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Effect of Organic Residues on Soil Microbial Biomass in Different Egyptian Soils

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Abstract: A green house experiment was conducted to compare the effects of different organic residues on soil microbial biomass C (C_{mic}) , N (N_{mic}) and their ratios with total C (C_{org}) and N (N_{total}) in different soils. Three types of organic residues used were farmyard manure (FYM), town refuse (TR), and sewage sludge (SS), applied separately in sandy, calcareous, and alluvial soils in various concentrations of 10t/fed, 20t/fed, and 30t/fed (1fed=0.42ha). Wheat plants were harvested after 6 weeks and the soils were analyzed for C_{mic}, N_{mic}, C_{org}, N_{total} and pH. The addition of organic residues significantly increased the size of soil microbial biomass. The biomass C and N (C_{mic} & N_{mic}) increased consistently with increasing levels of the organic residues in the soil. The FYM was found to be more effective than TR and SS in increasing microbial biomass and this sequence was observed in all the soils used. Similarly, addition of organic residues also caused significant stimulation in C_{org} and N_{total} in all soils. Also, the ratios of C_{mic}/N_{mic}, C_{mic}/C_{org} percentage and N_{mic}/N_{total} percentage were increased with increasing levels of organic residues. The soil pH was decreased significantly with the higher rates of application in all the treatments (FYM, TR, and SS) but remained unaffected at lower rates. The linear regression between different ratios under different levels of organic residues application was also calculated.

Key words: Organic residue, microbial biomass, Egypt, FYM, TR and SS

Introduction

Soil microbial biomass (SMB) is mainly responsible for organic matter transformations and nutrient cycling in soil. Long-term stubble retention, reduced tillage systems and manuring have been shown to increase microbial biomass carbon, nitrogen and microbial activity in soil (Haines and Uren, 1990; Carter and Mele, 1992).

Because it is living, the microbial biomass responds much more quickly to changing soil conditions, particularly decreases or increases in plant or animal residues, than does soil organic matter as a whole. Measurable changes in microbial biomass may thus reflect changes in soil fertility, due, for example, to changing soil management, long before such changes are reflected in changes in the total pool of soil organic matter (Brookes, 1995).

In many developing countries organic materials which include farmyard manure, sewage sludge, and town refuses are the major sources of plant nutrients, and play an important role in maintaining aggregate stability, water holding capacity and soil structure (Delibacak *et al.*, 2000; Brown *et al.*, 2000; Nkongolo *et al.*, 2000). These soil properties play an important role for increasing soil microbial biomass (Kanazawa *et al.*, 1988; Ibrahim and Shindo, 1999).

It is well-established fact that organic manure generally has beneficial effects on soil microbial biomass and microbial activity (Fraser *et al.*, 1988; Kanazawa *et al.*, 1988). The highest microbial biomass C and N contents were observed under the integrated usage of organic manure (Santhy *et al.*, 1999).

Alvarez *et al.* (1999) found that sludge applications produced an increase of the CO_2-C efflux in the field of 30-50% during summer. Microbial biomass was not affected by sludge some months after the application, but metabolic activity and organic matter mineralization were enhanced. The increase in CO_2-C emission from the soil represented 21% of the sludge C applied the year of the experiment and 15% of the C applied the year before. Consequently, an important quantity of the sludge C was retained in the soil.

Johansson, (1999) reported that long-term effects of sewage sludge amendments were monitored in a field experiment after 12 and 16 years of sludge addition. Long-term sludge addition affected several of the parameters investigated, biological as well as chemical. However, no severe negative effects on soil microorganisms were detected at these moderate levels of sludge amendment.

The present study was aimed to investigate the effect of different organic residues (farmyard manure, sewage sludge, and town refuses) on soil microbial biomass in the soils with different characteristics.

Materials and Methods

Soils: A greenhouse experiment was conducted to see the effects of different organic residues including farmyard manure (FYM), sewage sludge (SS), and town refuses (TR)) on microbial biomass C, N in different types of soils (sandy, calcareous, and alluvial). The soils used were sampled from the surface layers (0~15 cm) of respective fields/areas. Sandy soil was collected from Alabsho, calcareous soil from Nobaria, and the alluvial soil from El-Mansoura. The soils were air-dried, passed through a 2-mm sieve and stored. A subsample of the soil was also taken, from each site, and analyzed for various physico-chemical characteristics listed in Table 1.

