INFLUENCE OF DIFFERENT PLANTING METHODS AND ORGANIC NUTRIENTS ON GROWTH AND YIELD OF RICE [ORYZA SATIVA (L.) SUB SP. JAPONICA]

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INTRODUCTION

India has 42.41 million hectare area under rice and production 104.40 million tonnes (GOI, 2013). Uttar Pradesh has an area of 5.86 million hectare, production 14.41 million tonnes (GOI, 2013). India is facing various constraints in rice production, viz., low and fragile productivity and production due to abiotic stresses mainly drought, flood and low input use acid soils with low organic matter content, low N and P and widespread Zn, boron deficiency. Further, decreased yield due to reduced plant population, severe competition due to closer spacing and poor tillering and increased cost of labour during peak farming operations such as transplanting, weeding and harvesting. Manual transplanting is quite expensive, laborious, time consuming and causes lot of drudgery. Manual transplanting takes about 300 to 350 man hours ha⁻¹ which is roughly 25% of the total labour requirement of the crop (Goel et al., 2008). Uttar Pradesh is also facing the similar problems which India is facing. The optimizing plant density and timeliness of operation is considered essential for maximizing yield in paddy. In order to get the maximum returns, cost of cultivation has to be reduced through minimizing the dependence on labour for transplanting. Under such conditions mechanized transplanting of rice can be considered as the most promising option, as it saves labour, ensures timely transplanting and attains optimum plant density that attributes to high productivity (Raj et al., 2012). During the last decade or 2, a new approach, widely known as system of rice intensification method of transplanting [SRI(t)] has attracted attention because of its apparent success in increasing rice yield. The SRI(t) was introduced in India during the year 2000 as a viable alternative of rice cultivation that enhances the productivity while minimizing the inputs. Sowmya et al. (2011) reported that nutrient management must be sound for achieving yield potential of rice under SRI. Untamed and excessive use of toxic chemicals has shown ugly consequences expressing erratic pattern in the environment in general and the soil system in particular, which has drastically changed the soil biota (Abraham, 2009) and reduced the crop yield. The nutrients required by the plants can be supplied through organic sources such as farmyard manure, green manure, green leaf manure and organic foliar spray. These manures can help to prevent soil erosion and also improving the infiltration capacity of the soil. FYM is a better source of plant nutrients (Nayak et al., 2014). It has potential in modifying the soil physical properties and improving crop yields (Mishra et al., 2015). The usage of fermented organic formulations with supportive beneficial microorganisms as foliar nourishment has come into the picture of modern agriculture for giving rise to good quality food (Galindo et al., 2007). Panchagavya, FAA, etc may be good

ABSTRACT

The experiment was carried out during Kharif season 2013 at Crop Research Farm, SHIATS Model of Organic Farm (SMOF), Department of Agronomy, Allahabad School of Agriculture, SHIATS, Allahabad (U.P.) to study the influenced of different planting methods, green manure crops and liquid forms of organic manures on growth and yield of organic japonica rice. Considering DSR method, Sesbania aculeata L. and FAA significantly higher CGR (0.61 g m⁻² day⁻¹) was registered. Considering SRI method of transplanting and MTR methods, Sesbania aculeata L. and FAA significantly higher number of effective tillers 10.46 hill⁻¹ was recorded (exactly same value). Considering CTR method, Sesbania aculeata L. and Panchagavya significantly higher harvest index (36.73%) was obtained. Considering SRI method of transplanting, Sesbania aculeata L. and Panchagavya significantly higher panicle length (17.40 cm) was observed. Considering SRI method of transplanting, Sesbania aculeata L. and FAA significantly higher dry weight (9.250 g hill⁻¹), higher number of grains 58.40 panicle⁻¹, higher test weight (27.70 g), higher grain yield (2.10 t ha⁻¹) and higher straw yield (3.90 t ha⁻¹) was recorded.

