Growth Rates and Correlations between some Growth Parameters of Sunflowers (*Helianthus annuus* L.) Irradiated Plants

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Abstract

Sunshine is a type of radiation that is needed for photosynthesis and normal plant growth, so, no all radiation is bad. This study aimed to evaluate the growth rates and correlation between them in sunflower (*Helianthus annuus* L.) irradiated with X-ray, Gamma-ray, and UV-light. The experiment was conducted in 2020, in the experimental farm, Faculty of Agriculture, University of Gezira, Sudan. A well-known variety of sunflower seeds were brought from Agricultural Research Corporation, Wad Medani, Gezira State, Sudan. The sunflower seeds were submitted separately to two treatments of X-ray (33.4 (LX) and 200.2 sec (HX), gamma-ray (200 (LG) and 800 cGy (HG)) and UV-light (for 30 sec. (UV)). In addition to control, all irradiated sunflower seeds were grown under the same environmental conditions. The growth parameters (plant weight, height, diameter, No. of leaves, tall, and width of leaves) were recorded every 10 days till 60 days. The results of this study revealed that LX sunflower plants have a daily increase in net weight of 0.24 g; 0.90 cm in stem tall; 0.03 cm in stem diameter; 0.12 cm in leaves tall; 0.06 cm in leaves width and 0.36 in leaves number, compared to 0.22 g in net weight; 1.10 cm in stem tall; 0.03 cm in stem diameter; 0.17 cm in leaves tall; 0.13 cm in leaves width and 0.36 in leaves number in C, white it was 0.09 g in net weight; 0.68 cm in stem tall; 0.01 cm in stem diameter; 0.04 cm in leaves tall; 0.01 cm in leaves width and 0.27 in leaves number in HG, which are relatively less than that of LX, HX and LG. Most of the growth parameters correlated to each other by a positive factor of more than (0.95). Further

studies should be conducted to evaluate the nutritional contents and human allergic ability.

Key words: sunflower, X-ray, Gamma-ray, UV light, growth rate, correlation

Introduction

Helianthus is a genus comprising about 70 species of annual and perennial flowering plants in the daisy family Asteraceae (Schilling, 2006). Except for three South American species, the species of *Helianthus* are native to North America and Central America. The common names "sunflower" and "common sunflower" typically refer to the popular annual species *Helianthus annuus*, whose round flower heads in combination with the ligules look like the sun (Shorter Oxford English Dictionary, 2007). This and other species, notably *H. tuberosus*, are cultivated in temperate regions and some tropical regions as food crops for humans, cattle, and poultry, and as ornamental plants. The species *H. annuus* typically grows during the summer and into early fall, with the peak growth season being mid-summer (USDA, 2019).

Sunflowers are usually tall annual or perennial plants that in some species can grow to a height of 300 cm (120 in) or more. They bear one or more wide, terminal capitula (flower heads), with bright yellow ray florets at the outside and yellow or maroon (also known as a brown/red) disc florets inside. Several ornamental cultivars of *H. annuus* have red-colored ray florets; all of them stem from a single original mutant (Heiser, 1981). During growth, sunflowers tilt during the day to face the sun but stop once they begin blooming. This tracking of the sun in young sunflower heads is called heliotropism. By the time they are mature, sunflowers generally face east (Atamian *et al*., 2016). The movement of sunflowers through heliotropism happens as the sunflower follows the sun, the opposite side of the sunflower stem begins to accumulate growth hormones and this causes growth which redirects the sunflower (Ben, 2020; Atamian *et al*., 2016). The rough and hairy stem is branched in the upper part in wild plants, but is usually unbranched in domesticated cultivars (Atamian *et al*., 2016).

The electromagnetic radiation emitted by X-ray had a longer wavelength than gamma rays emitted by radioactive nuclei (Dendy and Heaton, 1999). Older literature distinguished between X- and gamma radiation on the basis of wavelength, with radiation

shorter than some arbitrary wavelength, such as 10−11 m, defined as gamma rays (Charles, 1961).

X-rays are emitted by definition by electrons outside the nucleus, while gamma rays are emitted by the nucleus (L'Annunziata and Baradei, 2003; Grupen *et al*., 2005). There is no lower limit to the energy of photons produced by nuclear reactions, and thus ultraviolet (UV) or lower energy photons produced by these processes would also be defined as "gamma rays" (Shaw *et al*., 1999).

