Original Research Article

Efficacy of Crop Establishment Methods on Yield and Economics of Rice (Oryza sativa L.) Under Puddled Condition


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A B S T R A C T

A field experiment was conducted during kharif season, 2015 at Birsa Agricultural University, Ranchi, Jharkhand to evaluate efficacy of crop establishment methods on yield and economics of rice under puddled condition. Results revealed that conventional transplanting produced higher panicles/m² (282), total (124.10) and filled (106.27) grains/panicle resulting in higher grain yield (44.18qha⁻¹) and straw yield (68.43qha⁻¹) over rest of the establishment methods except drum seeding of sprouted seeds and mechanical transplanting. However, conventional transplanting had edge by 19 and 21 % over broadcasting of either sprouted or dry seeds, respectively whereas drum seeding of sprouted seeds (43.70 q ha⁻¹) was significantly higher by 17.7 and 19.7 % over broadcasting of either sprouted or dry seeds, respectively in grain production. Drum seeding(Rs.49293.61ha⁻¹) being on par with conventional transplanting (Rs.45704.42ha⁻¹) in net return had significant edge by 23.9, 26.9 and 27.1% over broadcasting of sprouted seeds, mechanical transplanting and broadcasting of dry seeds, respectively. The Benefit: Cost ratio (2.34) under drum seeding showed significant edge by 20.6, 23.8, 30 and 55% over broadcasting of either sprouted or dry seeds, conventional and mechanical transplanting, respectively. Hence, for higher productivity, establishment of rice through drum seeding can be a feasible alternative of transplanting method as it gives similar grain yield, straw yield and net return to conventional transplanting with higher benefit: cost ratio.

Keywords
Rice, Establishment methods, Drum seeding, Yield, Economics

Introduction

Rice (Oryza sativa L.), ‘Crop of the Millennium’, covering 161.2 million hectares (mha) and contributing 471.09 million tonnes (2015-16) is gaining popularity worldwide. It is now being grown in different parts of the world particularly in South Asia as one of the major cereal crops, having high calorific value. Rice covered about 42 mha during 2015-16 and accounts for about 103.61 million tonnes of the country’s total food grain production (Anonymous, 2016 a). However, rice suffered a production fatigue, stagnation or decline during 2015-16 mainly due to erratic rainfall in major rice growing areas (Anonymous, 2016 b). This anticipated year-to-year drop of global production very much reflects the negative expectations in Asia, where the season is expected to close with a minor 0.5 % decline in the total rice stocks. Singularly, India is set to account for much of the region’s shortfall, reflecting the overall subdued monsoon performance. The productivity of the crop has to be increased
by 0.21% p.a. in order to meet the projected rice demand of the nation of 125 million tonnes by 2025 AD as possibility of expanding the area under rice cultivation is very meagre. Therefore, this extra rice production needed has to come from a productivity gain which is to be achieved with less water, labour, and chemicals, thereby ensuring long-term sustainability in rice production, that still remains a major challenge.

In Jharkhand, a productivity gain of 2.57 t/ha was achieved during 2014-15 from 14.94 lakh hectares of area under rice cultivation. The Chotanagpur plateau is dominated by monocropping of rice being commonly grown by conventional transplanting. Farmers of Jharkhand are facing problems in rice establishment through transplanting because of higher production costs particularly due to shortages of labours (during peak period), water and escalating fuel prices. The rice cultivation is mostly monsoon dependent in Jharkhand, which in turn is extremely erratic in onset, distribution, intensity and cessation. Late monsoon usually delays seedlings raising and transplanting operations thus resulting in lower yield.

In such circumstances, direct seeding comprising of drum seeding, broadcasting of either dry or sprouted seeds under puddled condition may be an alternative to transplanting in boosting the rice production in Jharkhand. Rice can be established well by direct sowing into the main field under puddled condition rather than raising nursery and then transplanting. Direct seeding with drum seeder is a successful method of cultivation which not only saves labour but also contributes in water conservation, thereby increasing the water use efficiency and ultimately enhances the productivity, therefore considered more economical as compared to transplanting. Thus, if the productivity of rice in India in general and Jharkhand in particular is raised by different establishment methods, it can bring about tremendous change in agricultural scenario and on rural economy. Keeping these points in view the present investigation was undertaken to evaluate the comparative effects of different crop establishment methods on yield attributes, yield and economics of rice.

