STUDIES ON FUNGI AND BACTERIA IN RELATION TO PHYSICO-CHEMICAL COMPLEXES FROM THREE SEMI-ARID TROPICAL SOILS

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Abstract

Fungi and bacterial numbers were estimated quantitatively from three soil types for a period of one year (1985-1986). Microbial numbers have shown positive correlation with certain physico-chemical factors. The soil possessing thick forest vegetation have shown greater microbial number and fungal species. Altogether 72 fungal species were has been recorded isolated. Definite seasonal variation has been recorded for microbes and physico-chemical factors.

Introduction

The importance of physico-chemical factors on the distribution, phenology, quantitative and qualitative aspects of terrestrial fungi have been emphasized by Alexander (1971), Garrett (1970), Griffin (1972), Park (1968), Saksena (1967), Subramanian (1973) and Wicklow and Carrol (1981). The influence of moisture, pH, temperature, organic carbon, phosphorus, nitrogen and other elements on the fungi of cultivated and forest soils have been worked out by Ahrens and Sattci (1985), Wicklow and Carrol (1981) and Widden (1981, 1986). However, the scrub jungle forest soils received only meagre attention (Manoharachary, 1977; Ramarao, 1970). In this paper an attempt has been made to study the influence of physico-chemical factors on the distribution and phenology of fungal and bacterial numbers besides emphasizing the qualitative composition of fungi in two scrub jungle forest soils from semi-arid tropical regions of Andhra Pradesh, India.

Material and methods

Composite soil samples were collected from two forest localities of Andhra Pradesh at 4-weekly intervals, starting from June, 1985 and continued to May, 1986. Sampling sites were designated as soil-1, soil-2 and soil-3. Soil-1 was taken from scrub jungle forest at Amrabad (606 meters above mean sea level) which covers an area of 1142 sq km. The following angiosperms were common in this area: *Acacia catechu* Willd., *Albizia procera* Benth,, *Madhuca latifolia* (Roxb.) Macbr., *Butea frondosa* Koen. *Cymbopogon* sp., *Dodonea viscosa* (Linn.) Jacq., *Euphorbia antiquorum* Linn., *Feronia elephantum* Corr, *Indigofera glandulosa* Will., *Lantana camara* Linn., *Saccharum spontaneum* Linn., *Vitex negundo* Linn.

Soil-2 was taken from Mannanur forest area (686 meters above mean sea level). It extends about 580 sq m. The following are the dominant angiosperms in the area: *Acacia arabica* Willd., *Aegle marmelos* Corr., *Asparagus racemosus* Willd., *Madhuca latifolia* (Roxb.) Macbr, *Bauhinia recemosa* Lam., *Bombax malabaricum* Dc., *Cassia fistula* Linn., *Hardwickia binata* Roxb., *Legerstroemia parviflora* Roxb., *Saccharum spontaneum* Linn., *Sapindus emarginatus* vahl, *Wrightia tinctoria* R. Br.

Soil-3 was taken from Krishan River bane, near Gadwal (239 meters above mean sea level). Angiosperms common in this area are: *Acacia arabica* Willd., *Acalypha indica* Linn., *Andrographis echinoides* Nees.. *Borreria hispida* K. Sch., *Calotropis* R. Br., *Heliotropium indicum* Linn., *Pavonia zeylanica* Cav., *Prosopis julifera* DC., *Pulicaria angustifolia* DC., *Tephrosia purpurea* Pers., *Xanthium strumarium* Linn. and *Zizyphus jujuba* Lam.

Soil-1 is a sandy clay loam type (coarse sand 33%, fine sand 26.5%, silt 16%, clay 4%, moisture 0.5%) and has 22% of water holding capacity. Soil-2 also is a sandy clay loam (coarse sand 36%, fine sand 17%, silt 17%, clay 19%, moisture 0.8% and had 24% of water holding capacity. The third soil is a sandy type having water holding capacity 27.74%. Soil samples were collected with a sterile metal soil sample tube. At least five samples were taken at random. Quantitative data of fungi and bacteria is based on number of colonies per 1g moisture free soil as estimated by dilution plate method. Soil plate method was also employed for qualitative account of fungi.

