Brown (7.5YR 6/1)
67.	<i>Salix psilostigma</i> Andersson	Tree	Salicaceae	5.52±4.71	68±0.82	32.2±0	0.72±0	Reddish (2.5YR 4/6)
68.	<i>Uncaria sessilifructus</i> Wall. Ex Roxb.	Climber	Rubiaceae	5.36±0.04	60±0.82	31.17±0	1.71±0	Reddish (2.5YR 4/6)
69.	<i>Macaranga denticulata</i> Muell Arg.	Tree	Euphorbiaceae	6.77±0.02	92.33±1.7	31.7±0	0.09±0	Brown (7.5YR 6/1)
70.	<i>Phlogacanthus thyrsiflorus</i> (Roxb.) Nees	Shrub	Acanthaceae	5.20±0.02	50.67±1.25	31.1±0	1.2±0	Reddish (2.5YR 4/6)
71.	<i>Ficus elastica</i> Roxb. ex Hornem	Tree	Moraceae	5.57±0.02	66.33±0.94	33.23±0	2.46±0	Brown (7.5YR 6/1)
72.	<i>Salix daphnoides</i> Vill.	Tree	Salicaceae	5.06±0.01	51.67±0.47	33.07±0	1.5±0	Dark brown (7.5YR 6/1)
73.	<i>Elaeocarpus floribundus</i> Bl.	Shrub	Elaeocarpaceae	5.38±0.02	55.33±0.47	33.3±0	2.22±0	Brown (7.5YR 6/1)
74.	<i>Alangium platanifolium</i> L.	Scrub	Alangiaceae	5.67±0.01	57.67±0.47	32.2±0	1.86±0	Brown (7.5YR 6/1)

75.	<i>Toona ciliata</i> Roem.	Tree	Meliaceae	5.60±0.01	56±0	32.67±0	2.52±0	Black (10YR 2/1)
76.	<i>Litsea glutinosa</i> C.B. Roxb.	Scrub	Lauraceae	5.64±0.02	51±0.82	32.67±0	1.68±0	Black (10YR 2/1)
77.	<i>Paspalidium flavidum</i> Stapf.	Herb	Poaceae	5.55±0.01	61.33±0.47	32.3±0	2.88±0	Black (10YR 2/1)
78.	<i>Dendrocalamus hamiltonii</i> Nees & Arn. ex Murno		Poaceae	5.30±0.01	59±0.82	32.07±0	2.16±0	Black (10YR 2/1)
79.	<i>Cinnamomum tamala</i> (Buch.- Ham.) Nees & Nees	Tree	Lauraceae	5.78±0.02	68.30±0.47	31.93±0	2.4±0	Black (10YR 2/1)
80.	<i>Ehretia laevis</i> Roxb.	Shrub	Boraginaceae	5.96±0.03	72.67±0.47	31.93±0	2.7±0	Brown (7.5YR 6/1)
81.	<i>Cyperus involuculatus</i> L.	Herb	Cyperaceae	5.53±0.03	42.33±0.94	25.5±0	2.58±0	Brown (7.5YR 6/1)
82.	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	Tree	Combretaceae	4.89±8.16	28.33±0.47	25.7±0	1.38±0	Brown (7.5YR 6/1)
83.	<i>Terminalia arjuna</i> (Roxb.) Wight & Arn.	Tree	Combretaceae	5.12±0.01	20.3±1.41	25.9±0	1.98±0	Brown (7.5YR 6/1)
84.	<i>Smilax aspera</i> L.	Climber	Smilacaceae	5.0±8.16	18.33±1.25	26±0	1.65±0	Brown (7.5YR 6/1)
85.	<i>Michelia champaca</i> L.	Tree	Magnoliaceae	5.37±0.44	46.33±0.47	25.5±0	1.65±0	Brown (7.5YR 6/1)
86.	<i>Tectona grandis</i> L.	Tree	Verbenaceae	4.98±0.01	31.33±0.47	28±0	1.92±0	Reddish (2.5YR 4/6)
87.	<i>Chlorophytum comosum</i> Thunb.	Herb	Liliaceae	5.29±0.29	67.67±2.62	25±0	2.61±0	Brown (7.5YR 6/1)
88.	<i>Amorphophallus</i> sp.	Herb	Araceae	5.29±0.28	35.67±1.7	25±0	2.28±0	Brown (7.5YR 6/1)
89.	<i>Impatiens balsamina</i> L.	Herb	Balsaminaceae	4.89±0.08	62.67±2.05	26.3±0	2.04±0	Brown (7.5YR 6/1)
90.	<i>Boechmeria platyphylla</i> Buch.-Ham. ex D.Don	Herb	Urticaceae	5.04±0.02	33.67±2.87	25±0	1.8±0	Brown (7.5YR 6/1)
91.	<i>Peperomia pellucida</i> (L.) Kunth	Herb	Piperaceae	6.56±0.02	65±1.63	25.7±0	2.58±0	Brown (7.5YR 6/1)
92.	<i>Centella asiatica</i> (L.) Urban	Herb	Apiaceae	8.31±0.08	79±0.82	36.9±0	0.84±0	Light brown (7.5YR 6/2)
93.	<i>Abroma augusta</i> (L.) L. f.	Shrub	Sterculiaceae	8.41±0.02	40±1.63	36.03±0	0.90±0	Black (10YR 2/1)
