EFFECT OF RICE STRAW COMPOST ON SOIL MICROBIOLOGICAL PROPERTIES AND YIELD OF RICE

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Abstract
Utilization of rice straw through composting and its effect on yield of rice was studied. The application of rice straw compost @ 5 t/ha along with half of the recommended dose of inorganic fertilizer increased the microbial biomass C from 136 to 258 mg/kg soil, dehydrogenase activity from 66 to 118 mg TPF/kg soil/24h and alkaline phosphatase from 370 to 680 mg PNP/kg soil/h. It also resulted in the build up of soil organic C and N from 0.471 and 0.039% to 0.545 and 0.064% respectively. Carbon and N mineralization rates were also higher than control and soils receiving recommended dose of inorganic fertilizers. The three years grain and straw yield of rice (Basmati and CSR-30) was comparable to the recommended dose of inorganic fertilizers.

Key words: Rice straw compost, Soil microbiological properties, Rice yield.

INTRODUCTION
Most tropical soils are poor in organic matter due to high rate of turnover and repeated cultivation. Recycling of organic wastes in agriculture is much needed and returns organic matter into the soils. In the Indo-Gangetic plains about 95 million tons of rice residues are produced which is about 39% of total crop residues generated (Sidhu et al., 2003). In Haryana about 6 million tons of rice straw is produced annually, out of which about 63% is burnt. Disposal of straw of high yielding varieties of rice is a problem. Burning has been traditionally used to dispose off crop residues. Burning of rice straw is known to induce environmental and health problems (Jacob et al., 1997; Reinhardt et al., 2001). Rice residue management through incorporation of rice straw is associated with certain problems such as, immobilization of plant nutrients particularly nitrogen, residues impede seed bed preparation and contribute to reduced germination of subsequent crops. Composting arises as a safe option which results in reusability of the nutrients contained in the residue. Production of compost from straw is an alternative to burning and direct incorporation in soil. The management of rice straw through composting will avoid air pollution caused by residue burning as well as loss of plant nutrients and organic matter. There is a need to utilize rice straw as a source of plant nutrients and organic matter to improve soil productivity. The present study was carried out with the objective of utilization of rice residue through composting and its use in agricultural soils as source of important plant nutrients and its effect on soil microbiological properties and yield of rice.

MATERIAL AND METHODS
Rice straw composting: Manually harvested rice straw was collected from the

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previous crops of rice and was stacked as a windrow (1m x 1m x 10m) after soaking in water containing urea @ 1g/l to adjust C:N ratio to 50:1 and was inoculated with fungal inoculum of *Aspergillus awamori* (1g/100 ml) and was covered with polythene sheet to conserve moisture. Moisture was maintained to 60% water holding capacity (WHC) by analyzing the moisture content time to time and adding water at different intervals of composting. The material was allowed to decompose for three months and two turnings were given at 15 and 45 days. The composted rice straw had C/ N ratio 16.2. The composted rice straw was applied in the fields at RRS, Kaul, CCS HAU, Hisar alone or along with inorganic fertilizers and there were following treatments:

T1: Control
T2: Compost (5t /ha)
T3: Inorganic fertilizer (N60 P2O5 30K2O ZnSO4 25 kg /ha)
T4: Compost (5t /ha) + Inorganic fertilizer (Same as T3)
T5: Compost (5t /ha) + N60 kg /ha
T6: Compost (5t /ha) + N30 kg /ha

**Experimental Design:** The experimental area lies approximately at 29.6°51’ North latitude and 76°40’ East longitude and at altitude of 266 m above mean sea level. Soils are mixed hyperthermic Typic Ustocrept. The soil of the area was clay loam. For each treatment there were three plots of size of 50 m² and experiment was planned in a randomized design and above treatments were employed. The composted rice straw was added at the rate of 5 t/ ha. Nitrogen was added in the form of urea and P was supplied as single super phosphate at different rates depending upon the treatments. Two varieties of rice (Basmati and CSR-30) were grown for three years and rice straw compost was applied to rice 15 days before transplanting in two split doses.

