Supported by tetfund

EVALUATION OF THE EFFECTS OF DIFFERENT FAST NEUTRON IRRADIATION (FNI) DOSES ON OBA98 MAIZE (*Zea mays* L.) IN KEFFI LGA, NASARAWA STATE NIGERIA

J. A. Alanana[1]*, S. Y. Dasikwo[1], K. A. Yusuf[1] and A. B. Usman[2]
[1]Department of Plant Science and Biotechnology, Nasarawa State University Keffi, Nigeria
[2]Biotechnology Advanced Research Center, Sheda, PMB 186, Abuja, Nigeria
Corresponding author: Joshua_abu@yahoo.com

Received: March 30, 2019 **Accepted:** July 04, 2019

Abstract: This study investigated the effect of different irradiation exposure periods (IEPs) of fast neutron irradiation on OBA98 maize. 20 seeds (per treatment) were carefully selected and exposed to fast neutron irradiation (FNI) from Americium Beryllium source (which was emitting 110 µSV/h as of 11/05/2017) for eight different IEPs: 0, 24, 48, 72, 96, 120, 144 and 168 h at the center for energy research and training (CERT) of Ahmadu Bello University, Zaria. The seeds were planted in a Complete Randomize Design at the Plant Science and Biotechnology Botanical Garden of Nasarawa State University, Keffi (NSUK). Data for number of leaves/plant, number of Cobs/plant, girth length and plant height were collected and analyzed using one way analysis of variance (one way ANOVA). Germination percentage decreases with increase in irradiation exposure period (IEP). 168 h showed the best result in all the growth and yield parameters observed. All the irradiation exposure periods (IEPs) used in this research caused genetic variability in *Zea mays* L. Different IEPs favors different growth and yield parameters except for 168 and 24 h that consistently showed improvement in all parameters observed. Based on this study, 168 h is the most effective irradiation exposure period to induce viable and useful mutation in maize.

Keywords: Fast neutron, irradiation exposure periods, *Zea mays*

Introduction

Botanically, maize *(Zea mays)* belongs to the grass family (gramineae) and is a tall annual plant with an extensive fibrous root system. It is a cross pollinating species, with the female (ear) and male (tassel) flowers in separate places on the plant (monoecious).

Maize has become a staple food in many parts of the world; it is after wheat and rice the most important cereal grain in the world, providing nutrient for humans and animals and serving as a basic raw material for the production of starch, oil and protein, alcoholic beverages, food sweeteners and, more recently, fuel. Maize is perhaps the most common food crop in Nigeria, and also the most important as it is eaten in various dishes and forms the basis for most of the meals prepared by the average Nigerian family. As we all know, corn is a crop cheaper than rice and wheat, two of the most consumed cereals, and this affordability makes maize hugely popular and highly demanded. This have fuelled a search for simple but viable ways of increasing supply of the product, independent of man-power and the adequacy of farming conditions. Thus, attention has gradually shifted towards improving the genetic quality of the species through plant breeding and selection. One possible means is through radiation-induced genetic variability (Falusi and Dauda, 2014). The FAO (2009) reported that 2008 marked the 80th anniversary of mutation induction in plants. The application of gamma rays and other physical mutagens such as fast neutrons has generated a vast amount of genetic variability and has played a significant role in plant breeding and genetic studies (David, 2010).

The widespread use of induced mutants in plant breeding programs throughout the world has led to the official release of more than 2700 plant mutant varieties (FAO, 2009). Mutation technology has been used to produce many cultivars with improved economic value and to advance the study of plant genetics and development (Adamu and Aliyu, 2007; Poornananda and Hosakatte, 2009; Renalli, 2012). According to Sodkiewicz and Sodkiewicz (1999), one of the ways to supplement an existing germplasm with additional variation and to improve cultivars is by inducing mutation.

Thus, fast neutron irradiation (FNI) induced mutations in maize could be useful as a new source of altered germplasm (Falusi *et al.*, 2012). Our study aimed at evaluating the effects of FNI on germination (survival) growth and yield of OBA98 variety of maize.

