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Morphological and growth studies of fungi isolated from marine ecosystem

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Abstract

The study area comprises a stretch of 16 kilometers in the coastal region of Thiruvarur, Pudukottai, and Ramanathapuram districts which were selected for present study.Totally11 sampling stations are as follows Muthupettai (S1),Iyampattinam(S2), Kumarapattinam(S3), Gopalapttinam(S4), R.Pudupattinam(S5), Arasangaripattinam(S6), Muthukadu(S7), Sethadimudi (S8),Sundarapandipattinam (S10),and Therthandathanam(S11) were selected based on the richness of natural substrates availability. They were collected to isolate the fungi. All the collected samples were plated, incubated and the fungal colonies were identified. The baits samples were regularly observed under aseptic conditions using stereoscopic dissection microscope. Maximum growth rate of fungi was observed in PDA than other media. Maximum fungal growth was observed in pH 8, 30ºC (temperature), 5% (salinity), $FeSO_4$ (metal), carboxy methyl cellulose (carbon source) and ammonium nitrate (nitrogen source) after 8 days of growth in liquid medium.18 species of fungi showed zone of clearance for amylase and protease followed by cellulase with 5 species,laccase (4sp.), xylanase (3 sp.), and pectate lyase (6 sp.). Enzyme assays were also done.From this investigation, we have concluded that the fungal biodiversity in Muthupet mangrove ecosystem, *Aspergillus* and *Penicillium* was the common fungal genera among the isolated from the study period. Fungi play an important role in decomposition of natural substrates in mangrove ecosystem. The fungi isolated from mangroves are mainly used in enzyme technology, biochemical, agricultural, pharmaceutical, molecular biology and other applied research fields.

Keywords: Marine fungi, Morphology, Growth Studies.

Introduction

In spite of this fact, the fungi in soil have a wide range of tolerance to the physico chemical properties of the soil (Garrett, 1956; Brown, 1958; Pugh, 1980; Lockwood, 1981). In most of the cases under soil dilution plate technique, the fungi of Deuteromycetes were reported from various soils with dominance of Aspergillus, Penicillium and Trichoderma, and suggested that they are developed from the dormant propagules (Christensen et al., 1962. Dwivedi, 1966). Since soil is a four-dimensional space-time continuum, it shows fluxuation in physicochemical parameters, which result in the dynamic change in the population of fungi (Austwick, 1968). The soil reaction (pH) in relation to soil microflora has been reported by several (Griffin, 1972; Bissett and Parkinson, 1979a,b). The fungi can be categories into three groups based on their range of tolerance to temperature. They include (a) C; (b) mesophilic°thermophilic fungi surviving at or above 40 C and (c) psychrophilic°C - 40°fungi – thriving between 10 C (Cooney and Emerson 1964;°fungi – thriving at or below 10 Crison, 1964; Emerson, 1968). Soil is a vulnerable site for the accumulation of chemicals, which results in a diverse array of effects on target and non-target organisms and

the associated ecological processes (Grossbard, 1976; Bollen, 1979). Temperature appears to be an important factor affecting the occurrence and distribution of fungi (Suberkropp, 1984). Some species are more common in temperate climates and others are more common in the tropics (Barlocher, 1992). In temperate climates, seasonal shifts in species composition can occur, with species common in the tropics becoming dominant during the summer and absent in winter (Chauvet, 1991; Suberkropp, 1984). The effect of temperature on the growth and sporulation of aquatic Hyphomycetes has received relatively little attention and in all instances, fungi were grown on agar media containing relatively high conc. of nutrients (Koske and Duncan, 1974; Suberkropp, 1984; Webster et al., 1976). Metal tolerance and antibiotic resistance has been studied by number of researchers (Nakahara et al., 1977; Hermansson et al., 1987; Sabry et al., 1997). It has been suggested that under environmental conditions of metal stress, metal and antibiotic Keywords Growth of the fungi Solid media Ecological parameters International Journal of Advanced Multidisciplinary Research 2(8): (2015): 1–22 2 resistant microorganisms will adapt faster by the spread of R- factors than by mutation and natural selection (Silver and Misra, 1988). High prevalence of metal tolerant microbes has been reported earlier from seawater (Sabry et al., 1997) and there are wide variations between the observations of different researchers (Nieto et al., 1989; Chang et al., 1997; Hassen et al., 1998). A deep penetration of Ascomycates and Denteromycetes is observed only in lightwood containing vessels with wide lumina inch permit adequate aeration of the interior (Becker and Kohlmeyer, 1958a,b). Vishniac (1960) reported that in 25 isolates of non- filamentous marine fungi and stimulation of growth by the addition of low levels of sodium bicarbonate to the medium. Siegenthaler et al. (1967) have shown that phosphate uptake in Thraustochytrium roseum is maximally stimulated by sodium chloride in range of concentrations 0.2 – 0.4 molar. Ritchie and Jacobson (1963) determined that the “Phoma pattern” in Zalerion maritima was based on an osmotic rather than an ionic effect of the seawater concentrations. In the present study was carried out to find the growth and various ecological parameters of fungi isolated from marine habitat of east coast of Tamil Nadu, India

Materials and Methods

Growth and Morphological characteristics of fungi on various media

In this study the most dominant species (18 sp.) of fungi were selected. All the fungi were inoculated (agar block containing fungi) in center of seven fungal media such as PDA, SDA, CMA, CZA, MA, RBA and OMA. The inoculated plates were incubated at room temperature (28ºC) for 6 days. After incubation period, the radial growth (diameter in mm) of each fungus was measured (Palacios – Cabrera *et al*., 2005).

