Rice Straw-Based Nutrient Management for Irrigated Lowland Rice
Rice Technology Bulletin Series

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Foreword

As an ISO-certified institution, caring for the people and the environment has always been our foremost concern. We strive for harmony between agriculture and the environment when we develop technologies. As much as possible, we make use of indigenous materials, we even recycle farm wastes, to save on production costs while at the same time, making rice farming a sustainable, productive, and profitable venture.

Rice straw, considered a major farm waste, has taken our research attention because of the increasing concern on how farmers manage it by burning after every harvest. Two possible reasons for this practice: (1) it is the most convenient way to get rid of the waste and (2) lack of knowledge on how this waste can benefit them.

A long-term trial on how rice straw can enhance soil and farm productivity and sustainability has made us confident in saying that this farm waste can help farmers save not only on their production costs, but save the degrading environment as well. It is hoped that this technology bulletin will help the farmers in these endeavors.
Introduction

Rice straw is the major indigenous organic material in the farm. Every harvest, about 5 tons per hectare of this can be collected. In areas where rice is planted two to three times a year, it becomes a fast-accumulating farm waste and farmers find burning as the easiest management practice.

However, rice straw burning causes loss of major nutrients: almost complete nitrogen (N) loss, phosphorous (P) losses of about 25 percent, potassium (K) losses of 20 percent, and sulfur (S) losses of 5 to 60 percent (Dobermann, A. and T.H. Fairhurst, 2002).

Proper management by incorporating it back into the soil can conserve soil nutrients because it contains all mineral elements consumed by the rice plant during vegetation. From a hectare of farm at harvest, about 25-40 kg nitrogen, 3-6 kg phosphorus, 60-85 kg potassium, 2-5 kg sulfur, 200-350 kg silicon, 2,000 kg carbon, and several other nutrients can be conserved especially when rice straw is completely decomposed.

Several studies prove that continuous rice straw incorporation can build up soil nutrient reserves especially potassium, which is essential for plant vigor. Further studies done by PhilRice researchers combining rice straw with other organic wastes (e.g., bokashi and animal manure) resulted in enhanced nutrient build up and accelerated rice straw decomposition. The studies also established that with this practice, reducing inorganic fertilizer input by up to 50% can still produce high yields.

As a result, rice straw-based nutrient management options were developed primarily aiming at soil rejuvenation and environmental conservation through good rice straw management. In the long term, it is hoped that these options will have greater impact on the sustainable productivity and profitability of the rice farmers.
Yearly Trend of Available N, P, and K in the Soil

**LEGEND:**
- RS - Rice Straw
- RSEM - Rice Straw with Effective Microorganism-Based Inoculant
- CM - Chicken Manure
- WSF - Wild Sunflower
- COF - Commercial Organic Fertilizer

(*) - Control + Full rate of recommended NPK fertilizers
(**) - Control + Half rate of recommended NPK fertilizers

**NOTE:**
Parameters were analyzed individually and per cropping season using the CropStat 7.1; comparison of means by LSD at 5% level of significance.
Benefits

- Enhanced nutrient availability and sustainability in the soil
- Maintain balanced soil nutrients
- Reduced cost on fertilizer inputs
- Environmental conservation
- Reduced/prevented buildup of farm waste

Important consideration

Rice straw does not easily decompose. As such, it may inhibit the release of soil nutrients affecting the crop’s growth and development. Using inoculants such as animal manure and the commercially-available Effective Microorganisms-based Bokashi (EMB) prove to hasten decomposition. These also serve as alternative sources of nutrients.

TIP:

Grasscutting the remaining stubbles immediately after harvest chops up the crop residues and accelerates their decomposition. It also makes land preparation easier and faster.
Know the inoculants!

**Animal (Chicken or Hog) manure**

- Contains high amount of enzymes, hormones, and minerals that hasten decomposition.
- Good alternative source of nitrogen, phosphorous, and potassium.
- Cheap and available in the farm.
- Accelerates decomposition of rice straw within two weeks of incorporation which is done during the last harrowing.

**Effective Microorganisms-based Bokashi (EMB)**

- Mixture of different organic matters fermented with a commercial chemical solution called Effective Microorganisms.
- Widely used by Japanese farmers to decompose various organic materials.
- Can be used as soil amendment to increase the microbial diversity of the soil, which also improves nutrient supply to the crop.
- Accelerates decomposition of rice straw within two weeks of incorporation which is done during the last harrowing.
Management Options and Procedures

Rice straw-based nutrient management does not completely eliminate the use of inorganic fertilizers. Instead, it encourages the recycling of rice straw into soil ameliorants while at the same time, managing the application of inorganic fertilizers at critical growth stages of the rice plant. With this management strategy, farmers (depending on their financial resources and yield targets) may choose from these options: (1) no application of inorganic fertilizer; (2) application of half the rate of recommended NPK fertilizers; and (3) application of the full recommended rate of NPK fertilizers.

