Effect of System of Rice Intensification (SRI) Practices on Yield Attributes, Yield and Water Productivity of Rice (*Oryza Sativa l.*)

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Abstract: Field experiments were conducted during wet and dry seasons of 2002 and 2003 at Tamil Nadu Agricultural University Farm, Coimbatore, India to study the effect of system of rice intensification (SRI) practices on yield attributes, yield, and water productivity of rice (*Oryza sativa* L.). The experiments replicated thrice were laid out in randomized block design. They were i) using 21 days (conventional) and 14 days (dapog nursery) old seedlings; ii) crop geometry at 15 × 10 cm; 20 × 20 cm and 25 × 25 cm; iii) irrigation at 5.0 cm depth (conventional) and 2.0 cm depth on development of hair-line crack (SRI); iv) weed control (conventional and SRI weeding) and v) nitrogen management (recommended and LCC based N application) during wet season, 2002. During the second crop season (dry season, 2003), all the treatments except nitrogen management was repeated since there was no response to LCC based N in the wet season. The treatments were slightly modified based on the results of wet season crop. The yield attributes viz., panicle length, number of panicles hill⁻¹, total number of grains panicle⁻¹ were significantly higher than other treatments during wet season in 14 days old seedlings + 25 × 25 cm spacing + water saving irrigation + LCC based N management + SRI weeding. During dry season, more panicle length, number of panicles hill⁻¹ and filled grains panicle⁻¹ were recorded in the treatment combination of 14 days old seedlings + 25 × 25 cm spacing + water saving irrigation + SRI weeding. The grain yield and water productivity were significantly increased at SRI weeding with 14 days dapog seedlings planted at 25 × 25 cm spacing to achieve 7009, 5655 kg ha⁻¹ and 0.610 kg and 0.494 kg per m³ of water respectively in wet and dry season.

Key words: Rice, yield attributes, yield, water productivity, system of rice intensification

INTRODUCTION

The production of rice, the ‘Global Grain’ in 89 nations is almost 518 million tonnes every year and it is the staple food for more than half of the global population. In India, it occupies about 44.6 million hectares with a production of 86.0 million tonnes and it continues to hold the key to sustain food production by contributing 20 to 25 percent of agriculture GDP and assures food security in India for more than half of the total population[3]. Export of rice, which steadily increased from 0.4 million tonnes in the mid eighties to 5.0 million tonnes by 1995-96 and earned Rs. 30 billion through foreign exchange[22]. However, the burgeoning population of our country may stabilize around 1.4 and 1.6 billions by 2025 and 2050 requiring annually 380 and 450 million tonnes of food grains respectively[20].

But in India, many challenges are faced in our quest to overcome food scarcity with limited resource available for agriculture. Though India tops the list in terms of area constituting 28 percent of world’s rice[16], the productivity is very low compared to leading rice growing countries. The major constraint in rice production is lack of suitable crop management practices and sufficient irrigation facilities. The recommended water management practice for rice is to provide irrigation up to 5 cm depth, one day after disappearance of ponded water[22]. However, many farmers keep their fields under flooded condition during the entire growing period, which is a wasteful practice. The total water input in rice fields varies widely between 500 and 3000 mm depending on the environmental conditions and the length of the growing period[9]. Considering the future food requirements, competition from non-agricultural uses for fresh water, and more amount of water currently used in rice cropping, new methods of rice cultivation must be identified aiming at less water requirement and higher crop productivity. Earlier studies revealed that rice can come up very well under semi aquatic conditions with little or no major reduction in yield and it has the self adjusting nature which will have synergetic effect on rice growth and yield. This has been derived from the concept of the System of Rice Intensification (SRI) developed by Fr. Henri de Laulanie along with farmers in Madagascar[23]. This system is composed of a package of agronomic measures that...
should be applied simultaneously to realise a yield increase. The components of SRI include transplantsing of young seedlings, usually 8-12 days and not more than 15 days old (4th phyllochron[24]). This preserves a potential for tillering and rooting that is reduced if transplanting occurs after the 4th phyllochron. Seedlings are transplanted singly and very carefully to cause minimum trauma to the young plants. Transplanting of seedlings with wider spacing in a square pattern which facilitates better weeding operations using mechanical weeder and consequent aeration of the soil. This gives more room for better root and canopy growth. The soil is kept moist but not inundated during vegetative growth phase, so that the soil is aerated and never become hypoxic. Early and frequent weeding is essential because otherwise weed growth will become a problem. Weeding should be started about 10 days after transplanting using a rotary hoe that churns up the surface soil to remove weeds and provides additional soil aeration. The practice of SRI is not only aiming at maximum yield but rather to promote the higher productivity of land, labour, capital, and water in ways that benefit the farmer especially poor one. Many countries like Indonesia, Madagascar, and Bangladesh etc. reported double or triple fold increase in rice grain yield with less water consumption. It was against this background that the field investigation was carried out to study the effect of system of rice intensification (SRI) practices on yield attributes, yield, and water productivity of rice (Oryza sativa L.).