KEY WORDS

Organic japonica rice
Green manure crops
Liquid forms of organic manures
Planting methods

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source of essential nutrients, vitamins, growth promoting substances and beneficial microorganisms. Keeping all these things in view to improve organic crop production the present investigation was undertaken to study the effect of different planting methods of rice and the effect of different organic sources of nutrients on growth and yield. Trials on *japonica* rice were initiated by Makino School of Continuing & Non Formal Education (MSCNE) and thereafter also in the Department of Agronomy at the SMOF, with promising results.

**MATERIALS AND METHODS**

The experiment was carried out during kharif season 2013 at Crop Research Farm, SHIATS Model of Organic Farm, Department of Agronomy, Allahabad School of Agriculture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad (U.P.). The soil of the experimental plot was sandy loam in texture, low in available nitrogen, medium in available phosphorus and high in available potash with 8.0 soil pH. The experiment was laid out in randomized block design with three replications, having four planting methods, viz., conventional transplanted rice (CTR, 20 × 15 cm), system of rice intensification method of transplanting [SRI(t), 20 × 20 cm], direct seeded rice (DSR, 20 × 10 cm) and machine transplanted rice (MTR, 30 × 10 cm); two green manure crops *Sesbania aculeata* L. and *Crotalaria juncea* L.; two foliar nutrition, i.e., *Panchagavya* (P) and Fish amino acid (FAA) were studied. The green manure crop (dhaincha and sunnhemp) were sown (April 22, 2013) in the field up to 70 days and buried in the field with tractor drawn disc plough on June 30, 2013. *Panchagavya* was prepared with a mixture of five components in the ratio of 5:4:3:2:1, viz., cow dung, cow urine, cow milk, curd and ghee respectively and twelve ripe bananas. Fish amino acid was prepared in the ratio of 1:1, with fish waste (3.0 kg) and jaggery (3.0 kg). *Panchagavya* (3%) and Fish amino acid (3%) were fermented for 20 days and applied after extraction as foliar spray at 20, 35 and 50 days after sowing/days after transplanting as per the treatment. 1 t ha⁻¹ of farm yard manure (FYM) applied as basal dose and 1 t ha⁻¹ of Bokashi applied as a soil application in all the treatments. There were total 16 treatment combinations in all. The net plot size was 4 × 4 m and net experimental area 768.00 m². The agronomic practices, viz., weeding with cono weeders in SRI method, wetland power weeder in MTR method, manual and hand weeding in CTR and DSR methods were done and irrigation was given according to the schedules for all treatments. The *japonica* rice variety *Akitakomachi* was sown. The Meteorological data observation total rainfall was 1127.70 mm. Data on plant dry weight (g hill⁻¹), CGR (g m⁻² day⁻¹), number of effective tillers hill⁻¹, panicle length (cm), number of grains panicle⁻¹, grain yield (t ha⁻¹), straw yield (t ha⁻¹), test weight (g) and harvest index (%) were recorded. Data recorded on different aspects of crop, viz., growth, yield attributes and yield were tabulated and subjected to statistical analysis as per Gomez and Gomez, 1976.

The unprecedented flood in the Aug to Sep, 2013 caused a setback to crop and thus overall productivity of the experimental crop was reduced. Floods occurred in the Crop Research Farm, not directly in the research field, but the power supply for the tube well was interrupted for several weeks, which affected the crop adversely due to unavailability of irrigation.