<table>
<thead>
<tr>
<th>Organic-based Management Options</th>
<th>Without chemical fertilizer</th>
<th>Half rate of recommended NPK fertilizers**</th>
<th>Full rate of recommended NPK fertilizers***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (no organic matter added)</td>
<td>4.28</td>
<td>6.01</td>
<td>6.40</td>
</tr>
<tr>
<td>Rice Straw</td>
<td>4.96&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.62&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.73&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Rice Straw with EMB</td>
<td>4.81&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.47&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.76&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Chicken Manure (CM)</td>
<td>5.69&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.72&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.70&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Wild Sunflower</td>
<td>5.11&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.52&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.57&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Commercial Organic Fertilizer</td>
<td>4.52&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.11&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.46&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

* average of 10 seasons using PSB Rc82 in experiments done at PhilRice Central Experiment Station, (2004DS-2009DS); using rice straw, returns of investment are 1.40 (without chemical fertilizer), 1.36 (half rate of recommended NPK fertilizers, and 1.53 (full rate of recommended NPK fertilizers)

** recommended rate based on soil analysis (DS: 120-40-40 Kg NPK; WS: 90-30-30 Kg NPK)

*** recommended rate based in soil analysis (DS: 60-20-20 Kg NPK; WS: 45-15-15 Kg NPK)

<sup>a</sup> significantly different from the control at 5% LSD

<sup>b</sup> not significantly different from the control at 5% LSD
Pre-planting procedures

- Assess soil nutrient deficiencies using Minus-One Element Technique (MOET).

  *MOET is a simple tool for diagnosing limiting nutrients such as phosphorus, potassium, zinc, and sulfur. Soil nutrient deficiencies are assessed based on plant nutrient deficiency symptom (refer to Technology Bulletin #30).*

- Decide on how rice straw should be decomposed. This affects the schedule of farm activities.

<table>
<thead>
<tr>
<th>Options for decomposition</th>
<th>Time for incorporation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice straw alone</td>
<td>4 weeks before transplanting</td>
</tr>
<tr>
<td>Rice straw + EMB at 10:1 ratio</td>
<td>2 weeks before transplanting</td>
</tr>
<tr>
<td>Rice straw + CM</td>
<td>during the last harrowing or 2 weeks before transplanting</td>
</tr>
<tr>
<td>Rice straw + hog manure</td>
<td>during the last harrowing or 2 weeks before transplanting</td>
</tr>
</tbody>
</table>

- Incorporate rice straw and other organic matters into the soil by plowing at recommended time spans to allow complete decomposition of organic matters. This will ensure that all toxic products of decomposition are eliminated.
Maintain a saturated field as this facilitates decomposition of organic matters.

Do the necessary harrowing activities. Harrow the field at least twice at one week interval to allow germination and incorporation of drop seeds and volunteer plant. Do the second harrowing across the direction of the first plow.

At harvest, 1 hectare of irrigated rice field can produce 5 tons of rice straw, which can be effectively decomposed with 3 tons of chicken manure, or 500 kg EMBI at specific time spans. Decomposition can be done in situ (on-site) or as where the organic materials are located.

Proper harrowing of the field helps reduce the initial pest host population, thereby avoiding yield losses due to pest damage.
Basal (1 day before transplanting)

- Apply all P and K according to the chosen nutrient management options. These elements are necessary for root development, and tiller and leaf formation. P increases the recovery of mineral fertilizer nutrients. K improves plant vigor and helps prevent lodging.

<table>
<thead>
<tr>
<th>Fertilizer recommendations (bags/ha) of different management options.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Season</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>Dry Season</td>
</tr>
<tr>
<td>Wet Season</td>
</tr>
</tbody>
</table>

Potassium allows faster sugar production and transport from the older parts of the plant to its actively growing parts.
At Vegetative Phase (30 days after transplanting)

- At this stage, the nutrients supplied by the decomposed rice straw and other organic matters are already consumed. Possible nutrient hunger will occur and demand for N and K, in particular, is high for the plant to complete its normal growth cycle. Application of recommended kinds and amounts of fertilizers is necessary to increase plant height, leaf area, and tiller number, which will influence panicle number and development.

- Apply the second dose of N fertilizer based on the chosen management option.

<table>
<thead>
<tr>
<th>Season</th>
<th>Half rate of recommended NPK fertilizers</th>
<th>Full rate of recommended NPK fertilizers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Season</td>
<td>1/2 bag urea or 1 bag 21-0-0</td>
<td>1 bag urea or 2 bags 21-0-0</td>
</tr>
<tr>
<td>Wet Season</td>
<td>none</td>
<td>1 bag urea or 2 bags 21-0-0</td>
</tr>
</tbody>
</table>
At Reproductive Phase

Panicle initiation

- Fertilizers applied at panicle initiation stage helps to attain optimum number of panicles with plenty of spikelets.
- Apply third dose of recommended fertilizers.

<table>
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<th>Fertilizer recommendations (bags/ha) of different management options.</th>
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<tr>
<td><strong>Season</strong></td>
</tr>
<tr>
<td>Dry Season</td>
</tr>
<tr>
<td>Wet Season</td>
</tr>
</tbody>
</table>

Early heading

- Fertilizers applied at this stage enhances grain filling.

