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MITOTIC INDEX OF ONION (*Allium cepa*) ROOT TIPS AS AFFECTED BY  
ULTRAVIOLET RADIATION AT DIFFERENT EXPOSURE PERIODS

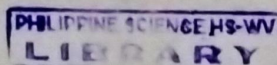
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Faculty of Philippine Science High School Western Visayas  
Iloilo City

In Partial Fulfillment  
Of the Requirements in  
Technology Research II

By

Patricia Joy A. Aldeguer  
Stephanie S. Katalbas  
Fabini D. Orata

January 2003



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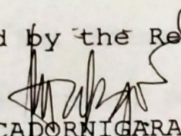
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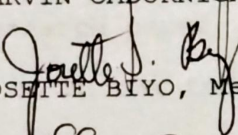
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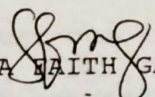
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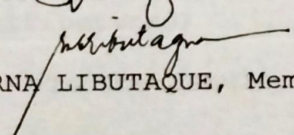
Patricia Joy A. Aldeguer  
Stephanie S. Katalbas  
Fabini D. Orata

Approved by the Research Committee

  
MARVIN CADORNIGARA, Research Committee Chair

  
JOSEITE BIYO, Member

  
SHENA FAITH GANELA, Member

  
MYRNA LIBUTAQUE, Member

January 2003

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Katalbas, Jr. and Mrs. Severa Katalbas, our parents, for their prayers, love, and for their unwavering support for us;

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PATRICIA JOY A. ALDEGUER  
STEPHANIE S. KATALBAS  
FABINI D. ORATA  
Researchers

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## Abstract

This study determined the effects of different exposure times to ultraviolet radiation on the mitotic activity on the onion root tip. Specifically, it aimed to determine the mitotic indices of the onion root tips when exposed to ultraviolet radiation for 5, 10, and 15 minutes. It also compared the mitotic indices of the onion root tips when exposed to ultraviolet radiation for 5, 10, and 15 minutes. It further determined the significant difference among the mitotic indices of the onion root tips exposed to ultraviolet radiation for 5, 10, and 15 minutes. It was hypothesized that there is no significant difference among the mitotic indices of the onion root tips when exposed to ultraviolet radiation for 5, 10, and 15 minutes. A Completely Randomized Design was used to determine the effects of varying exposure periods to ultraviolet light or radiation on the mitotic activity of onion root tips. The independent variables of this study were the different exposure times of the onions to ultraviolet radiation, while the dependent variables were the observed changes in the mitotic activity of

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the onion root tips. Onions were randomly chosen and purchased at the Iloilo Central Market and were then exposed to UV radiation. There were three treatment groups, namely, 5 minutes, 10 minutes, and 15 minutes exposure to ultraviolet radiation. Data gathered were analyzed using the mean and standard deviation, the One Way Analysis of Variance, and the Scheffe test.

Based on the results of this study, exposure to UV radiation in a given period of time has a significant effect on the mitotic activity of onion (*Allium cepa*) root tips. The longer the period of exposure to UV radiation, the more damaged cells, the lower is the mitotic index, and there is less mitotic activity. The shorter the exposure period, the less damaged cells, the higher the mitotic index of the root tip, and there is more mitotic activity.

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## TABLE OF CONTENTS

Chapter 1	1
INTRODUCTION TO THE STUDY	1
Background of the Study	1
Statement of the Problem and the Hypothesis	2
Significance of the Study	3
Definition of Terms	5
Scope and Delimitation of the Study	7
Chapter 2	9
REVIEW OF RELATED LITERATURE	9
Onion	9
Ultraviolet Radiation	9
Mitosis	11
Cell Cycle	11
Root Tip	12
Root cap	12
Quiescent center	12
Chapter 3	13
RESEARCH DESIGN AND METHODOLOGY	13
The Research Design	13
Materials and Equipment	14
General Procedures	15
Preparation of materials	15

