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Microfungal Biomass in the Understorey Soils of Some Arid Zone Trees

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Abstract: Agar film technique was used to study the ecology of microfungal biomass and efficiency of carbon immobilization in the understorey soils of *Acacia tortilis*, *Azadirachta indica*, *Prosopis cineraria* and *Prosopis juliflora*. The tree species play a major role in the population and the growth of microfungal hyphae in their understorey soils. *A. indica* and *P. cineraria* understorey soils recorded higher microfungal biomass and more efficient immobilization as compared to those recorded by *A. tortilis* and *P. juliflora*.

Key words: Microfungal biomass, carbon immobilization, trees.

Micro-organisms, especially in numbers, vary more widely in desert soils than in any other climatic zone (Rao, 1984). The population of microorganisms in aridisols are generally low as compared to any other tropical soil, mainly due to poor vegetation cover which is the result of erratic and scanty rainfall. The decomposer community function is often compared to a station through which, sooner or later, all carbon originating from dead organic material passes (Jenkinson and Ladd, 1981).

Microfungi are considered to be one of the most important microbial decomposers dominating microbial biomass and activity in many types of soil (Kjoller and Struwe, 1982; Behera *et al.*, 1990; Basu *et al.*, 1993). The review of the literature (Kjoller and Struwe, 1982) indicates, that through microfungal, biomass have been adequately investigated in different temperate soils, however, reports from tropical soils are scanty. Some information about microfungal biomass in some Indian tropical soils are available from the investigations of Dash *et al.* (1985), Behera *et al.* (1990), Basu *et al.* (1991, 1992, 1993).

However, the ecological approach to microfungal status to understorey soils of some arid zone trees was not covered. Hence, in the present study, an attempt was made to estimate the microfungal biomass and fungal carbon to soil organic carbon ratio in the understorey soils of four arid zone trees.

Methodology

Soil samples were collected aseptically (Parkinson *et al.*, 1971) in sterilized polythene packets at 0 (0-2), 15 (15-17) and 30 (30-32) cm depths under *A. tortilis*, *A. indica*, *P. cineraria* and *P. juliflora* at the end of monsoon (September last week). Necessary care was taken to select five uniform trees in each species in the New Campus area of JNV University. All the trees were in and around the ploughed, rainfed cropping fields with similar cropping operations. Soil samples were pooled species,depth wise and from sub-samples, some

Table 1. Selected characteristics of the understorey soils of some arid zone trees

Tree species	Soil depth (cm)	Soil moisture (%)	pH	EC at 25°C (mmohs)	Organic carbon (mg 100 g^{-1})	Total nitrogen (mg 100 g^{-1})	Available phosphorus (mg 100 g^{-1})
Acacia tortilis	0	6.7	7.94	0.1317	315	81.25	16.44
	15	10.5	8.15	0.1343	315	53.13	9.90
	30	11.5	8.50	0.1032	189	24.38	9.19
Azadirachta indica	0	8.8	7.83	0.1633	168	103.13	15.75
	15	12.3	8.18	0.1330	112	43.75	13.68
	30	12.5	8.13	0.1152	118	50.63	12.42
Prosopis cineraria	0	7.6	7.93	0.4272	375	109.38	14.28
	15	11.2	8.25	0.2296	315	30.00	13.29
	30	12.3	8.41	0.2256	255	31.88	14.66
Prosopis juliflora	0	6.0	8.23	0.1441	273	87.50	11.50
	15	10.2	8.35	0.1032	129	43.75	9.69
	30	11.3	8.39	0.0947	136	37.50	10.94

selected soil characteristics and microfungal biomass were determined. Prior to soil analysis, one part of subsample was oven dried to determine moisture content and other part was air dried, passed through 0.5 mm sieve and analyzed for pH, EC (1:5 ratio solution), organic carbon, total nitrogen and available phosphorus (Allen *et al.*, 1976).

For estimation of microfungal biomass, the agar film technique of Jones and Mollison (1948) was used. The individual hyphal length (x 100) was measured by camera lucida and diameter with precalibrated ocular micrometer. For each soil sample, five agar films were prepared and all hyphae occurring in the film were counted and measured for length and diameter. Hyphal length and diameter were converted to biovolume (Parkinson *et al.*, 1971). Biovolume data were converted into fresh weight considering the fungal protoplasmic specific gravity of 1.1 (Bakken and Olsen, 1983). Using the model composition of Baath and Soderstrom (1979), the amount of carbon, nitrogen and carbon ratio with total available in the soils were computed. Data were analyzed statistically for variance (Gomez and Gomez, 1984).

