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Research Article

IMPACT OF SUPPLEMENTARY ULTRAVIOLET-B RADIATION ON THE NODULATION IN THREE VARIETIES OF GREEN GRAM

***Rajendiran K., Vidya S. and Arulmozhi D.**
Department of Botany, K.M. Centre for Post Graduate Studies, Pondicherry - 605 008, India
**Author for Correspondence*

ABSTRACT
In symbiotic associations, both partners are subject to biological constraints, such as disease and predation which can directly or in directly affect the amount of nitrogen fixed, as well as the quantity made available to other components of the cropping system. In addition, adverse climatic conditions can also cause disturbance in the nitrogen assimilation processes. Hence a plot was hatched out to evaluate the variations in nodulation in three varieties of green gram (*Vigna radiata* (L.) Wilczek.) *viz.* CO-8, NVL-585 and VAMBAN-2 under *in situ* supplementary ultraviolet-B (UV-B) radiation. The fully developed root systems were harvested on 30 and 45 DAS (days after seed germination) from three varieties of green gram after exposure to supplementary UV-B radiation (2 hours daily @ 12.2 kJ m^{-2} d^{-1}; ambient = 10 kJ m^{-2} d^{-1}). The nodule formation in all the varieties of green gram was always below than their respective controls after UV-B radiation. Reduction in nodulation (above 55 %) by UV-B occurred on 30 DAS in all varieties. VAMBAN-2 recovered from UV-B stress and recorded a minimum of 30.76 % less nodules than control on 45 DAS. The suppressive nature of UV-B radiation continued in NVL-585 and CO-8 varieties of green gram as they exhibited heavy nodule reduction (58.33 and 70 %) than their controls on 45 DAS. The same trend continued with fresh weight of nodules showing reductions below control on 30 DAS (55.56 to 65.22 %) and on 45 DAS (45.45 to 66.67 %).

Keywords: *Ultraviolet-B, Green Gram, Three Varieties, Nodulation*

INTRODUCTION
Symbiotic systems such as that of legumes and *Rhizobium* can be a major source of nitrogen in most cropping systems. While several environmental factors that affect biological nitrogen fixation have been studied, uncertainties still remain on how legume-*Rhizobium* association responds to elevated ultraviolet-B environment (Zahran 1999). The present work evaluates the nodulation in three varieties of green gram under *in situ* ultraviolet-B condition.

MATERIALS AND METHODS
Green gram (*Vigna radiata* (L.) Wilczek.), the nitrogen fixing grain legume was chosen for the study. Viable seeds of the three varieties of green gram *viz.* CO-8, NVL-585 and VAMBAN-2 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 ºC, night temperature minimum 18 ± 2 ºC, 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 ($UV\text{-}B_{BE}$) of 12.2 kJ m^{-2} d^{-1} equivalent to a simulated 20 % ozone depletion at Pondicherry (12º2'N, India). The control plants, grown under natural solar radiation, received $UV\text{-}B_{BE}$ 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 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 green 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 green gram, dendrogram was draw to derive the interrelationship between them and presented in tables and plates.

RESULTS AND DISCUSSION

The number of nodules in the UV-B irradiated three varieties of green gram was always less than the control. A reduction above 55 % was recorded on 30 DAS in all varieties of green gram after UV-B exposure, while VAMBAN-2 on 45 DAS showed a sign of recovery as the reduction was only 30.76 %. However the suppressive tendency of UV-B irradiation continued in the remaining two varieties *viz.,* NVL-585 and CO-8 as they produced less number of nodules compared to their controls by 58.33 and 70 % respectively on 45 DAS. The inhibitory tendency of UV-B continued in fresh weight of nodules also. The nodules of all the three varieties of green gram weighed less by 55.56 to 65.22 % below control on 30 DAS and by 45.45 to 66.67 % on 45 DAS (Table 1, Plate 1). These results were in accordance with the reports of Rajendiran and Ramanujam (2006) in green gram, Sudaroli and Rajendiran (2013a) in *Sesbania grandiflora* (L.) Pers., Sudaroli and Rajendiran (2013b) in *Vigna unguiculata* (L.) Walp. c.v. BCP-25, Kokilavani and Rajendiran (2014) in ten varieties of cowpea, Sudaroli Sudha and Rajendiran (2014a) in *Vigna unguiculata* (L.) Walp. cv. COVU-1, Sudaroli and Rajendiran (2014b) in *Vigna mungo* (L.) var. T-9, Sudaroli and Rajendiran (2014c) in *Vigna unguiculata* (L.) Walp. c.v. CO-1, Arulmozhi and Rajendiran (2014a) in *Lablab purpureus* L. var. Goldy, Arulmozhi and Rajendiran (2014b) in hyacinth bean, Arulmozhi and Rajendiran (2014c) in *Vigna unguiculata* (L.) Walp. cv. COFC-8, Vijayalakshmi and Rajendiran (2014a) in *Cyamopsis tetragonoloba* (L.) Taub. var. PNB, Vijayalakshmi and Rajendiran (2014b) in *Phaseolus vulgaris* L. cv. Prevail and Vijayalakshmi and Rajendiran (2014c) in *Vigna unguiculata* (L.) Walp. cv. CW-122 after UV-B irradiation. Rajendiran (2001) opined that UV-B stressed shoot system decreased allocation of food to root system which reacted quickly with reduced root system, thereby providing lesser surface area for *Rhizobium* inoculation and root nodules formation.