# PHILIPPINE SCIENCE HIGH SCHOOL WESTERN VISAYAS

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Iloilo City

Exposure to UV radiation	15
Care and maintenance of onion bulbs	15
Collection of roots	16
Fixation	16
Staining of chromosomes using the Squash and Smear Technique	17
Determination of mitotic index	17
Statistical Data Analysis	18
Mean	18
Standard Deviation	18
One Way Analysis of Variance	19
Scheffe Test	19
Chapter 4	20
RESULTS	20
Mitotic indices of onion root tips exposed to UV radiation for 5, 10, and 15 minutes	20
Significance of the differences among the mitotic indices of onion root tips when exposed to UV radiation for 5, 10, and 15 minutes	23
Chapter 5	26
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS	26
Summary	26
Conclusions	27
Recommendations	28



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Iloilo City

LIST OF TABLES

Table 1	Means of mitotic indices of onion root tips exposed to ultraviolet radiation for 5, 10, and 15 minutes	22
Table 2	One Way ANOVA of the significant difference in the mitotic indices of the onion root tips exposed to ultraviolet radiation for 5, 10, and 15 minutes	24
Table 3	Scheffe test as post hoc multiple comparison test of the One-Way ANOVA in Table 2	25

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## LIST OF FIGURES

- Figure 1 The mitotic index of onion root tips when exposed to ultraviolet radiation for 5, 10, and 15 minutes 4

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Iloilo City

APPENDIX

Plate 1	The set-up: onion bulbs on wide-mouthed bottles filled with water up to the bottom of the bulbs	30
Plate 2	A sample of an onion that has grown roots	30
Plate 3	Two of the researchers working in the Laboratory	31
Plate 4	The hood: the source of Ultraviolet Radiation For this study	31
Plate 5	Most of the materials the researchers used in the conduct of this study	32
Plate 6	A sample of the pictures the researchers used in determining the mitotic index of the onions in this study	32

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MITOTIC INDEX OF ONION (*Allium cepa*) ROOT TIPS AS AFFECTED BY  
ULTRAVIOLET RADIATION AT DIFFERENT EXPOSURE PERIODS

Chapter 1

Introduction to the Study

Background of the Study

In the atmosphere, the chemical compound ozone plays a vital role in absorbing harmful ultraviolet radiation from the sun. Human-made gases, including CFCs, have threatened concentrations of this important compound.

The depletion of the ozone layer leads to an increase in ground-level ultraviolet radiation. Some of this UV radiation is especially effective in causing damage to living beings, for example, sunburn, skin cancer, and eye damage to humans.

People are at risk of developing both benign and malignant neoplasms. Outdoor sports enthusiasts are at greater risk of developing melanoma and non-melanoma skin cancer. Athletes spend a great deal of time outdoors, typically during peak hours of ultraviolet exposure (Adams, 2001). Cases of skin cancer and cataracts are increasing in Australia, New Zealand, South Africa, Argentina, and Chile, where the ozone layer is very thin for several months after masses of ozone-depleted air over the South

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2

Pole drift northward (Greer, 1997). It is hoped that the results of this study might contribute to eventual medical researches, which may be aimed at formulating ways of improving living organisms' resistance to the negative effects of ultraviolet radiation.

In this study, the researchers determined the effects of exposure to ultraviolet radiation on the mitotic activity of onion (*Allium cepa*) root tips.

The independent variables of this study were the different exposure times of the onions to ultraviolet radiation, while the dependent variables were the observed changes in the mitotic activity of the onion root tips.

The relationship between the variables is a cause-and-effect relationship, which is presented in Figure 1.

#### Statement of the Problem and the Hypothesis

The researchers determined the effects of different exposure times to ultraviolet radiation on the mitotic activity of the onion root tip.

Specifically, it aimed to:

1. determine the mitotic indices of the onion root tips when exposed to ultraviolet radiation for (a) 5, (b) 10, and (c) 15 minutes;

2. compare the mitotic indices of the onion root tips when exposed to ultraviolet radiation for (a) 5, (b) 10, and (c) 15 minutes; and

3. determine the significant difference among the mitotic indices of the onion root tips exposed to ultraviolet radiation for (a) 5, (b) 10, and (c) 15 minutes.

It was hypothesized that there is no significant difference among the mitotic indices of the onion root tips when exposed to ultraviolet radiation for 5, 10, and 15 minutes.

#### Significance of the Study

With this study, we were able to observe the changes in the mitotic activity of the onion root tips due to exposure to ultraviolet radiation.

