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Germination Rates and Some Growth Parameters of Sesame (*Sesamum indicum* L.) Irradiated with X-Ray, Gamma-Ray, and UV-Light

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Abstract: ***The needs for increasing productivity and decreasing expenses had been the reasons for proposing using irradiation techniques in crop production. This study aimed to evaluate the germination rates and some growth parameters of sesame (Sesamum indicum L.) irradiated with X - ray, Gamma - ray and UV - light. The experiment was conducted during 2020, in the experimental farm, Faculty of Agriculture, University of Gezira, Sudan. Certain variety of sesame seeds were brought from Agricultural Research Corporation, Wad Medani, Gezira State, Sudan. The sesame 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 sesame seeds were grown at the same agricultural conditions. The germination rate (%) and some growth parameters (plant weight, height, diameter, No. of leaves, tall and width of leaves) were recorded each 10 days till 60 days. The results of this study revealed that, the germination rates ranged between (74 - 94%), while the daily constant increase of growth ranged between (0.49 cm in C and LX to 0.17 cm in HX) in plant height; (0.07 g in LX - 0.01 g in HX) in plant weight; (0.23 in UV to 0.20 in LG and HX) in No. of leaves, (0.02 cm in C, UV, HG and LX to 0.01 cm in HX and LG) in stem diameters, (0.11 cm in C to 0.05 cm in HX and LG) in leaves tall, and (0.02 cm in HX, LG and UV to 0.04 cm in LX) in leaves width. LX treatments showed heavier and taller plant with large and wide leaves, in comparison to other treatments. Proximate and sensory tests should be conducted in order to evaluate the effect of these radiations on their nutritional contents and human allergic ability.***

Keywords: sesame, X - ray, Gamma - ray, UV light, growth rate, germination

1. Introduction

Sesame (*Sesamum indicum*) is a flowering plant. World production in 2018 was 6 million tonnes, with Sudan, Myanmar, and India as the largest producers (FAOSTAT, 2020). Sesame seed is used as oilseed crops, most being wild and native to sub - Saharan Africa. *S. indicum* is originated in India (Ogasawara *et al*., 1988). Sesame has one of the highest oil contents of any seed. With a rich, nutty flavor, it is a common ingredient in cuisines across the world (Hansen, 2011). Like other seeds and foods, it can trigger allergic reactions in some people.

Sesame is an annual plant growing 50 to 100 cm tall, with opposite leaves 4 to 14 cm long with an entire margin; they are broad lanceolate, to 5 cm broad, at the base of the plant, narrowing to just 1 cm broad on the flowering stem. The flowers are tubular, 3 to 5 cm long, with a four - lobed mouth. The flowers may vary in colour, with some being white, blue, or purple. Sesame seeds occur in many colours depending on the cultivar. Sesame fruit is a capsule, and can naturally splits to release the seeds. Sesame seeds are about 3 to 4 mm long by 2 mm wide and 1 mm thick. The mass of 100 seeds is 0.203 g (Tunde - Akintunde and Akintunde, 2004).

Sesame varieties have adapted to many soil types. The high - yielding crops thrive best on well - drained, fertile soils of medium texture and neutral pH. However, these have a low tolerance for soils with high salt and water - logged conditions. Commercial sesame crops require 3 - 4 months. Warm conditions above 23 °C (73 °F) favor growth and yields. Sesame crops can grow in poor soils (TJAI, 2002).

Radiation is a source of energy present in our daily lives, originating from natural and manmade sources. Living organisms are profoundly affected by radiation - induced cellular damage, threatening healthy and diseased tissues (*e. g*., tumors). Radiation is classified in two major forms: ionizing and non - ionizing. Environmental radiation is largely the non - ionizing type, including ultraviolet (UV) rays from the sun and electromagnetic radiation associated with radio waves and microwaves. The ability of sources of UV rays (from the sun or tanning beds), to harm biological tissues is now well - established (Karagas *et al*., 2002, Zhang *et al*., 2012).

