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Research Paper

Radiation induced polygenic mutation in two common Nigerian sesame (*Sesamum indicum* L.) cultivars

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Abstract. In order to study the level of tolerance of Sesame (*Sesamum indicum* L.) to Fast Neutron Irradiation (FNI) as well as induction of valuable mutants, two sesame cultivars (Ex-Sudan and Kenana-4) were exposed to FNI from an Americium Beryllium source with a flux of 1.5×10^4 $ncm^{-2}s^{-1}$. Seeds of Ex-Sudan and Kenana-4 were irradiated with 4, 8, 12 and 16 µSv doses of FNI before they were grown to maturity, alongside their respective controls (0 µSv dose of FNI). The parameters investigated include number of flowers per plant, number of capsules per plant, length of capsule, weight per capsule, number of seeds per capsule, percentage flowering and oil content. No significant differences ($P > 0.05$) were observed for all the yield parameters of sesame plants after exposure of seeds to different doses of FNI except for Length of capsule, weight of capsule and number of seeds per capsule in Ex-Sudan and weight of capsule in Kenana-4. Similarly, the two varieties showed significant differences in oil content ($P \leq 0.01$) at different doses of FNI. Even though none of the correlation coefficients were significant, they were generally positive in Ex-Sudan and negative in Kenana-4 suggesting that the two varieties respond to FNI in different ways. 12 and 16 µSv were the most potent dose to induce viable mutant in Sesame especially in Ex-Sudan accession since it resulted in better yield parameters. Therefore FNI may serve as a valuable tool for the improvement of Sesame.

Keywords: Fast neutron irradiation, mutants, Ex-Sudan, Kenana-4, yield parameters, improvement.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is an ancient oil crop considered to be still at early stage in breeding. There are different types of sesame produced in Nigeria, the white raw seeds which are used in bakery industries, the brown/mixed seeds which are primarily oil grade seeds. The oil is used locally for cooking as well as for some medicinal purposes such as the treatment of ulcers and burns. The stem and the oil extracts are equally used in making local soups (Falusi and Salako, 2003). It is an ancient oil crop that has been referred to as the 'Queen of oilseeds' by the virtue of its high quality oil (Salako and Falusi, 2001). Sesame belongs to the *Pedaliaceae* family, which contains 60 species organised into 16 genera (Ashir, 1998). The chromosome number of the cultivated sesame was reported as 2n = 26 (Toan et al., 2009). The crop has early origins in East Africa and in India (Bedigian, 2003). Today, India and China are the world's largest producers of sesame, followed by Myanmar, Sudan, Uganda, Nigeria, Pakistan, Tanzania, Ethiopia, Guatemala and Turkey (Toan et al., 2010). World production fluctuates due to local economic, crop production disturbance and weather conditions. Although sesame seeds are used as an ingredient in many different food supplies, a major part of the sesame seed production is processed into oil and meal (Morris, 2009). Sesame oil is, as mentioned before, an excellent vegetable oil because of its high contents of antioxidants such as sesamin, sesamol and sesamolin and its fatty acid composition (Suja et al., 2004). The antioxidants make the oil very stable and it has therefore a long shelf life (Suja et al., 2004). The high levels of unsaturated (UFA) and polyunsaturated fatty acids (PUFAs) increase the quality of the oil for human consumption (Nupur et al., 2010). Moreover, high level of PUFAs in sesame oil is claimed to reduce blood cholesterol, high blood pressure and play an important role in preventing atherosclerosis, heart diseases and cancers (Hibasami et al., 2000; Miyahara et al., 2001).

The fact that sesame is a crop of mainly developing countries with limited available research funds for long term breeding programmes resulted in very few breeding efforts in research stations. Furthermore, sesame is not a mandate crop of any of the international agriculture research centres (IAEA, 2001). The current uses to which sesame have been put into has led to increased demand of the crop; however, efforts are now gearing towards improving the genetic make-up of the available cultivars in Nigeria. This may be achieved through plant breeding and selection made possible by radiation induced polygenic characters that will eventually be sought for the improvement of the crop.