94.	<i>Houttuynia cordata</i> Thunb.	Herb	Saururaceae	8.89±1.41	172.1±0.51	20.5±0	0.42±0	Brown (7.5YR 6/1)
95.	<i>Bauhinia purpurea</i> L.	Shrub	Caesalpineaceae	5.45±8.16	185.6±0.85	27.8±0	2.34±0	Red (2.5YR 4/6)
96.	<i>Ficus palmata</i> L.	Tree	Moraceae	5.40±9.43	54.3±0.4	28.0±0	2.25±0	Red (2.5YR 4/6)
97.	<i>Phyllanthus fatraenus</i> L.	Herb	Phyllanthaceae	5.31±4.71	174.2±1.41	27.7±0	2.1±0	Black (10YR 2/1)
98.	<i>Clerodendrum serratum</i> L.	Shrub	Verbenaceae	5.90±4.71	39.7±2.04	27.8±0	2.19±0	Blackish (10YR 2/1)
99.	<i>Cassia obtusifolia</i> (L.) Irwin & Barneby	Shrub	Caesalpinaceae	5.47±4.71	40.9±0.94	28.2±0	1.71±0	Blackish (10YR 2/1)
100.	<i>Roylea cineria</i> (D. Don) Baillon		Labiatae	5.12±0	40.2±0.82	28.2±0	2.79±0	Light red (2.5YR 4/6)

101.	<i>Grewia abutifolia</i> L.		Tiliaceae	5.28±0.02	172.1±2.45	29.3±0	2.58±0	Black (10YR 2/1)
102.	<i>Cassia occidentalis</i> L.	Shrub	Caesalpiniaceae	6.36±0.02	118.9±5.71	29.2±0	1.62±0	Dark brown (7.5YR 6/1)
103.	<i>Selaginella velutina</i> Ces.	Herb	Selaginellaceae	5.19±0.01	34.4±2.08	29.5±0	1.02±0	Light brown (7.5YR 6/2)
104.	<i>Trevesia palmata</i> Roxb.	Tree	Araliaceae	5.43±0.02	199.7±4.10	27.8±0	1.68±0	Black (10YR 2/1)
105.	<i>Phoebe attenuata</i> Nees	Tree	Lauraceae	5.08±0.02	105.5±3.16	28.1±0	0.84±0	Brown (7.5YR 6/1)
106.	<i>Celtis orientalis</i> L.	Tree	Ulmaceae	5.51±0.01	70.8±0.42	29.2±0	1.08±0	Light brown (7.5YR 6/2)
107.	<i>Caryota urens</i> L.	Tree	Arecaceae	5.47±0.01	64.3±1.9	28.4±0	1.98±0	Brown (7.5YR 6/1)
108.	<i>Smilax zeylanica</i> L.	Climber	Smilacaceae	5.78±9.43	70.1±1.41	28.6±0	2.46±0	Brown (7.5YR 6/1)
109.	<i>Dicliptera cuneata</i> Juss.	Herb	Acanthaceae	6.13±8.16	79.2±3.45	26.5±0	0.30±0	Brown (7.5YR 6/1)
110.	<i>Celastrus paniculatus</i> Willd.	Climber	Celastraceae	5.72±0.02	60.9±1.31	27.9±0	1.74±0	Brown (7.5YR 6/1)
111.	<i>Albizia chinensis</i> (Osb) Merr.	Tree	Leguminosae	5.95±0.01	60.1±1.04	28.1±0	2.22±0	Brown (7.5YR 6/1)
112.	<i>Rubia cordifolia</i> L.	Climber	Rubiaceae	6.07±0.02	135.4±0.75	27.6±0	1.98±0	Brown (7.5YR 6/1)
113.	<i>Commelina erecta</i> L.	Herb	Commelinaceae	5.68±8.16	77.1±1.41	27.8±0	2.88±0	Black (10YR 2/1)
114.	<i>Michelia champaca</i> L.	Tree	Magnoliaceae	6.47±0.01	86.4±0	27.6±0	2.22±0	Black (10YR 2/1)
115.	<i>Indigofera hebetata</i> (Benth)	Climber	Fabaceae	5.53±0.03	39.1±0.5	28.1±0	2.28±0	Brown (7.5YR 6/1)
116.	<i>Rubus indicus</i> Thunb.	Shrub	Rosaceae	4.89±8.16	58.4±0.49	27.1±0	0.3±0	Red (2.5YR 4/6)
117.	<i>Crassocephalum crepidioides</i> (Benth.) S. Moore	Herb	Asteraceae	6.24±0.02	59.20±0	27.5±0	1.38±0	Red (2.5YR 4/6)

**Table 2.** Different types of root colonization in roots of forest plant species of NRF, Nongpoh, Meghalaya.(Abbreviations: % **AM RC**: % AM root colonization; **CI**: Colonization Intensity; **AI**: % Arbuscular infection; **VI**: % Vesicular infection)

S. No.	Botanical Names	% AM RC	% CI	AM Spore (50 g soil)	Presence of			% Hypal infection	% AI	% VI
					Hyp.	Arb.	Ves.			
