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Full Length Research Paper

Farm Practices and fertilizer effect on soil microbial biomass and respiration, and on enzyme activities

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Application of liquid pig manure on soil for agricultural use increases the organic matter content and constitutes an important input of nutrients into the soil, increasing microbial activity through the direct addition of nutrients and microorganisms. The objective of this study was to determine the influence of both tillage and liquid pig manure application on soil microbial biomass, enzyme activities and microbial respiration in a meadow soil. The results obtained did not show any significant effect of tillage and manure on microbial biomass carbon (C) and nitrogen (N) nor on soil acid phosphatase activity. However, these treatments significantly increased microbial biomass P, urease, alkaline phosphatase and ammonification rates. The maximum microbial activity was observed in surface soil layer both under conventional tillage and zero-tillage. In fact, microbial respirations (CO_2) of bacteria and actinomycetes were higher in the surface soil and increased with the level of manure. Tillage and manure application had no significant effect on fungal respiration but interaction between tillage and manure application significantly influenced soil urease and ammonification rates. Hence, we suggested that soil microbial biomass and enzyme activities were closely correlated to the N mineralization potential, N and C mineralization rates, total amounts of C or N, soil pH, ammonification rates and soil structural stability.

Key words: Microbial biomass, enzyme activities, respiration, pastures soil.

INTRODUCTION

Tillage systems can have a major effect on the physical, chemical, and biological properties of soils. The effects of tillage systems, including conventional tillage (CT), reduced tillage, and no tillage, on soil properties have been extensively reviewed (Campbell et al. 1991; Griffith et al., 1992). The use of conservation tillage sys-tems or reduction in tillage frequency increases the amounts of crop residues in the upper layer of soil, and thus influences soil microbial activity and organic matter dynamics (Doran, 1987). Carter (1986) reported that tillage intensity resulted in greater microbial biomass in soil. However, cultivation of native or pasture soils usually induces a decline in microbial biomass in the surface soil horizon and leads to a considerable loss of soil organic matter at that level, whereas minimum tillage that maintains crop residues at the soil surface, promotes microbial growth (Doran,1980a) and accumulation of carbon (C) and nitrogen (N) (Doran, 1980b, Chan et al., 1992).

Soil organic matter distribution as well as cycling and availability of nutrients to plants, are often influenced by the type and the degree of soil tillage (Fleige and Baeumer, 1974; Dowdell and Cannel, 1975; House et al., 1984). Higher contents of soil water and organic matter levels coupled with changes in soil bulk densities at the surface of no-tillage soils often result in changes in microbial populations and N cycling when compared to plowed ecosystems (Doran, 1980b; Blevins et al., 1984; Linn and Doran, 1984). Doran (1987) observed that microbial biomass N and potential mineralizable nitrogen (PMN) rate in the top 0 to 7.5 cm of no-till soils were on average 13 to 45 and 12 to122 $kgha^{-1}$ respectively higher than in plowed soils. Doran (1980b) also reported that soil phosphatase activity in the top 0 ot 7.5 cm were 1.1

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to 1.5 times higher for no-till soils than for soils under conventional tillage and that at 15 to 30 cm depth the phosphatase activity for the conventionally tilled soil was similar or higher than that of the no-till soil. Doran (1980b) reported however that the numbers of facultative and total anaerobes in no-till soils decreased much less with depth than the population of aerobic bacteria and fungi and plowed soils have significantly higher population of fungi, aerobic and autotrophic nitrifiers than no-tilled soils.

Organic fertilization presents advantages over mineral fertilization such as the improvement of soil structure and water retention, increase in cation exchange capacity (Acharya et al., 1988; Latif et al., 1992); reduction in plant diseases and soil-borne pathogens (Reeves et al., 1984; Cook, 1986; Hoitink and Fahey, 1986; Sivapalan et al., 1993) and increase of soil organic matter (Fraser et al., 1988). Fertilization affects the soil microbial biomass by increasing root biomass, root exudates and crop residues, thus providing increased substrate for microbial growth. Martyniuk and Wagner (1978) found that populations of microorganisms were greater in fertilized soil than in unfertilized soil. Any management practice that increases total C accumulation should also increase the size and activities of the soil microbial biomass. Much interest in organic fertilization has also arisen because of perceived benefits to soil fauna and microflora such as the population of bacteria and fungi (Arden-Clarke and Hodges, 1988).

