

EFFECTS OF ULTRAVIOLET LIGHT ON GROWTH AND YIELD OF TOMATOES (*Lycopersicon esculentus*)

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Abstract

A greenhouse experiment was conducted in 2017 and 2018 at the Federal College of Education (Technical) Gombe Research Farm. Gombe, which is located on 11°02' Longitude East and 10°19' latitude North has an average elevation of 380 meter above sea level. This region belongs to the Northern Guinea savannah ecological zone of Nigeria. To determine the effect of Ultraviolet light on the Germination, Growth, and Physiological response of Tomatoes, Tomatoes seedlings were exposed to different levels of Ultraviolet – B for 12hours, 6hours and 3hours respectively, three growth parameters were measured and analysed plant height, number of fruits set, and leaf greenness. The analysis of variance (ANOVA) of the plant height exposed to the three levels of UV-B shows a significant variations exist the calculated value of the Plant height at Ultraviolet-B of 12hours in centimetre (79.2**) is higher than the table value F Critical (2.5) that shows a highly significant level, and the means were separated using LSD all the vertical means with the same letter do not differ significantly at ($P=0.005$). A negative correlation existed between plant height and number of fruits set at UV-B level of 12hours ($r = -0.695$) but positive correlation exists between plant height and leaf greenness ($r = 0.999$). Positives correlation was established between plant height at UV-B level of 6hours and 3hours against number of fruits set and leaf greenness. Graphical presentation of plant height, number of fruits set, and leaf greenness against UV-B of 12hours, 6hours, and 3hours shows that plants at UV-B of 3hours performed better with the highest curve. Plant height, leaf greenness, and number of fruits set have shown a decrease, whereas other Physiological process are difficult to quantify such as photosynthesis is by and large unaffected by heightened UV-B illumination under this studies therefore, recognizes the need for further research on different plants to determine the overall effects on various Physiological process.

Keywords: Ultraviolet (UV) radiation; UV-B radiation; Tomatoes; Solar Light.

Introduction

Ultraviolet (UV) radiation is a component of the solar light that

naturally reaches the Earth, depending on its wavelength; it can be divided into three different ranges: UV-A (315-390 nm), UV-B (280-315 nm) and UV-

C (100-280 nm). Different species have different response to the level of UV-B irradiation (Matthew *et al.* 1996, Skorska 1996a, b). In the study of Furness *et al.* (1999) vertical leaf orientation and a concealed terminal bud may protect *Tragopogon pratensis* dicot from UV-B radiation. On the other hand, in the case of *Cynoglossum officinale* with the creeping leaves habit and exposure of shoot terminals to radiation resulted in higher susceptibility to UV-B radiation. Cline and Salisbury (1966) proposed that monocots might be less affected by UV-C radiation than dicots because of their vertical leaf orientation, protective basal sheath, and concealed apical meristem. The changes in plants morphology induced by UV-B may affect competition for light (Barnes *et al.* 1988). The negative effects of UV-B radiation results in deformed morphological parameters, the exposure to UV-B decreased plant height, leaf area and plant dry weight increased auxiliary branching and leaf curling (Dai *et al.* 1995, Greenberg *et al.* 1997, Furness *et al.* 1999). Dai *et al.* (1995) reports that after a few weeks of UV-B exposure, leaf area and plant dry weight of rice were significantly reduced. Weigh *et al.* (1998) stated that enhanced UV-A decreased leaf area per unit plant biomass (leaf area ratio) but increased biomass productivity both per unit leaf area (leaf area productivity) and per unit leaf nitrogen (leaf nitrogen productivity). High levels of UV-B clearly decreased the relative growth rate and nitrogen productivity, as leaf area ratio, leaf area productivity and leaf nitrogen productivity were all

decreased. Fortunately, Ultraviolet (UV) radiation is strongly affected by the ozone layer in the stratosphere, so that the amount of this radiation reaching the Earth's surface, except for high mountains, is extremely low (Häder *et al.*, 2007). Nevertheless, in the last decades, human activities have produced dangerous chemicals, such as chlorofluorocarbons (CFC), which have been released into the atmosphere and have contributed to the depletion of ozone protective layer. Therefore, in the future UV-B radiation could increase as the result of stratospheric ozone depletion due to atmospheric pollution. In fact, the stratospheric ozone layer reduction highlights the ecological implication of increasing UV-B radiation on natural ecosystems and on Agricultural productions (Kataria & Guruprasad, 2012). In this scenario, characterized by an increasing trend of UV-B flux on Earth, the study of the effect of this radiation on some crops becomes important.