Materials and Methods

A field experiment was conducted at agronomical research farm of Birsa Agricultural University, Ranchi (23°17´ N latitude and 85°10´ E longitude with an altitude of 625 m above the mean sea level) during kharif season of 2015, in the clay-loam soil, slightly acidic in reaction (pH 6.1), low in organic carbon (3.6 g/kg) as well as in available nitrogen (200.7 kg/ha), high in available phosphorus (33.54 kg/ha) and medium in potassium (187.04 kg/ha). The climate of Ranchi is sub humid with large water deficiency and is characterized by hot summer and cold winter. The agronomical research farm of Ranchi falls under sub zone V of Agro-climatic zone VII of India i.e. Eastern Plateau and Hill Region. This place receives rainfall from both the streams of monsoon i.e. South-West monsoon and North-East monsoon. The experiment was laid out in Randomized Block Design with four replication and the rice variety used was Naveen (CR-749-20-2). The treatments comprised of five different rice establishment methods – conventional transplanting, mechanical transplanting, drum seeding of sprouted seeds, broadcasting of sprouted seeds and broadcasting of dry seeds. Uniform fertilization (120: 60: 40 kg N: P₂O₅: K₂O ha⁻¹) was done for all the rice establishment methods through urea, diammonium...
phosphate and muriate of potash, respectively. After ploughing and leveling layout of field was done which followed puddling with the help of tractor drawn puddler, 5 days before as well as on the day of sowing/transplanting and then leveling was done.

In main field half dose of nitrogen and full dose of phosphorus and potassium were applied as basal. Rest of the nitrogen was top dressed in two equal splits at 25 days after sowing/transplanting (tillering stage) and at 50 days after sowing/transplanting (panicle initiation stage). Whereas, in nursery fertilizers was applied @ 12: 6: 4 kg N: P₂O₅: K₂O per 1000 sq m. In conventional transplanting, half dose of N and full dose of P₂O₅ and K₂O were applied as basal and remaining N was top dressed at 15 DAS. While, in case of rice nursery for mechanical transplanting full dose of N was applied as basal. For conventional transplanting, seeds were sown in nursery and seedlings were raised by wet nursery method and 2-3 seedlings/hill (21 days old) were transplanted at 20 x 15 cm spacing. Whereas, in case of mechanical transplanting seedlings were prepared on mat type nursery and 4-5 seedlings/hill (15 days old) were transplanted at 25 x 15 cm spacing. Sprouted seeds were used for direct seeding by broadcasting and drum seeding with 20 cm row spacing. Direct seeding was done on the same day i.e. the day seeds were placed in nursery. Observations on yield attributes and yield were recorded. Collected data was statistically analyzed as per the methods by Gomez and Gomez, 2003.

**Results and Discussion**

**Yield attributes**

In the present investigation, crop establishment methods differed significantly in their ability to produce panicles m⁻², panicle length and filled grains panicle⁻¹. Rice established by conventional transplanting, drum seeding of sprouted seeds and mechanical transplanting had similar yield attributes except 1000 g weight (Table-1). However, conventional transplanting (282 m⁻²) and drum seeding of sprouted seeds (275 m⁻²) showed significant edge by 22.9 and 19.8%, respectively over broadcasting of dry seeds (229.50 m⁻²) in panicle production. Further, broadcasting of dry seeds being similar to broadcasting of sprouted seeds recorded the lowest panicles per unit area which might be due to less availability of nutrients and moisture to the crop at panicle initiation stage resulting from the crop-weed competition (Raj et al., 2013). These findings are also in close conformity with those obtained by Prasad 2001; Aslam et al., (2008) who reported higher yield attributes under transplanted rice than direct seeded.

Among various establishment methods, higher panicle length and filled grains panicle⁻¹ were recorded in conventional transplanting (23.46 cm and 106.27) that being similar to drum seeding of sprouted seeds (23.18 cm and 105.28), mechanical transplanting (22.08 cm and 100.82) and broadcasting of sprouted seeds (21.73 cm and 96.81), had edge of 9.7 and 10.5 % in panicle length and filled grains panicle⁻¹, respectively over broadcasting of dry seeds. Further, broadcasting of dry seeds being similar to that of sprouted seeds registered the minimum panicle length and filled grains panicle⁻¹. The panicle length in transplanted rice was significantly longer as compared to direct seeded crop because of more space, sunlight and nutrients availability in transplanted crop, whereas higher weed densities in direct seeded crop hinders the development of panicle length and other yield attributes (Hussain et al., 2013).
Test weight or 1000 grain weight is a function of various production factors that gives an indication of grain development and filling patterns. However, rice establishment methods had no significant affect on this attribute. This result confirms the observations of Gill et al., 2006; Ehsanullah et al., 2007 and Jha et al., 2011.

