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Effects of Some Plant Residues on Nitrogen Mineralization and Biological Activity in Soils

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Abstract: The objective of this experiment was to determine the rate of decomposition and nitrogen mineralization of plant residues in soil under laboratory conditions. The experiment consisted of six treatments: control, industrial tobacco residues, rice straw, rice straw + mineral nitrogen, rice husks and rice husks+mineral nitrogen. The plant materials were added at a rate of 2000 mg/kgC and the amount of NH_4^+-N completed the C:N ratio of the added materials to 12.5. After adding the plant material the following measurements were carried out: soil respiration measurements 14 times, dehydrogenase activity 14 times, mineral nitrogen (ammonium and nitrate). The results show that the C:N ratio was found to affect the net mineralization and nitrogen mineralization under the present conditions for decomposition of plant residues. Mineral nitrogen addition is conducive for short-term decomposition when the C:N ratio is large.

Bazı Bitki Hasat Artıklarının Toprağın Biyolojik Aktivitesi ve Azot Mineralizasyonuna Etkisi

Özet: Laboratuvar koşullarında yürütülen bu çalışmada, bitki hasat artıklarının toprağın azot mineralizasyonuna, toprağın biyolojik aktivitesina olan etkilerini ve bitki hasat artıklarının topraktaki ayrışma oranını belirlemek amaçlanmıştır. Deneme; kontrol, tütün'ün fabrikasyon atığı, çeltik anızı+mineral azot, çeltik kavuzu ve çeltik kavuzu+mineral azot olmak üzere 6 uygulama şeklinde düzenlenmiştir. Bitki hasat artıkları toprağa 2000 mgC/kg toprak olacak şekilde, mineral azot ise toprağa ilave edilen bitki materyalinin C:N oranını 12.5 düzeyine getirecek şekilde hesaplanarak verilmiştir. Bitki hasat artıklarının toprağa karıştırılmasından sonra toprağa tarla kapasitesine getirilinceye kadar su ilave edilmiştir. Karıştırma işleminden sonra toprakta belirli dönemlerde (14 kez) toprak solunumu ölçülmüş, dehidrogenaz enzim aktivitesi ve mineral azot (amonyum ve nitrat) tayin edilmiştir. Araştırma sonucunda bitki hasat artıklarının topraktaki ayrışması ile toprağın azot mineralizasyonu ve net mineralizasyona olan etkilerinin C:N oranına göre değiştiği belirlenmiştir. Ayrıca C:N oranı geniş olan organik materyalin ayrışmasının mineral azot ilavesi ile hızlandığı ortaya konmuştur.

Introduction

Soil organic matter is one of the most important regulatory soil components for productive and sustainable agriculture as well as the main source of C, N, P and S (1). In particular, N largely depends on soil organic matter and microbial activity (2). The C:N ratio plays a critical role in the N budget in soil during decomposition of added organic material. Higher available C content in the added material was found to be leading the N-immobilization during the early phase of decomposition (3).

A surplus of nitrogen, especially nitrate, in the root zone after harvesting the crops means a significant hazard of environmental contamination via leaching, erosion and denitrification. All of these processes strongly require a good understanding of nitrogen under different environmental conditions. The nitrogen supplying capacity of a certain soil layer could be characterized by nitrogen mineralization of soil organic matter and by accumulated mineral nitrogen (4).

Since increasing public environmental concern brings about intensive usage of organic wastes in agriculture, scientists have focused on investigating the decomposition and availability of various organic materials for sustainable agriculture and their effects on the biological and chemical properties of soil, especially N and C budget in soil as an amendment practice (5). Measuring the variations in mineral N over time allows the quantification of net immobilization and net mineralization. The quality of plant residue added to soil determines both the rate of decomposition and the dynamics of mineral N. In the absence of recent additions of fresh organic matter, the soils generally present regular net mineralization kinetics during incubations. The dynamics as well as the net amounts of N immobilized varied greatly in these experiments according to the nature of plant residues (6). The amount of N immobilized appeared to be dependent on the type of substrate, particularly its C:N ratio (7). The kinetics of decomposition are much more related to the biochemical composition of the residue, such as soluble C, cellulose and lignin contents (8; 3). Our objective was to study the effect of added nitrogen and three different plant residues (industrial tobacco residue, rice straw and rice husks) on the mineral nitrogen (NH_4^+-N and NO_3-N) content, soil CO_2 production and soil dehydrogenase (DHG) activity.

Materials and Methods

A laboratory study was conducted with a clay soil with a pH of 6.3, total N content of 0.072%, organic C of 0.84% and $CaCO_3$ of 0.03%. The most important properties of industrial tobacco residue, rice straw and rice husks are given in Table 1.

Table 1. Composition of plant residues (9)

Residue	N(%DM)	P (%DM)	K (%DM)	TOC(%DM)	C/N
Industrial tobacco res.	2.7	0.5	1.5	30.6	11.3
Rice straw	0.3	0.4	1.0	20.0	66.7
Rice husks	0.5	0.3	1.2	38.0	76.0

The experiment consisted of six treatments: 1. Control soil without residue; 2. Industrial tobacco residues; 3. Rice straw; 4. Rice straw + $(NH_4)_2SO_4$; 5. Rice husks; 6. Rice husks+$(NH_4)_2SO_4$. The plant materials were added at NH_4^+-N was to complete the C:N ratio of the added materials to 12.5 (10).

