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### Growth and yield of strawberry plant as affected by Ultraviolet-B radiations

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#### Abstract

Strawberry plants were exposed to UV-B (280nm - 320nm) radiations in order to determine the effect of UV-B radiations on its growth and yield. The plants were transplanted in pots and the transplanted plants were exposed to UV-B radiation ( $0.4\text{wm}^{-2}$ ) in UV-B chamber. Plants were irradiated with UV-B radiations on 20<sup>th</sup>, 40<sup>th</sup>, and 60<sup>th</sup> day after transferring (DAT) for 30, 60, 90 and 120 minutes referred as  $T_{30}$ ,  $T_{60}$ ,  $T_{90}$ ,  $T_{120}$  respectively.  $T_0$  was the control plant. The effects of different UV-B treatments on growth and yield of strawberry plants were determined. All treatments were replicated four times in a randomized block design (RBD). The enhanced UV-B radiation caused a negative effect on plant growth and yield. Results showed that strawberry is a potentially UV-B sensitive plant and shows direct correlation with UV-B intensity.

**Key words:** Growth, Yield, Strawberry, UV-B radiation, UV-B sensitive.

#### INTRODUCTION

The UV portion of the spectrum is divided into UV-A (>320nm), UV-B (280- 320nm), and UV-C (<280). A 1% decrease in ozone layer will cause a estimated 2% increase in UV-B irradiation. UVR constitutes approximately 5% of the solar radiation that reaches the earth's surface. Of the solar UV energy reaching the equator, 95% is UV-A, and 5% is UV-B. No measurable UV-C from solar radiation reaches the earth's surface, because the shortest UV wavelengths are completely absorbed by ozone, molecular oxygen, and water vapor in upper atmosphere. Yet UV radiations at different wavelengths differ in their effects, and we have to live with harmful effects as well as the useful ones. Radiation of the longer UV wavelengths of 320-400 nm, designated as UV-A, plays a helpful and essential role in formation of vitamin D by the skin, and a harmful role in that it causes sunburn on human skin and cataracts in the eyes. Artificial sources of broad-spectrum UVR have many uses, including tanning, medical diagnosis and treatment and promotion of polymerization reactions (e.g. curing of protective coating). Broad spectrum UVR has both diagnostic and

therapeutic uses in medicine and dentistry. More than 30 disorders now can be treated through UV-A exposure combined with compounds called psoralens (PUVA therapy). Psoriasis and eczema are the skin diseases most frequently treated with PUVA therapy. In addition, broad spectrum UVR and more commonly, UV-B are used with coal-tar creams to treat psoriasis. UV-B may also be used to convert 7-dehydrocholesterol (Provitamin D) to vitamin D in vitamin D-deficient patients. UV-A has been found to react with melatonin, a hormone that helps to regulate sleep-wake cycles. UVR (usually UV-C at 260 to 265nm) is used to sterilize and disinfect tools and materials. UV-A's biological effects are indirect and largely the result of energy transferred through reactive oxygen intermediates (free radicals), whereas UV-B and UV-C are absorbed by DNA and directly damage DNA through base modification. Most of the DNA breakages are repaired by proteins present in the cell's nucleus but unpaired genetic damage of DNA can lead to skin cancers. The last two decades have witnessed a decrease in ozone concentration within the stratosphere which has resulted in more UV-B radiations striking the earth surface. Studies have shown that penetration of harmful UV-B radiations has caused deleterious biochemical as well as physiological effect on the plant kingdom. These effects are mainly due to the absorption of these rays by proteins, nucleic acid lipids which have resulted in reduced photosynthesis, reduced growth and reduced biomass accumulation in plants. Ever since the appearance of ozone hole over the Antarctic in early 1980s, many researchers have tried to study the effect of increased UV-B radiation.

