International Journal of Food, Agriculture and Veterinary Sciences ISSN: 2277-209X (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jfav.htm
2015 Vol. 5 (3) September-December, pp. 67-74/Rajendiran et al.
Research Article

YIELD ATTRIBUTES OF THREE VARIETIES OF BLACK GRAM UNDER *IN SITU* SUPPLEMENTARY UV-B IRRADIATION

***Rajendiran K., Thiruvarasan K. and Vijayalakshmi R.**
Department of Botany, K.M. Centre for Post Graduate Studies, Pondicherry - 605 008, India
**Author for Correspondence*

ABSTRACT
The heat trapping gases dumped by human activity into the atmosphere acts like a blanket holding the heat around the earth. These gases are warming the troposphere and cooling the stratosphere thereby indirectly depleting the ozone layer in addition to the direct method by ozone depleting substances (ODS). The depletion in the stratospheric ozone allows more amount of ultraviolet-B (UV-B) radiation into Earth's surface, thus affecting the growth and yield. The present study deals with the harvest of three varieties of black gram (*Vigna mungo* (L.) Hepper) *viz.* VAMBAN-3, NIRMAL-7 and T-9 after exposure to supplementary UV-B radiation (2 hours daily @ 12.2 kJ m^{-2} d^{-1}; ambient = 10 kJ m^{-2} d^{-1}) supplied under *in situ* condition. UV-B exposure reduced the number of pods (16 to 20 %), weight of pods (16.52 to 32.04 %), length of pods (7.14 to 18.60 %), number of seeds (28.57 to 64.55 %) and mass of seed (19.90 to 61.14 %). In general, UV-B treated plants had more fruits with few seeds. NIRMAL-7 under UV-B treatment showed severe reduction in harvest index (32.67 %) followed by VAMBAN-3 (28.98 %) than the controls. T-9 recorded only little reduction in harvest index (13.57 %) after UV-B stress. Similar trend was noticed in shelling percentage. Over all, NIRMAL-7 performed poorly showing severe reduction in yield.

Keywords: *Ultraviolet-B, Black Gram, Three Varieties, Harvest*

INTRODUCTION
Black gram is one of the common legumes grown in India. Apart from producing better yield this crop helps in enriching the soil with its symbiotic nitrogen fixing ability with *Rhizobium.* Even though black gram was known for its tolerance to various biotic and abiotic stresses its response to ultraviolet-B rays needs to be evaluated. In recent years increases in UV-B flux severely affects the leaves (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 objective of the present study was to screen the three varieties of black gram for their yield attribute under supplementary UV-B irradiation.

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

RESULTS AND DISCUSSION

UV-B exposure given under *in situ* condition consistently decreased the entire yield characteristics per plant basis, the decreases being 16 to 20 % in the pod number, 16.52 to 32.04 % in pod weight, 7.14 to 18.60 % in pod length, 28.57 to 64.55 % in seed number and 19.90 to 61.14 % in seed mass (Table 1; Plate 1 to 2). Out of the three varieties of black gram, NIRMAL-7 performed poorly showing severe reduction in yield. Evaluated on the basis of number of seeds per pod, only the UV-B treated plants had more fruits with fewer number of seeds. Harvest index was the least in NIRMAL-7 variety of black gram after UV-B treatment which showed severe reduction of 32.67 % followed by VAMBAN-3 which recorded 28.98 % reduction compared with the controls. Despite UV-B stress T-9 recorded only little reduction of harvest index by 13.57 % when compared with the performance of the respective control crop. A similar pattern was obtained for data on shelling percentage also (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: VAMBAN-3