The root distribution in different soil layers changes after long-term application of manure. The weight of roots in deeper soil layer increases following manure applications. The roots are mainly located in the top-soil (0 to 10 cm) and the application of manure increases the shoot/root ratio. The high level of soil enzyme activity in manure amended soils is not only the result of a larger microbial biomass, but also of a higher rate of enzyme production by the microbial biomass (Kandeler et al., 1994). N'dayegamiye and Coté (1989) indicated that soil respiration activity (CO_2) also increased with manure application and that fungal respiration was highest in the soil amended with 120 $m^3 ha^{-1}$ of liquid manure.

However little is known about the combined effect of liquid manure application and tillage management practice on soil biomass and enzyme activity. The objective of this study was thus to determine the influence of tillage and liquid manure application on soil microbial biomass, enzyme activities and microbial respiration in a meadow soil.

MATERIALS AND METHODS

Soil sampling

This long term experiment on a meadow soil began in 1978. The study was carried on a silt loam soil at the MAPAQ experimental farm in St. Lambert, Quebec Canada. Treatments in a split-plot design consisted of no-till and tillage as principal treatments and three rates of liquid pig manure (0, 50 and 100 mg ha^{-1}) as secondary treatments. Since 1978, some plots have never been plowed down (no-till treatments) whereas in the tilled treatment soil was plowed in the every five years. Liquid manure was applied in the spring of each year. Soil sampling study was performed in June 1994 and July 1995. The soil samples were taken from the 0 to 15 and 15 to 30 cm depth. The moist soil samples were sieved at 6 mm to remove roots and stubble in the field and were kept at 4°C until both physical and microbial activity analyses were performed. For chemical analysis, sub-samples were air-dried and screened at 2 mm and 250 µM.

Soil microbial biomass, phosphorus (P) carbon (C) and nitrogen (N) determinations

Microbial biomass C, N and P were determined using the chloroform-fumigation-incubation method (Jenkinson and Powlson, 1976) and were estimated from the difference between organic C, N and P extracted with 0.5 M potassium sulfate from chloroform fumigated and un-fumigated soil samples, using K_C K_N and K_p factors of 0.38, 1.85 and 0.40, respectively. Microbial biomass levels were expressed as kg ha^{-1} soil.

Acid and alkaline phosphatase determinations

Acid and alkaline phosphatase activities were determined at pH 6.5 by measuring p-nitrophenol produced when soil was incubated with buffered sodium p-nitrophenol phosphate solution and toluene at 37°C for 1 h (Tabatabai and Bremner, 1969).

Urease determination

Urease activity was determined by incubation of air-dried soil for 2 h at 37°C with a urea solution (pH 9.0) followed by soil extraction with 1 M KCl and 0.01 M HCl solution (Kandeler and Gerber, 1988).

Determination of the contribution of bacteria, fungi and actinomycetes to soil respiration

A technique using selective inhibitors was used to estimate the relative contributions of bacteria, fungi and actinomycetes to soil respiration (CO_2 production). The CO_2 produced by the different microbial groups was determined by titration. Glucose was the substrate used. Streptomycin and actidione were used to inhibit both actinomycetes and bacteria or fungi, respectively (Anderson and Domsch, 1974).

Ammonification determination

Arginine ammonification was carried out as described by Alef and Kleiner (1987), with some minor technical modifications. Briefly, soil samples (2 g of moist soil) were placed in plastic tubes (12 ml) stoppered and heated at 30°C for about 1 h, and arginine (0.5 ml of a 0.2% solution in H_2O) was added dropwise. After about 6 h, the tubes were removed and stored at -20°C for one week. After storage, the samples were thawed and immediately mixed with 8 ml ammonium free KCl (2 M). The tubes were sealed and shaken (180 rev min^{-1}) for 15 min. After centrifugation (5 to 10 min), ammonium was estimated colorimetrically on a Technicon Autoanalyzer.