**RESULTS AND DISCUSSION**

**Growth parameters**

**Plant dry weight (g)**

Significantly higher plant dry weight 9.250 g hill⁻¹ was registered in the treatment T₆ [SRI(t) + *Sesbania aculeata* L. + Fish amino acid], which was 296.48% higher than T₉ [DSR + *Crotalaria juncea* L. + *Panchagavya*] with 2.333 g hill⁻¹. However, T₁₂ (CTR + *Sesbania aculeata* L. + Fish amino acid), T₁₃ (CTR + *Sesbania aculeata* L. + *Panchagavya*), T₄₄ (MTR + *Sesbania aculeata* L. + Fish amino acid), T₁₅ (MTR + *Panchagavya*), T₉₉ (MTR + *Sesbania aculeata* L. + Fish amino acid) and T₉₉₉ (MTR + *Sesbania aculeata* L. + *Panchagavya*) were observed to be statistically at par with T₁₆ [SRI(t) + *Sesbania aculeata* L. + Fish amino acid] (Table 1). Higher plant dry weight with SRI method of transplanting component might have induced both greater and deeper root growth, thereby contributing to increased nutrient uptake throughout the crop cycle (Barison and Uphoff, 2011). Further, green manure, particularly *Sesbania aculeata* L. may have influenced the availability of nutrients through its decomposition (Boparai et al., 1992).

**CGR (g m⁻² day⁻¹)**

Significantly higher CGR of 0.61 g m⁻² day⁻¹ was recorded in the treatment T₂ (CTR + *Panchagavya*), T₃ (CTR + *Sesbania aculeata* L. + *Panchagavya*), T₅ (CTR + *Sesbania aculeata* L. + Fish amino acid), T₆ (CTR + *Sesbania aculeata* L. + *Panchagavya*), T₇ (CTR + *Crotalaria juncea* L. + *Panchagavya*) and T₈ (CTR + *Crotalaria juncea* L. + Fish amino acid), T₉ (CTR + *Sesbania aculeata* L. + Fish amino acid) and T₁₀ (CTR + *Crotalaria juncea* L. + *Panchagavya*). The experiment was laid out during kharif season 2013 at VICTOR DEBBARMA  et al., 2010). Further, availability of ample supply of nutrients especially nitrogen due to the decomposition of *Sesbania aculeata* L. may be the reason for the better performance with regard to CGR.

**RGR (g g⁻¹ day⁻¹)**

Highest RGR of 0.004 g g⁻¹ day⁻¹ was recorded (with exactly same values) in the treatment T₁ (CTR + *Sesbania aculeata* L. + *Panchagavya*), T₆ (CTR + *Sesbania aculeata* L. + Fish amino acid), T₇ (CTR + *Crotalaria juncea* L. + *Panchagavya*), T₉ (CTR + *Sesbania aculeata* L. + Fish amino acid) and T₁₀ (CTR + *Crotalaria juncea* L. + *Panchagavya*). However, there was a general increased in the crop growth rate in all the planting methods afterward it decreased. Higher radiation use efficiency in the leaf photosynthesis might have led to higher photoassimilate production and thus increased the CGR and net assimilation rate (NAR) (Naing et al., 2010). Further, availability of ample supply of nutrients especially nitrogen due to the decomposition of *Sesbania aculeata* L. may be the reason for the better performance with regard to CGR.

**Number of effective tillers hill⁻¹**

The combined effect of planting methods, green manure crops and liquid forms of organic manures in the trial indicated that...
INFLUENCE OF DIFFERENT PLANTING METHODS AND ORGANIC NUTRIENTS

Table 1: Influence of different planting methods and organic nutrients on growth parameters of japonica rice