**Soil sampling:** Soils (0-15 cm) from each replicate of treatment were sampled in April 2005 after the harvest of wheat crop from 10 different locations in each plot and pooled together and analyzed in the Department of Microbiology, CCS HAU, Hisar... The soil samples were sieved through 2 mm sieve and adjusted to 40 % water holding capacity and pre-incubated for 7 days to allow microbial activities to settle down after initial disturbances. Other portions of soils were air dried and ground for chemical analysis.

**Chemical analysis of soil:** Soil pH and EC were determined in suspension of air dried soil using 1:2 ratio of soil to water using pH and electrical conductivity meter respectively.

Soil organic C was measured by the dichromate digestion method (Kalembassa and Jenkinson, 1973). Total N was measured by Kjeldahl steam distillation method (Bremner, 1965), ammoniacal and nitrate nitrogen by method of Keeney and Bremner (1965) and available P was measured by the method as described by John (1970).

**Carbon and nitrogen mineralization:** Carbon mineralization was determined by the method of Pramer and Schmidt (1984) with slight modification. One hundred gram soil was placed in 500 ml Erlenmeyer flask and 10 ml of 1N NaOH was kept inside each flask to absorb CO₂ evolved from soil. Flasks were stoppered with rubber corks, sealed with paraffin wax and incubated at 30°C. The CO₂ evolved at different intervals was estimated and mineralization of carbon was calculated.

**Microbial biomass carbon:** Soil microbial biomass carbon was estimated by the chloroform–fumigation extraction method (Vance *et al.*, 1987). Biomass C was calculated by the following formula:

Biomass C = 2.64 [extractable C in fumigated soil - extractable C in unfumigated soil]
Table 1: Soil chemical properties after three years of application of rice straw compost alone or along with inorganic fertilizers

<table>
<thead>
<tr>
<th>Treatments</th>
<th>pH</th>
<th>EC (dS/m)</th>
<th>Organic C (%)</th>
<th>Total N (%)</th>
<th>Mineral N (NH\textsubscript{4}+N + NO\textsubscript{3}-N) (mg/kg soil)</th>
<th>Available P (mg/kg soil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>7.6</td>
<td>0.64</td>
<td>0.471</td>
<td>0.039</td>
<td>6.2</td>
<td>4.8</td>
</tr>
<tr>
<td>Compost (5t/ha)</td>
<td>7.7</td>
<td>0.67</td>
<td>0.523</td>
<td>0.064</td>
<td>12.2</td>
<td>6.5</td>
</tr>
<tr>
<td>Recommended dose of fertilizer</td>
<td>7.6</td>
<td>0.62</td>
<td>0.485</td>
<td>0.041</td>
<td>7.6</td>
<td>5.2</td>
</tr>
<tr>
<td>Compost (5t/ha) + recommended dose of fertilizer</td>
<td>7.6</td>
<td>0.65</td>
<td>0.545</td>
<td>0.062</td>
<td>11.9</td>
<td>6.8</td>
</tr>
<tr>
<td>Compost (5t/ha) + N60 kg/ha</td>
<td>7.5</td>
<td>0.65</td>
<td>0.528</td>
<td>0.059</td>
<td>10.6</td>
<td>6.2</td>
</tr>
<tr>
<td>Compost (5t/ha) + N30 kg/ha</td>
<td>7.6</td>
<td>0.62</td>
<td>0.551</td>
<td>0.058</td>
<td>10.4</td>
<td>6.2</td>
</tr>
<tr>
<td>LSD (P=0.05)</td>
<td>NS</td>
<td>NS</td>
<td>0.01</td>
<td>0.01</td>
<td>2.1</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Enzyme activities: Soil dehydrogenase activity was determined by method of Casida et al. (1964) by 2,3,5 triphenyl tetrazolium chloride reduction and Alkaline phosphatase activity was measured by the method of Tabatabai and Bremner (1969).