In astronomy, higher energy gamma and X-rays are defined by energy, since the processes that produce them may be uncertain and photon energy, not origin, determines the required astronomical detectors needed. High-energy photons occur in nature that are known to be produced by processes other than nuclear decay but are still referred to as gamma radiation (NASA, 2011).

High-energy (from 80 GeV to ~10 TeV) gamma rays arriving from far-distant quasars are used to estimate the extragalactic background light in the universe: the highest-energy rays interact more readily with the background light photons and thus the density of the background light may be estimated by analyzing the incoming gamma ray spectra (Alberto, 2015).

The effects of high doses of radiation on plants are lethal, although different species of plants vary greatly in their sensitivity to ionizing radiation. A stimulating effect on growth when seeds or seedlings are exposed to light doses of ionizing radiation was reported. Irradiation of seeds of various plants with 3000 r or X-rays seemed to stimulate the growth of lettuce and cabbage, but more critical tests showed no significant effect of the irradiation. Irradiation of Gladiolus bulbs with 4000 r of X rays did results in significantly earlier flowering (Sax, 1955).

Material and Methods

Study area

The present study was carried out in the experimental Farm, University of Gezira. Gezira is one of the 18 States of Sudan. The State lies between the Blue Nile and the White Nile in the east-central region of the country (14^{o}30N – 33^{o}30 E). It has an area of about 28000 km^{2}.

Radiation treatment

The sunflower seeds were brought from Agricultural Research Corporation, Wad Medani, Gezira State, Sudan. The sunflower seeds were separated to five Petri dishes: treated with (33.4 and 200.2 sec.) of X-ray using X-ray device, (200 and 800 cGy) of gamma ray using Co-60 device and (30 sec.) of UV-light. The sunflower seeds were irradiated by X-ray and Gamma-ray in the National Cancer Institute, University of Gezira, while the submission to UV-light was run in the Microbiology Lab, Faculty of Engineering and Technology, University of Gezira.

Field Experiments

The five treated sunflower seeds in addition to control were planted in the Experimental Farm within one feddan area. Soil, irrigation, other agricultural conditions and insect's pressure were same for all treatments. Neither fertilizers nor pesticides were used. About 100 seeds of each treatment were sawn. During the first week, the germination rates (in %) were recorded (in respect to the original 100 seeds) for each treatment. After 10 days of sawing, three random samples of each treatment sunflower growing plants were picked out completely from the soil to measure the weight (g) using an electrical balance, No. of leaves, height (cm), diameter (cm), length and width of largest leaves (cm) using graded ruler. The average of the three was calculated. The same measurement process was repeated in the 20^{th}, 30^{th}, 40^{th}, 50^{th} and 60^{th} days of sawing. According to their treatment, sunflower samples were termed as LX (lower dose of X-ray), HX (higher dose of X-ray), LG (lower dose of gamma-ray), HG (higher dose of gamma-ray), UV (treated with UV light), and C (control = untreated).

Data analysis

The mean values for each measured growth parameter were used to run regression analysis between days (X) and the corresponding growth value (Y). Also, the correlation analysis was run for all the tested growth parameters.

Results and Discussion

Table (1) showed that, the LX sunflower plants has the following growth rates: the daily increase in net weight was 0.24 g; 0.90 cm in stem tall; 0.03 cm in stem diameter; 0.12 cm in leaves tall; 0.06 cm in leaves width and 0.36 in leaves number. Concerning LX sunflower plants, there were a great correlations between net weight and stem tall (0.96); net weight and stem diameter (0.98); net weight and No. leaves (0.96); stem tall and stem

diameter (0.99); stem tall and No. of leaves (0.96); leaves tall and width (0.99) leaves tall and No. leaves (0.96); and leaves width and No. leaves (0.97)

Table (2) showed that, the HX sunflower plants has the following growth rates: the daily increase in net weight was 0.19 g; 0.85 cm in stem tall; 0.02 cm in stem diameter; 0.10 cm in leaves tall; 0.04 cm in leaves width and 0.36 in leaves number. These rates in comparison are relatively less than that of LX. There were great correlations between all measured growth parameters of HX sunflower plants with each other (correlations were 0.96 and more)