1.	<i>Castanopsis indica</i> (Roxb.) DC.	60±0.94	48±0.45	255 ±4.08	+	-	+	45±1.41	0	35±0.72
2.	<i>Sterculia villosa</i> Roxb.	64.28±1.24	45.45±0.07	673±4.89	+	+	+	57.14±1.19	7.14±0.27	28.6±0.72
3.	<i>Melastoma malabathricum</i> L.	100±0.27	68.75±0.53	605 ±8.16	+	+	-	100±0.27	10±0.27	0
4.	<i>Curcuma pseudomontana</i> Graham	50±0.98	50±0.31	155 ±22.04	+	-	+	28.6±0.72	0	42.9±0.82
5.	<i>Aquilaria agallocha</i> Roxb.	25±0.27	40±0.34	194 ±2.45	+	+	-	20±0	5±0.27	0
6.	<i>Artocarpus chaplasha</i> Roxb.	75±0.47	51.6±0.2	476 ±21.23	+	+	+	70±0.27	30±0.47	5±0.27
7.	<i>Mussaenda frondosa</i> Sensus G. Forst., non L.	85±1.09	57.35±0.96	651 ±20.55	+	+	+	55±0.82	25±0.54	60±0.72
8.	<i>Garcinia cova</i> L.	90±0.47	91.67±0.24	378 ±12.25	+	+	+	85±0.27	35±0.72	20±0.72
9.	<i>Shorea robusta</i> C.F. Gaertn.	70±0.72	71.23±0.54	130 ±4.08	+	-	-	70±0.72	0	0
10.	<i>Smilax hispida</i> Muhl.	30±0.54	29±0.65	560 ±4.08	+	-	-	30±0.54	0	0
11.	<i>Emblica officinalis</i> Gaertn.	25±0.27	25±0.14	372 ±1.63	+	+	-	25±0.27	5±0.27	0
12.	<i>Lagerstroemia parviflora</i> Roxb.	20±0.27	31.8±0.18	630 ±26.13	+	+	-	50±0.27	10±0.27	0
13.	<i>Solanum khasianum</i> C.B. Clarke	70±1.19	46.43±0.56	903 ±1.63	+	+	-	60±0	40±0.27	0
14.	<i>Sida cordifolia</i> L.	20±0.27	31.25±0.18	566 ±10.61	+	-	-	20±0.27	0	0
15.	<i>Solanum toroum</i> Sw.	100±0.27	68.75±0.53	743 ±7.34	+	-	-	100±0.27	0	0
16.	<i>Asplenium nidus</i> L.	100±0.27	80±0.36	191 ±4.08	+	+	+	100±0.27	70±0.98	30±0.47
17.	<i>Mesua ferrea</i> L.	20±0.27	30±0.34	301 ±5.71	+	-	-	20±0.27	0	0
18.	<i>Spilanthes paniculata</i> L.	80±0.27	66.7±0.54	542 ±5.71	+	+	-	45±0	45±0.47	0

19.	<i>Eryngium foetidum</i> L.	80±0.27	43.75±0.18	476 ±4.08	+	-	-	70±0.27	0	0
20.	<i>Polystichium braunii</i> Spenner	80±0.27	66.7±0.54	236 ±3.56	+	-	+	80±0.27	0	30±0
21.	<i>Polypodium vulgare</i> L.	100±0.27	80±0.36	439 ±5.71	+	+	+	100±0.27	70±0.72	15±0.82
22.	<i>Pteridium aquilinum</i> (L.) Kuhn.	60±0.47	62.5±0.66	366 ±10.61	+	+	+	60±0.47	10±0.27	5±0.27
23.	<i>Alpinia allughas</i> (Retz.) Rose	100±0.27	68.75±0.53	175 ±7.35	+	+	-	100±0.27	20±0.54	0
24.	<i>Callicarpa arborea</i> Roxb.	100±0.27	70±0.61	471 ±11.89	+	+	-	100±0.27	90±0.47	0
25.	<i>Thysanoleana maxima</i> (Roxb.) O. Ktze	100±0.27	72.5±0.6	464 ±3.26	+	+	+	100±0.27	50±1.09	10±0.27
26.	<i>Manihot esculanta</i> Herm.	90±0.54	35.52±0.36	504 ±2.45	+	+	+	90±0.47	10±0.54	5±0.27
27.	<i>Ficus glomerata</i> L.	100±0.27	70±0.61	582 ±4.89	+	+	+	100±0.27	30±0.82	20±0.72
