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Original Article

Mutagenic Effects of Fast Neutron Irradiation on Selected Morphological Characters and Yield of the African Long Pepper (*Capsicum annum* var. *occuminatum*)

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ABSTRACT

The effects of fast neutron irradiation using an Americium-Beryllium source with a flux of 1.5 $\times 10^4$ n cm^{-2} s^{-1} on the morphological and yield traits of African long pepper (*Capsicum annum* var. *occuminatum*) were studied. The pepper seeds were irradiated for 0, 30, 60, 90 and 120 minutes before they were sown, with their respective controls, in order to assess the effects of the different irradiation treatments on percentage survival, days to maturity, plant height, number of fruits per plant, number of seeds per fruits, height of fruit, weight of fruit and width of fruit in the M_1 generations. All irradiation periods caused leaf abnormalities such as leaves with invaginated or inverted margins, or with a blunt or bifurcated apex, or leaves that turned bifoliage when compared with Control plants. There was, also, pronounced variation in germination percentage, plant height, number of leaves/plant, fruits/plant, seeds/fruit, weight of fruit, length and width of fruits; all essentially may affect productivity negatively. Moreover, 120 min was an effective irradiation period to induce viable and useful mutations for yield parameters in pepper. These results suggest the possibility of evolving higher yield variants of pepper through proper selection.

Key words: Americium-Beryllium, M_1 generations, Leaf Abnormalities, Selection

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INTRODUCTION

Capsicum belongs to the nightshade Family, Solanaceae (GRIN, 2009). The genus consists of over 100 species and even more botanical varieties (Ado, 1999; Falusi, 2007), including five domesticated species (i.e. *C. annum*, *C. frutescens*, *C. baccatum*, *C. chinense* and *C. pubescens*) all believed to have originated from the New World (Bosland, 1994). *C. annum* and *C. frutescens* are the most recognized species grown in commercial quantities all over Nigeria (Falusi and Morakinyo, 2001; Mady *et al.*, 2005). These two species form an important ingredient in people's diet around the world (GRIN, 2009), due to the pungency properties of the fruits resulting from their high concentration of capsaicinoid alkaloid (Bosland and Vostava, 2000). In addition, *Capsicum* is a rich source of vitamins A and C (Gill, 1992; Ado, 1999). *Capsicum* fruits are also popular as food spices, as a colouring agent and serve as pharmaceutical ingredients (Bosland, 1996). In African medicine, it is used to treat sore throats (Abdullahi *et al.*, 2003).

Mutations, which result in alteration of the genetic information of a cell or living creature are the tools used to study the nature and function of genes which are the building blocks and basis of plant growth and development, thereby producing raw materials for genetic improvement of economic crops (Adamu and Aliyu, 2007).

Mutation technology has been used to produce many cultivars with improved economic value and to advance the study of genetics and plant developmental phenomena (Bertagne-Sagnard *et al.*, 1996;

Poornananda and Hosakatte, 2009). Genetic variability for desired characters can be induced successfully through mutations, with high practical value in plant improvement programs (Fahad and Salim, 2009).

Induced mutations have been used to generate genetic variability for the improvement of yield components of various crops like *Oryza sativa* (Awan *et al.*, 1980; Singh *et al.*, 1998), *Hordeum vulgare* (Ramesh *et al.*, 2001), *Triticum durum* (Sakin and Yildirim, 2004), *Cicer arietinum* (Wani and Anis, 2001), *Vigna mungo* (Misra *et al.*, 2001), *Helianthus annuus* (Elangovan, 2001) *Cajanus cajan* (Ravikesavan *et al.*, 2001), *Sesame indicum* (Mensah *et al.*, 2007), *Guizotia abyssinica* (Misra, 2001). These reports show that mutagenesis is a potential tool to be employed for crop improvement.

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 programmes throughout the world has led to the official release of more than 2700 plant mutant varieties (FAO 2009). The present work aimed to investigate the growth responses and the yield of the African Long Pepper (ALP) to different doses of Fast Neutron Irradiation (FNI).

MATERIALS AND METHODS

Description of African Long Pepper

Medium-sized annual plant with a long pointed and pendant fruits with hot taste; it produces one pedicel per node.

Fifty fresh fruits of ALP accessions were bought from a local farmer in Minna (North Central geopolitical zone of Nigeria, found within longitude 6°34' East and latitude 9°36' North), Niger State, Nigeria. The fruits were kept in a clean polythene bag. The accessions were identified as *Capsicum annum* var. *abbreviatum* Fingerh using taxonomic aid provided by Simmonds (1976), as well as morphological descriptions of Hutchinson and Dalziel (1963), Schippers (2000) and Abdullahi *et al.*, (2003). Each fruit of the ALP accessions was cut open; the seeds removed, and separately sun-dried for 8 h. The sun-dried seeds were tested for viability using the floatation method before FNI treatment.