Yield

Grain and straw yield differed significantly by various rice establishment methods under puddled soil except the harvest index of rice. Rice established through conventional transplanting, drum seeding and mechanical transplanting had similar grain and straw yield (Table 1). Conventional transplanting (44.18 q ha$^{-1}$) had edge by 19 and 21 %, respectively over broadcasting of either sprouted (37.13 q ha$^{-1}$) or dry seeds (36.50 q ha$^{-1}$) whereas drum seeding of sprouted seeds (43.70 q ha$^{-1}$) was significantly higher by 17.7 and 19.7 %, respectively over broadcasting of either sprouted (37.13 q ha$^{-1}$) or dry seeds (36.50 q ha$^{-1}$) in grain production.

Further, among the direct seeded rice, broadcasting of dry seeds being similar to broadcasting of sprouted seeds recorded the lowest grain yield. Rice established through transplanting and drum seeding recorded significantly higher paddy yield because the the beneficial effects of puddling in transplanting as well as in drum seeding together with uniform stand establishment, ideal rhizosphere environment might have contributed to higher nutrient uptake which resulted in the production of greater source and efficient translocation of photosynthates into the larger sink as indicated by higher yield attributes. In case of straw yield, crop established through conventional transplanting (68.43 q ha$^{-1}$) and drum seeding of sprouted seeds (67.90 q ha$^{-1}$) showed significant edge by 15.3 and 14.5%, respectively over broadcasting of dry seeds (59.32q ha$^{-1}$). Further, rice established through broadcasting of dry seeds being similar to that of sprouted seeds recorded the minimum straw yield. Transplanting method of establishment recorded significantly higher straw yield compared to direct sowing of rice under puddled condition due to less crop weed competition in transplanting method which led to taller plants, more number of tillers and dry matter production which in turn resulted in higher straw yield (Parameshwari and Srinivas, 2014). Subramanyam et al., (2007) also reported similar results.

Being a varietal character, harvest index was not influenced by different rice establishment methods under puddled condition, however highest harvest index was recorded with conventional transplanting (39.19%) followed by drum seeding of sprouted seed (39.13%), mechanical transplanting (38.38%), broadcasting of sprouted seeds (38.18%) and broadcasting of dry seeds (38.13%).This confirms the findings of Jha et al., 2011.

Economics

Economic analysis of the treatments shows the relevance to consider the practical adaptability of a particular treatment from the farmers’ point of view (Jha et al., 2011). Cost of cultivation for mechanically transplanted and conventionally transplanted rice was Rs.25648.13 ha$^{-1}$ and Rs.25409.58 ha$^{-1}$, respectively. Whereas rice grown by broadcasting of either sprouted or dry seeds had equal cost of cultivation i.e. Rs.20534.60 ha$^{-1}$. Establishment of rice with the help of drum seeder required cultivation cost of Rs. 21096.89 ha$^{-1}$. Rice establishment methods under puddled soil had a significant impact on gross return.
### Table 1