28.	<i>Pueraria tuberosa</i> (Roxb. ex Willd.) DC.	85±0.27	35.29±0.24	530 ±4.08	+	+	+	80±0.27	40±0.72	10±0.54
29.	<i>Pteris cretica</i> L.	40±0.72	25±0.18	497 ±1.63	+	-	-	40±0.72	0	0
30.	<i>Cocculus hirsutus</i> L.	95±0.54	65.79±1.24	297 ±4.9	+	+	+	95±0.54	55±1.09	10±0.54
31.	<i>Nephrodium hirsutum</i> C.Presl.	85±0.27	41.18±0.38	406 ±6.53	+	+	-	85±0.27	35±0.54	0
32.	<i>Adiantum tenerum</i> Sw.	90±0.47	63.89±0.99	276 ±8.18	+	+	+	90±0.47	55±0.98	30±1.25
33.	<i>Bridelia retusa</i> Spreng.	20±0.27	25±0.07	121 ±0.82	+	-	-	15±0.47	0	0
34.	<i>Mimosa himalayensis</i> Gamble	85±0.27	52.63±0.53	112 ±2.05	+	+	+	90±0.27	45±0.47	10±0.27
35.	<i>Crotolaria alata</i> Buch.-Ham. ex D.Don	50±0.27	45±0.42	200 ±14.29	+	-	-	50±0.54	0	0
36.	<i>Castonopsis concinna</i> (Champ.ex Benth.) A.DC.	95±0.54	78.95±0.62	59 ±1.25	+	+	+	95±0.54	30±1.25	25±0.27
37.	<i>Boechmeria macrophylla</i> Hornem	100±0.27	40.62±0.38	181±4.9	+	+	+	93.75±0.27	25±0.72	25±0.72
38.	<i>Uncaria rhynchophylla</i> Schreb.	60±0.94	58.33±0.53	277 ±1.63	+	+	+	50±0.98	10±0.27	10±0.27
39.	<i>Festuca pratensis</i> Huds.	95±0.54	55.26±0.12	394 ±3.26	+	+	+	95±0.54	30±0.54	45±0.47
40.	<i>Leea indica</i> (Burm.) Merr.	95±0.27	52.63±0.36	444 ±3.26	+	+	+	95±0.27	35±0.72	5±0.27
41.	<i>Duabanga grandiflora</i> Roxb. ex DC.	80±1.36	65.62±1.16	226 ±4.08	+	+	+	80±1.36	35±1.19	25±0.27

42.	<i>Boechmeria nivea</i> Hk. et Arn.	90±0.27	60.53±0.38	130 ±4.08	+	+	+	90±0	45±0.47	10±0.27
43.	<i>Begonia crenata</i> L.	80±0.27	75±0.36	322 ±4.89	+	+	-	80±0.27	10±0.27	0
44.	<i>Dioscorea bulbefera</i> L.	100±0.27	85±0.54	143 ±2.45	+	+	+	100±0.27	80±0.54	25±0.54
45.	<i>Costos speciosa</i> (Koenig) Smith	50±0.27	30±0.12	257 ±6.53	+	+	-	50±0.27	30±0	0
46.	<i>Crotolaria juncia</i> L.	95±0.27	94.74±0.24	254 ±3.26	+	+	+	95±0.27	75±0.47	30±0.47
47.	<i>Elephantopus scaber</i> L.	85.75±0.82	58.3±0.76	127±3.26	+	+	+	85.75±0.82	42.85±0.94	7.14±0.27
48.	<i>Richardia scabra</i> L.	75±0	50±0.24	228 ±4.08	+	+	+	60±0.47	25±0.27	5±0.27
49.	<i>Zanthoxylum armatum</i> DC	20±0.54	25±0.14	49 ±2.45	+	-	-	20±0.54	0	0
50.	<i>Abrus fruticulosus</i> W.& A.	84.21±0.27	56.25±0.2	230 ±4.9	+	+	+	68.42±0.54	31.58±0.47	15.79±0.47
51.	<i>Holmskioldia sanguinea</i> Retz	95±0.54	65.79±0.58	56 ±4.9	+	+	+	95±0.54	25±0.72	50±0.27
52.	<i>Semecarpus anacardium</i> L. f.	55±0.72	71.23±0.54	347 ±4.89	+	+	+	50±1.19	40±0.72	20±0.54