The studies have shown alteration in chloroplast and thylakoid membrane [6], reduced RUBISCO activity, changes in functioning of the PS-II reaction center and oxygen evolving complex [24], stomatal closure and reduced photosynthesis due to induced UV-B radiation. The reduction in O<sub>3</sub> column is ascribed to the anthropogenically emitted CFC's (chlorofluorocarbon) and other O<sub>3</sub> depleting substances reaching the stratosphere [18]. Human activities have led to the increase of halogenated hydrocarbons causing depletion of the stratospheric O<sub>3</sub> layer [23]. India lies in a low stratospheric O<sub>3</sub> belt and receives high flux of UV-B radiation, which on increase may be damaging to the plants. Chlorofluorocarbons can remain in the upper atmosphere for 40-150 years [20]. Even about 30 years after release, CFC's still percolate into the stratosphere where in a reaction involving short wavelength ultraviolet radiation, CFC breaks down into chlorine. This reacts with O<sub>3</sub> and metabolizes into oxygen, thereby destroying the O<sub>3</sub> layer. Thus, in a chain reaction each CFC molecule can break as many as 100,000's of O<sub>3</sub> molecules. Ozone depletion necessarily occurred at different rates in different countries across the world. The alternative to CFCs used during present day is hydrogenated CFCs (HCFC's), which have relatively shorter life span (i.e. about 30yr). However, even if all CFCs usage stops, the CFCs already released in the atmosphere will continue to affect the O<sub>3</sub> for a considerable period of time. UV-B radiation affects plants in several ways e.g. decrease in protein synthesis [14] and lowering of m-RNA levels of photosynthetic genes [19]. UV-B exposure also resulted in up regulation of genes involved in the synthesis of phenolic compounds [29]. Increased UV-B radiation may include detrimental changes to plants anatomical features, photosynthesis, biomass and flowering, although some of the changes may be taken as positive responses for some plants [9]. It has been reported that photosynthesis and photosynthetic productivity of some higher plants are vulnerable to increased UV-B radiation [8, 32, 14-15] has shown that water oxidizing complex (WOC) is the most sensitive target of UV-B damage in PS-II. Effect of UV-B on the epidermal layer includes the inhibition of cell expansion, leaf branching and curling [11] and alterations in stomatal apertures and/or stomatal conductance [10, 37, 22, 13]. UV-B radiation decreased leaf area, but at the same time leaf thickness increased [21, 9]. Ultraviolet-B radiation affected plant growth and functions mostly through its absorptions by proteins, nucleic acids, lipids and the subsequent deleterious effects on their integrity and function [8, 12]. DNA is particularly sensitive to UV-B radiation because absorption of UV-B causes photo transformation resulting in the production of cyclo-

butane pyrimidine dimmers (CPD's) and pyrimidine (6-4) pyrimidinone dimmers (6-4pp's) causing DNA mediated damage [7]. Because DNA and RNA polymers are not able to read through these photoproducts, their elimination is essential for DNA replication and transcription and thus for survival. Therefore attempts have been made to study of the effects UV-B radiation on the growth and yield of strawberry plant.

## MATERIALS AND METHODS

The experiments were performed at Department of Biological Sciences of Sam Higginbottom Institute of Agriculture, Technology and Science (SHIATS), Allahabad and Department of Chemistry, Ewing Christian College, Allahabad. Name of the variety of Strawberry used: "Sweet charley". After drying the soil and FYM, they were strained and mixed in 3:1 ratio respectively. In each pot 4 Kg of this mixture was added. Before transplantation urea, phosphorus, and potash was mixed in 1:2:2 ratio and also sprayed with Dithan M-45 at the rate of 0.2% in each pot. Supplemented UV-B was provided artificially by Q panel UV-B 313 fluorescent lamps (Q panel, Cleveland, Ohio, USA) in UV-B chamber. Banks of 3 lamps (120 cm long) fitted 45 cm apart on a steel frame were suspended above and perpendicular to base of UV-B chamber. Plants were irradiated at 20<sup>th</sup>, 40<sup>th</sup>, and 60<sup>th</sup> day after transferring for 30, 60, 90 and 120 minutes.

### Characters studied

#### Pre-harvest observations

##### Number of leaves per plant

The open leaves of all four plants from each treatment were counted and average number of leaves per plant was calculated. These observations were recorded at 20<sup>th</sup>, 40<sup>th</sup>, 60<sup>th</sup> day after planting.

##### Leaf area (cm<sup>2</sup>)

The leaf area of four plants of the all treatments was measured with the help of graph paper and average leaf area per plant was calculated. These observations were recorded at 20<sup>th</sup>, 40<sup>th</sup>, 60<sup>th</sup> day after planting.

##### Plant height (cm)

The height of four plants of all the treatments was measured from the ground level up to the highest level reached by the plant in natural condition. These observations were recorded at 20<sup>th</sup>, 40<sup>th</sup>, 60<sup>th</sup> day after planting.

