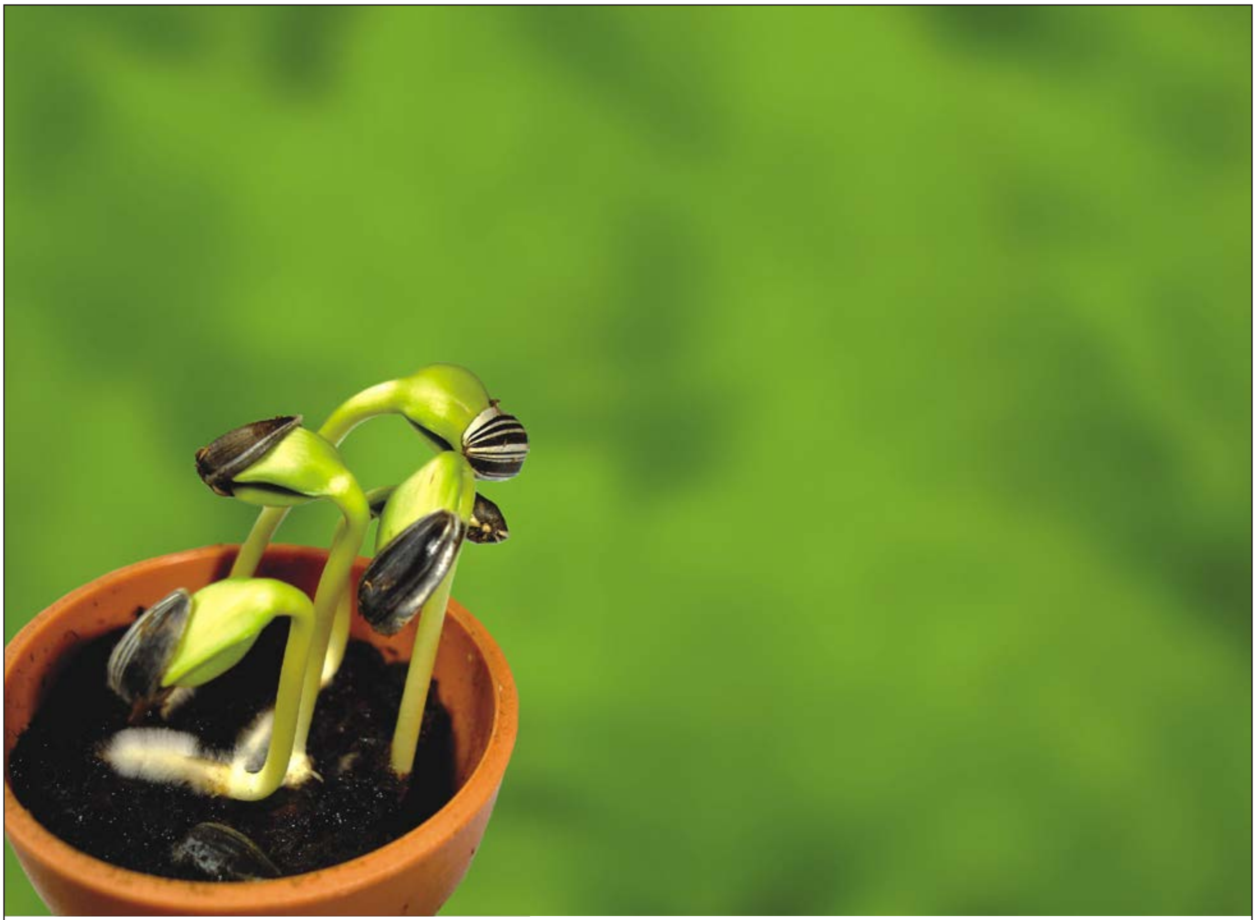

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Research Article

Induced Capsules Alteration for Improved Yield in Sesame (*Sesamum indicum* L.)

