INFLUENCE OF PUDDLING INTENSITY AND ORGANIC AMENDMENTS ON WATER PRODUCTIVITY UNDER SRI AND CONVENTIONAL TRANSPLANTING OF RICE AND THEIR RESIDUAL EFFECT ON SUCCEEDING WHEAT CROP

Veena Sharma, J. Prabhakara, Dilip Kachroo and Abhijit Samanta
Sher-e-Kashmir University of Agricultural Sciences and Technology- Jammu-180 001, India

ABSTRACT
A field experiment was carried for three *kharif* and two intervening *rabi* seasons, beginning with *kharif* 2006 at WMRC research farm of SKUAST Jammu on clay loam soil, to analyze the influence of puddling intensities and organic amendments on water productivity of rice basmati and its residual effect on following wheat. Water productivity of basmati rice achieved as a consequence of incident rainfall and applied differential irrigation in $C_1, C_2$ with 7cm depth of irrigations at 8-day frequency) and $S_1, S_2$ (System of Rice Intensification) with 5cm irrigation at 8 day frequency or less) monitored at 3 week intervals throughout rice growth seasons of *kharif* 2006 and 2007 revealed that water productivity was significantly higher in conventionally transplanted plots without organic amendments ($C_i$) than the other treatments ($C_{ij}, S_{ij}$), all receiving organic sources of nutrients during the first season. But in the next two *Kharif* seasons, SRI plots and conventionally transplanted plots had similar water productivity. There was neither any residual influence of puddling intensities, nor of methods of rice establishment nor of organic additions to soil during rice crop on the grain yield of succeeding wheat crop.

Key words: System Rice Intensification (SRI), Puddling intensity, Organic amendments, Conventional transplanting, Water productivity.

INTRODUCTION
Puddling is the most common practice of establishing rice in south Asia. It reduces water losses through percolation and controls weeds in rice fields (Adachi, 1992). However, practiced over a long time, it results in degradation of soil and other natural resources and poses difficulties in seedbed preparation for succeeding crop in rotation. High puddling intensity results in the development of hard pans which has detrimental effects on the growth and yield of succeeding wheat crop (Aggarwale et al., 1995). In addition there has been deterioration in soil physical conditions (Kukal and Aggarwal, 2003) and resultant reductions in wheat yields following rice (Gill and Aulakh 1990). This decrease in wheat yield may be due to the reduction in root growth and distribution in a poor soil physical environment. (Ishaq et al., 2001). Natural structural regeneration of puddled soils is generally slow. Use of organic amendments, such as FYM, compost, plant residue etc. improve soil physical properties of puddled soils (Bhagat and Verma, 1991). Traditional transplanted rice with continuous standing water has relatively high water inputs. Because of increasing water scarcity, there is a need to develop alternative systems that require less water. Recently , the system of rice intensification ( SRI) has been introduced in irrigated lowland rice in order to reduce the amount of water used for irrigation and negate the impact of puddling on the succeeding crop ( e.g. wheat) (Uphoff, 2003). The SRI advocates a combination of management practices e.g. use of organic manures, reduction of age and planting density, avoiding anaerobic condition during vegetative phase etc., which helps in maintaining the system productivity as well as sustainability. Although a few studies have been conducted on water productivity under SRI, very limited information is available on the residual impact of this system on succeeding crop. Therefore, in present study the comparative performance of SRI

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and rice production with conventional method with continuous standing water in respect of water productivity in rice and succeeding wheat crop was evaluated.

**MATERIALS AND METHODS**

A field experiment on basmati rice (cv. Basmati-370) was conducted on clay loam soil of Chatha, Research Farm, SKUAST-Jammu located at 74°58’ E, 32°40’ N and 295m above msl, under rice-wheat cropping system for the past 5-6 decades under tube-well irrigation. The physico-chemical characteristics of study soil are shown in Table 1. Long term (32-year) mean annual rainfall was 1236 mm and mean seasonal rainfall of kharif and rabi were 827mm and 288mm respectively. The experimental layout in strip-plot design with five replications consisted of four treatments of puddling intensities in the main plots (strips): Zero puddling (P1) – wet ploughing through one pass of 11-tyne tiller. Conventional puddling (P2) – wet ploughing through two passes of tiller followed by two planking, medium puddling (P3) - two passes of 8-ft Agriking Paddy puddler followed by 2 planking and thorough puddling (P4) - four passes of 8-ft Agriking Paddy puddler followed by 2 planking. In the sub-plots, the four treatment combinations of methods of rice establishment and organic additions were applied: C1, C2= Conventional transplanting of 25-day old seedlings, two per hill, at spacing of 20cm x 15cm, with inorganic fertilizers of N:P2O5:K2O= 30:20:15 kg ha⁻¹ and 3 t ha⁻¹ farm yard manure respectively. with 7cm depth of irrigations at 8-day frequency; S1, S2= SRI transplanting of 10-day old seedlings, one per hill, 25cm x 25cm spacing, with 3 t ha⁻¹ of FYM and wheat Bhusa respectively, with 5cm irrigation at 8 day frequency. Soil water content in 0-20 depth was determined gravimetrically 48 hours after termination of infiltration of added irrigation water by taking samples Field capacity by field method (Coleman, 1944) and permanent wilting point (PWP) by pot method were determined. Then the plant available water was computed using the information on field capacity and permanent wilting point (Table 2). The basic reason for choice of 3000 kg ha⁻¹ of farm yard manure in sub plots S1 & S2 is to match the basal dose of N for the cultivar viz. 15 kg N ha⁻¹ in C1 plots (control). Based on the analysis of farm yard manure, inorganic fertilizers applied in C1 plots were corrected to 30:20:15. [50% N and full P & K as basal dose and balance N in two equal splits at tillering and panicle initiation stages of rice].

