https://dx.doi.org/10.4314/dujopas.v10i1a.16
ISSN (Print): 2476-8316
ISSN (Online): 2635-3490
Dutse Journal of Pure and Applied Sciences (DUJOPAS), *Vol. 10 No. 1a March 2024*

Growth and Yield Performance of X-Ray Irradiated Cucumber

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Abstract

Cucumber (Cucumis sativus L.) is a very important fruit which makes its demand and consumption continually on the increase all over the world. X-ray is an ionizing radiation and a physical mutagen with great potentials in creating artificial variability in crops. The employment of x-ray irradiation has been underutilized in plant mutagenesis, hence this study sought to determine its effect on the germination and agro-morphological traits of cucumber. Cucumber seeds were obtained from an agro-allied store and exposed to x-ray radiation from a source 70 KVA at a distance of 90cm and doses 10, 20, 30 and 40mAs. The field experiment was carried out in duplicate using a Randomized Complete Block Design (RCBD). Irradiated and unirradiated (control) seeds were sown directly on a total of ten prepared plots measuring 2.44 by 1.50 m. The result generated in this study show a positive shift at the higher doses (30 and 40 mAs) with reduced number of days to fruit maturity and increased number of fruits per plant when compared to the control and other doses. A strong positive correlation was observed among some traits studied, indicating the possibility of such traits being under the influence of the same gene and the ability to be inherited together. Zonata, a chlorophyll mutant was observed at 30 mAs indicating how successful the dose was in inducing beneficial mutation on the Cucumber. Higher doses of x-ray irradiation as used in this study is therefore recommended for the genetic improvement of other vegetable and under developed crops.

Keywords: *Cucumis sativus*, X- ray, Mutagenesis. Agro-morphological traits and Zonata

INTRODUCTION

Cucumber belongs to the Family Cucurbitaceae, Subfamily Cucurbitoideae, Tribe Melothrieae, Subtribe Cucumerinae, Genus *Cucumis* and Species *sativus* L. (Long, 2015). The plant is cultivated throughout the world for immature fruit that are eaten fresh or processed into pickles. The fruit are formed from an inferior ovary and harvested toward the end of its exponential growth, approximately two weeks after it begins to flower (Grumet *et al*., 2023). Cucumber (*Cucumis sativus* L.) 2n = 2x = 14, is a vegetable grown all around the world (Huh *et al*., 2008), as is one of the most widely cultivated plants in the world. Its cultivation is also becoming common in most part of Nigeria, probably due to its high nutritional and medicinal values (Nweke *et al*., 2013). Cucumbers are rich in vitamins A, C, E, and K, as well as protein, dietary compounds, folate, niacin, pyridoxine, riboflavin, thiamine, sodium, and potassium, it also contains important healthy minerals such as calcium, iron, magnesium, manganese, phosphorus and zinc (Anonymous, 2023)

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Mutation breeding is an alternative to conventional breeding which increases genetic variability and confers specific improvements on crops without alteration of the acceptable phenotype of the crop (Udage, 2021; Ikani *et al*., 2023). Various mutagenic agents have been used to induce favourable mutations at high frequency. This includes ionizing radiation and chemical mutagens. X-ray like gamma and fast neutrons are ionizing radiations used to induce mutations on crop. X-ray radiation is an underutilized physical mutagen that is rarely used in the breeding of crops (Reznik *et al*., 2021). There is no information on the response of cucumber to the effects of x-ray radiation, hence this study was undertaken to ascertain its effects on the growth and yield of cucumber.

METHODOLOGY

This study was carried out at the Botanical garden (9°20'59"N, 12°29'7"E), of the Department of Plant Science, Modibbo Adama University, Yola. Cucumber seeds were obtained from an agro-allied store at Jimeta, Adamawa state. Cucumber seeds were treated with x-ray radiation from a 70 KVA source, at a distance of 90 cm and doses of 10, 20, 30, 40 mAs at the Apical medical center Jimeta Yola, Adamawa State, Nigeria, according to the methods of Reznik *et al*. (2021). The experiment was done in duplicate, using a Randomized Complete Block Design (RCBD). Seeds were sown directly on already prepared plots in rows. One plot per treatment per replicate (Ikani *et al*., 2017).

Data Collection

Three plants were tagged per plot per replicate, upon which data collection was done. Data were collected on Days to 50% germination, Germination percentage, Vine length, Number of branches per plant, Number of leaves per plant, number of days to first matured fruit, Number of fruits per plant, Weight of a fresh fruit, Length of fruits, Width of fruits and Number of days to first female flowering according to the method of Adinde *et al*. (2016).

