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PRELIMINARY STUDIES ON EFFECTS OF GAMMA RAY ON SEED RETENTION INDICES OF THREE NIGERIAN SESAME (*SESAMUM INDICUM* L.) VARIETIES

Muhammad Liman MUHAMMAD[1*], Olamide Ahmed FALUSI[1], Mathew Omoniyi ADEBOLA[1], Onyedi David OYEDUM[2], Oladipopu Abdulazeez Yusuf DAUDU[1], Gado Adamu AISHATU[1]

Abstract: In an attempt to improve sesame for reduction of seed loss due to shattering of capsule at harvest, the seeds of three varieties of sesame (NCRIBEN-04E, NCRIBEN-01M and NCRIBEN-03L) were treated with five different doses (0, 250, 350, 450 and 550 Gy) of gamma irradiation; 0 Gy being the control. All the treatments including the controls, were grown and monitored till maturity. The seed retention power of the treatments were assessed. From the results, the treatment due to 550 Gy had highest score (6) for both NCRIBEN-04E and NCRIBEN-01M and was categorized as non-shattering (NSH) type. All other treatments were categorized as shattering (SHA) type. Similarly all the treatments from NCRIBEN-03L were categorized as SHA with treatment due to 250 Gy having highest score (5). The three varieties showed positive correlations between the seed/capsule in upright (U) and seed/capsule in inverted (I) position but NCRIBEN-01M was not significant (r = 0.650). The NCRIBEN-04E showed negative correlation between U and length of suture (L) and I and L (r = -0.570 and -0.358 respectively). This result has shown that the dose 550 Gy seems to be promising in generating mutants with high resistance to capsule shattering in sesame. There is need to advance these mutants to M_2 and M_3 generations to ascertain this seed retention capacity.

Keywords: Gamma Irradiation, inverted, non-shattering, resistance, shattering, upright.

Introduction

Sesame (*Sesamum indicum* L.) is a very ancient crop and one of the earliest domesticated oil crops in the world [ASHRI, 2007]. According to KUMAR & YADAV (2010), some archeological findings have supported that sesame is one of the most important crops in the world. It is known in Vietnam as the king of oil seeds due to the high oil content of its seed which ranged from 50-60% [TOAN & al. 2010]. Sesame is an important source of cheap vegetable oil and proteins, good source of natural oxidants (sesamin and sesamolin) which are unique for sesame and present in the oil [ASHRI, 2007].

The majority of the world's sesame (probably over 99%) have shattering capsule, and most of the harvest is manual [LANGHAM, 2001]. Shattering of capsules at maturity has posed serious problem in sesame production worldwide [ASHRI, 1994] and can account for up to 50% seed loss during harvest. Indehiscent capsules and superior architecture are amongst the basic objectives laid down for sesame breeding and the degree of dehiscence is a cultivar characteristic and is of great importance for mechanized harvesting [YADAVA & al. 2012; VAN ZANTEN, 2001]. This is achievable through mutation breeding [VAN

[1] Department of Biological Sciences, Federal University of Technology, Minna – Nigeria.
[2] Department of Physics, Federal University of Technology, Minna – Nigeria.
[*] Corresponding author. E-mail: ml.muhd@futminna.edu.ng

ZANTEN, 2001]. Developing mutants with shattering resistance will help curtail seed loss at harvest.

Irradiations have been routinely used in developing plant varieties with agriculturally and economically important traits [BOUREIMA & al. 2009; VAIZOĞULLAR & KARA, 2016]. Gamma rays has been reported to be very effective and economical among all the physical mutagens for crop improvement [VAIZOĞULLAR & KARA, 2016]. Thus this study designed to assess the effects of gamma irradiation on seed retention power of three varieties of Sesame is indeed a strategy in its improvement through mutation breeding programmes.

Higher yields, improved plant architecture, adapted crop duration, resistance to diseases and pests and indehiscent capsules are the major objectives in this crop. In an attempt to test the hypothesis that "closed capsule mutants are inducible with efficient mutagenesis and screening large populations", DIOUF & al. (2010) treated three varieties of sesame with two different doses (300 and 400 Gy) of gamma irradiation. They reported in M_2 and M_3 that at least one closed capsule mutant could be induced from each of the three genetic backgrounds of sesame tested. Also ÇAĞIRGAN (2007), irradiated four varieties of sesame with gamma rays (150-750 Gy) and evaluated the M_1 and M_2 populations for some breeding objectives of sesame. Mutants with closed capsule, determinate growth habit, wilting tolerance, chlorophyll deficiency, hairy capsule and multicarpelate, sterility as well as quantitative traits such as flowering time, capsule size, and plant height were reported. According to VAN ZANTEN (2001), 142 mutants from different national sesame improvement programmes have been registered all of which possessed agronomically useful characters. Most mutants (76) were selected for capsule related characters such as, 3-capsules-per-leaf-axil, shape, size, non/semi shattering, and capsule density on the stem.