MATERIALS AND METHODS

Field experiments on rice were carried out at Tamil Nadu Agricultural University, Coimbatore, India during wet and dry seasons of 2002 and 2003. Coimbatore is situated in the Northwestern agro-climatic zone of Tamil Nadu at 11°N latitude and 77°E longitude and at an altitude of 426.7 m above mean sea level. The soil of the experimental field was a deep, moderately well drained clay loam, low in available N (244 kg N ha⁻¹), medium in available P (17.2 kg P₂O₅ ha⁻¹) and high in available K (560 kg K₂O ha⁻¹). The electrical conductivity of the soil was 0.80 ds m⁻¹ and the pH was 8.2. Mechanical analysis of the soil showed 18.2 %, 18.1%, 19.0% and 44.2% of coarse sand, fine sand, silt and clay, respectively. The rice variety CO.47, with field duration of 110 days, was used in the trial. The dates of sowing and harvest were 11 Jul. and 7 Nov. in 2002 and 23 Jan. and 21 May in 2003, respectively.

Based on the previous year’s findings of individual technologies, the main objective was fixed to study only the combined effect of this individual technology as a package under SRI practices. The experiments were laid out in a randomized block design replicated thrice. The selected packages of treatment details are as follows:

The result of experiment-I revealed that younger seedlings (14 days old) from dapog nursery recorded higher yield than conventional seedlings. In Leaf Color Chart (LCC) based N management the nitrogen requirement was 140 kg N ha⁻¹ whereas it was only 120 kg N ha⁻¹ in recommended practice. Moreover there was no significant difference in yield between LCC and traditional fertilization. The cost of fertilization was also higher in LCC than traditional fertilization. So it was decided to include both younger seedlings (14 days old) from dapog nursery and aged seedlings (21 days) from conventional nursery and also exclude the LCC treatment and retain recommended N management as common for all the treatments in the experiment-II (dry season). The modified treatment details of the experiment II are furnished below.

The recommended rate of N, P and K (120: 38: 38 kg ha⁻¹) was applied as urea (46% N), single super phosphate (16% P₂O₅) and muriate of potash (60% K₂O), respectively. Nitrogen was applied as urea either at recommended level or LCC schedule depending upon the treatment. In the recommended practice, N in four splits viz., 1/6 at 7 days after transplanting (DAT) 1/3 at 21 DAT, 1/3 at panicle initiation (PI), 1/6 at first flowering (FF) was applied. In LCC based nitrogen management treatment, the LCC values were recorded as per the standard procedure (IRRI, 1996) at weekly
results and discussions

Yield attributes: Most of the yield components were significantly improved under the combination of younger seedlings which are transplanted before the growth of the 4th phyllochron starts (14 days old), wider spacing with a plant density of 16 seedlings m$^{-2}$, either conventional irrigation or limited irrigation and mechanical weeding (Table 1). Under younger seedlings combination, increased leaf area and subsequent increase in photosynthetic activity were exhibited through increased biomass production as a major portion of photosynthates accounted for dry matter and all these factors favoured the yield components under SRI practices[15]. Wider spacing was the reason for less below and above ground competitions for better grain filling, higher grain weight and more number of filled grains per panicle[15]. Optimum supply of irrigation water with mechanical weeding resulted in higher nutrient availability subsequently resulting in better source to sink conversion and in turn enhanced the production of more total number of seeds and filled seeds panicle$^{-1}$. The above discussion
on yield characters of rice points out that number of filled seeds, total number of grains and test weight were influenced by agronomic manipulations like younger seedlings, limited irrigation, wider spacing and mechanical weeding practices.

