ASSESSMENT OF NODULATION IN THREE VARIETIES OF BLACK GRAM UNDER ELEVATED UV-B RADIATION

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ABSTRACT
Among symbiotic nitrogen fixing systems, nodulated legumes have been used in cropping systems for centuries. But change in environmental conditions like elevated UV-B can hinder the process of symbiotic nitrogen fixation. In this connection the impact of UV-B rays on nodulation in black gram (Vigna mungo (L.) Hepper), the nitrogen fixing grain legume is evaluated. The fully developed root systems were harvested on 30 and 45 DAS (days after seed germination) from three varieties of black gram viz. VAMBAN-3, NIRMAL-7 and T-9 after in situ supplementary UV-B radiation (2 hours daily @ 12.2 kJ m$^{-2}$ d$^{-1}$; ambient = 10 kJ m$^{-2}$ d$^{-1}$). Nodule number fell below control after UV-B exposure at all stages of plant growth. NIRMAL-7 recorded heavy reduction in nodule number on 30 DAS (63.63 %) and 45 DAS (80 %). VAMBAN-3 showed only little inhibition (28.20 %) in nodulation on 30 DAS, but the suppression was severe on 45 DAS (82.35 %). T-9 which showed only 4.65 % reduction in nodule number at early stage, recorded 41.17 % reduction on 45 DAS. Nodules weighed less than their controls in NIRMAL-7 (14.37 to 64.86 %), VAMBAN-3 (26.67 to 41.66 %) and T-9 (6.29 to 9.36 %).

Keywords: Ultraviolet-B, Black Gram, Three Varieties, Nodulation

INTRODUCTION
The economic and environmental costs of the heavy use of chemical nitrogen fertilizers in agriculture are a global concern. Sustainability considerations mandate that alternatives to nitrogen fertilizers must be urgently sought. Biological nitrogen fixation, a microbiological process which converts atmospheric nitrogen into a plant usable form, offers this alternative Bohlool et al., (1992). Adverse environmental conditions created by stresses like salt, drought, acidity, alkalinity, nutrient deficiency, fertilizers, heavy metals, and pesticides suppress the growth and symbiotic characteristics of most Rhizobia; however, several strains, distributed among various species of Rhizobia, are tolerant to stress effects (Zahran 1999). The present work is an effort to screen the effect of yet another abiotic stress viz., ultraviolet-B rays on nodulation in three varieties of black gram.

MATERIALS AND METHODS
Black gram (Vigna mungo (L.) Hepper) the nitrogen fixing grain legume was chosen for the study. Viable seeds of the three varieties of black gram viz. VAMBAN-3, NIRMAL-7 and T-9 were procured from Saravana Farms, Villupuram, Tamil Nadu and from local farmers in Pondicherry. The seeds were selected for uniform colour, size and weight and used in the experiments. The crops were grown in pot culture in the naturally lit greenhouse (day temperature maximum 38 ± 2 °C, night temperature minimum 18 ± 2 °C, relative humidity 60 ± 5 %, maximum irradiance (PAR) 1400 µmol m$^{-2}$ s$^{-1}$, photoperiod 12 to 14 h). Supplementary UV-B radiation was provided in UV garden by three UV-B lamps (Philips TL20W/12 Sunlamps, The Netherlands), which were suspended horizontally and wrapped with cellulose diacetate filters (0.076 mm) to filter UV-C radiation (< 280 nm). UV-B exposure was given for 2 h daily from 10:00 to 11:00 and 15:00 to 16:00 starting from the 5th day after sowing. Plants received a biologically effective UV-B dose (UV-B$_{BE}$) of 12.2 kJ m$^{-2}$ d$^{-1}$ equivalent to a simulated 20 % ozone depletion at Pondicherry (12°2’N, India). The control plants, grown under natural solar radiation, received UV-B$_{BE}$ 10 kJ m$^{-2}$ d$^{-1}$. Ten plants from each treatment were carefully uprooted from the soil at 30 and 45 DAS when the nodulation was at its peak and the number and fresh weight of nodules were recorded after removing the soil particles by
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washing them repeatedly and blotting to dryness. Whole plants and plant parts were photographed in daylight using a Sony digital camera fitted with appropriate close-up accessories. At least ten replicates were maintained for all treatments and control. The experiments were repeated to confirm the trends. The result of single linkage clustering (Maskay, 1998) was displayed graphically in the form of a diagram called dendrogram (Everstt, 1985).

