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J Soil Biol Ecol 15(2) 103-108 Sept 1995

Soil Surface Management Practices and Their Effects on Microorganisms of an Alfisol*

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Abstract

The effects of tillages organic amendments and perennial crops on the population and biomass of soil microorganisms including vesicular arbuscular (VA) mycorrhiza was studied using the experiment in which the response of soil processes to modification of soil structure of an Alfisol is being studied Both soil microbial C and N were highest in one of the perennial treatments *Stylosanthes hamata* This trend coincided with the abundance of soil aggregates larger than 2 mm between the treatments used for this study On the contrary VA mycorrhizal infection was the least in perennial treatments and it increased in the deep tillages except in the one with farm yard manure (FYM) Populations of bacteria and fungi in earthworm cast were consistently greater than those in the field soils, but they did not differ between the treatments.

Introduction

Soil productivity greatly depends on the balance between physical, chemical and biological properties of soil Biological property of soil largely comprises the size and the activity of microflora and fauna Their size and activity are important from the point of view of crop production, and can be influenced by agronomic practices Soil management has a great impact on the size and activity of microflora and fauna, through alteration of soil environment addition of energy source for soil biota and interaction between members of soil biota

A project was established in 1988 by ICRISAT and the Queensland Department of Primary Industry (QDPI), Australia, at ICRISAT Asia Center, Patancheru, Andhra Pradesh, to study the response of soil processes to the modification of soil structure of an Alfisol (Smith *et al*, 1992) As the experiment in the project has various soil surface amendment treatments including different tillages and organic amendments it was contemplated that these experiments would provide information on the effect of soil amendments on soil microorganisms and in the long run interrelate soil microbial activities with soil processes This paper presents the results of a study on population and biomass of soil microorganisms, as affected by soil surface management, and earthworms and vesicular-arbuscular (VA) mycorrhiza, as affected by soil surface amendment

Submitted as ICRISAT Journal Article No. 1832

Materials and Methods

The details of the experiment of the project have been described by Smith *et al*., (1992) Out of 15 treatments, 8 treatments were selected for the present study zero tillage with no amendment (bare) (ZTB), zero tillage with 15 t/ha FYM (ZTF) zero tillage with 5 t ha^{-1} rice straw (ZTS) 20 cm deep tillage with no amendment (bare) (DTB), 20 cm deep tillage with 15 t ha^{-1} FYM (DTF), 20 cm deep tillage with 5 t ha^{-1} rice straw (DTS), a perennial grass *Cenchrus ciliaris* without tillage (C) and a perennial crop *Stylosanthes hamata* without tillage (S) Pearl millet in 1988, sorghum in 1989 and 1990, and maize in 1991 were planted in all the tillage treatments except in perennial treatments In 1992, all the treatments including perennial treatments were planted to maize, and in 1993 to sorghum

Soil samples were collected from the top soil 0-20 cm depth in 1991 93 a time when maize or sorghum reached about 50% inflorescence stage Fifteen g-samples were analysed for soil microbial biomass N and C, using fumigation extraction procedure that was developed by Brooks *et al* (1985) and by Vance *et al*., (1987), respectively

In 1991 the roots of maize from tillage treatments and *C ciliaris* and *S hamata* from perennial treatments, were sampled Roots of maize and sorghum were sampled from all the treatments in 1992 and 1993, respectively The roots were washed free of soil, cleared in 10% KOH by autoclaving and stained in trypan blue-lacto-glycerol Percentage of infection was estimated by the gridline intersect method under 40 x magnification described by Giovannetti and Mosse (1980)

Earthworm cast and underlying soil (field soil) were collected from all the treatments in 1993, and analysed for the enumeration of bacteria and fungi Bacteria were enumerated by plating aliquots of diluted soil solution on nutrient agar medium (Wollum, 1982) Likewise, fungi were estimated using rose bengal agar medium (Martin, 1950)

Results

The means of soil microbial biomass C measured one time each year for 3 years, are shown in Figure 1a The trend that perennial treatments have higher biomass C was found, but it was not statistically significant Biomass C was significantly lower in deep tillage with no amendment treatment than in any other treatment Figure 1b shows the means of soil microbial N for 3 years, which was significantly higher in *S hamata* treatment than in any other treatments

The means of VA mycorrhizal infection are shown in Figure 2 Contrary to biomass C and N, mycorrhizal infection was lower in perennial treatments Deep tillage treatments, except the one with FYM, showed higher mycorrhizal infection

The population of bacteria in field soil and earthworm cast are shown in Figure 3a Across the treatments, the bacterial population in the cast was significantly higher ($P < 0.05$) than that in the field soil The population of bactena