Table (3) showed that, the LG sunflower plants has the following growth rates: the daily increase in net weight was 0.11 g; 0.81 cm in stem tall; 0.02 cm in stem diameter; 0.06 cm in leaves tall; 0.04 cm in leaves width and 0.30 in leaves number. These rates in comparison are relatively less than that of LX and HX. Concerning LG sunflower plants, there were a great correlation between net weight and stem tall (0.99); net weight and stem diameter (0.98); net weight and No. leaves (0.95); stem tall and stem diameter (0.99); stem tall and No. of leaves (0.98); stem diameter and No. leaves (0.95), stem diameter and leaves width (0.97); and leaves width and No. leaves (0.98)

Table (4) showed that, the HG sunflower plants has the following growth rates: the daily increase in net weight was 0.09 g; 0.68 cm in stem tall; 0.01 cm in stem diameter; 0.04 cm in leaves tall; 0.01 cm in leaves width and 0.27 in leaves number. These rates in comparison are relatively less than that of LX, HX and LG. Concerning HG sunflower plants, there were a great correlation between only net weight and stem diameter (0.99); net weight and No. leaves (0.96); stem tall and No. of leaves (0.98); stem diameter and No. leaves (0.98)

Table (5) showed that, the UV sunflower plants has the following growth rates: the daily increase in net weight was 0.16 g; 0.89 cm in stem tall; 0.02 cm in stem diameter; 0.08 cm in leaves tall; 0.07 cm in leaves width and 0.36 in leaves number. These rates in comparison are relatively less than that of LX and HX. Concerning UV sunflower plants, there were a great correlation between net weight and stem tall (0.98); net weight and stem diameter (0.98); net weight and No. leaves (0.98); stem tall and No. of leaves (0.96); stem diameter and No. leaves (0.97); leaves tall and leaves width (0.99).

Table (6) showed that, the C sunflower plants has the following growth rates: the daily increase in net weight was 0.22 g; 1.10 cm in stem tall; 0.03 cm in stem diameter; 0.17 cm in leaves tall; 0.13 cm in leaves width and 0.36 in leaves number. These rates in comparison are better or relatively similar to than that of LX. Concerning C sunflower plants, there were a great correlation (0.96 and more) between the majorities of the growth parameters each other, except those considerable correlations (less than 0.95) were noticed between stem tall and diameter (0.92); stem diameter and No. leaves (0.93).

Since the energy of photons is proportional to their frequency and inversely proportional to wavelength, this past distinction between X-rays and gamma rays can also be thought of in terms of its energy, with gamma rays considered to be higher energy electromagnetic radiation than are X-rays (Charles, 1961). And this explain why gamma treated samples of sunflower (LG and HG) has week performance than X-ray treated samples (specially LX).

Not all radiation is bad. Sunshine is a type of radiation that is needed for photosynthesis and normal plant growth. And to understand the different physiological behavior exerted by sunflower treated samples in their growth rates, Steve (2017) summarized the effect of radiation on plant growth and development in several aspects as follows: Ultraviolet radiation affects plant growth and development in many ways. First, it gradually stops seed growth and sprouting, depended on the how much radiation is released. Higher doses of radiation administered to the plants were very damaging. If there is too much evaporation due to intense radiation, the stomata closes to reserve water. If the stomata are unable to open for a long period of time, the growth of the plant is stunted. Prolonged periods of radiation can completely damage the stomata and destroy the plant. The cells of living organism are also damaged and killed by radiation. If the cell is overly damaged by radiation, then reproduction is hindered, and the chances of mutation are great. Prolonged radiation can completely destroy the fertility of a plant. The plant gradually dies. The surroundings become poisoned and prevent the growth of future offspring.

Table (1) Mean growth parameters of LX sunflower plants

Time	Net weight	Stem tall	Stem diameter	Leaf tall	Leaf width	No. leaves
10 days	0.89	19.65	0.7	3.1	1.5	6
20 days	1.87	27.15	0.8	5.1	2.2	10
30 days	2.14	34.1	0.9	6.8	3.2	12
40 days	6.51	36.1	1.1	7.8	3.8	18
50 days	7.88	52.3	1.5	8.6	4.2	20
60 days	13.28	67.5	2.0	9.2	4.4	24
Regression analysis						
R^2	0.90	0.93	0.90	0.95	0.95	0.98
Intercept	-3.01	7.80	0.29	2.57	1.11	2.40
Slope	0.24	0.90	0.03	0.12	0.06	0.36

Correlation Analysis

	Net weight	*Stem tall*	*Stem diameter*	*Leaf tall*	*Leaf width*
Stem tall	0.96				
Stem diameter	0.98	0.99			
Leaf tall	0.86	0.90	0.85		
Leaf width	0.87	0.89	0.85	0.99	
No. leaves	0.96	0.95	0.94	0.96	0.97