##### Fresh weight (gm)

Four healthy and uniform plants from each treatment were sampled and washed carefully. Precautions were taken against any loss and then surface water was dried with blotting paper. Then the plants were weighed directly on electronic balance. These observations were recorded at 20<sup>th</sup>, 40<sup>th</sup>, 60<sup>th</sup> day after planting.

##### Dry weight (gm)

Four healthy and uniform plants from each treatment were sampled and washed carefully. Precautions were taken against any loss and then surface water was dried with blotting paper. The plants were oven dried at 70°C for 24 hrs. so that moisture is evaporated and then the plant was weighed carefully. These observations were recorded at 20<sup>th</sup>, 40<sup>th</sup>, 60<sup>th</sup> day after planting.

**Harvest observation:****Fresh fruit weight (g)**

Weight of three fruits of four plants of each treatment was taken. From this average weight of the fruit was calculated.

**Length of fruit (cm)**

The length of three fruits from four plants of each treatment was taken with the help of a scale and average length of fruit was calculated.

**Number of fruit per plant**

The number of fruits from four plants of each treatment was counted, from this average number of fruits per plant was calculated.

**Fruit yield (gm)**

Fresh weight of the fruits from four plants of each treatment was recorded. From this average fruit yield per treatment was calculated.

**Statistical analysis and presentation of data**

The data recorded during the course of the study was subjected to statistical analysis as per method of 'Analysis of variance' suggested by Prof. R. A. Fisher (1958). The interpretation of the results was carried out on the basis of 'F' test and C.D. (at 5% level between means). For testing the hypothesis, ANOVA table was used.

**RESULTS AND DISCUSSION**

In the present investigation UV-B radiation showed negative influence on growth and dry matter accumulation in the test crop. Growth reductions have been described for a large number of plant species at different developmental stages when tested for tolerance against high intensity of UV-B sources [25], [33], [34]. In all such cases growth reduction can be explained as consequence of adverse changes in metabolic or developmental processes.

**Pre-harvest observations**

The number of leaves and leaf area of strawberry was reduced highly significantly due to UV-B exposure (Table 1) at various stages of growth i.e. 20 DAT, 40 DAT and 60 DAT.

**Table 1: Growth of strawberry under enhanced levels of UV-B radiation at different stages of plant growth**

**Table 1a: Growth of strawberry plant on 20DAT**

UV-B treatments (min)	20 DAT				
	No. of leaves	Leaf area (cm <sup>2</sup> )	Plant height (cm)	Fresh weight (g)	Dry weight (g)
T <sub>0</sub>	17 ± 1.0a	104 ± 4.9a	1.6 ± 0.14a	26 ± 1.4a	6 ± 0.32a
T <sub>30</sub>	16 ± 1.0a	100 ± 4.9a	1.6 ± 0.14a	25 ± 1.4a	5 ± 0.32a
T <sub>60</sub>	13 ± 1.0a	83 ± 4.9a	1.3 ± 0.14a	24 ± 1.4a	5 ± 0.32a
T <sub>90</sub>	11 ± 1.0a	77 ± 4.9a	1.2 ± 0.14a	17 ± 1.4a	4 ± 0.32a
T <sub>120</sub>	12 ± 1.0a	69 ± 4.9a	1.2 ± 0.14a	18 ± 1.4a	4 ± 0.32a

Each value is the mean of 4 measurements ± S.E. Mean in each column for each treatment followed by the same letter are highly significantly different at  $P \leq 0.05$  according to Prof. R.A. Fisher 'F' test

**Table 1b: Growth of strawberry plant on 40DAT**

UV-B treatments (min)	40 DAT				
	No. of leaves				
T <sub>0</sub>	21±1.2a	21±1.2a	21±1.2a	21±1.2a	21±1.2a
T <sub>30</sub>	19±1.2a	19±1.2a	19±1.2a	19±1.2a	19±1.2a
T <sub>60</sub>	16±1.2a	16±1.2a	16±1.2a	16±1.2a	16±1.2a
T <sub>90</sub>	14±1.2a	14±1.2a	14±1.2a	14±1.2a	14±1.2a
T <sub>120</sub>	14±1.2a	14±1.2a	14±1.2a	14±1.2a	14±1.2a

