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Research Article

UV-B INDUCED CHANGES IN THE YIELD ATTRIBUTES OF THREE VARIETIES OF GREEN GRAM

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ABSTRACT
The data available on UV-B effects on plants grown in growth chambers showed heavy reductions in growth and yield. The present study was carried out to evaluate the yield attributes of three varieties of green gram (*Vigna radiata* (L.) Wilczek.) *viz.* CO-8, NVL-585 and VAMBAN-2 exposed to supplementary UV-B radiation (2 hours daily @ 12.2 kJ m^{-2} d^{-1}; ambient = 10 kJ m^{-2} d^{-1}) under *in situ* conditions. The fruits were harvested from each plant on 60 DAS (days after sowing) and the length and weight of the pod, number of seeds per pod and number of seeds per plant and weight of seeds per plant were recorded. All the yield parameters of the three varieties suffered heavily after UV-B radiation. The pod number decreased by 33.33 to 66.67 %, pod weight by 16.14 to 79.87 %, pod length by 16.20 to 54.73 %, seed number by 27.27 to 63.64 % and seed mass by 25.97 to 85.96 % under ultraviolet-B rays compared with the controls. Many fruits under UV-B stress contained less number of seeds. Least harvest index was recorded in NVL-585 (67.73 %) followed by CO-8 (61.09 %). UV-B irradiated VAMBAN-2 recorded only 14.15 % reduction in harvest index compared with control. However, under UV-B exposure, CO-8 recorded only little reduction in shelling percentage (27.47 %) followed by NVL-585 (36.93 %) and VAMBAN-2 (52.72 %).

Keywords: *Ultraviolet-B, Green Gram, Three Varieties, Yields Attributes*

INTRODUCTION
New varieties of green gram with high yield are introduced in India more frequently, but their adaptation to elevated UV-B remains to be evaluated. Depletion in stratospheric ozone increases UV-B flux in the sunlight which in turn severely damages the foliage (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 growth (Rajendiran and Ramanujam, 2003; Rajendiran and Ramanujam, 2004; Kokilavani and Rajendiran, 2014o), suppresses yield (Kokilavani and Rajendiran, 2014e) and reduces 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 sensitive crops. The present study was carried out to identify the variety of green gram that can tolerate elevated UV-B and produce better harvest under *in situ* conditions.

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-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}.

Mature fruits were harvested periodically from each plant and the length and weight of the pod, number of seeds per pod and number of seeds per plant and weight of seeds per plant were recorded. Harvest index (Mohan *et al.*, 1992) and shelling percentage (Francis *et al.*, 1978) were calculated using the following formulae.

$$\text{Harvest index} = \frac{\text{Yield of the plant (g)}}{\text{Biomass of the plant (g)}} \times 100$$

$$\text{Shelling percentage} = \frac{\text{Seed wt. plant}^{-1}}{\text{Fruit wt. plant}^{-1}} \times 100$$

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

RESULTS AND DISCUSSION

In situ UV-B radiation decreased all the yield attributes per plant basis, the decreases being 33.33 to 66.67 % in the pod number, 16.14 to 79.87 % in pod weight, 16.20 to 54.73 % in pod length, 27.27 to 63.64 % in seed number and 25.97 to 85.96 % in seed mass in the three varieties of green gram (Table 1; Plate 1 to 2). Analysed on the basis of number of seeds per pod, only the UV-B treated green gram crops had more fruits with fewer number of seeds.

Harvest index was the least in NVL-585 variety of green gram after UV-B treatment which showed severe reduction of 67.73 % followed by CO-8 which showed 61.09 % reduction compared with the controls. Despite UV-B stress VAMBAN-2 recorded only little reduction of harvest index by 14.15 % when compared with the performance of the respective control crop. However a different pattern was obtained for data on shelling percentage.

CO-8 under UV-B exposure recorded only 27.47 % reduction followed by NVL-585 and VAMBAN-2 which had higher values of 36.93 and 52.72 % respectively (Table 1). Kokilavani and Rajendiran (2014e) 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 and Rajendiran *et al.*, (2015g) in *Vigna mungo* (L.) Hepper var. ADT-3 have reported similar yield reductions under supplementary UV-B exposure.