Effect of physical and chemical parameters on fungal growth

In this study, the most dominant fungal species (18 sp.) were selected and studied for biomass, effect of various parameters such as pH, temperature, salinity and carbon and nitrogen sources (Booth, 1971a; Boyd and Kohlmeyer, 1982; Aneja, 2001).

Effect of Fungal Biomass

All the fungi were inoculated into Potato Dextrose broth (PD) and incubated at room temperature. After incubation for 8 days, the optical density was measured at 600 nm. The fungal fresh and dry weights were also determined.

Effect of pH on fungal growth

All the fungi were inoculated into Potato Dextrose broth (PD) broth containing different pH ranges (5, 6, 7, 8 and 9) and incubated at room temperature. After incubation for 8 days, the optical density was measured at 600 nm. The fungal fresh and dry weights were also determined.

Effect of Temperature on fungal growth

All the fungi were inoculated into Potato Dextrose broth (PD) broth and the tubes were incubated at different temperature range (20, 30, 40, 50 and 60°C) and incubated at room temperature. After incubation for 8 days, the optical density was measured at 600 nm. The fungal fresh and dry weights were also recorded.

Effect of Salinity on fungal growth

All the fungi were inoculated into Potato Dextrose broth (PD) containing different salinity ranges such as 5, 10, 20, 30 and 40 % and incubated at room temperature. After incubation for 8 days, the optical density was measured at 600 nm. The fungal fresh and dry weights were also recorded.

Effect of Carbon and Nitrogen Sources on fungal growth

All the fungi were inoculated into Potato Dextrose broth (PD) broth containing different carbon sources (Carboxy Methyl Cellulose, Starch, Mannitol) and nitrogen Source (Ammonium nitrate and Calcium nitrate) and incubated at room temperature. After incubation for 8 days, the Optical density was measured at 600 nm. The fungal fresh and dry weights were also determined.

Effect of Heavy Metals on fungal growth

All the fungi were inoculated into Potato Dextrose broth (PD) broth containing different heavy metals (Ferric sulphate and Zinc sulphate) and incubated at room temperature. After incubation for 8 days, the Optical density was measured at 610 nm. The fungal fresh and dry weights were also measured.

Screening and Assay of Fungal Enzymes

In this fungal enzyme study, 18 species of fungi (most dominant) were selected and screened for the production of 4 microbial enzymes (cellulase, pectate lyase, xylanase, and laccase).

Screening of Fungal Enzymes

Screening of enzymes were done by employing plating technique with specific media such as cellulase (Czapek - minimal salt agar), pectate lyase (Hankin's medium), xylanase (Akiba and Horikoshi medium), and laccase (Liquefied basal medium). All the inoculated plated were incubated at room temperature (28ºC) and the zone of clearance were observed around the colonies and noted.

Results and Discussion

Growth and morphological characteristics of fungi on various media

In this study, the 18 species of fungi was inoculated in 7 different media like PDA,SDA, CMA, CZA, MA, RBA and OMA respectively. All the plates were incubated for 8 days at room temperature. The maximum growth rate was observed in PDA plates by *P.fumiculosum* (78 mm in dia), and SDA plates(60 mm in dia) by A.clavatus followed by CMA plates by *P.jamnethellam* (69 mm in dia),CZA plates by *R.oligosporum* (57 mm in dia),MA plates by *A.cineriae (*74 mm in dia)RBA plates by *R.stolonifer* (54mm in dia) andOMA plates by P.jamnethellam(55 mm in dia).

The minimum growth showed by PDA plates by *Fusarium oxysporum* (11 mm in dia),SDA plates by *A.fumigatus* (12 mm in dia),CMA plates *by R.oryzae* (10 mm in dia), CZA plates by *P.Fumiculosum* (15 mm in dia),MA plates by *A.fumiculous* (20 mm in dia),RBA plates by *P.fumiculosum* (10 mm in dia) and OMA plates by *V.longisporum* (11 mm in dia).

This study was well correlated with earlier findings by Palacios - Cabrera *et al*. (2005). They studied that the influence of three culture media with different water activity, time of incubation and temperature on the growth of *Aspergillus ochraceus*, *A. niger* and *A. carbonarius* on GYA, DG18, Malt agar with 40% glucose agar.

Growth characteristics of fungi on various parameters

Fungal biomass study

In this study, *R.stolonifer* showed maximum optical density with 1.940 followed by *V. longisporum* (1.930) were showed maximum growth on 8 days of incubation and least by *A. clavatus* (0.365) (Table 6).

Fresh weight of the fungi were also maximum in *R.stolonifer* with 9.13 mg/g followed by Minimum of fresh weight was observed in *P.frequentans* (0.14 mg/g). Dry weights of the fungi were also maximum *A.ustus* with (3.05mg/g) and minimum of dry weight was observed in *F.oxysporum(*0.15 mg/g) (Table 7).

Ecological studies were carried out by various physico-chemical parameters. Among these, pH (8), temperature (30°C), salinity (5%), metals (FeSO4), carbon source (CMC) and nitrogen source (ammonium nitrate) influenced the maximum growth of fungi in liquid media on 8 days of incubation at room temperature. Fresh and dry weights of the fungi were maximum in above conditions.

