MECHANISM OF SALT TOLERANCE IN RICE GENOTYPES 
DURING GERMINATION AND SEEDLING GROWTH

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ABSTRACT
Four rice (Oryza sativa L.) genotypes with varying levels of tolerance to salinity were used for assessing their response at germination and seedling stage to salt. Differential response of genotypes to salt concentration was observed. Germination of tolerant genotypes was better (more than 90%) in highly tolerant varieties and it was low (below 70%) in susceptible variety. Shoot and root length, vigour index and germination per cent were affected by increasing salinity. Co 43 and Pokkali found to be tolerant and IR 50 and ADT 38 are the susceptible variety. Antioxidant enzyme like peroxidase and catalase under salt stress in rice are important. Among the four genotypes viz., Co 43, Pokkali, ADT 38 and IR 50. Pokkali showed a higher activity of peroxidase and catalase followed by Co 43. ADT 38 and IR 50 showed a lesser activity of these enzyme showing that it is susceptible for salt stress.

INTRODUCTION
Salinity affects plant vigour in several ways leading to the very low productivity and even to no productivity level. About 10 million hectares of land in India are affected by soil salinity and alkalinity (Bhargava, 1989). This problem can be overcome either by reclaiming the environment by soil amendments which are costly and tentative. Inherent capacity of genotype or by genetically changing the plant to improve its tolerance level which is more permanent and environment friendly (Christiansen and Lewis, 1976). Crop responses to salinity are controlled by genes. To breed a tolerant line one must be aware of crop genetics and physiology and armed with an efficient screening system based on stable selection criteria. Soil salinity increases the catalase and peroxidase enzyme activity among tolerant and sensitive varieties of Cotton (Gossett et al., 1994). The relationship between salinity and antioxidants were studied by Swamy and Reddy (1991) and they reported that $O_2^-$ radical and $H_2O_2$ could play an important role in the mechanism of adaptation. The aim of the study was to understand the role of antioxidant enzymes, viz., peroxidase and catalase in relation to salinity.

MATERIAL AND METHODS
Matured seeds of four genotypes viz., Co 43, Pokkali, ADT 38 and IR 50 were considered for the study. The data were recorded on germination percentage, shoot and root length, vigour index. The 7 day old seedlings were used for analysis of catalase and peroxidase enzyme. Germination test was carried out as suggested by Maliwal and Paliwal (1971) and Gupta (1993). The petridishes lined with filter paper having 100 seeds of each treatment were used. Seeds were treated with 0.0, 50, 100, 200, 300 and 400 mM NaCl solution. Double distilled water was used as a control. The treatment was replicated thrice and germination count was done 10 days after sowing and expressed in percentage. The length from the seed to the tip of the leaf blade was taken. The average height of twenty five seedlings was taken and expressed in centimeters. The length of root from the base of the seed to the tip of the root was taken as the root length. The average of twenty five seedlings were recorded and expressed in centimeters. Vigour index was calculated as follows.

\[ VI = (\text{Average shoot length} + \text{Average Root length}) \times \text{Germination percentage} \]
The analysis for catalase and peroxidase enzyme activity was estimated as suggested by Gossett et al. (1994). The catalase enzyme activity was expressed in μg of H₂O₂/min/g and peroxidase in change in absorbance at 430nm/min/g respectively. All experiments were conducted in FRBD and statistical analysis was carried out as suggested by Panse and Sukhatme (1961).

RESULTS AND DISCUSSION

Germination percentage: Germination of seeds involve the activation of enzyme systems as well as mobilization of reserve foods and these process are adversely affected by NaCl (Levitt, 1980). Among the genotypes the highest germination percentage was observed in Pokkali (92.08), followed by Co 43 (Table 1) and the lowest germination percentage was observed in IR 50 (60.33). Among the salt doses, highest germination was observed in 100 mM (83.65) and lowest in 300 mM (67.41). Below 70 per cent germination was recorded in IR 50 showing the susceptible nature. Pokkali is a highly tolerant variety (above 90 per cent germination). It is clear from the study that there is a significant difference for germination percentage and interaction of genotypes and NaCl concentration. Decrease in germination percentage with the increase in salt concentration. The same trend was noticed by Maliwal and Paliwal (1971), Varsheney and Bajal (1985) and Singh and Rana (1989).

