Role of microbes in *ex-situ* and *in-situ* decomposition of agricultural waste

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Biocompost production and Utilization Innovations in Organic Agriculture
Introduction

• Crop residues are generated in large quantities and 75% of the total generated are produced by three crops.

• On an average these residues contain about 0.5% N, 0.2% P$_2$O$_5$ and 1.5% K$_2$O.

• When agro-residues are applied directly it creates hazards related to nutrient management due to wide C: N ratio.

• The crop biomass is composed of lignocelluloses, several microorganisms possess cellulolytic enzymes which can be used for bioconversion of agricultural residues

• A consortium of microorganisms is needed which can degrade lignocellulose efficiently.
Problem

• Post harvesting of Kharif crops mainly rice leaves abundant waste.

• Fruit and forest waste residues during this onset of winter season also gets abundant due to maximum demand and production.

• During the harvesting season the constraints of low temperature provides hindrance to the composting process making the agro-residues accumulated.

• Disposal of the accumulated biomass create problems and the widely practised incineration process increases environmental concerns.
Approach

- Low cost eco-friendly technology
- preparation of compost
- *Ex-situ* Pit or heap method- small, medium farmers & windrow for large scale composting mainly at community level
- *In-situ* (On farm)

Incorporating lignocellulolytic microorganisms intensify the biodegradation process
Raw Materials

Crop Residues
- Rice husks
- Rice straw
- Barley Straw
- Maize cobs
- Maize stalks
- Millet stalks
- Banana stems
- Coconut stem
- Castor stem
- Castor stem
- Cotton stick
- Sugarcane trash

Crop Residues
- Cotton leaves
- Jamun leaves
- Coconut leaves
- Coconut husks
- Cassava leaves
- Tamarind leaves

Human Habitation Wastes
- Solid wastes (e.g.; excreta)
- Liquid wastes (e.g.; urine)
- Garbage

Kitchen wastes
- Vegetable residues
- Fruit residues

Meat waste
- Fish waste

Forest Residues
- Non-edible seeds
- Pine needles
- Leaves
- Sawdust

Animal shed Wastes
- Dung
- Urine
- Biogas slurry
Main Objectives of Composting

- Conserving and recycling farm residue resources.
- Maintaining or improving the quality of the environment.
- Supplementing major plant nutrients (NPK).
- Minimize the pollution of water and land resources.
- Safeguarding rural public health.
Methods of composting

Aerobic

• Aerobic decomposers work faster and more efficiently than their anaerobic counterparts, providing you with finished compost on a faster time.

Anaerobic

• Anaerobic composting work at slower rates than their aerobic counterparts. Basically, you dig a hole, fill it with organic matter, and seal it with a layer of soil.

A well-constructed compost pile doesn't smell bad. In fact, it emits a refreshing earthy aroma, like kicking up leaves during a walk through the woods.
Factors effecting composting

• Carbon/Nitrogen ratio
• Moisture and aeration
• Microbial inoculants
• Temperature
• pH
• EC
A C/N ratio of 30 to 40 is optimal for efficient composting and ratios between 25 and 40 have been found satisfactory.

High C/N ratios are generally caused by organic materials poor in nitrogen such as straw of cereals, sugarcane trash, maize stalks, cotton stalks, jute stems and sawdust. In such cases although the process of decomposition goes on, the unassimilable nitrogen is lost by volatilization as ammonia or by denitrification.

Composting high C/N residues can be reduced by adding a nitrogen source or by blending with organic residues richer in nitrogen like legume residues, grass cuttings, aquatic weeds, green leaves.
Moisture and aeration

• Aerobic decomposition will occur at any moisture content between 30 and 100% if adequate turning is provided but higher moisture contents should be avoided.

• The optimum moisture level for aerobic composting is 50-60% however; a range of 40-80% is quite satisfactory depending upon the nature of the material to be composted.

• Experiments with straw (a fibrous material) have resulted for the maintenance of 80-85% moisture content.
• During aerobic composting, there is a rapid rise in ambient temperature from 55°C to 65°C in the first three to five days.

• The failure to attain thermophilic temperature:
  - the heap is too small to retain the heat or moisture.
  - excessive or insufficient carbon nitrogen relationships.

• Cooling is reliable indicator of finished compost only if the material does not re-heat after turning and moistening.