Tomato is one of the three most important vegetables crop in the world. Adapted to winter greenhouse conditions, fresh tomatoes are now available all year long and their consumption has increased regularly during the last 10 years. Tomato consumption has been shown to reduce the risks of certain types of cancer and cardiovascular diseases (Giovannucci 1999). Much of the health benefit derived from tomatoes can be attributed to lycopene content (Bramley 2000), but tomatoes are also an important source of vitamin C (Offord 1998). This work represents a first study on the possible implications

of UV-B irradiation on tomato production, one of the most economically important crops in Nigeria making it necessary, also in order to deepen the ecophysiological response of this crop to a changing climate thereby making this study a necessity.

Materials and Methods

The experiment was carried out at the Federal College of Education (Tech) Gombe Greenhouse to assess the effect of UV-B radiation on tomato plants (*Lycopersicon esculentum* Mill.) The experimental materials are tomatoes seedling raised in the nursery for one month, the tomatoes used in this research were the industrial types popularly known as Roma VH which is a popular variety commonly cultivated by our local farmer. The variety is resistant to fungal disease and nematode. In all the stages, three seedlings were transplanted in plastic pots of 5L capacity the pots were filled with a mixture of loamy soil and in each pot, 2g of compound fertilizer (NPK 15:15:15), thoroughly mixed with the soil. Completely randomized Block design was used. The three tomatoes seedlings planted in each plastic pot served as replicate making thirty (30) plastic pots divided into three (3) of ten (10) pots each. The first ten were exposed to 12 hours of light, the second ten exposed to 6 hours of

light and the last ten pots, to 3 hours of light, till the planted seedlings started flowering, to the final setting of the last fruit- growth. Three parameters were collected viz plant height was measured using a ruler in centimetre and the number of fruit set by each plant by counting, and the Leaf greenness from chlorophyll extract, which is subjected to absorption analysis using a UV-Vis spectrophotometer (Shimadzu Scientific Instruments Inc., Columbia, MD)

The data collected was subjected to analysis of variances (ANOVA) to test their significance differences and their mean were separated using LSD at (0.05) level of significant to evaluate the effect of UV light on the tomatoes, also the parameters were correlated to determine the extent of the effect.

Results

Correlation Coefficient of Mean Plant Height and Number of Fruit Sets and Leaf Greenness

When the means of the plant height were correlated with the mean number of fruits set it shows a negative correlation which is significant at 5% level of significant ($r = -0.695$), but there was a positive correlation between mean plant height and leaf greenness which is highly significant ($r = 0.999$). (Table 1)

TABLE 1 CORRELATION COEFFICIENT OF MEAN PLANT HEIGHT WITH NUMBER OF FRUIT SETS AND LEAF GREENNESS

PARAMETERS	CORRELATION COEFFICIENT	
Plant height	Number of fruit set/plant	Leaf greenness
UV-B 12 HOURS	r = -0.695	r = 0.999
UV-B 6 HOURS	r = 0.999	r = 0.9996
UV-B 3 HOURS	r = 0.999	r = 0.9997

Mean Plant Height Result and Analysis

The means of the ten tomatoes replicated three times for this treatment of 12hours. The analysis of variance (ANOVA) indicated a significant variation exist, the means were separated, all the vertical means with the same letter do not differ significantly at (P = 0.05) using LSD. The means of the ten tomatoes replicated three times for this treatment of 6hours. The analysis of variance (ANOVA) indicated a significant

variation exist, the means were separated, all the vertical means with the same letter do not differ significantly at (P = 0.05) using LSD. The means of the ten tomatoes replicated three times for this treatment of 3hours. The analysis of variance (ANOVA) indicated a significant variation exist, the means were separated, all the vertical means with the same letter do not differ significantly at (P = 0.05) using LSD (TABLE 2)

TABLE 2 MEAN PLANT HEIGHTS IN CENTIMETER (ANOVA)

Plants number	UV-B 12 HOURS	UV-B 6 HOURS	UV-B 3 HOURS
1	44.1e	58.5d	57.2f
2	33.5g	48.2h	67.1e
3	47.1cd	44.4i	85.9ab
4	52.6b	53.4ef	65.6e
5	48.4c	64.3b	87.4a
6	36.7f	50.9g	74.2d
7	54.7b	68.3a	82.5b
8	59.1a	52.2fg	68.5e
9	45.3de	61.1c	54.2f
10	38.6f	55.1e	77.2cd

