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Effects of Rice Straw Application on the Immobilization of Applied Nitrogen in a Submerged Soil

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논 土壤에서 볏짚施用時 施用窒素의 有機化에 関한 研究

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摘 要

논 土壤에서 볏짚施用量을 달리했을 때 施用된 窒素肥料의 無機 및 有機化 過程을 알기 위하여 室內에서 恒温 試驗한 結果를 要約하면 다음과 같다.

1. 土壤微生物 利用可能 炭素源이 豊富한 볏짚施用時 施用窒素의 有機化 過程은 볏짚施用量이 많을 수록 窒素 有機化 速度가 빨랐음.

2. 볏짚施用時 施用窒素의 90%以上이 恒温20日傾 모두 有機化 되었음.

3. 施肥窒素의 無機化量은 볏짚施用量에 関係없이 恒温 10日以後 土壤無機態 窒素까지 有機化시켰음.

4. 볏짚施用時 施用된 窒素는 恒温 50日까지 再無機化되지 않했음.

Introduction

In the studies of Chu and Knowles[6], nitrogen^{15}-enriched *Pseudomonas* spp. cells and $(NH_4)_2SO_4$ were added separately to a Chicot sandy loam and to a black spruce raw humus. At the initiation 92.5% of the added NH_4-N appeared the exchangeable fraction of the two soils, respectively; and 55.3 and 83.7% of the added cell-N appeared in the amino acid fraction of the two soils, respectively. During incubation, about 40% of the added NH_4-N remained in the exchangeable fraction and 50 to 60% were immobilized in the amino acid fraction. In the raw humus about 13% of the added NH_4-N appeared in the insoluble humin fraction. In both soils, 20-30% of the added cell-N were rapidly mineralized, but at least 50% remained in the amino acid fraction. Rapid net immobilization followed by rather rapid net mineralization was often observed when readily available carbohydrate substances were added to soil[2]. The use of soluble carbohydrate materials resulted in higher net nitrogen immobilization per unit of substrate by the use of normal crop residues[3]. This high immobilization was followed by rapid mineralization from much of the immobilized nitrogen, and the mineralized nitrogen reappeared in the inorganic fraction later[4]. The rapid nitrogen tie-up and release pattern observed when soluble carbohydrates were added to soil and were not typical of the net immobilization and net mineralization changes which occured during plant residues decomposing.[1][9] Where the fresh residues were low in nitrogen, an initial rapid increase in organic nitrogen was observed. When the fresh residues were high in nitrogen, an initial rapid net mineralization occurred. After the first few weeks of decomposition, further net changes in organic nitrogen were slow regardless of the quantity of nitrogen in the residue materials. The increase in numbers of microbes in soil resulting from addition of crop residues closely coincided with the changes in organic nitrogen[5].

Nommik[11] and Kuo[10] found that low temperature reduced biological activity, and thus delayed the maximum net immobilization time. After extensive decomposition, unfavorable moisture and temperature influenced minorly on the magnitude of

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net immobilization.

In most of rice field, during the rice cultivation season, some organic matters such as compost, manure and rice straw have been applied with some amounts of fertilizer nitrogen before transplanting of rice seedlings.

Applied fertilizer nitrogen may be not recovered all as mineral nitrogen in soil. During the decomposition of applied organic matter in the system, some of the applied fertilizer nitrogen can be found as immobilized organic form. Thereby, recovery of applied nitrogen may be different with soil condition and method of soil treatment.

The study reported here was to measure the recovery of applied nitrogen with different amounts of energy rich rice straw in submerged condition during the different incubation periods.

Materials and Methods

Soil and soil treatments

The soil used in this experiment was Yeongsan silty loam with imperfectly drainage. Some chemical properties were described in Table 7-1. Soil samples were taken from the field and air dried under shadow to avoid desiccation effect. Air-dried samples were passed through 2mm sieve and thoroughly mixed before experiment. Matured rice straw (T-N 0.65%, T-C 45%) was pulverized and was passed through 2mm sieve. Then 30mg and 60mg of pulverized rice straw were added in 10g of soil. In addition, 0mg, 1.1mg, and 2.2mg of nitrogen as urea were added in 10g of soil, and were thoroughly mixed. Treatments with no nitrogen and no rice straw were also included compare with the straw and nitrogen additions. Then 10g of prepared soil sample was placed in 100ml Erlenmyer flasks with addition of 30ml demineralized water. Flasks were closed with rubber stoppers and incubated at 28°C. At appropriate intervals: 5, 10, 20, 30, and 50 days, the soil samples were analyed ammonium nitrogen. Determination of soil NH_4-N was used by means of Micro-Kjeldahl method. A 10g of air-dried sample was placed in 100ml Erlenmyer flask with 25ml of 1N KCl solution and shaken one hour. The extractant was filtered with Watman No. 6 filter paper. Exactly 10ml of extracted solution was treated with 10% MgO and immediately distilled by means of micro-kjeldahl apparatus. The distillate Erlenmyer flask with 10ml of 3% borate solution. About 50ml of collected ammonia in borate solution was titrated with 0.005 N H_2SO_4 standard solution.