Table 1: Characteristics of the soil used

Properties		Sandy	Calcareous	Alluvial
Particle size distribution	Coarse Sand, %	47.4	57.1	7.8
	Fine Sand, %	51	12.9	22.7
	Silt, %	0.1	26.9	41.4
	Clay, %	1.5	3.1	28.1
Texture grade		Sand	Sandy Loam	Clay Loam
Saturation %age		25.53	38.26	77.41
Total organic matter, (%)		0.27	0.75	1.98
Total N, %		0.0098	0.0213	0.0382
Total $CaCO_3$, %		0.13	33.07	3.44
EC, dS m^{-1} (Ext.1:5)		0.65	1.74	0.59
pH (in soil paste)		7.7	7.3	7.6

Organic residues used: Three organic residues used were farmyard manure (FYM), sewage sludge (SS) and town refuses (TR). The FYM was taken from the Station of Animal Production, Faculty of Agriculture, Mansoura University, the SS from Mansoura Sanitary Drainage Station, El-Mansoura

Table 2: Chemical properties of the organic residues used

Determination		Farmyard manure	Town refuse	Sewage
Total C%		16	22.3	19.8
Total N%		1.04	0.91	0.85
C:N ratio		15.4:1	24.5:1	23.3:1
Total macronutrients (%)	P	0.48	0.4	0.43
	K	2.69	0.78	0.48
Avail. macronutrients ppm	P	940	930	810
	K	3680	1970	1260
Total micronutrients ppm	Fe	3221	13452	16321
	Mn	281	267	390
	Zn	76	74	250
	Cu	18	186	312
Avail. micronutrients ppm	Fe	44	157	287
	Mn	28	34	44
	Zn	5.2	4.6	16.4
	Cu	2.3	14.5	19.8

Dakahlia Governorate, and the TR was taken from Mansoura Manufactory for organic manure, Sandob, Dakahlia Governorate. Some chemical properties of the organic residues are listed in Table 2.

Soil treatments: In 5 kg capacity plastic pots (25x16 cm^2 dia.), wheat grains (Sakha 69) were sown in sandy, calcareous and alluvial soils and three organic residues (FYM, TR, SS) were applied at three rates of 5, 10, and 15%. The mineral fertilizers N, P, K (as ammonium nitrate, single superphosphate and potassium sulphate) were added at recommended rates. Pots containing 5 kg soil were mixed with 5, 10 and 15% of all organic residues (by weight) and were irrigated with water to reach the moisture content at saturation percentage. Then left for one month to elucidate the damage on seedlings and their roots resulted from the heat of decomposition. The sowing and harvesting of wheat was done on 1st November and 15th December, respectively. After plants have been taken , the microbial biomass in the moist soil was measured immediately using fumigation extraction-method.

Soil assay and statistical analysis: Soil mechanical analysis and $CaCO_3$ % was done according to piper (1974), pH , EC, available P as by Jackson (1967), available N and K according to Hesse (1971), and available Fe, Mn, Zn, and Cu by the methods of Lindsay and Norvell (1978). Total organic carbon in soil was measured by the dichromate digestion method (Nelson and Sommers, 1982), Total nitrogen by Kjeldahl digestion (Bremner and Mulvaney, 1982). Microbial biomass carbon in soil was determined by chloroform fumigation-extraction method (CFEM) using a carbon analyzer (Wu *et al.*, 1990), and microbial biomass N by chloroform fumigation-extraction method (Brookes *et al.*, 1985)
The statistical analysis was performed according to the methods described by (CoStat software, 1991) using LSD to compare the treatment effects.

