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Research Article

IMPACT OF SUPPLEMENTARY UV-B RADIATION ON THE MORPHOLOGY AND GROWTH OF *IN SITU* GROWN THREE GREEN GRAM VARIETIES

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

ABSTRACT

The growth parameters studied in three varieties of green gram *viz.* CO-8, NVL-585 and VAMBAN-2 after *in situ* supplementary ultraviolet-B (UV-B) radiation (2 hours daily @ 12.2 kJ m^{-2} d^{-1}; ambient = 10 kJ m^{-2} d^{-1}) showed variations in the plant height, number of leaves, total leaf area, fresh weight, dry weight and relative growth rate during different stages of growth (15, 30, 45 and 60 DAS - days after sowing). Number of leaves was reduced by 33.33 % under UV-B stress in all varieties on 30 DAS compared to controls, but the crops recovered quickly equalling controls at later stages, with only CO-8 showing a reduction (33.33 %) during harvest stage. UV-B reduced the total leaf area (15.32 to 67.33 %), specific leaf weight (SLW) (16.86 to 49.71 %), fresh weight of leaves (12.49 to 78.22 %) and dry weight (23.09 to72.74 %) at all stages of growth. UV-B exposures reduced root length (10.86 to 74.07 %) and shoot length (16.25 to 39.60 %). VAMBAN-2 had less S / R ratio (10.91 % on 15 DAS) under UV-B stress while CO-8 and NVL-585 recorded higher values (7.2 to 44.30 %) till 60 DAS over control. Fresh weight of roots increased with age in all treatments. But the biomass accumulation in root was inhibited by UV-B treatment by 13.29 to 69.87 % on 15 DAS, the maximum reduction being in CO-8. On 30, 45 and 60 DAS all the varieties of green gram did not show any recover as the reduction continued to reach 27.06 to 77.28 %. UV-B stress imposed a general decrease in fresh weight (11.27 to 78.22 %), root biomass (18.85 to 93.97 %) and plant dry weight (58.40 to 70.29 %). The relative growth rate (RGR) was enhanced in all UV-B irradiated plants as the values were significantly higher (66.66 %) over control. The performances of CO-8 and VAMBAN-2 varieties of green gram were very poor under UV-B exposure at all stages of growth.

Keywords: *Ultraviolet-B, Green Gram, Three Varieties, Morphology, Growth*

INTRODUCTION

Plant habit is carved out by the habitat where it grows. However, the environmental factors of a place become limiting factors when they cross the ideal levels supporting plant growth. Depletion in Earth's stratospheric ozone allowing ultraviolet-B (UV-B) radiation into the atmosphere would create such stress on the growth and morphology of the crop that struggles to tide over unfavourable conditions and grow normally (Rajendiran, 2001). Enhancement in UV-B radiation damages the leaves to larger extent (Kokilavani and Rajendiran, 2013; Kokilavani and Rajendiran, 2014a; Kokilavani and Rajendiran, 2014b; Kokilavani and Rajendiran, 2014c; Kokilavani and Rajendiran, 2014d; Kokilavani and Rajendiran, 2014f; Kokilavani and Rajendiran, 2014g; Kokilavani and Rajendiran, 2014h; Kokilavani and Rajendiran, 2014j; Kokilavani and Rajendiran, 2014k; Kokilavani and Rajendiran, 2014l; Kokilavani and Rajendiran, 2014m; Kokilavani and Rajendiran, 2014n; Kokilavani and Rajendiran, 2015a; Kokilavani and Rajendiran, 2015b), inhibits plant growth (Rajendiran and Ramanujam, 2003; Rajendiran and Ramanujam, 2004; Kokilavani and Rajendiran, 2014o), reduces harvest (Kokilavani and Rajendiran, 2014e) and suppresses nodulation and nitrogen metabolism (Rajendiran and Ramanujam, 2003; Sudaroli and Rajendiran, 2013a; Sudaroli and Rajendiran, 2013b; Kokilavani and Rajendiran, 2014i; Sudaroli and Rajendiran, 2014a; Sudaroli and Rajendiran, 2014b; Sudaroli and Rajendiran, 2014c; Arulmozhi and Rajendiran, 2014a; Arulmozhi and Rajendiran, 2014b; Arulmozhi and Rajendiran, 2014c; Vijayalakshmi and Rajendiran, 2014a; Vijayalakshmi and Rajendiran, 2014b; Vijayalakshmi and Rajendiran, 2014c) in a variety of sensitive crops. Even though literature on UV-B and plant interaction is voluminous, most of the studies deal with the gross effects on growth and yield under controlled environmental conditions and hardly 5% of the over 600 publications relate to field studies (Caldwell *et al.*, 1998). According to Adamse and Britz (1992) and Jordan (1997) this has been blamed as the major defect leading to overstating the damaging influence of UV-B as plants under natural day light conditions with high PAR (photosynthetically active radiation) are affected very little. This work gains significance as the three varieties of green gram *viz.* CO-8, NVL-585 and VAMBAN-2 were grown under field conditions (*in situ*) allowing the interaction of PAR (photosynthetically active radiation) and other environmental factors with ultraviolet-B radiation.

