Urea hydrolysis in wetland soil amended with *Sesbania aculeata* green manure and rice straw

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**Summary.** The effect of incorporating sesbania and rice straw and of period of decomposition on urea hydrolysis was studied in a wetland soil under laboratory conditions. Urea hydrolysis proceeded more rapidly in the crop residue-amended soil than in the control soil, and increased with increases in the rate of addition of crop residues and with longer periods of decomposition. Irrespective of amendment treatment, urea hydrolysis followed first-order reaction kinetics, and rate constants in the un-amended soil ranged from 0.021 to 0.024 h⁻¹ after urea application of 200 µg N g⁻¹ soil. In the amended soil, hydrolysis rates ranged from 0.033 to 0.149 h⁻¹ with sesbania and 0.071 and 0.250 h⁻¹ with rice straw, depending on the length of decomposition period.

**Key words:** Green manure – Straw – Decomposition period – Urea hydrolysis – Wetland soil

Chemical fertilizers have, in recent years, been considered the cheapest sources for supplying nutrients to crops. This has led to great increases in the use of fertilizers in agriculture. However, in the face of high costs of chemical fertilizers and growing concern for maintaining long-term soil productivity and ecological sustainability, a tremendous renewal of interest in using leguminous green manure crops and proper management of crop residues has developed. The available data indicate that soil fertility maintenance necessary for sustainable crop production is achieved by a judicious combination of leguminous green manure crops and chemical fertilizers (Yadvinder-Singh et al. 1991). Large amounts of residues from high-yielding cultivars are incorporated into soil before N application for the successive crop.

Urea hydrolysis in soil is affected by various environmental factors which have been studied extensively, but the effects of organic matter decomposition are not well understood (Sankhayan and Shukla 1976, Bremner and Mulvaney 1978; Kumar and Wagenet 1984; Thomas and Santaram 1984; Bolten et al. 1985; Saini 1990). Bajpai et al. (1984) observed that the rate of urea hydrolysis was enhanced by the addition of sesbania green manure in both normal (pH > 7.5) and saline-alkali soil (pH 9.8). Similarly, Carmona et al. (1990) reported that in soybean straw-amended soil, 90% of the urea was hydrolysed in 2 days compared with 48% of unamended soil.

In northwestern India, rice-wheat is the main cropping system, and the crops are mainly combine-harvested, thereby leaving large amounts of crop residues. After wheat harvest, there is a sufficient time for growing short-duration leguminous green manure crops. Little information seems to be available on the effects of length of decomposition period of leguminous green manure and crop residues on urea-N transformations in soil. Therefore, we studied the effects of incorporating sesbania green manure and rice straw residue (organic materials differing widely in their C:N ratios) and the length of incubation on urea hydrolysis in a wetland soil. This information could help in efficient management of urea in wetland rice, particularly when urea applications are subject to high losses through NH₃ volatilization.

**Materials and methods**

A laboratory incubation experiment was conducted to study the changes with time in urea hydrolysis rates in wetland sandy loam (Typic Ustic Haplustoll) soil amended with sesame and rice straw. The soil had a pH of 8.1, electrical conductivity of 0.16 dS m⁻¹, 0.35% organic C, 0.06% total N, and cation exchange capacity of 8.3 cmol (p+) kg⁻¹.

Ten-gram samples of air-dry soil were placed in plastic containers (25 mm inside diameter) fitted with stoppers. Finely ground (40 mesh) oven-dried sesbania (*Sesbania aculeata* Pers.) plants (2-month-old, 2.5% N) and rice straw (0.60% N) were thoroughly mixed with the soil at 0.2 and 0.5% on a dry weight basis. The soil samples were submerged to a depth of 1 cm with deionized distilled water. The samples were incubated at 30±1 °C in the dark for 1, 7, and 14 days. Controls without sesbania and rice straw were included. After the incubation periods, a urea solution at 200 µg N g⁻¹ soil was added to the overlying floodwater.
Two samples from each treatment were taken 0, 4, 8, 12, 16, 20, and 24 h after the urea application and extracted with 2 M KCl containing 5 μg ml⁻¹ phenylmercuric acetate, following the method of Douglas and Bremner (1970). In the controls, samples were taken up to 96 h with an interval of 12 h each after the 24-h sampling time. Urea concentrations in the KCl-phenylmercuric acetate extracts were determined by the modified diacetyl monoxime method (Mulvaney and Bremner 1979).

The rate of urea hydrolysis was calculated as:

\[ \ln C = \ln C_0 - kt \]

where \( C_0 \) is the initial concentration of urea, \( C \) is the concentration of urea at time \( t \), and \( k \) is a rate constant.

**Results and discussion**

The disappearance of urea with time is plotted in Figs. 1 and 2, and rate constants (\( k \)) and coefficient of determination (\( R^2 \)) were calculated after taking logarithms of urea concentrations. Irrespective of sesbania and rice straw treatments, urea hydrolysis rates different significantly depending on the type of crop residue added, the rate of addition, and the period of decomposition. In the control treatments, without sesbania or rice straw, no significant difference in urea hydrolysis rates were observed with the length of incubation period, and hydrolysis was complete in 96 h. The average time for half the urea to hydrolyze for the control soil varied from 28.9 to 33.0 h, and the rate constants varied from 0.021 to 0.024 h⁻¹ depending on submergence time.

In soil amended with crop residues, urea hydrolysis proceeded very rapidly compared to the control. It took only 16 h for completion of urea hydrolysis in the soil amended with 0.5% rice straw, and 24 h in the soil that had been treated with the same application of sesbania. Also, urea hydrolysis increased with increases in the rate of addition of crop residues and with longer periods of decomposition. In soil treated with sesbania, the urea hydrolysis rates ranged from 0.033 to 0.149 h⁻¹ (\( t_{1/2} = 4.65–21.0 \) h, Fig. 1) whereas for the rice straw-amended soil, it ranged from 0.071 to 0.250 h⁻¹, with \( t_{1/2} \) values ranging from 2.77 to 9.76 h (Fig. 2).

The study shows that the rates of urea hydrolysis can vary considerably and be changed quickly by the addition