ABUNDANCE OF SOIL FUNGAL DIVERSITY AND SEASONAL VARIATION IN MATTAVARA FOREST OF CHIKKAMAGALURU, KARNATAKA.

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Abstract

In the present study thirty six soil samples were collected from scrub jungle with moist and dry deciduous forest of Mattavara Chikkamagaluru Karnataka to explore the diversity of soil fungi during winter, summer and rainy season. Soil samples were collected out at the depth of 15 – 30 cm and fungi were enumerated by serial dilution method on PDA medium.. During the study period maximum number of fungal Species obtained in winter season 41 species belonging to 24 genera followed by summer season with 39 species belonging to 16 genera and in Rainy season 33 species belonging to 18 genera were recorded. Fungal class Deuteromycetes was recorded with highest percentage in all the three seasons followed by Zygomycetes , Ascomycetes , Oomycetes, Chytridomycetes and three types non sporulating fungi. The diversity indices of soil fungi over three seasons were recorded in winter Shannon index is 3.141, in summer 3.114 and 2.584 in rainy season. During rainy season Simpson's index is 0.1242 followed by winter 0.07026 and 0.06001 in summer season. Recorded Dominance index for the summer season is 0.94 followed by winter 0.9297 and 0.8758 in rainy season. Evenness values lies around 0.40 to 0.57. Fisher Alpha index during summer is 7.568 rainy followed by winter 4.919 and rainy 3.759 season. No single factor can be spotted as an important microbial determinant and all the environmental factors of the forest ecosystem are responsible for the variation in the distribution of soil fungi in different seasons.

Key words: Forest soil, Fungi, Mattavara, Abundance, Variation.

Introduction

Fungi are the most important diverse group of eukaryotic organisms which plays a valuable basic role in the forest soil to enrich the above ground biomass production by interacting with the climatic factors to maintain the equilibrium in the ecosystem to give mechanical and nutritional support to the higher plants. Diversity of soil fungi is not evenly distributed, it varies across the globe and also within the region. Seasonal variation affects the distribution of fungi of particular area (Aarati *et al.,* 2013). The variety and galaxy of soil fungi and their natural beauty occupy prime place in the biological world. Therefore they are given a prime importance. India has been cradle for such fungi (Crous *et al*., 2006). The existence of these fungal forms has been recognized almost since the beginning of man's recorded experiences and impression of nature (Ainsworth and Bisby, 1996). There is over 1.5 million fungal species distributed widely throughout the globe (Hawks worth, 2004).The tropical forests are the dwelling place of greatest microbial activity on the earth and numerous new fungal species were reported by mycologist. This may be due to the nature of the forest soil. Impacts of environmental change on fungal diversity could influence ecosystem function via decomposition, so it is important to understand the dependence of decay rates on the number, frequency occurrence and function of the fungal species present in the soil (Deacon *et al.,* 2006). So we focused to enumerate diversity of soil fungi in a mixed forest ecosystem to record the seasonal changes in the species composition in Mattavara forest.

Materials and Methods

Study area

Mattavara forest is rich in biodiversity situated between 12^0 54' 42" and 13 53'53" north latitude and between 75 04'46" and 76 21'50" east latitude and located eight km away from Chikkmagaluru . The forest cover is about 224.23 hectare**.** The terrain is flat with scrub jungle and patches of dry and moist deciduous forest.

Climate and rain fall

During summer the temperature remains maximum 31 to 34^0 c and reaches minimum of 18 to 21^0 c, during winter maximum of 21 to 23^0 c and minimum of 14 to 17^0 c. and during rainy season maximum of 25 to 29 ^{0} c and minimum of 18 to 20^0 c. Average rain fall is 600 - 750 mm (mini) and maximum of 1650mm. Wind velocity is 2- 4km/hour, atmosphere pressure is 1489.8 - 1516 milli bars and RH is minimum of 60 -70% and maximum of 90 – 100%.