During kharif 2006, total rainfall during rice growth period was 820 mm (occurring on 27 rainy days), necessitating application of 8 & 9 irrigations in SRI (S1, S2) and conventional (C1, C2) plots respectively. Total rainfall during the entire rice growth period during kharif 2007 was 744.6 mm (in 32 days), leading to application of 10 and 12 irrigations in S1,S2 plots and C1, C2 plots respectively.

The water productivity of rice crop (kg m⁻³) was computed on the basis of total water input to the crop yield in each season as

\[
\text{Water productivity (kg m}^{-3}\text{)} = \frac{\text{Grain yield in kg ha}^{-1}}{\text{Total water consumed in m}^3\text{ ha}^{-1}}
\]

Wheat crop, (chosen for the study of residual effects of treatments applied to previous rice crop), was sown in 20 cm rows under zero till conditions, one week after the harvest of rice crop without any preparatory soil tillage by opening up of soil between rows of rice stubble to 2” depth using a liner. Recommended inorganic fertilizer dose of N: P₂O₅: K₂O=100:50:25 was applied. Other than post sowing and CRI stage irrigations, 60 mm irrigation at net CPE of 60 mm was applied.

**RESULTS AND DISCUSSION**

During kharif 2006, conventionally transplanted plots without organic amendments (C1) recorded significantly higher water productivity of

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**Table 1**: Physico-chemical characteristics of soil at the experimental site.

<table>
<thead>
<tr>
<th>Soil depth</th>
<th>Sand (%)</th>
<th>Silt (%)</th>
<th>Clay (%)</th>
<th>pH</th>
<th>EC (dSm⁻¹)</th>
<th>Organic carbon</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20 cm</td>
<td>32</td>
<td>34</td>
<td>34</td>
<td>7.62</td>
<td>0.029</td>
<td>0.58</td>
</tr>
<tr>
<td>20-40 cm</td>
<td>30</td>
<td>28</td>
<td>42</td>
<td>7.81</td>
<td>0.027</td>
<td>0.41</td>
</tr>
</tbody>
</table>
TABLE 2: Bulk density, field capacity, permanent wilting point and available water range.

<table>
<thead>
<tr>
<th>Soil depth</th>
<th>Bulk density (Mg m⁻³)</th>
<th>Field capacity % w/w</th>
<th>Permanent wilting point % w/w</th>
<th>Available water range (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>1.54</td>
<td>26.0</td>
<td>7.8</td>
<td>28.2</td>
</tr>
<tr>
<td>10-20</td>
<td>1.56</td>
<td>40.3</td>
<td>12.1</td>
<td></td>
</tr>
<tr>
<td>20-30</td>
<td>1.66</td>
<td>27.0</td>
<td>7.5</td>
<td>31.4</td>
</tr>
<tr>
<td>30-40</td>
<td>1.56</td>
<td>43.5</td>
<td>12.1</td>
<td></td>
</tr>
</tbody>
</table>

Volumetric water content in (0-20) cm layer at 50% available water = 26.2%.
Volumetric water content in (20-40) cm layer at 50% available water = 27.8%.

TABLE 3: Water productivity (kg m⁻³) of basmati rice as influenced by puddling intensities and treatment combinations of rice establishment methods and organic amendments, kharif 2006

<table>
<thead>
<tr>
<th>Treatments</th>
<th>P₁</th>
<th>P₂</th>
<th>P₃</th>
<th>P₄</th>
<th>S/C Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>S₁</td>
<td>0.1191</td>
<td>0.1233</td>
<td>0.1758</td>
<td>0.1395</td>
<td>0.1400</td>
</tr>
<tr>
<td>S₂</td>
<td>0.1223</td>
<td>0.1401</td>
<td>0.1680</td>
<td>0.1334</td>
<td>0.1396</td>
</tr>
<tr>
<td>C₁</td>
<td>0.1363</td>
<td>0.1535</td>
<td>0.2216</td>
<td>0.1528</td>
<td>0.1855</td>
</tr>
<tr>
<td>C₂</td>
<td>0.1556</td>
<td>0.1666</td>
<td>0.2141</td>
<td>0.1476</td>
<td>0.1522</td>
</tr>
<tr>
<td>Pi –Mean</td>
<td>0.1333</td>
<td>0.1459</td>
<td>0.1543</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CDS%</td>
<td>S/C</td>
<td>0.0212</td>
<td>CVa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pi</td>
<td>NS</td>
<td></td>
<td>CVb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pi x S/C</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0.1855 kg m⁻³ than the other treatments (C₀, S₁, S₂), all receiving organic sources of nutrients (Table 3).