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 $\mu mol\ m^{-2}\ s^{-1}$, 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 on 15, 30, 45 and 60 DAS and their axial growth (roots and shoot length and plant height) and fresh biomass were measured. They were then dried in an oven at 80º C for 48 h and weighed again for dry mass measurements. Alongside, morphological and developmental abnormalities if any, caused by UV-B radiation were also recorded. Assessment of growth of ten varieties of cowpea on 15, 30, 45 and 60 DAS were recorded and calculated using standard methods. Ten plants were selected at random from each of the treatments. The leaf area (the leaflets from all the nodes) was determined at various stages using Area meter (Analytical Development Corporation, UK, model AM100). The total leaf area per plant was obtained by summing up the area of the leaves from all the nodes of the plant. Leaf area index (LAI) (Williams 1946), specific leaf weight (SLW) (Pearce *et al.*, 1968), relative growth rate (RGR) (Williams, 1946) and shoot / root ratio (Racey *et at.*, 1983) were calculated using the following formulae.

$$\text{LAI} = \frac{\text{Leaf area of the plants (cm}^2\text{)}}{\text{Ground area occupied (cm}^2\text{)}}$$

$$\text{SLW} = \frac{\text{Leaf dry weight (g)}}{\text{Leaf area (m}^2\text{)}}$$

$$\text{RGR} = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{t_2 - t_1}$$

where, W_1 and W_2 are dry masses of whole plants at t_1 and t_2 (time in days) respectively.

$$\text{S/R ratio} = \frac{\text{Shoot weight (g)}}{\text{Root weight (g)}}$$

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 green gram, dendrograms were draw to derive the interrelationship between them and presented in tables and plates.

RESULTS AND DISCUSSION

The responses of three varieties of green gram *viz.* CO-8, NVL-585 and VAMBAN-2 in control and supplementary UV-B irradiation under *in situ* condition were assessed in terms of growth on 15, 30, 45 and 60 DAS and yield performances at the final stage (60 DAS). There were fewer leaves only (33.33 %) under UV-B stress in all the three varieties of green gram on 30 DAS compared to their respective controls.

However all the stressed plants recovered quickly to have more number of leaves and equalled the controls on 30, 45 and 60 DAS except CO-8 which had a reduction by 33.33 % during harvest stage. Supplementary UV-B irradiation reduced the total leaf area throughout the growth period starting with a severe reduction of 52.06 to 66.98 % on 15 DAS and after a short recovery on 30 and 45 DAS reaching a reduction of 15.32 to 67.33 % on 60 DAS (Table 1 to 4; Plate 1).

CO-8 and VAMBAN-2 performed poorly at all stages compared with NVL-585 under UV-B. The trend that was observed in total leaf area continued with LAI also. The LAI was reduced by UV-B exposure to a larger extent, the maximum reduction being 93.55 % below control on 30 DAS in CO-8. Out of the three green gram varieties NVL-585 and VAMBAN-2 recorded a recover as they showed only 1 to 2 % less LAI on 60 DAS, while CO-8 still showed 23.51 % suppression.

The SLW in UV-B irradiated decreased with age. An average decrease ranging from 16.86 to 49.71 % was observed on 15, 30, 45 and 60 DAS in all the three varieties of green gram. However, the pattern of SLW reduction (45.83 to 49.71 %) was very severe in all the varieties on 60 DAS.

UV-B stress decreased the fresh weight of leaves by 12.49 to 78.22 %, with maximum reductions being on 15 DAS. However, except VAMBAN-2 other two varieties suffered heavily under UV-B radiation on 30, 45 and 60 DAS. The trend recorded in fresh weight continued with dry weight of foliage at all stages of UV-B exposed green gram crops. UV-B suppressed dry weight of foliage by 23.09 to72.74 % on 15, 30, 45 and 60 DAS (Table 1 to 4). On prolonged exposure to UV-B the leaves of all the three varieties of green gram exhibited various kinds of abnormalities. The leaves became generally pale which at times occurred in patches. The yellowing intensified and became discretely chlorotic. Browning developed in patches indicating necrosis of the underlying tissues during later stages.

Necrotic lesions appeared in older leaves which have received UV-B over a long time. The leaves also exhibited bronzing and became silvery and brittle (Plate 2 to 4). Similar results were reported by Kokilavani and Rajendiran (2014o) in ten varieties of cowpea, Rajendiran *et al.*, (2015a) in *Amaranthus dubius* Mart. Ex. Thell., Rajendiran *et al.*, (2015b) in *Macrotyloma uniflorum* (Lam.) Verdc., Rajendiran *et al.*, (2015c) in *Momordica charantia* L., Rajendiran *et al.*, (2015d) in *Spinacia oleracea* L., Rajendiran *et al.*, (2015e) in *Trigonella foenum-graecum* (L.) Ser., Rajendiran *et al.*, (2015f) in *Benincasa hispida* (Thunb.) Cogn. and Rajendiran *et al.*, (2015h) in *Vigna mungo* (L.) Hepper var. ADT-3 after enhanced UV-B exposure. On the contrary Rajendiran *et al.*, (2015g) in *Portulaca oleracea* L. reported healthy and more number of leaves after UV-B irradiation. Reductions in leaf area and mass were observed in the field-grown sweetgum plants exposed to elevated UV-B radiation (Sullivan *et al.*, 1994). According to Britz and Adamse (1994) changes in the leaf area and dry mass indicated that cell elongation as well as cell contents were affected. According to Britz and Adamse (1994) inhibitions are part of general UV-B effects.