The term dendrogram is used in numerical taxonomy for any graphical drawing giving a tree-like description of a taxonomic system. The similarity indices between the three varieties of black gram under study were calculated using the formula given by Bhat and Kudesia (2011).

\[
\text{Similarity index} = \frac{\text{Total number of similar characters}}{\text{Total number of characters studied}} \times 100
\]

Based on the similarity indices between the three varieties of black gram, dendrogram was draw to derive the interrelationship between them and presented in tables and plates.

RESULT AND DISCUSSION

Nodule number in all the UV-B irradiated varieties of black gram were always less than the control on 30 and 45 DAS. A reduction of 63.63 % and 80 % was recorded on 30 and 45 DAS respectively in NIRMAL-7. Even though VAMBAN-3 recorded only 28.20 % reduction in nodulation on 30 DAS, the suppression was severe on 45 DAS as it reached 82.35 % reduction. T-9 which showed a sign of recovery with only 4.65 % less than control crops, on prolonged UV-B exposure recorded 41.17 % reduction on 45 DAS.

The inhibitory tendency of UV-B continued in fresh weight of nodules also. The nodules in NIRMAL-7 variety of black gram weighed less by 14.37 to 64.86 % compared to control on 30 and 45 DAS followed by VAMBAN-3 (26.67 to 41.66 %). T-9 was least affected by UV-B as the nodules weighed better than other two varieties showing only 6.29 to 9.36 % reduction (Table 1, Plate 1).


Table 1: Changes in nodulation of three varieties of 30 and 45 DAS Vigna mungo (L.) Hepper under control and supplementary UV-B exposed conditions – In situ

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Treatment</th>
<th>Nodule number plant (^{-1})</th>
<th>Fresh weight of nodule plant (^{-1}) (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 DAS</td>
<td>45 DAS</td>
<td>30 DAS</td>
</tr>
<tr>
<td>VAMB-3</td>
<td>Control</td>
<td>39</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>UV-B</td>
<td>28</td>
<td>3</td>
</tr>
<tr>
<td>NIRMAL-7</td>
<td>Control</td>
<td>22</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>UV-B</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>T-9</td>
<td>Control</td>
<td>43</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>UV-B</td>
<td>41</td>
<td>7</td>
</tr>
</tbody>
</table>
Plate 1: Comparative gross morphology of root systems showing nodulation in three varieties of *Vigna mungo* (L.) Hepper on 45 DAS. (1: Control, 2: UV-B)
Plate 2: Dendrogram showing the interrelationship between the three varieties of Vigna mungo (L.) Hepper in nodulation under control and supplementary UV-B - In situ

Table 2: The similarity indices in nodulation of three varieties of Vigna mungo (L.) Hepper under supplementary UV-B exposed conditions – In situ

<table>
<thead>
<tr>
<th>Varieties</th>
<th>VAMBAN-3</th>
<th>NIRMAL-7</th>
<th>T-9</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAMBAN-3</td>
<td>100%</td>
<td>62.5%</td>
<td>50%</td>
</tr>
<tr>
<td>NIRMAL-7</td>
<td>62.5%</td>
<td>100%</td>
<td>37.5%</td>
</tr>
<tr>
<td>T-9</td>
<td>50%</td>
<td>37.5%</td>
<td>100%</td>
</tr>
</tbody>
</table>

The number and fresh weight of nodules in three varieties of black gram exhibited differences on 30 and 60 DAS due to in situ supplementary UV-B radiation. NIRMAL-7 and T-9 varieties formed one group with 37.5% similarity index between them (Table 2; Plate 2). VAMBAN-3 remaining alone in the cluster had 62.5% and 50% similarity indices with NIRMAL-7 and T-9 respectively.

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REFERENCES


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