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Influence of tillage and microarthropod abundance on some nutrients during decomposition of rice-straw mulch in a semi-arid tropical Alfisol

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Abstract: Changes in concentration of nutrients of rice straw during decomposition in relation to soil microarthropod densities were studied across tillage treatments over the seasons in a semi-arid tropical alfisol sorghum ecosystem. The total N content of the straw increased under shallow tillage while the available K, Mg and Ca increased in zero tillage. Tillage and the interaction of tillage and the duration of decomposition significantly affected the concentrations of available K and Mg of the straw ($P < 0.01$). The population densities of microarthropods explained upto 41% variation in total N and 63% variation in available K concentration of decaying straw in the mesh bags ($P < 0.05$).

Resumen: Se estudiaron los cambios en las concentraciones de nutrientes en la paja de arroz durante la descomposición en relación con las densidades de microartrópodos del suelo entre varios tratamientos de labranza a lo largo de una estación en el ecosistema de sorgo de Alfisol semiárido tropical. El contenido total de N de la paja incrementó con la labranza superficial, mientras que el K, Mg y Ca disponibles incrementaron con labranza cero. La labranza y la interacción de la labranza con la duración de la descomposición afectaron significativamente las concentraciones de K y Mg disponibles en la paja ($P < 0.01$). Las densidades poblacionales de los microartrópodos explicaron hasta el 41% de la variación en la concentración de N total y 63% de la variación de la concentración de K disponible en la paja en las bolsas de malla ($P < 0.05$).

Resumo: As mudanças na concentração dos nutrientes durante a decomposição da palha de arroz em relação às densidades dos micro artrópodes foram estudadas ao longo das lavouras efectuadas no ciclo cultural de um ecossistema de sorgo num alfisol tropical semi-árido. O teor total de N da palha cresceu com uma lavoura ligeira enquanto o K, Mg e Ca aumentaram com a supressão da lavoura. A lavoura e a sua interacção com a duração da decomposição afectou significativamente as concentrações do K e Mg disponíveis na palha ($P<0,01$). As densidades populacionais dos micro artrópodes explicaram até 41% da variação do N total e 63% da variação do K dioponível na palha nos sacos de rede ($P<0,05$).

Key words: Decomposition, rice-straw, soil microarthropods, soil nutrients, sorghum ecosystem, tillage.

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Introduction

Crop residues are mineralized through the process of decomposition and show a tendency towards greater immobilization of nutrients during decomposition in conservation or no-tillage systems (Hendrix *et al.* 1986). However, the decomposition rate is accelerated in the conventional tillage systems, and the mobility and mineralization of nutrients are increased because of more intimate soil-crop residue contact following its incorporation in the surface-soil which leads to greater mechanical disintegration. Greater decomposition and mineralization rates have been reported in the incorporated crop-residue compared to the residue left on the soil surface in the field (Reddy 1999; Summerell & Burges 1989).

The decomposition and mineralization of crop-residue are influenced by various environmental and management practices (Reddy 1995; Reddy *et al.* 1994). The effects of tillage mechanism on the nutrient cycling is associated with decomposer communities across the tillage treatments (Hendrix *et al.* 1986). However, there is very little information on the influence of various environmental factors on the decomposition and subsequent changes in the chemical composition of the cereal straw residue (Reddy 1999; Summerell & Burges 1989). There is also a paucity of information on the rate of decomposition and changes in the nutrient contents of straw during decomposition in relation to various management practices and soil faunal abundance particularly in tropical agroecosystems (Reddy *et al.* 1994). The present paper reports the influence of different tillage amendments and microarthropod densities, on the changes in concentrations of total N, available P, K, Mg and Ca of rice-straw during the decomposition in a semi-arid tropical alfisol sorghum field.

Materials and methods

The experiment was performed at the International Crop Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh, Indian and the details of the study site are described in Smith *et al.* (1992). The experiment was conducted under three tillage treatments (zero-0 cm, shallow-10 cm and deep-20 cm), each treatment with three replicates each with plot size 28 m x 5 m, in a balanced incomplete randomized block design. The rice straw mulch was placed @5 t ha^{-1} as one of the organic amendments across the tillage treatments on the alfisol. The sorghum crop was grown. The straw and the associated microarthropod population densities were sampled by litter-bag method, as described in Reddy *et al.* (1994). Nylon bags of 10 x 10 cm size of two mesh size (1 mm fine and 4 mm coarse) were used. Total nitrogen and available phosphorus concentrations of the decayed straw were measured by Technicon Auto Analyser II (Industrial Method No. 218-72A and 144-71A, respectively). Concentrations of available K, Mg and Ca of the straw were estimated by Tri acid digestion method (Jackson 1967) using Atomic Absorption Spectrophotometer (Varian AA20).