Figure 2: NIRMAL-7

Figure 3: T-9

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

Figure 1: VAMBAN-3

Figure 2: NIRMAL-7

Figure 3: T-9

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

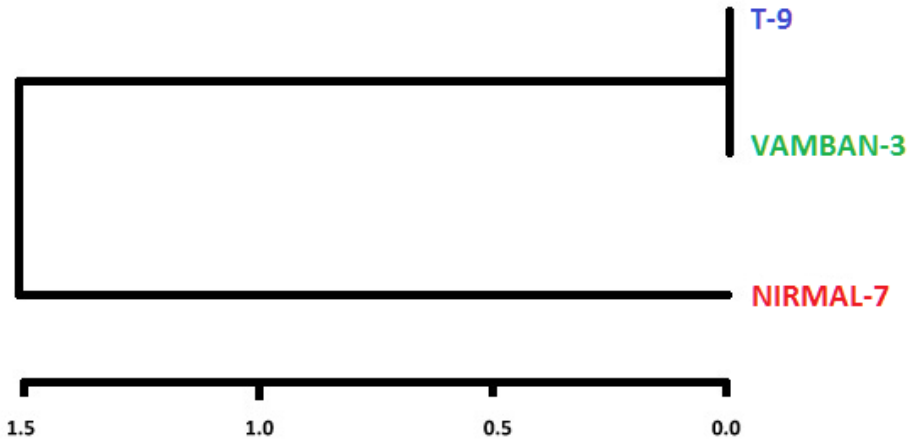

Plate 3: Dendrogram showing the interrelationship between the three varieties of *Vigna mungo* (L.) Hepper in yield attributes under control and supplementary UV-B - *In situ*

Table 1: Changes in yield components of three varieties of *Vigna mungo* (L.) Hepper 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
VAMBAN-3	Control	6	0.318	1.540	4.2	7	38	0.364	1.789	59.62	39.82
	UV-B	5	0.260	0.886	3.9	6	25	0.239	1.314	48.79	28.28
NIRMAL-7	Control	5	0.341	1.377	4.3	7	31	0.325	1.287	45.57	32.75
	UV-B	3	0.231	0.624	3.5	6	11	0.312	0.500	37.28	22.05
T-9	Control	5	0.318	1.504	4.2	6	28	0.286	1.064	49.60	32.95
	UV-B	4	0.265	1.038	3.9	5	20	0.348	1.368	40.71	28.48

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

Varieties	VAMBAN-3	NIRMAL-7	T-9
VAMBAN-3	100%	50%	55%
NIRMAL-7	50%	100%	50%
T-9	55%	50%	100%

The yield attributes assessed in three varieties of black 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 VAMBAN-3 and T-9 was the highest with 75 % (Table 2; Plate 3). These two varieties remained as one group and showed 50 % similarity with NIRMAL-7.

ACKNOWLEDGEMENT
The authors thank Prof. Dr. Thamizharasi Tamizhmani, Director, KMCPGS, Puducherry for providing research facilities and Dr. M. P. Ramanujam for his support and encouragement.

REFERENCES
Arulmozhi D and Rajendiran K (2014a). Effect of supplementary ultraviolet-B radiation on nodulation and nitrogen metabolism in *Lablab purpureus* L. var. Goldy. *International Journal of Advanced Biological Research* **4**(3) 343-346.

Arulmozhi D and Rajendiran K (2014b). Supplementary ultraviolet-B induced reduction in nodulation and nitrogen metabolism in hyacinth bean. *International Journal of Geology, Earth and Environmental Sciences* **4**(2) 73-77.

Arulmozhi D and Rajendiran K (2014c). Effect of elevated ultraviolet-B irradiation on the nodulation and nitrogen metabolism in *Vigna unguiculata* (L.) Walp. cv. COFC-8. *International Journal of Food, Agriculture and Veterinary Sciences* **4**(2) 184-188.

Bhat TM and Kudesia R (2011). Evaluation of Genetic Diversity in Five Different Species of Family Solanaceae using Cytological Characters and Protein Profiling. *Genetic Engineering and Biotechnology Journal* **2011** 1-8.

Everstt B (1985). *Clustering Analysis* (John Wiley and Sons, New York).

Francis CA, Flor CA and Prager M (1978). Effects of bean association on yield component of maize. *Crop Science* **18** 760 - 764.

Kokilavani V and Rajendiran K (2013). Ultraviolet-B induced changes in the leaf epidermal and anatomical characteristics of *Vigna mungo* L. var. KM-2. *International Journal of Science and Nature* **5**(1) 126-130.

Kokilavani V and Rajendiran K (2014a). Changes in leaf architecture of *Vigna unguiculata* (L.) Walp. cv. BCP-25 after exposure to elevated ultraviolet-B radiation. *International Journal of Science and Nature* **5**(3) 542-546.

Kokilavani V and Rajendiran K (2014b). Ultraviolet-B induced changes in the leaf architecture of *Cucumis sativus* L. var. CO 1. *International Journal of Geology, Earth and Environmental Sciences* **4**(2) 208-215.

Kokilavani V and Rajendiran K (2014c). Alterations in leaf architecture of *Ocimum sanctum* L. under elevated ultraviolet-B stress. *Global Journal of Bio-Science and Biotechnology* **3**(4) 374-378.