Effect of pH on the growth of fungi

In this study, the maximum growth was observed in pH 8 after 8 days of incubation. In this pH, *R.stolonifer* showed maximum growth with 2.826 (optical density) and minimum growth rate was observed in *A. lunchensis* (0.612). (Table 7)

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The effect of temperature, pH, salinity and salinity-temperature interaction for thermophilic and thermotolernt fungi from Sundarban mangrove swamp have been investigated by several investigators (Jaitly, 1982, 1983; Jaitly and Rai, 1982). They have observed that forms like *A. fumigatus, Humicola* and *Thermomyces* have a wide range of temperature tolerance.

Effect of temperature on the growth of fungi

In this study, the maximum growth was observed in temperature range of 30ºC after 8 days of incubation. In this temperature study, *V.longisporum* showed maximum growth with 2.645 (optical density) and minimum growth rate was observed in *A.cineriae with 1.317 optical density.*

Fresh weight of the fungi were also maximum in *A. cineriae* with 1.71 mg/g and Minimum of fresh weight was observed in A. *fumigatus*(0.32 mg/g) **.** Dry weight of the fungi was also maximum *P.rubrum* (0.51 mg/g) and Minimum of dry weight was observed in *R. oryzae* (0.09 mg/g).(Table 4)

This result was discussed with earlier studies by Ritchie (1957,1959). They found that water, temperature and salinity have a combined effect on the growth rate of certain fungi. Studies of some fungi isolated from mangrove swamps and marine habitats clearly indicate that the incubation temperature increases, the salinity optima also increase until the temparature becomes a limitting factor (Chowdhery, 1975; Jaitly, 1983; Ritchie, 1957, 1959).

The effect of temperature, pH, salinity and salinity-temperature interaction for thermophilic and thermotolernt fungi from Sundarban mangrove swamp have been investigated by several investigators (Jaitly, 1983; Jaitly and Rai, 1982). They have observed that forms like *A. fumigatus, Humicola* and *Thermomyces* have a wide range of temperature tolerance. Boyd and Kohlmeyer (1982) studied that the influence of temperature on the seasonal and geographic distribution of three marine fungi and dry weight of fungi analysed. The effect of temperature on the growth and sporulation of aquatic hyphomycetes has been studied by Koske and Puncan (1974), Suberkropp (1984) and Webster *et al*. (1976).

Effect of salinity on the growth of fungi

In this study, the maximum growth (optical density) was observed in salinity 5% after 8 days of incubation. In this salinity study *P.rubrum* showed maximum growth (2.773) and Minimum growth rate was observed in *R.oligosporum* (0.376). (Table 8)

Fresh weight of the fungi were also maximum in *P.frequentalis* (2.96mg/g) and minimum of fresh weight was observed in *A. fumigatus* (0.62mg/g) (Table 9)**.** Dry weights of the fungi were also maximum *A.fumigatus* (0.62 mg/g)and minimum of dry weight was observed in *P.jamnethallum* (0.15 mg/g)

The above parameters were discussed with the studies carried out by Hohnk (1952, 1953, 1955, 1956) on the physiology, ecology and distribution of marine fungi in relation to salinity. Chowdhery (1975) reported that mangrove isolates have higher osmotic optima as compared to their fertile soil counterparts. In mangrove swamps, the microbial life has to withstrand high salinity and fungi found in this habitat show a high degree of osmotic tolerance and increased salinity optima. Jaitly, (1983), Jaitly and Rai, (1982) investigated the effect of temperature, pH, salinity and salinity- temperature interaction for thermophilic and thermotolernt fungi from sundarban mangrove swamp.

It is intersting therefore that in considering the physiological response of terrestrial and marine fungi to increasing salinities, it can be seen that there is good correlation with the observed distribution of these fungi under natural conditions. Typically marine fungi exhibit a broad tolerance to salinity while the terrestrial fungi are inhibited by higher salinities, especially their reproduction and spore germination. Thus, the statement of Jones and Jennings (1964) can be extended 'the reduced vegetative growth, reproduction and spore germination in terrestrial fungi under saline conditions may be the factors in maintaining the fungus flora of the sea distinct from that of non-marine habitats. Studies on the salinity tolerance of marine fungi have preoccupied many mycologists as can be seen from the following papers (Borut and Johnson, 1962; Jones, 1963; Jones *et al*., 1971).

Effect of carbon and nitrogen sources on the growth of fungi

In this study, the maximum growth was observed in carboxy methyl cellulsoe after 8 days of incubation. *R.stolonifer* showed maximum growth with 2.844(OD) *and* minimum growth rate was observed in A.clavatus 0.456 (OD)

Fresh weight of the fungi were also maximum in *A.fumiculous 2.56(mg/g)* and minimum in *R.stolonifer* (0.41mg/g)**.** Dry weights of the fungi was maximum in *R.oryzae* (0.49 mg/g) and minimum in *A. ustus* (0.12 mg/g)

In starch after 8 days of incubation, *R.oligosporum* was showed maximum growth with 2.769 (OD) and minimum growth rate was observed in and *A.fumigatus* with 0.310 (OD) (Table 11).