The interaction of ionizing radiation with biomolecules is, however, much more aggressive than non - ionizing radiation due to the ability of ionizing radiation to induce atom ionization. The major types of ionizing radiation are alpha and beta particles, X - rays, and gamma rays. Since alpha and beta particles can be stopped by physical barriers, such as a sheet of paper or an aluminum plate, while X - and gamma rays are more penetrating, environmental exposure to gamma rays induces a greater degree of biological damage than exposure to alpha or beta particles (Lawrence and Rosenberg, 2008). Gamma radiation of cellular water rapidly generates the reactive oxygen species hydroxyl radical and ionized water, as well as the less investigated reductants hydrogen radical and hydrated electrons (Singh and Singh, 1983).

In biology, a mutation is an alteration in the nucleotide sequence of an organism DNA. Mutations result from errors during DNA replication, mitosis, or meiosis or other types of damage to DNA (such as exposure to radiation), which then may undergo error - prone repair (Sharma *et al*., 2015), cause an error during other forms of repair (Rodgers and McVey, 2016; Chen *et al.*, 2014) or cause an error during replication. Mutations may also result from insertion or deletion of segments of DNA due to mobile genetic elements (Bertram, 2000; Aminetzach *et* al., 2005; Burrus and Waldor, 2004).

Induced mutations are alterations in the gene after it has come in contact with mutagens and environmental causes. Induced mutations on the molecular level can be caused by Chemicals or Radiation (Ultraviolet light (UV) and the Ionizing radiation. Exposure to ionizing radiation, such as X - and gamma radiation, can result in mutation, possibly resulting in cancer or death (Kozmin *et al*., 2005).

This study aimed to evaluate the germination rates and some growth parameters of sesame (*Sesamum indicum* L.) irradiated with X - ray, Gamma - ray and UV - light.

2. Materials 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^o30N – 33^o30 E). It has an area of about 28000 km^2.

Radiation treatment

The sesame seeds were brought from Agricultural Research Corporation, Wad Medani, Gezira State, Sudan. The sesame seeds were irradiated by X - ray and Gamma - ray in the National Cancer Institute, University of Gezira. The sesame 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 in the Microbiology Lab, Faculty of Engineering and Technology, University of Gezira.

Field Experiments

The six treated sesame seeds in addition to control were planted in definite sites in the Experimental Farm within one feddan area. Soil, irrigation, other agricultural conditions and insect pressure were same for all treatments. No 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 were picked out completely from the soil to measure the weight (in g) using an electrical balance, No. of leaves, height (in cm), diameter (in cm), length and width of largest leaves (in 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, sesame 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).

3. Results and Discussion

Germination rates

Table (1) showed that, after one week, 86% of the sesame seeds treated with LX were germinated, while only 70% of the HX were germinated. Relatively similar finding was noticed in gamma treated samples (89% was the germination rate for LG and 63% for HG).74% of the UV treated samples were germinated within one week. The control sesame seeds showed 92% germination rate. All sesame treatments have a germination rates less than the control, and this may exclusively be due to the type of treatment they deal with.

Growth parameters

The mean weight of the sesame seedlings (Table 2) showed that, most treatments were light in weight after 10 days (about 0.05 g), but with time it increased gradually to reach 4.11 g in LX and C, but it was 0.52 g in HX after 60 days. The daily constant increase in weight ranged between 0.07 g in C and LX to 0.01 g in HX and LG.

The mean stem tall of the sesame seedlings (Table 3) showed that, most treatments were short in tall after 10 days (ranged between 2.8 cm in C and LX to 4.7 cm in HG), but with time the sesame plant - tall increased gradually to reach 29.1 cm in LX and C, but it was 13.5 cm in HX after 60 days. The daily constant increase in tall ranged between 0.49 cm in C and LX to 0.17 cm in HX.

The mean stem diameter of the sesame seedlings (Table 4) showed that, all treatments were narrow in diameter after 10 days (0.1 cm), but with time the sesame plant - diameter increased gradually to reach 1.2 cm in UV, but it was 0.8 cm in HX and LG after 60 days. The daily constant increase in stem diameter ranged between 0.02 cm in C, UV, HG and LX to 0.01 cm in HX and LG.

The mean leave tall of the sesame seedlings (Table 5) showed that, all treatments have short leaves after 10 days (0.4 - 0.7 cm), but with time the sesame leaves - tall increased gradually to reach 6.1 cm in LX and C, but it was 2.9 cm in LG after 60 days. The daily constant increase in leaves tall ranged between 0.11 cm in C to 0.05 cm in HX and LG.

