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Research Article

ULTRAVIOLET-B RADIATION INDUCED SUPPRESSION OF NODULATION IN THREE VARIETIES OF COWPEA

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ABSTRACT
Nitrogen is one of the main chemical elements required for plant growth and reproduction. Nitrogen is a component of chlorophyll and therefore essential for photosynthesis. It is also the basic element of plant and animal proteins, including the genetic material DNA and RNA, and is important in periods of rapid plant growth. The present study deals with the assessment of nodulation in three varieties cowpea (*Vigna unguiculata* (L.) Walp.) *viz.* GOWMATHI, FOLA and NS-634 in ultraviolet-B (UV-B) elevated environment. The well developed root systems were harvested on 30 and 45 DAS (days after seed germination) from three varieties of cowpea, *Vigna unguiculata* (L.) 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 number of nodules in all the UV-B stressed plants was always less than the control. On 30 DAS the reduction in number of nodules was heavy above (65 %) in all the varieties. While GOWMATHI recovered on 45 DAS showing only little reduction (11.76 %), UV-B induced suppression continued in the other two varieties *viz.*, FOLA and NS-634 (65 %). The fresh weight of nodules was reduced by UV-B radiation in the three varieties of cowpea on 30 DAS (4.19 to 89.29 %) as well as on 45 DAS (61.45 to 80.52 %).

Keywords: *Ultraviolet-B, Cowpea, Three Varieties, Nodulation*

INTRODUCTION
Supply of useable nitrogen into the soil and the rate of depletion from the soil affect the sustainability of production. If left unnoticed, continued loss of nitrogen can result in economic loss to the producer and cause grave environmental repercussions. Biological nitrogen fixation represents the major source of nitrogen input in crop fields and plays a significant role in improving the fertility and productivity of nitrogen deficient soils. Change in environmental conditions such as salt stress, drought stress, 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). In this connection, this study reports the nodulating efficiency of three varieties of cowpea grown under ultraviolet-B stress.

MATERIALS AND METHODS
Cowpea (*Vigna unguiculata* (L.) Walp.) belonging to the family Fabaceae which is a nitrogen fixing grain legume was chosen for the study. Viable seeds of the three varieties of cowpea *viz.* GOWMATHI, FOLA and NS-634 (Namdhari Seeds) 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-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-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 ten varieties of cowpea 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 cowpea, dendrogram was draw to derive the interrelationship between them and presented in tables and plates.

RESULTS AND DISCUSSION

Nitrogen calls the tune in the performance of the plant. For this reason investigating the nodulation becomes critical, especially when the test plants are legumes. Assessed at a time when the nodulation is reportedly peaking (30 and 45 DAS), nodule number in all the UV-B irradiated varieties of cowpea were always less than the control. A reduction above 65 % was recorded on 30 DAS while out of the three varieties, GOWMATHI showed a sign of recovery as the reduction was only 11.76 % on 45 DAS. However the suppressive tendency of UV-B irradiation continued in the remaining two varieties *viz.*, FOLA and NS-634 as they produced less than 65 % of nodules even on 45 DAS. The inhibitory tendency of UV-B continued in fresh weight of nodules also. The nodules weighed less by 4.19 to 89.29 % below control on 30 DAS and 61.45 to 80.52 % on 45 DAS (Table 1, Plate 1). Similar results of reduced nodulation were reported in UV-B irradiated green gram by Rajendiran and Ramanujam (2006), in *Sesbania grandiflora* (L.) Pers. by Sudaroli and Rajendiran (2013a), in *Vigna unguiculata* (L.) Walp. c.v. BCP-25 by Sudaroli and Rajendiran (2013b), in ten varieties of cowpea by Kokilavani and Rajendiran (2014), in *Vigna unguiculata* (L.) Walp. cv. COVU-1 by Sudaroli and Rajendiran (2014a), in *Vigna mungo* (L.) var. T-9 by Sudaroli and Rajendiran (2014b), in *Vigna unguiculata* (L.) Walp. c.v. CO-1 by Sudaroli and Rajendiran (2014c), in *Lablab purpureus* L. var. Goldy by Arulmozhi and Rajendiran (2014a), in hyacinth bean by Arulmozhi and Rajendiran (2014b), in *Vigna unguiculata* (L.) Walp. cv. COFC-8 by Arulmozhi and Rajendiran (2014c), in *Cyamopsis tetragonoloba* (L.) Taub. var. PNB by Vijayalakshmi and Rajendiran (2014a), in *Phaseolus vulgaris* L. cv. Prevail by Vijayalakshmi and Rajendiran (2014b) and in *Vigna unguiculata* (L.) Walp. cv. CW-122 by Vijayalakshmi and Rajendiran (2014c). 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 (Rajendiran 2001).