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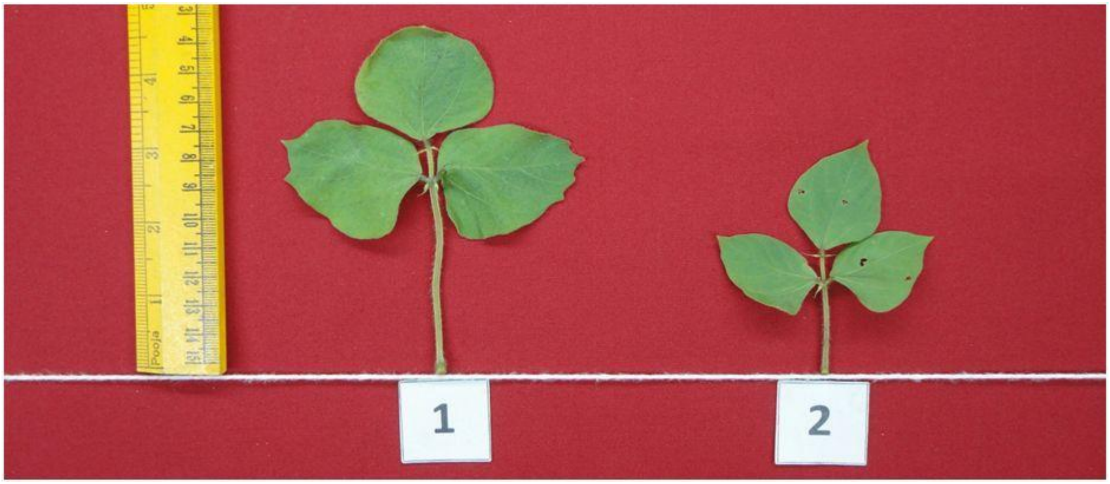

Figure 1: CO-8

Figure 2: NVL-585

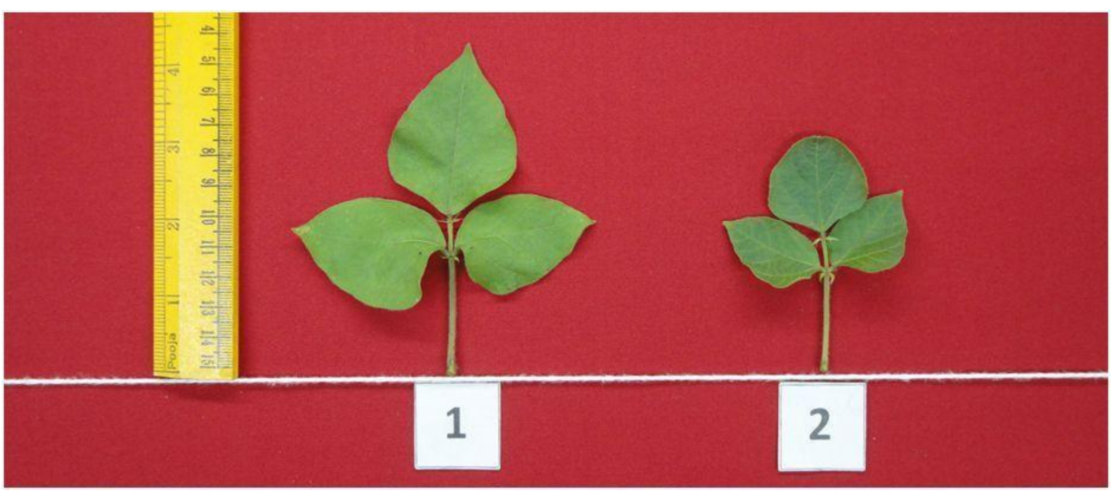

Figure 3: VAMBAN-2

Plate 1: First fully expanded trifoliate leaves from the three varieties of *Vigna radiata* (L.) Wilczek on 45 DAS. (1: Control, 2: UV-B)

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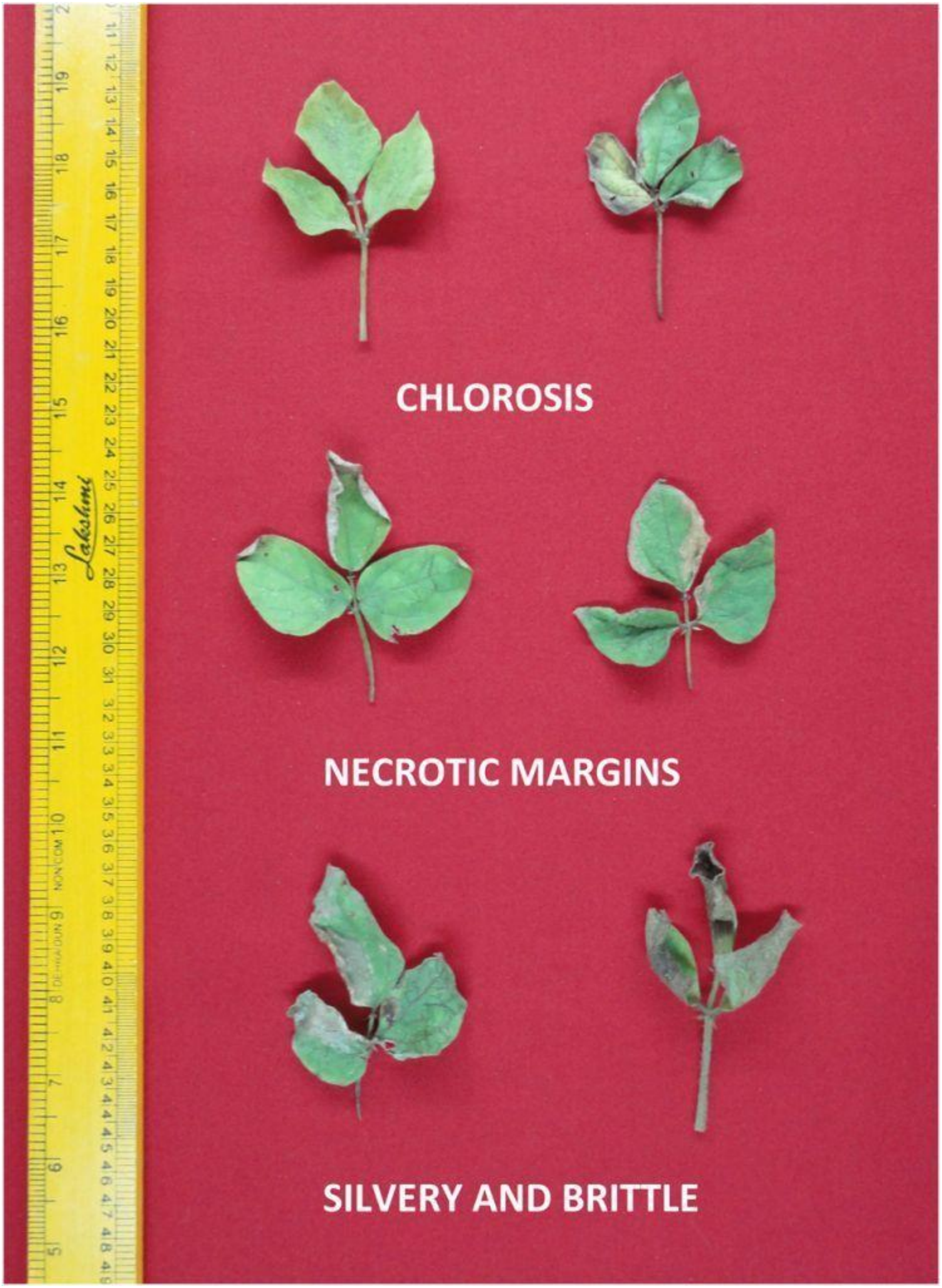

