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Effects of Shearing Force in Surface Runoff on Nutrient Losses from Chemical and Organic Fertilizers

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Abstract: Organic fertilizer, especially compost, is apt to be focused as it contributes to reduce the expense of chemical fertilizer and may harmonize with natural environment. So, this study dealt with the nutrient losses from chemical and organic fertilizers under various simulated shearing forces from 0 to 0.25 dPa and the difference in plant growth among chemical fertilizer, conventional compost and granular compost applications. For demonstrating shearing forces caused by surface runoff, water resistance experiment was conducted employing a rotating machine. The experimental results showed the losses of total nitrogen, total phosphorus and suspended solids from granular compost of 2.5, 5, 10 and 15 mm in diameter were significantly lower than that from chemical fertilizer or conventional compost at 95% confidence interval. Furthermore, plant length and live weight of Komatsuna from the pots applied granular compost of 5, 10 and 15 mm in diameter showed no significant difference from the pots applied chemical fertilizer or conventional compost.

Keywords: Fertilizers, Granular compost, Nutrient loss, Shearing force, Surface runoff

1. Introduction

Increasing amounts of agricultural chemicals applied in agricultural land cause the severe environmental problems, such as eutrophication in water systems or land degradation (Carpenter *et al*., 1998). Recently, organic fertilizer, especially compost, is apt to be focused as it contributes to reduce the expense of chemical fertilizer and may harmonize with natural environment. However, nutrient components from compost happen to be washed off by rainfall or irrigated water (Gaudreau *et al*., 2002). Accordingly, attention has been paid to granular compost as an alternative organic fertilizer for decreasing nutrient losses (Siriwattananon and Mihara, 2008).

Hara (2001) reported the benefits of forming cattle manure into granular form from viewpoints of soil chemical properties and plant growth. Additionally, George *et al*. (1964) reported that the physical properties of fertilizer have been recognized to be particle size, shape and density. Allaire *et al*. (2004) suggested that granular size distribution is one of the most important physical properties, which controls segregation during storage, blending and spreading. Furthermore, the particle strength is important in relation to quality requirements that fertilizers have to meet (Hofstee and Huisman, 1990).

Recently, little work has been done in order to evaluate the effects of granular compost on reducing nutrient losses comparing with that of chemical fertilizer or conventional compost. So, the objectives of this study are to observe nutrient losses from chemical and organic fertilizers under various shearing forces and to discuss the difference in plant growth among chemical fertilizer, conventional compost and granular compost applications.

2. Materials and Methods

Mincing machine of the extrude type (**Figure 1**) was employed for making granular compost. It contains fermented plant residues, clayey soil and molasses at the ratio of 10:1:0.01. The mixing ratio was referred to the former study of Mihara *et al*. (2005). The length and diameter of granular compost can be changed up to strainer size in plate of mincing machine.

Based on the former study (Mihara *et al*., 2005) concerning suitable percentage of molasses added (0.1%), 4 sizes of granular compost were produced as 2.5, 5, 10 and 15 mm in diameter. These various sizes of granular compost were compared with chemical fertilizer shaped granularly or conventional

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compost of less than 2 mm in diameter without any clod in water resistance experiment and plant growth experiment.

For demonstrating shearing forces caused by surface runoff, water resistance experiment was conducted employing a rotating machine (**Figure 2**). The rotating speed was set up from 0 to 600 rpm, those were equivalent to 0 to 0.25 dPa in shearing force, and the experiment at each speed was run for 2 hrs.

Also, Komatsuna (*Brassica rapa var. perviridis*) was cultivated (**Figure 3**) for evaluating the difference in plant growth among chemical fertilizer, conventional compost and granular compost applications. All types of fertilizers were spread uniformly on soil surface in every pot at the same rate of 10.0 gN/m^2. The plant growth experiment was repeated 3 times in the glass house kept constant temperature at 25 ± 1 degree Celsius. During the cultivation, same amount of irrigation water in the range from 1.0 mm/day to 7.0 mm/day was supplied to each pot. After 1.5 months growing, the length and live weight of all plants in each pot were observed.

Fig. 1. Mincing machine with 4 sizes of plate.