Results and Discussion

The understorey soil analysis of *A. tortilis*, *A. indica*, *P. cineraria* and *P. juliflora* for soil pH, electrical conductivity, organic carbon, total nitrogen and available phosphorus revealed a general trend of reduction of all parameters with increasing depth except pH and soil moisture, where reverse trend was observed. Higher pH value of 8.39 was in *P. juliflora* soil at 30 cm. Ec, organic carbon and total nitrogen, were higher in *P. cineraria* soils, whereas, available phosphorus in *A. indica*. Soil moisture content ranged between 6.0-8.8, 10.2-12.3, 11.3-12.5% at 9, 15 and 30 cm depths, respectively. *P. juliflora* soils were less moist, whereas, *A. indica* soils were comparatively wet (Table 1).

Maximum total length of hyphae at 30 cm depth was recorded in soil under *A. indica*, minimum being in *A. tortilis*. With increasing depth, the total hyphal length decreased in the soil under *A. tortilis* and *P. cineraria*, whereas a reverse trend was recorded under *A. indica* and *P. juliflora*. The analysis of variance of total hyphal length revealed that the tree species play a major role in the growth of micro-fungal hyphae in their understorey soils. Variation due to depth was non-significant. The analysis of hyphal length at different diameter classes revealed higher concentration in the category of 12.1-16.0 μ and the dominance was clear at 30 cm depth than at the surface (Table 2).

Similar to total hyphal length with increasing depth, the density decreased in the understorey soils of *A. tortilis* and *P. cineraria*, whereas a reverse-trend was

Table 2. Length and diameter class importance of fungal hyphae of the understorey soils of some arid zone trees

Tree species	Soil depth (cm)	Total hyphal length cm g^{-1} (x ± SD)	Percentage of hyphal length at different diameter classes					
			4-8	8.1-12	12.1-16	16.1-20	20.1-24	>24
Acacia tortilis	0	102.70 (±36.83)	1.61	22.54	27.81	28.01	9.61	10.42
	15	81.80 (±39.58)	16.07	21.46	22.66	20.48	11.69	7.65
	30	67.52 (±34.06)	14.38	6.71	57.42	12.92	8.57	–
Azadirachta indica	0	138.40 (±58.12)	–	11.71	41.62	38.87	4.45	3.35
	15	76.60 (±33.34)	–	1.25	37.46	45.88	11.93	3.48
	30	183.18 (±78.09)	0.70	20.32	35.88	28.71	5.98	8.41
Prosopis cineraria	0	152.08 (±34.35)	8.50	23.02	20.52	22.31	14.47	11.20
	15	95.88 (±41.55)	11.20	13.56	23.63	19.74	6.13	24.96
	30	90.45 (±28.22)	1.80	4.42	52.57	17.72	17.50	6.00
Prosopis juliflora	0	78.68 (±29.07)	17.82	10.17	28.45	27.12	16.44	–
	15	92.83 (±46.06)	6.84	28.06	30.41	34.69	–	–
	30	112.20 (±28.09)	4.65	23.98	51.06	11.58	–	–

Mean sum squares: .
Trees = 6928.54*, Error a = 1603.80, Depths 5674.06^{ns}, Interactions 5849.05* and Error b 1902.38
* = Significant at 5% level: ^{ns} = Non-significant

Table 3. Hyphal density, diameter and biomass in the understorey soils of some arid zone trees