Determination of organic C, soil water soluble C and total N

The organic C content was determined by wet oxidation procedure (Walkley and Black, 1934). Total N was estimated by Kjeldahl digestion (Nelson and Sommers, 1982), while the soil water-soluble C

was assessed as previously described by Dormaar et al. (1984).

Physical analysis

Distribution of aggregate size was carried on samples sieved at 6 mm. Structural stability measurements were determined by wet sieving (> 2 mm; > 1 mm; > 0.5 and 0.25 mm) on moist soil as described by Angers and Mehuys (1993).

Nitrogen and carbon mineralization measurements (incubation studies)

Field-moist samples (400 g) were incubated for 270 days in 4-L cylinders to ensure optimum aeration and microbial activity (Stanford and Smith, 1972). Carbon dioxide evolution was trapped in 1 N NaOH (5 ml) solution and the excess of NaOH was titrated with HCL 1 M (5 ml) (Anderson, 1982). For N mineralization analysis, the soil samples were leached as described by Stanford and Smith (1972), with 100 ml of 0.01 M $CaCl_2$ followed by 25 ml of N-free nutrient solution (0.002 M $CaSO_4.2H_2O$; 0.002 M $MgSO_4$; 0.005 M $Ca(H_2PO_4)2.H_2O$ and 0.0025 M K_2SO_4). Nitrogen-N was determined colorimetrically on a Technicon Autoanalyzer.

Statistical analyses

The effect of tillage and liquid pig manure application on soil microbial biomass, enzyme activities and microbial respiration were analyzed with the procedure of SAS (SAS Institute, 1990). Sources of variation included tillage practices; levels of manure applied and soil depth as well as their interactions. Analysis of variance (ANOVA) and correlations were used to determine the effects of tillage and manure applications on soil microbial biomass, enzyme activities and microbial group respiration.

RESULTS

Soil microbial biomass

Microbial biomass P

Soil microbial biomass P ranged from 13 to 358 kg ha^{-1}. Results indicate that manure application treatments had significant effect (F=4.36*) on soil microbial biomass P (Table 1). The analysis of variance indicated that this parameter was not influenced by the different tillage treatments, but was significantly decreased by soil depth (F=20.38**). Furthermore, we observed significant interaction between soil tillage practices and manure application in 0 to 15 and 15 to 30 cm depths (F=5.85**, Table 1).

Microbial biomass C

Soil microbial biomass C ranged from 309 to 1062 kg ha^{-1} soil. No effect of tillage management practices or manure application on soil microbial biomass C was observed. However, depth affected soil microbial biomass C (F=4.5*, Table 1). The values of soil microbial biomass C/ total organic C ranged from 0.44 to 1.69.

Microbial biomass N

Microbial biomass N ranged from 94 to 407 kg ha^{-1}. Tillage practice and manure application did not affect soil microbial biomass N. However, soil microbial biomass N was significantly higher (F=6.18*) in the surface soil (Table 1). Microbial biomass N/%N varied from 1.27 to 12.1. Soil tillage treatments, manure application and soil depth significantly affected the soil microbial biomass N/%N ratio (F=4.82**, Table 1).

Soil ammonification rate (NH_4-N) and enzyme activities

Arginine ammonification rate

The observed arginine ammonification rates ranged from 1.3 to 2.8 ∝g NH_4-N g^{-1} h^{-1}. Liquid manure applications significantly increased soil arginine ammonification rate (F=4.74*, Table 1). It was also observed that arginine ammonification was influenced by soil depth (F=8.67**). However, soil tillage had no significant effect on ammonification. Furthermore, we observed a significant interaction between soil tillage management practices and soil depth (F=10.46**).

Urease activity

Soil urease activity ranged from 16 to 57 µg g^{-1} per hour. Soil urease activity was not affected by tillage, but it tended to decrease with manure application (F=11.13**, Table 1) at the 15 to 30 cm depth (F=41.99**, Table 1). Moreover, a significant interaction was observed between soil tillage management practices and manure applications on soil urease activity (F=13.68**, Table 1).