In Kharif 2007 and 2008 all the SRI plots (S₁, S₂) and conventionally transplanted plots (C₁, C₂) recorded statistically similar water productivity values (Table 4 and Table 5). During all the three seasons, influence of puddling intensities as well as interaction effect of treatments (Pi x S/C) on water productivity in rice were non-significant. Puddling intensities, methods of rice establishment and organic additions to soil in rice crop did not show any residual effect on the grain yield of succeeding wheat crop during both the years of investigation. Similar results were obtained by Choudhury et al., 2007.

Water productivity of wheat was not computed, as there was no differential irrigation input made to the test crop. Wheat crop was grown only to assess the residual effects of treatments imposed on previous kharif basmati rice on wheat grain yield. There were no residual effects of either puddling intensities or organic additions or methods of rice establishment adopted during Kharif on the grain yields of succeeding wheat during rabi 2006-07 and 2007-08 (Tables 6&7). Similar results were obtained by Parihar, (2004). The very good (4.2 t ha⁻¹) and good (3.3 t ha⁻¹) grain yields during the two seasons were a function of efficient rain-water management. However, wide variation in yield level in both the years may be due to supra normal at 397.6 mm and sub normal at 191.4 mm seasonal rainfall conditions respectively.

TABLE 4: Water productivity (kg m⁻³) of basmati rice as influenced by puddling intensities and treatment combinations of rice establishment methods and organic amendments, Kharif 2007.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>P₁</th>
<th>P₂</th>
<th>P₃</th>
<th>P₄</th>
<th>S/C Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>S₁</td>
<td>0.2009</td>
<td>0.184</td>
<td>0.1692</td>
<td>0.184</td>
<td>0.1845</td>
</tr>
<tr>
<td>S₂</td>
<td>0.1829</td>
<td>0.1935</td>
<td>0.2009</td>
<td>0.1749</td>
<td>0.1881</td>
</tr>
<tr>
<td>C₁</td>
<td>0.1619</td>
<td>0.1898</td>
<td>0.1802</td>
<td>0.1811</td>
<td>0.1782</td>
</tr>
<tr>
<td>C₂</td>
<td>0.1747</td>
<td>0.1872</td>
<td>0.1559</td>
<td>0.1875</td>
<td>0.1763</td>
</tr>
<tr>
<td>Pi –Mean</td>
<td>0.180147</td>
<td>0.1886</td>
<td>0.1766</td>
<td>0.1818</td>
<td></td>
</tr>
<tr>
<td>CDS%</td>
<td>S/C</td>
<td>NS</td>
<td>CVa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pi</td>
<td>NS</td>
<td></td>
<td>CVb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pi x S/C</td>
<td>NS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
TABLE 5: Water productivity (kg m⁻³) of basmati rice (cv. Basmati-370) as influenced by puddling intensities and treatment combinations of establishment and organic amendment, kharif 2008.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>P₁</th>
<th>P₂</th>
<th>P₃</th>
<th>P₄</th>
<th>S/C Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>S₁</td>
<td>0.1887</td>
<td>0.2075</td>
<td>0.2187</td>
<td>0.2046</td>
<td>0.2049</td>
</tr>
<tr>
<td>S₂</td>
<td>0.1797</td>
<td>0.1866</td>
<td>0.225</td>
<td>0.1814</td>
<td>0.1932</td>
</tr>
<tr>
<td>C₁</td>
<td>0.1791</td>
<td>0.208</td>
<td>0.1826</td>
<td>0.1800</td>
<td>0.1874</td>
</tr>
<tr>
<td>C₂</td>
<td>0.1676</td>
<td>0.1862</td>
<td>0.1609</td>
<td>0.2016</td>
<td>0.1791</td>
</tr>
<tr>
<td>Pi –Mean</td>
<td>0.1788</td>
<td>0.1971</td>
<td>0.1968</td>
<td>0.1979</td>
<td></td>
</tr>
</tbody>
</table>

CD5% S/C NS CVa 17.00%
Pi NS CVb 15.65%
Pi x S/C NS

CONCLUSION

Puddling intensity, organic amendments and system of rice culture have similar water productivity in basmati rice to conventional method using organic fertilizer. Either of these had no effect on following wheat crop so, depending on the situation and availability any of these can be practiced.

REFERENCES