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Growth parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry weight (g hill⁻¹)</td>
</tr>
<tr>
<td>T₁; CTR + Sesbania aculeata + Panchagavya</td>
<td>8.116b</td>
</tr>
<tr>
<td>T₂; CTR + Sesbania aculeata + Fish amino acid</td>
<td>8.900b</td>
</tr>
<tr>
<td>T₃; CTR + Crotalaria juncea + Panchagavya</td>
<td>4.966</td>
</tr>
<tr>
<td>T₄; MTR + Sesbania aculeata + Fish amino acid</td>
<td>4.683</td>
</tr>
<tr>
<td>T₅; SR(t) + Sesbania aculeata + Panchagavya</td>
<td>6.400b</td>
</tr>
<tr>
<td>T₆; SR(t) + Sesbania aculeata + Fish amino acid</td>
<td>9.250a</td>
</tr>
<tr>
<td>T₇; SR(t) + Crotalaria juncea + Fish amino acid</td>
<td>5.183</td>
</tr>
<tr>
<td>T₈; MTR + Crotalaria juncea + Fish amino acid</td>
<td>3.833</td>
</tr>
<tr>
<td>T₉; DSR + Sesbania aculeata + Fish amino acid</td>
<td>2.650</td>
</tr>
<tr>
<td>T₁₀; DSR + Sesbania aculeata + Fish amino acid</td>
<td>2.566</td>
</tr>
<tr>
<td>T₁₁; DSR + Crotalaria juncea + Panchagavya</td>
<td>2.333c</td>
</tr>
<tr>
<td>T₁₂; DSR + Crotalaria juncea + Fish amino acid</td>
<td>2.450</td>
</tr>
<tr>
<td>T₁₃; MTR + Sesbania aculeata + Panchagavya</td>
<td>7.000b</td>
</tr>
<tr>
<td>T₁₄; MTR + Sesbania aculeata + Fish amino acid</td>
<td>7.566b</td>
</tr>
<tr>
<td>T₁₅; MTR + Crotalaria juncea + Fish amino acid</td>
<td>5.600</td>
</tr>
<tr>
<td>T₁₆; MTR + Crotalaria juncea + Fish amino acid</td>
<td>5.150</td>
</tr>
</tbody>
</table>

Table 2: Influence of different planting methods and organic nutrients on yield attributes and yield of japonica rice

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Panicle length (cm)</th>
<th>Number of grains panicle⁻¹</th>
<th>Grain yield (t ha⁻¹)</th>
<th>Straw yield (t ha⁻¹)</th>
<th>Harvest Index (%)</th>
<th>Test weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁; CTR + Sesbania aculeata + Panchagavya</td>
<td>16.95b</td>
<td>49.26</td>
<td>1.88b</td>
<td>3.23b</td>
<td>36.73a</td>
<td>27.03</td>
</tr>
<tr>
<td>T₂; CTR + Sesbania aculeata + Fish amino acid</td>
<td>16.52b</td>
<td>55.26b</td>
<td>2.08b</td>
<td>3.66b</td>
<td>36.54b</td>
<td>26.86</td>
</tr>
<tr>
<td>T₃; CTR + Crotalaria juncea + Panchagavya</td>
<td>16.06</td>
<td>37.93</td>
<td>1.18</td>
<td>2.13</td>
<td>33.15b</td>
<td>26.60</td>
</tr>
<tr>
<td>T₄; MTR + Sesbania aculeata + Fish amino acid</td>
<td>15.73</td>
<td>39.66</td>
<td>0.96</td>
<td>1.91</td>
<td>33.47</td>
<td>26.30</td>
</tr>
<tr>
<td>T₅; SR(t) + Sesbania aculeata + Panchagavya</td>
<td>17.40a</td>
<td>50.53</td>
<td>1.53</td>
<td>2.76</td>
<td>35.66b</td>
<td>27.63b</td>
</tr>
<tr>
<td>T₆; SR(t) + Sesbania aculeata + Fish amino acid</td>
<td>16.72b</td>
<td>58.40a</td>
<td>2.10a</td>
<td>3.90a</td>
<td>35.02b</td>
<td>27.07a</td>
</tr>
<tr>
<td>T₇; SR(t) + Crotalaria juncea + Panchagavya</td>
<td>15.94</td>
<td>40.13</td>
<td>1.21</td>
<td>2.28</td>
<td>34.67b</td>
<td>26.46</td>
</tr>
<tr>
<td>T₈; SR(t) + Crotalaria juncea + Fish amino acid</td>
<td>16.00</td>
<td>35.86c</td>
<td>0.91</td>
<td>1.80</td>
<td>33.45</td>
<td>25.96c</td>
</tr>
<tr>
<td>T₉; DSR + Sesbania aculeata + Panchagavya</td>
<td>16.08</td>
<td>48.26</td>
<td>0.83</td>
<td>1.78</td>
<td>31.68c</td>
<td>27.03</td>
</tr>
<tr>
<td>T₁₀; DSR + Sesbania aculeata + Fish amino acid</td>
<td>16.04</td>
<td>48.46</td>
<td>0.83</td>
<td>1.75</td>
<td>32.26</td>
<td>27.17b</td>
</tr>
<tr>
<td>T₁₁; DSR + Crotalaria juncea + Panchagavya</td>
<td>15.34</td>
<td>36.66</td>
<td>0.80</td>
<td>1.63</td>
<td>32.58</td>
<td>26.16</td>
</tr>
<tr>
<td>T₁₂; DSR + Crotalaria juncea + Fish amino acid</td>
<td>15.40</td>
<td>36.26</td>
<td>0.71c</td>
<td>1.55c</td>
<td>31.71</td>
<td>26.06</td>
</tr>
<tr>
<td>T₁₃; MTR + Sesbania aculeata + Panchagavya</td>
<td>15.62</td>
<td>43.80</td>
<td>1.58</td>
<td>2.95b</td>
<td>33.12b</td>
<td>26.36</td>
</tr>
<tr>
<td>T₁₄; MTR + Sesbania aculeata + Fish amino acid</td>
<td>15.58</td>
<td>44.80</td>
<td>1.73b</td>
<td>3.06b</td>
<td>36.53b</td>
<td>26.70</td>
</tr>
<tr>
<td>T₁₅; MTR + Crotalaria juncea + Fish amino acid</td>
<td>15.56</td>
<td>36.13</td>
<td>1.23</td>
<td>2.41</td>
<td>33.85</td>
<td>26.63</td>
</tr>
<tr>
<td>T₁₆; MTR + Crotalaria juncea + Fish amino acid</td>
<td>15.32c</td>
<td>36.53</td>
<td>1.20</td>
<td>2.13</td>
<td>33.78b</td>
<td>26.06</td>
</tr>
</tbody>
</table>