53.	<i>Hyptis suaveolens</i> (L.) Poit.	100±0.27	80±0.36	184 ±3.26	+	+	+	100±0.27	90±0.47	40±0.27
54.	<i>Schima wallichii</i> (DC.) Korth.	90±0	91.67±0.24	448 ±7.34	+	+	+	90±0	75±0.47	40±0.72
55.	<i>Leucas cephalotes</i> (Roth) Spreng.	100±0.27	72.5±0.6	106 ±4.08	+	+	+	95±0.54	80±0.54	10±0.27
56.	<i>Bidens pilosa</i> L.	100±0.27	65±0.59	168 ±3.26	+	+	+	100±0.27	50±1.36	5±0.27
57.	<i>Phyllanthus glaucus</i> Wall. Ex Mull.Arg.	100±0.27	68.75±0.53	237 ±4.89	+	+	+	100±0.27	75±0.94	10±0.27
58.	<i>Dicliptera paniculata</i> Forssk.	100±0.27	80±0.59	202 ±5.71	+	+	-	100±0.27	85±0.72	0
59.	<i>Lepidagathis hyaline</i> Nees	85±0.27	73.53±0.92	112 ±2.45	+	+	-	85±0.27	55±0.27	0
60.	<i>Achyranthes aspera</i> L.	25±0.27	40±0.18	286 ±3.26	+	-	-	25±0.27	0	0
61.	<i>Urena picta</i> L.	88.88±0.54	59.375±0.34	170 ±4.89	+	+	+	44.44±0.72	55.55±0.27	44.44±0.98
62.	<i>Selaginella exalta</i> (Kunze) Spring.	20±0.54	31.25±0.18	130 ±2.45	+	-	-	15±0.47	0	0
63.	<i>Carissa spinarum</i> L.	70±0.54	46.43±0.56	112 ±4.08	+	+	-	45±0.82	5±0.27	0
64.	<i>Pteris umbrosa</i> R.Br.	60±0.47	62.5±0.66	120 ±2.45	+	+	-	45±0.47	20±0.72	0

65.	<i>Crepis japonica</i> (L.) Benth.	95±0.54	84.21±0.68	122 ±2.05	+	+	+	85±0.72	40±0.27	20±0.72
66.	<i>Hypoestes aristata</i> (Vahl) Sol. ex R.Br.	85±0.72	67.65±0.92	61 ±3.26	+	+	+	75±0.94	30±1.25	5±0.27
67.	<i>Salix psilostigma</i> Andersson	100±0.27	70±0.6	72 ±2.45	+	+	+	90±0.47	25±0.72	30±0.82
68.	<i>Uncaria sessilifructus</i> Wall. Ex Roxb.	80±0.72	59.36±0.41	159 ±2.45	+	+	-	65±0.54	15±0	0
69.	<i>Macaranga denticulata</i> Muell.Arg.	85±0.27	61.76±0.47	108 ±3.26	+	+	+	85±0.27	10±0.27	35±0.27
70.	<i>Phlogacanthus thyrsoiflorus</i> (Roxb.) Nees	25±0.54	25±0.14	63 ±1.63	+	-	-	25±0.54	0	0
71.	<i>Ficus elastica</i> Roxb. ex Hornem	25±0.54	40±0.34	123 ±4.08	+	-	-	25±0.54	0	0
72.	<i>Salix daphnoides</i> Vill.	15±0.47	25±0.12	45 ±1.63	+	-	-	15±0.47	0	0
73.	<i>Elaeocarpus floribundus</i> Bl.	70±0.54	60.71±0.65	45 ±3.26	+	+	+	60±0.94	20±0.72	5±0.27
74.	<i>Alangium platanifolium</i> L.	40±0.72	31.25±0.25	66 ±0.82	+	+	-	15±0.47	10±0.27	0
75.	<i>Toona ciliata</i> Roem.	21.42±0.47	25±0.12	49 ±0.82	+	-	-	21.42±0.47	0	0
76.	<i>Litsea glutinosa</i> C.B. Roxb.	33.33±0.27	30±0.12	345 ±3.26	+	-	+	20±0.47	0	20±0.47
77.	<i>Paspalidium flavidum</i> Stapf.	95±0.54	65.79±0.85	417 ±2.45	+	+	+	95±0.54	50±0.27	30±0.47
78.	<i>Dendrocalamus hamiltonii</i> Nees & Arn. ex Murno	73.33±0.27	40.91±0.12	499 ±4.9	+	-	-	53.33±0.27	0	0
