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The Influence of Synthetic Soil Conditioners on the Size of Soil Microbial Biomass in a Loamy Sand Soil

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Abstract: The effect of polyacrylamide (PAM) (synthetic soil conditioners) application on soil microbial biomass C (C_{mic}) and N (N_{mic}) were examined under laboratory conditions. Two types of polymers Acqua-Kept (P1) and Super-Hydro (P2) were mixed separately with a loamy sand soil in various concentrations of 25, 50 and 100 µg g^{-1} soil. After 1, 7, 14 and 28 days of incubation, the soils were analyzed for C_{mic} and N_{mic}. The two PAMs have shown almost similar effects on the soil microbial biomass C and N. The amount of soil microbial biomass (C_{mic} and N_{mic}) was increased with the lower polymer applications of 25 and 50 µg g^{-1} soil, while it decreased at the higher dose of 100 µg g^{-1} soil addition. The response exhibited a parabolic curve. The response was found more pronounced with P2 than P1 application. A slight increase in C_{mic} and N_{mic} was observed with the advancement of incubation stages. The results indicate unpredictable changes in soil microbial biomass due to the application of different synthetic soil conditioners.

Key words: Loamy sand soil, soil microbial biomass, polyacrylamides, soil conditioners

Introduction

During the past few decades it was suggested that synthetic soil conditioners, serving as cementing and stabilizing agents, may be applied in cases where natural causes and anthropogenic practices result in deterioration of the soil structure (Wallace and Nelson, 1986). New, longer-lasting polyacrylamides (PAM) are currently under investigation and are sold commercially as promising compounds for improving soil structure and water infiltration. PAM is a long-chain polymer organic compound, which is prepared by acrylamide polymerization. The use of effective synthetic soil conditioners at present is limited to special soil conditions and to fields in which high cash crops are grown.

The polymers applications are in the form of solutions, emulsions or as powders, the reaction with the soil particles takes place rather quickly (De Boodt *et al.*, 1991). The hydrogels are polymeric materials, which absorb a considerable quantity of water but do not dissolve in it. They comprise a large family of materials having widely different properties (Graham, 1988).

To cite a few examples: the effect of soil conditioners can be very different in function of the soil moisture content of the initial aggregate sizes, porosity, bulk density, evaporation, hydraulic conductivity, infiltration rate, and increase the soil available water contents (Canarutto *et al.*, 1992; El-Ghamry, 1996; No *et al.*, 1987; Shainberg and Levy, 1994; Aly and Miller, 1995; El Hedy and Azam, 1983).

It is generally recognized that the microbial biomass is the eye of the needle through which all organic matters that enter the soil must pass (Jenkinson, 1988). Although the soil microbial biomass represents only a small fraction of the total amount of soil C, N, P and S, it has a relatively rapid turnover (Amato and Ladd, 1980). The maintenance of soil fertility depends on the size and the activity of soil microbial biomass (Alexander, 1977).

PAMs of the type used in soil applications do affect the growth of bacteria. Under aerobic conditions, some strains of *Pseudomonase* are stimulated, primarily because the polymers can provide a reservoir of ammonium nitrogen for the bacteria. It should be noted that, at least with some strains under some conditions, growth in the presence of PAM may alter the pH drastically. This was observed in a medium with low buffering capacity, whether it would occur in field conditions is unknown (Grula *et al.*, 1994). The data available on PAMs deal mainly with their effects on soil structure, which are due to the physical-chemical interaction between these polymers and soil particles (Terry and Nelson, 1986; Wallace *et al.*, 1986). However, reports on the effects of synthetic conditioners on soil biota components are limited. The scarcity of available information on possible interactions between PAMs and soil microorganisms is somewhat surprising, considering their important role in biological processes occurring in the soil, including structure, formation, and stability (Molope *et al.*, 1987; Griffiths, 1965), nutrint cycling and availability to plants.

Keeping in view the above stated work conducted by different workers it is hypothesized that these soil conditioners may help to increase soil microbial population through better soil conditions and hence, will improve soil fertility. Therefore, the present study was undertaken to investigate the response of the soil microbial biomass to the addition of two PAM compounds (P1 and P2) in a loamy sand soil.

Materials and Methods

Soil samples: A laboratory incubation experiment was conducted using the loamy sand soil having 1.76% total organic-C, 0.158% total-N, 22.4% soil moisture at 33 kPa, with pH 6.27. The soil was collected from the surface layer (0-20 cm) from Hangzhou, Zhejiang province, China.

Soil conditioners: Two soil conditioners (polymers) used were; Acqua-Kept (P1): it was introduced by Chemil S.R.L. Milano Italy Company, its absorption capacity with deionized water is 500- 600 g/g, and Super- Hydro (P2) was introduce for Al-Dohasa Rue Ceard Genev Company, its absorption capacity is 500-700 (distilled water cm^3/g of product) and it also contain 20% N.