Results and Discussion

The relationship between immobilization of applied fertilizer nitrogen and energy rich rice straw was showed in Fig.-1.

The recovery of ammonium nitrogen shown in Fig. 1. revealed the net amount of fertilizer nitrogen, which was calculated by subtracting the amount of soil ammonium nitrogen in check treatment from soil and fertilizer nitrogen. After 5 days incubation, in 1.1mg of added nitrogen remained 0.5-0.6mg, and no remarkable difference was observed among the different amounts of rice straw; however, as incubation time progressed remarkable difference took place among the different amounts of added rice straw. The increasing amount of rice straw enhanced the immobilization of added fertilizer nitrogen. After 15 days of incubation period, little amount of added fertilizer nitrogen was observed when 60mg rice straw was added. The amounts of applied amonium nitrogen in control and addition of rice straw was not much

Table 1. Chemical properties of soil used.

Soil series	PH (1 : 5)	O-M (%)	Available		Exch. bases (me/100g)		
			P_2O_5 (ppm)	SiO_2 (ppm)	Ca	Mg	K
Yeongsan	6.4	1.10	14	147	6.5	3.0	0.20

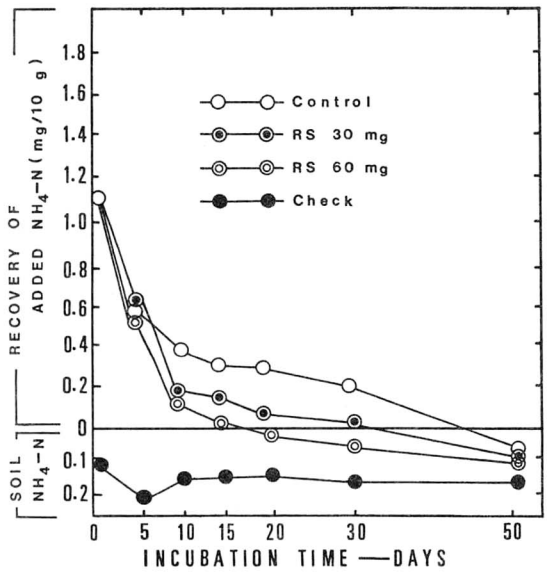

Fig. 1. Average amounts of recovery of added urea nitrogen in soil with rice straw applied for 30 and 60 mg per 10g soil and release of soil native ammonium nitrogen.

different at 50 days after incubation. All added fertilizer nitrogen have been changed to immobilizer nitrogen form.

On the other hand, the amounts of soil nitrogen in check treatment showed a little increase after 5 days incubation, and the increased amount was returned to previous level at 10 days incubation period. The amount of soil nitrogen after 10 days did not change until 50 days incubation period.

The recovery trends of three different levels of added nitrogen at different levels of rice straw were illustrated in Fig. 2.

Nitrogen transformation occurred at the early stage of incubation and continued during the whole incubation period. After 5 days of incubation, soil ammonium nitrogen in the plot without nitrogen was not recovered by addition of 30mg rice straw and this was continued during the incubation period. After 10 days of incubation period, only 0.15mg of nitrogen was recovered when 1.1mg of nitrogen were added. The transformation of added nitrogen lasted until 50 days of incubation. After 40 days of incubation period, whole added fertilizer nitrogen was transformed to immobilized nitrogen when 2.2mg of nitrogen were added.