Kokilavani V and Rajendiran K (2014d). Ultraviolet-B induced changes in the leaf epidermal and anatomical characteristics of *Vigna mungo* L. var. KM-2. *International Journal of Advanced Biological Research* **5**(1) 126-130.

Kokilavani V and Rajendiran K (2014e). Effect of supplementary UV-B radiation on the yield of ten varieties of cowpea. *International Journal of Geology, Earth and Environmental Sciences* **4**(3) 65-73.

Kokilavani V and Rajendiran K (2014f). Influence of elevated Ultraviolet-B radiation on foliar organisation in *Vigna unguiculata* (L.) Walp. c.v. CW-122. *International Journal of Innovative Research and Review* **2**(4) 53-60.

Kokilavani V and Rajendiran K (2014g). Evaluation of the impact of Ultraviolet-B radiation on the foliar epidermal and anatomical characteristics of *Vigna unguiculata* (L.) Walp. c.v. COVU-1. *International Journal of Innovative Research and Review* **2**(4) 61-68.

Kokilavani V and Rajendiran K (2014h). Variation in leaf architecture of *Vigna unguiculata* (L.) Walp. c.v. COFC-8 induced by supplementary UV-B exposure. *International Journal of Innovative Research and Review* **2**(4) 69-76.

Kokilavani V and Rajendiran K (2014i). Ultraviolet-B induced reduction in nodulation in ten varieties of cowpea. *International Journal of Innovative Research and Review* **2**(4) 77-82.

Kokilavani V and Rajendiran K (2014j). Efficacy of *Vigna unguiculata* (L.) Walp. cv. Vamban leaves to withstand supplementary ultraviolet-B irradiation. *International Journal of Geology, Earth and Environmental Sciences* **4**(3) 203-210.

Kokilavani V and Rajendiran K (2014k). Anatomical and epidermal alterations in the leaves of *Vigna unguiculata* (L.) Walp. cv. CO-6 due to UV-B exposure. *International Journal of Geology, Earth and Environmental Sciences* **4**(3) 211-218.

Kokilavani V and Rajendiran K (2014l). A survey on the adaptive mechanism in leaf architecture of *Vigna unguiculata* (L.) Walp. cv. KM-1 under ultraviolet-B radiation. *International Journal of Food, Agriculture and Veterinary Sciences* **4**(3) 50-57.

Kokilavani V and Rajendiran K (2014m). Modifications in leaf architecture of *Vigna unguiculata* (L.) Walp. cv. COVU-2 to defend from ultraviolet-B radiation. *International Journal of Food, Agriculture and Veterinary Sciences* **4**(3) 65-72.

Kokilavani V and Rajendiran K (2014n). Analysis of the UV-B induced changes in morphology, anatomy and epidermis of *Vigna unguiculata* (L.) Walp. cv. CO-1 leaves. *International Journal of Food, Agriculture and Veterinary Sciences* **4**(3) 87-94.

Kokilavani V and Rajendiran K (2014o). Influence of elevated ultraviolet-B radiation on the morphology and growth of ten varieties of cowpea. *International Journal of Food, Agriculture and Veterinary Sciences* **4**(3) 171-189.

Kokilavani V and Rajendiran K (2015a). Variations in foliar morphology and anatomy of *Vigna unguiculata* (L.) Walp. c.v. CO-3 after supplementary ultraviolet-B exposure. *International Journal of Advanced Biological Research* **5**(1) 23-28.

Kokilavani V and Rajendiran K (2015b). Study of leaf architecture of *Vigna unguiculata* (L.) Walp. cv. Puduvai under elevated ultraviolet-B radiation. *International Journal of Advanced Biological Research* **5**(1) 34-39.

Maskay N (1998). Single linkage clustering. In: *Encyclopedia of Biostatistics*, edited by Armintage P and Cotton T (Wiley, New York) **5** 4121- 4122.

Mohan P, Bhat MG, Singh NN and Singh P (1992). Variability of biomass and harvest index in Asiatic *(Gossypium arboreum* L.) and American *(Gossypium hirsutum)* cottons. *Advance in Plant Science* **5** 100 - 105.

Rajendiran K and Ramanujam MP (2003). Alleviation of ultraviolet-B radiation-induced growth inhibition of green gram by triadimefon. *Biologia Plantarum* **46** 621-624.

Rajendiran K and Ramanujam MP (2004). Improvement of biomass partitioning, flowering and yield by triadimefon in UV-B stressed *Vigna radiata* (L.) Wilczek. *Biologia Plantarum* **48** 145-148.

