Effects of manure application on soil fertility and potential nitrogen supply in the production of rice for whole crop silage

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[Introduction]

Rice consumption in Japan has declined since the 1960s. Consequently, the production of rice for whole crop silage (WCS) has emerged radically having surpassed 15000 ha in 2010. In the production of rice for WCS, straw is not incorporated in the soil. Lack of organic matter in the fields may potentially affect soil fertility in the long run. Animal manure has been suggested to have two potential roles – to provide organic matter sustaining soil fertility and to provide nutrients for crops’ growth. Previous researchers also claimed that appropriate application of animal manure can provide nutrients to crops while also maintaining soil fertility. The production of rice for WCS is not essentially profitable, making cost reduction vitally important. Therefore, whether manure can substitute for chemical fertilizer to minimize cost should be investigated.

This study aimed to investigate effects of manure application on soil fertility and potential nitrogen (N) supply in the production of rice for WCS.

[Materials and methods]

Field surveys were conducted in 2013 and 2014 in Itoshima region, Fukuoka Prefecture, Japan (33°30’N to 33°34’N, 130°08’E–130°15’E). The numbers of surveyed fields were 9 in 2013 and 13 in 2014 (i.e., 22 fields in total). They were classified into three groups based on manure and fertilizer application manners – only manure (OM) with 9 fields, only chemical fertilizer (OC) with 10 fields, and combination application of manure and chemical fertilizer (COM) with 3 fields. The Tachiaoba cultivar (Oryza sativa) was cultivated in all surveyed fields.

Table 1 Outline of manure and fertilizer applications.

<table>
<thead>
<tr>
<th>Application types</th>
<th>Manure</th>
<th>Fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TN amount (kg N ha⁻¹)</td>
<td>Basal TN Amount (kg N ha⁻¹)</td>
</tr>
<tr>
<td>OM</td>
<td>186-1213</td>
<td>0</td>
</tr>
<tr>
<td>OC</td>
<td>0</td>
<td>48-70</td>
</tr>
<tr>
<td>COM</td>
<td>585-728</td>
<td>32-84</td>
</tr>
</tbody>
</table>

TN represents total nitrogen.

Soil fertility was assessed by using soil TN content after harvesting. Potential N supply in the fields was evaluated by using mineralized N from soil sampled before transplanting, which was measured by incubation tests for 4 and 12 weeks.

[Results and discussion]

Soil TN after harvesting in OM were found to be significantly higher than OC (Fig. 1). This implied that continuous application of manure in OM fields replenished organic matter and sustained soil fertility. However, OC fields, where organic matter was not supplied, could face soil fertility deterioration.

Fig.1 Soil TN after harvesting in three application manners. n was 9, 10, and 3 for OM, OC, and COM, respectively. Error bars represent SD and data labels represent mean value. Different letters show statistical significance (Tukey-Kramer method, p < 0.05).

Potential N supply for 4 weeks and 12 weeks were significantly higher in OM as compared with OC. There were large differences of 71 kg ha⁻¹ and 87 kg ha⁻¹ for 4-week and 12-week potential N supply, respectively. The application amount of N fertilizer had variations in surveyed fields (Table 1) but on average it was 59 kg N ha⁻¹ at basal application and 20 kg N ha⁻¹ at topdressing. The differences of both 4-week and 12-week potential N supply were larger than N supply from chemical fertilizer. Thus continuous application of manure could substitute for chemical fertilizer application.