Plate 2: Types of foliar injury caused by elevated UV-B radiation in *Vigna radiata* (L.) Wilczek var. CO-8 on 30 DAS

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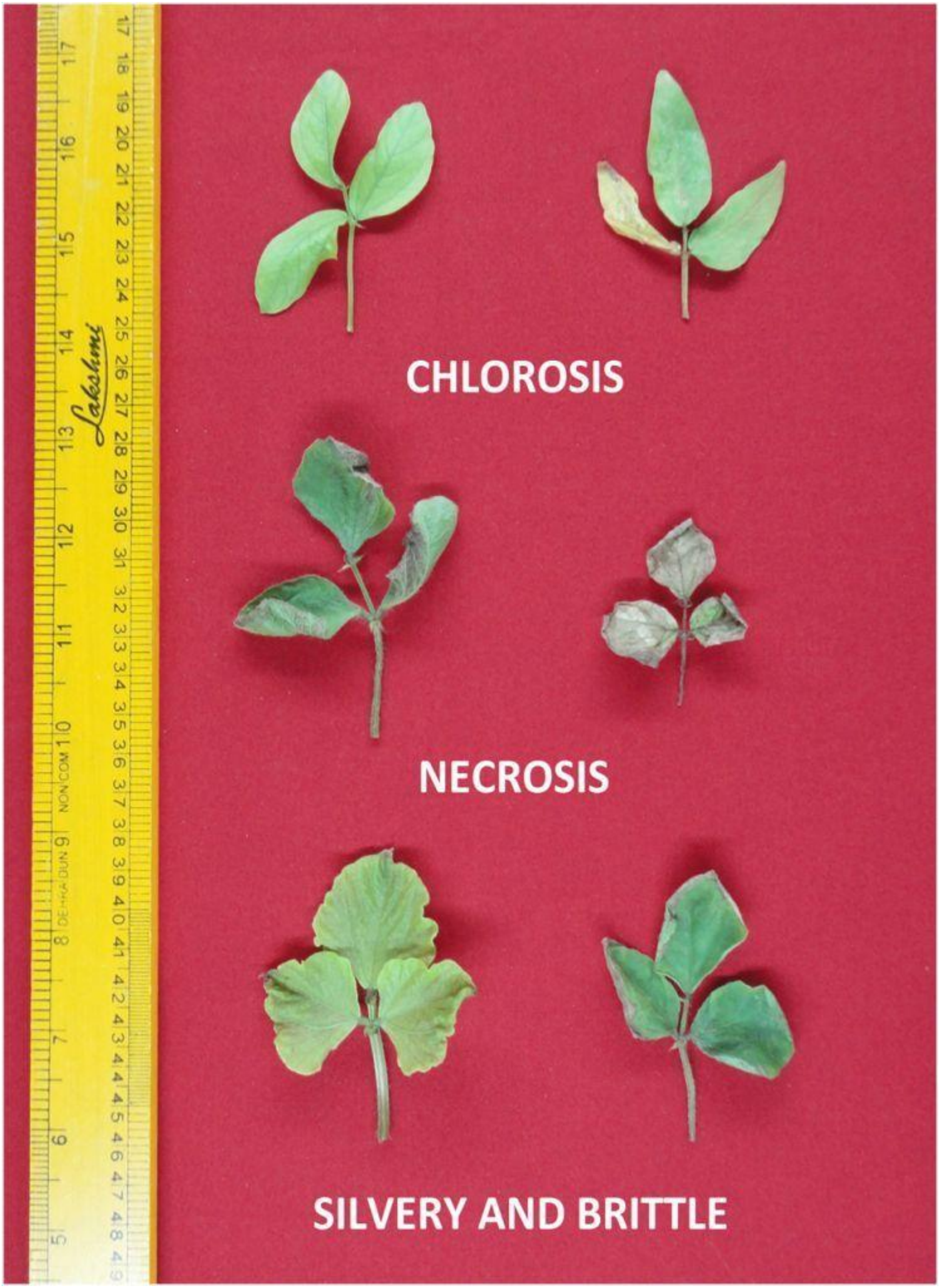

Plate 3: Types of foliar injury caused by elevated UV-B radiation in *Vigna radiata* (L.) Wilczek var. NVL-585 on 30 DAS

