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EFFECTS OF CARBONACEOUS MATERIALS ON THE ACCUMULATION OF READILY MINERALIZABLE ORGANIC NITROGEN IN SOIL

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Decomposition of organic nitrogenous materials in soil was affected by C/N ratio. Immobilization of nitrogen mineralized from nitrogenous material added to the soil was influenced by the degradability of carbonaceous and nitrogenous materials. The turnover of nitrogen which had been freshly immobilized in the presence of glucose in the soil was faster than that immobilized with cellulose or lignin.

The effect of soil-drying on the mineralization of organic nitrogen immobilized through the decomposition of carbonaceous and nitrogenous materials in the soil depended significantly on the availability of carbonaceous materials as a microbial energy source. However, the drying effect was not always proportional to the amount of organic nitrogen accumulated in the soil.

Additional Index Words: mineralization, immobilization, drying effect, readily mineralizable organic nitrogen.

Application of carbonaceous materials together with inorganic nitrogen to soil causes nitrogen immobilization, and turns into remineralization after some interval. It was observed that the process is dependent on many factors such as the kind of carbonaceous material incorporated, the C/N ratio, the form of inorganic nitrogen, soil reaction, soil moisture, and soil temperature (*1–5*). However, little is known about the quality and quantity of carbonaceous materials affecting the accumulation of readily mineralizable organic nitrogen which is an important source of soil fertility.

In this paper, a model experiment of the effects of some carbonaceous materials on the accumulation of readily mineralizable organic nitrogen in soil was carried out.

MATERIALS AND METHODS

Materials. The carbonaceous and nitrogenous materials used are shown in Table 1.

Soil sample collected from the plow layer of paddy field at Yamaguchi University Farm was treated with hydrogen peroxide, washed with 0.01 N HCl and distilled water successively, and air-dried. The soil (T-C, 0.19%; T-N, 0.04%; texture, CL; clay

Table 1. Carbonaceous and nitrogenous materials used.[1]

Material	Total-C (%, dry matter)	Total-N (%, dry matter)	C/N
Carbonaceous			
Glucose (G)	39.4	—	—
Cellulose (C)	37.5	—	—
Lignin (L)	46.9	0.06	777
Nitrogenous			
Ammonium sulfate (AS)	—	21.7	—
Glycine (Gly)	31.2	18.7	1.7
Gluten (Glu)	50.3	12.0	4.2
Gelatin (Gel)	42.4	14.9	2.8
Chitin (Chi)	47.3	6.9	6.9

[1] These materials were all commercial and passed through a 32 mesh sieve.

content, 22.0%; main clay minerals, kaolin minerals; CEC, 16.0 me/100 g; pH 6.5) thus treated, was used as the medium.

Methods of incubation. Five grams of soil sample (dry weight basis) was weighed into 50-ml Erlenmeyer flask. Nitrogenous materials containing 4 mg of N and enough carbonaceous material to make the C/N ratio 20 were added to the flask. Mineral nutrients (*6*) and water suspension of wet paddy soil (1 : 10) were added as inoculum and the moisture was adjusted to 60% of maximum water holding capacity with distilled water. Each flask was covered with polyethylene film. One group of flasks was incubated at 30°C for 8 weeks (Undried sample). The other group was incubated for 4 weeks, dried at 80°C for 4 hr, and reincubated for further 4 weeks after the addition of water and inoculum (Dried sample).

Determination of mineralized nitrogen and the drying effect. After different periods of incubation, the nitrogen mineralized in the sample was extracted with 1 N KCl and determined by the Conway's micro-diffusion method using Devarda's alloy as reducing agent (*7*). The effect of drying on acceleration of the mineralization of the organic nitrogen (the drying effect) which had accumulated in the sample after 4 weeks of incubation was shown as the difference between the inorganic nitrogen of the "Dried sample" and "Undried sample" during the 4 weeks after drying treatment (at 8 weeks) (*6*, *8*).

RESULTS AND DISCUSSION

Effects of carbonaceous materials on the mineralization and immobilization of nitrogen in nitrogenous materials

The pH values of the samples after 8 weeks of incubation were in the range of 6.0 to 6.5.

As shown in Fig. 1, in the mixture of ammonium sulfate (AS) with glucose, nitrogen immobilization by soil microorganisms rapidly occurred within 1 week and then the remineralization of immobilized nitrogen took place. On the other hand, inorganic nitrogen was immobilized more slowly with cellulose than glucose. With lignin, a slight immobilization of nitrogen was found after 4 weeks. By visible observation, the number of fungus colonies on the soil surface after 4 weeks were in the order of glucose (>5)>cellulose (3–5)>lignin (0–2). This trend may be related to the availability of carbonaceous materials as a microbial energy source.

The mineralization rates of organic nitrogen without carbonaceous materials for 5 days were in the order of glycine (Gly)>gelatin (Gel)>gluten (Glu)≫chitin (Chi). This order was in accordance with their C/N ratios.