Fresh weight of the fungi were also maximum in *Absidia* (1.75 mg/g) and minimum of fresh weight was observed in *A.fumigatus,A.funiculous,A.luchensis* (0.36 mg/g). Dry weight of the fungi were also maximum *R.stolonifer* (0.56mg/g) and minimum of dry weight was observed in *P.fumiculosum* (0.07 mg/g)

In mannitol after 8 days of incubation, *P. rubrum* was showed maximum growth with 2.520 (OD) and Minimum growth rate was observed in *R. stolonifer* with 0.324 (OD) .

Fresh weight of the fungi were also maximum in *Absidia* (1.83 mg/g) and minimum of fresh weight was observed in *R.oligosporum* (0.45 mg/g). Dry weight of the fungi were also maximum *A.funiculous* (0.45 mg/g) and minimum of dry weight was observed in *P.frequentans* with (0.06mg/g)

In ammonium nitrate after 8 days of incubation, maximum growth was observed in P.*rubrum* with 2.669 (OD). Minimum growth rate was observed in *V.longisporum* with 0.202 (OD) .

Fresh weight of the fungi was also maximum in *A. lunchensis* (1.73 mg/g) and minimum of fresh weight was observed *in Absidia* (0.36 mg/g). Dry weight of the fungi were also maximum in *Alternaria brasicola* (0.26mg/g) and minimum of dry weight was observed in *A.ustus* with 0.02mg/g

In calcium nitrate on 8 days of incubation, *Absidia* showed maximum growth with 1.512 (OD) followed by *R.oryzaer* with 1.482 (OD) and *P.citricum* with 1.418 (OD). Minimum growth rate was observed in *A.ustus* with 0.135 (OD) and *A.cineriae*. with 0.125 (OD)

Fresh weight of the fungi were also maximum in *V.longisporum* (1.50 mg/g) and minimum of fresh weight was observed in *A.fumiculous* (0.12 mg/g). Dry weight of the fungi were also maximum *V.longisporum* (0.22 mg/g) and minimum of dry weight was observed *in R.oryzae* (0.04 mg/g)

Swart (1958) studied that the mycoflora in the soil of mangrove swamp of Inhaea Island has suggested that these swamp are rich in simple carbohydrate and nitrogen and the dominance of the speices of *Aspergillus* and *Penicillium* indicates their preference for simple organic compounds.

Effect of metals on the growth of fungi

In ferric sulphate after 8 days of incubation. In this study, *R. stolonifer* and *V.longisporum* showed maximum growth with 2.052 (OD). Minimum growth rate was observed in *A. fumigatus* with 1.038 (OD) and *A.clavatus* with 1.029 (OD)

Fresh weight of the fungi were also maximum in *P.rubrum* (1.65 mg/g) and minimum of fresh weight was observed in *A.cineriae* (0.56 mg/g). Dry weight of the fungi was also maximum in *R.stolonifer* (1.24 mg/g) and minimum of dry weight was observed in *V.longisporum,A.ustus, P.fumiculosum* (0.11 mg/g)

In zinc sulphate after 8 days of incubation, *F.oxysporum* showed maximum growth with 1.833 (OD) and minimum growth rate was observed in *A. oryzae* with 0.354 (OD)

Fresh weight of the fungi were also maximum in *A. cineriae* (1.42 mg/g) and minimum of fresh weight was observed in *R.oryzae* (0.08 mg/g). Dry weight of the fungi were also maximum *A. funiculous* (0.41 mg/g) and minimum of dry weight was observed in *Absidia* (0.09 mg/g)

Various reserchsers (Gourdon *et al*., 1990) have studied the mechanism of heavy metal biosorption and reported involvement of different mechanism such as intracellular uptake and storage via active cationic transport system, surface binding and other undefined machanisms. Since most metal microbes interactions are initiated at the level of uptake, the uptake machanism is likely to be closely linked to the machanism of metal resistance in the microorganisms (Yilmaz, 2003).

Table 1. Growth and morphological characteristics of fungi on various media .
(The values are represented in mm in diameter).

S.No	Name of the fungi	PDA	SDA	CMA	CZA	MA	RBA	OMA
1	*Absidia*	50	32	41	35	56	25	40
2	*R. stolonifer*	60	14	33	45	37	54	26
3	*R. oryzae*	45	52	10	54	36	32	23
4	*R.oligosporum*	66	58	14	57	23	47	21
5	*A.clavatus*	54	60	30	40	60	31	25
6	*A.fumigatus*	36	12	46	54	24	23	34
7	*A. fumiculous*	12	52	45	36	20	10	41
8	*A.luchensis*	45	45	13	54	36	44	17
9	*A. cineriae*	11	58	43	24	74	38	21
10	*Alternaria brasicola*	12	29	41	36	34	23	41
11	*Vericillium longisporum*	56	32	41	25	58	36	11
12	*A. ustus*	11	20	39	24	44	12	14
13	*A. 0ryzae*	20	45	45	56	32	12	18
14	*Fusarium oxysporum*	11	17	37	45	41	23	16
15	*P.frequentans*	34	37	22	24	65	21	48
16	*P.fumiculosum*	78	45	17	15	45	10	23
17	*P.rubrum*	44	53	19	36	39	13	20
18	*P.jamnethnellam*	69	44	69	45	24	12	55

Table 2. Effect of biomass of dominant species of fungi
(The values are represented in OD at 600 nm)