Data on nutrient concentrations of the straw at various stages of decomposition in the fine and coarse mesh bags, in relation to tillage were analysed statistically (ANOVA). The influence of tillage and microarthropod densities on nutrient concentrations of the straw was estimated using multiple regression analysis.

Results and discussion

The microarthropods inhabiting the straw filled nylon mesh bags belonged to Acarina, Collembola, and other miscellaneous arthropods such as termites, Coleoptera and their larvae, Psocoptera, Dermaptera, Battidea, Homoptera, Thysanoara, Pauropoda and Pseudoscorpions (Reddy *et al.* 1994). Initially, at the time of placing the straw in the field, the concentration of total N was 0.96 ± 0.03%, that of available K was 1.53 ± 0.4%, available P was 0.14 ± 0.01%, Mg was 0.49 ± 0.04% and Ca was 0.49 ± 0.08%. The average concentrations of total N and Ca increased upto 60 days of decomposition in both mesh size bags across the tillage treatments (Fig. 1). This could be due to immobilization by microorganisms and from inorganic nitrogen sources from surrounding substrates (Seastedt & Crossley 1983). It may also be attributable to the presence of total microarthropods as their densities were high during initial 60 day of decomposition.

The differences in N and P concentrations, among the tillage treatments were not significant (Table 1). In case of P a steep decrease was noticed upto 60 day of decomposition in both mesh size bags, beyond which its concentration did not change (Fig. 1). A significant effect of interaction between the decomposition period and tillage was observed for K concentration, and the effects of