Mutations are known to enhance the genetic variability of crop plants as the variability at species level has reached the ceiling due to high breeding intensity and rapid erosion of genetic resources (Poornananda and Hosakatte, 2009). Mutation breeding has played a productive role in sustainable agriculture (Larik and Jamro, 1993) as it is a supplementary approach for crop improvement which increases unselected genetic variability for practical breeding application. It has been found that irradiation of seeds increases mutation frequency, promote gene recombination and widen the mutation spectrum (Micke, 1996). Beside the vital role in plant breeding programs, a new role of induced mutations in releasing of gene silencing in transgenic plants has been reported (Bhat et al., 1999). Daudu and Falusi (2011) and Falusi et al. (2012), exposed fresh fruit of Nigerian pepper varieties to Fast Neutron Irradiation (FNI) for different periods; they concluded that FNI could effectively induce viable and useful mutations in pepper yield parameters.

The present study was designed to compare relative effectiveness of FNI for inducing improvement in yield and yield components of some Nigerian sesame cultivars. The study also discusses the magnitude of induced changes with particular references to genetic selection parameters of yield and yield components.

MATERIALS AND METHODS

Collection and FNI treatment of sesame seeds

Seeds of two varieties of sesame (Ex-Sudan and Kenana-4) were obtained from the National Cereal Research Institute (NCRI) Baddegi, Niger State, Nigeria.

Seeds of each variety were divided into 5 groups. The first group was not exposed to FNI and served as the control, while the remaining four groups were irradiated with fast neutrons for 30, 60, 90 and 120 min (resulting in 4, 8, 12 and 16 µSv, respectively) at the Centre for Energy and Research Training (CERT), Ahmadu Bello University, Zaria, Kaduna State, Nigeria. 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).

Experimental design

Field experiments were conducted during the 2012 rainy season between May and August in the Experimental Garden, Federal University of Technology, Minna, Niger State, Nigeria. The experimental design used was a randomized block design with 30 pots per block. The experiment was replicated four times, with a total of 120 pots. Ten seeds were planted per pot (that is, 5 per hole in each pot). Three weeks after planting, each pot was thinned to two plants per pot. A total of 8 pots for each treatment combination were used.

Soil analysis

The physical and chemical properties of the soil used were determined using the procedures adopted by International Institute for Tropical Agriculture (IITA) Ibadan, Nigeria and the result is shown in Table 1.

Yield parameters

The percentage flowering 45 days after planting (for each treatment) was taking as number of plants bearing flower over the total number of the treated plant with a given dose. The length of capsule, number of seeds per capsule, number of capsules per plant and weight per capsule were taken at the maturity and the oil content of the seeds from each treatment.

Data analysis

The results of this research were subjected to analysis of variance (ANOVA) to show whether there were significant differences among the yield parameters. Duncan Multiple Range Test (DMRT) was used to separate the means. The Pearson's correlation was used to show relationships between the irradiation doses and the parameters.

RESULTS

The results obtained for all the yield parameters showed an interesting variation between and within the varieties

Table 1. Some physical and chemical properties of the soil used.

P^H	OC	OM	TN	Exchangeable cations (Cmol/kg)				EA (Cmol/kg)	CEC (Cmol/kg)	Sand (%)	Silt (%)	Clay (%)
				Na	K	Ca	Mg					
6.72	1.63	2.84	0.1	0.133	0.153	5.936	4.117	0.18	10.52	82.52	10.28	7.2

OC = Organic carbon, OM = Organic Matter, TN = Total Nitrogen, EA = Exchange acidity, CEC = Cation Exchange Capacity.

Table 2. The yield parameters of the two varieties at different doses of FNI.