Results

Effect of organic residues on sandy soil health: The changes in soil microbial biomass C and N, total organic C and N, their ratios and soil pH as influenced by different organic residues in sandy soil are shown in Table 3.
The additions of organic residues to the soil sharply increased the microbial biomass contents of the soil. The biomass C and N (C_{mic} & N_{mic}) increased consistently with increasing levels of all the organic residues in the soil. The data exhibited that the FYM was more effective than SS and TR in its response to SMB. The results further showed that FYM addition at 30t/fed (L3) produced significant increments in the C_{mic} and N_{mic} followed by the same rates of TR and SS additions.
In addition, the results further indicated that C_{org} and N_{total} were significantly stimulated with organic residues addition in the order of 30t/fed>20t/fed>10t/fed. The C_{org} and N_{total} were increased in the organic residues in the order of FYM>TR>SS.
Further more, the ratio of C_{mic}/N_{mic} was increased with increasing levels of organic residues but these increases have no significant effects as compared with control and this increase was observed again in the order of FYM>TR>SS.
On the other hand, the applications of organic residues to the soils increased the ratios of C_{mic}/C_{org} and N_{mic}/N_{total} percentages and these percentages increased with increasing application rates. These increases in C_{mic}/C_{org} percentages were non-significant among various levels in different soils. But have significant effects in N_{mic}/N_{total} percentages and these increases with increased levels in different treatments and were in the order of FYM>SS>TR.
The results further showed that soil pH decreased significantly with the higher rates of application in all treatments (FYM>TR>SS), while lower rates have no significant effects as against the control.

Effect of organic residues on calcareous soil health: The responses of different soil properties to the addition of various organic residues at different rates in calcareous soil are given in Table 4.
The data indicated that the microbial biomass C and N contents (C_{mic} & N_{mic}) were improved significantly with the increased rates of residues levels in the relative order of FYM>TR>SS. The addition of residues at different rates caused a significant increase in C_{org} and N_{total} contents. The incorporation of FYM was found to be more effective than others in increasing the contents of C_{org} and N_{total} as compared with the control.
Further more, the ratio of C_{mic}/N_{mic} increased significantly with increasing levels of organic residues in the order of FYM>SS>TR.
The application of organic residues significantly increased the C_{mic}/C_{org} and N_{mic}/N_{total} percentages and it increased with increasing application rates. This effect displayed the trend of SS>FYM>TR.
The results further showed a slight decrease in soil pH with increasing levels of application. This decrease was found to be non-significant except the highest level of SS (30t/fed) relative to the control and it (decrease) was found in the order of SS=TR>FYM.

Effect of organic residues on alluvial soil health: The results (Table 5) exhibited that the soil microbial biomass C and N contents increased significantly with increasing application levels of organic residues . It was observed that the increase in C_{mic} was higher than N_{mic} and this increase was found in the

Table 3: Effect of organic residues on soil health in sandy soil.

Treatment		C_{mic} µg/g	C_{org} %	C_{mic}/C_{org} %	N_{mic} µg/g	N_{total} %	N_{mic}/N_{total} %	C_{mic}/N_{mic} ratio	pH
Control		16.50 f *	0.156 j	1.06 c	2.000 e	0.010 f	2.03 f	8.25 ab	7.7 a
FYM	L1	90.90 e	0.469 h	1.94 ab	10.28 d	0.035 de	2.92 de	8.84 a	7.6 ab
	L2	161.5 bc	0.782 b	2.06 bc	17.30 b	0.039 cd	4.39 ab	9.34 a	7.4 c
	L3	201.3 a	0.939 a	2.14 bc	20.40 a	0.042 c	4.84 a	9.87 a	7.4 c
TR	L1	89.60 e	0.548 g	1.64 bc	10.78 d	0.042 c	2.56 e	8.31 ab	7.6 ab
	L2	121.3 d	0.626 e	1.94 ab	14.13 c	0.049 b	2.87 e	8.58 ab	7.5 bc
	L3	172.0 b	0.743 c	2.32 abc	19.97 a	0.056 a	3.55 cd	8.64 b	7.4 c
SS	L1	79.30 e	0.430 l	1.84 ab	9.430 d	0.031 e	3.05 de	8.41 ab	7.7 a
	L2	117.6 d	0.587 f	2.00 ab	13.88 c	0.035 de	3.95 bc	8.47 ab	7.6 ab
	L3	150.5 c	0.665 d	2.26 a	17.46 b	0.042 c	4.14 bc	8.62 ab	7.5 bc
LSD	0.01	26.050	0.0134	0.7418	2.972	0.0062	0.835	3.420	0.278
	0.05	19.048	0.0098	0.5438	2.179	0.0045	0.612	2.507	0.1523

* Means with different letters, within column, differ significantly according to LSD ($P<0.05$)
L1 = 10t/fed, L2 = 20 t/fed, L3 = 30t/fed.

Table 4: Effect of organic residues on soil health in calcareous soil.