Shoot length (cm): Among the genotypes, Pokkali recorded the maximum (10.15 cm) and IR 50 recorded the minimum (7.97 cm) shoot length. Salt concentration 100 mM recorded the maximum (9.04 cm) and this was significantly higher than the rest. Like the germination percentage, shoot length also decreased when the salt concentration increased (Table 1). The interaction between genotypes and salt concentration were significant. At 300 mM, Pokkali recorded shoot length of 9.75 cm followed by ADT 38 (8.88 cm). Retardation of shoot length was more in susceptible genotypes like IR 50 which was 60.0 per cent of the control. Similar result was observed by Gill and Singh (1989).

Root length (cm): Among the genotypes, the highest root length was observed in Co 43 (8.55 cm) followed by Pokkali (8.46 cm). The lowest root length was observed in IR 50 (6.73 cm). Among the salt doses 100 mM recorded the maximum root length of 7.73 cm followed by 200 mM (7.44 cm). The interaction between genotypes and salt doses are highly significant (Table 2). The percentage of reduction of root length was higher in IR 50 (42.10); whereas the reduction was less in Pokkali (3.67) in tolerant varieties at 300 mM concentration over its control. Further a general trend of decrease in root length like shoot length, germination percentage with increase in salt was observed in all genotypes. Similar results were reported by Datta and Bal (1993). A comparison of shoot and root length indicates when salt concentration increases the length of shoot and root decreased. Percentage of decrease of shoot and root length was less for tolerant varieties than susceptible. Whereas intermediate growth response was noticed resulted moderately tolerant. This confirms the findings with Balakrishna and Iyengar (1980).

Vigour Index: IR 50 recorded a minimum (692.18) vigour index (Table 2). Salt concentration 100 mM recorded the maximum (1392.72) and the lowest vigour index in 300 mM (1138.99). There is decrease trend in vigour index when salt concentration increases. The interaction between varieties and salt concentration was significant. Similar trend was noticed in shoot, root length and germination percentage. Resistant genotypes showed less reduction of vigour index than susceptible. This suggest that genotypes constitution play an important role in seedling vigour.
Table 1. Effect of salt stress on germination percentage and shoot length

<table>
<thead>
<tr>
<th>Variety</th>
<th>Control</th>
<th>100mM</th>
<th>200mM</th>
<th>300mM</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germination percentage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co43</td>
<td>98.66</td>
<td>94.66</td>
<td>81.66</td>
<td>81.66</td>
<td>89.16</td>
</tr>
<tr>
<td>Pokkali</td>
<td>96.33</td>
<td>91.33</td>
<td>90.34</td>
<td>90.33</td>
<td>92.08</td>
</tr>
<tr>
<td>ADT38</td>
<td>92.00</td>
<td>88.66</td>
<td>84.20</td>
<td>69.33</td>
<td>85.54</td>
</tr>
<tr>
<td>IR 50</td>
<td>94.33</td>
<td>60.00</td>
<td>58.66</td>
<td>28.33</td>
<td>60.33</td>
</tr>
<tr>
<td>Mean</td>
<td>95.33</td>
<td>83.65</td>
<td>79.63</td>
<td>67.41</td>
<td>81.28</td>
</tr>
<tr>
<td>C.D (5%)</td>
<td>0.9159**</td>
<td>0.4317**</td>
<td>2.2436**</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Shoot length (cm)</th>
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<tbody>
<tr>
<td>Co43</td>
</tr>
<tr>
<td>Pokkali</td>
</tr>
<tr>
<td>ADT38</td>
</tr>
<tr>
<td>IR 50</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>C.D (5%)</td>
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Table 2. Effect of salt stress on root length (cm) and vigour index in rice genotypes

<table>
<thead>
<tr>
<th>Variety</th>
<th>Control</th>
<th>100mM</th>
<th>200mM</th>
<th>300mM</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root length (cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co43</td>
<td>9.64</td>
<td>8.26</td>
<td>8.22</td>
<td>8.08</td>
<td>8.55</td>
</tr>
<tr>
<td>Pokkali</td>
<td>8.66</td>
<td>8.48</td>
<td>8.36</td>
<td>8.35</td>
<td>8.46</td>
</tr>
<tr>
<td>ADT 38</td>
<td>8.97</td>
<td>7.85</td>
<td>7.33</td>
<td>7.08</td>
<td>7.80</td>
</tr>
<tr>
<td>IR 50</td>
<td>9.50</td>
<td>6.33</td>
<td>5.61</td>
<td>5.50</td>
<td>6.73</td>
</tr>
<tr>
<td>Mean</td>
<td>9.19</td>
<td>7.73</td>
<td>7.44</td>
<td>7.25</td>
<td>7.87</td>
</tr>
<tr>
<td>C.D (5%)</td>
<td>0.0640**</td>
<td>0.0302**</td>
<td>0.1570**</td>
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<table>
<thead>
<tr>
<th>Vigour index</th>
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<tbody>
<tr>
<td>Co43</td>
</tr>
<tr>
<td>Pokkali</td>
</tr>
<tr>
<td>ADT 38</td>
</tr>
<tr>
<td>IR 50</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>C.D (5%)</td>
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</table>