Treatment combination (µSv)	Number of flower/plant	Number of capsule/plant	Length of capsule (cm)	Weight of capsule (g)	Number of seeds per capsule
Ex-Sudan					
0	30.00 ± 12.63[a]	34.00 ± 16.70[a]	2.35 ± 0.17[bc]	0.28 ± 0.05[bc]	52.00 ± 9.33[b]
4	31.00 ± 10.93[a]	36.00 ± 20.28[a]	2.49 ± 0.27[b]	0.23 ± 0.05[c]	47.00 ± 1.83[b]
8	27.00 ± 10.03[a]	35.00 ± 16.67[a]	2.53 ± 0.20[a]	0.30 ± 0.08[bc]	50.00 ± 7.50[b]
12	34.00 ± 27.49[a]	46.00 ± 22.41[a]	2.42 ± 0.26[b]	0.31 ± 0.09[b]	53.00 ± 7.76[ab]
16	24.00 ± 9.90[a]	30.00 ± 11.37[a]	2.55 ± 0.16[a]	0.32 ± 0.06[a]	59.00 ± 4.89[a]
Kenana-4					
0	30.00 ± 16.24[a]	34.00 ± 6.40[a]	2.37 ± 0.37[bc]	0.46 ± 0.11[a]	55.00 ± 12.04[a]
4	31.00 ± 18.58[a]	36.00 ± 17.97[a]	2.49 ± 0.21[ab]	0.23 ± 0.05[bc]	49.00 ± 8.65[a]
8	26.00 ± 12.12[a]	35.00 ± 13.33[a]	2.31 ± 0.21[b]	0.20 ± 0.06[c]	52.00 ± 7.73[a]
12	31.00 ± 9.45[a]	46.00 ± 16.63[a]	2.55 ± 0.23[a]	0.29 ± 0.05[b]	51.00 ± 5.43[a]
16	21.00 ± 5.53[a]	30.00 ± 5.36[a]	2.27 ± 0.33[c]	0.15 ± 0.03[d]	47.00 ± 5.53[a]

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

(Table 2).

Number of flower/plant

In Ex-Sudan, the least and the highest number of flower/plant (24.00 and 34.00) were due to 16 and 12 µSv respectively; these values were statistically the same ($p > 0.05$) and were not different statistically from all other treatments including the control.

In Kenana-4 also, similar trend was observed where the least number of flower per plant (21.00) was due to 16 µSv while the highest (31.00) were due to 4 and 2 µSv. These values are statistically the same and are not statistically different from all the other accessions.

Number of capsule/plant

In Ex-Sudan, the maximum and the minimum number of capsule/plant (46.00 and 30.00) respectively were due to 12 and 16 µSv; these values are statistically the same and significantly the same with the other treatments.

In Kenana-4 also, the maximum and the minimum number of capsule/plant (46.00 and 30.00) respectively were due to 12 and 16 µSv; these values are statistically the same and not significantly different from the other treatments.

Length of capsule (cm)

In Ex-Sudan, 16 µSv produced the highest number of capsule (2.55 cm); this value was significantly different ($p < 0.05$) from the control (0, 4 and 12 µSv) but significantly the same with 8 µSv. The least value (2.35) here was due to the control, and the value is significantly different from all the other treatments.

In Kenana-4 however, 12 µSv produced the highest length of capsule (2.55 cm), this value was significantly different from all other the other treatments ($p < 0.05$). The least value (2.27 cm) was due to 16 µSv and the value is statistically different ($p < 0.05$) from the control and other treatments.

Weight of capsule (g)

Ex-Sudan showed a fascinating trend in term of weight of capsule, the highest weight (0.32 g) was due to 16 µSv and the value is significantly different from all the other treatments. This is followed by 12 µSv (0.31 g), this value is also significantly different from all the other treatments. The least weight (0.28 g) was observed in the control, this value is significantly the same with 8 µSv (0.30 g) but statistically different from all the other treatments. Interestingly, in Kenana-4, the 0 µSv has the highest weight of capsule (0.46 g); this value was statistically