Experimental study: After sampling and preparation of soil, both the polymers i.e. Acqua-Kept (P1) and Super-Hydro (P2) were separately mixed with the soil to maintain the concentrations of: 0 (control), 25 (L1), 50 (L2) and 100-(L3) µg g^{-1} soil. All the treatments were replicated thrice.

Soil moisture was adjusted to 60% water content at 33 kPa and incubated in the dark at 25°C ± 1. The beakers were removed from the incubator every day and brought to the original weight by adding the required amount of distilled water. Three beakers each for control and treated soils were removed and submitted to analysis for soil microbial biomass C and N at 1, 7, 14 and 28 days after polymers application.

Soil analyses: Soil samples for the determination of microbial

biomass C were extracted by a fumigation-extraction (FE) method (Vance *et al.*, 1987) and the organic carbon in the soil extracts was measured using an automated total organic carbon analyzer (Wu *et al.*, 1990). Soil samples for the determination of microbial biomass N were extracted by a fumigation-extraction (FE) method (Brookes *et al.*, 1985b) and the total nitrogen in the soil extracts was measured after Kjeldahl digestion (Brookes *et al.*, 1985a).
Water contents at an applied pressure of 33 kPa (0.33bar) were determined using a pressure membrane system similar to that described by Reining (1963). The pH (in water, 1:2.5) of the soils was measured with a pH meter. Total N was determined by Kjeldahl method and total organic carbon by Walkley-Black procedure (Jackson, 1958).

Statistical analysis: Data were examined by analysis of variance completely randomized and Duncan's multiple range tests using statistix software (CoStat Statistical Software, 1990).

Results

Effect of polymers on soil microbial biomass-C (C_{mic}): The data regarding the effect of two polymers on soil microbial biomass C is presented in Table 1. The results showed that when the polymers were applied at lower concentrations of 25 and 50 µg g^{-1} soil, they showed a positive response on C_{mic} and increased it, while the highest concentration (100 µg g^{-1} soil) used has decreased it, as compared with the control. The data further revealed that the soil microbial biomass has not reacted much differently against the two polymers used. Increasing the concentrations of P1 resulted in a gradual increase, except L3 where it was decreased, in the soil microbial biomass although it was not effected significantly ($p<0.05$) in almost all the incubated stages at all levels (except L2 level after 1 d incubation), as compared with the nontreated control soil. The data obtained after the application of P2 also showed a similar pattern like P1 i.e., a parabolic pattern, where 50 µg g^{-1} soil showed the maximum increase in C_{mic} at all the incubation stages (1, 7, 14 and 28 d) studied, as against the control. After 1 and 28 d of incubation, only the L2 level was found significantly different than the control while all other treatments, though they showed some increase/decrease, were found at par with the control. The increase in C_{mic} content was more in P2 as compared to P1 and a slight increase was noticed with the passage of time.

Effect of polymers on soil microbial biomass-N (N_{mic}): The additions of two polymers (P1 and P2), applied at different levels, have produced different effects on N_{mic} contents at different incubation stages, as compared with the control (Fig. 1 and 2). The P1 polymer was found to be increased the N_{mic} contents with L1 and L2 levels, while L3 level has decreased it. The maximum N_{mic} contents (46.86 µg g^{-1} soil) were found at 28th day of incubation with 50 µg g^{-1} soil of P1 addition which was found significant than control. The addition of P2 significantly increased the N_{mic} at two lower levels (L1 and L2) while the higher level (L3) non-significantly decreased it, as compared with the control. When % increase/decrease in N_{mic} with P1 and P2 application was calculated, it was noticed that the maximum % increase of 12.3 was found with 50 µg g^{-1} soil of P1 addition at 28th day of incubation and it was 31.9% with P2 addition with the same level and at same incubation periods as P1. The higher concentration of 100 µg g^{-1} soil of both the polymers were found to have a depressing effect on the N_{mic} contents, as compared with the

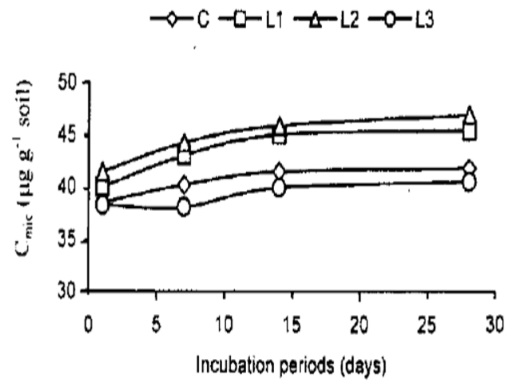

Fig. 1: Effect of Aqua-Kept (P1) polymers on microbial biomass N (µg g^{-1} soil)

