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Relationship Between Soil Microbial Activities with Organic and Conventional Farming Systems

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Abstract: Soil micro biota exhibit wide variation in population which is dependent on various soil parameters. The total microbial biomass of the conventional rice, pulses and vegetable field was calculated to be 82%, 75% and 99% (winter) and 81%, 78% and 95% (rainy) and 83%, 75% and 87% (summer) than that of the organic one as estimated from conventional method. Again total microbial biomass as obtained from fumigation method (µg/g soil) were 204.61 (organic) and 165.72 (conventional). Thus fumigation methods showed marginal higher microbial biomass (µg/g soil) [204.61 (organic) and 165.72 (conventional)] than conventional method [203.26 (organic) and 164.85 (conventional)]. Nevertheless, organic farming showed higher microbial biomass independent of crop and sampling periods.

Key words: Organic farming % Conventional farming % Bacterial biomass % Fungal biomass

INTRODUCTION

Biomass estimation is very important for assessing the functional role of microbes. Fungi in the soil exist as actively growing hyphae, resting mycelium, dormant spores and sclerotia. Morphological diversity of fungi in soil imposes difficulty for investigating its biomass. To estimate the amount of fungal material in soil, many workers have resorted to count obtained by use of the dilution plate technique. The counts obtained by soil dilution plate method allow to estimate the spore content of the soil, but do not allow one to obtain any idea of the amount of fungal mycelium in a given weight or volume of soil. For determination of fungal biomass in soil, it is a common practice to determine the total hyphal length and to calculate biomass from these values. The agar film technique [1] is a widely used technique for determination of hyphal length and has been recommended by IBP [2]. Microbial biomass levels, averaged across sampling depths and treatments, differed significantly between sampling periods [3]. Microbial biomass levels were generally high in treatments planted to red clover and least in the legume/cash grain rotation planted to oats and red clover. Microbial biomass carbon increased significantly at 1% level from May to the second sampling date (September) in soil. Microbial biomass carbon in September compared averaged 52.5, 68.7 and 18.2% greater under cereal, vegetable and pastures soil, respectively [3].

MATERIALS AND METHODS

The study was conducted during March 2007 to January 2009 in three different seasons. Soil samples were collected from rice, pulses and vegetable crop field under both organic and conventional farming systems located in Khurda district of Orissa state, India. The dilution plate count technique [4] was used to calculate bacterial biomass. The fungal biomass was estimated using the standard protocol [5]. The standard Fumigation-Incubation (FI) method [6] used for determining the total microbial biomass.

RESULTS

The seasonal and depth wise variation of bacterial and fungal biomass (µg/g soil) for all the study sites has been presented in Table 1. Both bacterial and fungal

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Table 1: Total microbial (T) biomass, Bacterial (B) and Fungal (F)) (µg/g soil) of the organic (O) and conventional (C) farming systems

