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Effect of Nitrogen Supplied from Poultry Manure and Sewage Sludge on Growth, Yield and Nitrogen Uptake of Rice

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Summary

Use of poultry manure and sewage sludge in agriculture is being considered as one of the methods for recycling of these wastes in an environmental beneficial manner. An investigation was undertaken to see the influence of added poultry manure and sewage sludge application on rice growth, yield and N uptake studied with pot experiment. There were four treatments consisting of control, chemical fertilizer, sewage sludge and poultry manure. The results showed that application of poultry manure and sewage sludge increased grain yield 34.8 and 38.3%, respectively over control. The nitrogen uptake was positively influenced by different treatments and the highest N uptake was obtained with chemical fertilizer. At maturity, N uptake of poultry manure was significantly higher than sewage sludge. The relative efficiency was varied with organic materials.

Introduction

Continuous use of chemical fertilizers for long time may accelerate the depletion of organic matter. It has been shown that crop N recovery from organic inputs such as poultry manure (PM) and sewage sludge (SS) or manures is often less than 20%[7)]. However, has been widely accepted that organic inputs play a significant role in the long-term build up of soil organic matter and associated soil stabilization. The use of poultry manure and domestic sewage sludge in agriculture is being considered as one of the methods for recycling of these wastes in an environmental beneficial manner. For soil management, it's well known that organic matter application plays important role in supplying nutrients[8)], stabilizing pH, EC and CEC, controlling the soil moisture and enhancing microbial activity and circulation of nutrients[4, 5)]. These processes are necessary for sustainable agriculture systems. Among the organic matter that can be used, poultry manure and sewage sludge are the most abundant organic materials in farming systems[6)]. Thus, evolution of

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poultry manure and sewage sludge from viewpoint of nitrogen is very important for integrated soil management for sustainable food production and conservation agricultural land[1)]. Information regarding the effect of poultry manure and domestic sewage sludge on yield and N uptake is still needed. The objective of this study was to investigate the fate of N in poultry manure and sewage sludge on rice growth, yield and N uptake.

Materials and Methods

The experiment was carried during 2006-2007 at the Experimental Farm, Ehime University, Matsuyama City, Japan, (33° 57' N, 132° 47' E) with the elevation of 20m above sea level. The soil belongs to low fertility, Fluvisol with the chemical characteristics: CEC, 9.80 cmol(+)kg^{-1}; pH, 6.5 (H_2O); EC, 0.32 dS m^{-1}; total-carbon (C), 1.50%; total-N, 0.17%; available P, 1.89 g kg^{-1}; exchangeable K, 0.63 g kg^{-1}; exchangeable Ca, 1.45 g kg^{-1}; exchangeable Mg, sand, 58.1, silt, 28.1 %, and clay, 13.4%. The experiment was set up as a completely randomized block design with four replications and the following treatments: control without fertilization or amendment, chemical fertilizer, sewage sludge and poultry manure. Nitrogen fertilizer was applied at rate of 8.0 g m^{-2} (^{14}N) applied three splits at different rice growth stages. The application rate of SS and PM was 160 and 200g FW m^{-2}, respectively, added at full just before transplanting. The application rates were based on the fresh weight since these materials are applied on a fresh weight basis in practical farming. Comparison of the N fate of organic materials, which were added at the likely weight, could provide significant information. Phosphorus from P_2O_5 and K from KCl were applied as basal dose to all pots at the rate of 80 kg N ha^{-1}. Wagner pots (0.025 m^2) were filled with 3.50 kg air-dried soil mixed with equivalent volume of amendments. Three 25-day-old seedlings of rice cultivar Sakha 103 were transplanted to the center of each pot with four replicates on June 22. The pots were maintained under flooding conditions until harvesting and drained thereafter.

