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ORIGINAL RESEARCH ARTICLE

Colchicine Effect on Growth and Yield Traits of M_1 and M_2 Generations in Sesame (*Sesamum indicum* L.)

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ABSTRACT

A study was conducted to evaluate the effects of different colchicine concentrations on the growth and yield of two sesame varieties. Seeds of two varieties, Ex-Sudan and E-8, were treated with four different colchicine concentrations (0.1, 0.5, 1.0, and 2.0 mM) by pre-soaking for four hours, while the controls were pre-soaked in distilled water. The treated seeds were sown in a completely randomized design with three replications in a factorial arrangement to produce the first mutant generation (M_1). Data were collected on growth and yield components, and the seeds harvested from the M_1 plants were advanced to the M^2 generation. All data obtained were analyzed using multivariate analysis of variance, with Duncan's New Multiple Range Test used to separate significant means. The results revealed a highly significant difference ($p \leq 0.01$) among mutants treated with various colchicine concentrations. The mutants exhibited early flowering (36 days after sowing), a high emergence rate (97.67%), larger leaves (75.50 cm^2), and a high number of capsules (14 capsules/plant), each bearing numerous seeds (100 seeds/capsule). The mutant seeds (3.90 g) also weighed more than the control seeds (3.00-3.09 g). The findings suggest that colchicine treatment enhances sesame growth and yield, with effects increasing as the concentration decreases. % emergence, plant height, leaf area, and yield showed high potential for selection with PC1 effectively functioning as a synthetic indicator of overall plant vigor and yield potential. Therefore, selecting a variety with high PC1 would probably favour simultaneous improvement across multiple yield components. The lowest concentration (0.1 mM) produced the greatest effect, with the variety E-8 responding more strongly to the mutagenic treatment.

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Colchicine, concentration, mutation, sesame, yield

INTRODUCTION

Sesame (*Sesamum indicum* L.), commonly known as Beniseed, is one of the major oilseed crops worldwide (Wang *et al.*, 2023). It is referred to as the 'queen of oilseeds' (Rajesh *et al.*, 2024) and belongs to the plant family *Pedaliaceae* (Komivi *et al.*, 2017). The importance of the plant lies in its oily seeds, which are used for several nutraceutical, pharmaceutical, and industrial purposes (Micheale *et al.*, 2021). The oil is rich in mono- and polyunsaturated fatty acids (Rauf *et al.*, 2024), and its edible leaves are used as vegetables (Mann *et al.*, 2003). The nutritional profile of sesame could help reduce the threat posed by the current and expected global food crisis (Gharby *et al.*, 2017). Research (Abbas *et al.*, 2022; Wang *et al.*, 2022; Oboulbiga *et al.*, 2023) reported that consumption of sesame seeds provides health benefits due to their high levels of antioxidants, lignans, and essential fatty acids. The oil is used against gastrointestinal disorders, cholesterol regulation, atherosclerosis, and arterial thrombosis (Hsu and Parthasarathy, 2017; Hanci *et al.*, 2018).

Despite the tremendous benefits of sesame to the Nigerian economy, its export is declining substantially due to the lack of high-yielding varieties. Farmers continue to grow local varieties with low yields. This constraint contributed immensely to the decline in sesame production in Nigeria. Therefore, desirable breeding targets to improve sesame yield and stress tolerance are urgently needed (Ebrahimian *et al.*, 2023; Jhar *et al.*, 2024). One such strategy to improve sesame is by induced mutagenesis. Mutation (change in genetic material of an organism) aimed at improving both the growth and yield parameters of economic plants. It provides raw materials for the genetic improvement of economic crops (Adamu *et al.*, 2004). Artificial induction of mutations using chemical mutagens, such as colchicine, has been used effectively to induce variability that can be exploited in the genetic improvement of plants at a faster rate (Weldemichael *et al.*, 2021). Colchicine (a poisonous alkaloid from the autumn crocus plant [*Colchicum autumnale*]) was reported to improve quantitative traits that are of agronomic interest in plants. Thus, this study aimed to assess the effects of various colchicine concentrations on growth and yield-associated traits of two sesame varieties commonly grown in Nigeria. The primary objective of the study is to test the hypothesis that low

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colchicine doses will increase the yield components of sesame by 100%.

