The comparison of water use efficiency of rice in semi-arid region, Namibia and in humid region, Japan.

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The north central regions in a semi-arid country, Namibia, has been offering a high potential of rice cropping, possessing seasonal wetlands locally called “Oshana”, even though water is scarce due to the high evaporation rate and limited rainfall. Therefore the introduction of higher water use efficient rice cultivar should be recommended. Rice is well known to be a heavy water consumer (Zhao \textit{et al.}, 2009), and many studies on water saving cropping system at field level have been reported so far (e.g. Bouman and Tuong, 2001; Sharma \textit{et al.}, 1995). Although some studies also reported cultivar difference of water use efficiency at plant level (e.g. Haefele \textit{et al.}, 2009; Hirai \textit{et al.}, 2002; Sumi \textit{et al.}, 1994; Maruyama \textit{et al.}, 1985), the results are yet limited in terms of the diversity of cultivars investigated and of the climatic conditions. The objective of this study is therefore to evaluate the rice cultivar (\textit{Oryza sativa} L. and interspecific progenies) difference of water use efficiency in semi-arid region, Namibia and in humid region, Japan.

\textbf{Materials and methods}

Pot exp. I. The 23 rice cultivars (\textit{Oryza sativa} L. and interspecific progenies) grown in west and south Africa were evaluated for water use efficiency in University of Namibia located in the north central Namibia. The rice was grown in pots in greenhouse and the weight of pot was measured every morning from 28 to 42 days after sowing (DAS) to estimate water consumption. The water use efficiency (\textit{WUE}, g kg\textsuperscript{-1}) was then calculated as follows,

\begin{equation}
\text{WUE} = \frac{\text{DW}_{\text{increase}}}{\text{Water}_{\text{consumed}}} \quad (1)
\end{equation}

where \(\text{DW}_{\text{increase}}\) and \(\text{Water}_{\text{consumed}}\) are the increase of plant biomass and the amount of water consumed between 28 and 42 DAS, respectively. \(\text{Water}_{\text{consumed}}\) is given as \(\text{TR}_{\text{total}}\) or \(\text{ET}_{\text{total}}\) for \(\text{WUE}_{\text{TR}}\) or \(\text{WUE}_{\text{ET}}\), respectively, indicating that \(\text{TR}_{\text{total}}\) and \(\text{ET}_{\text{total}}\) are total transpiration and total evapotranspiration from 28 to 42 DAS, respectively.

Pot exp. II. Seven rice cultivars (\textit{Oryza sativa} L.) chosen from the Pot exp. I based on its \textit{WUE} diversity were grown in pot in greenhouse in Kinki University, Nara Japan. The measurement of pot weight was operated from 32 to 45 DAS and \textit{WUE} was calculated by the equation (1).

\textbf{Results and discussion}

The \(\text{WUE}_{\text{TR}}\) was significantly different among rice cultivars in both Namibia (Data is not shown) and Japan (Table 1). The \(\text{WUE}_{\text{TR}}\) obtained in Namibia was considerably greater than that in Japan. The relationship between \(\text{WUE}_{\text{TR}}\) and \(\text{WUE}_{\text{ET}}\) of Pot exp. II was linear (Fig. 1-b) while that of Pot exp. I was not correlated (Fig. 1-a). The \(\text{TR}_{\text{total}}\) was estimated by the difference of
water consumed between bare pot (without plant) and rice-growing pot assuming that the amount of water surface evaporation in rice-growing pot is the same as that in bare pot. If this assumption works out, the relationship between $WUE_{TR}$ and $WUE_{ET}$ must be linear. The Fig. 1-a may therefore suggest the difference of the amount of water surface evaporation between pots, pointing out the possibility of overestimation of the $WUE_{TR}$ in Namibia due to the underestimation of $TR_{total}$ caused by greater amount of water surface evaporation in bare pot than in rice-growing pot.

Further pot experiments have been conducted in Namibia and Japan considering the difference of the amount of water surface evaporation between pots.

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Keywords: rice, water use efficiency, semi-arid region, humid region

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Table 1. The biomass increase, amount of transpiration, $WUE_{TR}$ and $WUE_{ET}$ between 32 and 45 DAS (Pot exp. II).

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Biomass increase (g)</th>
<th>Transpiration (kg 13days$^{-1}$)</th>
<th>$WUE_{TR}$ (g kg$^{-1}$)</th>
<th>$WUE_{ET}$ (g kg$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR24</td>
<td>6.73 ± 0.26 a</td>
<td>1.85 ± 0.06 c</td>
<td>3.63 ± 0.04 a</td>
<td>2.80 ± 0.04 a</td>
</tr>
<tr>
<td>WAB56–104</td>
<td>4.57 ± 0.08 b</td>
<td>1.41 ± 0.03 e</td>
<td>3.24 ± 0.11 b</td>
<td>2.34 ± 0.07 b</td>
</tr>
<tr>
<td>Pokkali</td>
<td>6.66 ± 0.35 a</td>
<td>2.35 ± 0.02 a</td>
<td>2.83 ± 0.13 c</td>
<td>2.30 ± 0.11 b</td>
</tr>
<tr>
<td>Tumo-Tumo</td>
<td>4.41 ± 0.20 b</td>
<td>1.61 ± 0.04 d</td>
<td>2.74 ± 0.07 c</td>
<td>2.04 ± 0.06 c</td>
</tr>
<tr>
<td>AZUCENA</td>
<td>4.90 ± 0.09 b</td>
<td>1.83 ± 0.03 c</td>
<td>2.67 ± 0.05 c</td>
<td>2.06 ± 0.03 c</td>
</tr>
<tr>
<td>IR64</td>
<td>4.47 ± 0.10 b</td>
<td>1.73 ± 0.04 cd</td>
<td>2.58 ± 0.07 cd</td>
<td>1.96 ± 0.05 c</td>
</tr>
<tr>
<td>LK1484–5</td>
<td>4.74 ± 0.26 b</td>
<td>2.05 ± 0.13 b</td>
<td>2.34 ± 0.20 d</td>
<td>1.84 ± 0.13 c</td>
</tr>
</tbody>
</table>

Data is the mean value ± standard error.

Values with same letters within each column are not significantly different at $P < 0.05$ by Fisher’s PLSD.

Fig. 1. Relationship between $WUE_{TR}$ and $WUE_{ET}$ from (a) Pot exp. I (Namibia) and (b) Pot exp. II (Japan).

The bars indicate standard error of the means for each cultivar. (a) n=3–6, (b) n=4–5.