Catalase and Peroxidase enzyme activity: Salinity caused significant increase in the catalase and peroxidase enzyme activity. From Table 3, we infer that Pokkali showed a maximum activity of 301.2 µg of H2O2/min/g of catalase activity at 300mM followed by Co 43 (340.8 µg of H2O2/min/g). ADT 38 and IR 50 recorded a value of 240.6 and 280.1 µg of H2O2/min/g of catalase activity.

From Table 3, it was observed that salinity resulted in increased activity of peroxidase enzyme activity. The increase was more in Pokkali (13.63 change in absorbance at 430nm/min/g) followed by Co 43 (11.17
### Table 3. Catalase and peroxidase activity in rice genotypes with different levels of NaCl treatment

<table>
<thead>
<tr>
<th>Variety</th>
<th>Control</th>
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<th>200mM</th>
<th>300mM</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Catalase</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co43</td>
<td>198.7</td>
<td>208.8</td>
<td>261.4</td>
<td>340.8</td>
<td>254.42</td>
</tr>
<tr>
<td>Pokkali</td>
<td>234.1</td>
<td>248.1</td>
<td>291.2</td>
<td>361.2</td>
<td>283.65</td>
</tr>
<tr>
<td>ADT 38</td>
<td>172.4</td>
<td>184.2</td>
<td>198.6</td>
<td>240.6</td>
<td>198.95</td>
</tr>
<tr>
<td>IR 50</td>
<td>187.2</td>
<td>190.1</td>
<td>210.4</td>
<td>280.1</td>
<td>216.95</td>
</tr>
<tr>
<td>Mean</td>
<td>198.1</td>
<td>207.8</td>
<td>240.4</td>
<td>305.6</td>
<td>238.49</td>
</tr>
<tr>
<td>C.D (5%)</td>
<td>4.2</td>
<td>5.2</td>
<td>7.4</td>
<td>10.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Peroxidase</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Co43</td>
<td>3.92</td>
<td>6.01</td>
<td>7.84</td>
<td>11.17</td>
<td>7.23</td>
</tr>
<tr>
<td>Pokkali</td>
<td>5.80</td>
<td>8.62</td>
<td>10.12</td>
<td>13.63</td>
<td>9.54</td>
</tr>
<tr>
<td>ADT 38</td>
<td>3.08</td>
<td>4.01</td>
<td>5.39</td>
<td>7.08</td>
<td>4.89</td>
</tr>
<tr>
<td>IR 50</td>
<td>3.41</td>
<td>4.36</td>
<td>6.84</td>
<td>8.16</td>
<td>5.69</td>
</tr>
<tr>
<td>Mean</td>
<td>4.05</td>
<td>5.75</td>
<td>7.54</td>
<td>10.01</td>
<td>6.83</td>
</tr>
<tr>
<td>C.D (5%)</td>
<td>0.57</td>
<td>0.91</td>
<td>1.01</td>
<td>1.09</td>
<td></td>
</tr>
</tbody>
</table>

change in absorbance at 430 nm/min/g). ADT 38 and IR 50 had an activity of 7.08 and 8.16 (change in absorbance at 430 nm/min/g). The increase may be one of the reasons for the successful establishment of tolerant rice varieties under salt condition. The increase in catalase activity over control was observed which was in accordance with results of Badhani et al. (1990) which, in wheat. The increase in activity was due to increase in salt concentration. The percentage increase was more in tolerant cultivars showing that it has the natural capacity of withstanding the stressful condition. This was in par with the results of Zhang and Kirkham (1991). The increase in the content of antioxidant enzyme may be due to the higher levels of O2 produced under stress. This shows that an efficient defence mechanism may be involved in the increase of the antioxidant levels.

### REFERENCES