Vertical Means with the same letters do not differ significantly, At P = 0.05 using LSD

Mean Number of Fruit Set/Plant

The performance of fruit set /plant at Ultraviolet – B of 12hours, plant number two (2) had the highest mean fruit set of twelve (12) fruits and plant number four (4) and eight (8) had the lowest means of seven (7) fruits set

respectively, the performance of fruit set /plant at Ultraviolet – B of 6hours, plant number seven (7) had the highest mean fruit set of fourteen (14) fruits and plant number three (3) had the lowest mean of nine (9) fruits set, the performance of fruit set /plant at

Ultraviolet – B of 3hours, plant number three (3), five (5) and seven (7) sets the highest mean fruits of seventeen (17) and plant number one (1) and nine (9) have the lowest means of eleven (11) fruits set respectively. (TABLE 3)

TABLE 3 MEAN NUMBER OF FRUIT SET/PLANT

<i>Plants number</i>	UV-B 12 HOURS	UV-B 6 HOURS	UV-B 3 HOURS
1	11	12	11
2	12	10	13
3	9	9	17
4	7	11	13
5	10	13	17
6	10	10	15
7	9	14	17
8	7	10	14
9	9	12	11
10	8	11	15

MEAN LEAF GREENNESS

The performance of leaf greenness at Ultraviolet – B of 12hours, plant number eight (8) had the highest leaf greenness of thirty (30) and plant number two (2) had the least leaf greenness of sixteen (16), the performance of leaf greenness at Ultraviolet – B of 6hours, plant number seven (7) had the highest leaf greenness of thirty-four (34) and plant number three (3) had the least leaf greenness of Twenty-two (22), the performance of leaf greenness at Ultraviolet – B of 6hours, plant number seven (7) has the highest leaf greenness of thirty-four (34) and plant number three (3) had the least leaf greenness of Twenty-two (22), the performance of leaf greenness at Ultraviolet – B of 3hours, plant number five (5) had the highest leaf greenness of forty-four (44) and plant number nine (9) has the least leaf greenness of Twenty-seven (27). (TABLE 4