MATERIALS AND METHODS

Study Area

The research was carried out at the Biological Garden, Ahmadu Bello University, Zaria (Latitude 11° N, Longitude 7° N, 42[1] E, Altitude 660m above sea level) during the 2024 and 2025 wet seasons. Seeds of two sesame varieties (Ex-Sudan and E-8) were obtained from the Jigawa State Agricultural and Rural Development Authority (JARDA), Jigawa State, and from the National Cereal Research Institute, Badeggi, Niger State, respectively. The selection of these varieties is based on the fact that they are the most commonly cultivated in the study area.

Treatment and Experimental Design

To prepare a 0.1 mM solution of colchicine (Molychem, India), 3.9 mg of the powdered mutagen was diluted in 100 ml of distilled water, following standard safety guidelines for handling chemicals. According to the safety protocol, plants added to the colchicine solution were stored in a dark hood to prevent light exposure during the treatment process (Park *et al.,* 2025). The 5g seeds of each variety were treated with colchicine via soaking at four different concentrations (0.1 mM, 0.5 mM, 1.0 mM, 2.0 mM) for four (4) hours. These concentrations and treatment duration were selected based on ranges commonly reported in plant mutation breeding studies by Cabahug *et al.* (2021). These ranges are generally sufficient to induce chromosome-doubling while minimizing lethal effects. Thus, lower concentrations and shorter durations to reduce mortality were selected, while also testing higher doses to assess toxicity thresholds as reported by Park *et al.* (2025). After the treatment duration, the treated seeds were washed in running water and allowed to dry overnight on Whatman No. 1 filter paper at room temperature. The treated seeds of all the varieties were sown along with respective controls to raise the first mutant (M_1) generation. The seeds were planted in a Completely Randomized Design (CRD) in a factorial arrangement, with three replications per plot, in a 10 m x 5 m plot. The seeds were sown at 20 cm intra-row and 40 cm inter-row spacing, respectively. All recommended agronomic and cultural practices, such as sowing, fertilizer application, weeding and thinning, as well as harvesting, were carried out according to the procedures described in the National Agricultural Extension Research and Liaison Services (NAERLS) Crops Production Guide (2012). A total of 90 plants/plot (45 plants per variety) were raised as M_1 plants. Seeds were randomly selected from the harvest of individual M_1 plants from each treatment and sown to raise the second mutant generation (M_2 generation) in three replicates in the same field as described by Wani *et al.* (2013). Quantitative data were obtained from: percentage germination (One Week After Planting), number of days to 50% flowering, height at maturity, number of leaves/plant, internode length, leaf area, number of capsules/plant, number of seeds/capsule, and 1000-seed weight.

Data Analyses

Based on observations of the quantitative traits of two sesame varieties, the data were subjected to Multivariate Analysis of Variance (MANOVA) using SAS (2012) Version 9.1. Duncan's New Multiple Range Tests (DNMRT) was employed to separate the significant means. Principal Component Analysis was used to examine the relationships among yield and its components.

RESULTS

The results of the analysis of variance for the effect of various colchicine concentrations on the growth and yield traits of two sesame varieties in the first generation are presented in Table 1. The result revealed a highly significant difference ($p \leq 0.01$) in the effects of different colchicine concentrations on all the growth and yield attributes of sesame. A similar result was found for the varieties, except for height, number of leaves, and leaf area, where significant differences ($p \leq 0.05$) were observed. It was found that it is only in the number of days to flowering and yield that the interaction between concentrations and varieties is significant ($p \leq 0.05$) and highly significant ($p \leq 0.0$), respectively.

The effects of various colchicine concentrations on the growth and yield of the M_1 generation of the sesame variety Ex-Sudan are shown in Table 2. The mutants treated with a lower colchicine concentration (0.1 mM) showed the highest values for percentage emergence (90.33%), height at maturity (92.60 cm), and the number of leaves (42), which were larger (75.50 cm2) and 7.37 cm apart. These mutants attained 50% flowering 36 days after planting. The control had the lowest yield (138.20 kg/ha). The highest yield (681.00 kg/ha) was found in 0.1 mM colchicine-treated plants, with the highest number of capsules (14 capsules/plant) and seeds per capsule (100 seeds/capsule). Higher colchicine concentrations (≥1.0 mM) reduced yield down to 229.33 kg/ha at 2.0 mM (even though higher than the control). A similar result was recorded for the 1000-seed weight.