			Soil Depth (cm)									
			0-4		4-8		8-12		12-16		16-20	
			Farming Systems									
Crops			O	C	O	C	O	C	O	C	O	C
Rice	Winter	F	732.71±25.54	612.12±23.11	627.61±43.91	572.43±24.12	608.23±41.2	481.23±52.21	552.95±47.33	421.01±0.0025	480.90±0.0578	383.01±0.031
		B	0.97±0.001	0.61±0.002	0.91±0.014	0.56±0.001	0.86±0.011	0.54±0.001	0.81±0.001	0.51±0.001	0.76±0.011	0.45±0.012
		T	733.67	612.71	628.50	572.96	609.06	481.74	553.71	421.51	481.66	383.55
	Summer	F	44.90±0.91	23.18±0.12	53.90±0.14	41.20±0.12	66.40±0.19	55.31±0.17	78..08±0.14	59.03±0.78	82.03±0.24	68.70±0.21
		B	0.19±0.002	0.17±0.011	0.20±0.013	0.18±0.002	0.24±0.001	0.21±0.001	0.25±0.011	0.21±0.011	0.26±0.011	0.23±0.021
		T	45.09	23.35	54.10	41.38	66.64	55.51	79.05	59.51	82.56	68.93
	Rainy	F	127.90±10.51	118.70±11.03	148.30±22.12	137.80±11.34	162.70±19.51	141.10±14.12	171.50±13.11	141.81±13.14	180.60±23.05	151.80±10.21
		B	0.88±0.014	0.53±0.013	0.80±0.011	0.57±0.002	0.83±0.011	0.50±0.011	0.74±0.001	0.51±0.001	0.69±0.012	0.40±0.001
		T	128.78	119.23	149.10	138.37	163.53	141.60	172.24	142.31	181.29	152.21
Pulses	Winter	F	468.30±48.52	387.50±32.12	483.04±40.04	364.10±10.89	407.40±27.11	312.01±14.23	378.60±24.34	271.02±31.12	288.50±30.04	214.01±15.89
		B	0.89±0.001	0.57±0.011	0.80±0.013	0.50±0.014	0.83±0.001	0.51±0.011	0.75±0.015	0.48±0.001	0.69±0.011	0.45±0.001
		T	469.19	388.07	484.21	364.60	408.23	312.51	379.35	271.48	289.19	214.45
	Summer	F	32.41±0.42	28.70±0.23	38.70±0.41	29.10±0.31	43.00±0.51	31.40±0.015	45.10±0.001	35.01±0.42	48.00±0.16	38.01±0.17
		B	0.19±0.011	0.13±0.001	0.19±0.002	0.18±0.001	0.23±0.011	0.19±0.001	0.24±0.013	0.21±0.012	0.25±0.001	0.21±0.001
		T	32.59	28.83	38.89	29.28	43.23	31.59	45.34	35.21	48.25	38.21
	Rainy	F	80.20±2.16	71.00±1.08	126.8±20.05	101.50±10.01	141.00±13.89	118.00±40.04	172.01±39.05	134.53±12.56	176.01±24.04	139.01±17.04
		B	0.85±0.012	0.57±0.001	0.83±0.011	0.53±0.001	0.81±0.001	0.49±0.011	0.76±0.013	0.47±0.012	0.61±0.011	0.36±0.001
		T	81.05	71.57	127.63	102.03	141.81	118.49	172.76	134.47	176.60	139.36
Vegetable	Winter	F	313.40±60.05	278.00±21.08	291.50±30.01	261.20±21.89	271.81±15.56	212.00±40.05	252.20±31.01	189.00±21.08	234.00±23.01	176.00±32.04
		B	0.88±0.011	0.56±0.011	0.74±0.001	0.44±0.001	0.69±0.001	0.40±0.001	0.62±0.001	0.38±0.012	0.59±0.012	0.34±0.001
		T	314.28	278.56	292.24	261.64	272.49	212.40	252.82	189.38	234.59	176.34
	Summer	F	23.20±1.28	21.00±3.01	29.30±3.14	22.80±2.13	31.80±1.13	29.80±1.15	33.60±2.11	31.04±1.89	38.71±1.14	32.02±1.51
		B	0.17±0.012	0.12±0.001	0.19±0.013	0.17±0.011	0.20±0.001	0.17±0.001	0.21±0.014	0.19±0.011	0.23±0.001	0.20±0.001
		T	23.37	21.12	29.49	22.97	32.00	29.97	33.81	31.19	38.93	32.20
	Rainy	F	62.20±4.87	53.00±6.51	93.30±13.71	71.00±11.12	124.50±3.17	108.00±13.04	134.00±20.07	115.01±14	138.00±13.05	119.00±13.79
		B	0.82±0.001	0.50±0.012	0.65±0.001	0.34±0.001	0.63±0.012	0.38±0.013	0.61±0.001	0.32±0.012	0.59±0.011	0.32±0.001
		T	63.02	53.50	93.95	71.34	125.13	108.38	134.61	115.32	138.59	119.32