Materials and Methods

OBA98 maize seeds were collected from Premier Seed Nigeria Limited, Zaria, Kaduna State. The 20 seeds were carefully selected and exposed to fast neutron irradiation (FNI) from Americium Beryllium source (emitting 110 µSv/h as at 11th May, 2017) for 0, 24, 48, 72, 96, 120, 144 and 168 h at Centre for Energy Research and Training (CERT) of Ahmadu Bello University, Zaria (Table 1). The seeds were planted in a Complete Randomized Design (CRD) at the Plant Science and Biotechnology Botanical Garden of Nasarawa State University, Keffi. The numbers of germinated seeds were taken as germination (survival) percentage (Falusi *et al.*, 2012). The plant heights were taken for 9, 23 and 69 days after germination, respectively. All plant heights measurements were made by holding the leaves erect and measuring the highest point of the highest leaf (Beard *et al.*, 1958). Girth lengths were also taken at 23 and 69 days after germination. The girth lengths were measured by placing a thread round the stem of the plant and measuring the length of the thread.

Thereafter, number of cobs/plant and number of leaves/plant were taken at 69 days after germination. All plant measurements were taken in centimeters and later converted to meters as the standard unit of measurement.

Table 1: The treatment details of the fast neutron irradiation from Americium Beryllium source

S/N	Date	Sample	Initial time	Final time	Duration (h)	Dose after irradiation
1.	11/05/17	OBA98$_{S1}$	09:00am	09:00am	24	0.22µSv/h
2.	11/05/17	OBA98$_{S2}$	09:00am	09:00am	48	0.25µSv/h
3.	11/05/17	OBA98$_{S3}$	09:00am	09:00am	72	0.34µSv/h
4.	11/05/17	OBA98$_{S4}$	09:00am	09:00am	96	0.37µSv/h
5.	11/05/17	OBA98$_{S5}$	09:00am	09:00am	120	0.28µSv/h
6.	11/05/17	OBA98$_{S6}$	09:00am	09:00am	144	0.38µSv/h
7.	11/05/17	OBA98$_{S7}$	09:00am	09:00am	168	0.40µSv/h
8.	–	OBA98$_{S3}$	–	–	–	0µSv/h

Results and Discussion

Data collected for plant height, girth length, number of leaves/plant and number of cobs/plant were analyzed using one way analysis of variance (ANOVA) in Smith's Statistical Package (SSP) software. There was a negative correlation between percent of germination and irradiation exposure period (IEP) which implies that as IEP increases, percentage of germination decreases (Table 2). While fast neutron irradiation (FNI) affected the percent of germination of the seed negatively, positive effects were recorded in terms of plant heights (Table 3), number of cobs/plant and number of leaves/plant (Table 4), girth lengths (Table 5) 69 days after germination.

Table 2: The effects of fast neutron irradiation on germination (survival) percentage of OBA98 maize variety

Irradiation time (h)	Germination percentage in the field (%)
0	100.00
24	90.00
48	90.00
72	75.00
96	75.00
120	55.00
144	55.00
168	75.00

Table 3: The effect of fast neutron irradiation on plant height at three periods after germination of OBA98 maize variety

Irradiation time (h)	Plant heights (m) 9 days	23 days	69 days
0	0.388±0.049	1.005±0.061	2.260±0.349
24	0.385±0.031	1.018±0.079	2.558±0.227
48	0.313±0.046	0.908±0.135	2.485±0.258
72	0.360±0.008	0.980±0.092	2.468±0.397
96	0.320±0.028	0.895±0.039	2.458±0.070
120	0.275±0.071	0.718±0.123	2.210±0.119
144	0.330±0.008	0.893±0.043	2.163±0.889
168	0.383±0.013	1.053±0.102	2.715±0.394

Values are mean ± SD; Means followed by the same superscript letter(s) within the same column do not differ statistically at 5% level, F vale = 0.8375, P value = 0.5672 for 69 days after germination

Table 4: The effects of fast neutron irradiation on the number of leaves/plant and cobs/plant of OBA98 maize at 69 days after germination