Similarly, the M_1 generation mutants of the sesame variety E-8 (Table 3) following treatment with a low colchicine concentration displayed a high emergence rate (86.67%) and taller stature (87.33%). The mutants produced the highest number of leaves (38) with an internode length of 6.33 cm and larger cross-sectional areas (71.33 cm²). The mutants attained 50% flowering 40 days after sowing and produced 10 capsules, each bearing 91 seeds. The 1000-seed weight of the mutants is 3.73 g. In terms of yield, the control yielded 118.00 kg/ha, with the maximum yield (438.73 kg/ha) recorded in 0.1 mM-treated plants, followed by a decline with increasing colchicine concentrations.

Table 1: M_1 Mean Squares for the effect of various colchicine concentrations on two sesame varieties

Sources of Variation	df	% Emergence	Height	No. of Leaves	Leaf Area	Internode Length	Days to 50 % Flowering	No. of Capsules	No. of Seeds/Capsule	1000 Seeds Weight	Yield
Concentration	4	219.22**	424.45**	218.80**	333.59**	4.17**	900.28**	44.78**	722.38**	0.68**	172814.93**
Variety	1	93.63**	58.52*	90.13*	35.21*	2.19**	61.63**	17.63**	270.00**	0.39**	82572.04**
Concentration x Variety	4	1.38	3.7	11.46	3.13	0.8	4.55*	2.38	20.42	0.02	10953.59**
Error	20	7.47	7.65	11.73	5.53	0.23	0.97	0.83	23.5	0.005	1.17
Total	44										

Key: **= Highly Significant different ($p \le 0.01$) *= significantly different ($p \le 0.05$)

Table 2: M_1 Growth and yield parameters of sesame (Variety Ex-Sudan) treated with Colchicine

Concentration (mM)	% Emergence (1 WAP)	Height at Maturity (cm)	No of Leaves/plant	Internodes Length (cm)	Leaf Area (cm^2)	No of Days to 50% Flowering	No of Capsules/plant	No of Seeds/Capsule	1000Seeds Weight(g)	Yield (kg/ha)
0	82.67^{c*1}	70.00^{e}	24.33^{e}	4.93^{d}	56.00^{d}	69.33^{a}	5.33^{d}	67.33^{d}	3.09^{d}	138.20^{e}
0.1	90.33^{a}	92.60^{a}	41.67^{a}	7.37^{a}	75.50^{a}	36.33^{e}	14.00^{a}	99.67^{a}	3.90^{a}	681.00^{a}
0.5	84.33^{b}	88.00^{b}	38.33^{b}	6.33^{b}	67.67^{b}	39.33^{d}	9.33^{b}	91.00^{b}	3.73^{b}	418.90^{b}
1	80.67^{c}	80.93^{c}	36.67^{c}	5.83^{c}	64.33^{c}	43.67^{c}	8.33^{c}	83.00^{c}	3.27^{c}	268.33^{c}
2	73.00^{d}	75.43^{d}	34.00^{d}	5.40^{c}	58.67^{d}	45.67^{b}	7.00^{c}	82.00^{c}	3.20^{c}	229.33^{d}
Mean	82.2	81.39	35	5.97	64.43	46.87	8.8	84.6	3.44	347.15
S.E(±)	3.19	2.78	3.27	0.41	2.26	1.59	0.94	4.54	0.06	0.52
p-value	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

N.B: *[1] Value(s) with the same superscript down a column are NOT significantly different at $p \le 0.05$

Table 3: M_1 Growth and yield parameters of sesame (Variety E-8) treated with Colchicine