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Abstract

Objective: A study was conducted with the aim of identifying the basis at which various concentrations of colchicine improve the yield components in sesame and to investigate the basis for improved yield due to colchicines treatments in sesame. **Materials and Methods:** The seeds of three sesame varieties (Ex-Sudan, Yandev and E8) were treated with five different colchicine concentrations (including the controls) via soaking for 4 h, washed in running water and allowed to dry for 24 h. The seeds were sown in a completely randomized block design for two mutant generations (M_1 and M_2). The data obtained were analyzed using analysis of variance (ANOVA) with Duncan's multiple range test used in separating the means. **Results:** The results from the M_1 generation indicated significant increased in the number of quadruplets capsules mutants from 13.24-32.78% in Ex-Sudan, 18.58-29.80% in E8 and 19.78-30.02% in Yandev with increase in the colchicine concentrations. However, the M_2 generation also revealed significant improvements in the yield of sesame due to alteration in the habit of capsules formation among the mutants from the normal bi-capsules alternate type around a node to the quadruplet whorls per node. The percentage alteration increased with decrease in colchicine concentration (16-36% in Ex-Sudan, 15.79-31.57% in E8 and 16.67-33.33% in Yandev). **Conclusion:** It was concluded that the basis for the improvement in sesame seeds yield induced by colchicine is by the ability of the mutagen to probably rectify the homeotic gene action leading to change in capsulation habit of sesame, increasing the number of capsules/plant with subsequent increase in the size and number of seeds produced per capsule. Therefore; it recommended the use of lower colchicines concentration (0.1 mM) and variety Ex-Sudan for sesame seed yield improvements.

Key words: Capsules, colchicine, Ex-Sudan, E8, mutation, M_1 generation

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the most important world oilseed plants. It belongs to the family Pedaliaceae[1-3]. The name sesame is used in literature worldwide. It is mentioned in the old Hebrew and Egyptian scripts and the ancient Sanskrit literature. Oplinger *et al*.[4] indicated that it to be the highly prized oilseed crop in Babylon and Assyria about 4,000 years ago. It was grown primarily for its oily seeds. It is ranked as 6th most important oilseeds crops in the world[5]. The oil extracted from sesame is second in quality to the olive oil. It is used in several industrial and pharmaceutical processes as it is free from oxidative rancidity due to the presence of sesamin and sesamolin ligninans. The oil is also rich in lecithin that prevents dissolution of fats in water environment[6] as such prevents artheriosclerosis, angina pectoris and acts against aging[7], functioning sexual glands and is an excellent nutritional complement for people undergoing high mental or intellectual activity and who wants to keep up good performance levels. It is therefore used against mental or nervous exhaustion, stress, loss of memory, melancholy, nervous depression, irritability insomnia and promotes milk secretion during breast feeding[6].

Seed yield is therefore the most important attribute needed intended in sesame cultivation. However, despite all the tremendous benefits of sesame to human well being and that Nigeria was characterized as one of the world sesame producing countries; its cultivation is at subsistence level due to poor yields and lack of improved varieties that could meet the demand of the world market. Mutation (a change in genetic material of an organism) induced both in seeds and vegetatively propagated crops are of scientific and commercial interest to improve both the growth and yield parameters of economic plants. It provides raw materials for the genetic improvement of economic crops[8]. It facilitates the isolation, identification and cloning of genes which would ultimately help in designing crops with improved yield, increased stress tolerance and longer life span and reduced agronomic in puts[9]. Although various mutagens are known to induce mutation in plants, this research aimed at identifying the basis at which colchicine improves the yield of sesame.

MATERIALS AND METHODS

Study site: The Study was conducted at the botanical garden of the Department of Biological Sciences, Ahmadu Bello University, Zaria, located within the tropical guinea savanna zone of Nigeria (Lat 11^0 12'N, Long 7^0, 37'E and on alt 660 m a.s.l.).

Sources of the seeds: Seeds of three varieties of sesame: Yandev, E8 and Ex-Sudan used for this study were obtained from the Jigawa State Agricultural and Rural Development Authority (JARDA), Ringim, Jigawa State.