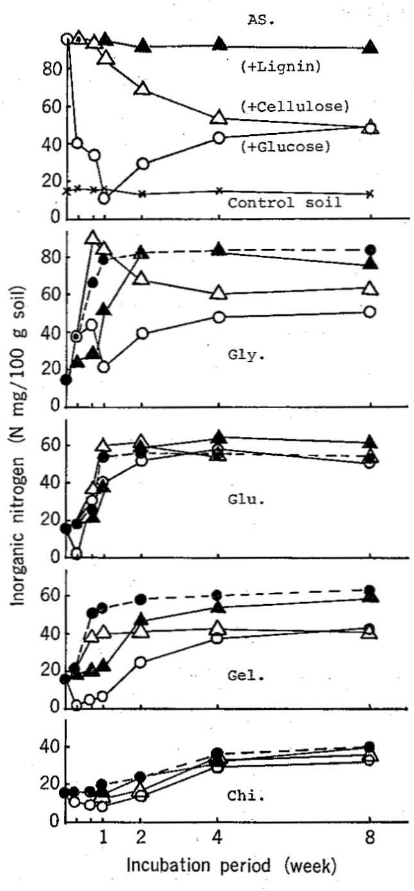

Fig. 1. Effects of some carbonaceous materials on mineralization and immobilization of nitrogen in some nitrogenous materials in the soil.
--●-- each nitrogenous material, —×— control soil, —○— +glucose, —△— +cellulose, —▲— +lignin.

Gly-N without carbonaceous materials was quickly mineralized and its mineralization rate was about 76% after 1 week. Gly-N with glucose was mineralized up to 5 days and then the rate of immobilization exceeded mineralization from 5 to 7 days. Afterwards, remineralization of newly immobilized nitrogen occurred. With cellulose, nitrogen mineralized from Gly-N was immobilized gradually from 5 days to 4 weeks, and then a slight remineralization occurred. With lignin, the mineralization rate of Gly-N was considerably low within the first week. This seems to indicate that lignin suppresses the initial decomposition of Gly. These phenomena were also found in the decomposition of Glu and Gel as shown in Fig. 1.

The mineralization patterns of Glu-N and Gel-N without carbonaceous materials were similar and their mineralization rates after 1 week were about 55 and 50%, respectively. With carbonaceous materials, however, the mineralization rate of the latter was lower than that of the former. With glucose, the remineralization rate of nitrogen in the latter was particularly low.

The mineralization rate of Chi-N without carbonaceous materials was about 27% after 8 weeks which was significantly lower than that of the other organic nitrogenous materials. Effect of each carbonaceous material on its mineralization was low. This may be due to the lower degradability of Chi.

These findings indicate that the immobilization of nitrogen mineralized from nitrogenous material added to the soil and its remineralization are strongly dependent on the degradability of carbonaceous and nitrogenous materials in the soil. The turnover of nitrogen which had been newly immobilized with glucose in the soil was faster than that with cellulose or lignin in general. It seems that soil microorganisms and their metabolic substances which contain the decomposable nitrogen were formed more rapidly with the addition of glucose. AHMAD *et al.* (*3*) and HIROSE and KUMADA (*5*) reported that the organic nitrogen newly formed through the decomposition of cellulose was remineralized more slowly than that formed through the decomposition of glucose.

Drying effect on the mineralization of organic nitrogen accumulated in the soil after 4 weeks of incubation

As shown in Table 2, the amount of organic nitrogen accumulated in the soil after 4 weeks when AS was incubated with carbonaceous materials was larger, being in the order of glucose > cellulose ≫ lignin. The drying effect at 4 weeks was also of the same order. Trace amounts were found due to the drying effect when lignin was added. This may be due to smaller amounts of organic nitrogen formed during the 4 weeks. This may be also supported by the previous results (*6*, *8*).

In all cases of Gly, Glu, Gel, and Chi without carbonaceous materials, the drying effects were negative. The immobilization of nitrogen was superior to mineralization after the drying treatment. It is considered that the negative drying effects in these nitrogenous materials may depend on the shortage of available carbon source. On the other hand, the drying effects by incubating with carbonaceous materials were all

Table 2. Effect of drying on the mineralization of organic nitrogen accumulated in the soil after 4 weeks of incubation.

Material		Organic-N accumulated in the soil after 4 weeks of incubation	Drying effect[1]
Nitrogenous	Carbonaceous	(N mg/100 g)	
—	—	25.6	−0.5
(Control soil)			
AS	G	78.5	8.6
	C	67.2	3.6
	L	29.5	tr
Gly	—	37.4	−22.7
	G	72.6	5.4
	C	60.2	1.6
	L	37.5	2.0
Glu	—	66.0	−9.7
	G	63.0	5.2
	C	62.8	1.3
	L	56.0	6.4
Gel	—	60.2	−11.1
	G	82.5	8.2
	C	78.7	1.6
	L	66.2	5.2
Chi	—	84.0	−4.4
	G	91.0	2.4
	C	86.0	1.3
	L	88.0	1.9

[1] Difference in the amount of nitrogen mineralized in "Dried sample" and "Undried sample" during 4 weeks of incubation after drying treatment (at 8 weeks).

positive and in the order of glucose>lignin>cellulose in general. When lignin was added, the drying effects were larger than those with cellulose in spite of lower immobilization of nitrogen. The reason why lignin was more effective than cellulose in the drying effect is not clear.

These findings indicated that the effect of drying on the mineralization of nitrogen immobilized through the decomposition of carbonaceous and nitrogenous materials in the soil depends largely on the availability of carbonaceous materials as a microbial energy source. However, the drying effects were not always proportional to the amount of organic nitrogen accumulated in the soil.

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