79.	<i>Cinnamomum tamala</i> (Buch.-Ham.) Nees & Nees	20±0.27	25±0.07	229 ±3.26	+	-	-	10±0.27	0	0
80.	<i>Ehretia laevis</i> Roxb.	70±0.98	57.14±0.98	211 ±4.9	+	+	+	70±0.98	5±0.27	5±0.27
81.	<i>Cyperus involuculatus</i> L.	70±0.27	67.86±0.54	202 ±4.08	+	+	-	70±0.27	25±0.27	0
82.	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	75±0.82	47.91±0.45	247 ±4.9	+	+	-	56.25±0.82	31.25±0.27	0
83.	<i>Terminalia arjuna</i> (Roxb.) Wight & Arn.	80±0.27	50±0.18	113 ±5.71	+	+	-	70±0.27	10±0.27	0
84.	<i>Smilax aspera</i> L.	85±0.72	79.41±0.51	101 ±1.63	+	+	+	85±0.72	55±0.27	5±0.27
85.	<i>Michelia champaca</i> L.	64.7±0.54	45.45±0.07	107 ±4.08	+	-	-	52.94±0.47	0	5.89±0
86.	<i>Tectona grandis</i> L.	92.85±0.27	46.15±0.24	132 ±2.6	+	-	-	85.71±0	0	0
87.	<i>Chlorophytum comosum</i> Thunb.	87.5±0.27	35.71±0.14	105 ±3.26	+	-	-	81.25±0.27	0	0

88.	<i>Amorphophallus</i> species Blume ex Decne.	35±0.54	25±0.14	88 ±2.86	+	-	-	35±0.54	0	0
89.	<i>Impatiens balsamina</i> L.	65±0.98	50±0.82	75 ±3.26	+	-	-	60±1.25	0	0
90.	<i>Boechmeria platyphylla</i> Buch.-Ham. ex D.Don	33.33±0.27	30±0.12	82 ±4.08	+	-	-	25±0.27	0	0
91.	<i>Peperomia pellucida</i> (L.) Kunth	85±0.52	82±0.2	43 ±1.63	+	+	+	95±0.35	60±0.72	30±0.65
92.	<i>Centella asiatica</i> (L.) Urban	80±0.72	85±0.36	26 ± 4.08	+	+	+	90±0.27	70±0.27	20±0.27
93.	<i>Abroma augusta</i> (L.) L. f.	100±0.27	68.75±0.53	163 ±2.45	+	+	+	100±0.27	35±0.47	10±0.54
94.	<i>Houttuynia cordata</i> Thunb.	100±0.27	80±0.41	37 ±4.9	+	+	+	100±0.27	70±0.54	15±0
95.	<i>Bauhinia purpurea</i> L.	66.66±0.27	56.25±0.62	35 ±1.63	+	+	-	50±0.47	25±0.27	0
96.	<i>Ficus palmata</i> L.	66.66±0.27	37.5±0.31	53 ±2.86	+	+	-	66.66±0.27	13.33±0.54	0
97.	<i>Phyllanthus fatraenus</i> L.	62.5±0.98	40±0.45	41 ±3.26	+	+	-	50±1.09	6.25±0.27	0
98.	<i>Clerodendrum serratum</i> L.	40±0.98	25±0.25	228 ±5.71	+	-	-	35±0.72	0	0
99.	<i>Cassia obtusifolia</i> (L.) Irwin & Barneby	60±0	33.33±0.14	104 ±4.08	+	-	-	40±0.54	0	0
100.	<i>Roylea cineria</i> (D. Don) Baillon	95±0.27	55.26±0.47	149 ±6.53	+	-	-	85±0.27	0	0
101.	<i>Grewia abutifolia</i> L.	100±0.27	71.4±0.67	142 ±4.08	+	-	-	100±0.27	0	0
102.	<i>Cassia occidentalis</i> L.	60±0.47	41.66±0.54	49 ±1.63	+	+	+	50±0.72	5±0.27	5±0.27
103.	<i>Selaginella velutina</i> Ces.	75±0.47	66.67±0.54	21 ±4.08	+	+	-	55±0.54	25±0.27	0
104.	<i>Trevesia palmata</i> Roxb.	18.75±0.47	33.33±0.18	36 ±4.49	+	-	-	18.75±0.47	0	0