**Grain yield:** The grain yield of rice was significantly influenced by the various SRI management factors tested in both the years. The combination of younger seedlings (14 days old) wider spacing (25 x 25 cm) limited irrigation of 2 cm at hairline crack development stage with incorporation of weeds through by mechanical weeder recorded the highest grain yield. The younger seedlings from dapog nursery increased the dry matter production after panicle initiation contribute to increased yield attributes consequently increased grain and straw yields. Similarly, wider spacing recorded more grain yield than narrow spacing due to more space and nutrients available for the individual plant. Wider spacing did not affect the grain and straw yields as well as harvest index.

For economizing water, water management in the early stage is very important for the success of seedlings from dapog nursery. The maintenance of thin film of water up to 11 days would facilitate better aeration and establishment that leads to increased tiller production. Continuous land submergence is not essential for optimum rice yields and also irrigation could be withheld for two or three days after disappearance of ponded water without any yield reduction. However, marginally lower yield was recorded under the combination of limited irrigation and conventional weeding. This might be due to low shoot: root ratio caused by mild stress experienced by the rice plant. Such reduction in grain yield is quite obvious.
as most of the growth and yield components, which have a direct bearing on yield, were adversely affected. Variation in DMP at particular stage due to varying water availability resulted in poor yield components and yield. The combination of limited irrigation and mechanical weeding increased the yield which might be due to the reason that this combination limited irrigation and mechanical weeding minimise weeds besides improving soil aeration and root pruning. The mechanical weeding with a rotary weeder increased the yield in dry season but not in wet season. As weeds in all the treatments were controlled effectively, the results suggest some kind of additional growth stimulating effect due to mechanical weed control. The effect of mechanical weeding resulted in better soil aeration. Improvements of soil aeration by using rotary hoe helps in better plant health and vigor which keeps pest and disease levels below threshold where use of pesticides and other agrochemical is economically profitable. Thus the mechanical weeding paves way for integrated weed and pest management.

Under SRI practices, the root system is several times longer and deeper enabling them to access for nutrients even in much greater volume of nutrient poor soil. A larger root system is more likely to capture some of the essential nutrients like Zn, Mg, B and other nutrients that are important for plant growth and health. This will give the balanced nutrition for the plant. In addition, mechanical weeding and alternate wetting and drying could also contribute to the biological N fixation dynamism. Deeper root growth encourages higher nutrient absorption subsequently higher assimilation which will favour higher yield attributes and yield. The combination of all these factors induced better physiological functions like required transpiration rate with reduced stomatal diffuse resistance and leaf temperature with higher relative leaf water content which had significant positive correlation with grain yield and higher levels of uptake of nutrient in an integrated manner which increased the grain yield of rice.

Table 2: Effect system of rice intensification (SRI) practices on yield attributes, yield, and water productivity of rice in wet season-2003

