Study on Rice Residue Management Options on Growth Parameters and Growth Indices of Rice Crop

A. Vijayaprabhakar¹, S. Nalliah Durairaj², M. Hemalatha³ and M. Joseph³

¹Institute of Agriculture, Agricultural Engineering College and Research Institute (AEC and RI), Kumulur, Tamilnadu, 621712, India.
²S. Thangapazham Agricultural College, Vasudevanallur, Tamilnadu, 627758, India.
³Department of Agronomy, Agricultural College and Research Institute (AC and RI), TNAU, Killikulam, Tamilnadu, 628252, India.

Authors’ contributions

This work was carried out in collaboration among all authors. Author AV designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SND and MH managed the analyses of the study. Author MJ managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JEAI/2020/v42i130451

Editors:
(1) Dr. Mirjana Bulatovic-Danilovich, Associate Professor, Consumer Horticulture, State Extension Master Gardener Program Coordinator, West Virginia University, USA.

Reviewers:
(1) Rene Arnoux Da Silva Campos, Universidade Do Estado De Mato Grosso, Brazil.
(2) Ningappa. M. Rolli, BLDEA’s Degree College, India.
(3) Narendra Kumawat, Rajnata Vijayaraje Scindia Krishi Vishvavidyalaya, India.

Complete Peer review History: http://www.sdiarticle4.com/review-history/54319

Received 01 December 2019
Accepted 06 February 2020
Published 15 February 2020

ABSTRACT

The research was conducted to study the effect of management options for combine harvested rice residue and its effect on succeeding rice crop growth responses. The experiment was laid out in field using a randomized block design with nine treatments and replicated three times. The computed biometric data were subjected to statistical scrutiny. Incorporation of combine harvested rice residue with 25 kg additional N ha⁻¹ as basal + bio-mineralizer (2 kg t⁻¹ of rice residue) and cow dung slurry (5%) recorded higher plant height, number of tillers, dry matter production (DMP), leaf area index (LAI), crop growth rate (CGR) and relative growth rate (RGR) of the succeeding rice irrespective of the growth stages. It was closely followed by straw incorporation with 25 kg additional N ha⁻¹ as basal + cow dung slurry (5%). Incorporation of straw alone and removal of straw negatively influenced the rice growth and growth indices. Hence, it is advisable to incorporation of rice residue with additives for better growth and growth indices of rice crop.

*Corresponding author: E-mail: a.vijayp@ymail.com, apavijip@gmail.com;
1. INTRODUCTION

In most of the rice growing areas of India, rice crop comes to harvest at the same time over a large area which creates labour shortage. Delayed harvest results in produce being wasted due to shattering. In addition, delays reduce turnaround time for taking the next crop [1].

To overcome this problem, local government has introduced rice combine harvester capable of harvesting, threshing, cleaning and packing at the same time. Advantages of using combine harvester are (i) overcoming labor-shortage and performing harvest in a timely manner, (ii) perfect harvesting even under water logged condition (iii) it reduces the wastages of grain due to shattering (iv) it reduces the turn-around time for taking the next crop (v) entire harvested grain crop is first grade allowing it be used as seed material (vi) it increases the net income from the farm and (vii) chopped paddy straw residue (5.0 to 6.0 t ha\(^{-1}\)) can be incorporated in-situ for nutrition to succeeding rice crop [1].

The main disadvantage during the combine harvesting is leaving the straw in entire field area in chopped form, which presents difficulty in collecting and feeding it to the cattle. A huge quantity of such rice straw in chopped form has been burnt in the field, which may result in pollution problems and wastage of valuable resources [2].

Hence, implementing an alternate way to effectively utilize the combine harvested straw become essential. In India, about 106 million tonnes of rice straw is produced annually valued at about 0.61, 0.27 and 1.76 million tonnes of N, P and K respectively [3]. Rice straw contains 0.5 to 8.0 per cent N, 0.16 to 0.27 per cent P, 1.4 to 2.0 per cent K, 0.05 to 0.10 per cent S and 4 to 7 per cent silica (Si) in its dry matter [4]. Though the nutrient availability of rice straw is well known, the downside is the lower decomposition rate of rice straw due to its higher C:N ratio (33) compared to cow dung and Dhanicha (green manure crop) [5]. Under such condition, planting immediately after incorporating the straw of preceding crop may hamper the establishment of the succeeding rice crop [6]. To overcome these problems, combine harvester paddy straw is incorporated along with additional N source, biomineralizer, cow dung slurry and its combinations to find the growth response of rice crop by faster decomposition. Keeping the above factors in mind, the present study was undertaken with the objective of finding the suitable residue management options for combine harvested rice field by understanding the growth response of rice crop by using different residue management options.