The dry seeds of *Capsicum* were irradiated at the Centre for Energy and Research Training (CERT), Ahmadu Bello University, Zaria with FNI using an Americium-Beryllium source with a flux of 1.5×10^{6} n cm^{-2} s^{-1} for five different irradiation exposure periods (IEPs): 0, 30, 60, 90, and 120 min. The equipment used was a Miniature Neutron Source Reactor (MNSR) designed by the China Institute of Atomic Energy (CIAE) and licensed to operate at a maximum power of 31 kW (Sar, 2005).

Treated seeds (100 from each treatment) were then planted in nursery trays to obtain seedlings, which were transplanted into 3.5 litres plastic pots containing garden soil, at a rate of three seedlings/pot, after 4 weeks in the nursery. No fertilizer was applied although, when the crop began to flower, an insecticide was applied to prevent insect-borne diseases. The planted seeds were watered once daily between 5.00-6.30 pm using bore-hole water. Each treatment was replicated four times, using a completely randomized design (CRD).

Data were collected from 15 plants for each accession for germination percentage, number of leaves/plant at maturity, height of plant at maturity (number of days to 50% flowering) and yield/plant in each M_1 (M = first filial mutant) generation. Data was analyzed using analysis of variance (ANOVA) and Least Significant Difference test was used to separate the means with significant differences detected at $P = 0.05$. Pearson's correlation analysis was used to find the relationship between treatments and selected parameters.

RESULTS AND DISCUSSION

There was a negative strong coefficient of correlation between irradiation period and seed survival percentage in MN/SH/001(Table 1), implying that as irradiation time increased, percentage survival decreased. Wide variation was observed in plant height, number of leaves/plant, fruits/plant, and seeds/fruit, and weight, length and width of fruits for the ALP accessions (Table 2). FNI is capable of producing significant changes in the morphological and yield parameters of the pepper plant. Similar effects of ionizing radiation on reproductive and other yield parameters has been reported for tomato exposed to Sodium azide with a concentration between 1 and 4 mM (Adamu and Aliyu, 2007) and also for Okra exposed to Gamma irradiation doses between 300 and 500 Gray (Hegazi and Hamideldin, 2010). Asmahan and Nada (2006), Fahad (2009) and Hegazi and Hamideldin (2010) reported that an increase in irradiation dose tended to increase certain morphological traits such as plant height.

FNI for 120 min could effectively induce viable and useful mutations in pepper yield parameters. A similar result was reported by Reddy and Smith (1978) and Adamu *et al.* (2004), who reported that obtaining mutations in the crops they studied (*Sorghum bicolor* and *Lycopersicon esculentum*, respectively) using ionizing radiation were dose dependent.

All the plants produced from the non-irradiated seeds which served as the control produced normal leaves which had pointed apices and entire margin (Fig. A). However, this was not the case among the ALP plants whose seeds were irradiated. Leaf irregularities such as leaves with invaginated or inverted margins, or with a blunt or bifurcated apex, or leaves that turned bifoliage were observed. These observed leaf morphological abnormalities are indications that FNI affected the plants negatively. Shah *et al.* (2008), Khan and Aslam (1982) and Islam *et al.* (1994) reported similar leaf morphological abnormalities in *Crotalaria saltiana* and *C. juncea* treated with ionizing radiation. Low genetic variability for major characters is a limiting factor for the improvement of a crop but induced mutations can provide an additional source of variability for quantitative and qualitatively inherited traits in a number of crop plants. FNI can be used to increase selected growth and yield characters and induce beneficial variability in peppers which can be incorporated in conventional breeding for the improvement of the crop.

Table 1: Correlation (r) between the treatments and percentage of seeds that germinated per 100 seeds sown for three pepper (*Capsicum* spp.) accessions.