Germination percentage

Data on germination percentage was obtained 7 days after sowing by counting the number of seedlings emerged and divided by the number of seeds sown then multiplied by 100.

Days to 50% germination

Days to 50% emergence was determined by counting the days from the date of sowing to the date up to half of the sown seeds emerged as seedlings.

Vine length

Vine length was measured with measuring tape in centimeters (cm) from the base to the growing tip of the main vine.

Number of branches per plant

Number of branches per plant was determined by direct counting of the branches per plant.

Number of leaves per plant

Number of leaves per plant was determined by direct counting of the leaves per plant.

Days to first female flower initiation

Days to first female flower initiation was determined by counting the days from the date of sowing to the date first female flower was seen in each plot.

Days to first matured fruit
Days to first matured fruit was taken by counting the number of days from germination to when the first matured fruit was harvested per replicate

Length of the fruit
The average length of the fruit in centimeters was computed using a meter rule

Width of the fruit
The average width of the fruit in centimeters was computed using a tape after using a rope.

Weight of a fresh fruit
Weight of each fresh fruit in grams was determined using weighing scale to get the total weight of the harvested fruits and divided by the number of fruits weighed.

Number of fruits per plant
Number of fruits per plant was determined by direct counting of the number of harvested fruits from the sample plants in each plot and dividing by the number of sample plants.

Statistical Analyses
Descriptive statistics was used to calculate the mean of the growth and yield parameters studied. One-way analysis of variance was used to analyze the agro-morphological data obtained and where significant difference exists Tukey's Honest Significant Difference (HSD) was used to separate the means. Correlation analysis was used to show the relationship between the traits studied. All test statistics was carried out at $p \leq 0.05$ level of significance using R software version 4.05.

RESULTS

Effect of X-ray on Growth performance of Cucumber
The growth performance of x-ray mutant is shown on Figure 1 below. The least percentage germination was observed at 10 mAs (59.00%) while the highest (74%) was observed at 40 mAs. Vine length varied slightly, with the least value recorded at 0 mAs with 120.40 cm while 30 mAs had the highest with 136.14 cm. Number of branches also varied slightly, 0 mAs had highest with a mean of 7.33 while 10 mAs had the least with a mean of 5.67 branches. There was no significant difference in the number of leaves per plant where 30 mAs had the highest number of leaves with 59.33 leaves and 20 mAs had the least with 43.00 leaves.

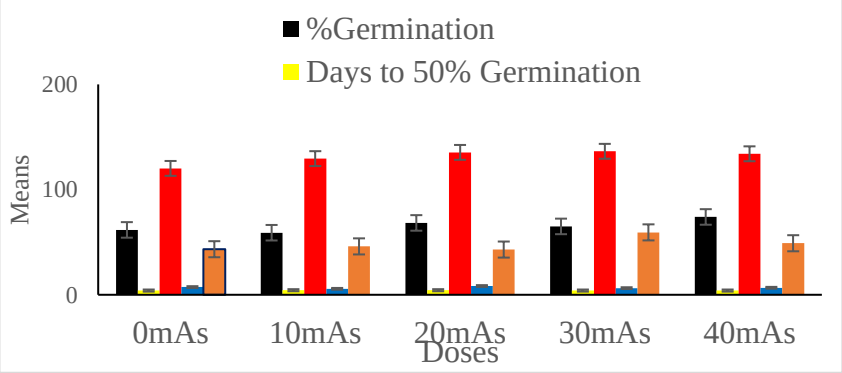

Figure 1: Growth performance of Cucumber Mutants

Effect of X-ray on Yield Performance of Cucumber

Mutants of 40 mAs had the least days to the initiation of first female flower (33.00 days) which is closely followed by 30 mAs (33.33 days) while the highest number of days (38.33) was recorded at 10 mAs. In days to first matured fruit, significant ($p \leq 0.05$) difference was observed. 10 mAs had the highest days to first matured fruit with 53.33 days while 40 mAs had the least number of days to first matured fruit (40.67days). Fruit length of all the treatment was not significantly ($p > 0.05$) different from that of the control (30 mAs had the highest with 22.15 cm and 10 mAs had the least with 18.92 cm). The highest fruit width, was recorded at 40 mAs (19.84 cm) while the least was seen in the control, 0 mAs (17. 27 cm) with no significant difference.

The highest fruit weight was recorded at 40 mAs (361.29 g) and the least at 20mAs (264.08 g), although no significant difference was observed. 30mAs showed the highest (6.44) number of fruits per plant followed by 40 mAs, (6.33), 20 mAs (5.29) and 10 mAs (5.88) and the least is 0mAs (3.44). Significant ($p \leq 0.05$) difference was found across the treatments with 30 mAs having the highest number of fruits, closely followed by 40 mAs, 20 mAs and 10 mAs respectively while the control had the least number of fruits per plant as shown on Figure 2.