**Yield attributes, yield and harvest index as influenced by different rice establishment methods under puddled condition**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Panicles m⁻²</th>
<th>Panicle length (cm)</th>
<th>Grains Panicle⁻¹</th>
<th>Filled Grain Panicle⁻¹</th>
<th>1000 Grain Weight (g)</th>
<th>Yield (q ha⁻¹)</th>
<th>Harvest Index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>T1 Conventional Transplanting</strong></td>
<td>282.00</td>
<td>23.46</td>
<td>124.10</td>
<td>106.27</td>
<td>22.98</td>
<td>44.18</td>
<td>68.43</td>
</tr>
<tr>
<td><strong>T2 Mechanical Transplanting</strong></td>
<td>258.00</td>
<td>22.08</td>
<td>118.38</td>
<td>100.82</td>
<td>23.13</td>
<td>39.80</td>
<td>63.76</td>
</tr>
<tr>
<td><strong>T3 Drum seeding of sprouted seeds</strong></td>
<td>275.00</td>
<td>23.18</td>
<td>122.85</td>
<td>105.28</td>
<td>23.03</td>
<td>43.70</td>
<td>67.90</td>
</tr>
<tr>
<td><strong>T4 Broadcasting of sprouted seeds</strong></td>
<td>238.25</td>
<td>21.73</td>
<td>113.71</td>
<td>96.81</td>
<td>24.66</td>
<td>37.13</td>
<td>60.21</td>
</tr>
<tr>
<td><strong>T5 Broadcasting of dry seeds</strong></td>
<td>229.50</td>
<td>21.39</td>
<td>112.25</td>
<td>96.13</td>
<td>24.70</td>
<td>36.50</td>
<td>59.32</td>
</tr>
<tr>
<td>SEm ±</td>
<td>12.98</td>
<td>0.64</td>
<td>3.36</td>
<td>3.10</td>
<td>0.56</td>
<td>1.90</td>
<td>2.62</td>
</tr>
<tr>
<td><strong>CD (P=0.05)</strong></td>
<td>39.84</td>
<td>1.97</td>
<td>10.30</td>
<td>9.50</td>
<td>NS</td>
<td>5.82</td>
<td>8.05</td>
</tr>
</tbody>
</table>

### Table 2

**Cost of cultivation, gross return, net return, benefit: cost ratio as influenced by rice establishment methods under puddled condition**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Cost of cultivation (Rs./ha)</th>
<th>Gross return (Rs./ha)</th>
<th>Net return (Rs./ha)</th>
<th>Benefit: cost ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>T1 Conventional Transplanting</strong></td>
<td>25409.58</td>
<td>71114.00</td>
<td>45704.42</td>
<td>1.80</td>
</tr>
<tr>
<td><strong>T2 Mechanical Transplanting</strong></td>
<td>25648.13</td>
<td>64492.50</td>
<td>38844.37</td>
<td>1.51</td>
</tr>
<tr>
<td><strong>T3 Drum seeding of sprouted seeds</strong></td>
<td>21096.89</td>
<td>70390.50</td>
<td>49293.61</td>
<td>2.34</td>
</tr>
<tr>
<td><strong>T4 Broadcasting of sprouted seeds</strong></td>
<td>20534.60</td>
<td>60304.00</td>
<td>39769.40</td>
<td>1.94</td>
</tr>
<tr>
<td><strong>T5 Broadcasting of dry seeds</strong></td>
<td>20534.60</td>
<td>59313.00</td>
<td>38778.40</td>
<td>1.89</td>
</tr>
<tr>
<td>SEm ±</td>
<td>-</td>
<td>2919.33</td>
<td>2919.33</td>
<td>0.13</td>
</tr>
<tr>
<td><strong>CD (P=0.05)</strong></td>
<td>-</td>
<td>8958.96</td>
<td>8958.96</td>
<td>0.39</td>
</tr>
</tbody>
</table>

**NOTE:** selling price of grain: Rs.1300/q, straw: Rs.200/q
The gross return of conventionally transplanted (Rs. 71,114 ha$^{-1}$), drum seeded (Rs. 70,390.50 ha$^{-1}$) and mechanically transplanted rice (Rs. 64,492.50 ha$^{-3}$) were on par with one another. However, rice established by conventional transplanting and drum seeding of sprouted seeds had significant edge over broadcasting of either sprouted (Rs. 60,304.00 ha$^{-1}$) or dry seeds (Rs. 59,313.00 ha$^{-1}$). The agriculture practices involving lower cost of production and giving higher net return and benefit: cost ratio are preferred for adoption. Direct seeding of sprouted seeds by drum seeder (Rs. 49,293.61 ha$^{-1}$) being on par with conventional transplanting (Rs. 45,704.42 ha$^{-1}$) in net return had significant edge by 23.9, 26.9 and 27.1% over broadcasting of sprouted seeds, mechanical transplanting and broadcasting of dry seeds, respectively. The higher net return under drum seeded and conventionally transplanted rice might be due to higher grain and straw yield of the crop. While benefit : cost ratio (2.34) under drum seeded rice was higher than all other methods of rice establishment and had significant edge by 20.6, 23.8, 30 and 55% over broadcasting of sprouted seeds, broadcasting of dry seeds, conventional transplanting, and mechanical transplanting, respectively (Table-2). This confirms the findings of Jha et al., 2011.

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