Acid phosphatase activity

The soil acid phosphatase activity varied from 152 to 502 µg g^{-1} soil. This parameter was significantly influenced by soil depth (F=17.67**, Table 1), but was not affected by manure applications or by tillage practices.

Alkaline phosphatase activity

The soil alkaline phosphatase activity ranged from 24 to71 µg g^{-1} soil. Alkaline phosphatase activity was higher in tillage treatments compared to no-till plots (F=7.40**, Table 1). Furthermore, we observed that soil alkaline phosphatase activity was always significantly lower compared to surface soil (F=8.77**) at a depth of 15 to 30 cm (Table 1). Analysis of variance indicated that soil alkaline phosphatase activity was not influenced by manure application.

Table 1. Analyses of variance (F-values) of the effect of tillage practices and manure application rates on microbial biomass and enzymes activities for a meadow soil.

Treatment	Biomass P	Biomass C	Biomass N	Urease	Acid phosphatase	Alkaline phosphatase	A.A NH_4
Tillage (T)	1.13	0.02	0.23	1.51	0.06	7,4*	1.50
Manure (M)	4.36*	0.57	0,49	11.13**	0.5	1.13	4.74*
Depth (D)	20.38**	4.5*	6,18*	41.99**	17.67**	8.77**	8.67**
T × M	1.2	2.76	1.82	13.68**	2.02	0.67	1.58
T × D	0.00	0.03	0.22	3.42	0.78	0.47	10.46**
M × D	2.18	0.81	0.78	2.91	0.09	1.58	1.19
T × M × D	5.85**	0.72	0.54	0.16	0.12	0.9	1.83

A.A, Arginine ammonification µg NH_4-N g^{-1} h^{-1}; **,*, significant at $p < 0.01$ and $P < 0.05$.

Table 2. Analysis of variances (F- values) of the effect of tillage practices and manure application rates on bacteria, fungi and actinomycetes respiration of a meadow soil at different times after incubation.

Treatment	24 h			336 h			672 h		
	Fungi	Bacteria	Act	Fungi	Bacteria	Act	Fungi	Bacteria	Act
Tillage (T)	0.36	0.13	3.68	0.99	1.33	1.54	1.43	0.30	1.38
Manure (M)	1.46	0.50	1.68	1.64	0.41	5.03*	0.03	1.25	0.25
Depth (D)	12.18**	4.74*	17.61**	2.47	4.31	4.48*	0.73	4.15	17.03**
T × M	2.32	0.05	1.27	0.40	0.09	1.7	0.00	1.18	1.91
T × D	0.41	0.37	0.40	0.48	5.02*	2.61	1.62	0.14	0.01
M × D	1.77	1.14	3.66	0.00	2,28	4.13	1.25	0.01	1.91
T × M × D	0.72	0.77	1.26	2.06	2.67	0.94	1.30	0.04	0.34

**,*Significant at $p < 0.01$ and $P < 0.05$; Act, actinomycetes.

Measurement of bacterial, fungal and actinomycetes contribution to microbial respiration (CO_2)

The results of the soil respiration studies in the presence of inhibitors are presented in Table 2. The addition of a mixture of streptomycin and actidione did not result in 100% inhibition of soil respiration. Analysis of variance indicated that 24 h after incubation, soil bacteria and actinomycetes respiration was influenced by soil depth (P>0.01) (Table 2). Also, soil actinomycetes respiration 336 h after incubation was significantly influenced by manure applications and soil depth (P>0.05). Additionally, 672 h after incubation, soil actinomycetes activity was significantly influenced by soil depth (P>0.01).

Relationship between microbial biomass P, C and N and some chemical, physical and biological characteristics

Soil microbial biomass P, C and N were highly correlated with some chemical, physical and biological properties (Table 3). Soil microbial biomass P was found to be closely related to total N ($P \leq 0.01$) and organic C (r=0.63**). A negative relationship between soil microbial biomass P and soil pH ($P \leq 0.01$) was also observed. Strong relationships ($P \leq 0.01$) were obtained between microbial biomass P and cumulative N mineralization (N_m) over the 270 day incubation period and nitrogen mineralization potential N_0 (Table 4). Soil microbial biomass C was closely positive correlated with soil N ($P \leq 0.05$). However, the initial C mineralization (C_e) was related to soil microbial biomass C ($P \leq 0.01$). Soil microbial biomass C was closely correlated with soil structure ($P \leq 0.01$) as measured by mean weight diameter (MWD).