Tree species	Soil depth (cm)	Density (No. g^{-1}) (x ± SD)	Hyphal diameter (mm) (x ± SD)	Biomass mg g^{-1} Fresh wt. (x = SD)	Biomass mg g^{-1} Dry wt. (x ± SD)
Acacia tortilis	0	1440 (±384.71)	18.141 (±3.90)	295.738 (±132.08)	62.105 (±27.74)
	15	1200 (±469.04)	16.111 (±5.37)	214.857 (±159.07)	45.120 (±33.41)
	30	960 (±167.33)	15.493 (±1.67)	136.153 (±76.10)	28.592 (±15.98)
Azadirachta indica	0	1920 (±672.31)	17.528 (±1.20)	377.638 (±194.40)	79.304 (±40.82)
	15	1440 (±517.69)	19.280 (±2.62)	230.191 (±66.18)	48.340 (±13.90)
	30	2240 (±684.11)	17.359 (±2.23)	474.758 (±200.88)	99.699 (±42.19)
Prosopis cineraria	0	2200 (±316.24)	17.83 (±3.36)	408.540 (±115.58)	85.793 (±24.27)
	15	1040 (±260.77)	18.91 (±4.68)	337.800 (±228.87)	70.938 (±48.06)
	30	960 (±260.77)	18.74 (±2.43)	280.237 (±131.49)	58.850 (±27.61)
Prosopis juliflora	0	1360 (±328.63)	16.17 (±1.93)	180.623 (±83.92)	37.931 (±17.62)
	15	1480 (±657.26)	14.65 (±1.12)	174.302 (±94.38)	36.603 (±19.82)
	30	1600 (±200.00)	16.64 (±2.23)	268.927 (±90.92)	56.475 (±19.09)

Mean sum squares:			
Trees	1170669**	23.43034^{ns}	108057.7**
Error a	141222	7.480306	17342.08
Depths	1000668*	0.64161^{ns}	23528.5^{ns},
Interactions	859332*	7.222982^{ns}	32879.83ns
Error b	208000	9.572266	22702.08

* = Significant at 5% level: ns = non-significant.

recorded in *A. indica* and *P. juliflora*. The tree species, soil depth and their interaction play significant role in the variation of hyphae population in the soil (Table 3). However, variation in the diameter due to tree species and soil depth appears to have non-significant role. The understorey soils of *P. juliflora* possessed thin hyphae.

Microfungal biomass (fresh and dry weight) was higher in *A. indica*, followed by that in *P. cineraria*, *A. tortilis* and *P. juliflora*. Tree species were the main source

Table 4. Microfungal carbon, nitrogen and ratio to understorey soils of some arid zone trees

Tree species	Soil depth (cm)	Microfungal carbon ($\mu g\ g^{-1}$)	Microfungal nitrogen ($\mu g\ g^{-1}$)	Fungal carbon/ soil carbon
Acacia tortilis	0	27.947 (±12.48)	2.298 (±1.03)	0.0088
	15	20.304 (±15.03)	1.669 (±1.24)	0.0065
	30	12.866 (±7.19)	1.058 (±0.59)	0.0068
Azadirachta indica	0	35.687 (±18.37)	2.934 (±1.51)	0.0212
	15	21.753 (±6.25)	1.789 (±0.514)	0.0194
	30	44.864 (±18.98)	3.689 (±1.56)	0.0380
Prosopis cineraria	0	38.607 (±10.92)	3.174 (±0.90)	0.0103
	15	31.922 (±21.63)	2.625 (±1.78)	0.0101
	30	26.482 (±12.43)	2.177 (±1.02)	0.0080
Prosopis juliflora	0	17.069 (±7.93)	1.403 (±0.65)	0.0063
	15	16.471 (±8.92)	1.3547 (±0.73)	0.0013
	30	25.414 (±8.59)	2.090 (±0.71)	0.0190

of variation in the microfungal growth. To understand the amount of carbon immobilized and its efficiency, the ratio of fungal carbon to soil organic carbon was computed. The soils of *A. indica* exhibited higher values indicating a favorable and fast nutrient recycling, followed by that of *P. cineraria*. However, *A. tortilis* and *P. juliflora* soils recorded lower values indicating slower nutrient recycling (Table 4).

Agar film and other direct microscopic observation techniques are generally to underestimate the soil microbial biomass (Dash *et al.*, 1985). There are also difficulties in distinguishing physiologically active hyphae from dead ones. Nevertheless, fungal length and biomass in soil are commonly estimated using microscopic measurements in the agar films (Kjoller and Struwe, 1982).

Dash *et al.* (1985), Behera *et al.* (1991), Basu and Behera (1993), Basu *et al.* (1993) have documented the microfungal hyphae length, diameter, biomass, microbial carbon and microfungal carbon to organic carbon ratio. On comparison, it was clear that in the present study, the values estimated were