Table (2) Mean growth parameters of HX sunflower plants

Time	Net weight	Stem tall	Stem diameter	Leaf tall	Leaf width	No. leaves
10 days	1.16	18.15	0.7	3.2	1.6	6
20 days	1.99	23.25	0.9	4.7	2.4	10
30 days	3.53	31.1	1.0	5.2	2.4	12
40 days	6.56	40.1	1.3	6.5	2.9	18
50 days	8.14	51.8	1.5	7.2	3.3	20
60 days	10.51	58.4	1.8	8.2	3.7	24
Regression analysis						
R^2	0.98	0.99	0.98	0.98	0.96	0.98
Intercept	-1.51	7.54	0.44	2.45	1.35	2.40
Slope	0.19	0.85	0.02	0.10	0.04	0.36

Correlation Analysis

	Net weight	*Stem tall*	*Stem diameter*	*Leaf tall*	*Leaf width*
Stem tall	0.99				

Stem diameter	0.99	0.99			
Leaf tall	0.98	0.98	0.99		
Leaf width	0.96	0.97	0.98	0.99	
No. leaves	0.99	0.99	0.99	0.99	0.98

Table (3) Mean growth parameters of LG sunflower plants

Time	Net weight	Stem tall	Stem diameter	Leaf tall	Leaf width	No. leaves
10 days	0.66	14.3	0.7	3.3	1.3	6
20 days	1.21	18.25	0.7	4.2	1.9	8
30 days	2.16	30.1	0.9	5.8	2.1	12
40 days	3.25	35.1	1.1	4.2	2.6	16
50 days	4.16	42.6	1.3	6.1	3.2	18
60 days	6.63	55.2	1.5	6.2	3.5	20
Regression analysis						
R^2	0.94	0.98	0.96	0.90	0.98	0.98
Intercept	-0.97	4.33	0.43	2.66	0.89	2.93
Slope	0.11	0.81	0.02	0.06	0.04	0.30

Correlation Analysis

	Net weight	*Stem tall*	*Stem diameter*	*Leaf tall*	*Leaf width*
Stem tall	0.99				
Stem diameter	0.98	0.99			
Leaf tall	0.76	0.82	0.77		
Leaf width	0.96	0.97	0.97	0.81	
No. leaves	0.95	0.98	0.98	0.78	0.98

Table (4) Mean growth parameters of HG sunflower plants

Time	Net weight	Stem tall	Stem diameter	Leaf tall	Leaf width	No. leaves
10 days	0.91	17.10	0.6	3.7	1.6	6
20 days	1.77	21.20	0.8	5.1	2.1	10
30 days	1.85	27.4	0.8	4.2	2.1	12
40 days	2.66	36.2	0.9	4.6	2.3	14
50 days	4.24	47.1	1.1	5.2	2.3	18
60 days	5.70	47.5	1.3	5.8	2.4	20
Regression analysis						
R^2	0.92	0.96	0.94	0.98	0.80	0.98
Intercept	-0.36	8.90	0.47	3.37	1.65	3.73
Slope	0.09	0.68	0.01	0.04	0.01	0.27

Correlation Analysis

	Net weight	*Stem tall*	*Stem diameter*	*Leaf tall*	*Leaf width*
Stem tall	0.94				
Stem diameter	0.99	0.94			
Leaf tall	0.87	0.75	0.90		
Leaf width	0.80	0.85	0.86	0.83	
No. leaves	0.96	0.98	0.98	0.83	0.91

Table (5) Mean growth parameters of UV sunflower plants

Time	Net weight	Stem tall	Stem diameter	Leaf tall	Leaf width	No. leaves
10 days	1.07	19.65	0.7	4.5	1.9	6
20 days	2.58	26.15	0.8	5.1	2.2	10
30 days	3.16	35.1	0.9	5.2	2.4	12
40 days	5.13	44.3	1.2	5.7	2.5	18
50 days	6.71	45.5	1.6	6.2	3.4	20
60 days	9.58	68.4	1.8	9.6	5.8	24
Regression analysis						
R^2	0.96	0.93	0.95	0.73	0.74	0.98
Intercept	-0.98	8.75	0.35	3.12	0.71	2.40
Slope	0.16	0.89	0.02	0.08	0.07	0.36