Note: SEd (±): Standard error of deviation; CD: Critical difference; CV: Co-efficient of variation

significant and maximum number of effective tillers hill⁻¹ of rice with 10.46 at 90 DAT (exactly same values) was registered in the treatment T₆ [SRI(t) + Sesbania aculeata L. + Fish amino acid] and T₈ [DSR + Sesbania aculeata L. + Panchagavya], which was 423% higher compared to T₇ [DSR + Crotalaria juncea L. + Panchagavya] and T₉ [DSR + Crotalaria juncea L. + Fish amino acid] with 2 tillers hill⁻¹ (exactly same values). However, T₁₃ [MTR + Sesbania aculeata L. + Panchagavya], T₁₅ [MTR + Crotalaria juncea L. + Panchagavya], T₁₆ [CTR + Sesbania aculeata L. + Panchagavya], T₁₇ [CTR + Crotalaria juncea L. + Fish amino acid], T₁₈ [CTR + Crotalaria juncea L. + Fish amino acid], T₁₉ [SRI(t) + Sesbania aculeata L. + Panchagavya] and T₂₀ [SRI(t) + Crotalaria juncea L. + Fish amino acid] were observed to be statistically at par with T₂₁ [SRI(t) + Sesbania aculeata L. + Fish amino acid] and T₂₂ [MTR + Sesbania aculeata L. + Fish amino acid] and T₂₃ [SRI(t) + Crotalaria juncea L. + Fish amino acid] (Table 1). Higher effective tillers realized with SRI method of transplanting and MTR component equally may be due to the use of younger seedlings (14 days old seedlings) and wide spacing, which provided more room for more canopy and root growth. More canopies utilize higher light radiation,
which increases the expression of effective tiller. It corroborates with the findings of Hugar et al. (2009). Further, Sesbania aculeata L. green manure may have accumulated higher N, P, K and Zn nutrients which on recycling into soil and increased the availability and resulting in increased number of effective tillers (Pooniya and Shivay, 2011). Another reason FAA being potential source of Auxin may have promoted vegetative growth by active cell division, cell enlargement and cell elongation thus helped in improving number of effective tillers (Muthukumar et al., 2005).