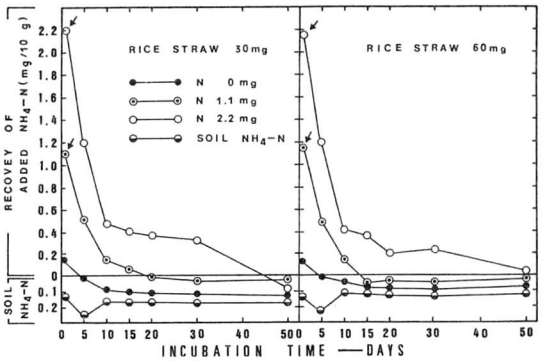

Fig. 2. Recovery of three different level of applied fertilizer nitrogen in soil amended with rice straw for 30 and 60 mg per 10 gram soil.

Similar transformation pattern of added fertilizer nitrogen was observed by addition of 60mg of rice straw as that by addition of 30mg of rice straw. However, more rapid and vigorous transformation of added nitrogen occurred when 60mg of rice straw were added than when 30mg of rice straw were added. Vigorous transformation occurred when the rice straw was added with less fertilizer nitrogen.

Harmssen and Kolenbrander[8] pointed out that the C/N ratio of the substrate itself might decrease during decaying and addition of fertilizer nitrogen sometimes resulted in an increased accumulation of inorganic nitrogen.

Bartholomew[2] pointed out that during the decomposition of organic matter with a low C/N ratio, inorganic nitrogen accumulates. Broadbent and Nakashima[4] found that addition of ammonium nitrogen increases the rate of mineralization of organic nitrogen, and attempted to explain the mineralization of organic nitrogen by osmotic effects. Hallam and Bartholomew[7] pointed out that the rate of decomposition of the soil organic matter was increased upon incorporation of the plant residue into the soil.

According to the results of this experiment, at a C/N ratio higher than 10, the applied nitrogen in soil was greatly immobilized during the early stage of incubation period. As far as 50 days of incubation,

remineralization of immobilized ammonium nitrogen and not take place in soil.

Abstract

Energy rich rice straw was subjected to biological processes involving the transformation of added nitrogen. A part of soil ammonium nitrogen was steadily exhausted when energy rich rice straw was decomposed. More vigorous transformation of added nitrogen occurred during the first 5 days of incubation period than after 10 days of incubation period. Furthermore, transformation of added nitrogen occurred more markedly when more rice straw and less nitrogen were added. Remineralization of immobilized nitrogen did not take place in this experiment with 50 days of incubation.

Reference

1. Bardia, M.C. and A.C. Gaur. 1968. Infuence of insecticides on Carbon dioxide evolution from Soil. Indian J. Microbi 8: 233-238.
2. Bartholomew, W.V. 1965. Mineralization and immobilization nitrogen in the decomposition of plant and animal residues, in soil nitrogen. Agronomy 10: 285-306.
3. Bowen, G.D. and A.D. Rovira 1961. The effects of microorganisms on plant growth. Plant and Soil. 9(2) 166-188.
4. Broadbent, F.E. and T. Nakashima. 1971. Effects of added salts on nitrogen mineralization in three California soils. Proc. Soil. Sci. Soc. Am. 35: 457-460.
5. Brown, M.E., Burlingham, S.K. and R.M. Jacson. 1962. Studies on *Azotobacter* species in Soil. I. Comparison of media and techniques for counting *Azotobacter* species in Soil. I. Comparison of media and techniques for counting *Azotobacter* in soil. Plant and Soil 17: 309-319.
6. Chu, J. P-H and R, Knowless 1966: Mineralization and immobilization of nitrogen in bacterial cells and in certain soil organic fraction. Soil Sci. Soc. Am. Proc. 30: 210-213.
7. Hallam, M.H.B, and J.L. Bartholomew. 1963. Influence of rate of plant residue addition in accelerating the decomposition of soil organic matter. Soil Sci. Soc. Am. Proc. 17: 365-368.
8. Hamssen, G.W. and G.W. Koenbrander. 1965. Soil inorganic nitrogen, In soil nitrogen. Agronomy. 10: 43-92. Am. Soil Soc. Agr. Madison, Wisconsin.
9. Harad. T, Hashimoto, H. and T. Yoshida. 1965. The relactionship between easily decomposable organic matter of paddy soil and its colloidal complexes. Soil and Plant Frod. 1(1): 49-50.
10. Kuo, H.H. 1968. Decompoonition of organic waster. Soil. Sci. 85: 52-54.
11. Nommik, H. 1962. Mineral nitrogen immobili zation and carbon dioxide production during decomponition of wheat straw of some cellulose-decomposing fungi. Ann. App. Biol. 18: 244-259.