Collection of soil samples and isolation of fungi

Soil samples were collected randomly during winter, summer and rainy season from Jan to Dec 2015. During each visit in different seasons twelve samples were collected. Altogether 36 samples were collected for fungal isolation. Samples were collected out at the depth of 15 – 30 cm after removing the surface organic matter and then brought to the laboratory for the isolation of fungi and for physicochemical analysis.. Isolation of soil fungi were enumerated by serial dilution method (Waksman, 1944). Ten grams of soil samples were serially diluted and one ml of sample was poured on PDA medium for the growth of fungi then incubated in an inverted position for 3-7 days at room temperature 25 ± 2^0 c. Slides of the isolated fungi was prepared in lacto phenol cotton blue method. Cultural characteristics such as color, size, shape etc. of fungal colonies and spores were studied and recorded. These fungal isolates were identified with the help of relevant literature (Barnet., 1972; Gilman., 1957, Nagamani *et.al.* 2006.).

Presentation of Data

The obtained data was presented in terms of Percent contribution and percentage of frequency by using following formula (Subha. *et al*. 2013)

The percent contribution of each isolate calculated by using the following formula.

$$\text{Percent contribution} = \frac{\text{No of colonies of an individual sps in a sample}}{\text{Total number of all colonies of all sps in a sample}} \text{ X } 100$$

The frequency denotes the number of samplings in which a fungus is present as against the total number of samplings.

$$\text{Percentage of frequency} = \frac{\text{No of samples in which a particular fungi recorded}}{\text{Total number of samples recorded.}} \text{ X } 100$$

Statistical analysis

Diversity of soil mycoflora was subjected to diversity indices like α diversity – Fisher's α, Shannon's diversity Index, Simpson's diversity index, Dominance Index and Evenness.

Results and Discussion

Totally 36 samples were collected during winter, summer and rainy season for the isolation of fungi. The abundance of soil fungi showed variation during different season in Mattavara forest soil. During the study period maximum number of fungal colonies obtained in winter (364 colonies) followed by rainy season (297) and (280) summer. During winter season 41 species belonging to 24 genera followed by summer season with 39 species belonging to 16 genera and in Rainy season 33 species belonging to 18 genera were recorded (Table 1) .Fugal class Deuteromycetes [70.73.% (S), 76.92% (R), 72.72% (W)] , was recorded with highest % in all the three seasons followed by Zygomycetes [14.63 %(S), 15.38 (R), 15.15 (W)], Ascomycetes [9.75% (W), 7.89%(S), 3.03% (R)], Oomycetes [-----, 2.56%(S). 3.03% (R))] and Chytridomycetes [2.43% (R), ---, 3.12% (W)], Non sporulating fungi [2.43%(S) , 5.12% (R), 3.03% (W)] were recorded (Fig.1). Isolated fungal population percentage showed variation in the distribution pattern in different seasons. Highest percentage found in winter (30%) followed by summer (22%) and rainy season with (14%). Fungal population of 12% recorded in winter and summer followed by (10%) summer and

rainy season. Only 6% of fungal population recorded in winter and summer and in winter and rainy season (Fig. 2). The physico-chemical analysis of forest soil showed seasonal variation in the study area (Table.2)

Diversity index

Diversity indices investigated with respect to species richness did not differ significantly for H, D, 1-D, S and E (Table.3). Shannon's diversity index (H) were reasonably high indicates communities with more taxa and found to be almost similar but slightly higher in winter and summer than rainy season. Dominance (D) values were also high indicates the domination of the all the taxa in the community are equally present and slightly higher in winter and summer than rainy season with almost similar values. Correspondingly Simpson's index (1-D) probability is slightly lower which showed variation in all three seasons represents the probability of any two individuals drawn at random from an infinitely large community belonging to the same species was less than one. Evenness (E) values lies around 0.456 to 0.583 indicates tilt towards even distribution of the species Fisher alpha (S), obtained value was higher in summer followed by rainy and winter season, The value increases with increasing population size when the size is large but the value is moderate for all three seasons because of medium population size.