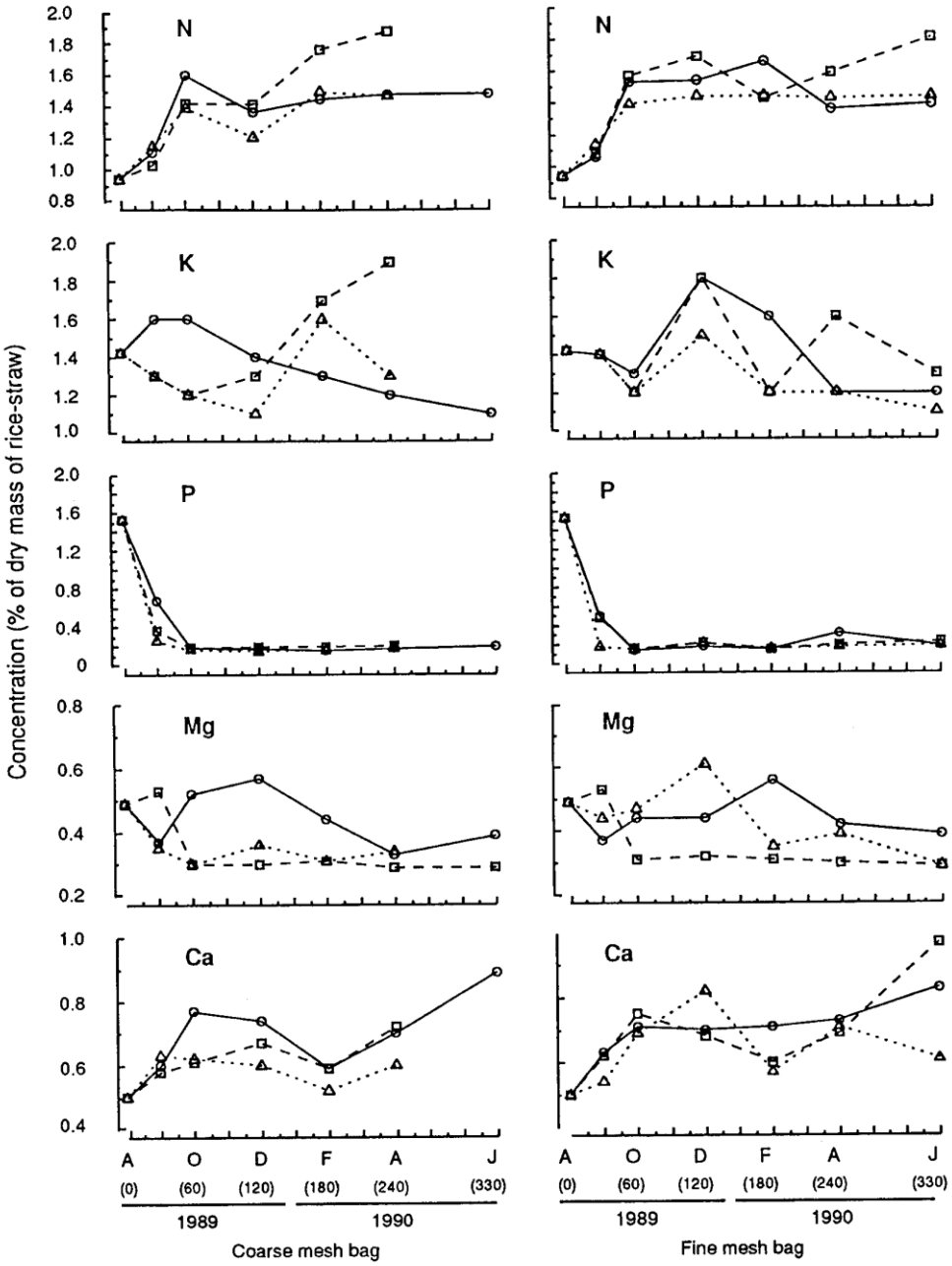

Fig. 1. Concentration (%) of total N, available K, P, Mg and Ca during different stages of decomposition of rice-straw across the tillage treatments in coarse and fine mesh size bags. Zero tillage (-o-), 10 cm tillage (--□--) and 20 cm tillage (… …).

differences in tillage were also significantly different. It is further observed that its concentration in the decomposed straw varied significantly over the period (Table 1). For Mg, all the variables were found significant except the interaction between the decomposition period and mesh size, the reasons of which are not known. It indicated that these variables significantly influenced the Mg concentration of the decaying straw.

Microarthropod densities influenced significantly the variations in the concentrations of total N and available K as revealed by coefficients of determinants and regression (Table 2). The effect of microarthropod densities on variation in Mg concentration was almost negligible. The effect of

Table 1. Analysis of variance (ANOVA) of different nutrients of decomposed rice straw in relation to tillage over seasons (period of decomposition).

Source	Mean squares					
	df	N	P	K	Mg	Ca
Period of decomposition (PD)	4	0.2074**	0.0003	0.0668**	0.0083**	0.0169**
Tillage (T)	2	0.0437	0.0007	0.0153**	0.0232**	0.0086
Mesh size (Coarse vs Fine) (M)	1	0.0003	0.00001	0.00003	0.0136**	0.0124
PD x T	8	0.0179	0.0005	0.0142**	0.0139**	0.0011
PD x M	4	0.0288	0.0009*	0.0039	0.0002	0.0012
T x M	2	0.0028	0.00004	0.0001	0.0112**	0.0020
PD x T x M	8	0.0130	0.0003	0.0045	0.0048**	0.0048
Error	56	0.0147	0.0003	0.0028	0.0015	0.0036

*P <0.05; **P <0.01

the arthropod densities on total N was negative but it is positive on K concentration of the straw as shown by the regression coefficient. It indicated that with the gradual decrease in arthropod densities because of dry conditions the total N concentration increased and the K concentration decreased in the decomposed straw. Seastedt & Crossley (1983) stated that N can be mineralized by grazing and excretory activities of microarthropods, and that leaching and volatilization remove these nutrients from the immediate surroundings. The feeding of microorganisms by microarthropods may be of some importance, and may cause rapid recycling of most of the nitrogen. However, Seastedt (1984) stated that these arthropods seem to have little effect on K concentration of decomposed plant residue. Seastedt & Crossley (1983) reported that the litter containing microarthropods possessed increased concentrations of P, without any outputs. As the microarthropods decreased in number during the present study the P concentration also reduced in both the mesh bags across the tillage treatments over the season. Microarthropod activities tend to enhance mineralization of P even when they do not have any effect on mass-loss (Reddy 1995; Seastedt & Crossley 1980). The present findings are in accordance with those of Seastedt (1984) that there is very little consistent effect of microarthropods on Ca and Mg concentrations of plant residues. These inconsistencies probably reflect the differences in feeding preferences of different microarthropods.

Table 2. Coefficient of determination of microarthropod densities on some nutrients of the decomposed straw over the seasons.

Nutrients	R^2(%)	Regression coefficient
Total N	41	-0.0018*
P	17	0.0009
K	63	0.0018*
Mg	<1	0.00012
Ca	24	-0.0005

*P <0.05

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