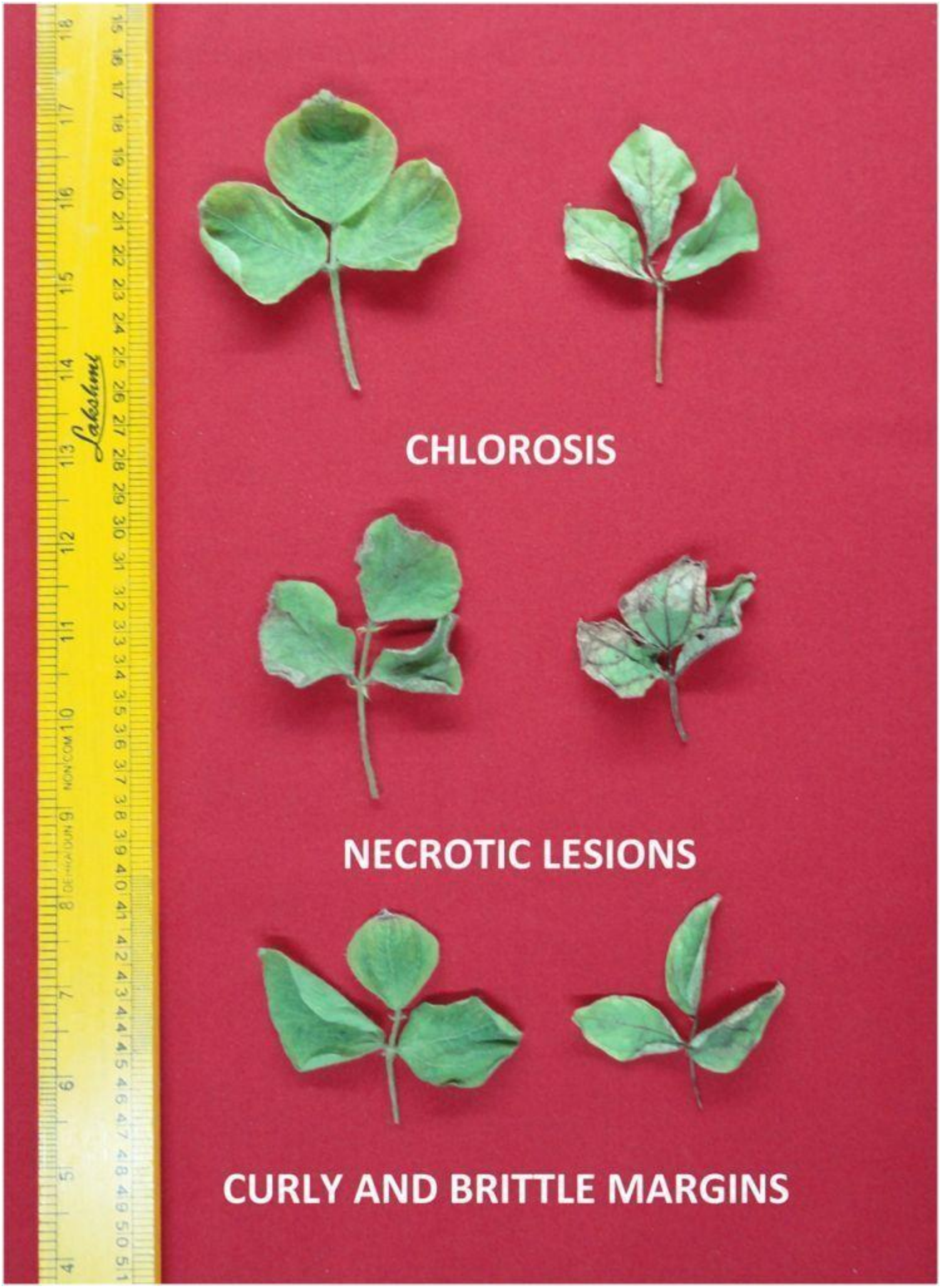

Plate 4: Types of foliar injury caused by elevated UV-B radiation in *Vigna radiata* (L.) Wilczek var. VAMBAN-2 on 30 DAS