The pH was read directly with optronics pH meter while the soil temperature was recorded with soil thermograph. The moisture content was determined by heating 10g of soil at 105°C in an oven for 11 hours until a constant weight was obtained. Water holding capacity, nitrogen, organic carbon, mechanical analysis, total soluble salts (Piper, 1944), phosphorus and potassium (Jackson, 1958) were estimated in the soil samples collected from three regions for a period of one year (1985 to 1986). These factors were correlated with the microbial numbers employing suitable statistical method.

Results

The data of fungal and bacterial numbers, the physico-chemical factors estimated and the statistical data have been given in Tables 1, 2 and 3 respectively.

From Table 1 it is clear that there is definite seasonal variation in the fungal and bacterial numbers of three soils. The fungal counts were very low during summer months, however, the highest fungal numbers were found from October to November in one or the other soil. The highest bacterial counts were recorded in monsoon. The three soils did not differ significantly in their moisture content (F ratio: 1: 994). Maximum moisture being in soil-2 followed by soil-1. More percentage moisture was recorded from June to August in all the

Table 1—Fungal and bacterial numbers in thousands per 1g moisture free soil

Month	S1		S2		S3	
	F	B	F	B	F	B
June	90	193	80	5460	112	4100
July	100	220	60	2280	125	8800
August	100	4260	60	1540	130	8880
September	80	3420	00	1830	122	8200
October	120	3840	110	2590	130	6500
November	220	2850	110	1220	120	8150
December	100	1260	60	1280	120	6400
January	50	1920	20	2130	100	510
February	50	1660	40	2180	40	1230
March	30	1110	50	2010	80	1520
April	42	1770	60	1530	90	1640
May	20	2811	40	5030	90	3 50

*S1 = Soil-1
*S2 = Soil-2
*S3 = Soil-3

three soils. From the statistical data it is evident that the percentage moisture has a significant correlation with the fungal numbers in soil-1 and 3, respectively. The bacterial numbers of soil-3 showed significant correlation with the percentage moisture. Higher temperatures were recorded in the month of May and early June and this factor differed significantly in the soils (F-ratio: 6.834). Temperature did not show any significant correlation with the fungal and bacterial numbers of three soils. The three soils differed significantly in their pH values. Both soil-1 and 2 had a pH range between 6.6-7.3, while soil-3 has 8.0-8.4. The monthly fluctuations were also observed. pH had a significant correlation with fungal numbers in soil-1 and with the bacterial numbers in soil-2, respectively. Highest organic carbon has been recorded in soil-2 followed by soil-1 and the minimum being in soil-3. All the three soils differed significantly for their organic carbon (F-ratio 250 399). This factor seems to have influenced fungal and bacterial numbers indirectly. Available phosphorus was more in soil-2 followed by soil-3 and the amounts of phosphorus did not differ significantly (F-ratio 2:162). The bacterial numbers of soils 2 and 3 were significantly correlated with the available phosphorus. Available potassium differed significantly in three soils (F-ratio: 4:848) and this factor did not show significant correlation with the microbial numbers. Available calcium was more in soil-3 and the amounts of available calcium in three soils differed significantly (F-ratio: 29:299). Statistically available calcium showed significant correlation with the bacterial numbers of soil-3 only. Soil-2 had the maximum amount of nitrogen followed by soil-1 and total nitrogen of the three soils differed significantly (F-ratio: 49:068). The bacterial numbers of soil-2 and 3 showed significant correlation with the total nitrogen. Soil-2 had the maximum total soluble salts and the amounts of total soluble salts in three soils differed significantly (F-ratio: 72:028). Both the fungal and bacterial numbers failed to show significant correlation with the total soluble salts The chlorides were present in traces in three soils. Both the forest soils which are found to support good angiospermic vegetation harboured more fungi than river bank soil which has faced frequent soil erosion besides being supported by less vegetation.