These changes helped to establish the fact that the continued depletion of the ozone layer indeed has negative effects on living plants, and that in the future, there may be mutated living organisms, which will not be able to survive.

The findings from this study may also contribute to future medical researches, which may be aimed at devising methods of repairing the ozone layer, limiting ground-level UV radiation, or devising methods of shielding plants and animals from UV.

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4

INDEPENDENT VARIABLE

DEPENDENT VARIABLE

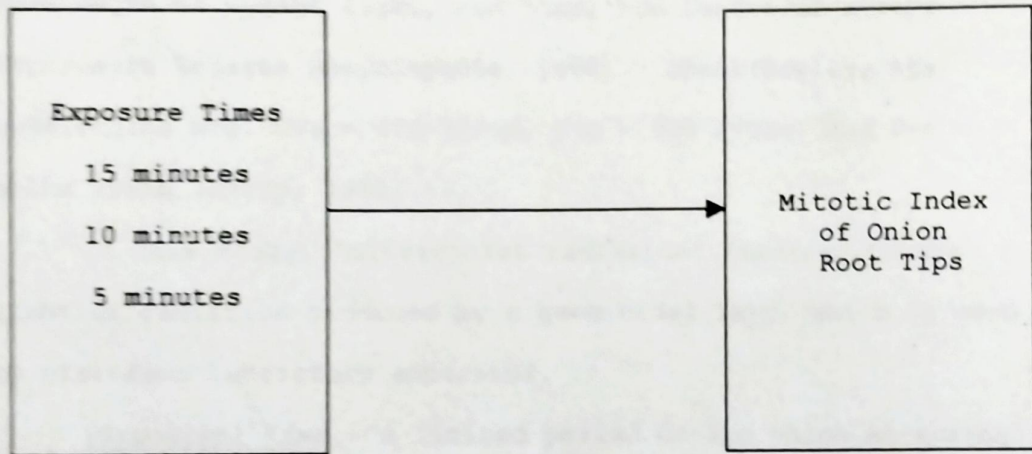


Figure 1. The mitotic index of onion root tips when exposed to ultraviolet radiation for 5, 10, and 15 minutes.

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5

Definition of Terms

The following terms used in this study were given their respective conceptual and operational meanings:

Ultraviolet radiation - is an electromagnetic radiation that has wavelengths in the range between 400 and 4nm, the wavelength of violet light, and 15nm, the length of x-rays (Microsoft Encarta Encyclopedia, 1998). Specifically, its wavelengths are: UVa = 400-320nm, UVb = 320-280nm, and UVc = below 280nm (Philp, 1995).

In this study, "ultraviolet radiation" referred to the light or radiation produced by a germicidal lamp, which is used to disinfect laboratory apparatus.

[Exposure] time - a limited period during which an action, process, or condition exists or takes place (Microsoft Encarta Reference Library, 2002).

In this study, "exposure time" referred to the duration of time for which the onion bulbs were exposed to ultraviolet radiation, i.e., 5 minutes, 10 minutes, and 15 minutes; before growing the roots.

Chromosomes - in cytology, are tiny thread-like structures, composed of nucleic acids and proteins (chromatin), found in all plant and animal cells (Microsoft Encarta Encyclopedia, 1998).



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6

They are the densely staining bodies that show movement in the different stages of mitosis (Weaver, 1992).

In this study, "chromosomes" referred to the stained structures whose activities determined the mitotic index of the onion root tips.

Mitosis - is the process by which a cell divides into two daughter cells, each of which has the same number of chromosomes as the original cell (Microsoft Encarta Reference Library, 2002).

In this study, "mitosis" referred to the actual activities of the chromosomes as seen under the microscope, i.e., condensing, migrating, or separating.

[Root] tip - is the end of an object, especially a narrow or pointed end (Microsoft Encarta Reference Library, 2002).

In this study, "root tip" referred to the terminal part of the onion bulb's roots, from which tissue samples to be examined were acquired.

Photomicrograph - a photograph made of something seen through a microscope (Microsoft Encarta Reference Library, 2002).

Mitotic index - is the percentage of cells undergoing mitosis (Williams, 1992).