Treatment		C_{mic} µg/g	C_{org} %	C_{mic}/C_{org} %	N_{mic} µg/g	N_{total} %	N_{mic}/N_{total} %	C_{mic}/N_{mic} ratio	pH
Control		44.98 h*	0.436 l	1.03 g	5.700 g	0.021 e	2.67 g	7.89 e	7.3 a
FYM	L1	191.3 de	0.990 c	1.93 f	23.13 cde	0.050 abc	4.64 ef	8.27 cd	7.3 a
	L2	233.3 bc	1.069 b	2.18 e	27.94bc	0.054 ab	5.17 c	8.35 bc	7.2 ab
	L3	284.6 a	1.109 a	2.57 b	33.15 a	0.057 a	5.82 b	8.59 a	7.2 ab
TR	L1	172.6 ef	0.871 e	1.98 f	20.98 def	0.046 abcd	4.61 f	8.23 d	7.3 a
	L2	214.6 cd	0.911 d	2.36 d	25.63 bcd	0.051 abc	5.00 d	8.37 bc	7.2 ab
	L3	252.0 b	0.990 c	2.55 b	29.89 ab	0.057 a	5.25 c	8.43 b	7.1 a
SS	L1	135.3 g	0.554 h	2.44 cd	16.55 f	0.036 d	4.65 ef	8.18 d	7.3 a
	L2	159.4 fg	0.634 g	2.52 bc	19.04 ef	0.040 cd	4.78 e	8.37 bc	7.2 ab
	L3	240.4 bc	0.832 f	2.89 a	28.12 bc	0.043 bcd	6.59 a	8.55 a	7.1 b
LSD	0.01	35.856	0.0199	0.1388	6.426	0.0146	0.1963	0.1543	0.1799
	0.05	26.287	0.0146	0.1017	4.711	0.0107	0.1439	0.1131	0.1319

* Means with different letters, within column, differ significantly according to LSD ($P<0.05$)
L1 = 10t/fed, L2 = 20 t/fed, L3 = 30t/fed.

Table 5: Effect of organic residues on soil health in alluvial soil.

Treatment		C_{mic} µg/g	C_{org} %	C_{mic}/C_{org} %	N_{mic} µg/g	N_{total} %	N_{mic}/N_{total} %	C_{mic}/N_{mic} ratio	pH
Control		118.8 h*	1.147 f	1.04 f	15.98 g	0.038 d	4.19 l	7.43 d	7.6 a
FYM	L1	270.4 f	1.656 d	1.63 d	33.06 e	0.061 bc	5.42 g	8.18 c	7.5 ab
	L2	346.9 c	1.911 bc	1.82 c	42.00 c	0.069 ab	6.12 e	8.26 bc	7.4 b
	L3	461.0 a	1.996 ab	2.31 a	54.24 a	0.076 a	7.11 b	8.50 a	7.4 b
TR	L1	244.7 g	1.826 c	1.34 e	29.80 f	0.055 c	5.42 g	8.21 c	7.6 a
	L2	320.6 d	1.911 bc	1.68 d	38.78 d	0.058 bc	6.69 d	8.27 bc	7.5 ab
	L3	398.5 b	2.081 a	1.91 bc	47.66 b	0.061 bc	7.81 a	8.36 b	7.4 b
SS	L1	228.9 g	1.444 e	1.59 d	28.06 f	0.056 c	4.97 h	8.16 c	7.6 a
	L2	290.7 e	1.571 d	1.85 c	35.15 e	0.060 bc	5.91 f	8.27 bc	7.6 a
	L3	360.2 c	1.826 c	1.97 b	42.37 c	0.061 bc	6.94 c	8.50 a	7.5 ab
LSD	0.01	27.476	0.1684	0.1198	4.075	0.0151	0.1143	0.1609	0.2079
	0.05	20.143	0.1235	0.0878	2.987	0.0111	0.0838	0.1179	0.1523

* Means with different letters, within column, differ significantly according to LSD ($P<0.05$)
L1 = 10t/fed, L2 = 20 t/fed, L3 = 30t/fed.