105.	<i>Phoebe attenuata</i> Nees	60±0.47	50±0.42	24±4.08	+	+	-	40±0.47	6.66±0.27	0
106.	<i>Celtis orientalis</i> L.	60±0.47	38.8±0.29	09±0.81	+	+	-	46.66±0.72	20±0.47	0
107.	<i>Caryota urens</i> L.	80±0.54	51.56±0.2	07±1.63	+	+	+	45±0.47	50±0.27	5±0.27
108.	<i>Smilax zeylanica</i> L.	87.5±0.72	53.6±0.66	20±4.89	+	+	+	87.5±0.72	37.5±0.47	6.25±0.27
109.	<i>Dicliptera cuneata</i> Juss.	90±0.47	55.55±0.68	41±2.45	+	+	+	65±0.98	5±0.27	5±0.27
110.	<i>Celastrus paniculatus</i> Willd.	65±0.54	69.23±0.54	18±3.26	+	+	-	65±0.54	20±0.27	0

111.	<i>Albizia chinensis</i> (Osb) Merr.	55±0.54	31.8±0.18	19±3.26	+	+	-	55±0.54	5±0.27	0
112.	<i>Rubia cordifolia</i> L.	100±0.27	73.75±0.29	35±2.44	+	-	-	95±0.54	0	0
113.	<i>Commelina erecta</i> L.	50±0.47	50±0.31	41±1.63	+	-	-	33.3±0.72	0	0
114.	<i>Michelia champaca</i> L.	90±0.47	72.2±0.36	30±2.44	+	-	-	50±0.72	0	0
115.	<i>Indigofera hebeptala</i> (Benth)	85±0.72	57.35±0.96	09±2.44	+	+	+	85±0.72	20±0.72	10±0.27
116.	<i>Rubus indicus</i> Thunb.	77.77±0.27	41.07±0.56	179 ±2.45	+	+	-	61.11±0.27	5.55±0.27	0
117.	<i>Crassocephalum crepidioides</i> (Benth.) S. Moore	70±1.09	55.35±1.07	174 ±4.08	+	+	+	55±1.44	5±0.27	10±0.27

**Table 3.** Density, Frequency (%) and Abundance of AM fungi of NRF (compartments wise)

Sl. No	AM Species	D	F (%)	A	Sl. No	AM Species	D	F (%)	A
1.	<i>Acaulospra laevis</i> Gerd. &Trappe	7.36	90.91	8.10	35.	<i>Gl. diaphanum</i> Morton &Walker	0.18	18.18	1.00
2.	<i>A. foveata</i> Trappe &Janos	1.82	54.55	3.33	36.	<i>Gl. dussi</i> Pat.	0.18	9.09	2.00
3.	<i>A. lacunosa</i> Morton	5.00	81.82	6.11	37.	<i>Gl. epigaeum</i> Daniels &Trappe	0.36	27.27	1.33
4.	<i>A. scrobiculata</i> Trappe	1.73	54.55	3.17	38.	<i>Gl. etunicatum</i> Beck. &Gerd.	0.55	36.36	1.50
5.	<i>A. denticulate</i> Siever. & Toro	0.91	54.55	1.67	39.	<i>Gl. fasciculatum</i> Walker &Koske	0.09	9.09	1.00
6.	<i>A. bireticulata</i> Rothwell &Trappe	3.45	63.64	5.43	40.	<i>Gl. flavisporum</i> Trappe & Gerd.	0.55	36.36	1.50
7.	<i>A. capsicula</i> Blaszk.	0.09	9.09	1.00	41.	<i>Gl. formosanum</i> Wu &Chen	0.55	36.36	1.50
8.	<i>A. rehmii</i> Siever. & Toro	1.55	45.45	3.40	42.	<i>Gl. fuegianum</i> Trappe & Gerd.	0.18	18.18	1.00
9.	<i>A. gerdemannii</i> Blaszk.	0.36	27.27	1.33	43.	<i>Gl. geosporum</i> Walker	3.91	81.82	4.78
10.	<i>A. elegans</i> Trappe and Gerd.	0.18	18.18	1.00	44.	<i>Gl. glomerulatum</i> Sieverd.	0.73	27.27	2.67