**Yield attributes and yield**

**Panicle length (cm)**

The combined effect of planting methods, green manure crops and liquid forms of organic manures in the treatment T$_4$ [SRI(t) + Sesbania aculeata L. + Panchagavya] was registered significance on panicle length of rice with 17.40 cm, which was 13.57% higher than T$_{16}$ (MTR + Crotolaria juncea L. + Fish amino acid) with 15.32 cm. However, T$_1$ (CTR + Sesbania aculeata L. + Panchagavya), T$_5$ [SRI(t) + Sesbania aculeata L. + Fish amino acid] and T$_7$ (CTR + Sesbania aculeata L. + Fish amino acid) were statistically at par with T$_6$ [SRI(t) + Sesbania aculeata L. + Fish amino acid] (Table 2). Panicle length was significantly higher in several treatment of green manure with *dhaincha* (Sesbania aculeata L.), which may have supplied of adequate macro and micronutrient, due to the solubilizing effect on native soil nutrients through the action of organic acids produced during decomposition (Pandey et al., 2007 and Tripathy et al., 2009). Further, longer panicle length in SRI method of transplanting may be due to the lower rate of leaf senescence in plants that have larger amounts of cytokinins transported into their canopies from the roots (Soejima et al., 2008). Other reason, FAA foliar application of organic nutrition may have increased the protoplasmic constituent and accelerated the process of cell division and elongation. Similar results have been reported by Muthukumar et al. (2005), Ashoka et al. (2008) and Bindhani et al. (2008).

**Number of grains panicle**

The combined effect of 3 factors showed the significant influence on number grains panicle of rice with 58.40 was registered in the treatment T$_8$ [SRI(t) + Sesbania aculeata L. + Fish amino acid], which was 195.77% higher than T$_9$ (DSR + Crotolaria juncea L. + Fish amino acid) with 0.71 t ha$^{-1}$. However, T$_5$ [SRI(t) + Sesbania aculeata L. + Fish amino acid], T$_7$ (CTR + Sesbania aculeata L. + Panchagavya) and T$_9$ (MTR + Sesbania aculeata L. + Fish amino acid) were statistically at par with T$_8$ [SRI(t) + Sesbania aculeata L. + Fish amino acid] (Table 2). The data apparently point that under SRI method of transplanting, single seedling, with a wider and square hill spacing, effectively reduced inter-plant competition for better nutrients (N and Mg), phenotype and physiology of SRI method of transplanting plants, leading to both root and canopy development, utilizing photosynthates for higher grain yield (Nyamai et al., 2012 and Thakur et al., 2010). Further, the improvement in grain yield could be due to increase in micronutrients (Fe and Mn) and of organic C after *Sesbania aculeata* L. green manuring. These results are agreement with the findings of Nayyar and Chhibba (2000).

**Straw yield (t ha$^{-1}$)**

The combined effect of the 3 factors in the trial registered significantly higher straw yield of rice with 3.90 t ha$^{-1}$ in the treatment T$_8$ [SRI(t) + Sesbania aculeata L. + Fish amino acid], which was 151.61% higher than T$_{12}$ (DSR + Crotolaria juncea L. + Fish amino acid) with 1.55 t ha$^{-1}$. However, T$_7$ (CTR + Sesbania aculeata L. + Fish amino acid), T$_9$ (CTR + Sesbania aculeata L. + Panchagavya), T$_{14}$ (MTR + Sesbania aculeata L. + Fish amino acid) and T$_{16}$ (MTR + Sesbania aculeata L. + Panchagavya) were statistically at par with T$_8$ [SRI(t) + Sesbania aculeata L. + Fish amino acid] (Table 2). The positive and synergetic effect of foliar feeding of FAA may have caused an enhancement of straw yield. Further, higher N accumulation by *Sesbania aculeata* L. green manuring crop may have led to increased straw yield. These results are in line with the findings of Porpavai (2009).