Treatment and experimental design: The seeds of three varieties of Sesame; Yandev, E8 and Ex-Sudan were treated each with colchicines at 5 levels (five different concentrations) including control i.e., 0.1, 0.5, 1.0 and 2.0 mM and control. The seeds were soaked in the chemical mutagen (colchicines) for 4 h, washed thoroughly and left to dry for 24 h. The seeds of each treatment were planted in plot containing two blocks 1 m by 0.5 m length and breadth respectively to raise the M_1 generation in a Completely Randomized Block Design (CRBD) in a factorial arrangement with three replications. The experiment was advanced to the M_2 generation. All cultural practices such as planting, fertilizer application, weeding and thinning as well as harvesting methodologies followed the method described on sesame cultural practices in the Kano State Agricultural and Rural Development Authority (KNARDA) crop production guide[10].

Data collection and analysis: Data were collected from number of leaves per plant, leaf area, flowering period, number of capsules per plant, length of capsules per plant, number of seeds per capsule and 1000 seeds weight. The data obtained from the altered podding habit was presented in percentage table. All the data obtained from growth and yield attributes were analyzed using analysis of variance using SAS[11] with Duncan's Multiple Range Test (DMRT) to separate the means.

RESULTS

The results obtained on the effects of different colchicine concentrations on some selected phenotypic traits of the two varieties of sesame in the M_2 generation showed the ability of the mutagen to alter the capsulation habit to whorled-capsules among the mutants instead of the normal alternate's capsules arrangement (Fig. 1-3). The highest percentage of whorled-capsule mutants in the M_1 generation (Table 1) was found in 0.1 mM concentration treated mutants (32.78% in Ex-Sudan, 29.08% in E8 and 30.08% in Yandev). The lowest number of quadruplets mutants was found in the 2.0 mM treated plants (13.24% in Ex-Sudan, 18.58% in E8 and 19.78% in Yandev).

Similarly, the same result was found in the M_2 generation (Table 2) with 36% of the mutants in Ex-Sudan, 31.57% in E8 and 33.33% in Yandev). While, the lowest percentage

Fig. 1(a-b): (a) Normal and (b) Mutated podding habit in variety Yandev

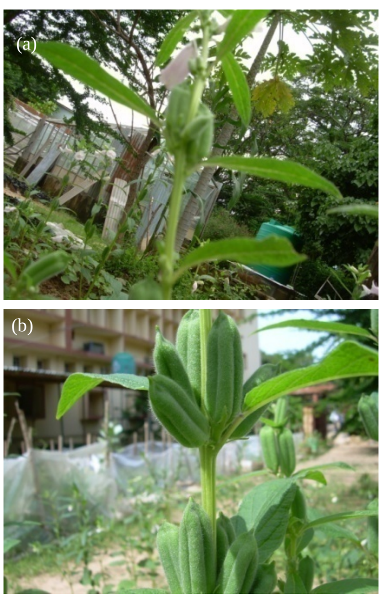

Fig. 2(a-b): (a) Normal and (b) Mutated podding habit in variety Ex-Sudan

Table 1: Percentages of M_1 generation whorled-fruits mutants induced by colchicine in sesame

Concentration (mM)	Ex-sudan	E8 (%)	Yandev (%)
0.0	-	-	-
0.1	32.78	29.08	30.02
0.5	27.97	27.48	27.06
1.0	26.01	24.86	23.14
2.0	13.24	18.58	19.78
Total	100.00	100.00	100.00

Fig. 3(a-b): (a) Normal and (b) Mutated podding habit in variety E8

Table 2: Percentages of M_2 generation whorled-fruits mutants induced by colchicine in sesame

Concentration (mM)	Ex-sudan	E8 (%)	Yandev (%)
0.0	-	-	-
0.1	36.00	31.57	33.33
0.5	28.00	26.32	25.00
1.0	20.00	26.32	25.00
2.0	16.00	15.79	16.67
Total	100.00	100.00	100.00

(Table 2) was found among 2.0 mM treated plants (16.00% in Ex-Sudan, 15.79% in E8 and 16.67% in Yandev). It was also discovered that the frequency of such whorled capsule mutants decreased with increase in the concentration of colchicine.