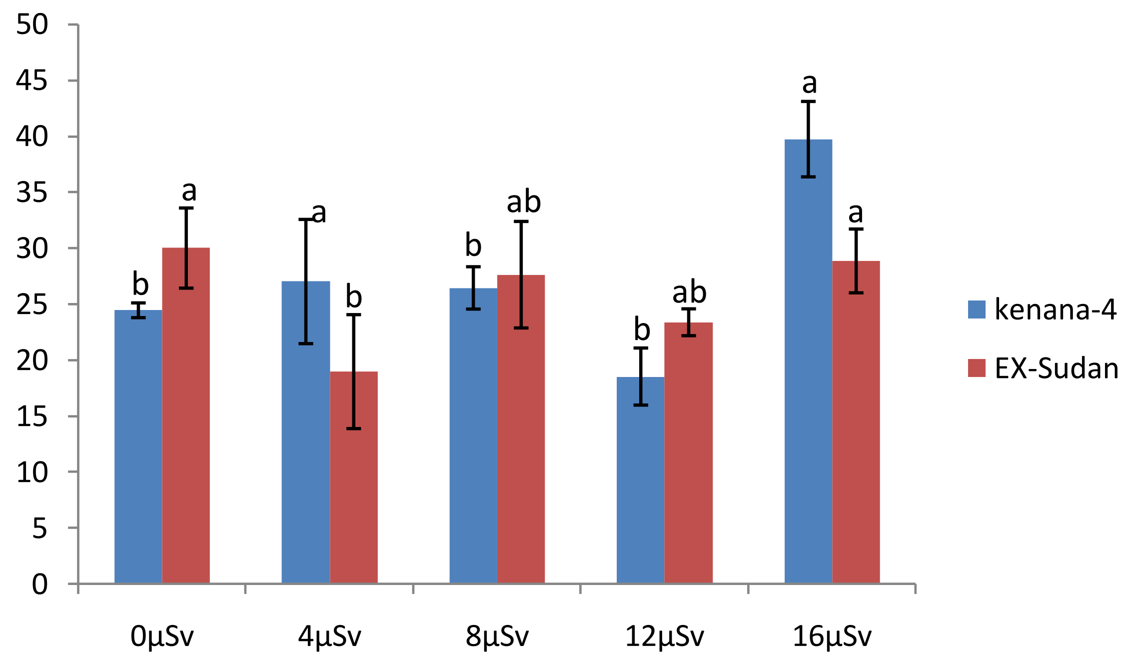

Figure 1. Percentage oil. *The bars represent mean ± SD. Bars of the same colour with the same letter are not significantly different at 0.01 level of significance.

different from all the other treatments. The 12 µSv is the next, having 0.29 g as the weight of capsule; this value was also significantly different from all the other treatments.

Number of seeds per capsule

In Ex-Sudan, the highest number of seeds per capsule (59.00) was due 16 µSv, this value is significantly different from all the other treatments. The 12 µSv also produced a significantly higher number of seeds per capsule (53.00); this value is statistically different from all the other treatments. However, the number of seeds per fruit produced by 0 µSv (52.00), 4 µSv (47.00), and 8 µSv (50.00) showed significantly the same results.

In Kenana-4 however, there is no significant different from the control (0 µSv) and all the other treatments; although the control has the highest value (55.00) while the 16 µSv has the lowest value (47.00).

DISCUSSION

No significant differences ($P \geq 0.05$) were observed for all the yield parameters of sesame plants after exposure of seeds to different doses of FNI except for length of capsule, weight of capsule and number of seeds per capsule in Ex-Sudan and weight of capsule in E-8 that were significantly different at $P \leq 0.05$ (Table 2 and Figure 1). Similarly, the two varieties showed significant differences in percentage oil at $P \leq 0.01$ (Figure 2). The variations observed in some of the parameters studied are in agreement with the reported by Falusi et al. (2012a, b) on *Capsicum annum* (peppers), Adamu and Aliyu (2007) and Asmahan and Nada (2006) on *Lycopersicon esculentum* (tomato), and by Hegazi and Hamideldin (2010) on *Abelmoschus esculentus* (okra). However, the statistical uniformity observed in other parameters could be associated to high irradiation tolerance of sesame as reported by (IAEA, 1994). The correlations between the various parameters and the irradiation doses indicate a general shift from the controls though they are not significantly different from one another (Table 3). The positive correlations obtained are in line with Falusi et al. (2012a). They reported positive correlations between the irradiation exposure period with certain morphological and yield traits of *Capsicum*. The negative correlations observed with respect to some of the parameters imply that as the irradiation level increases, these parameters decrease. This is close to the findings of Muhammad et al. (2003) who reported that seedling emergence, panicle fertility and grain yield declined with increasing dose level in all the varieties of Basmati rice studied and Daudu et al. (2012) who reported negative strong correlation in seed survival percentage in African Long Pepper exposed to Fast Neutron Irradiation. The 12 and 16 µSv seemed to be the most potent dose to induce polygenic character in Ex-Sudan as these doses tend to favour all the yield parameters tested. This present result is similar to that of Muhammad et al. (2005) on *Cicerarientinum* and Falusi et al. (2012b) on *Capsicum annuum*. In contrast, in Kenana-4, the 16 µSv did not favour the yield parameters