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

Varieties	Treatment	Nodule number plant $^{-1}$		Fresh weight of nodule plant $^{-1}$ (g)	
		30 DAS	45 DAS	30 DAS	45 DAS
CO-8	Control	14	10	0.023	0.006
	UV-B	9	3	0.008	0.002
NVL-585	Control	20	12	0.036	0.022
	UV-B	9	5	0.016	0.012
VAMBAN-2	Control	25	13	0.047	0.010
	UV-B	9	9	0.019	0.005

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

Varieties	CO-8	NVL-585	VAMBAN-2
CO-8	100%	30%	50%
NVL-585	30%	100%	30%
VAMBAN-2	50%	30%	100%

Figure 1: CO-8

Figure 2: NVL-585

Figure 3: VAMBAN-2

Plate 1: Comparative gross morphology of root systems showing nodulation in three varieties of *Vigna radiata* (L.) Wilczek on 30 DAS (1: Control, 2: UV-B)

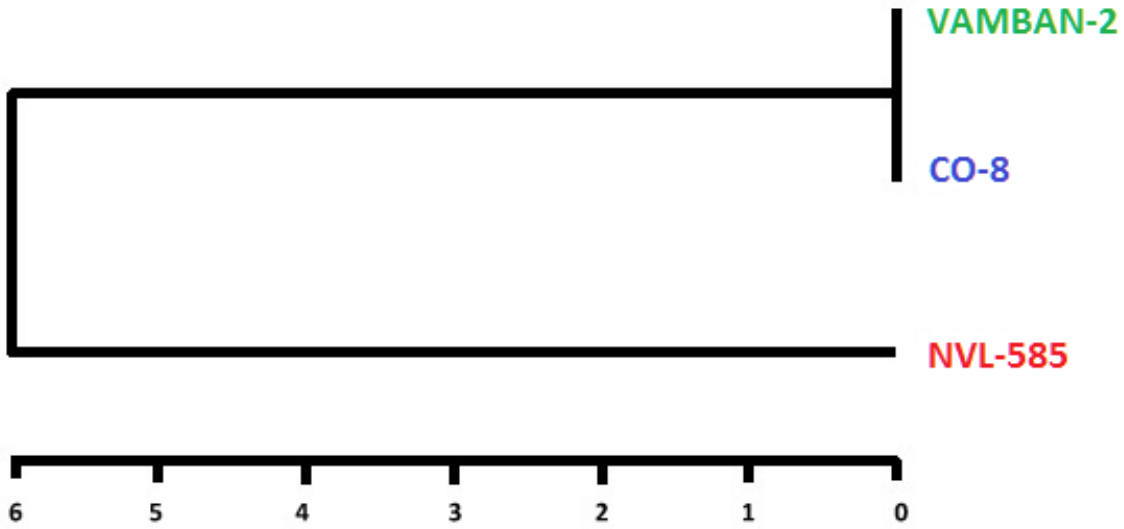

Plate 2: Dendrogram showing the interrelationship between the three varieties of *Vigna radiata* (L.) Wilczek in nodulation under control and supplementary UV-B - *In situ*

The similarity index divided the three varieties into two groups consisting of two members and one member. The two varieties *viz.,* CO-8 and VAMBAN-2 formed one group showing 50 % similarity the highest affinity recorded among varieties (Table 2; Plate 2). The other group consisting of a lone member NVL-585 showed similarities of 58.33 and 56.66 % with NVL-585 and VAMBAN-2 respectively.

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