Discussion

Inspite of having a constellation of physico-chemical and biological factors still terrestrial ecosystem such as soil seems to be a dynamic medium for fungi and bacteria. The forest soil of Amrabad, Mannanoor and Krishna River bank soil in the present investigation were not explored for microbiological aspects earlier. The present data confirmed that the scrub jungle forest and river bank soils were influenced by the physico-chemical factors hence showed marked seasonal variation. In the present study the regular low fungal counts during summer and two fungal peaks in winter and monsoon revealed the effect of season. However, the bacterial numbers were also high in monsoon but not in winter indicating that the bacteria present in soil were not antagonistic to the fungi. The two fungal peaks for forest soil can be ascribed to the availability of nutrients and monthly fluctuations and other physico-chemical factors. It is obvious from the present data that the higher number of fungi present during winter were because of the availability of moisture, sufficient nutrients and low temperature, while the high temperature and drought situations are the limiting factors in summer. Moisture seems to influence fungal and bacterial numbers indirectly. In the present investigation a temperature range between 26% to 37°C favoured the fungal numbers favourably. In conclusion, it is stated that most fungi have rather a wide range of pH tolerance, while an exceptional pH outside the range of some fungi may be the eliminating factor and with in the range small changes may not have such a great effect. Organic matter along with other factors showed positive influence on the microbial biomass and their distribution. Nitrogen, phosphorus and potassium and their fluctuations showed greater impact on the fungi and bacteria. Soil-1 and 2 which have supported luxuriant vegetation harboured greater number of fungal species than soil-3 which has least fertility. Further notable amounts of clay were found in two forest soils than the river bank soil. Thus it is concluded that the bacterial and fungal numbers along with qualitative changes in fungal flora are controlled by physico-chemical and biotic factors although some of them

Table 2—Physico-chemical

Month	% moisture			pH			Temperature in °C			% organic Carbon		
	1	2	3	1	2	3	1	2	3	1	2	3
June	9.3	14.4	1.8	6.8	7.3	8.2	42	26	39	0.55	3.1	0.25
July	8.24	11.33	2.8	6.6	7.3	8.1	30	27	35	0.66	3.1	0.26
August	8.9	10.3	7.4	6.6	7.1	8.2	25	24	30	0.78	2.6	0.23
September	1.4	6.2	6.2	6.6	7.2	8.0	37.5	27	36	0,62	3.1	0.23
October	2.4	5.6	6.0	6.7	7.1	8.2	35	29	37	0.74	2.8	0.10
November	8.8	7.5	6.2	6.6	6.9	8.3	27	26.5	34.5	0.85	2.6	0.10
December	1.9	2.3	1.8	6.7	7.0	8.3	28	26	31	0.97	2.2	0.10
January	1.85	2.7	1.6	6.8	6.8	8.2	27	22.5	33	0.84	2.2	0.10
February	1.4	2.9	1.3	6.9	6.9	8.2	32	24	33	0.92	2.3	0.10
March	1.25	3.35	1.8	6.8	7.0	8.3	32	37	36	0.66	1.8	0.13
April	0.3	2.0	1.8	6.7	7.0	8.4	37	44	32	0.82	2.1	0.14
May	1.05	2.9	2.85	6.8	7.3	8.4	41	30	40	0.86	2.3	0.14

Table 3—Correlation Coefficients ('r') and their calculated ('t') values obtained between physical-chemical factors and microbial number

