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Effects of X-ray irradiation on growth physiology of *Arachis Hypogaea* (Var. Kampala)

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Small doses of X-ray may stimulate cellular activities and growth while higher doses may cause higher aberrations. Seeds of *Arachis hypogaea* cv Kampala were exposed singly to X-ray radiations (6 mA-77 mA) X-ray significantly decreased seed germination above 6 mA, reduced root and shoot growth as X-ray exposure increased. X-ray radiation causes chromosomal aberration. Therefore higher X-ray radiation affects the plant germination negatively by retarding the growth.

Capsule Summary: Effects of X-ray irradiation on growth physiology of *Arachis Hypogaea* was studied and found that X-ray irradiation affected the chromosomal setup along with germination and growth negatively.

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INTRODUCTION

Electromagnetic radiation (the designation 'radiation' excludes static electric and magnetic and near fields) is classified by wavelength into radio, microwave, infrared, the visible region (we perceive as light), ultraviolet, X-rays and gamma rays. Arbitrary electromagnetic waves can always be expressed by Fourier analysis in terms of sinusoidal monochromatic waves which can be classified into these regions of the spectrum (Serway et al., 2004).

The behavior of EM radiation depends on its wavelength. Higher frequencies have shorter wavelength, and lower frequencies have longer wavelength. When EM radiation interacts with single atoms and molecules, its behavior depend on the amount of energy per quantum it carries. Spectroscopy can detect a much wider region on the EM spectrum than the visible range of 400 nm to 700 nm. A common laboratory spectroscope can detect wavelengths from 2 nm to 2500nm. Detailed information about the physical properties of objects, gases, or even stars can be obtained from this type of device. It is widely used in astrophysics. For example, hydrogen atoms emit radio waves of wavelength 21.12 cm (Hecht et al., 2001).

Plants

Plants are living organisms belonging to the kingdom Plantae. They include familiar organisms such as trees, herbs, bushes, grasses, vines, ferns, mosses, and green algae. Green plants, sometimes called *Viridiplantae*, are a clade of eukaryotic organisms made up of the green algae, which are primarily aquatic, and the land plants (embryophytes), which evolved within them. (Cocquyt et al., 2009; Becker et al., 2007; Kim et al., 2008). Plant growth and distribution are limited by the environment. Limiting factors are also responsible for the geography of plant distribution. Plant growth problems are caused directly or indirectly by environmental stress. Hence, it is important to understand the environmental aspects that affect plant growth. These factors are light, temperature, water (humidity), and nutrition. Light has three principal characteristics that affect plant growth: quantity, quality, and duration. The more sunlight a plant receives (up to a point), the better capacity it has to produce plant food through photosynthesis. As the sunlight quantity decreases the photosynthetic process decreases (Arizona University, 1992).

Growth is also determined by environmental factors, such as temperature, available water, available light, and available nutrients in the soil. Any change in the availability of these external conditions will be reflected in the plants growth.

Groundnut

Peanut, or groundnut (*Arachi hypogaea*), is a species in the legume "bean" family (*Fabaceae*) native to South America, Mexico and Central America. It is an annual herbaceous plant growing 30 to 50cm tall. The leaves are opposite, pinnate with four leaflets (two opposite pairs; no terminal leaflet), each leaflet 1 to 7cm long and 1 to 3cm broad. The flowers are a typical pea flower in shape, 2 to 4cm across, yellow with reddish veining. After pollination, the fruit develops into a legume 3 to 7cm long, containing 1 to 4 seeds, which forces its way underground to mature (https://en.wikipedia.org/wiki/Peanut, 2016). Peanuts are known by many local names, including earthnuts, groundnuts, goober peas, monkey nuts, pygmy nuts and pig nuts. The term "Monkey nut" is often used to mean the entire pod.

Classification

Kingdom: Plantae
Division: Tracheophyta
Order: Fabales
Family: *Fabaceae*
Subfamily: *Faboideae*
Tribe: *Aeschynomeneae*
Genus: *Aracis*
Species: *Ahypogaea*

Importance of groundnut (Arachis hypogaea)

Groundnut oil is edible, used in cookery and in the manufacture of vanaspathi. Groundnut kernel is rich and cheap source of vegetable protein, oil is used for making soap, as illuminant and lubricant. Oil cake is used as cattle feed and organic manure. Groundnut shell is sued as activated carbon. Nutritious pea nut butter is prepared from kernels. Primarily used as a vegetable cooking oil. Kernels are used directly as food or snacks for human consumption. A large number of food products are prepared from groundnuts-boiled nuts, roasted nuts, salted nuts, groundnut milk, groundnut yogurt, groundnut bars, groundnut butter, groundnut cheese and bakery products etc.