Concentration (mM)	% Emergence (1 WAP)	Height at Maturity (cm)	No of Leaves/plant	Internodes Length (cm)	Leaf Area (cm²)	No of Days to 50% Flowering	No of Capsules/plant	No of Seeds/Capsule	1000 Seeds Weight(g)	Yield (kg/ha)
0	77.67^{e*1}	68.67^{e}	24.67^{e}	4.73^{d}	53.00^{e}	69.33^{a}	4.67^{e}	66.67^{e}	3.00^{c}	118.00^{e}
0.1	86.67^{a}	87.33^{a}	38.33^{a}	6.33^{a}	71.33^{a}	40.00^{e}	10.33^{a}	91.33^{a}	3.73^{a}	438.73^{a}
0.5	81.00^{b}	84.67^{b}	36.00^{b}	6.03^{b}	67.00^{b}	44.00^{d}	8.67^{b}	86.33^{b}	3.33^{b}	293.30^{b}
1	77.3 ^{c}	78.67^{c}	31.67^{c}	5.43^{c}	62.33^{c}	46.67^{c}	6.67^{c}	77.00^{c}	3.03^{c}	194.77^{c}
2	70.67^{d}	73.67^{d}	27.00^{d}	4.63^{d}	57.67^{d}	48.67^{b}	6.00^{d}	71.00^{d}	2.96^{d}	166.33^{d}
Mean	78.67	78.6	31.53	5.43	62.27	49.73	7.27	78.6	3.21	242.43
S.E(±)	3.19	2.78	3.27	0.41	2.26	1.59	0.94	4.54	0.06	0.54
p-value	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

N.B: *^{1} Value(s) with the same superscript down a column are NOT significantly different at $p \le 0.05$

Table 4: M_2 Mean Squares for the effect of various colchicine concentrations on two sesame varieties

Sources of Variation	Df	% Emergence	Height	No. of Leaves	Leaf Area	Internode Length	Days to 50 % Flowering	No. of Capsules	No. of Seeds/Capsule	1000 Seeds Weight	Seed Yield
Concentration	4	384.13**	460.83**	113.30**	282.02**	2.32**	735.62**	22.08**	478.97**	0.62**	106153.54**
Variety	1	192.53**	8.01*	97.20**	135.68**	2.52**	53.33**	14.70**	229.63**	0.05**	51038.63**
Concentration x Variety	4	13.03	24.42**	3.37	2.79	0.04	1.42	1.12	23.47	0.002	6860.31**
Error	20	19.3	2.6	2.27	1.78	0.05	3	0.93	11.1	0.004	0.72
Total	44										

Key: **= Highly Significant different ($p \le 0.01$)   *= significantly different ($p \le 0.05$)

Table 5: M_2 Growth and yield parameters of sesame (Variety Ex-Sudan) treated with Colchicine at varying levels

Concentration(mM)	% Emergence (1 WAP)	Height at Maturity (cm)	No of Leaves/plant	Internodes Length (cm)	Leaf Area (cm^2)	No of Days to 50% Flowering	No of Capsules/plant	No of Seeds/Capsule	1000 Seeds Weight(g)	Yield (kg/ha)
0	79.00^{d*1}	66,80^{d}	19.67^{d}	4.67^{e}	48.57^{e}	66.33^{a}	5.67^{d}	68.00^{d}	3.03^{e}	145.67^{e}
0.1	97.67^{a}	91.27^{a}	33.00^{a}	6.40^{a}	65.47^{a}	36.33^{d}	12.00^{a}	94.33^{a}	3.88^{a}	580.33^{a}
0.5	90.33^{b}	81.33^{b}	28.33^{b}	5.53^{b}	60.63^{b}	42.67^{c}	9.33^{b}	82.67^{b}	3.64^{b}	373.67^{b}
1	86.67^{c}	74.27^{c}	25.67^{c}	5.30^{c}	55.10^{c}	42.67^{c}	8.00^{bc}	78.67^{c}	3.44^{c}	269.00^{c}
2	81.00^{d}	72.10^{c}	24.33^{c}	4.93^{d}	50.67^{d}	44.67^{b}	7.67^{c}	77.33^{c}	3.20^{d}	238.67^{d}
Mean	86.93	77.15	26.2	5.35	56.09	46.53	8.53	80.2	3.44	321.47
S.E(±)	4.13	1.72	1.49	0.3	1.25	1.57	0.92	3.29	0.05	0.42
p-value	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

N.B: *[1] Value(s) with the same superscript down a column are NOT significantly different at $p \leq 0.05$

Table 6: M_1 Growth and yield parameters of sesame (Variety E-8) treated with Colchicine