The mean leave width of the sesame seedlings (Table 6) showed that, most treatments have narrow leaves after 10 days (0.6 - 0.7 cm), but with time the sesame leaves - width increased gradually to reach 2.4 cm in LX and C, but it was 1.7 cm in HX after 60 days. The daily constant increase in leaves width ranged between 0.02 cm in HX, LG and UV to 0.04 cm in LX.

The mean No. of leaves of the sesame seedlings (Table 7) showed that, most treatments have only two leaves after 10 days (except HG, that possess 4 leaves), but with time the sesame leaves number increased gradually to reach 14 leaves, except those of HX and LG (possess 12 leaves) after 60 days. The daily constant increase in leaves number ranged between 0.23 in UV to 0.20 in LG and HX.

It was noticed that, LX and to some extent UV sesame samples have genetic expression on some of the studied morphological aspects (on phenotype level at least) similar to that of Control (some time LX act better than control), unlike HX and LG, which have relatively low genetic performance compared to control.

It was also noticed that, although there was clear differences in the degrees of growth rates among different sesame treatments, but Anova confirmed no significant differences between them either in weight, length, diameter, leaves tall, leaves width or number of leaves (f values were less than f - crit in all cases).

Mutations may or may not produce detectable changes in the observable characteristics (phenotype) of an organism. Mutations play a part in both normal and abnormal biological processes including: evolution and the development of the immune system. Mutation is the ultimate source of all genetic variation, providing the raw material on which evolutionary forces such as natural selection can act.

Mutation can result in many different types of change in phenotypes and genotypes. Mutations in genes can have no effect. A 2007 study on genetic variations between different species of *Drosophila* suggested that, if a mutation changes a protein produced by a gene, the result is likely to be harmful, with an estimated 70% of amino acid polymorphisms that have damaging effects, and the remainder being either neutral or marginally beneficial (Sawyer *et al.*, 2008). Due to the damaging effects that mutations can have on genes, organisms have mechanisms such as DNA repair to prevent or correct mutations by reverting the mutated sequence back to its original state (Bertram, 2000).

Table 1: Germination rates of sesame seeds

Time	**X - ray**		**Gamma - ray**		**UV light**	**Control**
	L	**H**	**L**	**H**		
4 days	37	35	39	30	32	65
7 days	49	35	50	33	42	37
Total	**86**	**70**	**89**	**63**	**74**	**92**

Table 2: Mean weights (g), of sesame newly grown plant

Time	X - ray		Gamma - ray		UV light	Control
	L	H	L	H		
10 days	0.0.5	0.05	0.07	0.07	0.05	0.05
20 days	0.0.8	0.07	0.09	0.08	0.07	0.08
30 days	0.19	0.14	0.15	0.15	0.20	0.19
40 days	0.25	0.08	0.27	0.31	0.26	0.25
50 days	1.11	0.33	0.62	0.79	0.52	1.11
60 days	4.11	0.52	0.77	0.91	1.41	4.11
Regression analysis						
R^2	0.62	0.76	0.88	0.87	0.73	0.62
Intercept	- 1.38	- 0.11	- 0.19	- 0.26	- 0.40	- 1.38
Slope	0.07	0.01	0.01	0.02	0.02	0.07
ANOVA Analysis						
f - stat	1.43					
f - crit	**2.42**					

Table 3: Stem tall (cm), of sesame newly grown plant

Time	X - ray		Gamma - ray		UV light	Control
	L	H	L	H		
10 days	2.8	4.1	4.5	4.7	3.7	2.7
20 days	3.8	5.6	5.9	5.3	4.8	3.8
30 days	6.6	5.9	7.5	8.25	7.65	6.6
40 days	8.4	7.6	11.0	11.6	11.6	8.4
50 days	16.2	9.4	15.3	18.1	18.1	16.2
60 days	29.1	13.5	16.3	20.4	24.1	29.1
Regression analysis						
R^2	0.84	0.90	0.96	0.95	0.94	0.83
Intercept	- 5.61	1.67	1.01	- 0.63	- 2.93	- 5.90
Slope	0.48	0.17	0.26	0.34	0.42	0.49
ANOVA Analysis						
f - stat	1.60					
f - crit	**2.42**					