Figure 1: CO-8 - 45 DAS 60 DAS Control UV-B

Figure 2: NVL-585 - 45 DAS 60 DAS Control UV-B

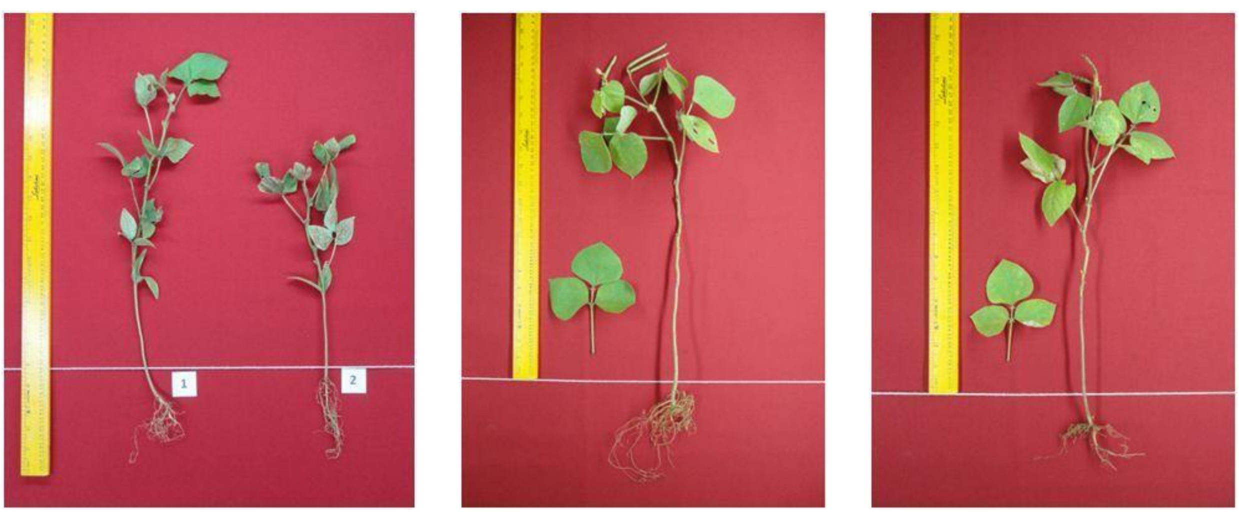

Figure 3: VAMBAN-2 - 45 DAS 60 DAS Control UV-B

Plate 5: The control and supplementary UV-B stressed plants of three varieties of *Vigna radiata* (L.) Wilczek on 45 and 60 DAS. (1: Control, 2: UV-B)

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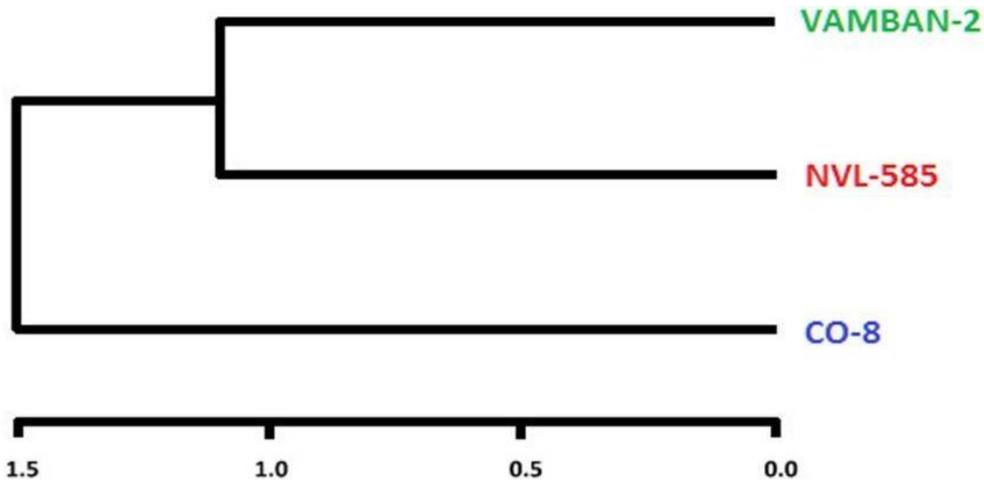

Plate 6: Dendrogram showing the interrelationship between the three varieties of *Vigna radiata* (L.) Wilczek in growth parameters under control and supplementary UV-B - *In situ*

Table 1: Changes in foliage of three varieties of 15 DAS *Vigna radiata* (L.) Wilczek under control and supplementary UV-B exposed conditions – *In situ*

Varieties	Treatment	Number of leaves	Total leaf area (cm^2)	Leaf area index	Specific leaf weight (g^{-2})	Fresh weight of foliage (g)	Dry weight of foliage (g)
CO-8	Control	3	125.017	0.671	0.193	0.815	0.157
	UV-B	2	41.276	0.535	0.134	0.177	0.042
NVL-	Control	3	169.408	0.637	0.187	1.258	0.201
585	UV-B	2	62.832	0.432	0.126	0.304	0.072
VAMB	Control	3	158.598	0.637	0.172	0.929	0.175
AN-2	UV-B	2	76.032	0.466	0.143	0.287	0.049

Table 2: Changes in foliage of three varieties of 30 DAS *Vigna radiata* (L.) Wilczek under control and supplementary UV-B exposed conditions – *In situ*

Varieties	Treatment	Number of leaves	Total leaf area (cm^2)	Leaf area index	Specific leaf weight (g^{-2})	Fresh weight of foliage (g)	Dry weight of foliage (g)
CO-8	Control	5	381.612	1.118	0.246	0.808	0.417
	UV-B	5	208.362	0.072	0.134	0.563	0.320
NVL-	Control	5	359.7	0.963	0.216	1.536	0.558
585	UV-B	5	275.2	0.930	0.112	0.861	0.332
VAMB	Control	5	453.915	1.004	0.230	1.720	0.421
AN-2	UV-B	5	267.168	0.841	0.122	0.950	0.324

Table 3: Changes in foliage of three varieties of 45 DAS *Vigna radiata* (L.) Wilczek under control and supplementary UV-B exposed conditions – *In situ*

Varieties	Treatment	Number of leaves	Total leaf area (cm^2)	Leaf area index	Specific leaf weight (g^{-2})	Fresh weight of foliage (g)	Dry weight of foliage (g)
CO-8	Control	5	349.14	0.889	0.321	3.040	0.572
	UV-B	5	201.96	0.840	0.176	2.338	0.269
NVL-	Control	7	326.19	1.114	0.316	3.455	0.652
585	UV-B	5	311.12	0.748	0.181	2.742	0.477
VAMB	Control	7	523.446	1.376	0.308	2.167	0.821
AN-2	UV-B	5	157.014	0.821	0.179	1.770	0.466

Table 4: Changes in foliage of three varieties of 60 DAS *Vigna radiata* (L.) Wilczek under control and supplementary UV-B exposed conditions – *In situ*