In this study, "mitotic index" shall be computed using the formula  $M.I. = \frac{\text{total number of cells undergoing mitosis}}{\text{total number of cells}} \times 100$

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7

The higher the mitotic index, the more active is the cell's division by mitosis; the lower the mitotic index, the less active is the cell's division by mitosis (Bermejo, 1995).

Onion (*Allium cepa*) - an Asian plant of the lily family with greenish-white flowers whose bulb is the onion (Microsoft Encarta Reference Library, 2002).

In this study, "onion" referred to the source of root tip tissue whose mitotic indices were determined when exposed to ultraviolet radiation.

#### Scope and Delimitation of the Study

This study aimed to determine if the onion (*Allium cepa*) is indeed affected by ultraviolet radiation. It determined the differences in mitotic activity among those exposed to ultraviolet radiation for 5 minutes, 10 minutes, and 15 minutes. Ultraviolet radiation came in the form of light or radiation from a germicidal lamp, which the root tips were exposed to.

This study observed the physical effects only, in terms of mitotic indices.

This study employed the mean, standard deviation, and One Way Analysis of Variance (ANOVA) as descriptive statistical tools, while the Scheffe test, set at 0.05 alpha level of significance, was employed as inferential statistical tool.

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8

This study was conducted at the University of the Philippines in the Visayas microbiology laboratory in Miag-ao, Iloilo and the Samaniego-Katalbas residence in Molo, Iloilo City (Iloilo) from summer 2002 to October 2002.

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Chapter 2

Review of Related Literature

This chapter consists of five topics, namely, (1) Onion, (2) Ultraviolet radiation, (3) Mitosis, (4) Cell cycle, and (5) Root tip.

Onion

The onion (*Allium cepa*) is a biennial plant, which may persist vegetatively as a perennial by means of bulbs. The root system is rarely shallow and fibrous. The underground stem is short and subconical; from it hollow cylindrical leaves are diverged in one-half phyllotaxy (leaf arrangement). The sheathing base of each leaf completely encircles the short stem, and it is the development of the fleshy leaf bases, together with the absence of internodal elongation, that results in the formation of the commercial bulb (Asis, 1971).

Ultraviolet Radiation

Ultraviolet (UV) radiation refers to a specific range of electromagnetic frequencies. This radiation may injure a person's skin or eyes. The harm to a person's skin includes sunburn, accelerated aging, and increased risk of cancer. The harm to the

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10

eyes is generally inflammation of the cornea, and at very high exposures, cataracts. UV is associated with sunlight and certain lamps used for tanning, special effects in the entertainment industry (i.e., black lights), Xenon lights in printing or photography and related industries, and germicidal control devices. Other sources of UV exposure include welding and mercury vapor lamps (Manning, Delton, 1996). UV radiation from the sun has always played important roles in our environment, and affects nearly all living organisms. Yet UV radiation at different wavelengths differs in its effects, and we have to live with the harmful effects as well as the helpful ones. Radiation at the longer UV wavelengths of 320-400nm, designated as UVA, plays a helpful and essential role in formation of Vitamin D by the skin, and plays a harmful role in that it causes sunburn on human skin and cataracts in our eyes. Radiation at shorter wavelengths of 280-320nm, designated as UVB, causes damage at the molecular level to the fundamental building block of life - deoxyribonucleic acid or DNA (Serra, Becker, 1997).

Retrospective epidemiological data have indicated that cutaneous malignant melanoma may arise as a consequence of intense, intermittent exposure of the skin to ultraviolet radiation, particularly in children, rather than from the cumulative lifetime exposure that is associated with other forms of skin

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11

cancer (Noonan, Recio & Takayama, 2001). Other effects of increased UV exposure are suppression of the immune system (which would reduce our bodies' defenses against a variety of infectious diseases and some forms of cancer), an increase in eye-burning, lower yields of key crops (such as corn, rice, soybeans, wheat, etc.), and a possible reduction in the productivity of surface-dwelling phytoplankton, which could upset aquatic food webs (Greer, 1997).

## Mitosis

Mitosis, which originated from the word 'mitosen,' which referred to the various stages of chromatin appearance, refers to the process of nuclear division. Mitosis refers to the separation of chromosomes and the formation of two genetically identical daughter nuclei (Moore, 1995).