Plant sampling

Plant height, number of tillers and leaf chlorophyll content were measured at different growth stages. Chlorophyll content was measured with a chlorophyll meter (SPAD-502; Minolta Co. Ltd., Japan). The rice plants were harvested at maturity and the relevant data were recorded from randomly selected plants and also from the pots. The plants were then separated into straw and grains and oven-dried to constant weight at 70℃. The dried samples were weighed and ground into a fine powder using a vibrating mill and total N was measured.

Statistical analysis

The significance of differences between the amendments was determined by a multiple comparison test using the Tukey-Kramer test ($P<0.05$) with the software KyPlot (KyensLab Inc., Tokyo, Japan).

Results and Discussion

Rice growth

The changes that occurred over time in plant height, number of tillers, and chlorophyll content are shown in Fig. 1, 2 and 3. The sewage sludge recorded the higher plant height; however, there was no significant difference in the mean plant height between the treatments (Fig. 1). There was a significant difference in the number of tillers between the amendments (Fig. 2). The number of tillers in sewage sludge was significantly higher than that of poultry manure and chemical fertilizer. The highest mean chlorophyll value was recorded at 18 DAT and was followed by a rapid decline in the chlorophyll content with no significant difference (Fig. 3).

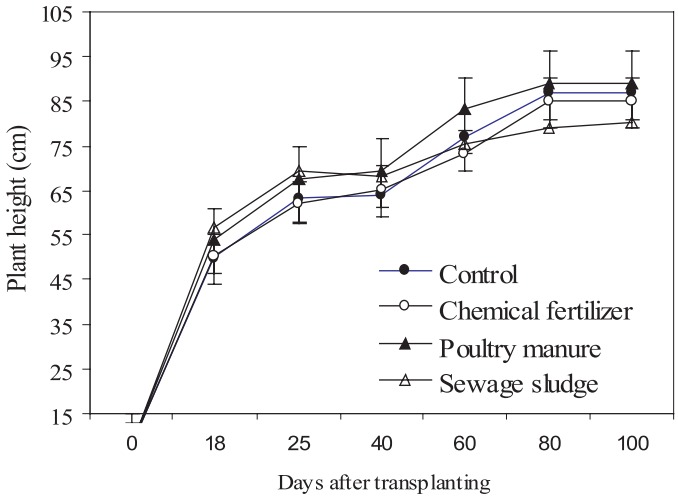

Fig. 1. Effect of organic amendments and chemical fertilizer application on plant height. Bars represent SE (n=5).

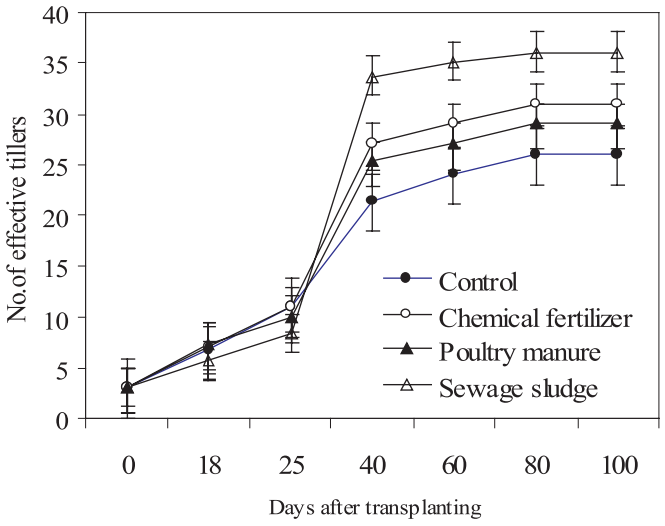

Fig. 2. Changes in tillers as affected by organic amendments and chemical fertilizer application. Bars represent SE (n=5).