Electromagnetic radiation **(X-Ray)**

X-rays have a wavelength in the range of 0.01 to 10 nanometers, corresponding to frequencies in the range 30 penta-hertz to 30 hexa-hertz ($3x10^{16}$ Hz to 3×10^{19} Hz) and energies in the range 120 eV to 120 keV. They are shorter in wavelength that UV rays and longer than gamma rays. X-rays from about 0.12 to 12 keV 910 to 1.10nm wavelength) are classified as "soft" X-rays, and from about 12 to 120 keV (0.10 to 0.01nm wavelength) as "hard" X-rays, due to their penetrating abilities.

Hard X-ray can penetrate solid objects, and their most common use is to take images of the inside of object in diagnostic radiography and crystallography. As a result, the term X-ray is metonymically used to refer to a radiographic image produced using this method, in addition to the method itself. By contrast, soft X-rays can hardly be said to penetrate matter at all; for instance, the attenuation length of 600 eV (~2 nm) x-rays in water is less than 1 micrometer. (L'Annunziata et al., 2003).

The maximum energy of the produced X-ray photon is limited by the energy of the incident electron, which is equal to the voltage on the tube, so an 80kV tube cannot create X-rays with energy greater than 80keV.

MATERIAL AND METHODS

Seed material

Dried seeds of groundnut, Arachis Hypogea "Kampala" cultivar were purchased from Ilishan market, Ogun State, Nigeria and identified by Prof. K.O. Ogunwenmo, a plant scientist in the Department of Chemical and Environmental Sciences, Babcock University.