Table 4: Stem diameter (cm), of sesame newly grown plant

Time	X - ray		Gamma - ray		UV light	Control
	L	H	L	H		
10 days	0.1	0.1	0.1	0.1	0.1	0.1
20 days	0.2	0.2	0.2	0.2	0.2	0.2
30 days	0.4	0.3	0.4	0.4	0.4	0.4
40 days	0.4	0.5	0.5	0.5	0.5	0.4
50 days	0.6	0.5	0.6	0.6	0.7	0.6
60 days	1.1	0.8	0.8	0.9	1.2	1.1
Regression analysis						
R^2	0.87	0.94	0.98	0.97	0.91	0.88
Intercept	- 0.15	- 0.06	- 0.05	- 0.08	- 0.19	- 0.15
Slope	0.02	0.01	0.01	0.02	0.02	0.02
ANOVA Analysis						
f - stat	1.64					
f - crit	**2.42**					

Table 5: Leave tall (cm), of sesame newly grown plant

Time	X - ray		Gamma - ray		UV light	Control
	L	H	L	H		
10 days	0.5	0.7	0.6	0.4	0.7	0.5
20 days	0.8	1.1	1.2	1.1	1.1	0.8
30 days	2.4	1.8	2.1	2.2	2.3	2.4
40 days	2.5	2.0	2.6	2.6	2.5	2.5
50 days	2.7	2.8	2.8	3.1	2.9	3.7
60 days	6.1	3.1	2.9	3.5	3.6	6.1
Regression analysis						
R^2	0.82	0.98	0.91	0.96	0.96	0.92
Intercept	- 0.88	0.19	0.35	- 0.04	0.17	- 1.01
Slope	0.10	0.05	0.05	0.06	0.06	0.11
ANOVA Analysis						
f - stat	1.12					
f - crit	**2.42**					

Table 6: Leave width (cm), of sesame newly grown plant

Time	X - ray		Gamma - ray		UV light	Control
	L	H	L	H		
10 days	0.6	1.0	0.7	0.6	0.7	0.6
20 days	0.6	0.8	0.8	0.9	1.0	0.8
30 days	1.3	0.9	1.2	1.1	1.2	1.3
40 days	1.4	1.1	1.4	1.2	1.3	1.4
50 days	1.7	1.4	1.7	1.5	1.5	1.8
60 days	2.4	1.7	1.8	2.1	2.1	2.4
Regression analysis						
R^2	0.93	0.75	0.97	0.93	0.93	0.96
Intercept	0.09	0.60	0.43	0.29	0.44	0.17
Slope	0.04	0.02	0.02	0.03	0.02	0.03
ANOVA Analysis						
f - stat	1.10					
f - crit	**2.42**					

Table 7: No. of Leaves of sesame newly grown plant

Time	X - ray		Gamma - ray		UV light	Control
	L	H	L	H		
10 days	2	2	2	4	2	2
20 days	4	4	4	4	4	4
30 days	8	4	6	6	6	8
40 days	8	6	8	8	8	8
50 days	10	10	10	12	10	10
60 days	14	12	12	14	14	14
Regression analysis						
R^2	0.95	0.93	0.99	0.94	0.98	0.95
Intercept	- 0.12	- 0.67	0.001	0.40	- 0.67	- 0.13
Slope	0.22	0.20	0.20	0.22	0.23	0.22
ANOVA Analysis						
f - stat	2.33					
f - crit	**2.42**					

4. Conclusions

The LX sesame sample has good germination rate (86%), compared to 63% for HG and 92% for C. After 60 days, LX and C sesame samples showed heavier weight (4.11 g), compared to 0.52 g in HX; taller plants (29.1 cm), compared to (13.5 cm) in HX; taller leaves (6.1 cm), compared to (2.9 cm) in LG; wider leaves (2.4 cm), compared to (1.7 cm) in HX, but UV sesame sample showed wider stem diameter (1.2 cm), compared to (0.8 cm) in HX and LG. Most treatments have 14 leaves, compared to 12 leaves in HX and LG. LX and to some extent UV sesame samples have genetic expression on phenotype level, at least similar to that of Control (some time LX act better than control), unlike HX and LG, which have relatively low genetic performance compared to control.

5. Recommendations

Further molecular, nutritional, and sensory tests should be conducted in order to evaluate the effect of these mutant sesame seeds on human before recommends to be consumed.

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