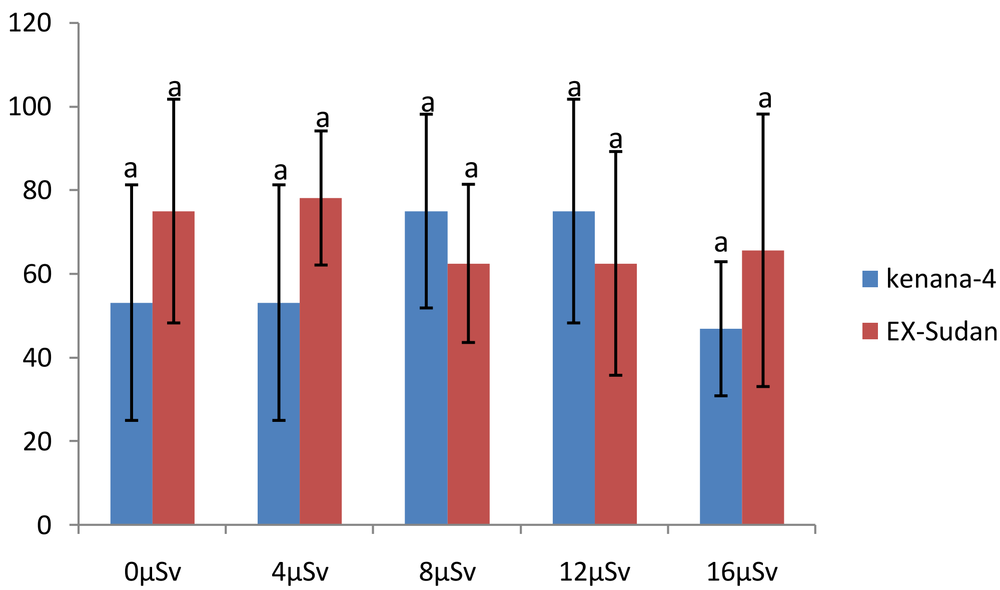

Figure 2. Flowering percentage. The bars represent mean ± SD. Bars of the same colour with the same letter are not significantly different at 0.05 level of significance.

Table 3. Coefficient of correlations (r) of the various yield parameters with the irradiation doses.

Variety	NOF/P	NOC/P	LOC (cm)	WPC (g)	NOS/C	Oil (%)	FLW (%)
Kenana-4	-0.618^{ns}	-0.745^{ns}	-0.186^{ns}	-0.734^{ns}	-0.732^{ns}	0.450 ^{ns}	-0.707 ^{ns}
Ex-Sudan	-0.344^{ns}	0.047 ^{ns}	0.632 ^{ns}	0.714 ^{ns}	0.716 ^{ns}	0.073 ^{ns}	-0.707 ^{ns}

NOF/P = Number of flower/plant, NOC/P = Number of capsule/plant, LOC = Length of capsule, WPC = Weight/capsule, NOS/C=Number of seed/capsule, FLW%= Flowering percentage. Ns = Not significant.

but the 12 µSv dose showed good results in some of the yield parameters (length of capsule and number of capsule/plant).

The variation in the strength of correlation coefficients among the varieties might be due to fact that the radio-sensitivity varies among sesame cultivars and that the seeds are highly resistant to irradiation as reported by Pathirana and Subasingbe (1993) and IAEA (1994). The dose generally did not show much differences on their effects on the cultivars, however the correlations showed that Ex-sudan is more sensitive than Kenana-4. Therefore, Ex-sudan can be recommended as the adequate variety and 12 and 16 µSv doses for irradiation breeders for further research.

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