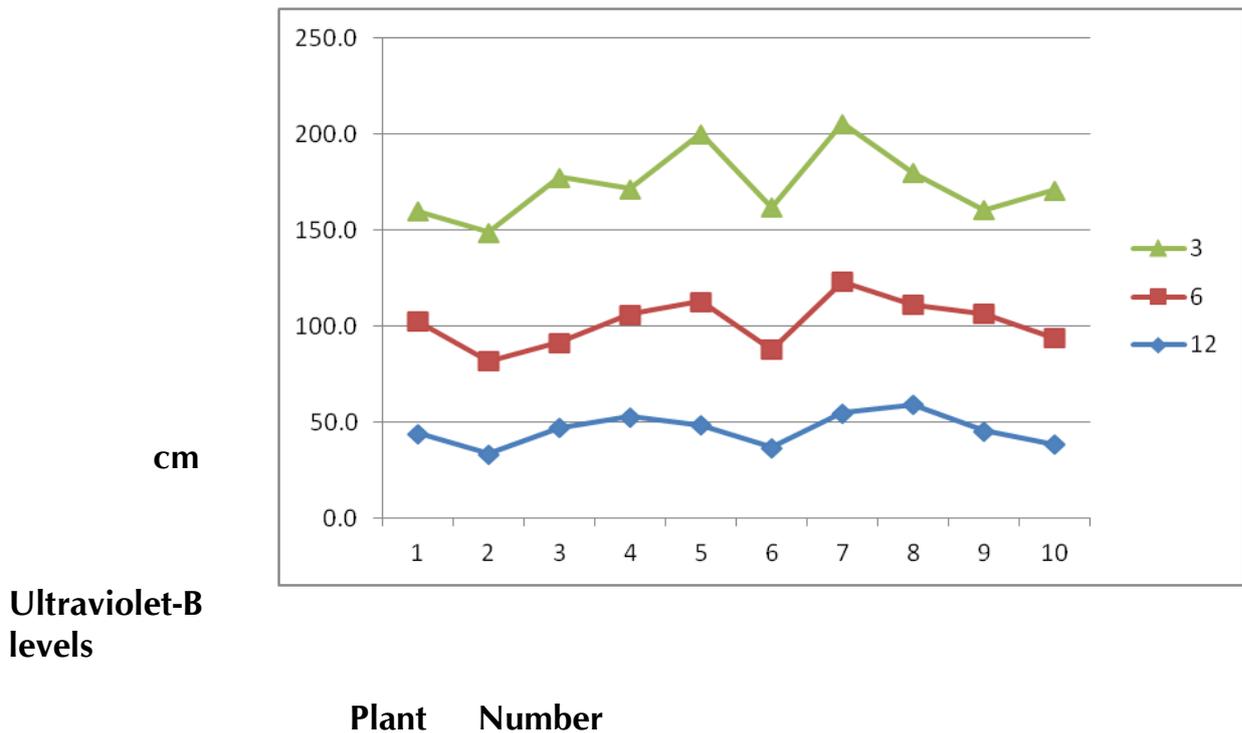
TABLE 4 MEAN LEAF GREENNESS

<i>Plants number</i>	UV-B 12 HOURS	UV-B 6 HOURS	UV-B 3 HOURS
1	22	29	29
2	16	24	34
3	24	22	43
4	26	27	33
5	24	32	44
6	18	25	37
7	27	34	41
8	30	26	35
9	23	31	27
10	19	28	39

GRAPHICAL PRESENTATION OF MEAN PLANT HEIGHT AGAINST ULTRAVIOLET – B

Graphical presentation of mean plant height against Ultraviolet – B of 3, 6, and 12hours shows that those plants with the 3hours Ultraviolet – B levels performed better than that of 6hours Ultraviolet – B and that of 12hours Ultraviolet – B level (Figure 1).

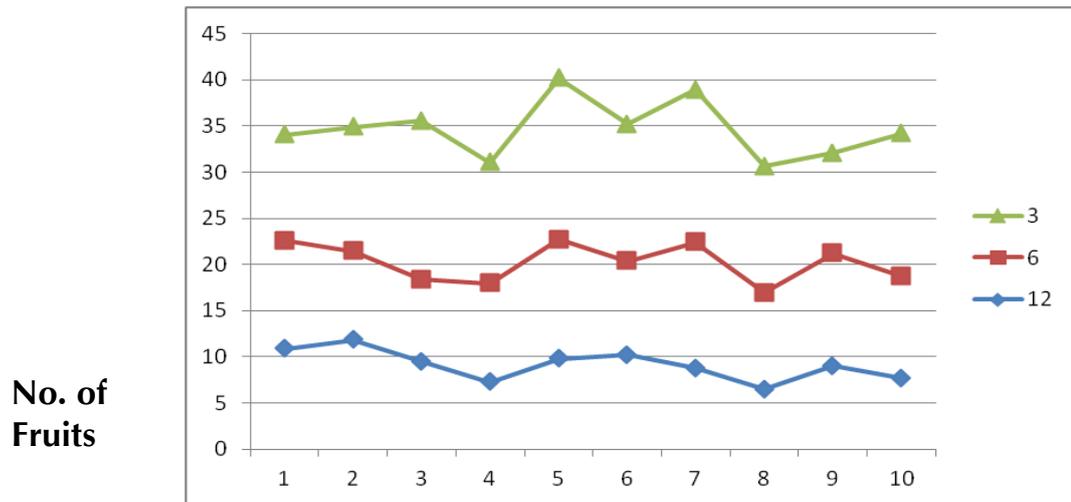
FIGURE 1 GRAPHICAL PRESENTATION OF MEAN PLANT HEIGHT AT ULTRAVIOLET-B OF 3, 6, AND 12HOURS DATA



GRAPHICAL PRESENTATION OF MEAN NUMBER OF FRUIT SET/PLANT

Graphical presentation of mean number of fruits set/plant against Ultraviolet – B of 3, 6, and 12hours shows that those plants with the 3hours Ultraviolet – B levels performed better than that of 6hours Ultraviolet – B and that of 12hours Ultraviolet – B level (Figure 2).