S.No	Name of the fungi	8days	Fresh & Dry weights in mg/g (After 8 days)	
			Fresh	Dry
1	*Absidia*	0.640	0.45	0.24
2	*R. stolonifer*	1.940	9.13	2.23
3	*R. oryzae*	1.840	8.45	1.36
4	*R.oligosporum*	1.745	7.36	0.69
5	*A.clavatus*	0.376	2.65	1.34
6	*A.fumigatus*	0.410	2.74	1.32
7	*A. fumiculous*	0.418	3.01	1.98
8	*A.luchensis*	0.365	2.60	1.78
9	*A. cineriae*	0.569	2.32	1.51
10	*Alternaria brasicola*	1.925	7.66	2.33
11	*Vericillium longisporum*	1.925	8.06	1.96
12	*A. ustus*	1.844	7.50	3.05
13	*A. 0ryzae*	0.420	0.15	0.74
14	*F.oxysporum*	1.235	0.30	0.15
15	*P.frequentans*	1.216	0.14	0.23
16	*P.fumiculosm*	1.569	3.01	0.23
17	*P.rubrum*	1.436	0.29	0.36
18	*P.jamanthellam*	1.539	0.97	0.56

Table3 . Effect of pH on fungal growth

(The values are represented in OD at 600 nm)

S.No	Name of the fungi	5	6	7	8	9
1	*Absidia*	0.965	1.054	0.765	2.144	1.352
2	*R. stolonifer*	0.863	0.925	0.721	2.826	0.451
3	*R. oryzae*	0.814	0.912	0.456	1.265	0.540
4	*R.oligosporum*	0.368	0.763	0.802	1.657	0.648
5	*A.clavatus*	1.564	1.646	1.236	1.993	1.127
6	*A.fumigatus*	0.645	1.114	1.456	1.972	0.601
7	*A. fumiculous*	0.621	1.254	0.639	1.457	1.153
8	*A.luchensis*	1.054	1.158	1.004	0.612	1.147
9	*A. cineriae*	0.652	0.636	0.596	0.711	0.697
10	*Alternaria brasicola*	1.215	1.168	1.385	1.458	1.365
11	*Vericillium longisporum*	1.014	1.116	1.789	2.814	1.174
12	*A. ustus*	1.269	1.563	1.845	1.992	1.330
13	*A. 0ryzae*	0.543	0.592	0.588	0.635	0.597
14	*P.citricum*	0.624	1.083	0.516	1.863	0.644
15	*P.frequentans*	2.148	1.876	1.587	2.876	2.174
16	*P.fumiculosm*	0.807	0.537	0.367	0.933	0.852
17	*P.rubrum*	1.922	2.157	0.594	2.223	2.004
18	*P.jamanthellam*	1.106	0.784	1.465	1.717	1.510

Table 4. Effect of pH on dry weight of fungal growth

(The values are represented in mg/ g)

S.No	Name of the fungi	5	6	7	8	9
1	*Absidia*	0.03	0.06	0.03	0.02	0.01
2	*R. stolonifer*	0.45	0.69	0.70	0.82	0.76
3	*R. oryzae*	0.47	0.80	0.08	0.90	0.13
4	*R.oligosporum*	0.04	0.06	0.05	0.19	0.12
5	*A.clavatus*	0.04	0.07	0.09	0.14	0.08
6	*A.fumigatus*	0.03	0.01	0.03	0.04	0.03
7	*A. fumiculous*	0.07	0.02	0.04	0.11	0.04
8	*A.luchensis*	0.01	0.06	0.09	0.17	0.01
9	*A. cineriae*	0.04	0.17	0.06	0.21	0.02
10	*Alternaria brasicola*	0.09	0.15	0.01	0.12	0.04
11	*Vericillium longisporum*	0.01	0.05	0.12	0.26	0.08
12	*A. ustus*	0.01	0.05	0.06	0.07	0.04
13	*A. 0ryzae*	0.01	0.02	0.10	0.23	0.01
14	*P.citricum*	0.02	0.03	0.04	0.05	0.01
15	*P.frequentans*	0.04	0.01	0.03	0.13	0.01
16	*P.fumiculosm*	0.03	0.04	0.09	0.18	0.09
17	*P.rubrum*	0.06	0.06	0.09	0.17	0.06
18	*P.jamanthellam*	0.02	0.01	0.06	0.26	0.03

Table 5. Effect of temperature on fungal growth

(The values are represented in OD at 600 nm)

S.No	Name of the fungi	20îC	30îC	40îC	50îC	60îC
1	*Absidia*	1.125	2.012	1.569	0.236	0.412
2	*R. stolonifer*	1.178	2.520	1.563	1.325	0.636
3	*R. oryzae*	1.235	2.412	1.263	0.114	0.632
4	*R.oligosporum*	0.504	1.568	1.025	0.238	0.381
5	*A.clavatus*	0.968	2.964	0.717	2.092	1.791
6	*A.fumigatus*	1.655	1.738	1.093	0.238	1.041
7	*A. fumiculous*	1.676	1.145	1.301	0.955	0.516
8	*A.luchensis*	1.866	1.904	1.611	1.369	1.262
9	*A. cineriae*	1.263	1.317	1.046	1.311	1.173
10	*Alternaria brasicola*	1.489	1.835	1.526	1.040	1.340
11	*Vericillium longisporum*	1.272	2.645	1.920	2.174	1.454
12	*A. ustus*	2.012	2.136	1.640	1.441	2.00
13	*A. 0ryzae*	1.173	2.448	1.854	0.934	0.869
14	*F.oxysporum*	1.147	1.968	1.764	1.653	1.193
15	*P.frequentans*	1.324	1.733	1.829	0.632	0.706
16	*P.fumiculosm*	1.455	1.528	1.338	1.390	0.908
17	*P.rubrum*	1.169	2.178	1.770	1.221	1.031
18	*P.jamanthellam*	1.473	1.620	1.569	0.653	0.281