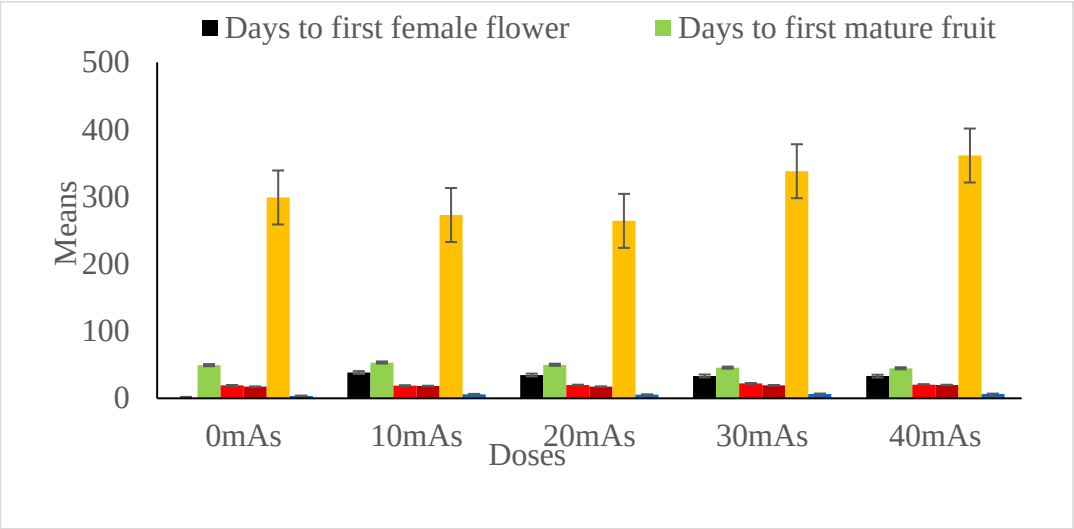

Figure 2: Yield Performance of Cucumber mutants

Correlation Coefficient of Agro-morphological Traits

The analysis on correlation coefficient showed that several quantitative traits recorded positive correlation (Table 1). Based on the results, number of branches is positively correlated to vine length (r = 0.59). Number of leaves correlated strongly to vine length (r = 0.68). Days to first female flower also had a strong correlation with the number of days to 50% germination (r = 0.73). Days to first matured fruit showed a positive correlation to days to 50% germination (r = 0.56) and also days to first female flower (r = 0.69). A positive correlation was seen between fruit length and vine length (r = 0.61). A strong correlation was recorded between fruit width and vine length (r = 0.72), number of leaves per plant (r = 0.63), days to first matured fruit (r = 0.57), and fruit length (r = 0.72). Fruit weight correlated positively with germination percentage (r = 0.76), days to first matured fruit (r = 0.59) fruit length (r = 0.51), and fruit width (r = 0.69). Number of fruits per plant correlates positively to vine length (r = 0.54), and fruit width (r = 0.51).

Chlorophyll Mutant induced by Treatment with X-ray Irradiation

The control plant which developed from seeds that were not exposed to x-ray irradiation had normal green leaf (Plate1) while a chlorophyll mutant called zonata according to Gustafson (1940 and 1941) system of classification was seen among the cucumber plant which developed from seeds irradiated with 30 mAs of x-ray (Plate 2). The zonata mutant showed a light yellow colour on about half of the leaf.

Plate1: Normal leaf of control

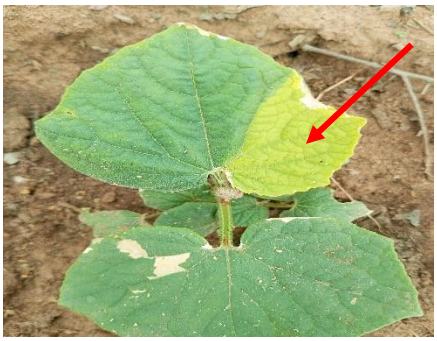

Plate 2: Zonata chlorophyll Mutant leaf (30mAs)