Table 1: Changes in nodulation of three varieties of Vigna *unguiculata* (L.) Walp. on 30 and 45 DAS 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
GOWMATHI	Control	45	13	0.0446	0.0684
	UV-B	15	15	0.0066	0.0162
FOLA	Control	20	21	0.1169	0.0262
	UV-B	6	8	0.112	0.0101
NS-634	Control	20	24	0.0971	0.048
	UV-B	6	10	0.0104	0.009

Figure 1: GOWMATHI

Figure 2: FOLA

Figure 3: NS-634

Plate 1: Comparative gross morphology of root systems showing nodulation in three varieties of *Vigna unguiculata* (L) Walp. on 45 DAS. (1: Control, 2: UV-B)

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

Varieties	**GOWMATHI**	**FOLA**	**NS-634**
GOWMATHI	100%	12.5%	55.55%
FOLA	12.5%	100%	62.5%
NS-634	55.55%	62.5%	100%

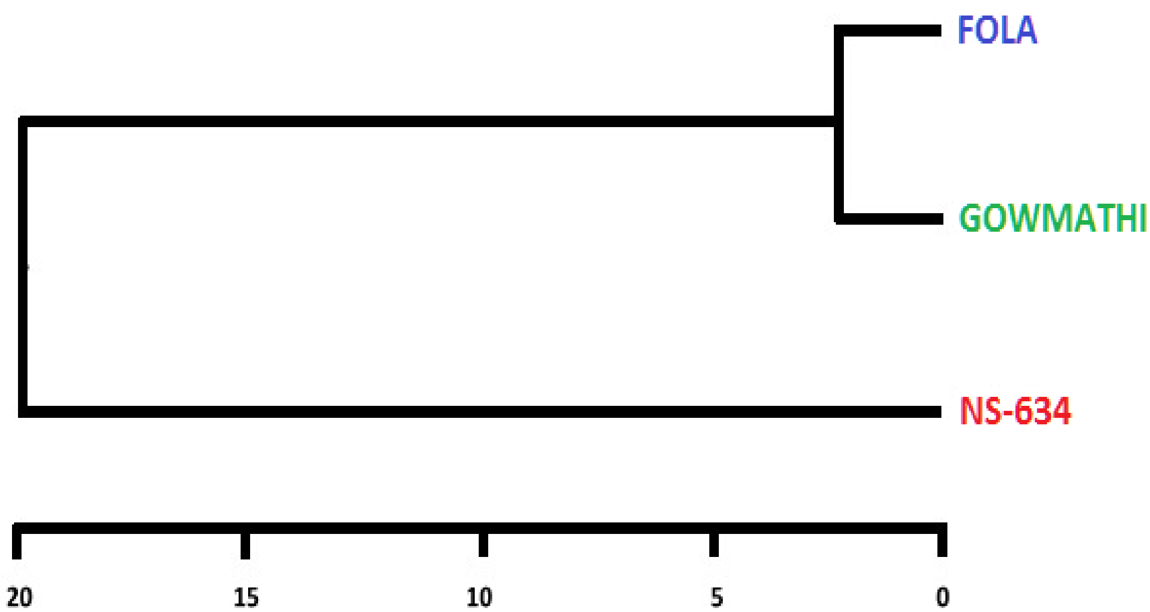

Plate 2: Dendrogram showing the interrelationship between the three varieties of *Vigna unguiculata* (L.) Walp. in nodulation under control and supplementary UV-B- *In situ.*

The number and fresh weight of nodules in three varieties of cowpea exhibited differences on 30 and 60 DAS due to *in situ* supplementary UV-B radiation. The similarity index divided the three varieties equally into two groups. The two varieties *viz.*, FOLA and GOWMATHI formed one group showing only 12.5 % similarities. The NS-634 alone showed 62.5 and 55.55 % similarity with NS-634 and GOWMATHI respectively (Table 2; Plate 2). From the overall results, it is concluded that out of the three varieties of cowpea *viz.*, GOWMATHI, FOLA and NS-634 receiving UV-B, GOWMATHI is best suited for cultivating in ultraviolet-B enhanced environment as it survived with very little nodule reduction.

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