Fertilizer application at early heading is done only during the Dry Season where solar radiation is high, which causes higher N uptake by the rice crop.
Apply the last dose of recommended fertilizers to achieve optimum number of filled spikelets and grain weight.

<table>
<thead>
<tr>
<th>Season</th>
<th>Half rate of recommended NPK fertilizers</th>
<th>Full rate of recommended NPK fertilizers</th>
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</thead>
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<tr>
<td>Dry Season</td>
<td>none</td>
<td>1 bag urea or 2 bags 21-0-0</td>
</tr>
<tr>
<td>Wet Season</td>
<td>none</td>
<td>none</td>
</tr>
</tbody>
</table>
Summary of rice straw-based nutrient management strategies at critical crop growth stages of the rice crop.

Incorporate rice straw and other organic matters into the soil by plowing at recommended time spans. This will allow complete decomposition of organic matters which will ensure elimination of toxic products that are harmful to the rice plants.

Apply recommended kinds and amounts of fertilizers during these critical periods to increase plant height, leaf area, tiller number, and panicle formation and density, which will influence panicle number and development.

Apply recommended kinds and amounts of fertilizers to ensure optimum panicle density, spikelet formation and development, as well as grain filling, all of which are associated with the attainment of optimum yield potential.

Nutrients (NPK) supplied by the decomposed organic materials are consumed by the plant at 30 days after transplanting.

Vegetative Phase  
Reproductive Phase  
Ripening/Maturity
Average grain yield (t/ha) and returns of investments (ROI) of different organic-based nutrient management options.

<table>
<thead>
<tr>
<th>Organic-based Management Options</th>
<th>Without chemical fertilizer ROI</th>
<th>Half rate of recommended NPK fertilizers ROI</th>
<th>Full rate of recommended NPK fertilizers ROI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (no organic matter added)</td>
<td>4.28 1.2</td>
<td>6.01 1.3</td>
<td>6.40 1.5</td>
</tr>
<tr>
<td>Rice Straw</td>
<td>4.96 1.4</td>
<td>6.62 1.4</td>
<td>6.73 1.5</td>
</tr>
<tr>
<td>Rice Straw with EMB</td>
<td>4.81 0.7</td>
<td>6.47 0.8</td>
<td>6.76 0.9</td>
</tr>
<tr>
<td>Chicken Manure</td>
<td>5.69 1.1</td>
<td>6.72 0.9</td>
<td>6.70 1.1</td>
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<tr>
<td>Wild Sunflower</td>
<td>5.11 1.3</td>
<td>6.52 1.2</td>
<td>6.57 1.5</td>
</tr>
<tr>
<td>Commercial Organic Fertilizer</td>
<td>4.52 1.0</td>
<td>6.11 1.1</td>
<td>6.46 1.3</td>
</tr>
</tbody>
</table>

**NOTE:**

<table>
<thead>
<tr>
<th>Materials</th>
<th>Cost/ha</th>
<th>Quantity Rqd:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seeds (PSB Rc82)</td>
<td>P1200.00 @ P30.00 /Kg</td>
<td>40 Kg</td>
</tr>
<tr>
<td>Chicken Manure</td>
<td>P6000.00 @ P40.00/bag (20Kg)</td>
<td>3tons (3000Kg)</td>
</tr>
<tr>
<td>EMB</td>
<td>P7500.00 at P15.00/Kg</td>
<td>500Kg</td>
</tr>
<tr>
<td>COF</td>
<td>P1750.00 at P175.00/bag</td>
<td>10bags</td>
</tr>
</tbody>
</table>
References


van Kessel, C and WR Holwarth. Long-term Rice Straw Incorporation: Does it Impact Maximum Yield? http://www.cdfa.ca.gov/is/docs/vanKessel00.pdf
Acknowledgement
Dr. Rolando T. Cruz for project funds and technical support, Dr. Eduardo Jimmy P. Quilang for administrative and technical support, and Mr. Andrei B. Lanuza and the DevCom Division staffers for the production of this technology bulletin.

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Published by the Philippine Rice Research Institute. 2009.
1st printing 3,000 copies

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We are a government corporate entity attached to the Department of Agriculture created through Executive Order 1061 on 5 November 1985 (as amended) to help develop high-yielding and cost-reducing technologies so farmers can produce enough rice for all Filipinos.

We accomplish this mission through research, development, and extension (RD&E) through our central and branch stations coordinating with a network that includes 57 agencies and 70 seed centers strategically located nationwide.

Our R&D structure for 2006-2010 includes four programs and 19 major projects. Our interdisciplinary programs are favorable environment, unfavorable environment, impact and policy research, and knowledge management and promotion. With these programs, we aim to develop and promote technologies that are ecosystem-based, location- and problem-specific, and profitable to the Filipino farmers.

We have the following certifications: ISO 9001:2000 (Quality Management System), ISO 14001:2004 (Environmental Management System), and OHSAS 18001:1999 (Occupational Health and Safety Assessment Series).

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