Correlation Analysis

	Net weight	*Stem tall*	*Stem diameter*	*Leaf tall*	*Leaf width*
Stem tall	0.98				
Stem diameter	0.98	0.94			
Leaf tall	0.93	0.94	0.87		
Leaf width	0.93	0.93	0.89	0.99	
No. leaves	0.98	0.96	0.97	0.85	0.84

Table (6) Mean growth parameters of C sunflower plants

Time	Net weight	Stem tall	Stem diameter	Leaf tall	Leaf width	No. leaves
10 days	0.37	9.15	0.6	2.6	1.0	6
20 days	1.29	17.4	0.6	4.6	1.8	10
30 days	2.57	28.0	0.8	5.6	2.7	12
40 days	4.96	36.2	1.1	6.1	4.5	18
50 days	8.52	42.4	1.9	9.3	5.7	20
60 days	11.08	69.3	2.1	11.4	7.4	24
Regression analysis						

R^2	0.95	0.94	0.89	0.95	0.98	0.98
Intercept	-2.96	-4.65	0.01	0.74	-0.70	2.40
Slope	0.22	1.10	0.03	0.17	0.13	0.36

Correlation Analysis

	Net weight	*Stem tall*	*Stem diameter*	*Leaf tall*	*Leaf width*
Stem tall	0.97				
Stem diameter	0.99	0.92			
Leaf tall	0.98	0.97	0.97		
Leaf width	0.99	0.98	0.96	0.97	
No. leaves	0.97	0.96	0.93	0.96	0.99

Conclusions

The LX sunflower sample has good growth rate compared to control (and some time better than control). HX and LG sunflower sample exhibit low growth rate compared to control. Most of the growth parameters correlated to each other by a positive factor of more than (0.95).

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References

Alberto, D. (2015). "All the Light There Ever Was". *Scientific American*. Vol. 312 no. 6. pp. 38–43. ISSN 0036-8075

Atamian, H. S.; Creux, N. M.; Brown, E. A.; Garner, A. G.; Blackman, B. K. and Harmer, S. L. (2016). "Circadian regulation of sunflower heliotropism, floral orientation, and pollinator visits". *Science,* **353**(6299): 587–590.

Ben, S. (2020)."How Sunflowers Move to Follow the Sun". UC Berkeley Rausser College of Natural Resources. *Retrieved 2020-05-01*.

Charles, H.(1961). CRC Handbook of Chemistry and Physics, 44th Ed. USA: Chemical Rubber Co. p. 2850.

Dendy, P. P. and B. Heaton (1999). Physics for Diagnostic Radiology. USA: CRC Press. p. 12. ISBN 0-7503-0591-6.

Grupen, C.; Cowan, G.; Eidelman, S. D. and Stroh, T. (2005). Astroparticle Physics. Springer. p. 109. ISBN 3-540-25312-2.

Heiser, C.B. (1981). *The Sunflower*. University of Oklahoma Press. 1981.

L'Annunziata, M. and Baradei, M. (2003). Handbook of Radioactivity Analysis. Academic Press. p. 58. ISBN 0-12-436603-1.

NASA (2011). "Gamma-Ray Telescopes & Detectors". NASA GSFC. Retrieved 2011-11-22.

Sax, K. (1955). Effect of ionizing radiation on plant growth. *Am. J. Bot*. 42: 360-365. https://doi.org/10.1002/j.1537-2197.1955.tb11132.x

Schilling, E. E. (2006). "Helianthus". In Flora of North America Editorial Committee (ed.). Flora of North America North of Mexico (FNA). **21**. New York and Oxford – via eFloras.org, Missouri Botanical Garden, St. Louis, MO & Harvard University Herbaria, Cambridge, MA.

Shaw, R. W.; Young, J. P.; Cooper, S. P. and Webb, O. F. (1999). "Spontaneous Ultraviolet Emission from ^{233}Uranium/^{229}Thorium Samples". Physical Review Letters. **82** (6): 1109–1111.

Shorter Oxford English Dictionary (2007). 6th ed. United Kingdom: Oxford University Press. 2007. p. 3804. ISBN 978-0-19-920687-2.

Steve, G. (2017). Effects of Radiation on Plant Growth & Development. *Sciencing*, available from: https://sciencing.com/bring-the-outdoors-inside-with-these-nature-kits-for-kids-13763822.html

USDA (2019)."Conservation Plant Characteristics - *Helianthus annuus* L. common sunflower HEAN3". USDA - Natural Resources Conservation Service. *Retrieved April 1, 2019.*