Concentration (mM)	% Emergence (1 WAP)	Height at Maturity (cm)	No of Leaves/plant	Internodes Length (cm)	Leaf Area (cm^2)	No of Days to 50% Flowering	No of Capsules /plant	No of Seeds/ Capsule	1000 Seeds Weight (g)	Yield (kg/ha)
0	70.00^{d*1}	63.07^{d}	17.67^{d}	4.13^{e}	43.53^{d}	67.67^{a}	5.33^{d}	62.33^{e}	3.00^{e}	130.00^{e}
0.1	92.00^{a}	84.43^{a}	27.33^{a}	5.53^{a}	61.40^{a}	40.33^{d}	9.33^{a}	83.67^{a}	3.78^{a}	391.33^{a}
0.5	88.67^{b}	82.90^{a}	24.67^{b}	5.03^{b}	54.47^{b}	45.67^{c}	7.67^{b}	80.67^{b}	3.51^{b}	271.87^{b}
1	80.33^{c}	76.03^{b}	23.33^{b}	4.77^{c}	52.03^{b}	45.00^{c}	7.00^{b}	77.33^{c}	3.36^{c}	227.67^{c}
2	78.33^{c}	74.17^{c}	20.00^{c}	4.37^{d}	47.73^{c}	47.33^{b}	6.33^{c}	69.33^{d}	3.15^{d}	173.00^{d}
Mean	81.87	76.12	22.6	4.77	51.83	49.2	7.13	74.67	3.37	238.77
S.E(±)	4.13	1.72	1.49	0.3	1.25	1.57	0.92	3.29	0.05	0.43
p-value	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

N.B: *[1] Value(s) with the same superscript down a column are NOT significantly different at $p \leq 0.05$

Table 7: Correlation between yield and yield components of colchicine-induced sesame mutants

	% Emergence	Height at Maturity	No of Leaves	Internodes Length	Leaf Area	Days to Flowering	No of Capsules	No. of Seeds/ Capsule	1000 Seeds Weight	Seed Yield
% Emergence	1									
Height at Maturity	0.84**	1								
No of Leaves	0.84**	0.87**	1							
Internodes Length	0.87**	0.89**	0.91**	1						
Leaf Area	0.85**	0.82**	0.91**	0.91**	1					
Days to Flowering	-0.73*	-0.84**	-0.80**	-0.74*	-0.78**	1				
No. of Capsules	0.75**	0.82**	0.89**	0.89**	0.88**	-0.75**	1			
No. of Seeds/capsule	0.84**	0.89**	0.93**	0.92**	0.89**	-0.83**	0.86**	1		
1000 Seeds Weight	0.83**	0.94**	0.89**	0.87**	0.95**	-0.81**	0.86**	0.89**	1	
Yield	0.84**	0.89**	0.93**	0.94**	0.93**	-0.75**	0.92**	0.91**	0.93**	

N.B: **= Highly significant correlation ***= Significant correlation** **^{ns} = No significant correlation correlation**

Table 8: Eigenvalues and contributions in each Principal Components

Traits	Eigenvalues	Variance (%)	Cumulative (%)	Communalities
% Emergence	8.77	87.71	87.71	0.79
Height at Maturity	0.36	3.64	91.34	0.88
No. of Leaves	0.27	2.72	94.06	0.92
Leaf Area	0.20	2.04	96.10	0.93
Internode Length	0.12	1.16	97.26	0.89
No. of Days to 50% Flowering	0.09	0.86	98.12	0.73
No. of Capsule	0.08	0.79	98.91	0.85
No. of Seeds/Capsule	0.05	0.49	99.39	0.91
1000 Seeds Weight	0.03	0.34	99.73	0.92
Yield	0.03	0.27	100.00	0.94