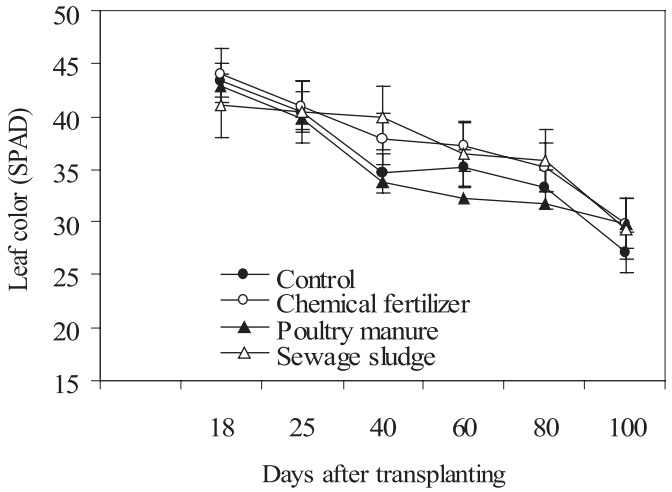

Fig. 3. Leaf chlorophyll at different growth stages in rice plants grown in soil amended chemical fertilizer and organic amendments. Bars represent SE (n=5).

Grain yield

A significant positive effect on the grain yield of Sakha 103 was observed from the application of poultry manure and sewage sludge (Table 1). Application of poultry manure and sewage sludge increased grain yield 34.8 and 38.3%, respectively over control. This might be due to the quick release of a number of nutrients like N and P from organic inputs. Asagi *et al.*[1)] also observed that the increase in rice growth and rice yield with sewage sludge application on sandy soil.

Table 1. Effect of organic amendments and chemical fertilizer application on yield contributing of Sakha 103 rice cultivar.

Treatment	Grain yield (g pot^{-1})	% increase over control	No. of panicle pot^{-1}
Control	14.1c	—	11.3a
Chemical fertilizer	17.3b	22.7	12.1a
Poultry manure	19.0a	34.8	12.3a
Sewage sludge	19.5a	38.3	15.1b

Figures in a column having common letters do not differ significantly at 5% (Tukey-Kramer test).

Table 2. Dry matter and total nitrogen uptake by rice grown in soil amended with either chemical fertilizer, sewage sludge or poultry manure.

Treatment	Dry weight g pot^{-1}	Total N uptake mg pot^{-1}
Control	33.0c	98.1d
Chemical fertilizer	44.7b	252.5a
Poultry manure	45.1b	196.7b
Sewage sludge	51.2a	173.6c

Different letters in each column refer significant differences within treatments (Tukey-Kramer test, $P<0.05$, n=6).

Dry weight and N uptake

Table 2 shows the dry weight of the rice plants and the total uptake of N derived from the organic fertilizers at harvesting. Poultry manure accounted for the highest dry weight. N uptake varied between the treatments, with the highest N uptake obtained from chemical fertilizer application. As compared to control treatment, N uptake was significantly higher ($P<0.05$) with chemical fertilizer. The higher N use efficiency in soil amended with chemical fertilizers was reported as compared to organic amendments which have low mineralization potential[4]. The relationship between fertilizer N uptake and total N uptake during the rice cultivation depends on the time at which the fertilizer N is applied[3] and the amount of available N[2].

Acknowledgments

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鶏糞堆肥および下水汚泥窒素が水稲の生育、収量およびN吸収に与える影響

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摘　　要

環境にとって有益な素材として鶏糞堆肥と下水汚泥の農業利用は廃棄物再利用技術の１つとして認識されつつある。鶏糞堆肥と下水汚泥の施用が水稲の生育、収量および窒素吸収に与える影響を調べるためにポット実験を行った。処理区として、無施肥区、化学肥料区、鶏糞堆肥区および下水汚泥区を設けた。鶏糞堆肥および下水汚泥区の水稲収量は、それぞれ無施肥区より34.8%および38.3%高かった。水稲窒素吸収量は、処理区により異なり、化学肥料区で最も高かった。登熟期において鶏糞堆肥区が下水汚泥区より有意に高かった。窒素の利用効率は有機物の種類によって違っていた。

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