• The checking of the temperature inside a compost pile can be accurately done with the use of a metal dial thermometer with a stem length of 0.5 to 0.75 m.
• The initial pH value in compost heaps is generally slightly acidic to neutral, around 6-7.

• EC is measured to determine the amount of nutrients present in the compost in form of salts. It should be 0-2 ds/m.
### Microorganisms in Different Phase of Composting

<table>
<thead>
<tr>
<th>Low Temperature</th>
<th>Mesophiles</th>
<th>Thermophiles</th>
</tr>
</thead>
</table>
| • *Eupenicillium crustaceum*  
  • *Paciliomyces sp.* | • *Aspergillus awamori*                                                      | • *Sporotrichum thermophile*                 |
|                          | • *Paceliomyces varioti*                                                    | • *Thermoascus aurantiacus*                  |
|                          | • *Phanerochaete chrysosporium*                                             |                                              |
|                          | • *Trichoderma viride*                                                      |                                              |
| • *Bacillus atropheus*    
  • *Bacillus sp.*          | *Bacillus subtilis*                                                          | *Bacillus stearothermophilus*                |
|                          | *Bacillus pumilus*                                                          | *Bacillus licheniformis*                     |
|                          | *Beta proteobacteria*                                                       | *Alpha proteobacteria*                       |

### Classification

- **Beta proteobacteria**
- **Alpha proteobacteria**
Role of Fungi For Rapid Degradation of Substrates

Biomass

PUSA COMPOSTING TECHNOLOGY
Compost Inoculants

- 500g Compost packet is for 1 tonne of material and cost is Rs.50
- 100 ml liquid culture for kitchen and green waste and cost is Rs.10
- 5 litres liquid inoculum for 1 tonne of material and cost is Rs.150
- Powdered formulation, a set of 5 capsules for 1 tonne of material (Cost to be decided)
Ex-situ Composting variants
Composting in Perforated Pits

Composting in closed pits
Mechanization of composting
Machines for composting

Shredder
Only for leaves, twigs & wood

Shredded material

Loader
for loading material

Compost Turner cum Mixer

Mixing of material
Preparation of compost

- Paddy straw & cowdung
- Inoculum application
- Addition of water for moisture maintenance
- Preparation of pile
Characteristics of finished compost

- Colour
- Texture
- Odour
- Water solubility
- C/N value
- Ions
- Nutrient content
# Salient Findings

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>C/N ratio</td>
<td>15.66</td>
</tr>
<tr>
<td>Available P %</td>
<td>0.31</td>
</tr>
<tr>
<td>C %</td>
<td>26</td>
</tr>
<tr>
<td>N %</td>
<td>1.66</td>
</tr>
<tr>
<td>Micronutrients ppm</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>166</td>
</tr>
<tr>
<td>Copper</td>
<td>26</td>
</tr>
<tr>
<td>Mn</td>
<td>371</td>
</tr>
<tr>
<td>Fe</td>
<td>2688</td>
</tr>
<tr>
<td>pH</td>
<td>8.8</td>
</tr>
<tr>
<td>EC (mS cm⁻¹)</td>
<td>3.8</td>
</tr>
<tr>
<td>Humus %</td>
<td>4.55</td>
</tr>
</tbody>
</table>
The traditional technology of composting, if improved in terms of nutrients content, may help in arresting trends of nutrient depletion to a greater extent. Further, the use of mineral additives such as rock phosphate and pyrites during composting have been found beneficial. A phosphocompost/N-enriched phosphocompost technology can be developed using phosphate solubilizing microorganisms, namely, Aspergillus awamori, Pseudomonas straita and Bacillus megaterium.

Raw material used for the production of one tonne of phosphocompost, includes materials such as 1900 kg organic/vegetable wastes/straw, 200 kg cow-dung (dry weight basis) and 250 kg phosphate rock (18% P2O5) are used.

To prepare N-enriched phospho-compost, nitrogen as urea @ 0.5-1% (w/w), rock phosphate (12.5% w/w) and pyrite @ 10% (w/w) are added into the composting mixture. The N-enriched phospho-compost contains 1.4-1.6% N and 15-20 C:N ratio.