## Cell Cycle

The cell cycle is a set of repeated processes that foster cell growth and division. When cell growth and division stop in mature cells, the cell cycle also stops. Such mature cells remain in the phase that precedes DNA synthesis, unless they are induced to divide by wounding or some other external influence.

The two main stages of the cell cycle are interphase, which mostly entails cell expansion and DNA synthesis, and cell division. Interphase is further recognized to have three phases: (1) the gap phase between the end of the previous mitosis and DNA synthesis ( $G_1$  phase), (2) the phase involving DNA synthesis (S phase), and (3) the gap between the end of DNA synthesis and the beginning of mitosis ( $G_2$  phase). Cell division may either be meiosis, or mitosis (which consists of Prophase, Metaphase, Anaphase, and Telophase) (Moore, 1995).

#### Root Tip

##### Root cap

A thick protective mass of cells that covers the growing tip of the root of a plant (Microsoft Encarta Reference Library, 2002). The tips of roots are covered by a thimble-shaped root cap, which has its own meristem that pushes cells forward into the cap (Moore, 1995).

##### Quiescent center

Just behind the root cap is the quiescent center, which consists of 500-1000 seemingly inactive cells. These cells are typically arrested in the  $G_1$  phase of the cell cycle and divide only once every 15-20 days (Moore, 1995).

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Chapter 3

Research Design and Methodology

This study determined the effects of different exposure times to ultraviolet radiation on the mitotic activity on the onion root tip.

Specifically, it aimed to determine the mitotic indices of the onion root tips when exposed to ultraviolet radiation for 5, 10, and 15 minutes. It also compared the mitotic indices of the onion root tips when exposed to ultraviolet radiation for 5, 10, and 15 minutes. It further determined the significant difference among the mitotic indices of the onion root tips exposed to ultraviolet radiation for 5, 10, and 15 minutes.

It was hypothesized that there is no significant difference among the mitotic indices of the onion root tips when exposed to ultraviolet radiation for 5, 10, and 15 minutes.

The Research Design

A Completely Randomized Design was used to determine the effects of varying exposure periods to ultraviolet light or radiation on the mitotic activity of onion root tips.

The independent variables of this study were the different exposure times of the onions to ultraviolet radiation, while the dependent variables were the observed changes in the mitotic



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Iloilo City

14

activity of the onion root tips. Onions were randomly chosen and purchased at the Iloilo Central Market and were then exposed to UV radiation. There were three treatment groups, namely, 5 minutes, 10 minutes, and 15 minutes exposure to ultraviolet radiation.

Data gathered were analyzed using the mean and standard deviation, the One Way Analysis of Variance, and the Scheffe test.

#### Materials and Equipment

The materials used in this study include the following: 12 pieces of similarly-sized onion (*Allium cepa*) bulbs locally known as "sibuyas bumbay," 12 pieces of clear wide-mouthed bottles, toothpicks, Laminar flow with germicidal lamp as the source of UV radiation, light compound microscopes, photomicroscope with camera attachment, scalpel, forceps, needle, glass slides, cover slips, alcohol lamp, slide box, ice cold water, 2 rolls of ASA 400 35mm color film for photomicrographs, digital camera, Farmer's Fluid, Aceto-Carmine Stain, mordanting solution (0.5% ferric chloride), tissue paper, and colorless nail polish.

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15

## General Procedures

### Preparation of materials

Onion bulbs were obtained from the Iloilo Central Market. Old roots were then scraped off the bottom of the bulbs. Clean bulbs were then brought to the UPV, Division of Biological Sciences' Microbiology Laboratory for exposure to UV radiation.

### Exposure to UV radiation

Three replicates of each treatment were made as follows:

Treatment group	Number of bulbs	Exposure time (minutes)
Control	3	0
A	3	5
B	3	10
C	3	15

### Care and maintenance of onion bulbs

After exposure to UV radiation, the onion bulbs were made to sit on top of the wide-mouthed bottles filled with water

reaching the bottom of the bulb. The bottles with onion bulbs were kept in a dark cabinet after exposure to UV radiation, to stimulate root growth. For 5 days, the bulbs were monitored to ensure that the roots are submerged in water.