2. MATERIALS AND METHODS

The field experiment was conducted in Agricultural College and Research Institute, Killikulam during Pishanam season of October 2014 - February 2015, to study the different rice residue management options in combine harvested rice field for using the rice straw as an organic manure, to avoid the burning of paddy straw in the field itself. The farm is geographically situated in the southern part of Tamil Nadu at 8°46' N latitude and 77°42' E longitude at an altitude of 40 m asl. The mean annual rainfall is 786.6 mm received in 40 rainy days. The mean maximum and minimum temperature of the location are 33.4°C and 23.6°C respectively. The relative humidity ranges from 60 to 80 per cent. Before laying out the experiment, five soil samples were randomly collected at the 15 cm depth and composite soil sample was obtained by quartering method and processed for analyzing its physicochemical characters (Table 1).

The soil of the experimental field is sandy clay loam in texture, neutral in reaction and low in available N and medium in available P and K contents. The experiment was laid out in randomized block design with control block and eight treatments [T\(_1\) - Incorporation of rice straw; T\(_2\) - T\(_1\) + 25 kg additional N ha\(^{-1}\) as basal; T\(_3\) - T\(_1\) + Bio-mineralizer (2 kg t\(^{-1}\) rice residue); T\(_4\) - T\(_1\) + Cow dung slurry (5%); T\(_5\) - T\(_1\) + 25 kg additional N ha\(^{-1}\) as basal + Bio-mineralizer (2 kg t\(^{-1}\) rice residue); T\(_6\) - T\(_1\) + 25 kg additional N ha\(^{-1}\) as basal + Cow dung slurry (5%); T\(_7\) - T\(_1\) + Bio-mineralizer (2 kg t\(^{-1}\) rice residue) + Cow dung slurry (5%); T\(_8\) - T\(_1\) + 25 kg additional N ha\(^{-1}\) as basal + Bio-mineralizer (2 kg t\(^{-1}\) rice residue) + Cow dung slurry (5%); T\(_9\) - Control (no residue)] and replicated thrice [7].

Rice variety ADT (R) 45 with the duration of 110 days was used as a test variety in this experiment. After combine harvesting, the rice straw retained on the field was collected and quantified at 5 t ha\(^{-1}\). The rice straw was
Table 1. Physicochemical characteristics of the experimental field

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I. Mechanical Analysis</strong></td>
<td></td>
</tr>
<tr>
<td>Coarse sand (per cent)</td>
<td>35.8</td>
</tr>
<tr>
<td>Fine sand (per cent)</td>
<td>28.5</td>
</tr>
<tr>
<td>Silt (per cent)</td>
<td>7.7</td>
</tr>
<tr>
<td>Clay (per cent)</td>
<td>27.3</td>
</tr>
<tr>
<td>Texture</td>
<td>Sandy Clay Loam</td>
</tr>
<tr>
<td><strong>II. Chemical Analysis</strong></td>
<td></td>
</tr>
<tr>
<td>Available N (kg ha(^{-1}))</td>
<td>246.00</td>
</tr>
<tr>
<td>Available P(_2)O(_5) (kg ha(^{-1}))</td>
<td>18.75</td>
</tr>
<tr>
<td>Available K(_2)O (kg ha(^{-1}))</td>
<td>236.00</td>
</tr>
<tr>
<td>Organic carbon (per cent)</td>
<td>0.56</td>
</tr>
<tr>
<td>pH (1:2 soil water suspension)</td>
<td>7.00</td>
</tr>
<tr>
<td>EC (dS m(^{-1})) (1:2 soil water suspension)</td>
<td>0.31</td>
</tr>
</tbody>
</table>

uniformly distributed to all the plots. The gross plot size and net plot size was 45 m\(^2\) (7.5 m \times 6.0 m) and 38.5 m\(^2\) (7.0 m \times 5.5 m) respectively, except control. TNAU Bio mineralizer was made into slurry by mixing with water (for 2 kg of material 40 liters of water) and sprinkled on the straw of respective experimental plots at 2 kg t\(^{-1}\) of rice residue on the next day of combine harvest of preceding rice crop i.e. 15 days ahead of transplanting. Cow dung slurry (5%) was prepared and sprinkled over the paddy straw in the corresponding treatment plots on the next day of combine harvest of preceding rice crop i.e. 15 days ahead of transplanting. After 15 days, every plot was individually puddled and levelled properly and rice transplanted with recommended dose of fertilizers additional 25 kg N was added as a basal in appropriate plots as per the treatment. Apart from the treatment, all the cultural practices for lowland rice strictly followed as per TNAU crop production guide.