11.	<i>A. mellea</i> Spain & Sch.	1.64	54.55	3.00	45.	<i>Gl. halonatum</i> Rose &Trappe	1.45	63.64	2.29
12.	<i>A. trappei</i> Ames &Lind.	0.09	9.09	1.00	46.	<i>Gl. invermaium</i> Hall	0.73	45.45	1.60
13.	<i>A. sp. (1)</i>	1.64	45.45	3.60	47.	<i>Gl. lacteum</i> Rose &Trappe	0.09	9.09	1.00
14.	<i>A. sp. (2)</i>	1.09	45.45	2.40	48.	<i>Gl. macrocarpum</i> Tula. &Tula.	6.00	81.82	7.33
15.	<i>Gigaspora gigantea</i> Gerd. & Trappe	0.27	18.18	1.50	49.	<i>Gl. maculosum</i> Mill. &Walker	2.00	63.64	3.14
16.	<i>Gi. rosea</i> Nicol. & Sch.	0.09	9.09	1.00	50.	<i>Gl. magnecaule</i> Hall	0.09	9.09	1.00
17.	<i>Gi. nigra</i> Walker& Sand.	0.09	9.09	1.00	51.	<i>Gl. merredum</i> Porter & Hall	0.55	36.36	1.50

18.	<i>Gi. margarita</i> Nicol. & Sch.	0.09	9.09	1.00	52	<i>Gl. microcarpum</i> Tula. &Tula.	1.73	63.64	2.71
19.	<i>Gi. gregaria</i> Walker& Sand.	0.09	9.09	1.00	53.	<i>Gl. monosporum</i> Gerd. & Trappe	0.18	18.18	1.00
20.	<i>Entrophospora</i> sp.	1.27	54.55	2.33	54.	<i>Gl. mosseae</i> Gerd. &Trappe	6.00	81.82	7.33
21.	<i>Scutellospora</i> sp.	0.18	18.18	1.00	55.	<i>Gl. multicaule</i> Gerd. & Bakshi	0.73	45.45	1.60
22.	<i>Sclerocystis</i> sp.	0.18	9.09	2.00	56.	<i>Gl. multisubstensum</i> Mukerji &Bhat.	0.09	9.09	1.00
23.	<i>Glomus albidum</i> Walker & Rhods	0.73	45.45	1.60	57.	<i>Gl. pallidum</i> Hall	1.45	72.73	2.00
24.	<i>Gl. badium</i> Redec. & Sieverd.	0.45	45.45	1.00	58.	<i>Gl. pansihalos</i> Berch &Koske	1.36	45.45	3.00
25.	<i>Gl. caesaris</i> Sieverd. & Oehl	0.09	9.09	1.00	59	<i>Gl. pulvinatum</i> Trappe & Gerd.	0.45	27.27	1.67
26.	<i>Gl. caledonium</i> Trappe &Gerd.	2.45	72.73	3.38	60	<i>Gl. reticulatum</i> Bhat. & Mukerji	1.18	63.64	1.86
27.	<i>Gl. callosum</i> Sieverd.	0.09	9.09	1.00	61.	<i>Gl. tortuosum</i> Sch. & Smith	0.36	27.27	1.33
28.	<i>Gl. clarum</i> Nicol. & Sch.	0.91	72.73	1.25	62.	<i>Gl. tubiforme</i> Tandy	0.27	18.18	1.50
29.	<i>Gl. clavisporum</i> Alm. &Sch.	5.64	72.73	7.75	63.	<i>Gl. velum</i> Blaszk.	0.09	9.09	1.00
30.	<i>Gl. claroideum</i> Sch. &Smith	0.18	9.09	2.00	64.	<i>Gl. verruculosum</i> Blaszk.	0.09	9.09	1.00
31.	<i>Gl. constrictum</i> Trappe	1.00	45.45	2.20	65.	<i>Gl. sp. (1)</i>	2.91	63.64	4.57
32.	<i>Gl. coronatum</i> Giov.	0.36	27.27	1.33	66.	<i>Gl. sp. (2)</i>	2.00	63.64	3.14
33.	<i>Gl. corymbiforme</i> Blaszk.	0.09	9.09	1.00	67.	<i>Gl. sp. (3)</i>	1.73	63.64	2.71
34.	<i>Gl. deserticola</i> Trappe	1.64	81.82	2.00					

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