#### Collection of roots

Actively growing roots were excised from the bulbs between 12:00 noon and 1:00 pm or 12:00 midnight to 1:00 am for this is the peak period for mitosis in *Allium cepa* (Bermejo, 1995).

#### Fixation

The excised roots were transferred to vials containing Farmer's Fluid, a fixative. The function of the fixative is to fix, or stop, the cells at a certain stage of cell division without causing deterioration, swelling, or shrinkage of the chromosomes. The root tips were kept in Farmer's Fluid for at least 24 hours.

A mordanting solution, 0.5% ferric chloride, was added to the fixative in a ration of 3 parts fixative is to 1 part mordant for the purpose of enhancing the ability of the chromosomes to absorb the stain, thus making them more visible under the microscope.

Staining of chromosomes using the Squash and Smear Technique

Root tips, approximately 0.5-1.0 cm long, were cut from roots previously fixed in Farmer's Fluid. The root tips were washed in water and soaked in 1M HCl to soften the tissues. The root tips were then placed on a clean slide and crushed with a scalpel. Two drops of aceto-carmine were placed on the crushed root tips and left for about 3 minutes. The slide was then heated very gently over the flame of an alcohol lamp. Care was taken to keep the stain from boiling. The materials on the slide were macerated with a scalpel until the pieces were less than the size of a pinhead. The specimen was covered with a cover slip. With a small piece of tissue paper, the excess stain was removed and the cover slip was pressed firmly to flatten the cells. Tapping on the cover slip with the eraser of a wooden pencil helped spread out the cells on the slide. The slides were examined under a microscope. The good slides were temporarily sealed with colorless nail polish and stored in a refrigerator.

Determination of mitotic index

The mitotic index was determined by focusing 5 microscopic fields in each slide (Bermejo, 1995). A total of 6 slides per treatment were observed and each focus was determined by using the slide center as the reference point. The slide, with the

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18

objective at HPO, was moved 3 gradations to the left, right, up, and down respectively. The mitotic index was computed using the

$$\text{formula: M.I.} = \frac{\text{total number of cells undergoing mitosis}}{\text{total number of cells}} \times 100$$

#### Statistical Data Analysis

Data gathered from this study were treated statistically, with the mean and standard deviation as descriptive statistical tools, and the One Way Analysis of Variance and Scheffe Test set at 0.05 alpha level of significance, as inferential statistical tools.

#### Mean

The mean was employed to express the average of all the values for the mitotic indices.

#### Standard Deviation

The standard deviation was employed to evaluate the spread of the individual values from their means.

One Way Analysis of Variance

The One Way ANOVA, set at 0.05 alpha level of significance, was used to determine the significant differences in the mitotic indices of onion root tips that were exposed to ultraviolet radiation for 5, 10, and 15 minutes.

Scheffe Test

The Scheffe test was used as post hoc multiple comparison test since the One Way ANOVA showed significance.

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Chapter 4

Results

This study determined the effects of different exposure times to ultraviolet radiation on the mitotic activity on the onion root tip.

Specifically, it aimed to determine the mitotic indices of the onion root tips when exposed to ultraviolet radiation for 5, 10, and 15 minutes. It also compared the mitotic indices of the onion root tips when exposed to ultraviolet radiation for 5, 10, and 15 minutes. It further determined the significant difference among the mitotic indices of the onion root tips exposed to ultraviolet radiation for 5, 10, and 15 minutes.

It was hypothesized that there is no significant difference among the mitotic indices of the onion root tips when exposed to ultraviolet radiation for 5, 10, and 15 minutes.

Mitotic indices of onion root tips exposed to UV radiation for 5, 10, and 15 minutes

This study revealed that the mitotic index of onion root tips exposed to ultraviolet radiation for 5 minutes was 13%. This means that among the cells observed under the microscope, only 13% underwent mitosis while the rest of the cells remained in the interphase stage, i.e., no mitotic division was evident.

Data are presented in table 1.

For the onion root tips that were exposed to UV radiation for 10 minutes, the mitotic index was 8%, which means that only 8% of all cells underwent mitosis, while the rest of the cells remained at the interphase stage, i.e., no mitotic division was evident.

Data are presented in Table 1.