Viability Test

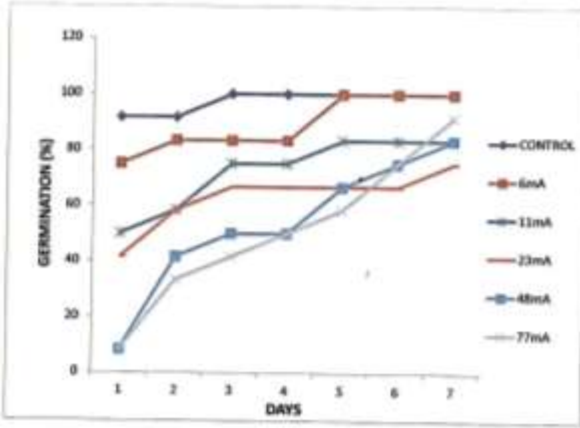

Fig. 1: Ex situ germination rate of Kampala seeds exposed to X-ray radiation

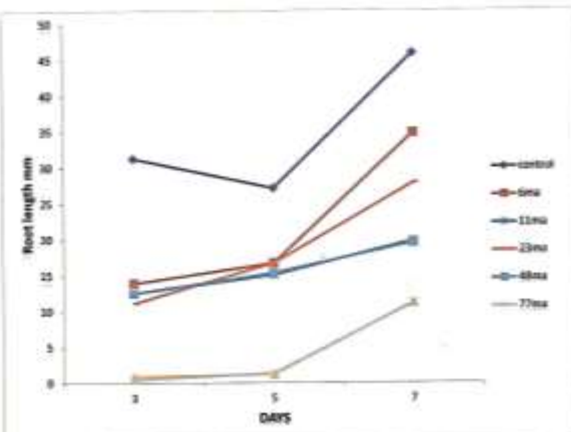

Fig. 2: Ex-situ root length of X-ray exposed Kampala

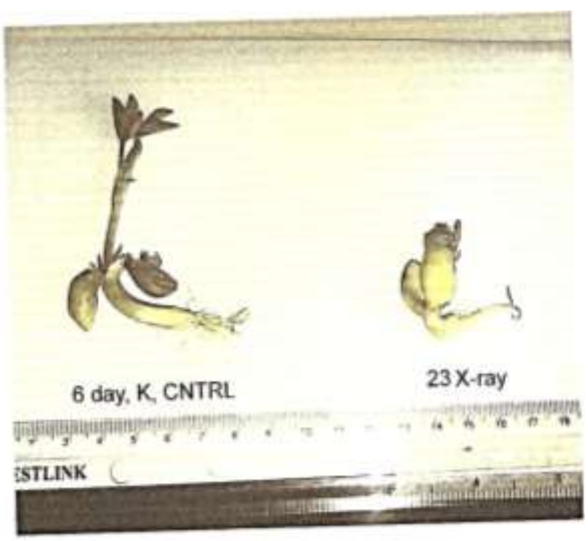

Fig. 3: 6-day Kampala shoot exposed to 56kV, 23mA X-ray

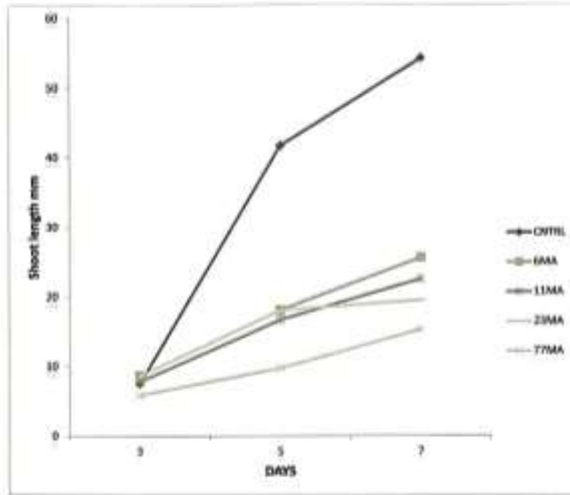

Fig. 4: Ex-situ shoot length of X-ray exposed Kampala.

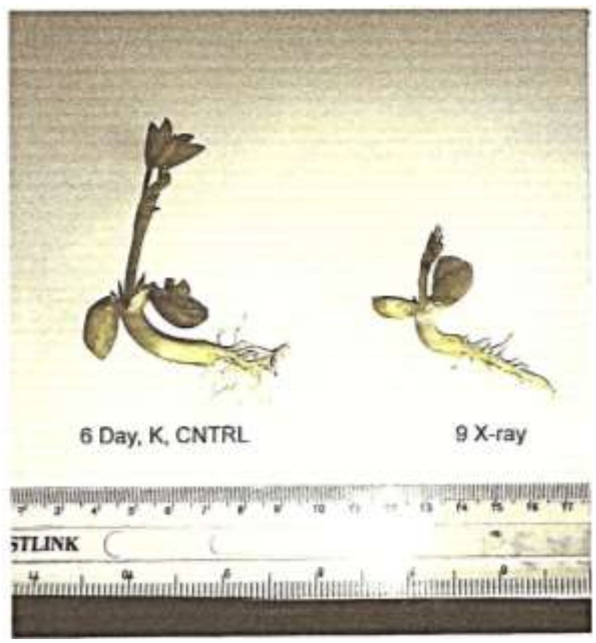

Fig . 5: Kampala seeds exposed to x-ray 56kV at 6mA only.

Two main tests were carried out to determine the viability of the different species of groundnut seed.

Flotation tests

Seeds were selected randomly and soaked in water for 6hours, the seeds that are found to be floating after soaking are considered not viable due to the degeneration or loss (light) of endosperm while those that sank are considered viable (i.e. full and intact endosperm).

Exposure to X-Ray radiation

Table 1: Ex-Situ percentage germination at different X-ray intensities exposure

Day	Control	6 mA	11 mA	23 mA	48 mA	77 mA
1.	92	75	50	42	7	7
2.	91	82	57	57	40	32
3.	100	81	72	65	48	40
4.	99	81	71	64.50	46	46
5.	100	98	81	65	65	55
6.	98	98	80	64	70	70
7.	98	98	80	70	80	90

Table 2: Ex-Situ root growth (root length, mm) of X-ray exposed Kampala at different intensities

Day	Control	6 mA	11 mA	23 mA	48 mA	77 mA
3	32	14	12.50	11.50	12.50	1
5	27	17	14	17	14	1.50
7	44	35	18	27	18	10.50