Table 6. Effect of temperature on fresh weight of fungal growth

(The values are represented in mg/ g)

S.No	Name of the fungi	20îC	30îC	40îC	50îC	60îC
1	*Absidia*	0.30	1.65	0.41	0.56	0.53
2	*R. stolonifer*	0.77	1.45	0.65	0.67	0.78
3	*R. oryzae*	0.70	0.97	0.54	0.49	0.77
4	*R.oligosporum*	0.60	0.82	0.57	0.76	0.64
5	*A.clavatus*	0.72	0.80	0.79	0.78	0.71
6	*A.fumigatus*	0.23	0.32	0.11	0.17	0.09
7	*A. fumiculous*	0.98	1.27	1.11	0.61	0.94
8	*A.luchensis*	0.28	0.63	0.57	0.59	0.50
9	*A. cineriae*	0.36	1.71	0.96	0.83	1.03
10	*Alternaria brasicola*	0.19	0.47	0.32	0.12	0.42
11	*Vericillium longisporum*	0.97	1.27	1.17	0.95	0.99
12	*A. ustus*	0.70	1.53	1.08	1.03	0.46
13	*A. 0ryzae*	0.98	1.09	0.15	1.02	1.07
14	*F.oxysporum*	0.40	0.74	0.19	0.44	0.40
15	*P.frequentans*	0.97	1.55	1.45	0.97	1.02
16	*P.fumiculosm*	0.32	1.27	1.21	0.34	0.56
17	*P.rubrum*	0.28	0.60	0.51	0.53	0.37
18	*P.jamanthellam*	0.59	0.94	0.69	0.41	0.78

Table 7 Effect of temperture on Dry weight of fungal growth

(The values are represented in mg/ g)

S.No	Name of the fungi	20îC	30îC	40îC	50îC	60îC
1	*Absidia*	0.09	0.12	0.07	0.10	0.06
2	*R. stolonifer*	0.16	0.21	0.06	0.02	0.09
3	*R. oryzae*	0.05	0.09	0.06	0.09	0.08
4	*R.oligosporum*	0.08	0.17	0.09	0.10	0.08
5	*A.clavatus*	0.09	0.16	0.08	0.10	0.10
6	*A.fumigatus*	0.22	0.31	0.22	0.07	0.02
7	*A. fumiculous*	0.23	0.32	0.28	0.09	0.04
8	*A.luchensis*	0.11	0.22	0.16	0.19	0.13
9	*A. cineriae*	0.11	0.11	0.03	0.05	0.11
10	*Alternaria brasicola*	0.13	0.25	0.32	0.21	0.23
11	*Vericillium longisporum*	0.01	0.09	0.04	0.02	0.05
12	*A. ustus*	0.21	0.32	0.16	0.06	0.04
13	*A. 0ryzae*	0.04	0.22	0.20	0.21	0.12
14	*F.oxysporum*	0.11	0.22	0.21	0.09	0.04
15	*P.frequentans*	0.10	0.11	0.03	0.09	0.03
16	*P.fumiculosm*	0.21	0.41	0.23	0.21	0.06
17	*P.rubrum*	0.11	0.51	0.24	0.22	0.03
18	*P.jamanthellam*	0.11	0.12	0.11	0.05	0.08

Table 8 Effect of salinity on fungal growth

(The values are represented in OD at 600 nm)

S.No	Name of the fungi	5%	10%	20%	30%	40%
1	*Absidia*	0.560	0.551	0.374	0.390	0.403
2	*R. stolonifer*	0.440	0.369	0.347	0.474	0.411
3	*R. oryzae*	0.420	0.214	0.341	0.256	0.376
4	*R.oligosporum*	0.376	0.508	0.354	0.227	0.402
5	*A.clavatus*	0.497	0.429	0.404	0.493	0.421
6	*A.fumigatus*	0.675	0.661	0.420	0.290	0.275
7	*A. fumiculous*	1.788	1.058	0.516	0.345	0.180
8	*A.luchensis*	1.672	0.569	0.669	0.139	0.104
9	*A. cineriae*	0.765	0.693	0.475	0.390	0.220
10	*Alternaria brasicola*	2.628	1.056	0.821	0.793	0.117
11	*Vericillium longisporum*	1.986	1.205	1.106	0.255	0.220
12	*A. ustus*	1.698	0.965	0.397	0.244	0.159
13	*A. 0ryzae*	1.092	0.858	0.560	0.320	0.250
14	*F.oxysporum*	1.660	0.995	0.760	0.435	0.520
15	*P.frequentans*	0.826	0.353	0.556	0.187	0.167
16	*P.fumiculosm*	1.007	1.001	0.523	0.288	0.132
17	*P.rubrum*	2.773	1.761	0.440	0.255	0.210
18	*P.jamanthellam*	1.136	1.072	0.713	0.457	0.320

Table 9 Effect of salinity on fresh weight of fungal growth

(The values are represented in mg/ g)