In this study, leaf number and leaf size was affected highly significantly indicating UV-B induced inhibition of cell division and cell expansion. UV-B induced cell inhibition of cell expansion has been observed in cucumber cotyledons [3], tomato hypocotyls [4], wheat and barley leaves [16-17]. UV-B could reduce cell expansion by changing turgor pressure or cell wall extensibility. [30] suggested that direct oxidation of auxin and indole acetic acid by UV-B resulted in reduction of cell wall expansion. Cell wall extensibility can also be reduced by the formation of cross links between cell wall carbohydrate and ferulic acid. Repair of UV-B damage to DNA before replication and direct UV-B induced oxidation of tubulin, delaying microtubule formation have been suggested as mechanisms for direct reduction of the rate of cell division [27]. Plant height increased with successive growth stages. However, UV-B exposure retarded plant height highly significantly at all the stages (Table 1).

The present observation of UV-B induced reduction in plant height of strawberry is in agreement with the results obtained in open top chamber experiment [36] and green house experiment [33] with faba bean. [23] and [24] reported reduction in length of cowpea seedling and shoot height of *Suaeda maritima*, respectively due to UV-B treatment. Height reduction was ascribed to photo-oxidative destruction of the phytochrome Indole Acetic Acid (IAA) followed by reduced cell wall extensibility as demonstrated in sunflower seedlings [25]. A reduction in plant height may reflect specific photomorphogenic response of plant to UV-B radiation mediated by UV-B photoreceptors [4]. Another potential mechanism for UV-B induced growth inhibition may be due to reduction of auxin and formation of growth inhibitor IAA photoproducts [25].

Fresh weight and dry weight of plant increased with age, but decreased highly significantly with treatments of UV-B radiation at all the growth stages (Table 1).

**Table 1c: Growth of strawberry plant on 60DAT**

UV-B treatments (min)	60 DAT				
	No. of leaves				
T <sub>0</sub>	25±1.1a	25±1.1a	25±1.1a	25±1.1a	25±1.1a
T <sub>30</sub>	23±1.1a	23±1.1a	23±1.1a	23±1.1a	23±1.1a
T <sub>60</sub>	19±1.1a	19±1.1a	19±1.1a	19±1.1a	19±1.1a
T <sub>90</sub>	18±1.1a	18±1.1a	18±1.1a	18±1.1a	18±1.1a
T <sub>120</sub>	17±1.1a	17±1.1a	17±1.1a	17±1.1a	17±1.1a

Reduction in fresh and dry weights was observed in strawberry during the present investigation for their response to UV-B. Reduction in total biomass is a consequence of decrease in plant height. [1] reported reduction in fresh and dry weight of wheat and pea seedlings after exposure to enhanced UV-B. Reduction in dry matter and yield were found associated with reduced photosynthetic rate [28], stunted growth and change morphology at UV-B radiation [5] and [26].

[35] observed a small but non significant reduction in fresh and dry weight of rice cultivars of USA with a UV-B exposure simulating 50% O<sub>3</sub> depletion.

### Harvest observations

The fresh fruit weight, fruit length, number of fruit per plant and yield of strawberry decreased highly significantly due to UV-B exposure (Table 2). Reduction in fresh fruit weight, fruit length, number of fruit per plant and yield are a typical index of sensitivity of plants to any stresses. In the present investigation the test plant showed reduction in yield with UV-B exposure. Another field

**Table 2: Yield of strawberry under enhanced levels of UV-B radiation**

UV-B treatments (min)	Fresh fruit weight (g)	Fruit length (cm)	No. of fruit	Fruit yield (g)
T <sub>0</sub>	10.2 (±0.32a)	3.5 (±0.05a)	19 (±0.42a)	186 (±3.7a)
T <sub>30</sub>	9.6 (±0.32a)	3.3 (±0.05a)	17 (±0.42a)	174 (±3.7a)
T <sub>60</sub>	9.2 (±0.32a)	3.1 (±0.05a)	16 (±0.42a)	160 (±3.7a)
T <sub>90</sub>	8.7 (±0.32a)	2.8 (±0.05a)	15 (±0.42a)	154 (±3.7a)
T <sub>120</sub>	8.4 (±0.32a)	2.5 (±0.05a)	14 (±0.42a)	143 (±3.7a)

Each value is the mean of 4 measurement ± S.E. Mean in each column for each treatment followed by the same letter are highly significantly different at  $P \leq 0.05$  according to Prof. R.A. Fisher 'F' test

experiment with *Glycine max* showed reduction in yield due to UV-B singly and in combination with O<sub>3</sub> [2].

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