FIGURE 2 GRAPHICAL PRESENTATION OF MEAN NUMBER OF FRUIT SET/PLANT AT ULTRAVIOLET-B OF 3, 6, AND 12HOURS DATA



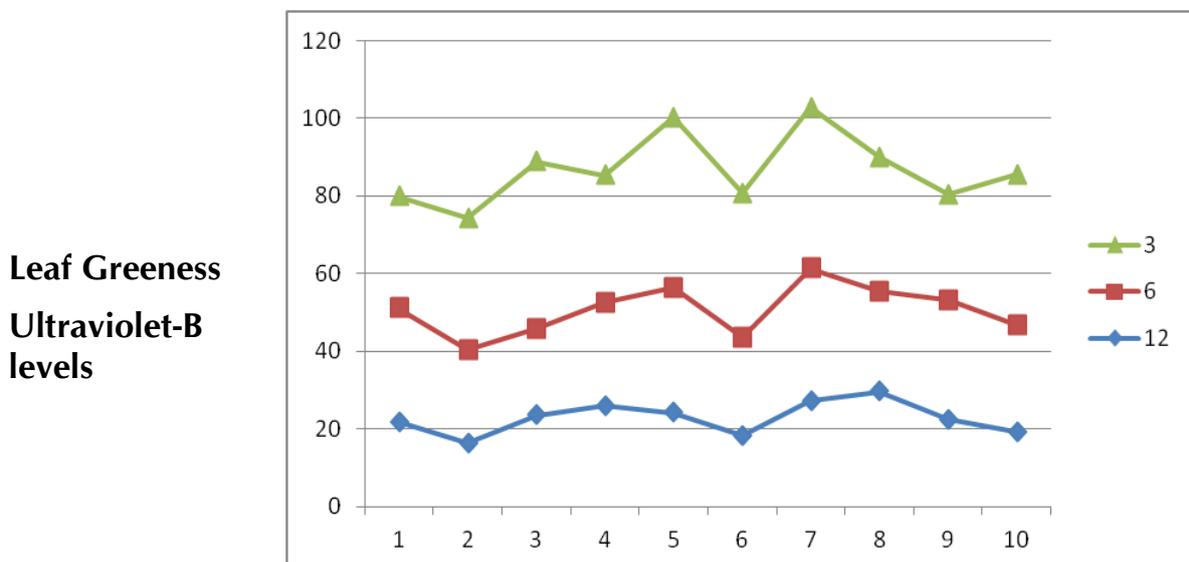
Ultraviolet-B levels

Plant Number

GRAPHICAL PRESENTATION OF MEAN LEAF GREENNESS

Graphical presentation of mean leaf greenness against Ultraviolet – B of 3, 6, and 12hours shows that those plants with the 3hours Ultraviolet – B levels performed better than that of 6hours Ultraviolet – B and that of 12hours Ultraviolet – B level (Figure 3).

GRAPHICAL PRESENTATION OF MEAN LEAF GREENNESS AT ULTRAVIOLET-B OF 3, 6, AND 12HOURS DATA



Conclusion

Plant growth and development depends mainly on energy derived from light, the habitat and ecosystem of plants can vary greatly even when there are minor changes in light. There are two properties of light that relate to plant growth and development: light quality and quantity. Light quality can refer to proportions of visible light within certain spectra which influences plant growth responses, e.g. changes in the ratio of red light to far red light can influence biomass allocation, and light quantity is the actual amount of energy associated with radiation hitting the earth's surface. There has been an increase in research concerning the effects of ultraviolet light (UV-B) on plant growth and development. Much of the early work concerning the effects UV-B illumination on terrestrial plants was conducted indoors using growth chambers or greenhouses. By the 1990s, a consensus was reached that many of these early reports of UV-B effects on terrestrial plants were exaggerated, and that extrapolating these results to field responses was a dubious endeavour. Since then, there has been more emphasis on field studies that take advantage of the UV irradiance provided by sunlight. The decrease in growth rate in the plants after exposure to UV light has been reported previously (Schmidt and Zhang, 2001). Reducing the efficiency of the photosynthetic machinery due to photolytic damage would effectively reduce plant productivity and explain previous findings. Biological variation and seasonal light changes affect plant maturation and may have affected the Tomatoes plants also, although

photosynthesis is by and large unaffected by heightened UV-B illumination in the field, exposure to solar UV-B does reduce biomass production in many terrestrial plant species (Day and Neale, 2002).

Recommendations

Little research has been carried out to quantify the effects of UV radiation on crop quality. UV radiation can be regarded as a stress factor which is capable of significantly affecting plant growth characteristics. Plant height, leaf greenness, and number of fruits set have been showed to decrease, whereas other Physiological processes are difficult to quantify such as photosynthesis, therefore the study recognizes the need for further research on different plants to determine the overall effects on various Physiological process, in this respect we recommends that this type of studies be implemented on all crops to determine the actual effect of Ultraviolet – B on our cultivated crops.

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