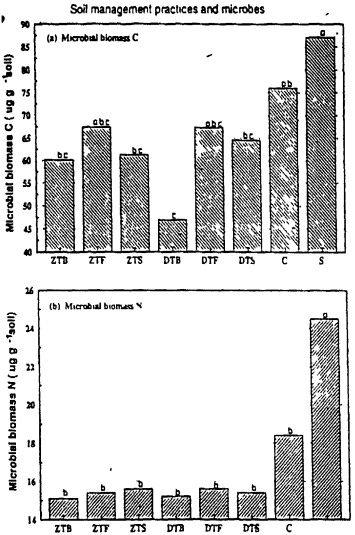


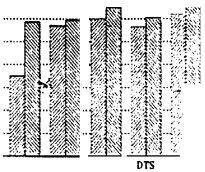
Fig 1 Soil microbial biomass C and N Values are the mean of three samplings during 1991, 1992 and 1993 Means followed by different letters are significantly different ($P < 0.05$)

was lowest in the field soil of zero tillage with straw treatment, but there was no significant difference in the population of earthworm casts across the treatments.

The population of fungi in earthworm cast across the treatments was significantly higher ($P < 0.05$) than that in the field soil (Fig 3b) As in the case of bacterial population, there was no difference in fungal populations of earthworm casts across the treatments.

Discussion

There are reports on the comparisons in soil microbial biomass between different tillage managements (Doran, 1987) or between straw applications (Saffigna *et al.*, 1989 and Ocio *et al.*, 1991). Generally, soil microbial biomass is higher in zero tillage or in straw application. In this study, biomass N was not affected by tillage treatments or organic material treatments, although there was a trend that biomass C was the lowest in zero tillage without organic material addition. Soil microbial biomass was measured around 50% inflorescence stage of maize and sorghum each year. Rao *et al.*, (1994) examined the effect of tillage on runoff in



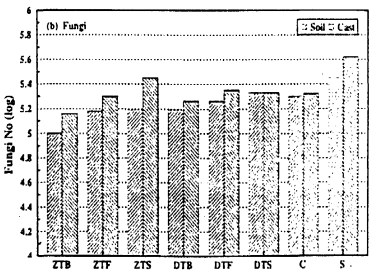


Fig. 2. Vesicular-arbuscular mycorrhizal infection. Values are the mean of three samplings during 1991, 1992, and 1993. Means followed by different letters are significantly different ($P < 0.05$).

the experimental field and observed that the tillage effect diminished in a short period, because of intensive rainfall and soil structure. This quick diminishment of tillage effect may have resulted, at least in part, in a no-tillage effect on soil microbial biomass. In the case of straw application, we observed that a great deal of straw applied had been carried away by termite before the straw was decayed by microorganisms (Reddy *et al.*, 1994). It is likely that much of organic fraction has not entered the soil due to termite activity.

One of the perennial treatments, *S. hamata* treatment, caused the largest increase in biomass C and N. Doran *et al.*, (1987) observed that biomass levels were generally greatest in the treatments planted to red clover, and least in those planted to maize or soybean regardless of nutrient management. It is surmised that leguminous pastures generally increase soil microbial biomass.

It is well recognised that soil microorganisms contribute to soil aggregate nation. From the same field experiment, Rao *et al.*, (unpublished data, 1994)

studied the effect of all the 15 soil management treatments on the abundance of aggregates larger than 2 mm Among the 8 treatments selected in this study the percentage soil aggregates larger than 2 mm was the highest in *S hamata* treatment followed by *C ciliaris* treatment As mentioned earlier soil microbial biomass C and N were the highest in *S hamata* treatment followed by *C ciliaris* treatment These two observations suggest the relationship between abundance of aggregates and soil microbial biomass in this study

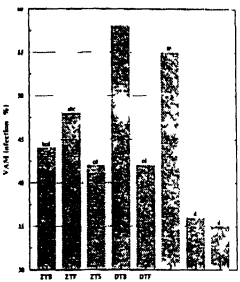


Fig 1 Population of bacteria in the field soils and earthworm casts Values are the mean of three replications

Evans and Miller (1988) observed that VA mycorrhizal infection was higher in maize grown in zero tillage soil than in disturbed soil Harinikumar and Bagyaraj (1989) observed that FYM application stimulated VA mycorrhiza Contrary to these observations in this study deep tillage treatments with no amendment and with straw application increased VA mycorrhizal infection and perennial treatments, which are considered as zero tillage caused a decrease in VA mycorrhizal infection There was no effect of FYM on VA mycorrhiza either At present we cannot explain the reasons for our observation which are contrary to those of Evans and Miller (1988) However it may be possible that increased VA mycorrhizal infection in deep tillage treatments is associated with increased dispersal of infective hyphae or propagules by disturbing soil

Generally earthworms are considered to increase the composition and activity of microbial populations in the soil (Lavelle 1988) We also observed an increase in the population of bacteria and fungi in earthworm casts in almost all the soil management treatments This result shows that bacteria and fungi can survive the passage through the earthworm gut and that earthworms play a role in increasing and dispersing microbial populations There was no distinct difference in the microbial population per unit weight of earthworm casts across different treatments in this study However it is important to estimate the total quantity of earthworm casts in different treatments so as to know the soil management effects on the interaction between earthworms and microorganisms

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