Irradiation time (h)	number of leaves	number of cobs
0	13.000±0.817	1.750±0.500
24	13.750±1.258	2.000±0.817
48	12.750±0.957	1.750±0.500
72	12.250±0.957	1.500±0.577
96	13.000±0.000	1.250±0.500
120	13.500±3.000	1.750±0.957
144	11.500±1.915	1.000±0.817
168	13.750±1.500	2.000±1.414
	F value = 1.0150	F value = 0.7500
	P value = 0.4456	P value = 0.6331

Values are mean ± SD; Means followed by the same superscript letter(s) within the same column do not differ statistically at 5% level

Table 5: Effects of fast neutron irradiation on the girth lengths of OBA98 maize at two periods after germination

Irradiation time (h)	Girth length (m) 23 days	69 days
0	0.046±0.007	0.061±0.007
24	0.056±0.004	0.063±0.005
48	0.045±0.008	0.059±0.011
72	0.051±0.004	0.061±0.009
96	0.051±0.005	0.066±0.013
120	0.040±0.007	0.065±0.007
144	0.052±0.008	0.064±0.021
168	0.063±0.014	0.072±0.015

Values are mean ± SD; Means followed by the same superscript letter(s) within the same column do not differ statistically at 5% level, F value = 0.4211, P value = 0.8794 for 69 days after germination.

Table 6: Differences between growth parameters of *Zea mays* following fast neutron irradiation for eight periods

Irradiation Time (h)	Growth parameters: Plant height	Girth length	No. of leaves/plant	No. of cobs/plant
0	2.260±0.349	0.061±0.007	13.000±0.817	1.750±0.500
24	2.558±0.227	0.063±0.005	13.750±1.258	2.000±0.817
48	2.485±0.258	0.059±0.011	12.750±0.957	1.750±0.500
72	2.468±0.397	0.061±0.009	12.250±0.957	1.500±0.577
96	2.458±0.070	0.066±0.013	13.000±0.000	1.250±0.500
120	2.210±0.119	0.065±0.007	13.500±3.000	1.750±0.957
144	2.715±0.394	0.064±0.021	11.500±1.915	1.000±0.817
168	2.715±0.394	0.072±0.015	13.750±1.500	2.000±1.414

Values are mean ± SD; Means followed by the same superscript letter(s) within the same column do not differ statistically at 5% level

Although, all the differences (Table 6) observed in the growth and yield parameters were statistically insignificant (i.e. P>0.05), plant heights were improved by 168, 24, 48, 72 and 96 h, consecutively. Similarly, 168, 24, and 120 h resulted in more leaves/plant, but more cobs/plant was seen in 168 and 24 h only, while 168, 96, 120, 144 and 24 h produced thicker stems, when compared with the control (0 h).

The negative correlation between irradiation exposure periods (IEPs) and percent of germination observed in this research, is similar to the findings of Falusi *et al.* (2012), on the effects of fast neutron irradiation (FNI) on pepper, also, Adamu (2004) and Amjad *et al*. (2008) reported similar negative effect of irradiation on chickpea seed germination. But Poornananda and Hosakatte (2009) reported 100% germination and survival when Niger (*Guizzotia abysinica*) seeds were treated with gamma irradiation. Small amount of FNI affected the plant growth positively as seen in 24 h and decreases as the radiation period increases as seen in 120 and 144 h. Sebastian (2012) reported a similar result on Alders and Norway spruce plants. But a very high IEP can increase plant growth as observed in 168 h and this is similar to the results of Asmahan and Nada (2006), Fahad (2009) and Hegazi and Hamidaldin (2010).

Generally, fast neutron irradiation increased the vegetative growth of OBA98 maize as shown by the number of leaves/plant (Table 4). This result is similar to the findings of Falusi *et al*. (2012) on the effects of FNI on three species of pepper but differs completely from the findings of Adamu and Aliyu (2007) on tomato, Poornananda and Hosakatte (2009) on Niger, and Adamu (2004) on pop-corn maize, whose results showed a decrease in the number of leaves/plant due to exposure to different irradiation sources.