Table 6: The linear regression between various parameters under different levels of organic residues in different soils

Axes		X: C_{mic}, Y: N_{mic}	X: C_{mic}, Y: C_{org}	X: C_{mic}, Y: Soil $_{pH}$	X: N_{mic}, Y: N_{total}	X: N_{mic}, Y: Soil $_{pH}$
S_1	Equation	$Y=0.1036x+1.1195$	$Y=0.0039x+0.1221$	$Y=-0.002x+7.7814$	$Y=0.0018x+0.0135$	$Y=-0.0189x+7.7961$
	R^2	0.9801	0.9661	0.8529	0.6981	0.824
	Significant	**	**	**	**	**
S_2	Equation	$Y=0.1149x+0.8477$	$Y=0.0029x0.2735$	$Y=-0.0008x+7.3678$	$Y=0.0013x+0.0156$	$Y=-0.0066x+7.3725$
	R^2	0.9988	0.7996	0.4631	0.8775	0.4457
	Significant	**	**	*	**	*
S_3	Equation	$Y=0.1125x+2.4979$	$Y=0.0026x+0.954$	$Y=-0.0008x+7.7381$	$Y=0.0008x+0.0298$	$Y=-0.0068x+7.7581$
	R^2	0.9991	0.7894	0.6822	0.8097	0.7016
	Significant	**	**	**	**	**

S_1 = Sandy Soil, S_2 = Calcareous Soil, S_3 = Alluvial Soil, ** Highly Significant, *Significant

order of FYM>TR>SS.

A significant increase in C_{org} and N_{total} contents was observed with all treatments at all levels and this increase was more pronounced in C_{org} than N_{total} as compared with the control. In addition. The TR treatment was more effective in improving C_{org} content, while FYM was in N_{total} as compared to other treatments.

The addition of organic residues at different rates caused a significant increase in C_{mic}/N_{mic} ratio compared with the control and it was observed in the order of FYM>SS>TR.

The results further indicated that the application of organic residues l produced a significant increase in C_{mic}/C_{org} and N_{mic}/N_{total} percentages and it increased with increasing application rates. This increase was found in the order of FYM>SS>TR and TR>FYM>SS for C_{mic}/C_{org} and N_{mic}/N_{total} percentages, respectively.

The results further showed that soil pH decreased significantly with the higher application rates of FYM and TR while, it was unaffected with the lower rates of FYM and TR and at all levels of SS. The capacity to decrease soil pH was

found to be in the order of FYM>TR>SS.
Briefly, the increase in C_{mic}, N_{mic} and their ratio was observed with the applications of FYM, TR, SS at different levels of 10, 20 and 30t/fed in all types of soils. The increase, generally, was found in the sequence of alluvial>calcareous>sandy soils; FYM>TR>SS and 30>20>10t/fed.

The linear regression between different parameters: The linear regression between different characteristics studied e.g., C_{mic}: N_{mic}, C_{mic}: C_{org}, N_{mic}: N_{total}, and C_{mic}: Soil $_{pH}$ under various levels of organic residues in different soils is displayed in Table 6.
There is a reasonably close, linear regression, and positive relationship was noted between different parameters of C_{mic} and N_{mic}, C_{mic} and C_{org} and N_{mic} and N_{total} in different soils treated with organic residues. The linear regression between C_{mic} and N_{mic}, C_{mic} and C_{org} and N_{mic} and N_{total} was highly significant in all soils used in this study. While, C_{mic} and Soil $_{pH}$ and N_{mic} and Soil $_{pH}$ showed negative relationship and was found highly significant in sandy and alluvial soils.