biomass was observed to be highest in winter followed by rainy and least in summer. Since the efficiency of dilution plate count technique for total bacterial enumeration is around 30%, the total bacterial biomass (µg/g soil) will be around 3 times higher. Thus, the total bacterial biomass (average) was found to be 2.58±0.48, 2.37±0.14 and 2.11±0.12 µg/g soil (winter) in organic rice, pulses and vegetable crop fields. The total average bacterial biomass in conventional rice field in winter, rainy and summer was found to be 1.59±0.54, 1.51±0.31 and 0.68±0.01 µg/g soil, respectively. The bacterial biomass of the conventional rice field was found to be 62%, 64% and 88% in winter, rainy and summer seasons than that of organic rice field soil. The corresponding percentage of bacterial biomass in conventional pulses and vegetable was found to be 63% and 57% in winter season. The total (average) fungal biomass (µg/g soil) was found to be highest in winter and lowest in summer. The fungal biomass of conventional rice field was found to be 82% and 83% in winter and summer seasons respectively than organic rice field soil.

The total microbial biomass was obtained by conventional method (dilution plate method for bacteria and agar film technique for fungi) by adding up bacterial and fungal biomass and fumigation technique by evolution of excess CO_2-C and thereby converting it to total microbial biomass.

Considering 30% efficiency of dilution plate method the total microbial biomass was calculated. The total microbial biomass of the conventional rice, pulses and vegetable field was calculated to be 82%, 75% and 99% (winter) and 81%, 78% and 95% (rainy) and 83%, 75% and 87% (summer) than that of the organic one as estimated from conventional method. Maximum variation in the microbial biomass between two farming systems was observed in pulses fields and minimum in vegetable fields.

The average total microbial biomass (µg/g soil) obtained by fumigation method (Table 2) was found to be highest in winter and minimum in summer. The total microbial biomass of the conventional rice, pulses and vegetable field was found to be 82%, 76% and 82% (winter), 82%, 79% and 82% (rainy) and 83%, 75% and 67% (summer) than organic one.

Table 2: Total microbial biomass (µg/g soil) of the study sites measured by fumigation technique.

		CO_2-C evolved		Biomass Carbon		Total Microbial Biomass	
Crop	Season	Organic	Conventional	Organic	Conventional	Organic	Conventional
Rice	Winter	120.03±8.76	99.01±12.03	271.71±11.34	223.32±10.25	603.31±12.78	495.71±11.89
	Summer	13.05±1.07	10.05±1.11	29.71±1.03	22.61±1.02	66.05±1.31	50.14±2.56
	Rainy	32.02±1.89	28.01±2.11	72.40±1.56	63.02±3.11	160.8±31.05	139.91±13.67
Pulses	Winter	81.06±1.08	62.30±1.01	183.07±14.06	140.02±12.89	407.08±14.34	311.03±21.08
	Summer	8.43±1.03	6.06±2.15	19.01±2.01	14.08±1.03	42.03±3.06	33.02±1.09
	Rainy	28.16±1.87	22.79±0.75	63.08±8.01	51.04±5.02	141.07±12.07	114.03±12.09
Vegetable	Winter	55.01±3.14	44.09±5.04	123.08±12.04	101.01±13.08	274.09±22.04	224.06±35.08
	Summer	6.04±0.13	5.05±0.51	14.04±1.81	12.05±1.02	31.09±2.02	27.08±2.03
	Rainy	22.05±1.03	18.09±1.21	50.07±8.03	42.05±4.01	112.05±10.34	94.04±11.02

DISCUSSION

The biomass of microbes is a direct indicator of the metabolic processes operating in soil. Soil with high mineralization efficiency generally harbours a robust biomass of microbes of diverse type. Therefore, measurement of biomass is required to determine the soil productivity potential as well as to predict the future changes in soil layers.

Even though various types of microbes ranging from viruses to microalgae and protozoa inhabit soil, soil fertility is significantly influenced by the density and diversity of bacteria and fungi. Thus the determination of biomass of bacteria and fungi in different soil layer provides information on the soil fertility and soil health.

Comparison of the biomass of microbes in this experiment indicated that the bacterial biomass was less in comparison to fungal biomass in all cases. The total microbial biomass was more in all organic fields than conventional fields irrespective of season, depth, crop, farming system and methods employed. The total microbial biomass was found to be more in organic fields irrespective of methods employed. The results are in agreement with earlier findings [7]. Highest microbial biomass C in organic soil and lowest in conventional monoculture system were also recorded by previous workers [7].