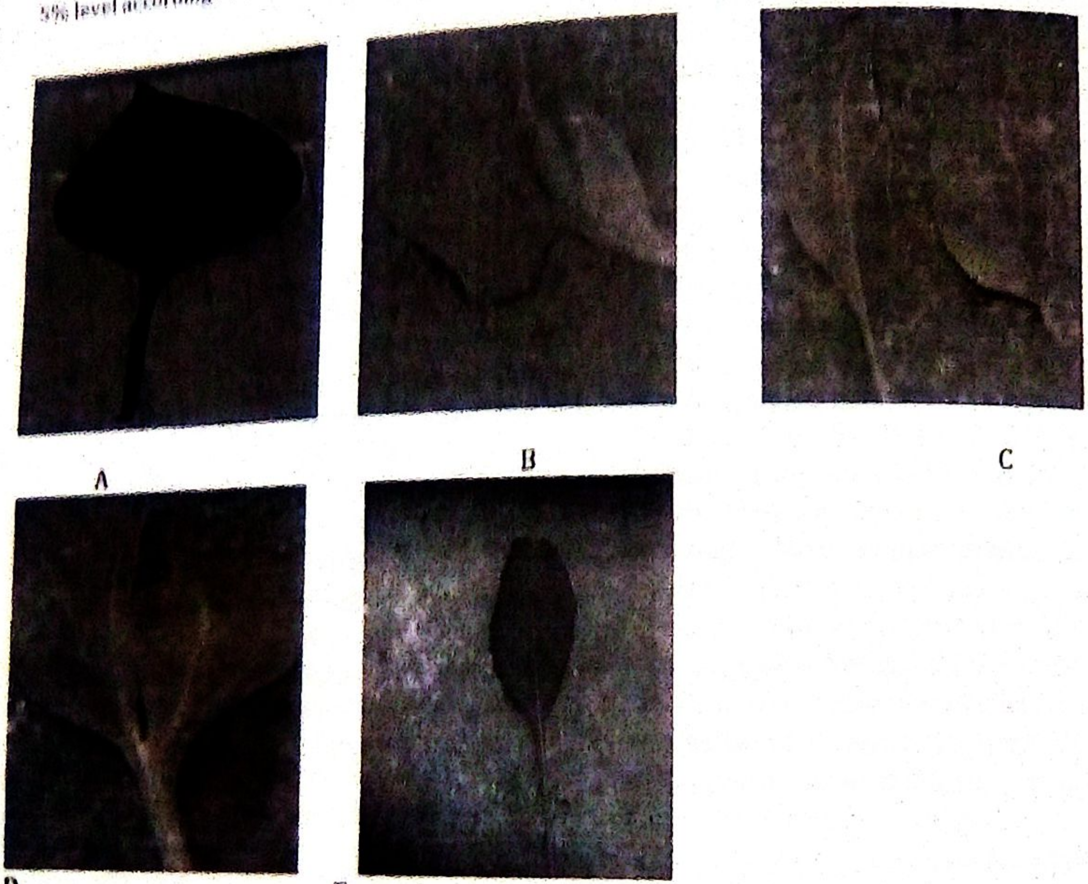
	ALP/%
Treatments	100
Control	50
30 min	51
60 min	51
90 min	37
120 min	-0.8156
R	

ALP: African Long Pepper

Table 2: LSD of the effects of Fast neutron irradiation on morphological and yield traits of ALP accessions

Characters	Productivity in ALP during the irradiation periods (min) 0	30	60	90	120
ALP					
Plant height (cm)	44.20 ± 5.19 a	45.27 ± 11.52 a	52.86 ± 4.93 ab	50.23 ± 14.13 ab	59.93 ± 6.00 b
Number of leaves/plant	120.93 ± 10.37 a	133.70 ± 44.61 a	173.00 ± 36.45 a	161.80 ± 62.46 a	230.80 ± 32.78 b
Number of fruits/plant	8.00 ± 2.48 a	15.30 ± 4.90 b	14.80 ± 3.79 b	14.30 ± 4.99 b	15.80 ± 4.94 b
Number of seeds/fruit	102.00 ± 18.21 a	105.00 ± 21.65 ab	108.10 ± 22.20 ab	110.30 ± 23.77 ab	125.80 ± 0.45 b
Length of fruit (cm)	7.26 ± 1.41 a	7.54 ± 1.70 a	6.94 ± 1.50 a	7.67 ± 1.49 a	8.20 ± 1.71 a
Width of fruit (cm)	1.93 ± 0.29 a	1.97 ± 0.21 abc	1.90 ± 0.26 ab	2.15 ± 0.18 bc	2.28 ± 0.45 c
Weight of fruit (g)	7.71 ± 0.67 a	8.40 ± 2.01 a	8.70 ± 1.84 a	9.10 ± 1.10 ab	10.2 ± 1.48 b

Values are mean ± SD. Values followed by the same letter(s) within the same row do not statistically differ at the 5% level according to LSD



A B C D E

Plate 1: A. Normal leaf of *C annum var accuminatum* B. A leaf with another leafy outgrow at the petiole (90 min IEP) **C. Leaves showing invaginated margins (120 min IEP) D.** The leaf that turned bifoliage (30 min IEP) **E.** Leaf **with bifurcated apex (60 min IEP).**

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