In the study area, during rainy season number fungal species is less compared to other two seasons because of the variation in the growth factors like pH, soil moisture, rainfall, temperature etc. Due to heavy rainfall the moisture content is sufficiently high, so the soil become water logged and it reduces aeration and that affects the growth of fungi. The depletion of macro and micro nutrient due to heavy rain leads to decrease in the number of colonies (Saravanakumar and Kaviyarasan, 2010). This deviating pattern of fungal diversity can be compared with the results of dry deciduous forest of Bhadra Wildlife Sanctuary, Lakkavalli (Banakar *et al.*, 2012) that more number of fungal isolates and species in summer followed by winter and rainy season were recorded. The soil fungi were minimum during monsoon and maximum during summer in terms of population mean density were reported in the terrestrial ecosystem of Melathiruppalakkudi, Tiruvarur district in Tamil Nadu (Subha *et al.*, 2013). The maximum counts were recorded in post monsoon and monsoon season due to fluctuation in ecological and biological factors (Arulmozhi *et al*., 2016) and support our results that more number of isolates can obtained in summer and less number in rainy season.

In general the nature of the soil mycoflora with respect to the ecological variation of its number is always not clear. Fungal diversity does not follow the same distribution pattern as that of other macro and meso organisms, but rather it is dependent on vegetation type and forest composition (Shi *et al.*, 2014). Diversity of soil fungi is not evenly distributed; it varies across the globe as well as with regions. Seasonal variations affect the distribution of fungi of particular area number and types of fungal species change with the season, geographical location and presence of local spore sources (Aarati and Singh, 2013). Variation in distribution fungal groups due to the different types of colonies that appeared in the initial stages of decomposition gradually disappeared and were replaced by new colonies in the later stages were efficient degraders of cellulose and lignin (Senthikumar *et al.*, 1993). *Penicillium, Cladosporium* and *Trichoderma* are commonly known as late-stage colonies in decomposing litter (Osono and Takeda, 2007). Earlier reports indicated that these genera appeared abundantly in Indian soils dominating both in the frequency and relative density (Behera *et al.*, 1991; Behera and Mukerji, 1985; Dkhar and Mishra, 1991; Bhagath and Pan, 2010). Domination of these saprobic fungi indicate faster decomposition and recycling of dead organic materials and leaf particles, hence maintain soil nutrient status (Baath, 1981) and this may be the reason for domination of Deuteromycetes in all the seasons.

Changes in precipitation patterns have markedly affected vegetation composition in tropical rainforest (Engelbrecht *et al.*, 2007) will alter nutrient competition between plant species, between plants and soil microbes, with potential consequences for ecosystem nutrient cycling and soil carbon exchange which lead to the seasonal variation in fungal diversity. Fungi can serve as indicators of environmental changes or disturbances resulting from natural or anthropogenic causes, including elevated carbon dioxide levels and global warming (Cabello and Arambarri, 2002; Van Maanen *et al.*, 2000; Gourbiere *et al.*, 2001).

Table 1. Soil fungal Diversity, percent contribution and percentage of frequency isolated during, Winter, Summer and Rainy season during 2015