The results of this study also showed that the mitotic index of onion root tips exposed to UV radiation for 15 minutes was 5%. This means that only 5% of the cells observed underwent mitotic division, i.e., there was no evidence of mitotic division among the other cells.

Data are presented in Table 1.

Finally, this study revealed that the mitotic index for the control group, i.e., no exposure to UV radiation, was 19%. This means that among the cells observed, only 19% of them underwent mitotic division, i.e., no evidence of mitotic division.

Data are presented in Table 1.

From the results of this study, we have observed that the mitotic indices of the onion root tips exposed to ultraviolet radiation for a shorter period of time were higher than those of the onion root tips exposed to UV radiation for longer time periods. With their mitotic indices as basis, we could say that there are less damaged cells in the root tips exposed to UV



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22

Table 1

Means of mitotic indices of onion root tips exposed to ultraviolet radiation for 5, 10, and 15 minutes

TREATMENT GROUPS (Minutes)	MEAN (%)	NUMBER OF REPLICATES	STANDARD DEVIATION
5	13	6	0.91
10	8	6	1.46
15	5	6	0.65
Control	19	6	4.54

radiation for shorter time periods, i.e., higher mitotic indices, meaning that there was more mitotic division, and that there are more damaged cells in the root tips exposed to UV radiation for longer time periods, i.e., lower mitotic indices, meaning that there is less mitotic division.

Significance of the differences among the mitotic indices of onion root tips when exposed to UV radiation for 5, 10, and 15 minutes

The One Way Analysis of Variance, set at 0.05 level of significance, revealed that there is a significant difference in the mitotic indices of onion root tips when exposed to UV radiation for 5, 10, and 15 minutes.

Data are presented in Table 2.

The mitotic indices are significantly different when the onion root tips are exposed to ultraviolet radiation for 5, 10, and 15 minutes. This means that the UV radiation had significantly different effects on the mitotic division of root tips from different treatment groups, i.e., 5, 10, and 15 minutes. And because these results differ significantly from the control, there is a significant effect on the mitotic indices of the onion root tips exposed to ultraviolet radiation for different time periods.

The Scheffe Test, run as post hoc multiple comparison test, showed that the mitotic indices of the onion root tips differ significantly between (treatment groups) 5 minutes and 10 minutes, and between 5 minutes and 15 minutes. No significant difference was observed between the 10 minutes and 15 minutes treatment groups.

Table 2

One Way ANOVA of the significant difference in the mitotic indices of onion root tips exposed to ultraviolet radiation for 5, 10, and 15 minutes

VARIABLE	SUM OF SQUARES	DEGREE OF FREEDOM	MEAN SQUARE	F	SIGNIFICANCE
Between groups	663.24	3	221.08	36.82	0.00
Within groups	120.09	20	6.01		
Total	783.33	23			

Each of the mitotic indices of the onion root tips exposed to UV radiation for 5, 10, and 15 minutes showed significant differences with the control group.

Data are presented in Table 3.

From the results, we observed that just after 5 minutes of exposure to UV radiation, there were already significant effects on the mitotic indices of the onion root tips. We also observed that there was no significant difference between the mitotic indices of the onion root tips exposed to UV radiation for 10 minutes and 15 minutes. This means that there is no significant

Table 3

Scheffe test as post hoc multiple comparison of the One Way ANOVA in Table 2

TREATMENT	MEAN DIFFERENCE	STANDARD ERROR	SIGNIFICANCE
5 minutes VS, 10 minutes	4.80 *	1.41	.026
5 minutes VS, 15 minutes	7.92 *	1.41	.000
5 minutes VS, Control	-6.01 *	1.41	.004
10 minutes VS, 15 minutes	3.12	1.41	.216
10 minutes VS, Control	-10.80 *	1.41	.000
15 minutes VS, Control	-13.92 *	1.41	.000

\* The mean difference is significant at 0.05 alpha level

difference between the effects of exposure to UV radiation for these exposure periods.

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Chapter 5

Summary, Conclusions, and Recommendations

The researchers determined the effects of different exposure times to ultraviolet radiation on the mitotic activity of the onion root tip.