Elevated UV-B altered the DNA and protein, which in turn altered the vital metabolisms including photosynthesis reflecting them in the form of reduced yield and nutrition content in the grains (Rajendiran and Ramanujam, 2003; Rajendiran and Ramanujam, 2004).

Figure 1: CO-8

Figure 2: NVL-585

Figure 3: VAMBAN-2

Plate 1: Harvested pods of three varieties of *Vigna radiata* (L.) Wilczek on 60 DAS (1: Control, 2: UV-B)

Figure 1: CO-8

Figure 2: NVL-585

Figure 3: VAMBAN-2

Plate 2: Harvested seeds of three varieties of *Vigna radiata* (L.) Wilczek on 60 DAS (1: Control, 2: UV-B)

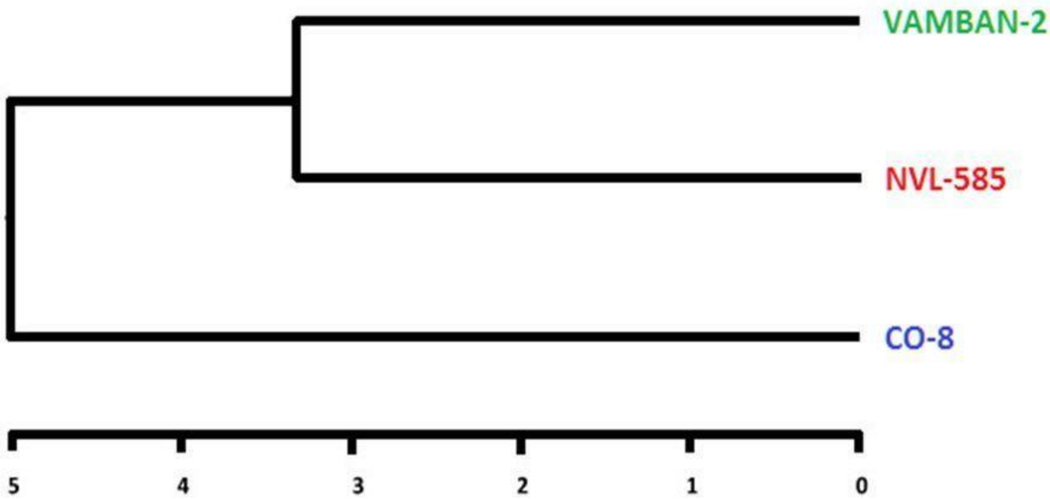

Plate 3: Dendrogram showing the interrelationship between the three varieties of *Vigna radiata* (L.) Wilczek in yield attributes under control and supplementary UV-B - *In situ.*

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

Varieties	Treatment	Pod number plant^{-1}	Single pod wt. (g)	Pod wt. plant^{-1} (g)	Length of the pod (cm)	Seed number pod^{-1}	Seed number plant^{-1}	Seed mass pod^{-1} (g)	Seed mass plant^{-1} (g)	Shelling percentage plant^{-1}	Harvest index
Co-8	Control	3	0.500	1.108	7.2	11	32	0.417	1.154	120.8	25.70
	UV-B	1	0.223	0.223	5.9	4	4	0.162	0.162	87.62	10
NVL-	Control	3	0.446	1.263	7.16	11	31	0.362	1.136	85.3	18.22
585	UV-B	1	0.374	0.374	6	8	8	0.268	0.268	53.8	5.88
VAMB	Control	3	0.568	1.208	6.76	13	35	0.250	0.915	81	13.41
AN-2	UV-B	2	0.206	0.332	3.06	9	11	0.197	0.303	38.3	11.77

Table 2: The similarity indices in yield 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%	70%	60%
NVL-585	70%	100%	80%
VAMBAN-2	60%	80%	100%

The yield attributes assessed in three varieties of green gram showed differences in pod number, pod length, pod weight, seed number, seed mass, shelling percentage per plant and harvest index after irradiation with supplementary UV-B on 60 DAS. The similarity index value between NVL-585 and VAMBAN-2 was 80 % (Table 2; Plate 3). These two varieties remained as one group with highest similarity index. On the other hand, CO-8 which had 70 and 60 % similarites with NVL-585 and VAMBAN-2 respectively was kept far away from rest of the varieties.

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