However, the result from the analysis of variance for the M_2 generation of sesame was presented in Table 3. The result showed highly significant difference ($p \leq 0.01$) in the effects of the mutagen on all the selected yield traits of sesame.

Furthermore, the result for the means of the mutagenic effect of colchicine on the M_2 generation yield components of sesame was presented in Table 4. The result showed that, the mutants producing 60-62 leaves per plant that are 51-53 cm^2 in size. Furthermore, the mutants are early flowering at 42 days. More so, the mutants produced 21 capsules per plant which are larger in size (2.10 cm in length) and which produced large number of seeds (43-45 seeds/capsules). Furthermore, the mutants 1000 seeds that weigh (3.35-3.4 g).

Table 3: Mean squares of the effects of different colchicine concentrations on sesame

Sources of variation	df	No. of leaves per plant	Leaf area (cm^2)	Flowering period (days)	No. of capsules	Length of capsules (cm)	No. of seeds per capsule	1000 seeds weight (g)
Blocks	2	32.17**	73765.40**	2.11^{ns}	3.10^{ns}	0.02^{ns}	78.80**	0.004^{ns}
Concentrations	4	966.21**	4416.30**	9942.50**	202.18**	0.14**	49.50**	0.27**
Error	8	0.15	293.80	1.94	1.61	0.01	0.65	0.003

ns: No significant difference, *Significant difference ($p \leq 0.05$), **Highly significant difference ($p \leq 0.01$), df: Degree of freedom

Table 4: Means for the effects of colchicine on sesame yields at M_2 generation

Variety	No. of leaves per plant	Leaf area (cm^2)	Flowering period (days)	No. of capsules	Length of capsules (cm)	No. of seeds per capsule	1000 seeds weight (g)
Ex-Sudan	60.4 ± 5.4^c	52.5 ± 4.7^b	42.2 ± 6.7^a	20.8 ± 2.4^b	2.1 ± 0.1^a	45.2 ± 1.3^a	3.40 ± 0.1^a
E8	61.9 ± 11.6^b	52.9 ± 17.1^a	42.1 ± 1.4^b	21.2 ± 7.1^a	2.1 ± 0.3^a	43.1 ± 9.4^b	3.40 ± 0.1^a
Yandev	62.2 ± 5.9^a	51.2 ± 3.7^c	42.1 ± 6.6^b	21.2 ± 1.9^a	2.1 ± 0.1^a	42.6 ± 1.04^c	3.35 ± 1.1^b

Means within the columns with the same letter(s) are not significantly different at $p \leq 0.05$

DISCUSSION

In view of the excellent possibilities to improve the quality and quantity of sesame plants, mutation induction through chemical mutagenesis was reported, which appears to fit well with the major role played by colchicines in the improvement of plants growth and yield parameters. The results obtained in this study implied that colchicines at various concentrations can improve the seed yield parameters of sesame. This was in agreement with the findings of Hoballah[12] reported significant difference in the sesame yield parameters in terms of seed yield, 1000 seeds weight, number of capsules per plant and number of branches per plant due to gamma irradiation. This seed yield improvement is due to the emergence of multiple capsules in whorls emerging from a single node (a minimum of four pods per node) instead of the normal two pods per node; thereby providing subsequent increase in the number of capsules and hence seed yields of the treated plants. The formation of whorled fruits instead of the normal double capsules per node may probably also indicate a clear manifestation of an alteration in the *Homeotic* genes due to the effect of colchicine. These structural changes induced by colchicine were probably more of evolutionary significance; since they are associated with the changes in the genetic make-ups of the cells producing such altered phenotypes. Similar finding was reported in the work of Fambrini *et al.*[13] where alteration in floral symmetry occurred in sunflower due to mutation.