This compost was prepared by inoculation with Trichurus spiralis, a quick decomposer of cellulosic matter; A.awamori as phosphate solubilizer and Azotobacter chroococcum as nitrogen fixer was evaluated in field trial with var. HD 2288.
## Paddy Straw collector-cum-chopper In-situ degradation

<table>
<thead>
<tr>
<th>Straw Size (cm)</th>
<th>Straw Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5</td>
<td>63.5</td>
</tr>
<tr>
<td>5-10</td>
<td>8.12</td>
</tr>
<tr>
<td>10-15</td>
<td>6.44</td>
</tr>
<tr>
<td>&gt;15 cm</td>
<td>17.92</td>
</tr>
</tbody>
</table>
**Experimental Design in Microstrips**

- **Above the Soil**
  - S1: Paddy straw + Compost Inoculum
  - S2: Paddy straw

- **Under the Soil**
  - S3: Paddy straw + Compost Inoculum
  - S4: Paddy straw

**Total length of strips**

22 m

- **Untreated (S2)**
- **Treated (S4)**
- **Untreated (S3)**
- **Treated (S1)**

Idle run track

Under the soil

Above the soil

1.5 m
Degradation Pattern

Above the soil

8th Jan

18th Jan

28th Jan

7th Feb

Under the soil
Application of Compost Inoculant
### Site 1

<table>
<thead>
<tr>
<th>Place – Eterna; Sonepat</th>
<th>Substrates – paddy straw; corn stover; Nitrogen source – urea; Amendments – FYM; No. of Pits – IV; Substrate application – 200 Kg</th>
</tr>
</thead>
</table>

#### Treatments

- **T1** – corn stover (uninoculated);
- **T2** – corn stover (inoculated);
- **T3** – paddy straw (uninoculated);
- **T4** – paddy straw (inoculated)

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Site 1–Eterna (Sonepat) : Both corncobs and paddy straw degraded in 90 days with 100% germination and 2.6% humic acid.
**Site 2**

**Place** – Nangalbhoor, Pathankot;
**Substrates** – paddy straw, fruit waste, leaves;
**Nitrogen source** – urea;
**Amendments** – FYM;
**No. of Pits** – IV;
**Substrate application** – 200 Kg

**Treatments**

T1 - Fruitwaste+leaves (uninoculated);
T2 - Fruit waste+leaves (inoculated);
T3 - Paddy straw (uninoculated);
T4 - Paddy straw (inoculated)

Nangalbhoor (Pathankot) : citrus fruits and leaf waste degraded in 45 days with 2.12% HA and paddy straw degraded in 90 days with 1.83% HA and no phytotoxicity.
### Site 3

<table>
<thead>
<tr>
<th>Place</th>
<th>Kohali; near Amritsar border</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrates</td>
<td>Paddy straw (chopped)</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>source – poultry manure</td>
</tr>
<tr>
<td>Amendments</td>
<td>FYM</td>
</tr>
<tr>
<td>No. of Pits</td>
<td>(II)</td>
</tr>
<tr>
<td>Substrate</td>
<td>application – 200 Kg</td>
</tr>
</tbody>
</table>

**Treatments**

- **T1** – Paddy straw (uninoculated);
- **T2** – Paddy straw (inoculated)

Kohali (Amritsar): Chopped paddy straw was used as substrate and degraded in 60 days with 1.56% HA
Site 4

Place – Kotla; Amritsar
Substrates – paddy straw (chopped and unchopped);
Nitrogen source – urea;
Amendments – FYM;
No. of Pits – IV;
Substrate application – 200 Kg

Treatments
T1 – Paddy straw unchopped (uninoculated);
T2 – Paddy straw unchopped (inoculated);
T3 – Paddy straw chopped (uninoculated);
T4 – Paddy straw chopped (inoculated)

Kotla (Amritsar) : showed degradation of chopped and unchopped paddy straw at 60 days with 1.56% and 1.91% HA respectively and nil phyto-toxicity
<table>
<thead>
<tr>
<th>Place</th>
<th>Treatment Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dhanda, Shimla</td>
<td>T1- Garden waste (inoculated)</td>
</tr>
<tr>
<td></td>
<td>T2- Oak leaves (inoculated)</td>
</tr>
<tr>
<td></td>
<td>T3- Garden waste (uninoculated)</td>
</tr>
<tr>
<td></td>
<td>T4- Oak Leaves (uninoculated)</td>
</tr>
</tbody>
</table>

Dhanda (Shimla): Experiment under progress