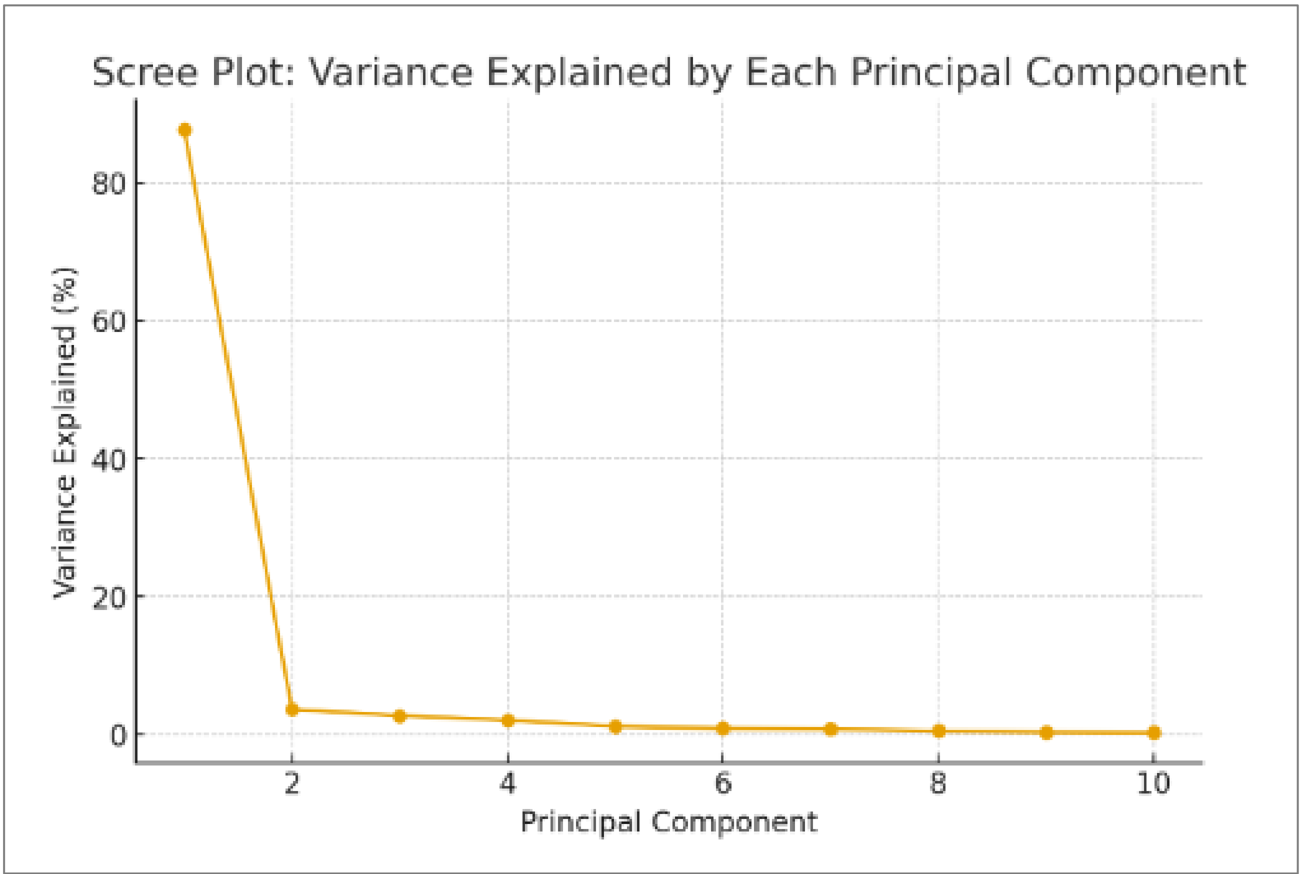

Figure 1: Scree Plot showing how much variance each principal component explains

Similarly, the results of the analysis of variance for the effect of various colchicine concentrations on the growth and yield traits of two sesame varieties in the second generation are shown in Table 4. The result indicated highly significant differences ($p \leq 0.01$) in the effects of different colchicine concentrations on all sesame traits and among varieties, except for height at maturity, where the effect among varieties was significant ($p \leq 0.05$). A highly significant difference ($p \leq 0.01$) was found only in the interaction between concentration and variety for height at maturity and yield.