RESULTS AND DISCUSSION

The application of rice straw compost alone or along with inorganic fertilizers did not affect pH and EC of the soil (Table 1). This was due to the high buffering capacity of the experimental soil. However, the three year continuous additions of rice straw compost alone or along with inorganic fertilizers resulted in an increase in organic C contents of the soil from 0.471 to 0.551%. Total N contents of the soil also increased from 0.039 to 0.064%. Increase in soil organic C with the application of inorganic fertilizers alone is attributed to the better plant growth resulting in more above and below ground plant biomass. The above ground plant biomass was removed however the below ground plant biomass increased the soil organic C from 0.471 to 0.551% in three years of experiments. Similar observations have also been made by Goyal et al. (1992). The increase in organic C in treatments receiving rice straw compost alone or along with inorganic fertilizers is also due to the input of organic matter in the form of rice straw compost (Rickman et al., 2002; Cerri et al., 2003; Dhull et al., 2004). Available P contents were also more with rice straw compost additions than inorganic fertilizers alone. It increased from 4.8 mg/kg soil to 6.8 mg/kg soil.

Application of rice straw compost improved micro biological properties of soils which is indicated by the increase in microbial biomass C from 136 mg/kg soil to 258 mg/kg soil. The microbial biomass C as percentage of soil organic C increased with rice straw compost additions alone or along with inorganic fertilizers. Microbial biomass C generally comprises about 1-5% of soil organic C (Jenkinson and Ladd, 1981) in the present study also it varied from 2.9 to 4.7%. Dehydrogenase activity which is an indicator of total microbial activity also increased from 66 mg triphenyl formazen/kg soil/24h to 118 mg triphenyl formazen/kg soil/24h. Additions of inorganic fertilizers along with rice straw compost had lesser dehydrogenase activity due to the competition of triphenyl tetrazolium chloride with NO\textsubscript{3} ions for electrons. Alkaline phosphatase activity also increased from 370 mg p-nitrophenol/kg soil/h to 680 mg p-nitrophenyl phosphate kg/s soil/h with the addition of rice straw compost along with inorganic fertilizers.

The carbon and nitrogen mineralization potential of the soil which was
Table 2: Changes in soil microbial biomass, soil enzyme activities and C and N mineralization after three years of application of rice straw compost along with inorganic fertilizers

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Microbial biomass C (mg/ kg soil)</th>
<th>Biomass C as percentage of soil C</th>
<th>Dehydrogenase activity (mg TPF/ kg soil /24h)</th>
<th>Alkaline phosphatase activity (mg PNP/ kg soil/ h)</th>
<th>C mineralization (mg CO₂-C/ kg soil/ day)</th>
<th>N mineralization (mg NH₄⁺-NO₃⁻ N/ day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>136</td>
<td>2.9</td>
<td>66</td>
<td>370</td>
<td>22.5</td>
<td>2.1</td>
</tr>
<tr>
<td>Compost (5t/ha)</td>
<td>232</td>
<td>4.4</td>
<td>133</td>
<td>640</td>
<td>38.4</td>
<td>3.1</td>
</tr>
<tr>
<td>Recommended dose of fertilizer(RDF)</td>
<td>186</td>
<td>3.8</td>
<td>93</td>
<td>590</td>
<td>30.7</td>
<td>5.5</td>
</tr>
<tr>
<td>Compost (5t/ha) + RDF</td>
<td>4.7</td>
<td>118</td>
<td>680</td>
<td>40.4</td>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td>Compost(5t/ha) + N60kg/ha</td>
<td>252</td>
<td>4.7</td>
<td>113</td>
<td>540</td>
<td>40.0</td>
<td>4.1</td>
</tr>
<tr>
<td>Compost(5t/ha) + N30 kg/ha</td>
<td>248</td>
<td>4.5</td>
<td>120</td>
<td>520</td>
<td>38.4</td>
<td>3.7</td>
</tr>
<tr>
<td>LSD (P=0.05)</td>
<td>12</td>
<td>-</td>
<td>8</td>
<td>22</td>
<td>1.2</td>
<td>0.4</td>
</tr>
</tbody>
</table>