Discussion

The results of the present study revealed that soil microbial biomass and its ratio responded differently in different soils. The C_{mic} and N_{mic} contents were the highest in alluvial soil than others. It may be due to more clay, C_{org}, and N_{total} in alluvial soil than other soils and due to differences in some other physical and chemical properties among these soils. Franzluebbers *et al.* (1996) reported that the proportion of soil organic C made up from soil microbial biomass increased with increasing clay content. Soil texture will also have a strong effect on decomposition rates as a result of differences in the protecting capacity for organic matter (Gorissen, 1996).
Our results showed that the addition of organic residues sharply increased the microbial biomass C & N at different rates in different soils. This might be attributed to stimulated suitable conditions for microbial growth where, development had acted as a good substratum for microbial activity. Shifts in microbial numbers and activity in soil are often related to changes in C inputs to soil as a result of management-related changes in residue addition.
Leita *et al.* (1999) indicated that soils treated with FYM and composts showed a significant increase in total organic C and biomass C in response to the increasing amounts of organic C added. It is well-established fact that organic manure addition, generally, increases the microbial biomass (Inubushi *et al.*, 1997).
Soil amendment with low-metal sludges has been shown to increase the C_{mic} significantly (Dar, 1997). Fließbach *et al.* (1994) found that addition of low-metal sludges at the rates of 100 and 300 m^3 ha^{-1} yr^{-1} to an arable and a former woodland soils caused a significant increase in the total C_{mic} compared with the unsludged control soil. Similarly, Dar (1997) reported that sludge application at the rate of 0.75 % to sandy loam, loam and clay loam soils caused an increase of 7 to 18 % in $C_{mic,}$ more in the sandy loam and less in loam soils.
Microbial biomass N was measured in laboratory incubation and under field conditions, as affected by organic matter application, and it was observed that biomass N was increased by continuous application of organic matter, such as rice straw, cow manure compost and dried cow manure, but remained fairly constant throughout the incubation, in contrast with N- mineralization (Inubushi *et al.*, 1997). They concluded that organic matter increased microbial biomass N, and mineralization of soil organic N.
Schnurer *et al.* (1985) studied the change in soil fertility caused by various organic (1800 kg C/ha/year as straw or FYM) and N-fertilizers (as $Ca(NO_3)_2$ @ 80kgN/ha/year) amendments in a long-term field trial and observed that both biomass estimates and activity measurements have highly significant correlation with soil organic matter. Lovell and Jarvis (1996) reported similar results.
El-Husseiny *et al.* (1988) reported that the farmyard manure (C: N = 24), town refuse compost (C: N = 36) or sewage sludge (C: N = 8) were added to alluvial (clay) and calcareous (clay loam) soil at the rate of 2% w/w to study their effect on fungi and aerobic cellulose decomposers in soil and the changes in the soil carbon: nitrogen ratio. The fungal colonies showed lower densities in the treated samples than the control, and the lowest numbers were observed with sewage sludge treatment. This was attributed to the competition between bacterial and fungal population. However, the number of fungi in calcareous soil treated with organic manures was markedly higher than that in the control. The counts of aerobic cellulose decomposers were enhanced by the application of organic manures to both soils tested. The C: N ratio of the soils treated with sewage sludge are greatest followed by farmyard manure and town refuse compost.
Our results further showed that the addition of organic residues increased the total organic C & N in different soils. This might be attributed to the addition of organic residues, as they are the sources of nitrogen and carbon in different soils. The organic carbon build-up was appreciable and significant in the case of organic matter applied soil. The soil organic carbon in inorganic fertilizer treatments was significantly lower compared with the treatments involving fertilizers with organic source (Baruah *et al.*, 1999; Swarup and Yaduvanshi, 2000). Also Kumar *et al.* (2000) found that the organic materials, applied alone or in combination with inorganic fertilizer gave greater residual soil fertility in terms of increase in organic carbon content from 0.36% to as high as 0.61% and the available N, P and K in the 2-years cropping cycle.
Ikonomova *et al.* (1999) reported that soils are very closely related to the increase in total nitrogen and organic matter contents and show improved nitrogen regime and fertility under the influence of long-term mineral and especially organic-mineral fertilization.
The results indicated that the addition of organic residues increased the C_{mic}: N_{mic} in different soils. The difference in the C: N ratio of the microbial biomass, a result of organic fertilizer application, could be due to a difference in efficiency for C; a difference not reflected in the measured values, or/and a difference in the dynamics of N. Dendooven *et al.* (2000) found that the dynamics of C and N as governed by the microbial biomass, C and N were different for the FYM plot compared with the NPK and controlled plots.
The addition of organic residues increased the C_{mic}/C_{org} & N_{mic}/N_{total} . Leita *et al.* (1999) found that the values of the C_{mic}:C_{org} ratio ranged from 1.4 to 2, without any significant difference among soil treatments. Sakamoto and Oba (1991) measured the relationship between the amount of organic material applied and soil biomass content in soils amended with various organic materials. They found that the values of the soil biomass in the soil amended with organic material were greater than those in the soil amended with inorganic fertilizer.
The addition of organic residues slightly decreased the soil pH in different soils. Christie and Beattie (1989) compared three application rates (50,100 and 200 m^3/ha/year) of pig and cow slurries with fertilized (200kg N/ha annually as ammonium nitrate or urea) and controlled plots for 17 yrs and found that the amount of C and N in the soil biomass was strongly correlated with soil pH. The soil became more acidic with increasing application rate of pig slurry but the opposite trend was shown with cow slurry.
Significant relationships were estimated between C_{mic} & Nmic, C_{mic} & C_{org}, N_{mic} & N_{total}, C_{mic} & soil $_{pH}$, and N_{mic} & soil $_{pH}$ under different levels of organic residue application in different types of soil. In various soils of different cropping histories (Chakrabarti *et al.*, 1998) it was observed that microbial

biomass-C of soils were related to total organic C and N, pH and maximum water-holding capacity of soils.