Furthermore, there was a significant relationship between initial N mineralization and soil microbial biomass N ($P \leq 0.05$). Soil microbial biomass N was closely related with soil organic C ($P \leq 0.05$) and cumulative N mineralization ($P \leq 0.01$) because soil C mineralization in tillage has limited effect on microbial characteristics and biodegradation of soil-Organic N. There were also significant relationships between soil microbial biomass P, C and N and ammonification (Table 3).

Table 3. Linear correlation coefficient between microbial biomass and some chemical, physical and biological characteristics of a meadow soil used in this study.

Microbial biomass	pH H_2O	C (%)	C_s	N (%)	N_m	N_0	C_m	C_0	A.A	MWD
Biomass P (kg/ha)	-0.43*	0.63**	0.08	0.62**	0.52**	0.43*	0.28	0.08	0.61**	0.25
Biomass C (kg/ha)	-0.20	0.35	-0.05	0.40*	0.27	-0.01	0.28	0.04	0.44*	0.66**
Biomass N (kg/ha)	0.07	0.43*	-0.14	0.07	0.57**	0,03	0.36	-0.01	0.63**	0.65**

N_m, Total amount of N mineralized (µg g^{-1}); N_0, N mineralization potential (µg g^{-1}); N_e, N mineralization over 10 days (µg g^{-1}); C_m, total amount of C mineralized (µg g^{-1}); C_0, C mineralization potential (µg g^{-1}); C_e, C mineralized over 10 day (µg g^{-1}); C_s; total C soluble (µg g^{-1}) are presented in chapter 1. MWD; Mean weight diameter (mm); A.A; Arginine ammonification (g N-NH_4 g^{-1} $h.^{-1}$). * *, *, Significant at P ≤ 0.01 and P ≤ 0.05, respectively.

Table 4. Linear correlation coefficient between enzymes activities and some chemicals, physical characteristics of a meadow soils.

Enzyme activity	N_m	N_e	N_0	C_m	C_e	C_0	MBP	MBN	MBC	A.A
Urease (µg/g)	0.46**	0.63**	-0.08	0.44*	0.55**	0,007	0.42*	0.51*	0.39*	0.71**
Acid phosphatase(µg/g)	0.60**	0.40*	-0.04	0.46*	-0,26	0.14	0.36	0.45*	0.33	0.37
Alkaline phosphatase (µg/g)	0.69**	0.13	0.22	0.07	0.24	-0.17	0.51**	0.46*	0.23	0.06

N_m, Total amount of N mineralized (µg g^{-1}); N_0, N mineralization potential (µg g^{-1}); N_e, N mineralization over 10 days (µg g^{-1}); C_m, total amount of C mineralization (µg g^{-1}); C_0, C mineralization potential (µg g^{-1}); C_e, C mineralized over 10 days (µg g^{-1}); MBP, microbial biomass P (kg ha^{-1}); MBN, microbial biomass N (kg ha^{-1}), MBC, microbial biomass C (kg ha^{-1}); A.A, arginine ammonification (µg NH_4-N g^{-1} $h.^{-1}$). * *, *: Significant at P < 0.01, and P < 0.05, respectively.

Table 5. Linear correlation coefficient between enzymes activities and some chemicals, physical characteristics of a meadow soils.

Enzymes activity	pH H_2O	C (%)	C_s	N (%)	C/N	MWD
Urease (µg/g)	-0.22	0.60**	0.03	0.68**	0.10	0.09
Acid phosphatase (µg/g)	-0.25	0.69**	0.22	0.76**	0.14	0.28
Alkaline phosphatase (µg/g)	-0.37	0.55**	-0.03	0.66**	0.09	0.28

C_s; Total C soluble (µg g^{-1}); MWD, mean weight diameter (mm). **, *Significant at P < 0.01, and P < 0.05, respectively.