Biometric observations were done on growth parameters and growth indices. In the net plot area, five hills were selected randomly and tagged for recording biometric observations. Growth components were recorded at entire cropping period, viz., active tillering, flowering and harvest stages. The plant height of the tagged plants were measured from the ground level to the tip of the top most fully opened leaf or flag leaf at active tillering and up to tip of the panicle at flowering and at harvest stages and the mean values were expressed in cm. In each net plot, total number of tillers was counted from the five sample hills tagged for biometric observation at active tillering, flowering and at harvesting stages and expressed in No. m\(^{-2}\). Five hills were randomly selected from the sampling area and they were pulled off at active tillering, flowering and at harvest stages. These samples were air-dried in the shade and then oven dried at 70\(^\circ\)C for 72 hours till they attain the constant weight. The dry weight was recorded using an electronic top pan balance and the dry matter was computed and expressed as kg ha\(^{-1}\). The leaf area index was worked out at tillering and flowering stages using the formula suggested by [8].

\[
\text{LAI} = \frac{L \times B \times K \times \text{Number of leaves plant}^{-1} (\text{cm}^2)}{\text{Land area occupied by the plant (cm}^2))}
\]

Where,

\[L = \text{Length of the 3rd leaf blade from the top (cm)}\]
\[B = \text{Maximum breadth of the same leaf (cm)}\]
\[K = \text{Constant factor (0.73)}\]

The crop growth rate was estimated by using the formula suggested by [9] and expressed in kg ha\(^{-1}\) day\(^{-1}\).

\[
\text{CGR} = \frac{W_2 - W_1}{t_2 - t_1}
\]

Where,

\[W_1 \text{ and } W_2 \text{ were DMP in kg ha}^{-1} \text{ at times } t_1 \text{ and } t_2 \text{ respectively.}\]

Relative growth rate during different growth periods were calculated using the following equations suggested by [10] and expressed in g kg\(^{-1}\) day\(^{-1}\).

\[
\text{RGR} = \left( \log_e W_2 - \log_e W_1 \right) / (t_2 - t_1)
\]

Where,

\[W_1 \text{ and } W_2 \text{ were DMP in kg ha}^{-1} \text{ at times } t_1 \text{ and } t_2 \text{ respectively.}\]
The collected analytical biometric data and the computed data were subjected to statistical scrutiny. Wherever, the treatment differences were found significant (F test), critical differences were worked out at 5 per cent probability level and the values were furnished.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters (Figs. 1, 2 and 3)

Among the different residue management options, treatment (T₈), showed significantly taller plant’s height (56.9 cm, 94.2 cm, 105.9 cm at active tillering, blooming and harvest stage respectively), the higher number of tillers m⁻² (377 and 492 at active tillering and flowering stage respectively) and dry matter production (1862 kg ha⁻¹, 10177 kg ha⁻¹ and 16084 kg ha⁻¹ at active tillering, flowering and harvest stage respectively). Compare to T₉ (where straw was removed) the increment in T₈ was 17% in plant height at harvest stage, 16.3% in number of tillers m⁻² at flowering stage and 37.5% in dry matter production at harvest stage. Next to this the treatment (T₆), registered higher plants height, number of tillers m⁻² and dry matter production (1856 kg ha⁻¹, 9834 kg ha⁻¹ and 15571 kg ha⁻¹ at active tillering, flowering and harvest stage respectively). Compare to T₆ (where straw was removed) the increment in T₈ was 17% in plant height at harvest stage, 16.3% in number of tillers m⁻² at flowering stage and 37.5% in dry matter production at harvest stage. Compare to control (T₉), T₈ and T₅ had 11.4% higher plant height at harvest stage, 13.2% higher number of tillers m⁻² at flowering stage and 29.2% higher dry matter production at harvest stage.

The increased plant height, number of tillers m⁻² and dry matter production (Figs. 1, 2 and 3) was due to the cumulative effect of all additives at the same period. The additional N could reduce the N immobilization in the early stages of paddy straw decomposition [11]. The bio-mineralizer contains a consortium of microorganism in sufficient numbers (BPD - TNAU) and the cow dung slurry also used as a source of microbial consortia for composting [12]. These microbial inoculants are ensured better decomposition of straw [13] and improved NPK content of the soil [14], which leads to better nutrient availability to the crop and resulted higher plant height, number of tillers m⁻² and DMP of rice. This result is in confirmation with the findings previously done [2,15,16].

In treatment (T₁), straw incorporated without additives recorded shorter plants, reduced no of tillers m⁻² and poor dry matter production, which was 15.5% lower in plant height at harvest stage, 16.8% lower in number of tillers m⁻² at flowering stage and 29% lower in dry matter production at harvest stage over best performance (T₈). This was on par with treatment (T₉), where the straw was removed. There was no significant difference in plant height, number of tillers m⁻² and DMP, when incorporation of straw alone without additives and straw removal (control). This was due to the immobilization of nitrogen in straw alone incorporated field and reduced soil nutrient availability at later stage in straw removal plots. The similar findings also reported by Ebid and Ueno [17].