Specifically, it aimed to:

1. determine the mitotic indices of the onion root tips when exposed to ultraviolet radiation for (a) 5, (b) 10, and (c) 15 minutes;
2. compare the mitotic indices of the onion root tips when exposed to ultraviolet radiation for (a) 5, (b) 10, and (c) 15 minutes; and
3. determine the significant difference among the mitotic indices of the onion root tips exposed to ultraviolet radiation for (a) 5, (b) 10, and (c) 15 minutes.

It was hypothesized that there is no significant difference among the mitotic indices of the onion root tips when exposed to ultraviolet radiation for 5, 10, and 15 minutes.

Summary

The findings of the study are summarized as:

1. The mitotic index of onion root tips exposed to ultraviolet radiation for 5 minutes was 13%, that of the

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27

root tips exposed to UV radiation for 10 minutes was 8%, that of the root tips exposed to UV radiation for 15 minutes was 5%, and that of the control was 19%.

2. Those exposed to UV radiation for 5 minutes had the highest mitotic index, while those exposed to UV radiation for 15 minutes had the lowest mitotic index, indicating that there was less mitotic activity in the root tips exposed to UV radiation for a longer period of time.

3. There was a significant difference in the mitotic index of onion root tips exposed to UV radiation for 5, 10, 15 minutes, and the control, indicating that the exposure to UV radiation for a given time period indeed has significant effect on the mitotic activity of the said plant.

#### Conclusions

Based on the results of this study, exposure to UV radiation in a given period of time has a significant effect on the mitotic activity of onion (*Allium cepa*) root tips.

The longer the period of exposure to UV radiation, the more damaged cells, the lower is the mitotic index, and there is less mitotic activity. The shorter the exposure period, the less damaged cells, the higher the mitotic index of the root tip, and there is more mitotic activity.

### Recommendations

For further studies related to this one, the researchers recommend exposure times of less than 5 minutes, and more than 20 minutes. These studies can verify whether or not there will be significant effects of exposure to UV radiation on the mitotic indices of onion root tips for time intervals less than 5 minutes, or more than 20 minutes.

Lastly, this study may also be done, in the same manner or with some modifications, on different plant types, i.e., aside from the onion.

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29

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APPENDIX



Plate 1. The set-up: onion bulbs on wide-mouthed bottles filled with water up to the bottom of the bulbs



Plate 2. A sample of an onion that has grown roots

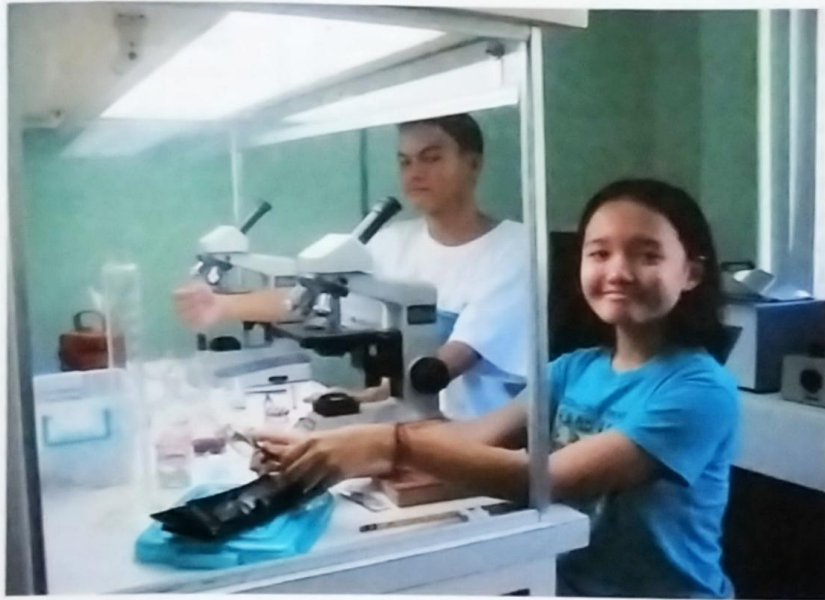


Plate 3. Two of the researchers working in the laboratory



Plate 4. The hood: the source of Ultraviolet Radiation for this study



Plate 5. Most of the materials the researchers used in the conduct of this study



Plate 6. A sample of the pictures the researchers used in determining the mitotic index of the onions in this study