TPF = triphenyl formazen; PNP = p nitro-phenyl phosphate

Table 3: Effect of paddy straw compost and inorganic fertilizers on grain and straw yield (q/ha) of different rice cultivars.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Rice Taraori</th>
<th>Basmati(q/ ha)</th>
<th>CSR-30(q/ ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grain</td>
<td>Straw</td>
<td>Grain</td>
</tr>
<tr>
<td>Control</td>
<td>24.63</td>
<td>32.25</td>
<td>21.63</td>
</tr>
<tr>
<td>Compost (5t/ha)</td>
<td>35.00</td>
<td>48.00</td>
<td>30.50</td>
</tr>
<tr>
<td>Recommended dose fertilizer</td>
<td>43.63</td>
<td>104.7</td>
<td>35.88</td>
</tr>
<tr>
<td>Compost (5t /ha) + RDF</td>
<td>33.25</td>
<td>97.50</td>
<td>27.75</td>
</tr>
<tr>
<td>Compost(5t/ha) + N60kg/ha</td>
<td>33.38</td>
<td>93.25</td>
<td>26.25</td>
</tr>
<tr>
<td>Compost(5t/ha) + N30 kg/ha</td>
<td>37.63</td>
<td>93.25</td>
<td>35.00</td>
</tr>
</tbody>
</table>

C.D. (P=0.05)
Cultivar 1.32 (3.20)
Treatment 2.28 (5.54)
Cultivar treatment = NS (7.34)
The average three years yield of rice (Basmati and CSR-30) is shown in Table 3. The grain and straw yield of cultivar CSR-30 and Basmati increased with the application of recommended dose of fertilizers or rice straw compost alone or in combination with rice straw compost. The increase in grain and straw yield of CSR-30 and Basmati was 41 and 42% and 47 and 49% respectively. Among both the varieties, higher yield was observed with basmati compared to CSR 30. Among the different treatments, grain and straw yield of rice was at par where 5t/ ha compost + recommended dose of fertilizers and 5 t/ ha compost + recommended N (N_{60}) were applied. However, highest yield was obtained where only recommended fertilizers were applied. The addition of half dose of nitrogen along with compost also resulted in increase in grain and straw yield of rice over the control or in the soils amended with rice straw compost alone. The grain and straw yield of rice also increased with inorganic fertilizers alone or along with organic residues in the form of rice straw compost significantly due to an overall improvement in the chemical and biological properties of the soil.

Utilization of rice straw through composting and its application in agricultural soils is one of the options for straw disposal. Burning of rice straw in situ is easy and convenient and can remove some of plant pathogens but it is not recommended as level of soil organic matter goes down. Incorporation of rice straw directly to soil will cause immobilization of nutrients. Maintenance of soil fertility and productivity is the need of the day as level of soil organic matter is going down due to injudicious use of inorganic fertilizers. There is evidence that use of organic amendments in the form of crop residues, FYM or compost increases the soil organic matter (Mahmood et al., 1997; Graham et al., 2002; Goyal et al., 2006). Microbial biomass which is responsible for carrying out the cycling of important plant nutrients increases or decreases in response to C inputs through organic amendments and is closely related to the amount of soil organic matter (Gregorich et al., 1996; Simek et al.,
The increase in microbial biomass C, dehydrogenase and phosphatase activities and C and N mineralization rate indicates the accumulation of labile pool of C and N with the application of rice straw compost alone or along with inorganic fertilizers. The use of rice straw compost alone or along with inorganic fertilizers had more positive effects on the buildup of soil organic matter level, microbial biomass and various activities. These improvements in organic matter and microbial activities due to integrated use of rice straw compost along with inorganic fertilizers is the best option left over the burning, removal or direct incorporation of rice straw in the agricultural soils. Under tropical soils the requirement for inorganic fertilizers is high which results in giving high yields of crops but the build up of organic C or nitrogen is low resulting in the poor fertility of agricultural soils. We also could found that addition of organic residues alone or along with inorganic fertilizers give comparable crop yield.

CONCLUSIONS

The composting of rice straw and its utilization in agricultural soils along with different doses of inorganic fertilizers is beneficial for maintaining soil organic matter level and microbiological properties. Composting of rice straw and its application along with inorganic fertilizers will reduce the cost of farming and will improve soil health by increasing C and N pool of the soils.

REFERENCES