Table 1: Correlation Coefficient of Agro-Morphological Traits

	G	*D50%G*	*VL*	*NB*	*NL*	*DFFF*	*DFMF*	*FL*	*FWd*	*FW*	*NFPP*
G	1										
D50%G	-0.03689	1									
VL	0.368841	-0.42219	1								
NB	0.107195	-0.22668	0.594268	1							
NL	0.157955	-0.52736	0.675956	0.220158	1						
DFFF	-0.47022	0.725213	-0.61507	-0.42074	-0.58529	1					
DFMF	-0.31639	0.5561	-0.4048	-0.27779	-0.62565	0.685388	1				
FL	0.19323	-0.36332	0.613234	0.406163	0.479833	-0.65497	-0.50804	1			
FWd	0.38911	-0.42467	0.724288	0.091656	0.629651	-0.6259	-0.57227	0.717761	1		
FW	0.760993	-0.50627	0.462665	0.012041	0.409165	-0.70949	-0.58584	0.511163	0.685622	1	
NFPP	0.09581	-0.17738	0.537216	0.280016	0.422333	-0.51515	-0.35875	0.336564	0.509177	0.151454	1

KEY: G: Germination percentage, D50%G: Days to 50% germination, VL: Vine length, NB: Number of branches, NL: Number of leaves, DFFF: Days to first female flower, DFMF: Days to first mature fruit, FL: Fruit length, FWd: Fruit width, FW: Fruit weight and NFPP: Number of fruits per plant

DISCUSSION

Germination percentage, days to 50% germination, vine length, number of branches per plant, number of leaves per plant fruit weight, fruit width and fruit length which showed slight difference could be as a result of a recessive mutation that might have occurred in the mutant. However, this can manifest in later generations when the genes must have begun to segregate. This is similar to the findings of Dubey *et al.* (2007) who reported an increase in plant height, number of branches per plant and number of leaves per plant in okra seed irradiated with different doses of gamma radiation.

The difference in the number of days to first matured fruit across the different doses of x-rays irradiation, could be as a result of a change in the gene responsible for days to flowering and maturing of fruit. X-ray is an ionizing radiation that might have induced substitution, deletion or insertion mutation (Singh, 2013). The change in the days to first matured fruit could imply that a positive mutation occurred which led to the production of an early maturing mutant.

This is contrary to the findings of Andrew *et al.* (2021) who reported that x-ray irradiated seeds of dark brown eye and black eye varieties of cowpea required more days to flower compared to the control.

The variation in number of fruits per plant could have been as a result of the occurrence of a beneficial mutation at this dose leading to the production of more female flowers which develops into the main fruit resulting in higher yield. This is in tandem with the findings of Dubey *et al*. (2007); Mishra *et al.* (2007); Sharma and Mishra (2007) who reported increased number of fruit per plant and fruit length in okra as a result of exposure to gamma radiation. Sundaravadivelu *et al*. (2006) and Sujaya *et al.* (2007) also reported enhancement in seed yield of cotton and mungbean treated with gamma radiation respectively.

Strong positive correlation coefficient as seen in this study could indicate the possibility of positively correlated traits being under the influence of same gene and hence an improvement in one trait automatically leads to the improvement of the other. This is similar to the findings of Laura *et al*. (2018) who reported positive correlations in some agro-morphological traits of *Phaseolus vulgaris*.

In this study chlorophyll mutation showed light yellow colour indicating that the carotenoid prevailed over the chlorophyll. And this could be as a result of the chloroplast which is responsible for the production of chlorophyll being temporarily affected by the mutagen. Chlorophyll mutation serves as reliable indicators for the effectiveness and efficiency of mutagen in inducing mutation (Ikani *et al.*, 2017). This is supported by the findings of Ikani *et al.* (2017) who reported the chlorophyll mutant Zonata in Lima bean treated with 0.2 Sv of fast neutron irradiation.

CONCLUSION

X-ray irradiation significantly induced early maturity and higher yield on cucumber at higher doses (30 and 40 mAs). However, 30 mAs proved to be the best in most of the agro-morphological traits studied. Many of the traits were positively correlated implying that breeding for one automatically bred for the other. A chlorophyll mutatnt called Zonata occurred at a dose of 30 mAs which is an indication its success in inducing beneficial mutation.

ACKNOWLEDGEMENTS

The authors want to express their profound gratitude to Dr. Pariya of the Apical Medical Center for his support in irradiating our cucumber seeds with x-ray

REFERENCES

Adinde, J. O. Anieke, U. J. Uche, O. J. Aniakor, A. C. Isani, L. C. and Nwagboso, A. A. (2016). Assessment of Performance of Four Cucumber (*Cucumis sativus* L.) Cultivars in Iwollo, South-Eastern Nigeria. *International Journal of Current Research in Biosciences and Plant Biology*, 3(10): 136-143

Andrew, O. V., Samuel, I. and Kelechukwu, C. E. (2021). Effects of x-ray irradiation on the growth and yield parameter of four Cowpea *(Vigna unguiculata* (L.) Walp) Genotypes. *Journal of Science and Technology Research*, pp 58-68.