Materials and methods

Collection of Sesame seeds and irradiation of the seeds

The seed collection and irradiation were done following the protocol of MUHAMMAD & al. (2013) as described by FALUSI & al. (2015). The seeds of three varieties of sesame (NCRIBEN-04E, NCRIBEN-01M and NCRIBEN-03L) were obtained from the National Cereal Research Institute (NCRI) Baddegi, Niger State, Nigeria. Seeds of each variety were divided into 5 groups. Group I was not exposed to gamma rays and served as the control. The remaining four groups were irradiated with gamma rays (from Co-60 source) at 250, 350, 450 and 550 Gy at the Centre for Energy and Research Training (CERT), Ahmadu Bello University, Zaria, Kaduna State, Nigeria.

Seed viability and experimental design

The seed viability test was done before and after irradiation using germination test method as described by STEPHEN (2009).

The pot experiments were conducted during the 2016 rainy season (August-November) at the Biological Garden, Federal University of Technology, Minna, Niger State, Nigeria. A randomized block design with 60 pots/block was used. The experiment was replicated three (3) times, with a total of 180 pots. Five seeds were planted per pot. Three weeks after planting, each pot was thinned to four plants/pot and 12 pots/treatment combination were used.

Assessment of Capsule Shattering

Assessment of shattering resistance was done following the pattern of MANEEKAO & al. (2001) with little modification. For each treatment, the number of seeds per mature capsule (brown capsule when it is upright), the number of seeds left per capsule when it is inverted and the size of opening of the capsule were determined as described in Tab. 1. To get number of seeds per capsule in upright position, a mature capsule was plucked gently and then placed in an inverted position with a sheet of paper underneath. The sheet was to hold any seed that escaped from the capsule when inverted. The number of seeds per capsule in inverted position was calculated as the number of seeds left in the capsule after inverting the capsule. The number of seeds per capsule in upright position was number of seeds in inverted position plus the seeds that fall on the sheet as indicated by the formula below.

$$U = I + E$$

Where U = number of seeds in upright position; I = number of seeds in an inverted position; E = seed that escaped during inversion of the capsule

The shatter resistance was classified by using the concept of LANGHAM as described by WONGYAI & al. (2001) with modifications. The method for measuring shatter resistance on a 0–8 scale is shown in Tab. 1. The modified scale of WONGYAI & al. (2001) used for rating the plants is shown in Tab. 2.

Tab. 1. Capsule Shattering resistance scale for sesame

Scale	U (%)	I (%)	L (%)
0	< 10	< 10	0.0–10.0
1	10–20	10–20	11.0–20.0
2	21–30	21–30	21.0–30.0
3	31–40	31–40	31.0–40.0
4	41–50	41–50	41.0–50.0
5	51–60	51–60	51.0–60.0
6	61–70	61–70	61.0–70.0
7	71–80	71–80	71.0–80.0
8	> 80	> 80	80.0–100.0

U = the amount of the seed in the capsule in upright (as % of total seeds set)
I = the amount of seed in the capsule in inverted position (as % of total seeds set)
L = Length of the capsule opening (as % total pod length)

Tab. 2. Characteristics and Scale rating for Seed retention

Seed retained in inverted position (I)	Name of category	Abbreviation
Less than 10%	Super shattering	SUS
10%–50%	Shattering	SHA
50%–70%	Non-shattering	NSH
70%–90%	Direct combine	DC

Data analysis

The length of capsule opening, seed/capsule in upright and inverted position were converted to simple percentages of the total capsule length and total seed set respectively. All the parameters in percentages were transformed using arcsine transformation and then subjected to linear correlation to show if the relationship exist between I, U and L.