**Harvest Index**

The combined effect of the 3 factors in the trial recorded significance on harvest index of rice with 36.73% in the treatment T$_1$ (CTR + Sesbania aculeata L. + Panchagavya), which was 15.94% higher than T$_{16}$ (MTR + Crotolaria juncea L. + Panchagavya) with 31.68%. However, T$_1$ (CTR + Sesbania aculeata L. + Fish amino acid) was statistically at par with T$_8$ [SRI(t) + Sesbania aculeata L. + Fish amino acid] with 35.86. However, T$_7$ (CTR + Sesbania aculeata L. + Fish amino acid) was statistically at par with T$_6$ [SRI(t) + Sesbania aculeata L. + Fish amino acid] (Table 2). Higher number of grains panicle, with *dhaincha* green manure may have more residual effect of biological N-fixation through the root nodules (Meena and Shivay, 2010). Further, under the SRI method of transplanting plants exhibit larger, deeper and longer-lived root systems which may have taken up not only more macronutrients but also greater amounts of micronutrients for their essential synthesis of the enzymes ultimately guiding and sustaining plant metabolism. More micronutrient uptake by plants could enable to convert macronutrients more efficiently into the cells and tissues that constitute grain (Uphoff et al., 2009).

**Grain yield (t ha$^{-1}$)**

The combined effect of planting methods, green manure crops and liquid forms of organic manures in the trial recorded significantly higher grain yield of rice with 2.10 t ha$^{-1}$ in the treatment T$_8$ [SRI(t) + Sesbania aculeata L. + Fish amino acid], which was 195.77% higher than T$_9$ (DSR + Crotolaria juncea L. + Fish amino acid) with 0.71 t ha$^{-1}$. However, T$_5$ [SRI(t) + Sesbania aculeata L. + Fish amino acid], T$_7$ (CTR + Sesbania aculeata L. + Panchagavya) and T$_9$ (MTR + Sesbania aculeata L. + Fish amino acid) were statistically at par with T$_8$ [SRI(t) + Sesbania aculeata L. + Fish amino acid] (Table 2). In the part of both the green manure (*Sesbania aculeata* L. and *Crotolaria juncea* L.) and foliar nutrition (Panchagavya and FAA) influences the harvest index. These may have had a positive effect of the availability on the nutrient including micro nutrients, particularly N and zinc (Muthukumar et al., 2005 and Ashoka et al., 2008).

**Test weight (g)**

The combined effect of 3 factors in the trial registered
significantly higher test weight of rice with 27.70 g in the treatment T₆ [SRI(t) + Sesbania aculeata L. + Fish amino acid], which was 6.70% higher than T₅ [SRI(t) + Crotonlaria juncea L. + Fish amino acid] with 25.96 g. However, T₇ [SRI(t) + Sesbania aculeata L. + Panchagavya] and T₈ (DSR + Sesbania aculeata L. + Fish amino acid) were observed to be statistically at par with T₅ [SRI(t) + Sesbania aculeata L. + Fish amino acid] (Table 2). SRI method of transplanting may have contributed to the larger root volume, profuse and stronger tillers and well filled spikelets with higher grain weight. Similar findings reported by Satyanarayana and Babu (2004). Further, Sesbania aculeata L. GM may be ascribed the better micro and macronutrient availability as well as physical condition of the soil and influencing the individual grain weight (Parihar, 2004).

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REFERENCES