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Panicle length (cm)</th>
<th>Panicle weight (g)</th>
<th>No. of panicles hill-1</th>
<th>1000 grain weight (g)</th>
<th>Total No. of grains panicle-1</th>
<th>No. of filled grains panicle-1</th>
<th>Sterility percentage</th>
<th>No. of productive tillers m-2</th>
<th>Grain yield (kg ha-1)</th>
<th>Water productivity kg m-3</th>
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<tbody>
<tr>
<td>T1</td>
<td>17.9</td>
<td>1.683</td>
<td>6.618</td>
<td>17.99</td>
<td>94.62</td>
<td>76.24</td>
<td>19.43</td>
<td>437</td>
<td>4414</td>
<td>0.2725</td>
</tr>
<tr>
<td>T2</td>
<td>18.4</td>
<td>1.511</td>
<td>6.451</td>
<td>17.78</td>
<td>109.39</td>
<td>80.37</td>
<td>19.51</td>
<td>427</td>
<td>4069</td>
<td>0.3482</td>
</tr>
<tr>
<td>T3</td>
<td>18.8</td>
<td>1.532</td>
<td>6.437</td>
<td>17.87</td>
<td>106.24</td>
<td>74.93</td>
<td>29.47</td>
<td>425</td>
<td>4649</td>
<td>0.3058</td>
</tr>
<tr>
<td>T4</td>
<td>19.2</td>
<td>1.769</td>
<td>6.610</td>
<td>17.96</td>
<td>115.91</td>
<td>80.37</td>
<td>29.43</td>
<td>437</td>
<td>5140</td>
<td>0.4888</td>
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<tr>
<td>T5</td>
<td>20.1</td>
<td>1.779</td>
<td>15.111</td>
<td>18.71</td>
<td>100.96</td>
<td>75.40</td>
<td>25.23</td>
<td>378</td>
<td>4637</td>
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<tr>
<td>T6</td>
<td>19.8</td>
<td>1.752</td>
<td>15.355</td>
<td>17.96</td>
<td>132.33</td>
<td>76.47</td>
<td>42.21</td>
<td>384</td>
<td>4817</td>
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<tr>
<td>T7</td>
<td>19.7</td>
<td>1.698</td>
<td>16.152</td>
<td>17.79</td>
<td>121.00</td>
<td>81.71</td>
<td>32.45</td>
<td>404</td>
<td>4855</td>
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<tr>
<td>T8</td>
<td>20.1</td>
<td>1.784</td>
<td>16.162</td>
<td>17.97</td>
<td>119.26</td>
<td>83.00</td>
<td>30.40</td>
<td>404</td>
<td>4459</td>
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<td>T9</td>
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<td>1.799</td>
<td>15.567</td>
<td>17.35</td>
<td>110.61</td>
<td>81.74</td>
<td>26.10</td>
<td>389</td>
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<td>T10</td>
<td>20.3</td>
<td>1.656</td>
<td>16.076</td>
<td>17.30</td>
<td>127.58</td>
<td>80.75</td>
<td>36.71</td>
<td>402</td>
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<tr>
<td>T11</td>
<td>20.5</td>
<td>1.802</td>
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<td>17.73</td>
<td>161.09</td>
<td>90.80</td>
<td>43.49</td>
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<td>T13</td>
<td>20.1</td>
<td>1.820</td>
<td>23.874</td>
<td>17.80</td>
<td>128.16</td>
<td>85.80</td>
<td>33.06</td>
<td>382</td>
<td>5592</td>
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<td>T14</td>
<td>20.8</td>
<td>1.761</td>
<td>23.939</td>
<td>18.10</td>
<td>136.30</td>
<td>83.18</td>
<td>39.71</td>
<td>383</td>
<td>5078</td>
<td>0.3057</td>
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<tr>
<td>T15</td>
<td>20.0</td>
<td>1.832</td>
<td>23.896</td>
<td>18.19</td>
<td>116.55</td>
<td>86.27</td>
<td>25.98</td>
<td>382</td>
<td>5242</td>
<td>0.3156</td>
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<tr>
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<td>20.8</td>
<td>1.736</td>
<td>25.272</td>
<td>17.83</td>
<td>138.26</td>
<td>91.19</td>
<td>35.67</td>
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<td>SEd</td>
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<td>0.016</td>
<td>0.962</td>
<td>1.13</td>
<td>4.91</td>
<td>2.49</td>
<td>4.77</td>
<td>39</td>
<td>158</td>
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</table>

CD (P = 0.05) 0.51 0.033 1.962 NS 10.02 5.08 9.73 NS 322 0.0533

NS: non significant

apertures, improved water relation in plants and thus sustains the grain yield.

As far as economic yield and biological yield are concerned, the combination of factors viz., seedling age, spacing, irrigation and weed management with optimum fertilizer management practices complemented with each other and boosted the grain yield.

**Water productivity:** The total quantity of irrigation water used and frequency of irrigation were higher in the dry season than that in wet season. In wet season less amount of water applied might be due to well-distributed high rainfall in more number of rainy days. However, under water saving irrigation, amount of water supplied in the dry season was less than the irrigation to 5cm depth one day after disappearance of ponded water in the wet season as given in Table 2.

Water productivity is the ratio of grain yield to the total water used plus cumulative rainfall. The higher water productivity was obtained for water saving irrigation and younger seedling combination in both crops. It might be due to the reason that younger seedling mature earlier than conventional seedlings and also higher grain yield and less water consumption under this treatment. These water productivity levels are in concomitant with the findings[3].

**Conclusions:** Under the present day constraints and scarcity for irrigation water the results of the two year experiments clearly revealed that younger seedlings raised under dapog method of nursery transplanted before the growth of 4\textsuperscript{th} phyllochron starts (14 days old) with a plant density of 16 seedlings m\textsuperscript{-2} (25 × 25 cm) adopting water saving irrigation schedule (2 cm on development of hairline crack) with SRI weeding practice was found optimum to achieve higher production, productivity and economic returns of rice. Thus the above SRI practices can be recommended to river command and deltaic areas.

**REFERENCES**