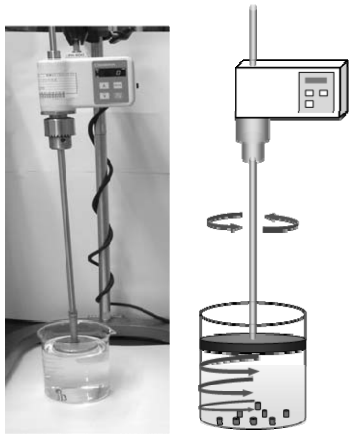


Fig. 2. Water resistance experiment with rotating machine.

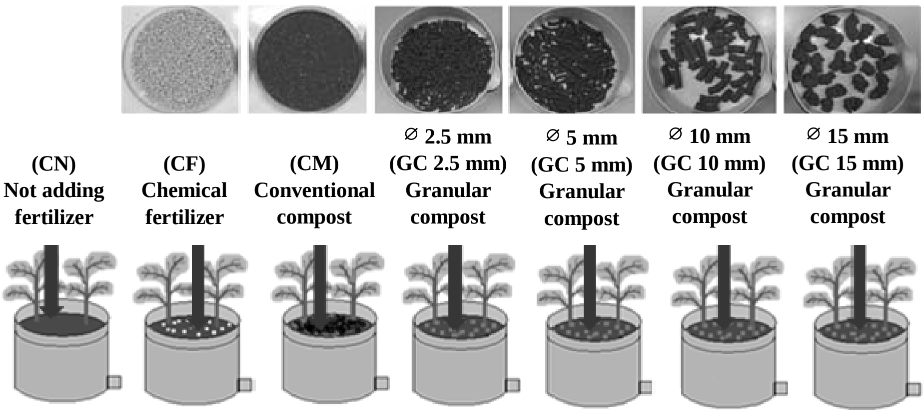


Fig. 3. Plant growth experiment under various fertilizers.

3. Results and Discussion

The results of total nitrogen, total phosphorus and suspended solid losses under shearing forces at 0, 0.06, 0.12 and 0.24 dPa were shown in **Figure 4**. The experimental results showed the losses of total nitrogen, total phosphorus and suspended solids from granular compost of 2.5, 5, 10 and 15 mm in diameter were significantly lower than that from chemical fertilizer and conventional compost at 95% confidence interval. Among various sizes of granular compost, although there was no significant difference in total nitrogen and suspended solid losses, total phosphorus loss from granular compost of 2.5

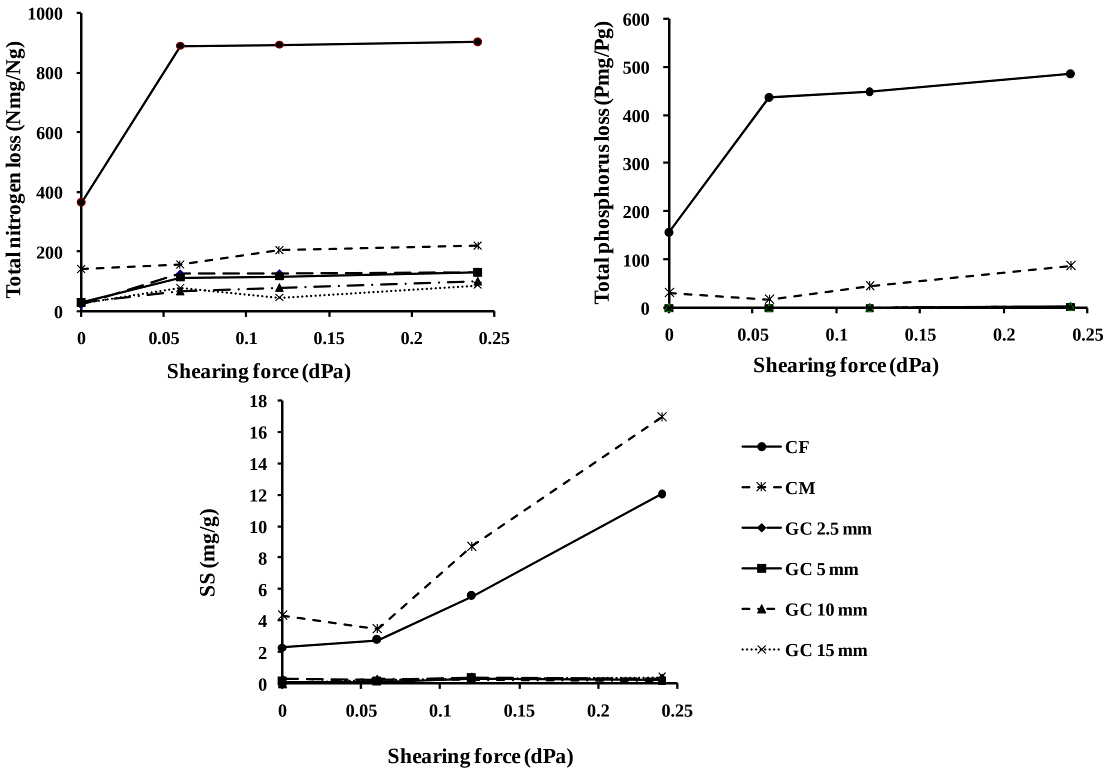
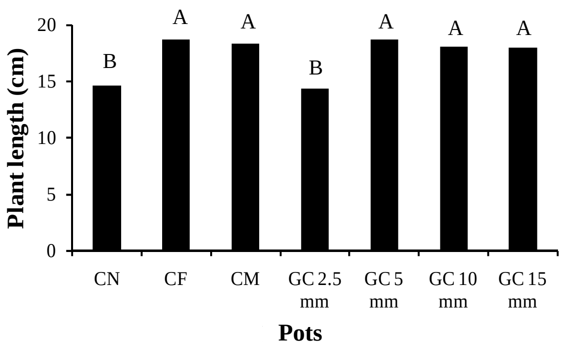
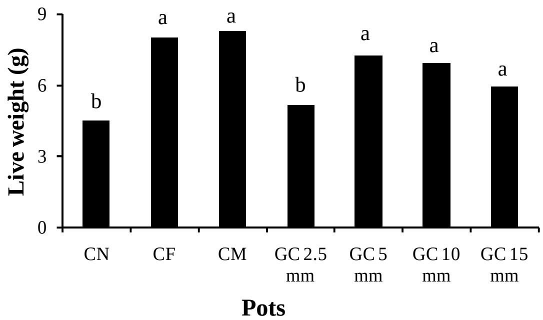