Relationship between urease, acid phosphatase, alkaline phosphatase, some chemical, physical and biological characteristics

Soil urease, alkaline phosphatase and acid phosphatase activities were very closely correlated with some selected chemical, physical and biological properties (Tables 4 and 5). Positive significant relationships between urease and soil microbial biomass P (P ≤ 0.05), microbial biomass N (P ≤ 0.01) and microbial biomass C (P ≤ 0.05) were observed. Soil urease activity was also closely related to total N (P ≤ 0.01), organic C (P ≤ 0.01), cumulative N mineralization (P ≤ 0.01), C mineralization (C_m, P ≤ 0.01), initial N mineralization (N_e, P ≤ 0.01) and ammonification rate (P ≤ 0.01). Soil acid phosphatase activity was closely related to microbial biomass P (P ≤ 0.01), microbial biomass N (P ≤ 0.05), total N (P ≤ 0.01), soil organic C (P ≤ 0.01), cumulative N mineralized (P ≤ 0.01) and cumulative C mineralized (P ≤ 0.05).

Alkaline phosphatase activity was closely related with microbial biomass P (P ≤ 0.01), microbial biomass N (P ≤ 0.05), initial N mineralization (N_e, P ≤ 0.05), soil organic C (P ≤ 0.01), soil total N (P ≤ 0.01) and the total amount N mineralized (P ≤ 0.01).

DISCUSSION

Effect of tillage practice on biomass P, C and N

There was no statistically significant effect of tillage on soil microbial biomass P. However, a significant relationship between soil microbial biomass P and soil biological properties suggested that soil microbial biomass P may be either a source or a competitor for plant available P and microbial growth (Sparling et al., 1994). Moreover, we did not observe any significant effect of tillage on soil microbial biomass C or N; however, soil microbial biomass C and N, increase in tilled soil treatments.

Srivastava and Singh (1989) and Singh and Singh (1993) observed that microbial biomass N and C were

higher in tilled than in no-tilled treatments in forest and tropical soils. Doran (1987) also reported that microbial biomass levels were closely associated with soil distributions of total C and N, water content, and water soluble C as influenced by tillage management. In this study, water soluble C and total N were higher in tillage treatments. The results differed from those of Carter and Rennie (1982), who found that soil microbial biomass C and N were higher in treatments with tillage than in those with zero-tillage. They also reported a decrease in microbial biomass N with depth; was also evident for microbial biomass C. Ratios of microbial C/N ranged from 2.2 to 6.8 in meadow soil horizon. These results were comparable to those of Sparling et al. (1994), who found that the range microbial biomass C/N was 3.5 to 6.7 in unfertilized and fertilized pasture soil within 0 to 20 cm soil depth. We also observed close relation between soil microbial biomass and soil total organic C, total Kjeldahl N (%) and pH. The results in this study corroborate with the results of Doran (1987), who observed similar trends with tillage and cropping management practices.

Effect of liquid manure application on biomass P, C and N

Although we did not observe any significant effect of manure application on soil microbial biomass C and N, the soil microbial biomass C and N tended to decrease with manure application at all depths in tillage treatments. This decrease can be attributed to the rapid mineralization of manure that did not allow a substantial increase of the microbial biomass. Masakazu and Tomohiro (1991) reported that chicken manure was rapidly mineralized and was not associated with biomass N in a sand, clay or loam soil. We observed that soil microbial biomass N and C were lower in soil that received manure and no-till treatments. In no-till soil, microbial activity decreased probably because high levels of liquid manure decrease soil structure. In fact, Lea et al. (1982) observed that soil structure degradation increased with high levels of liquid manure.

As previously observed by Goyal et al. (1992), the ratios of microbial C/ organic C and microbial N/ organic N increase with manure application in the no-till soil because root distribution in different soil layer changes after long term application of pig manure and animal manure supplies additional mineralizable C and N that directly stimulated microbial activity. In general, manure application increased soil microbial biomass P. The results are similar to those of Campbell et al. (1986).