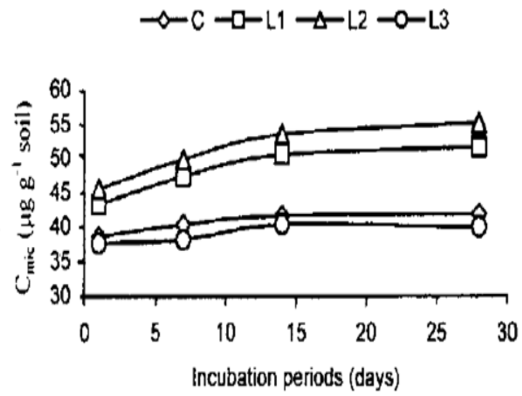

Fig. 2: Effect of Super-Hydro (P2) polymers on soil microbial biomass N (µg g^{-1} soil)

Table 1: Effect of polymers (P1 and P2) on soil microbial biomass C (µg g^{-1} soil)

Polymers application (µg g^{-1} soil)		Time after application (days)			
		1	7	14	28
Control	0 (check)	162.9 bc	173.0 a	182.6 a	182.6 a
P1	25(L1)	180.3 ab	185.6 a	188.6 a	190.0 a
	50 (L2)	183.2 a	190.1 a	190.6 a	193.5 a
	100 (L3)	154.5 c	160.2 a	172.5 a	178.6 a
LSD	(0.05)	17.91	31.32	31.71	22.22
Control	0 (check)	162.9 b	173.0 a	182.6 a	182.6 b
P2	25 (L1)	186.2 a	191.6 a	197.4 a	201.8 ab
	50 (L2)	190.4 a	194.2 a	200.5 a	214.6 a
	100 (L3)	158.5 b	168.2 a	178.6 a	181.5 b
LSD	(0.05)	21.49	34.51	32.14	22.76

control. With the advancement of incubation periods, an increase in N_{mic} contents were observed. The increase in N_{mic} was more in P2 than P1, might be due to 20% N contents of P2.

Discussion

Our results indicated that the addition of two polymers {Acqua-Kept (P1) and Super-Hydro (P2)} at 25 and 50 μg g^{-1} soil have shown positive effect on soil microbial biomass. However, the higher concentration of 100 μg g^{-1} soil has depressing effect on microbial biomass.

In the loamy soil, Steinberger *et al*. (1993), also found that the soil microbial biomass reacted differently to the two PAMs. Increasing the concentrations of 21J resulted in a gradual decrease in the microbial biomass, although the microbial biomass content was not significantly ($p<0.05$) affected by the 25 mg kg^{-1} compared with the nontreated control soil. The data obtained after the addition of 2J showed a parabolic pattern, where 50 mg kg^{-1} was the maximum and significantly ($p<0.05$) different. They suggested that the compound added to the soil may, above a threshold amount, serve as an available and consumed carbon source, while a higher PAM concentration may be toxic.

They further concluded that that the use of synthetic soil conditioners may result in unpredicted changes in the soil microbial community. The various effects are related to the soil type, to the physical and chemical properties of synthetic compounds, to the adsorption/desorption characteristics of the substance and to the availability of the chemicals to the microorganisms. Our results are in line with their findings.

Polyacrylamides (PAMs) are xenobiotic polymers consisting of covalently linked carbon atoms ($-CH_2-CH_2$), unlike the anhydro bonds of many biological polymers. Although the carbon chains are resistant to microbial breakdown, field observations by people in the oil industry support the notion that polyacrylamides can somehow stimulate the growth of microorganisms. Growth of sulfate-reducing bacteria is also stimulated by polyacrylamides, with a loss of screen factor of the polymer solution accompanying the growth. They explained that, to some extent this is because the polymer serves as a N-source (Grula *et al.*, 1994).

The polymer P2, we used in our study, contained about 20% N and a more increase in microbial biomass –N contents is understood, as stated by Grula *et al*. (1994).

Preliminary tests with members of the order Actinomycetales (including the genera *Streptomyces*, *Nocardia*, and *Mycobacterium*) as well as certain strains of facultative methylotrophs obtained from oil reservoirs, indicated no toxicity, a possible stimulation of growth, and no effect on viscoelastic flow properties (Grula *et al.*, 1994).

The increase in soil microbial biomass-C contents might be due to the reason that the polymers, being the organic compounds, serve as an available and consumed carbon source, while a higher PAM concentration may be toxic (Steinberger *et al*., 1993). Our results are in accordance with this statement.

As expected, the lower concentrations of the two polymers used increased the soil microbial biomass and which consequently would result in better soil conditions. A better understanding of the interrelations between synthetic compounds, soil properties, and soil biota components is needed for the efficient and safe use of synthetic soil conditioners.

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