The result for the effect of various colchicine concentrations on the sesame variety Ex-Sudan in the second mutant generation (M_2 generation) is presented in Table 5. The result revealed that the mutants showed 81.00-97.67% emergence after one week of planting and, at maturity, attained a height ranging from 72.10-91.27 cm. The mutants were found to produce a high number of leaves (24-33 leaves/plant) that were 4.93-6.40 cm apart and larger in size (50.67-65.47 cm^2). The number of days to attain 50% flowering decreased substantially in the mutants (from 45 to 36 days). Similarly, the mutants produced a high number of capsules (8-12 capsules/plant) that bear large numbers of seeds (77-94 seeds/capsule), which weigh 3.20-3.88g per 1000 seeds. The yield ranges from 238.67 to 580.33 kg/ha among the mutants.

Similarly, the sesame variety E-8 treated with various colchicine concentrations at the M_2 generation (Table 6) showed highly significant differences ($p \leq 0.01$) in the observed traits. The results indicated that the mutants displayed a high emergence rate (78.33-92.00%) and attained heights of 74.17-84.43 cm at maturity. The mutants produced a high number of leaves (20-27 leaves/plant), which are 4.37-5.53 cm apart and 47.73-61.40 cm^2 in cross–sectional area. The mutants attained 50% flowering at 40-47 days after planting, producing 6-9 capsules with 69-84 seeds/capsule. The weight of 1000 mutants' seeds ranges from 3.15g to 3.78g, and the yield ranges between 173.00 kg/ha to 391.33 kg/ha.

Similarly, Table 7 presents the results of the Principal Components Analysis (PCA) for the correlation between yield and yield components of M_2 generation sesame mutants. The results showed highly significant correlations ($r \leq 0.75$) between the yield and yield components of the sesame mutants. However, highly significant negative correlations ($r \leq 0.75$) were found between the studied traits and the number of days to 50% flowering, except for % emergence and internode length, for which significant negative correlations ($r \leq 0.45$) were found.

Table 8 showed variations in the interrelationships among the studied traits using Principal Component Analysis. The result showed that the first principal component (PC1), associated with the trait % Emergence, has a very high eigenvalue (8.77) and explains 87.71% of the total variation. This suggests that most of the dataset's variability can be attributed to this single component, implying that the traits are strongly correlated. PC2 (Height at Maturity) contributes 3.64%, followed by leaf number (2.72%) and Leaf Area (2.04%). The first four components explain 96.1% of the total variance, which is quite high, indicating that the dataset can be effectively summarized with fewer dimensions. The results indicated high communalities (0.73–0.94), indicating that the extracted principal components well represent the components. The highest communality is observed for Yield (0.94) and Leaf Area (0.93), suggesting that these variables are strongly associated with the main principal components. The lowest communality (0.731) is for No. of Days to 50% Flowering, meaning this trait contributes less to the overall variability structure.

Figure 1 presents a Scree Plot showing how much variance each principal component explains.

The first component accounts for the majority of the variance (~87.7%), followed by a steep drop in the remaining components. This indicates that most of the dataset's variability can be captured by the first principal component alone.

DISCUSSION

Artificial induction of mutation using colchicine in sesame has significantly influenced growth and yield-related traits of the sesame varieties Ex-Sudan and E-8 across both the M_1 and M_2 generations. The present study reported that all the growth and yield parameters responded in a dose-dependent manner to colchicine treatments. There is significant variation in the traits of all the studied mutants induced by colchicine relative to the control, indicating the mutagen's role in creating variability in sesame for improvement. The high rate of emergence induced by a low dose of colchicine in sesame demonstrated the mutagen's role in stimulating germination. This is in line with the findings of Hemavathy (2015), who reported a decrease in mung bean (Vigna radiata) germination rate with increasing mutagenic doses. The increased percentage emergence among colchicine-induced mutants of sesame indicates the mutagen's ability to improve germination rates. This conforms with the work of Ambli and Mullainathan (2018), who reported similar findings among pearl millet plants treated with a chemical mutagen.

The increased plant height reported in this investigation due to colchicine treatment can be attributed to the mutagen's ability to stimulate cell division in meristematic tissues. This particular positive action of colchicine upon morphogenic processes in plants causes alteration of the plant genome integrated by environmental signals, as reported by Uno *et al.* (2001), probably by increasing the rates of cellular division and expansion at their meristems. However, this finding contradicts that of Maluszynski *et al.* (2001), who reported a decrease in plant height following induced mutation in rice with physical mutagens. Higher doses of mutagens induce cellular injury, thereby interfering with growth and certain metabolic processes. The increased in leaf attributes due to low colchicine concentrations reported by this study is in line with the findings of Usharani and Ananda Kumar (2015) in blackgram (*Vigna mungo*) and Nura *et al.* (2017) among mutants of fonio. The mutagen might have influenced auxin or cytokinin activity, which are of paramount importance in fundamental processes of plant development, including cell division and morphogenesis, as stressed by Sarwar and Butt (2015).