Effect of tillage practice on urease, acid and alkaline phosphatase activities and ammonification rate

The data reported showed that urease activity and ammonification rate decreased markedly with depth in all treatments; these decreases were associated with a decrease in organic C. In fact, urease activity was significantly correlated (r=0.60**) to soil organic C content (Table 5). A similar observation was previously reported by Tabatabai (1977). In general, soil ammonification rate significantly decreased with soil depth. Alef et al. (1988) attributed this decrease to the lower microbial biomass and soil ammonification rate in the 15 to 30 cm depth. In this study, a close correlation existed between arginine ammonification rate and microbial biomass. This results presented that soil arginine ammonification can be used as an indicator of microbial activity in soil (Alef and Kleiner, 1987).

Meanwhile, no effect of tillage practice on soil acid phosphatase activity was observed. However, tillage had an effect on soil alkaline phosphatase activity. Soil alkaline phosphatase activity increased by 18.7 and 27.2% for tillage treatments within the 0 to 15 and 15 to 30 cm soil layers, respectively. Soil acid phosphatase is an extracellular enzyme that is accumulated in soil and is often related to organic P content of soil (Doran, 1980b); therefore the differences observed in this study were likely to be associated to those measured in soil phosphorus content induced by tillage (13 to 27 µ/g soil). The relationship found between soil urease, acid and alkaline phosphatase activities and some soil chemical and biological properties indicates that these enzymes play an important role in the cycling of elements and the initial phases of the decomposition of organic residues and biota soil.

Effect of liquid manure application on urease

Urease activity was significantly increased by theapplication of 100 mg ha^{-1} manure in the no-till soil, but it decreased in the tilled soil. Kandeler and Gerfried (1993) reported that the addition of cattle slurry to a grassland increases urease activity not only by supporting a larger microbial biomass, but also by increasing the level of enzyme production by this biomass.

Effect of tillage on bacteria, fungi and actinomycete respiration

Addition of antibiotics to the soil did not result in 100% reduction of soil respiration. A similar observation was made by Anderson and Domsch (1975), who explained this by the possible resistance of some glucose-metabolizing systems initially present in soils to the antibiotics treatment. Moreover, the total soil fungal activity in the plowed treatment was higher than in no-till. As well, fungal activity in the soil surface layer was relatively higher, the reason being that relative differences in physical and chemical parameters measured

such as H_2O, water-soluble C, total C and total N were significantly greater in the 0 to 15 cm depth for both tilled and no-tilled soil. Linn and Doran (1984) reported that increased levels of organic substrates and water in the surface soil are related to greater microbial populations present at this sampling depth.

Total soil bacterial and actinomycetes respiration measured after 1032 h (24 h + 336 h + 672 h) of incubation were higher in plowed soil than in no-till soil for the 0 to 15 cm depth. This can be explained in part by the presence of more important aerobic and anaerobic bacteria populations in the surface of plowed soils (Linn and Doran, 1984). The activities of the glucose-metabolizing systems present in soils at the time of actidione and streptomycin treatments were not blocked by these inhibitors, and would probably be able to decompose the substrate for a long period of time.

Conclusion

The results of this study did not show any significant change of soil microbial biomass C and N in manured or plowed soils. However, results indicate that among the different soil microbial biomass studied (microbial biomass C, microbial biomass N, microbial biomass P), the soil microbial biomass P appeared to be most sensitive to the manure application treatments. Also, soil microbial biomass significantly decreased with increasing soil depth.

Analysis of variance indicated that generally soil bacteria and actinomycetes respiration was higher in the surface layer of manured soil. The results of this study also showed that soil tillage and liquid manure application significantly influenced enzymatic activities in general, and the no-tillage system proved to be effective in reducing soil erosion and loss of agricultural chemicals. Enzymes activities were generally higher in the surface soil layer; the obtained results indicate that the enzymes activity roots are very significantly influen-ced by tillage systems. The maximal acid phosphatase activity soil was found in the maturity stage in tillage systems (333.55 µg/g soil).

Therefore, biological approach such as, enzymatic activities, ammonification and soil bacteria, fungal and actinomycetes respiration of soil are greatly modified by tillage and liquid manure application. This approach is complementary to that undertaken in the Canadian soil resources information system project previously reported. Finally, the biofertilizer applications promoted the plant grow and production of dry matter in a meadow soil.

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