Fig. 4. Changes in total nitrogen, total phosphorus and suspended solid losses with shearing forces.



*The data followed by different letters differs significantly at 95% confidence interval based on ONE-WAY ANOVA.

Fig. 5. Plant length in plant growth experiment.



*The data followed by different letters differs significantly at 95% confidence interval based on ONE-WAY ANOVA.

Fig. 6. Live weight in plant growth experiment.

mm was significantly higher than other sizes of granular compost at 95% confidence interval.

Furthermore, Komatsuna was cultivated for evaluating plant growth in the pots applied granular compost of different 4 sizes, chemical fertilizer and conventional compost in plant growth experiment. After 1.5 months growing, the length and live weight of all plants in each pot were observed. As shown in **Figures 5** and **6**, plant length and live weight from pots applied granular compost of 5, 10 and 15 mm in diameter had no significant difference with that from pots applied chemical fertilizer or conventional compost at 95% confidence interval based on one-way ANOVA analysis. Additionally, the results of plant growth experiment showed that plant growth of pot applied 2.5 mm granular compost was lower than that applied bigger sizes. Granular compost of 2.5 mm tended to be dried easier compared with other granular compost of bigger sizes as the surface area of 2.5 mm granular compost was remarkably larger than that of bigger sizes. So, it was considered that microorganism activity for decomposing granular compost of 2.5 mm was restrained.

4. Conclusions

The study dealt with the effects of shearing force on nutrient losses from chemical fertilizer, conventional compost and granular compost. For demonstrating shearing forces caused by surface runoff, water resistance experiment was conducted employing a rotating machine. Also, plant growth was evaluated under various fertilizations.

The results showed the losses of total nitrogen, total phosphorus and suspended solids from granular compost of 2.5, 5, 10 and 15 mm in diameter were significantly lower than that from chemical fertilizer and conventional compost at 95% confidence interval. However in granular compost, total phosphorus loss from granular compost of 2.5 mm was significantly higher than that from other sizes of granular compost. Furthermore, plant length and live weight of Komatsuna from pots applied granular compost of 5, 10 and 15 mm in diameter had no significant difference from pots applied chemical fertilizer or conventional compost.

So, it was concluded that granular compost, which diameter is bigger than 5 mm, worked better for reducing surplus losses with shearing forces and for making plants grow effectively as well as chemical fertilizer or conventional compost.

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