Varieties	Treatment	Number of leaves	Total leaf area (cm^2)	Leaf area index	Specific leaf weight (g^{-2})	Fresh weight of foliage (g)	Dry weight of foliage (g)
CO-8	Control	6	712.8	1.008	0.344	4.700	2.301
	UV-B	4	232.848	0.771	0.173	2.207	1.014
NVL-585	Control	6	882.09	11.050	0.336	5.678	3.907
	UV-B	6	742.5	1.031	0.182	2.726	2.413
VAMBAN-2	Control	6	660.528	1.115	0.312	5.003	3.812
	UV-B	6	521.769	1.088	0.167	4.378	2.292

Table 5: Changes in growth parameters of three varieties of 15 DAS *Vigna radiata* (L.) Wilczek under control and supplementary UV-B exposed conditions – *In situ*

Varieties	Treatment	Root length (cm)	Shoot length (cm)	Shoot / root ratio	Root fresh wt. (g)	Shoot fresh wt. (g)	Plant fresh wt. (g)	Root dry wt. (g)	Shoot dry wt. (g)	Plant dry wt. (g)	Relative growth rate
CO-8	Control	11	16.5	1.5	0.107	1.526	1.633	0.027	0.228	0.255	-
	UV-B	8	12.5	1.56	0.032	0.387	0.389	0.010	0.076	0.086	-
NVL-585	Control	9.6	15.5	1.61	0.148	1.896	2.044	0.034	0.308	0.342	-
	UV-B	5.5	12.5	2.27	0.030	0.642	0.672	0.014	0.128	0.142	-
VAMBAN-2	Control	11.9	20.8	1.74	0.069	1.665	1.734	0.026	0.284	0.310	-
	UV-B	8.7	13.5	1.55	0.060	0.529	0.589	0.018	0.084	0.102	-

Table 6: Changes in growth parameters of three varieties of 30 DAS *Vigna radiata* (L.) Wilczek under control and supplementary UV-B exposed conditions – *In situ*

Varieties	Treatment	Root length (cm)	Shoot length (cm)	Shoot / root ratio	Root fresh wt. (g)	Shoot fresh wt. (g)	Plant fresh wt. (g)	Root dry wt. (g)	Shoot dry wt. (g)	Plant dry wt. (g)	Relative growth rate
CO-8	Control	16.8	29.5	1.77	0.340	3.593	3.933	0.068	0.716	0.784	0.03
	UV-B	12.7	23.5	1.87	0.169	2.257	2.516	0.060	0.555	0.615	0.05
NVL-585	Control	13.8	28.5	2.06	0.652	3.707	4.359	0.105	0.950	1.055	0.03
	UV-B	12.3	26.5	2.15	0.482	2.617	1.099	0.098	0.587	0.685	0.05
VAMBAN-2	Control	13.5	32.5	2.40	0.468	5.142	5.610	0.096	0.792	0.888	0.03
	UV-B	10.5	28.5	2.71	0.231	2.885	3.116	0.041	0.592	0.633	0.05

Table 7: Changes in growth parameters of three varieties of 45 DAS *Vigna radiata* (L.) Wilczek under control and supplementary UV-B exposed conditions – *In situ*

Varieties	Treatment	Root length (cm)	Shoot length (cm)	Shoot / root ratio	Root fresh wt. (g)	Shoot fresh wt. (g)	Plant fresh wt. (g)	Root dry wt. (g)	Shoot dry wt. (g)	Plant dry wt. (g)	Relative growth rate
CO-8	Control	12.3	37	3.00	0.387	5.546	5.933	0.138	1.531	1.669	0.02
	UV-B	6.5	31	4.76	0.236	4.519	4.755	0.087	1.009	1.096	0.01
NVL-585	Control	12.5	29	2.32	0.312	6.162	6.474	0.087	1.195	1.278	0.005
	UV-B	7.5	24	3.2	0.305	5.468	5.773	0.083	0.859	0.946	0.009
VAMBAN-2	Control	14	38	2.71	0.463	5.315	5.778	0.181	2.099	2.280	0.02
	UV-B	11.5	30	2.60	0.182	3.963	4.145	0.068	1.152	1.220	0.01

Table 8: Changes in growth parameters of three varieties of 60 DAS *Vigna radiata* (L.) Wilczek under control and supplementary UV-B exposed conditions – *In situ*

Varieties	Treatment	Root length (cm)	Shoot length (cm)	Shoot / root ratio	Root fresh wt. (g)	Shoot fresh wt. (g)	Plant fresh wt. (g)	Root dry wt. (g)	Shoot dry wt. (g)	Plant dry wt. (g)	Relative growth rate
CO-8	Control	15.5	50.5	3.25	1.712	15.709	17.411	0.465	4.025	4.490	0.028
	UV-B	6.5	30.5	4.69	0.389	4.964	5.353	0.028	1.592	1.620	0.011
NVL-585	Control	16	40	2.5	2.213	15.155	17.368	0.488	5.746	6.234	0.045
	UV-B	12.5	33.5	2.68	1.614	11.535	13.149	0.396	4.159	4.555	0.045
VAMBAN-2	Control	14	47.5	3.39	1.299	15.575	16.874	0.518	6.301	6.819	0.031
	UV-B	8.7	39.5	4.54	0.481	6.537	7.018	0.148	2.425	2.573	0.021

Table 9: The similarity indices in growth parameters 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%	28.46%	29.58%
NVL-585	28.46%	100%	24.65%
VAMBAN-2	29.58%	24.65%	100%