Leaves attributes such as size and number were also affected by colchicines. Increased leaf area in the sesame mutants induced by different colchicines concentrations was in agreement with the findings of Maluszynski *et al.*[14] reported an increase in leaf area among *Zea mays* mutants. The increase in leaf area provides an increase in the surface area for gaseous ex-change which has considerable effect on the process of photosynthesis. Similar finding was found in the study of Duranceau *et al.*[15] reported a greater leaf mass per leaf area and enriched organic matter in the leaves of *Nicotiana sylvestris* mutants. This was also consistent with the findings of Gnanamurthy and Dhanavel[16] discovered the effects of EMS in changing the leaves attributes of cowpea (*Vigna unguiculata* L. [Walp]). The mutagen stimulated growth of the cells of the lamina causing its remarkable expansion. Thus, increase in the area of leaf of sesame has a strong relationship with the yield components. Besides the leaf area, the number of leaves produced per plant increased under different concentrations of colchicine. This finding was in agreement with that of Hoballah[12] reported increase in the number of branches among sesame mutants due to gamma irradiation.

The switch from vegetative phase to reproductive phase entails an irreversible transition in which the shoot apical meristems stop to initiate leaves but committed to form flower as reported by Fambrini *et al.*[13]. The period of anthesis and fruiting in the sesame varieties were found to be increased with increase in the concentration of colchicines. This improved earliness was in agreement with the study of Hoballah[12] reported improved earliness among the gamma irradiated mutants of sesame. This may probably be due to the tendency of the mutagen to turn on the gene responsible for inducing flowering, by making the plant to respond to environmental signals such as photoperiodism and hormonal actions as suggested by Lewis *et al.*[17]. Mutation induction for improved earliness in sesame is also in agreement with the findings of Rutger[18] reported early flowering mutants in medium grain *Japonica* cultivar; but was in contrast to that of Archana *et al.*[19] who reported increase in the number of days required for maturity due to increased doses of mutagen treatments in *Glycine max* (soyabeans).

The mean increase in the number of capsules produced per plant in sesame was in agreement with the study of Roslim *et al.*[20] who reported increase in the number of pods per plant among mungbean mutants. The size of the capsules also increases considerably to facilitate improvement in the sesame seeds yield. This was in conformity with the findings of Pathak[21] who reported increase in pods length due to gamma irradiation among M_2 cowpea mutants. This increase in size of the capsules permits a substantial increase in the surface area that accounts for the number of packages in which the seeds are produced; thereby facilitating the production of large number of seeds. Increase in number of seeds produced per pod due to colchicines treatment was similar to the study of Lonnig[22] who discovered similar result among x-rays induced mutants of pea. Xu[23] also reported increase in grain number among gamma rays irradiated mutants of wheat. Similarly, Umalkar *et al.*[24] reported induced variability in number of seeds per pod and 100 seeds weight in *C. annum* due to induced mutation sodium azide. The increase of 1000 seeds weight of sesame was due to colchicines treatment which was in line with the work of Nura *et al.*[25] who reported increase in grain weight of sesame due to cholchicine mutagenesis in sesame and false sesame.

Artificial induction of mutation through the use of colchicines improves the genetic variability in economic plants. The alkaloid causes alteration in phenotypes of the treated plants. Different concentrations of colchicines have different affinity to various gene loci that in turn genetically affect valuable traits in plants. Mutation breeding therefore represents a complementary method of modern plant improvement as suggested by Lysenkov[26] providing genetic variability in germ-plasm collections that provide genes at previously unknown loci as well as new series of alleles with similar phenotypic expressions with better genetic background as suggested by Gustafsson and Lundgvist[27]. Thus, as reported by Mosisa *et al.*[28] that chemical mutagenesis is a simple technique used to create mutation in plants for their improvement of their potential agronomic traits.

CONCLUSION

Chemical mutagenesis induced by various concentrations of colchicine improves sesame seed yield by altering the capsulation habit from doublets to quadruplets thereby increasing the number of capsules and seeds produced by the mutants. Variety Ex-Sudan’s response was the highest and that lower concentrations of colchicine (0.1 mM) had the highest potentiality of altering the podding habit with subsequent increase in the yield of sesame.

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