![Fig. 1. Effect of rice residue management on plant height (cm) of rice crop](image-url)
Fig. 2. Effect of rice residue management on tillers production of rice crop

Fig. 3. Effect of rice residue management on dry matter production (kg/ha) of rice crop

3.2 Growth Indices (Figs. 4, 5 & 6)

The observation on growth analysis of the crop has become an important in identifying the causes for variation in grain and straw yield. Hence, growth analysis was done for the following characters viz., LAI, CGR and RGR at different growth stages and is presented below.

3.2.1 Leaf area index

Higher LAI was observed (Fig. 4) at tillering and flowering (3.80 and 6.51 respectively) stages by the treatment (T8), which was 19% higher than T9 at flowering stage of rice crop. This was followed by treatment (T6), which recorded LAI of 3.72 and 6.36 at tillering and flowering stages.
respectively. The LAI was also high with T5 and T2 which recorded the LAI of 3.70 & 6.35 and 3.58 & 6.15 respectively. The treatment (T1), where straw alone incorporated, it recorded the lower LAI of 2.95 and 5.06 respectively at tillering and flowering stages and it was on par with control, where no residue was added (T9), registering lower LAI of 3.20 and 5.47 at tillering and flowering stages respectively. Leaf area index is determined by the number of tillers, number of green leaves per hill and average leaf size [18]. It determines the total photosynthesizing area available to the plant and quantum of source that would be translocating to sink. The LAI was found to increase all along the vegetative phase and attained its maximum at flowering stage. The LAI was significantly increased by different residue management practices (Fig. 4). The treatment (T8), registered higher LAI at tillering and flowering stage of rice, it was due to the effect of early decomposition of rice straw. These findings are agree with Marimuthu and Hemalatha [19], who reported that, incorporation of rice straw and stubbles with additives significantly increased the LAI of rice crop.

3.2.2 Crop growth rate and relative growth rate

The different rice residue management practices significantly influenced the crop growth rate (CGR) and relative growth rate (RGR) at all stages (Figs. 5 and 6). At active tillering to flowering stage, the CGR and RGR were faster; thereafter the CGR and RGR rate were rather slow. Straw incorporation along with application of 25 kg additional N ha⁻¹ as basal, bio-mineralizer (2 kg t⁻¹ of rice residue) and cow dung slurry (T6) significantly recorded the higher CGR (277 kg ha⁻¹ day⁻¹, and 197 kg ha⁻¹ day⁻¹ at active tillering to flowering and flowering to harvest stage respectively), RGR (56.620 and 15.260 g kg⁻¹ day⁻¹ at active tillering to flowering and flowering to harvest stage respectively). This was followed by the treatment (T5), recorded the higher crop growth rate and relative growth rate. This was on par with treatment (T5), which recorded CGR of 257 kg ha⁻¹ day⁻¹ and 187 kg ha⁻¹ day⁻¹ and RGR of 55.88 g kg⁻¹ day⁻¹ and 15.48 g kg⁻¹ day⁻¹ at active tillering to flowering and flowering to harvest stage respectively. This effect was caused by gradual release of nutrient due to the effect of additives on straw decomposition of rice [20,19].

Incorporation of straw alone (T1) showed the lower CGR at active tillering to flowering stage and flowering stage to harvesting stage as 194 and 141 kg ha⁻¹ day⁻¹ respectively and RGR 55.89 g kg⁻¹ day⁻¹ and 15.48 g kg⁻¹ day⁻¹ at active tillering to flowering stage and flowering stage to harvesting stage and it was on par with control (no residue) (T9).

![Fig. 4. Effect of rice residue management on leaf area index of rice crop](image-url)
4. CONCLUSION

Our study indicates that the plant height, number of tillers and DMP were significantly influenced by various residue management practices. Residue management practices with additives positively influenced the plant growth, whereas the plant height, DMP and tiller production were adversely affected when residue was incorporated without additives. The best performance was realized, when rice residue was incorporated with 25 kg additional N ha\(^{-1}\) as basal, bio-mineralizer (2 kg t\(^{-1}\) of rice residue) and cow dung slurry (5%). Growth indices such as LAI, CGR and RGR were also significantly influenced by all the residue management practices except straw incorporation alone and straw removal. Rice straw incorporated with 25 kg additional N ha\(^{-1}\) as basal, bio-mineralizer (2 kg t\(^{-1}\) of rice residue) and cow dung slurry (5%) registered significant increase in all the growth indices. Incorporation of residues without additives and removal of residues does not favor growth and growth indices of rice crop. Incorporating residue with additives can encourage the growth response of rice crop.
COMPETING INTERESTS
Authors have declared that no competing interests exist.

REFERENCES

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/54319