It may be noted that the growth vis-à-vis biomass of microbes in soil is determined by soil organic carbon content which is higher in the organic field than in the conventional one. It has already been observed that the organically managed soil not only has high load of mineralizable carbon but also show minimum seasonal fluctuation of the organic reserve facilitating its availability to microbes and enhancing microbial biomass.

Microbial biomass was more in rainy than summer in both the farming systems supporting of the earlier results [8] where an increase in soil microbial biomass C from May to September was indicated. Microbial biomass estimated as C_{mic} was found to be consistently higher in the organic cropping system than conventional one [9]. Soil microbial biomass was higher in organic than conventional agricultural system [10]. However, comparison between rainy and winter period showed that the microbial biomass was the highest in winter. It may be noted that microbial growth is not only determined by the availability of organic carbon but also by several other physicochemical factors such as soil pH, soil moisture content, oxygen availability and temperature. The reduced growth of the microbes in summer may be attributed to the unfavourable soil temperature and reduced moisture level. Growth regulation in rainy months may be attributed to the oxygen limitation since during this period the soil is less porous and saturated with water limiting the oxygen availability.

The average bacterial biomass (µg/g soil) was found to be 0.585 and 0.374 for organic and conventional field as a whole respectively. These figures were calculated to be 1.755 and 1.123 considering the 30% efficiency of dilution plate method. But Bacterial biomass can be recalculated by subtracting fungal biomass from total microbial biomass. When this was applied to the present investigation, average bacterial biomass was found to be 1.936 and 1.239 for organic and conventional fields taken together. These estimations are 3.309 (organic) and 3.31 (conventional) times higher than those obtained from dilution plate count. In the other way this reveals the efficiency of dilution plate method as approximately 33% which agrees to the views already mentioned. As earlier stated, that estimates of dilution plate count account only viable bacterial cells of the total bacterial population. Thus 33% efficiency of dilution plate method directly proves 33% of total bacterial cells to be active. This agrees with the previous views that indicated that under favourable condition only 15-30% of bacterial populations are active.

The fungal biomass (µg/g soil) was found to be 202.67 (organic) and 164.48 (conventional). In the present study seasonal variation of hyphal content coincided with moisture content confirming the view of other workers [12, 13]. The variation in fungal activity to be governed more by soil moisture than any other factors [12].

The total microbial biomass (µg/g soil) as obtained from conventional method was found to be 203.26 (organic) and 164.85 (conventional). But considering 30% efficiency of dilution plate method for bacterial biomass these figures were calculated to be 204.43 (organic) and 165.67 (conventional). Again total microbial biomass as obtained from fumigation method (µg/g soil) were 204.61 (organic) and 165.72 (conventional). Thus fumigation methods showed marginal higher microbial biomass than conventional method. Fumigation technique was critically analyzed by different investigators [14]. A limitation to the use of this method as an absolute measure of biomass is that, the efficiency of fumigation is uncertain [15]. Fumigation technique underestimates microbial biomass in peat and acidic soils, as there is suppression of CO_2 evolution from fumigated soil [14]. Another major factor essential for accuracy of the technique is mineralization factor (K). A new 'K' value of 0.45 for soil microbial estimation has again readopted [16]. Further to get exact biomass value by fumigation technique, accurate estimation of CO_2 evolution is highly essential, which in present study was measured by alkali absorption technique. Efficiency of this method is reported to be less in comparison to other improved technique such as infrared gas analysis [17]. Hence above mentioned aspects are to be carefully investigated for standardization of fumigation technique to get accurate biomass in soil. Comparison was also made among the microbial biomass obtained from different crop fields with a view to examine the effect of crop on soil microbial density.

CONCLUSIONS

Irrespective of the farming system rice field soil experienced higher microbial biomass than that of the other field soils. The seasonal fluctuation of microbial biomass was not found to be influenced by crop types or farming systems. Minimum biomass of microbes was reported in the vegetable field soil. However, the most interesting thing noted in the present study was that the variation of biomass between two farming systems was found maximum in the pulses field soil than those of the other two remaining crop field soils. This may be attributed to the healthy rhizospheric microflora of legume root system than that observed in the vegetable or rice field.

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