Table 3: Ex-situ shoot length (mm) of X-ray exposed Kampala at different intensities

Day	Control	6 mA	11 mA	23 mA	48 mA	77 mA
3	7	8	7	8	7	6
5	43	18	16	18	16	8.50
7	55	25	22	18.50	22	13

The exposure of the X-ray to the cultivae was done on Wednesday 23rd February, 2015 at Ayotola Specialist Hospital, Shagamu in Ogun State. The Kampala seeds were grouped into 12 groups each containing 30 pieces of cultivar in a group. The 12 groups were exposed to X-ray at different time intervals 6 MA, 7 MA, 9mA, 11mA, 13mA, 19mA, 23mA, 29mA, 38mA, 48mA, 62mA, 77mA. The time shows the amount of ray that was exposed to the groundnut at constant voltage of 56kV.

EXPERIMENTAL DESIGN

Control experiment

Nine seeds were sown in folds of filter paper in a glass Petri dish at room temperature 29±2^{0}C, after which they were moistened with 10ml of distilled water daily. The 9 soaked Kampala seeds, were sterilized with 10 ml of 1% sodium hypochlorite solution for 1 minute. This was done to prevent the growth of fungi on the seeds since groundnut seeds are susceptible to attack by fungi. This group was free of X-ray exposure The sterilized seeds were sown in sterilized Petri dish. 10ml of distilled water was added to each Petri dish preparation, covered with filter paper and kept in the dark for 48h. 10ml distilled water was added each day and observed for germination. The seeds were considered germinated with the emerging of radicles. The average root, shoot and seedling length were measured at three days interval and recorded.

Ex-situ seed germination experiment

Another group of nine seeds were exposed to X-ray at different intensities. Then the same seeds were surface sterilized with 1% Sodium hypochlorite solution for 1min. Nine seeds of the cultivar, Kampala (X-ray exposed) were placed in each sterilized Petri dish laden with folds of filter paper. The Petri dishes were moistened with 10ml of distilled water daily and kept in the dark for 48h and observed for germination. The seeds were considered germinated with the emerging of radicles. The average root, shoot and seedling length were measured at three days interval and recorded.

Computation and statistical analysis

Percentage germination: The percentage seed germination was calculated for each species using relation shown in Eq. 1.

$$Germination = \frac{X \, . \, 100}{n} \qquad (1)$$

Where, X is the mean seed germination at each concentration of the seeds and n is the total number of seeds planted.

RESULTS AND DISCUSSION

The germination rate of ex-situ Kampala

Figure 1 shows the effect of X-ray radiation on germination. The control which is at zero X-ray exposure increased in germination to the maximum level as the number of day's increases. The figure also shows that at low X-ray irradiation of 6mA, the germination rate is affected for the first few days (10%, 3 days) before it rises to the maximum just as the control. However, germination was retarded greatly as the concentration of the radiation increases. The germinations in percentages at different days can be observed in Table 1.

Germination rate of ex-situ (X-ray exposed) Kampala root

Figure .2 shows the root growth for the control and the other seeds exposed to radiation. There was negligible root growth before the first five days. From the sixth day, there was uniform growth in the root. However, root growth reduces considerably as the concentration of the X-ray increases. Root length decreased significantly ($P<0.05$) with increase in X-ray radiation. The stunted growths in the roots are shown in Figs. 3 & 4. Table 2 shows the root lengths for different days at different X-rays exposures. It shows that radiation cut the root growth by approximately fifty percent (50%) and almost one hundred percent (100%) at maximum radiation exposure concentration.

Germination rate of ex-situ (X-ray exposed) Kampala shoot

Figure 5 shows that the shoot growth were retarded with increasing X-ray radiation exposure while those of the control experienced rapid shoot growth , however, there is an aberration at 11mmA. Shoot length decreased significantly ($P<0.050$) with increasing time of exposure to X-ray. There was inhibition at 62 mA (Figs. 4 & 5).

CONCLUSIONS

X-ray radiation retards seed germination, plant growth which is suspected to be due to chromosomal aberration .Low intensity of X-ray irradiation may produce moderate effect on the germination and growth of plants but, at higher intensities would affect the germination, root and shoot developments. This might lead to premature death or poor yield.

Conflict of interest

Author declared no conflict of interest.

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