References

Alexander, M., 1977. Introduction to soil microbiology. John Wiley & Sons, New York.
Baruah R., H. Talukdar and N.C. Talukdar, 1999. Soil chemical properties as influenced by the application of fertilizers and farm yard manure (FYM). Int. J. Trop. Agric., 17: 153-158.
Bremner, J. M. and C. S. Mulvaney, 1982. Nitrogen-total. pp 595-624. In A. L. Page (ed.) Methods of soil analysis Part 2. Amer. Soc. Agron., Madison, USA.
Brookes, P. C., A. Landman, G. Pruden and D. S. Jenkinson, 1985a. Chloroform fumigation and the release of soil N: a rapid extraction method to measure microbial biomass N in soil. Soil Biol. Biochem., 17: 837-842.
Brookes, P.C., 1995.The use of microbial parameters in monitoring soil pollution by heavy metals. Biol. Fertil. Soils, 19: 269-279.
Brown, S. M. A., H.F. Cook and H.C. Lee, 2000.Topsoil characteristics from a paired farm survey of organic versus conventional farming in southern England. Biol. Agric. & Hort., 18: 37-54.
Carter, M.R. and P.M. Mele, 1992. Changes in microbial biomass and structural stability at the surface of a duplex soil under direct drilling and stubble retention in northeastern Victoria. Australian J. Soil Res., 30: 493-503.
Chakrabarti, K., P. Bhattacharya, A. Chakraborti, P. Banik, D.K. Bagchi, 1998. Microbial biomass-C and urease activity of soils: influence of soil properties. Indian Agriculturist, 42: 27-36.
CoStat Statistical Software, 1990. CoStat. Manual Revision 4.2 pp: 271.
Dar, G. H., 1997. Impact of lead and sewage sludge on soil microbial biomass and carbon and nitrogen mineralization. Bull. Environ. Contam. Toxicol., 58: 234-240.
Delibacak, S., B. Okur and D. Esiyok, 2000. Effect of manure doses and growth media on some physical properties of soil. Ege University Ziraat Fakultesi Dergisi, 37:113-120.
Dendooven, L., E. Murphy and D.S. Powlson, 2000. Failure to simulate C and N mineralization in soil using biomass C-to-N ratios as measured by the fumigation extraction method?. Soil Biol. Biochem., 32: 659-668.
El-Husseiny, T. M., M.K. Sadik and N.M. Badran, 1988. Interactions between soil C/N ratio and saprophytic microorganisms in alluvial and calcareous soils. Egyptian J. Microbiol., 23: 109-122.
Fließbach, A., R. Martens and H. Reber, 1994. Soil microbial biomass and activity in soils treated with heavy metal contaminated sewage sludge. Soil Biol. Biochem., 26: 1201-1205.
Fließbach, A. and P. Mader, 2000. Microbial biomass and size-density fractions differ between soils of organic and conventional agricultural systems. Soil Biol. Biochem., 32:757-768.
Franzluebbers, A. J., R.L. Haney, F.M. Hons and D.A. Zuberer, 1996. Active fractions of organic matter in soils with different textures. Soil Biol. Biochem., 28: 1367- 1372.
Fraser, D. G., J.W. Doran and W. Sahs, 1988. Soil microbial population and Activities under Conventional and Organic Management. J. Env. Qual., 17: 585-590
Gorissen, A., 1996. Elevated CO<sub(2 evokes quantitative and qualitative changes in carbon dynamics in a plant/soil system: mechanisms and implications. Plant and Soil, 187: 289-298.
Haines, P.J. and N.C. Ureen, 1990. Effect of conservation tillage farming on microbial biomass, organic matter and earthworm populations, in northeastern Victoria. Austr. J. SoilRes., 30: 365-371.
Hesse, P. R., 1971. "A Text Book of Soil Chemical Analysis" Jonn Murry (publishers Ltd, 50 Albemarle Street, London.