The incubation was conducted in 18 large rectangular containers, with three replicates of each treatment. Soil samples of 3 kg (DM basis) were mixed with the appropriate amount of residue and placed in the containers. Water was added to adjust the moisture content to 70 % of water holding capacity. $(NH_4)_2SO_4$ was added with the water, in two portions applied while filling the containers with the soil residue mixtures, to avoid the retention of all the added N on the surface. The containers were placed uncovered in a dark room at a constant temperature of 30±2°C. The moisture content was readjusted once a week, for 3 months. Soil samples were taken 14 times in the course of the experiment (2, 3, 5, 8, 10, 20, 30, 40, 50, 60, 70, 80, 90 days after starting the incubation). The container was weighed before and after sampling, to determine the soil moisture and the weight of the soil moisture and the weight of the soil removed for subsequent moisture readjustment by weight. The moist soil was analyzed for ammonium and nitrate (11), soil respiration (12) and dehydrogenase (DHG) activity (13).

Results and Discussion

Dehydrogenase activity was highest after 2 days of addition of plant residues (Fig. 1). Similarly, high enzyme activity during the early stage of decomposition of organic wastes was found by Kara (14). With increasing incubation period, up to 10 days, dehydrogenase activity was nearly constant with a little fluctuation and then decreased to the same level as the control. The highest dehydrogenase activity was observed with industrial tobacco residue, and rice straw, followed by rice husks, rice straw+NH_4, rice husks+ NH_4 and the control.

Reducing the C:N ratio of rice straw and rice husks by the addition of mineral nitrogen increased the dehydrogenase activity drastically in the first day of incubation, suggesting immediate use of mineral nitrogen by microbial activity (Table 1).

Soil CO_2 production followed a similar trend for all plant residues except that rice straw which showed a considerable deviation for the first days of incubation (Fig. 2).

The lower rate of CO_2 production with rice husks might be attributed to the presence of highly decomposition resistant compounds (i.e. lignin) for bacteria and a high C:N ratio. In fact, the addition of mineral nitrogen could not facilitate decomposition in the first day of incubation due to a relatively high lignin content of rice straw and especially decomposition of rice rice husks by microorganisms is hardly possible. Since a C:N ratio of around 15 favors bacterial activity, the differences in CO_2 production rates among the treatments may be partly related to the C:N ratio. The plant residues used in this experiment were industrial tobacco residue, rice straw and rice husks. Industrial tobacco residue has a high N content and therefore a low C:N ratio (Table 1), and rice straw and rice husks have a low N content and a high C:N ratio, and therefore are expected to induce N immobilization during decomposition in soil. The N mineralization rate varied with the C:N ratio and nitrogen addition (Fig. 3).

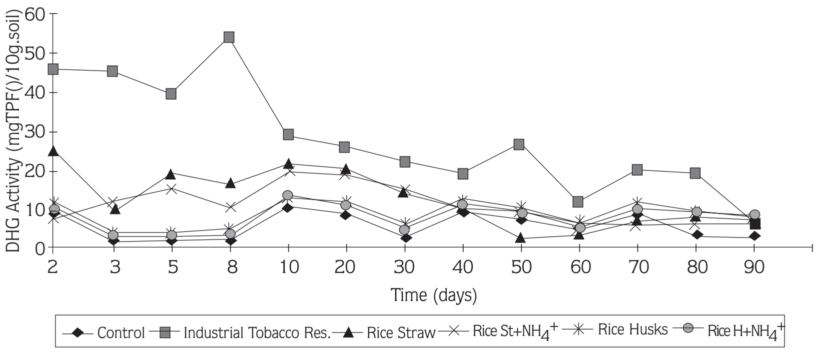

Figure 1. The effect of plant residues on dehydrogenase activity

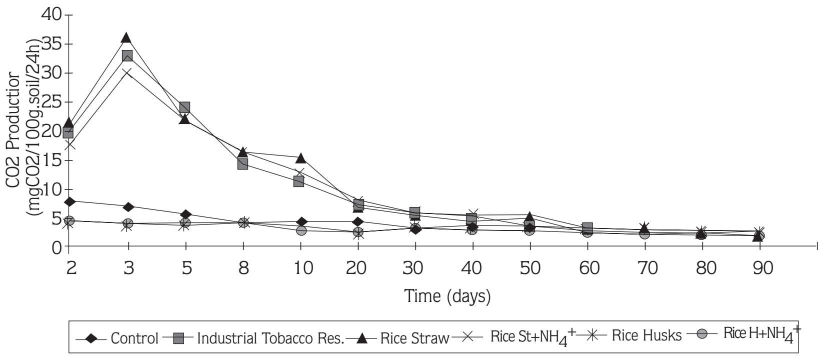

Figure 2. The effect of plant residues on CO_2 production

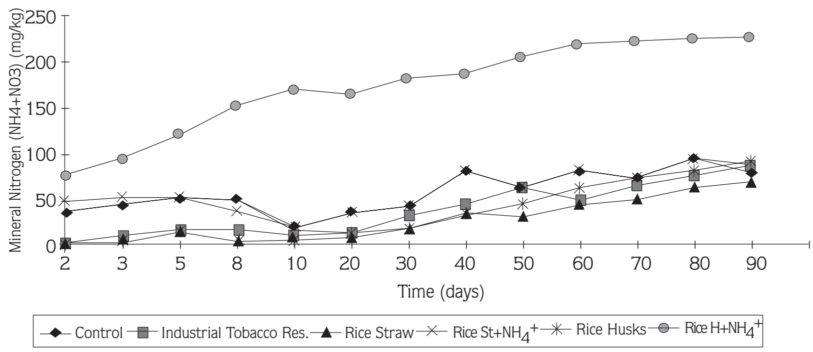

Figure 3. The effect of plant residues on nitrogen mineralization

Due to a larger microbial activity in the first 10 days a net biological immobilization of mineral N was observed, however, a longer incubation period led to an increase in the mineral nitrogen for all plant residues. Rice husks+NH_4^+ was the combination likely to be most beneficial in terms of nitrogen balance in this study.

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