S.No	Name of the fungi	5%	10%	20%	30%	40%
1	*Absidia*	1.69	1.63	0.77	0.27	0.14
2	*R. stolonifer*	1.63	1.03	1.07	1.65	1.05
3	*R. oryzae*	1.61	0.87	1.03	1.57	1.29
4	*R.oligosporum*	1.89	0.88	0.77	1.17	1.15
5	*A.clavatus*	2.79	0.75	0.70	1.27	1.04
6	*A.fumigatus*	0.62	0.08	1.12	1.15	0.93
7	*A. fumiculous*	2.03	1.99	1.96	1.90	1.80
8	*A.luchensis*	1.40	1.84	1.79	1.68	1.04
9	*A. cineriae*	2.06	1.70	1.59	1.57	0.66
10	*Alternaria brasicola*	1.38	1.10	1.02	1.22	1.01
11	*Vericillium longisporum*	1.90	1.86	1.78	1.57	1.10
12	*A. ustus*	1.85	1.49	1.41	1.09	1.08
13	*A. 0ryzae*	1.96	1.80	1.14	0.61	0.80
14	*F.oxysporum*	2.38	2.08	2.08	1.77	1.01
15	*P.frequentans*	2.96	2.86	2.16	2.08	1.96
16	*P.fumiculosm*	1.86	1.67	1.67	1.48	1.06
17	*P.rubrum*	1.81	1.40	1.09	1.07	0.88
18	*P.jamanthellam*	2.01	1.98	1.69	1.90	2.04

Table 10. Effect of salinity on dry weight of fungal growth

(The values are represented in mg/ g)

S.No	Name of the fungi	5%	10%	20%	30%	40%
1	*Absidia*	0.55	0.42	0.32	0.22	0.17
2	*R. stolonifer*	0.53	0.47	0.34	0.21	0.16
3	*R. oryzae*	0.49	0.45	0.47	0.11	0.09
4	*R.oligosporum*	0.43	0.40	0.29	0.27	0.12
5	*A.clavatus*	0.45	0.40	0.29	0.18	0.12
6	*A.fumigatus*	0.62	0.79	0.22	0.21	0.20
7	*A. fumiculous*	0.61	0.33	0.32	0.31	0.27
8	*A.luchensis*	0.46	0.44	0.39	0.38	0.34
9	*A. cineriae*	0.36	0.47	0.43	0.24	0.12
10	*Alternaria brasicola*	0.60	0.64	0.52	0.52	0.47
11	*Vericillium longisporum*	0.44	0.32	0.28	0.25	0.18
12	*A. ustus*	0.44	0.28	0.27	0.22	0.22
13	*A. 0ryzae*	0.41	0.60	0.15	0.09	0.05
14	*F.oxysporum*	0.61	0.56	0.26	0.21	0.15
15	*P.frequentans*	0.47	0.43	0.39	0.39	0.36
16	*P.fumiculosm*	0.36	0.32	0.29	0.18	0.11
17	*P.rubrum*	0.26	0.24	0.21	0.13	0.12
18	*P.jamanthellam*	0.15	0.11	0.10	0.07	0.06

Table 11 Effect of carbon and nitrogen sources on fungal growth
(The values are represented in OD at 600 nm)

S.No	Name of the fungi	CMC (1%)	Starch (1%)	Mannitol (1%)	Amm.Nitrate (1%)	Cal.Nitrate (1%)
1	*Absidia*	1.576	1.420	1.412	1.409	1.512
2	*R. stolonifer*	2.844	1.563	0.324	0.256	0.808
3	*R. oryzae*	2.826	2.320	0.802	0.220	1.482
4	*R.oligosporum*	2.815	2.769	1.698	0.356	0.278
5	*A.clavatus*	0.456	0.987	1.569	2.021	0.463
6	*A.fumigatus*	0.963	0.310	0.746	1.921	0.369
7	*A. fumiculous*	1.648	0.454	1.697	2.011	0.978
8	*A.luchensis*	2.871	1.882	2.159	1.402	0.835
9	*A. cineriae*	2.290	2.145	2.130	1.534	0.125
10	*Alternaria brasicola*	0.694	0.322	1.369	1.234	0.314
11	*Vericillium longisporum*	0.789	1.369	1.506	0.202	0.106
12	*A. ustus*	1.896	2.270	2.245	1.258	1.214
13	*A. 0ryzae*	2.732	2.569	0.538	1.369	0.514
14	*F.oxysporum*	1.446	1.420	1.419	1.437	1.418
15	*P.frequentans*	0.697	0.478	0.569	1.005	1.032
16	*P.fumiculosm*	0.785	0.469	1.369	2.011	2.005
17	*P.rubrum*	1.485	2.164	2.478	2.669	1.489
18	*P.jamanthellam*	1.856	1.256	2.520	0.697	0.683

Table 12. Effect of carbon and nitrogen sources on fresh weight of fungal growth
(The values are represented in mg/ g)