Anonymous. (2023). Fourteen Proven Health Benefits & Uses of Cucumber: Try It Now. Plants hospital. https://plantshospital.com/benefits-ofcucumber/

Dubey, A. K., Yadav, J. R. and Singh, B. (2007). Studies on induced mutations by gamma irradiation in okra *(Abelmoschus esculentus* (L.) Monch). *Progressive Agriculture*, 7(1/2): 46-48.

Grumet, R., Lin, Y. C., Rett-Cadman, S. and Malik, A. (2023). Morphological and Genetic Diversity of Cucumber (*Cucumis sativus* L.) Fruit Development. *Plants*, 12(1): 23. https://doi.org/ 10.3390/plants12010023

Gustafsson, A. (1940). The Mutation System of the chlorophyll apparatus. Lunds Universitets Arsskrift, *N. F. Avd*. 2. Bd. 36: 1-40.

Gustafsson, A. (1941). Mutation experiments in barley. *Hereditas,* 27: 225-242

Huh, Y. C., Solmaz, I. and Sari, N. (2008). Morphological characterization of Korean and Turkish Watermelon germplasm. In: Pitrat M., Cucurbitaceae; Proceedings of the IXth EUCARPIA meeting on genetics and breeding of cucurbitaceae, INRA; Avignon, France, 399-406.

Ikani, V. O., Adelanwa, M. A. and Aliyu, R. E. (2017). Mutagenic Effects OF Fast Neutron Irradiation on Some Growth and Yield Parameters at M1 and M2 of Lima bean (*Phaseolus lunatus* Linn.). *International Journal of Applied Biological Research*, 8(1): 142 – 150.

Ikani, V. O., Ibrahim, Z. A. and Sakiyo, D. C. (2023). Qualitative Mutations Induced by Ethyl Methane Sulphonate on *Phaseolus lunatus L. Trends in Agricultural Science,* 2 (1): 88-92. https://doi.org/10.17311/tas.2023.88.92

Laura, E. Yenyinou, L., Azize, O., Arlette, A., Joel, A., Joelle, T., Gustave, D. and Alexander, D. (2018). Morphological characterization of common bean *(Phaseolus vulgaris* L.) landraces of Central Region of Benin Republic. *Journal of Plant Breeding and Crop Science,* 10(11): 304-318.

Long, A. (2015). *Cucumis sativus*-Cucumber. The Worldwide Vegetables. http://theworldwidevegetables.weebly.com/cucumissativus-cucumber.html.

Mishra, M. N., Hina, Q. and Shivali, M. (2007). Macro and micro mutations, in gamma rays induced M2 populations of okra *[(Abelmoscus esculentus* (L.) Moench). *International of Journal of plant science, 2*(1):44-47.

Nweke, I. A., Orji, E. C and Ijearu, S. I. (2013). The effect of Staking and Plant Spacing on the growth and yield of Cucumber (*Cucumis sativus* L.). *Journal of Environmental Science, Toxicology and Food Technology*, 3: 26-31.

Reznik, N., Subedi, B. S., Weizman, S., Friesem, G., Carmi, N., Yedidia, I., and Sharon-Cohen, M. (2021). Use of X-ray Mutagenesis to Increase Genetic Diversity of Zantedeschia aethiopica for Early Flowering, Improved Tolerance to Bacterial Soft Rot, and Higher Yield.*Agronomy*:11(2537):1-13.https://doi.org/ 10.3390/agronomy11122537

Sharma, B. K. and Mishra, M. N. (2007). Micro-mutations for fruit number, fruit length and fruit yield characters in gamma-irradiation generation of ANKUR-40 variety of okra *[Abelmoscus esculentus* (L.) Monech] *International Journal of Plant Science.* 2(2): 208-211.

Singh, B. D. (2013). Plant Breeding: Principles and Methods. Kalyani Publishers New Delhi-110 002, India. 923pp.

Sujaya, D., Anirban, M., Puspendu, S. and Sarkar, K. K. (2007). Selection of some useful mutants of mungbean *Vigna radiata* (L.) Wilczek in generation. *Environ*mental *Ecology* 255 (2): 258-260.

Sundaravadivelu, K., Ranjithselvi, P. and Reddy, V. R. K. (2006). Induced genetic variwbility in cotton *(Gossypium hirsutum L.)* for yield and its components. *Crop Research- Hirsar*. 32(3): 442-446.

Udage, A. C. (2021). Introduction to plant mutation breeding: Different approaches and mutagenic agents. *Journal of Agricultural Science*s, 16: 466-483.