UV-B exposure reduced root length significantly by 10.86 to 74.07 % on all stages of growth till 60 DAS (Table 5 to 8; Plate 5). UV-B stressed VAMBAN-2 showed maximum reduction of root growth which progressively decreased from 74.07 % on 30 DAS to 17.87 % on 45 DAS. Shoot length of UV-B stressed plants decreased by 19.35 to 35.09 % within 15 DAS and continued so till 60 DAS with 16.25 to 39.60 % reduction. CO-8 recorded the major reduction in shoot growth compared to plants grown under control condition. The S / R ratio was decreased by 10.91 % in UV-B stressed VAMBAN-2 on 15 DAS while it increased by 12.91 to 33.92 % over control plants on rest of the stages of growth. CO-8 and NVL-585 recorded higher values (7.2 to 44.30 %) till 60 DAS. Fresh weight of roots increased with age in all treatments. But the biomass accumulation in root was inhibited by UV-B treatment by 13.29 to 69.87 % on 15 DAS, the maximum reduction being in CO-8. On 30, 45 and 60 DAS all the varieties of green gram did not show any recover as the reduction continued to reach 27.06 to 77.28 %. A general decrease of 11.27 to 78.22 % in shoot fresh weight of UV-B treated plants was observed with the maximum sensitivity shown by CO-8 and VAMBAN-2. The same trend was maintained at all stages of growth and the inhibitions were consistent with little recovery with the advancing age of plants. The trends observed in root and shoot biomass pattern were reflected at the whole plant level too with inhibitions at UV-B, little improvement in later stages with severe reductions of 69.27 and 58.41 % in CO-8 and VAMBAN-2 respectively on 60 DAS. A gradual reduction in the root biomass content starting from 29.88 to 60.81 % on 15 DAS and reaching 18.85 to 93.97 % on 60 DAS, the maximum being in CO-8 was caused by UV-B treatment. UV-B exposure suppressed dry weight of shoot by 58.33 to 70.29 % on 15, reaching a reduction of 27.62 to 61.51 % on 60 DAS over control. The severity of UV-B stress was experienced by CO-8 and VAMBAN-2 at all stages of growth. Plant dry weight increased with age in all varieties of green gram, but after UV-B stress it fell below control by 58.40 to 70.29 % on 15 DAS and 26.93 to 64 % on 60 DAS. The performances of CO-8 and VAMBAN-2 varieties of green gram were very poor under UV-B exposure at all stages of growth (Table 5 to 8).

Inhibition of growth indicated by reductions in root and shoot length and biomass content due to UV-B stress were apparent at all stages. Such inhibitions are characteristic of UV-B stressed legumes as in *Vigna unguiculata (*Kulandaivelu *et al.,* 1989), *Phaseolus vulgaris* (Mark and Tevini, 1997), *Vigna mungo* (Rajendiran and Ramanujam, 2000) and *Vigna radiata* (Rajendiran and Ramanujam, 2003). Similar reductions in growth parameters were reported by Kokilavani and Rajendiran (2014o) in ten varieties of cowpea, Rajendiran *et al.,* (2015a) in *Amaranthus dubius* Mart. Ex. Thell., Rajendiran *et al.,* (2015b) in *Macrotyloma uniflorum* (Lam.) Verdc., Rajendiran *et al.,* (2015c) in *Momordica charantia* L., Rajendiran *et al.,* (2015d) in *Spinacia oleracea* L., Rajendiran *et al.,* (2015e) in *Trigonella foenum-graecum* (L.) Ser., Rajendiran *et al.,* (2015f) in *Benincasa hispida* (Thunb.) Cogn. and Rajendiran *et al.,* (2015h) in *Vigna mungo* (L.) Hepper var. ADT-3 after enhanced UV-B exposure. The stunting of UV-B stressed plants is attributed to destruction of endogenous IAA whose photo-oxidative products may be inhibitory (Kulandaivelu *et al.,* 1989; Tevini and Teramura, 1989) as indicated by a decrease in IAA content concomitant with a corresponding increase in IAA oxidase activity in rice leaves (Huang *et al.,* 1997). However *Portulaca oleracea* L. plants were taller and healthy than controls after UV-B irradiation (Rajendiran *et al.,* 2015g).

The relative growth rate (RGR) was enhanced in all UV-B irradiated plants as the values were significantly higher (66.66 %) over control on 30 DAS. However, RGR was reduced in CO-8 and VAMBAN-2 by 60.71 % and 32.25 % respectively, while NVL-585 equalled control on 60 DAS (Table 5 to 8). Similar inhibitions of RGR by UV-B were observed by Jain *et al.,* (1999) in mungbean, by Kokilavani and Rajendiran (2014o) in ten varieties of cowpea, Rajendiran *et al.,* (2015a) in *Amaranthus dubius* Mart. Ex. Thell., Rajendiran *et al.,* (2015b) in *Macrotyloma uniflorum* (Lam.) Verdc., Rajendiran *et al.,* (2015c) in *Momordica charantia* L., Rajendiran *et al.,* (2015d) in *Spinacia oleracea* L., Rajendiran *et al.,* (2015e) in *Trigonella foenum-graecum* (L.) Ser., Rajendiran *et al.,* (2015f) in *Benincasa hispida* (Thunb.) Cogn. after enhanced UV-B exposure. However Rajendiran *et al.,* (2015g) in *Portulaca oleracea* L. reported enhanced RGR after UV-B exposure.

The growth parameters studied in three varieties of green gram after *in situ* supplementary UV-B irradiation showed variations in the plant height, number of leaves, total leaf area, fresh weight, dry weight and relative growth rate after exposure to supplemenaty UV-B radiation *in situ* during different stages of growth. The similarity index between VAMBAN-2 and NVL-585 was the least with a value of 24.65 %. These two varieties remained as one group as they showed similarity indices of 28.46 and 29.58 % with CO-8. The response of CO-8 to elevated UV-B irradiation was unique to it and was totally isolated from the rest of the varieties in the cluster (Table 9; Plate 6).

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