Conclusion

Conclusively, all the irradiation exposure periods (IEPs) used in this study caused genetic variability in maize. But for 168 and 24hrs, different IEP, tend to favour different growth and yield parameters. 168 h showed the best result in terms of number of leaves/plant and all other growth and yield parameters observed, this implies that the higher the number of leaves in a plant, the better the photosynthesis of the plant. Thus, based on this study, 168 h is the most effective irradiation exposure period to induce viable and useful mutation in maize.

Acknowledgement

All thanks to Almighty God for the strength and privilege to carry out this research work, also appreciating Mr. A. B. Usman for his tireless effort and advice during the period of this research.

Conflict of Interest

Authors declare that there is no conflict of interest related to this study.

References

Adamu AK, Aliyu H 2007. Morphological effect of sodium azide on tomato (*Lycopersicones culentum* Mill.). *Scientific World Journal*, 2(4): 9-12.

Adamu AK 2004. Gamma rays (Co) and thermal Neutron induced mutant in popcorn (*Zea mays* Var. Praccox Sturt). *Nig. J. Scientific Res.*, 4(2): 52-63.

Amjad H, Tariq MS, Babar MA, Ahsanulhaq M & Hina S 2008. Gamma irradiation effects on seed germination and growth, protein contontperoxidese and protease activity, lipid peroxidation in Desi and Kabull chickpea. *Pakistan Journal of Botany*, 40(3): 1033-1041.

Asmahan AM & Nada A 2006. Effect of gamma iradiation and soduim azide on some economic traits in tomatoes. *Saudi J. Biol. Sci.*, 13(1): 44-47.

Beard BH, Haskins Francis A & Gavelner CO 1958. Comparison of Effects of X – Ray and Thermal Neutron on Dormant seeds of Barley, Maize, Mustard, and Safflower. Agronomy & Horticulture – Faculty Publications. Paper 215, http://digitalcommons.unl.edu/agronomyfacpub/215

David T 2010. All you wanted to know about induced mutations in crop breeding. *Bulletin of Biofortified.*

Fahad A 2009. Effects of sodium azide on growth and yield traits of *Eruca sativa* (L). *World Appl. Sci. J.*, 7(2): 220-226.

Falusi OA, Daudu OA & Teixeira da Silva JA 2012. Effects of fast neutron irradiation on agronomic traits of Nigerian pepper (*Capsicum annum* L.). *Euro. J. Hortic. Sci.*, 77(1): 41-45.

Falusi OA & Daudu OY 2014. The effect of fast Neutron irradiation on the Leaf Morphology of *Capsicum annuum* L. *Int. Conf. on Advances in Agric. Bio. & Envtal. Sci.* (AABES-2014) Oct. 15-16, 2014 Dubai (UAE).

HegaziAz Hamildeldin N 2010. The Effect of gamma irradiation on enhancement of growth and seed yield of okra (*Abelmos chusesculentus* (L.) Moench) and associated molecular changes. *Journal of Horticulture For.*, 2(3): 38-51.

Poornanada MN & Hosakatte NM 2009. The effect of Gamma and ethylmothylsulphonet treatments on agronomica traits of niger (*Guizotiaabys siniea* Cass.). *Afr. J. Biotech.*, 8(18): 4459-4464.

Ranalli P 2012. The role of induced plant mutations in the present era. In: Induced mutagenesis in plants. *Biorem., Biodiv. Bioavail.*, 6(Special Issue 1): 1 – 5.

Sebastian Di C 2012. X-ray Radiation Effect on Germination and Growth of *Edinacea anagustifolia.*"

Sodkiewicz T & Sodkiewicz W 1999. Effectiveness of fast neutron irradiation for the stimulation and induction of genetic changes in soybean (*Glycine max*) genome. *International Agrophysics*, 13: 503-507.

United Nations Food & Agriculture Organization (FAO) 2009. Induced Plant Mutations in the Genomic Era. Publication of the Food and Agricultural Organization of the United Nations (FAO) Rome.