Results

Mutants with closed capsules and with shattering capsule are presented in Plate I (A and B respectively). All the treatments from Variety NCRIBEN-04E retained more than 50% of the total when in upright position (U), except the control which retained less than 50% (42.71%) of total seeds (Tab. 3). When the capsules were inverted (I), only the treatment with highest dose (550 Gy) retained more than 50% (63.99%) of the total seeds and was scored 6 and classified as non-shattering type, the other treatments retained less than 50% and were classified as shattering type (Tab. 3). Similarly, all the treatments from NCRIBEN-01M and NCRIBEN-03L, retained more than 50% of total seeds when in upright position. However, only 3 treatments from 01M (0, 350, and 550 Gy) and one (250 Gy) retained more than 50% of the total seeds in inverted position (Tab. 3). In terms of ranking of NCRIBEN-01M, the treatment due to 550 Gy scored highest (6) and those due to 250 and 350 Gy were least scored (4). In contrary, for 03L, the highest score was due to 250 Gy, and 350 Gy was the least (3) (Tab. 3). The control, 350 and 550 Gy treatments were classified as non-shattering (NSH), while others were shattering (SHA) (Tab. 3). All treatments of NCRIBEN-03L were classified as shattering type, except the treatment due to 250 Gy which was non-shattering (Tab. 3). The three varieties showed positive correlations (between U and I) but that of NCRIBEN-01M was not significant ($r = 0.650$), where NCRIBEN-03L was significantly correlated, NCRIBEN-04E was highly significantly correlated (Tab. 4). The NCRIBEN-04E showed negative correlation between U and length of suture (L) and I and L ($r = -0.570$ and -0.358 respectively); although they are not significantly correlated.

Discussion

The dose range 350-550 Gy generated mutants which were categorized as non-shattering type, for NCRIBEN-04E and NCRIBEN-01M. This implies that the dose range is capable of inducing mutants with capsule shattering resistance. This is similar to the report of ÇAĞIRGAN (2007) and DIOUF & al. (2010) on sesame. They opined that 300-400 Gy dose range of gamma rays is effective enough to induce closed capsule mutants from any sesame background. VAN ZANTEN (2001) had also reported that for gamma rays, doses ranging from 150-800 Gy proved successful in inducing useful mutations and that gamma ray (300-750 Gy) induced mutants with indehiscent (closed) capsules in sesame. The ability of gamma irradiation to induce indehiscent capsule trait could be due to the bombardments caused by the irradiation, thereby changing the genetic make-up of the crop.

The non-significant correlation of (U&L) and (I&L) for the three varieties implies that the seed retention in upright and inverted positions do not necessarily depend on the length of suture. This might be due to presence of membrane sheet which covers the locules thereby preventing direct exposure of the seeds.

Tab. 3. Assessment of seed retention power of the treatments

Variety	Seed in Upright position (U) (%)	Seed in inverted position (I) (%)	Length of split (%)	Score	Category
NCRIBEN-04E					
0 Gy	42.71	20.97	32.97	2	SHA
250	52.07	30.06	34.78	3	SHA
350	60.31	28.25	29.56	2	SHA
450	60.28	42.59	29.40	4	SHA
550	73.15	63.99	30.95	6	NSH
NCRIBEN-01M					
0 (Gy)	69.12	50.54	32.11	5	NSH
250	69.57	47.60	33.11	4	SHA
350	74.37	51.96	36.26	5	NSH
450	68.70	41.48	28.76	4	SHA
550	72.62	62.18	31.68	6	NSH
NCRIBEN-03L					
0 (Gy)	80.19	49.93	33.92	4	SHA
250	78.73	57.84	34.50	5	NSH
350	66.20	36.68	32.21	3	SHA
450	74.15	46.16	31.87	4	SHA
550	72.16	45.78	31.55	4	SHA

*SHA = Shattering, NSH = Non-shattering

Tab. 4. Linear correlation among the certain parameters of the capsules

Varietal name	U&I	U&L	I& L
NCRIBEN-04E	0.903**	-0.570	-0.358
NCRIBEN-01M	0.650	0.733	0.343
NCRIBEN-03L	0.887*	0.740	0.747

*Significant difference at P< 0.05
**Highly significant difference at P< 0.05

Plate I. A. Mutant with closed capsule; B. shattering capsule

Conclusions

The dose 550 Gy seems to be effective for NCRIBEN-04E and NCRIBEN-01M in generating mutants with shattering resistance. Thus the treatments with high scores should be advanced to M_2 and M_3 for further investigation of the seeds retention capability.

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