Rajendiran K, Ariswary D, Arulmozhi D and Kokilavani V (2015a). Screening of explants of ultraviolet-B exposed *Amaranthus dubius* Mart. Ex. Thell. for *in vitro* propagation. *International Journal of Food, Agriculture and Veterinary Sciences* **5**(2) 33-45.

Rajendiran K, Iswarya R, Arulmozhi D and Kokilavani V (2015b). Evaluation of ultraviolet-B stressed explants of *Macrotyloma uniflorum* (Lam.) Verdc. For *in vitro* propagation. *International Journal of Innovative Research and Review* **3**(2) 19-31.

Rajendiran K, Julie Soniya F, Vijayalakshmi R and Kokilavani V (2015c). *In vitro* propagation of ultraviolet-B stressed *Momordica charantia* L. *International Journal of Geology, Earth and Environmental Sciences* **5**(2) 92-104.

Rajendiran K, Periyalakshmi D, Vijayalakshmi R and Kokilavani V (2015d). *In vitro* propagation of explants from ultraviolet-B stressed *Spinacia oleracea* L. *International Journal of Innovative Research and Review* **3**(2) 32-44.

Rajendiran K, Priyadarsini V, Sudaroli Sudha J and Kokilavani V (2015e). *In vitro* propagation of *Trigonella foenum-graecum* (L.) Ser. after supplementary UV-B irradiation. *International Journal of Food, Agriculture and Veterinary Sciences* **5**(2) 46-57.

Rajendiran K, Riswan A, Sudaroli Sudha J and Kokilavani V (2015f). *In vitro* propagation of *Benincasa hispida* (Thunb.) Cogn. explants after enhanced UV-B exposure. *International Journal of Innovative Research and Review* **3**(2) 45-56.

Rajendiran K, Vidya S, Gowsalya L and Thiruvarasan K (2015g). Impact of supplementary UV-B radiation on the morphology, growth and yield of *Vigna mungo* (L.) Hepper var. ADT-3. *International Journal of Food, Agriculture and Veterinary Sciences* **5**(2) 104-112.

Sudaroli Sudha J and Rajendiran K (2013a). Effect of elevated UV-B irradiation on the nodulation and nitrogen metabolism in *Sesbania grandiflora* (L.) Pers. *International Journal of Science and Nature* **4**(4) 664-667.

Sudaroli Sudha J and Rajendiran K (2013b). Effect of elevated UV-B irradiation on the nodulation and nitrogen metabolism in *Vigna unguiculata* (L.) Walp. c.v. BCP-25. *International Journal of Food, Agriculture and Veterinary Sciences* **3**(3) 77-81.

Sudaroli Sudha J and Rajendiran K (2014a). Impact of ultraviolet-B radiation on nodulation and nitrogen metabolism in *Vigna unguiculata* (L.) Walp. cv. COVU-1. *International Journal of Geology, Earth and Environmental Sciences* **4**(2) 224-230.

Sudaroli Sudha J and Rajendiran K (2014b). Ultraviolet-B induced reduction in nodulation and nitrogen metabolism in *Vigna mungo* (L.) Hepper var. T-9. *Global Journal of Bioscience and Biotechnology* **3**(4) 370-373.

Sudaroli Sudha J and Rajendiran K (2014c). Ultraviolet-B induced reduction in nodulation and nitrogen metabolism in *Vigna unguiculata* (L.) Walp. cv. CO-1. *Global Journal of Bioscience and Biotechnology* **4**(3) 10-14.

Vijayalakshmi R and Rajendiran K (2014a). Impact of ultraviolet-B radiation on nodulation and nitrogen metabolism in *Cyamopsis tetragonoloba* (L.) Taub. var. PNB. *International Journal of Geology, Earth and Environmental Sciences* **4**(2) 78-82.

Vijayalakshmi R and Rajendiran K (2014b). Impact of ultraviolet-B radiation on nodulation and nitrogen metabolism in *Phaseolus vulgaris* L. cv. Prevail. *International Journal of Advanced Biological Research* **4**(3) 339-342.

Vijayalakshmi R and Rajendiran K (2014c). Effect of elevated ultraviolet-B irradiation on the nodulation and nitrogen metabolism in *Vigna unguiculata* (L.) Walp. cv. CW-122. *International Journal of Food, Agriculture and Veterinary Sciences* **4**(2) 189-193.