Name of the fungus	Diversity			Percent occurrence			Percentage of frequency		
	Winter	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy
Oomycetes									
Achlya debaryana Humphrey.	-	-	+			0.81			8.33
Pythium elongatum V.D.Matthews.	-	+	-		4.01			8.33	
Chytridomycetes									
Allomyces anomalus R.Emers.	+	-	+	0.27		0.40	8.33		8.33
Zygomycetes									
Absidia cylindrospora Hagem.	-	+	-		2.67			8.33	
Absidia fusca Linnemann.	-	-	+			8.16			33.33
Absidia repenes Tiegh.	+	-	-	1.62			8.33		
Cunninghamella blakesleeana Lendh.	+	-	+	1.89		2.45	16.66		8.33
Cunninghamella echinulata Thaxt. Ex Blakeslee.	+	-	-	1.08			8.33		
Gongronella butleri (Lendn), Peyronel & DalVesco.	-	+	-		0.89			8.33	
Mortierella sp. Coem.	+	-	-	0.27			8.33		
Mucor hiemalis Wehmer.		+	+		0.89	0.40		8.33	8.33
Mucor varians Pišpek..	+	_	+	2.16		0.81	25		8.33
Name of the fungus	**Diversity**			**Percent occurrence**			**Percentage of frequency**		
	Winter	**Summer**	**Rainy**	**Winter**	**Summer**	**Rainy**	**Winter**	**Summer**	**Rainy**
Rhizopus microspores Schipper & Stapers.	-	+	-		8.92			8.33	
Rhizopus oryzae Went & Prinns, Geeri.	-	+	-		0.44			8.33	
Rhizopus stolonifer Vuillemin.	+	+	+	4.86	7.14	2.45	41.66	33.33	8.33
Ascomycetes									
Chaetomium homopilatum Omviik.	-	-	+			0.81			16.66
Chaetomium spirales Zopf.	+	-	-	0.81			8.33		
Nectria humicola P.Rama Rao.	+	-	-	0.81			8.33		
Setosphaeria rostrata K.J. Leonard.	+	-	-	1.08			8.33		
Soradaria fimicola (Roberge ex Desm) Ces. & De Not.	+	-	-	1.08			8.33		
Deuteromycetes									
Acremonium strictum W.Gams.			+			2.44			8.33
Aspergillus candidus Link.	+	+		1.08	0.89		8.33	16.66	
Aspergillus clavatus Desm.	+	+	+	1.08	1.78	9.79	8.33	16.66	25
Aspergillus deflectus Fennell & Raper.	+	-	-	1.89			8.33		
Aspergillus fischeri Wehmer.	-	+	-		0.89			16.66	
Aspergillus flavipes Thom & Church.		+	+		3.12	0.81		16.66	16.66
Aspergillus flavus Link.	+	+	+	5.67	1.78	0.81	25	16.66	16.66
Aspergillus fumigatus Fresenius.	-	+	+		5.80	0.81		8.33	8.33
Aspergillus kanagawaensis Nehira..	-	-	+			0.40			8.33
Aspergillus nidulans Fennella &Raper.	-	+	-		0.89			8.33	
Aspergillus niger Tiegh.	+	+	+	20	16.51	32.24	100	66.66	66.66
Aspergillus ochraceus Wilh.	-	+	+		0.89	0.41		16.66	8.33
Aspergillus parasiticus Speare..	-	+	-		1.78			16.66	
Aspergillus ruber Thom & Church.	+		-	0.54			8.33		
Aspergillus sulphureus Thom & Church.	-	+	-		0.44			8.33	
Aspergillus sydowii Thom & Church.	-	+	-		5.80			8.33	
Aspergillus terreus Thom.	+	+	+	9.72	4.46	0.81	8.33	8.33	8.33
Aspergillus ustus Thom & Church.	+	+	-	1.35	1.33		8.33	8.33	
Aspergillus versicolor (Vuillemin) Tiraboschi.	+	+	-	6.75	0.44		33.33	8.33	
Aspergilus funiculosus Sm., Trans. Br.	_	+	-		0.89			16.66	
Aureobasidium pullulans de (Bary) G.Amaud.	-	-	+			0.40			8.33
Chaetospheria talbotti Huges & Kendrik.	+	-	-	3.24			16.66		
Cladosporium cladosporioides (Fresen.) G.A. de Vries.	+	+	+	1.89	15.62	6.93	41.66	33.33	25
Cladosporium spherospermum Penz.	+	-	+	1.62			8.33		8.33
Cylindrocladium parvum P.J. Anderson, Boesew..	-	+	-		2.23			8.33	
Cylindrocladium torvum P.J. Anderson Bull.	-	+	-		2.23			8.33	