S.No	Name of the fungi	CMC (1%)	Starch (1%)	Mannitol (1%)	Amm. Nitrate (1%)	Cal. Nitrate (1%)
1	*Absidia*	0.45	1.75	1.75	0.36	0.89
2	*R. stolonifer*	0.41	0.49	0.49	0.72	0.66
3	*R. oryzae*	0.56	0.96	0.54	1.65	0.53
4	*R.oligosporum*	1.85	0.36	0.45	1.36	0.57
5	*A.clavatus*	1.94	0.96	0.78	1.12	0.96
6	*A.fumigatus*	0.96	0.36	1.02	1.25	1.42
7	*A. fumiculous*	2.56	0.36	0.56	0.89	0.12
8	*A.luchensis*	0.85	0.36	1.23	1.85	1.36
9	*A. cineriae*	1.53	1.07	1.40	1.15	0.95
10	*Alternaria brasicola*	0.89	0.61	0.71	1.24	1.18
11	*Vericillium longisporum*	0.48	1.28	1.83	1.68	1.50
12	*A. ustus*	1.21	1.04	1.21	1.73	1.23
13	*A. 0ryzae*	1.07	1.00	1.04	1.57	1.43
14	*F.oxysporum*	1.70	1.28	1.05	1.57	1.49
15	*P.frequentans*	0.98	0.75	0.83	1.22	1.02
16	*P.fumiculosm*	0.23	0.95	1.10	1.05	0.95
17	*P.rubrum*	1.72	1.51	1.25	1.38	1.31
18	*P.jamanthellam*	1.45	1.22	1.20	1.03	0.97

Table 13. Effect of carbon and nitrogen sources on dry weight of fungal growth
(The values are represented in mg/ g)

S.No	Name of the fungi	CMC (1%)	Starch (1%)	Mannitol (1%)	Amm. Nitrate (1%)	Cal. Nitrate (1%)
1	*Absidia*	0.45	0.11	0.09	0.13	0.06
2	*R. stolonifer*	0.19	0.56	0.23	0.13	0.09
3	*R. oryzae*	0.49	0.45	0.22	0.18	0.04
4	*R.oligosporum*	0.29	0.07	0.10	0.04	0.06
5	*A.clavatus*	0.27	0.15	0.10	0.13	0.06
6	*A.fumigatus*	0.15	0.12	0.13	0.26	0.16
7	*A. fumiculous*	0.10	0.11	0.45	0.13	0.12
8	*A.luchensis*	0.28	0.12	0.07	0.14	0.13
9	*A. cineriae*	0.17	0.09	0.09	0.19	0.11
10	*Alternaria brasicola*	0.13	0.12	0.12	0.26	0.15
11	*Vericillium longisporum*	0.15	0.18	0.11	0.14	0.22
12	*A. ustus*	0.09	0.14	0.06	0.02	0.12
13	*A. 0ryzae*	0.16	0.11	0.11	0.18	0.17
14	*F.oxysporum*	0.12	0.08	0.08	0.30	0.20
15	*P.frequentans*	0.10	0.09	0.06	0.18	0.16
16	*P.fumiculosm*	0.13	0.07	0.07	0.19	0.12
17	*P.rubrum*	0.19	0.11	0.08	0.23	0.16
18	*P.jamanthellam*	0.15	0.18	0.09	0.19	0.13

Table 14 Effect of metals on fungal growth
(The values are represented in OD at 610 nm)

S.No	Name of the fungi	FeSo4 (1 %)	Zn So4 (`1%)
1	*Absidia*	1.485	0.945
2	*R. stolonifer*	2.052	0.936
3	*R. oryzae*	1.689	1.184
4	*R.oligosporum*	1.087	0.375
5	*A.clavatus*	1.029	0.563
6	*A.fumigatus*	1.038	0.456
7	*A. fumiculous*	1.789	0.779
8	*A.luchensis*	1.698	1.568
9	*A. cineriae*	1.456	0.985
10	*Alternaria brasicola*	1.715	1.452
11	*Vericillium longisporum*	2.052	0.674
12	*A. ustus*	1.458	1.659
13	*A. 0ryzae*	0.180	0.354
14	*F.oxysporum*	1.805	1.833
15	*P.frequentans*	1.569	0.470
16	*P.fumiculosm*	1.964	0.796
17	*P.rubrum*	1.358	0.772
18	*P.jamanthellam*	1.907	0.557

Table 15 Effect of metals on dry and fresh weight of fungal growth

(The values are represented in mg/ g)

S.No	Name of the fungi	FeSo4 (1%)		ZnSo4(1%)	
		FW	DW	FW	DW
1	*Absidia*	1.23	1.03	0.14	0.09
2	*R. stolonifer*	1.25	1.24	0.18	0.16
3	*R. oryzae*	0.96	1.11	0.08	0.12
4	*R.oligosporum*	1.29	0.87	0.16	0.15
5	*A.clavatus*	1.40	0.96	1.32	0.36
6	*A.fumigatus*	1.36	0.36	1.01	0.33
7	*A. fumiculous*	1.41	0.12	0.92	0.41
8	*A.luchensis*	1.10	0.15	1.15	0.13
9	*A. cineriae*	0.56	0.21	1.42	0.22
10	*Alternaria brasicola*	1.15	0.12	0.59	0.21
11	*Vericillium longisporum*	1.13	0.11	1.42	0.10
12	*A. ustus*	1.25	0.11	1.29	0.11
13	*A. 0ryzae*	0.81	0.31	0.59	0.31
14	*F.oxysporum*	1.07	0.21	1.21	0.31
15	*P.frequentans*	1.06	0.22	0.79	0.32
16	*P.fumiculosm*	1.48	0.11	1.12	0.31
17	*P.rubrum*	1.65	0.22	1.11	0.21
18	*P.jamanthellam*	0.05	0.31	0.08	0.31

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