Ibrahim, S. M. and H. Shindo, 1999. Relationships between aggregation and hyphal length and microbial biomass C in soil amended with rice straw and Azolla. Pedologist, 43: 82-87.
Ikonomova, E., V. Koutev and R. Balabanova-Georgieva, 1999. Changes of nitrogen regime of cinnamonic-podzolic soil in South Bulgaria as affected by long-term mineral and organic-mineral fertilization. Bulgarian J. Agric. Sci., 5: 128-130.
Inubushi, K., F. Shibahara, K. Hasegawa and S. Yamamuro, 1997. Effects of added organic matter on microbial biomass nitrogen dynamics and plant uptake in paddy soils. In: Adeno *et al.* (Eds.) Plant Nutrition-for sustainable food production and Environment. 777-778.
Jackson M. L., 1967. " Soil Chemical Analysis" Printice –Hall of India New Delhi.
Jenkinson, D. S., 1988. Determination of microbial biomass C and N in soil. In Wilson, J. R. (ed.) Advances in Nitrogen Cycling in Agricultural Ecosystems. CAB International, Wallingford, pp:368-386.
Kanazawa, S., S. Asakawa and Y. Takai, 1988. Effect of fertilizer and manures application on microbial numbers, biomass, and enzyme activities in volcanic soils. Soil. Sci. Pl. Nutr., 34: 429-439.
Kumar V., B.C. Ghosh and R. Bhat, 2000. Complementary effect of crop wastes and inorganic fertilizers on yield, nutrient uptake and residual fertility in mustard (*Brassica juncea*) - rice (*Oryza sativa*) cropping sequence. Indian J. Agric. Sci., 70: 69-72.
Leita, L., Nobili, M. de, C. Mondini, G. Muhlbachova, L. Marchiol, G. Bragato and M. Contin, 1999. Influence of inorganic and organic fertilization on soil microbial biomass, metabolic quotient and heavy metal bioavailability. Biology and Fertility of Soils, 28: 371-376.
Lindsay W. L. and W. A. Norvell, 1978. Development of DTPA Soil test for zinc, iron, manganese and copper. Soil Sci. Soc. Amer. J. 42: 421-428.
Lovell, R. D. and S. C. Jarvis, 1996. Effect of cattle dung on soil microbial biomass C and N in a permanent pasture soil. Soil Biol. Biochem., 28: 291-299.
Nelson, D. W. and L. E. Sommers, 1982. Total carbon, organic carbon, and organic matter. p. 539-577. In A. L. Page (ed.) Methods of soil analysis. Part 2. ASA and SSSA, Madison, WI.
Nkongolo, N. V., J. Caron, F. Gauthier, M. Yamada, 2000. Organic wastes for improving soil physical properties and enhancing plant growth in container substrates. J. Crop Prod., 3: 97-112.
Santhy, P.; M.S. Velusamy, V. Murugappan and D. Selvi, 1999. Effect of inorganic fertilizers and fertilizer-manure combination on soil physicochemical properties and dynamics of microbial biomass in an Inceptisol. J. Indian Soc. Soil Sci., 47: 479-482.
Schnurer, J., M. Clarholm and T. Rosswall, 1985. Microbial biomass and activity in an agricultural soil with different organic matter contents. Soil Biol. Biochem., 17: 611-618.
Swarup A. and N.P.S. Yaduvanshi, 2000. Effects of integrated nutrient management on soil properties and yield of rice in alkali soils. J. Indian Soc. Soil Sci., 48: 279-282.
Wu, J., R. G. Joergensen, B. Pommerening, R. Chaussod and P. C. Brookes, 1990. Measurement of soil microbial biomass by fumigation-extraction; an automated procedure. Soil Biol. Biochem., 22: 1167-1169.
Johansson, M., 1999. Urban organic waste in agriculture - risk or resource? Acta Universitatis Agriculturae Sueciae - Agraria, No.178, 35 pp.
Alvarez, R., M. Alconada and R. Lavado, 1999. Sewage sludge effects on carbon dioxide - carbon production from a desurfaced soil. Communications in Soil Science and Plant Analysis, 13/14: 1861-1866.