Factors	S1		S2		S3	
	B	F	B	F	B	F
% Moisture	r=0.425 t=1.484	r=0.706* t=3.148	r=0.266 t=0.874	r=0.335 t=1.124	r=0.749 t=3.571	r=0.855* t=5.227
Temperature—	r=0.036 t=0.115	r=0.404 t=1.397	r=0.062 t=0.197	r=0.012 t=0.039	r=0.088 t=0279	r=0.014 t=0.045
pH	r=0.563 t=2.155	r=0.618* t=2.484	r=0.622 t=2.519	r=0.235 t=0.766	r=0467 t=1671	r=0.322 t=1.076
% Organic Carbon	r=01.66 t=05.33	r=0.034 t=0.109	r=0.280 t=0.921	r=0.573 t=2.208	r=0.469 t=1.677	r=0.405 t=10.43
Available P	r=0479 t=1.724	r=0.187 t=0.601	r=0.620* t=2.498	r=0.328 t=1.099	r=0591* t=2.317	r=0.514 t=1.894
Available K	r=0.032 t=0.101	r=0.029 t=0.092	r=0.222 t=0.720	r=0485 t=1.756	r=0418 t=1.456	r=0.214 t=0.693
Available Ca	r=0.162 t=0.518	r=0.109 t=0.347	r=0.436 t=1.533	r=0.530 t=1.974	r=0.620* t=2.497	r=0.448 t=1.583
Total N	r=0.367 t=1.249	r=0.334 t=1.120	r=0.777* t=3.900	r=0.060 t=0.191	r=0.716 t=3.241	r=0564 t=2.158
Total soluble salts	r=0.513 t=1.888	r=0.229 t=0.744	r=0524 t=8.947	r=0.335 t=1.123	r=418 t=1.458	r=0249 t=0.813

S1 — Soil-1 S2 — Soil-2 S3 — Soil-3

*Significant at 5% level.

factors of three soils

Phosphorus in PPM			Potassium in PPM			Calcium in mg			Total N in mg			Total soluble Sa ts		
1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
0.2	4 0	1.8	14.1	29.4	25.0	50.5	177.6	50.5	13.0	27.6	6.4	8.3	23.0	14.0
0.2	2.0	1.8	16.9	28.0	24.8	60.6	172.3	52.0	17.2	20.0	7.6	8.9	21.7	14.1
0.2	0.2	2.0	18.0	26.6	25.2	60.6	140.4	52.0	10.2	11.7	9.9	7.6	19.2	14.0
0.2	0.2	2.0	16.9	30.8	25.2	44.7	167.0	51.5	10.6	17.2	7.8	7.6	17.2	14 0
0.2	0.2	2.0	21.1	21.1	0.26	23.5	140.4	50.5	12.3	14.9	5.6	5.1	17.28	10.1
0.2	0.2	0.2	23.5	21.1	2.265	81.9	145.7	50.0	13.0	16.0	4.9	7.04	19.2	12.2
0.2	0.2	0.2	19.7	23.8	0.250	55.3	135.1	50.0	12.0	18.0	4.7	10.2	14.0	10.2
2.0	2.0	0.2	50.2	12.7	0.270	129.5	103.2	49.0	18.0	13.8	4.6	7.0	14.7	10.2
2.0	2.0	0.4	14.1	13.3	11.3	50.0	119.1	50.0	13.3	17.3	4.8	8.32	16.0	11.5
2.0	0.2	0.1	15.5	15.5	11.3	44.7	103.2	49 0	12.0	16.4	4.4	7.0	12.1	11.0
0.2	4.0	0.2	18.3	12.7	0.266	44.7	119.1	46.0	14.8	18.01	4.3	38.9	14.0	11.4
0.2	4.0	0.2	16.9	21.1	0.265	50.0	151.0	44.0	16.9	20.7	4.1	8.3	19.2	11.5

exhibited a significant influence. The present investigation has shown that the common soil fungal flora has been represented by *Apergillus*, *Alternaria*, *Cladosporium*, *Curvularia*, *Cunninghaemella*, *Drechslera*, *Fusarium*, *Humicola*, *Monodictys*, *Mucor*, *Penicillium*, *Phoma*, *Pythium*, *Rhizopus*, *Syncephalastrum*, *Thielavia* and *Trichoderma*. Aspergilli are not only dominant but also common in the soils under study. Penicillia dominated the winter soils amply while the Aspergilli were more in summer. In monsoon and winter months the fungal composition changed, with the appearance of many Mucorales, Ascomycetes and Fungi-Imperfecti over and above the Aspergilli and Penicillia. Similar dominance was noted by Manoharachary (1977), Moubasher and Dohloab (1970), Ramarao (1970) and Wicklow and Carrol (1981). Seventy two fungal speceis were isolated and identified up to species level. The present data forms new information to the microbial ecology of semi-arid tropical soil.

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