Fusarium oxysporum Schlecht.	-	-	+			2.04			16.66
Geotrichum candidum Link.	-	+	+		0.44	0.81		8.33	8.33
Graphium penicillioides Corda.	+		-	0.54			8.33		
Humicola fuscoatra Traaen.		+	-		0.44			8.33	
Myrothecium sp.Tode ex Fries.	+		-	0.81			8.33		
Oidiodendron flavum Szilvinyi.	-	+	-		0.89			8.33	
Penicillium adametzii Zaleski.	-	-	+			0.81			8.33
Penicillium chrysogenum Thom.	+	+	-	4.05	1.33		25	8.33	
Penicillium decumbens Thom.	-	+	-		0.44			8.33	
Penicillium sp.Link.	+	+	+	1.35	15.17	22.44	16.66	41.66	33.33
Penicillium aurantiogriseum Dierckx.	-	-	+			0.81			8.33
Name of the fungus	**Diversity**			**Percent occurrence**			**Percentage of frequency**		
	Winter	**Summer**	**Rainy**	**Winter**	**Summer**	**Rainy**	**Winter**	**Summer**	**Rainy**
Penicillum digitatum (Pers) Sacc.	-	-	+			0.81			8.33
Periconia byssoides Pers.	+	-	-	1.08			8.33		
Periconia macrospinosa Lefebvre & Aar. G. Jhonson.	+	-	-	3.51			16.66		
Phoma glomerata (Corda) Wollenw &Hochaptel.	+	-	-	0.27			8.33		
Phoma nebulosa (Pers), Berk.	+	-	-	1.62			8.33		
Phoma terricola Boerema.	+	-	-	0.27			8.33		
Pithomyces maydicus (Sacc.) M.B. Ellis.	-	-	+			0.40			8.33
Pithomyces terricola (Manohar & Rama Rao) P.M.Kirk.	+	-	-	1.62			16.66		
Pyrenochaeta globosa T. Watanabe.	+	-	-	0.54			8.33		
Stachybotrys parvispora S.Hughes.	+	-	-	2.70			16.66		
Torula caligans M.B.Ellis.	+	-	-	0.27			8.33		
Torula herbarum (Pers) Link.	+	-	-	3.51			16.66		
Trichoderma aureoviride Ritai.	+	+	+	1.08	4.01	11.42	16.66	16.66	41.66
Trichoderma fertile Bisset.	+	+	+	0.81	2.67	2.45	8.33	8.33	16.66
Trichoderma harzianum Rifai.	-	+	+		0.44	2.45		8.33	16.66
Trichoderma virens Von Arx.	-	+	-		7.58			33.33	
Trichoderma viride Pers.	+		+	2.70		7.75	25		41.66
Tritirachium dependence Limber.	-	+	+		0.89	0.81		16.66	16.66
Non-sporulating									
NSF White	-	+	+		12.94	20.81		58.33	83.33
NSF Brown	+	-	-	0.81			25		
NSF Red color	-	+	-		0.89			8.33	

Table .2. Physico-chemical parameters of Mattavara forest soils during the study period

Sl.No	**Parameters**	**2015**		
		Winter	**Summer**	**Rainy**
1.	Rain fall in mm	249.33±3.29	220±16.32	666.33±84.84
2.	Atmospheric temperature (^{0}C)	23.66±0.94	30±1.63	23±1.63
3.	Soil temperature (^{0}C)	21±1.63	29.33±2.02	22±1.63
4.	RH %	72.66±6.59	63±4.93	90.33±4.49
5.	Soil moisture %	19.81±1.20	16.43±1.66	20.18±2.08
6.	Soil P^H	5.45±0.792	7.42±0.409	5.88±0.777
7.	EC dSm^{-1}	0.373±0.372	0.18±0.01	0.15±0.008
8.	C %	2.86±0.087	2.50±0.029	2.47±0.31
9.	N Kg ha^{-1}	357.19±1.23	334.46±0.83	315.76±0.76
10.	P (Kg ha^{-1})	37.66±1.24	35±0.81	28.33±1.24
11.	K (Kg ha^{-1})	530.89±0.95	518.07±0.02	496.54±0.02
12.	S (Kg ha^{-1})	6.33±1.24	3.66±0.471	5.66±1.24
13.	Zn ppm	3.85±0.02	3.76±0.01	3.12±0.016
14.	Boron ppm	0.8±0.008	0.60±0.01	0.39±0.43
15	Fe ppm	29.11±0.02	26.12±0.033	23.66±0.40
16	Mn ppm	32.54±0.016	30.46±0.02	27.37±0.016