The present study reported a decreased in the number of days to 50% flowering with a decrease in colchicine concentration. This physiological attribute is an important quality parameter in crop improvement, as it serves as an index of early maturity. A similar finding was reported by Hamisu *et al.* (2024), who found an increase in the number of days to 50% flowering with increasing dose and a decrease with decreasing dose of the chemical mutagen, Ethyl Methanesulfonate (EMS). A similar finding was also reported by Kumar and Pandey (2019) among EMS-induced mutants of *Coriandrum sativum* L., and by Siddique *et al.* (2020) in *Capsicum.* Moreover, Kumar and Shunmugavalli (2017) reported an increase in Days to first flowering in EMS-induced mutants of sesame at both M_1 and M_2 generations.

The present study reported that, across generations and varieties, 0.1 mM colchicine treatment yielded the highest performance. This finding is consistent with the findings of Mosisa *et al.* (2013) and Etther et al. (2019), who reported low yields among mutants treated with high concentrations of chemical mutagens in barley and *Cajanus cajan*, respectively. Conversely, higher doses (≥0.5 mM) led to a gradual decrease in yield attributes; at times, values even fell below control levels. This pattern implies that a low concentration of colchicine induced beneficial genetic variations that enhanced both vegetative and reproductive vigor, whereas high concentrations probably exerted cytotoxicity, leading to a reduction in plant performance. However, the finding contradicts that of Parchin *et al.* (2021), who reported a higher yield from fenugreek (Trigonella foenum-graecum) plants treated with a higher EMS dose. Jhar *et al.* (2024) reported negative relationships between mutagenic dose and the measured traits: germination percentage, branch number, capsule number, 100 seed weight, and yield in sesame. However, Hamisu *et al.* (2024) reported improvement in growth and yield of soybean varieties treated with low concentrations of sodium azide and ethyl methanesulfonate.

More so, Shehu *et al.* (2024) reported improvement in sesame growth and yield attributes due to colchicine treatment. The induced variability observed in this study due to colchicine showed two contrasting 'Gigas' effects: stimulation at low doses and inhibition at higher doses on growth and yield attributes. The observed *Gigas* effect due to colchicine in sesame is consistent with the findings of Yadav et al. (2016), who reported significant improvements in growth and yield attributes in low-dose-induced mutants of maize (*Zea mays*).

The consistency of the optimal effects of low colchicine concentration (0.1 mM) across both generations and varieties suggests a stable mutagenic response threshold. The steeper decline in yield metrics for E-8 at elevated concentrations further suggests differences in varietal response to colchicine treatments, which is an important consideration for mutation breeding programs. The preponderance of variance explained by PC1 reveals that most of the trait variation aligns along a single major axis of growth and yield. The high communalities suggest that each trait contributes meaningfully to the multivariate variation. The dominance of the first component (% emergence) indicates a high degree of interdependence among the studied traits, possibly controlled by common genetic or environmental factors, and since cumulative variance reaches 100%, the PCA effectively captures all variability across traits. These findings are consistent with those of Debnath et al. (2022), who reported similar findings among lentil mutants. The strong contribution of traits such as % **e**mergence**,** plant height**,** leaf area, and **y**ield highlights their potential importance for selection or classification within the studied population. Thus, PC1 effectively functions as a synthetic indicator of overall plant vigor and yield potential. Therefore, selecting a variety with high PC1 would probably favour simultaneous improvement across multiple yield components.

CONCLUSION

It was concluded that various colchicine concentrations improve the growth and yield of sesame, with the effect increasing with decreasing concentration. Based on the PCA, traits such as % emergence, plant height, and leaf area are to be used for selection, and the mutagen induces variability that could be use in the genetic improvement of sesame. The lowest concentration (0.1 mM) produced the greatest effect, and variety E-8 showed the highest response to colchicine treatments.

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