17	Cu ppm	2.07±0.05	1.8±0.0081	1.44±0.01
18	Ca ppm	3.06±0.008	5.43±0.20	6.2±0.08
19	Mg ppm	4.22±0.012	3.06±0.008	6.06±0.12

Note: Mean ± Standard deviation

Table 3. Diversity indices of soil fungi in Mattavara forest over three seasons 2015

Year	Seasons	Diversity indices							
		Total number of organisms	Total number of species	Average population size	Shannon Index	Simpson Index	Dominance Index	Evenness	Fisher Alpha
2015	Winter	364	41	8.878	3.141	0.07026	0.9297	0.564	4.919
	Summer	280	39	7.179	3.114	0.06001	0.94	0.577	7.568
	Rainy	297	33	9	2.584	0.1242	0.8758	0.401	3.759

Fig. 1. Graphical representation of occurrence of fungal groups in Matthavara forest over three seasons during 2015

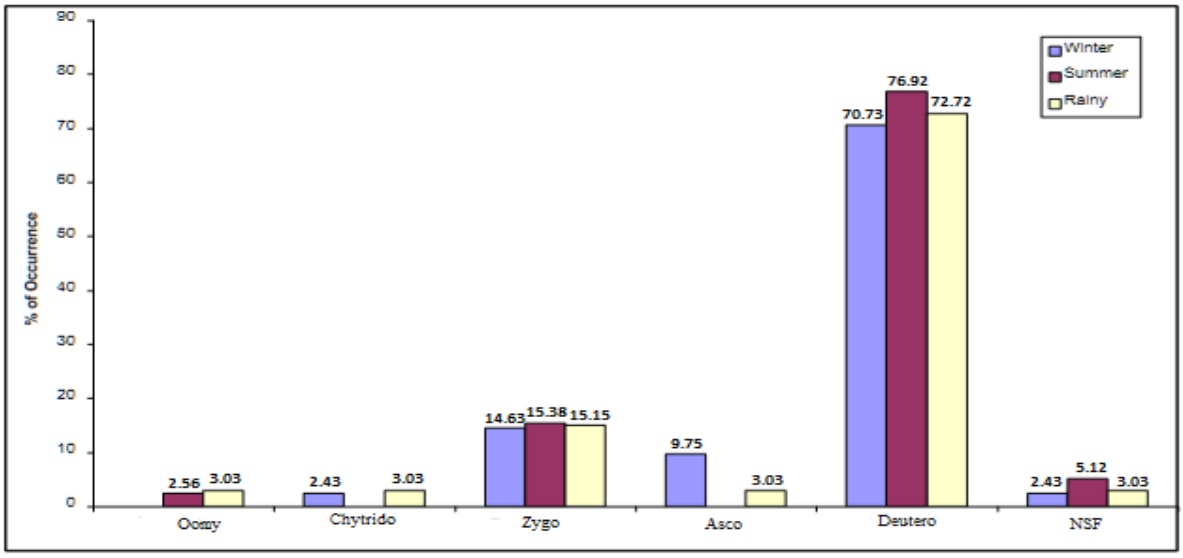
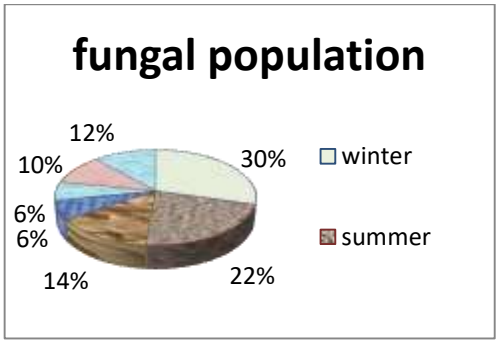


Fig.2. Percentage of fungal species isolated during the study period in different season



Conclusion

It can be concluded from the results that precipitation with alternate sunshine, optimum soil moisture content and temperature, pH, vegetation type, carbon and nitrogen availability are the important factors favors the microbial activity results in variation in the abundance of fungal diversity during different season in the study area.

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