



Effects of Colchicine on Growth and Yield Traits of Okra (*Abelmoschus esculentus* [L] Moench) Varieties

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Abstract

Abelmoschus esculentus is one of the most nutritious vegetable crops, but its production has declined in Nigeria over the years. This study aimed to determine the effect of colchicine on growth and yield traits of *Abelmoschus esculentus*. The experiment was conducted at the Botany Garden of Ahmadu Bello University. Three okra varieties (Clemson Spineless, Yar'Balla, and Yar'Sumaila) were treated with five different concentrations of colchicine for five hours, washed in running water, and air-dried for 24 h. The treated seeds were sown in polythene bags arranged in a Completely Randomized Design (CRD) in a factorial arrangement for first and second generations. Data were collected on percentage emergence, percentage survival, plant height (cm), leaf area (cm²), number of leaves, number of flowers, capsule length and width (cm), and number of seeds per capsule. Growth and yield data were analyzed using Multivariate Analysis of Variance (MANOVA), and means were separated using Duncan's New Multiple Range Test. Colchicine treatments significantly improved growth and yield traits such as percentage emergence (84%), survival (80%), plant height (39cm), and leaf area (85cm²). Also produced the highest number of flowers (18), number of capsules (14) capsules length (10.33cm), and number of seeds per capsule (33). In conclusion, colchicine enhanced the growth and yield performance of okra varieties, with lower concentrations producing superior results compared to higher concentrations.

Keywords: Colchicine, Mutation breeding, Okra variety, yield, Polyploidy

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Introduction

Abelmoschus esculentus (L.) Moench (2n = 58) is a vegetable crop belonging to the family Malvaceae and the genus *Abelmoschus* (IBP, 2023). It is widely cultivated in tropical and subtropical regions under both rain-fed and irrigated conditions (Singh & Pandey, 2024). In Nigeria, okra is commonly known as Kubewa in Hausa, Ila in Yoruba, and Olewele in Igbo. Globally, okra covers about 2.81 million hectares,

with an annual production of 11.5 million tons. Nigeria produces 1.9 million tons, making it the second-largest producer (FAOSTAT, 2023). Around 75% of the okra market is dominated by India, followed by Nigeria at 12%. In recent years, okra has garnered increasing recognition and acceptance as a global crop, attributed to the growing appreciation for its nutritional benefits among consumers (Singh and Pandey, 2024). All plant parts of okra, such

as fresh leaves, buds, flowers, pods, stems, and seeds, have significant value (Swamy, 2023).

Okra plays an important economic role for Nigerian farmers and marketers, who derive income from the sale of fresh immature leaves as well as fresh and dried fruits (Singh *et al.*, 2023). It can be found in almost every market in Africa (Singh, 2023). Nutritionally, okra is considered a powerhouse of essential nutrients, including minerals, vitamins, proteins, carbohydrates, fats, unsaturated fatty acids, and α -tocopherol, which contribute to its dietary and medicinal value (El-Khalifa *et al.*, 2021). The seeds of this plant are containing moisture 11.14%, protein 2.3%, starch 13.35%, fatty oil 14.5%. Seeds yield a volatile oil, is viewed as an alternative source for edible oil; its main constituent is a sesquiterpene alcohol, farnesol. The okra seed oil provided powerful odour (musk odour) is due to the presence of a ketone-ambrettelide, a lactone of ambrettolic acid. Despite the continuous expansion of the okra cultivation area in Nigeria, its production rate is four times less than India's. Okra yields have drastically decreased from 27,275 kg/ha to 11,459 kg/ha (FAOSTAT, 2023), largely due to a lack improved (Babalola *et al.*, 2020).

A total of 33 okra varieties and hybrids have been released from different public sector institutions world-wide, to covering all the agro-climatic zones for the benefit of farming communities (Singh *et al.* 2023). While in Nigeria about 659 improved crop varieties have been released, yet only three okra varieties have been registered since 1980s (Nigeria Seed Portal, 2024). This indicates a clear neglect in okra improvement, as the majority of farmers still rely heavily on local varieties, with only a few adopting improved cultivars.

Induced mutagenesis is widely recognised as a powerful and relatively simple method for plant genetic improvement, and offers a cost-effective way to generate genetic variation and develop new crop varieties with desirable traits. These mutagens have diverse effects on DNA and chromosomes, leading to functional changes genomic resulting in diversity in quantitative and qualitative traits of crops (Sankare *et al.*, 2021; Shelar *et al.*, 2021). Colchicine

($C_{22}H_{25}NO_6$) is a natural, highly toxic alkaloid compound extracted from *Colchicum autumnale* (*autumn crocus*), a member of the family Liliaceae (Gultom, 2016). Since its discovery, it has been widely recognized for its ability to modify morphological and yield attributes, but its effects on different okra varieties remain insufficiently studied. Exploring these effects could provide valuable insights for breeding programs aimed at enhancing the productivity and adaptability of okra.

Materials and Methods

The research was carried out at the Botanical Garden of the Department of Botany, Ahmadu Bello University, Zaria, Nigeria (latitude 11°11'N, longitude 07°38'E, altitude 660 m above sea level). Seeds of three cultivated okra varieties (Clemson Spineless, Yar'Balla, and Yar'Sumaila) were obtained from the Institute for Agricultural Research (I.A.R.), Ahmadu Bello University, Zaria.

Fifteen seeds of each variety were pre-soaked in distilled water for four hours, then soaked in five different concentrations of colchicine (0.1, 0.5, 1.0, and 2.0 mM, plus a control) for five hours at room temperature. After treatment, the seeds were thoroughly washed in tap water and allowed to dry overnight on Whatman No. 1 filter paper. The treated seeds were sown in polythene bags arranged in a Completely Randomized Design (CRD) with three replications in a factorial arrangement across two mutant generations (M1 and M2). All agronomic practices followed the protocols described by Vikash *et al.* (2019).

Data collected included percent emergence (week two after sowing), percent survival (30 days), Plant Height (cm), Leaf area (cm²), Number of Leaves, number of capsules, number of flowers per plant, length and width of Capsule (cm), Number of Seeds per capsule.

Data obtained were analysed using Multivariate Analysis of Variance using SAS (2012), Version 9.1 software. Duncan's New Multiple Range Test (DNMRT) was used to separate the means that were significant.

Results

The effect of colchicine on growth and yield traits of the M1 generation of okra varieties is presented in Table 1. A significant difference ($p \leq 0.05$) was noted among concentrations for each variety character except length of capsules in Yar, Sumaila. In Clemson Spineless, the 0.1 mM treatment recorded the highest values for percentage emergence (70.33%), survival (71.00%), plant height at maturity (34.33 cm), leaf area (73.16 cm²), number of leaves per plant (11.00), number of flowers per plant (13.33), number of capsules per plant (10.33), capsule length (9.00 cm), and capsule circumference (9.00 cm), compared to the control and other concentrations.

A similar trend was observed in Yar'Balla, where the 0.1 mM treatment resulted in the highest percentage emergence (84.44%), survival (70.00%), plant height at maturity (38.00 cm), leaf area (85.97 cm²), number of leaves per plant (12.00), number of flowers per plant (18.33), capsule circumference (13.00 cm), and number of seeds per capsule (31.67). However, the longest capsule length (8.27 cm) was recorded at 0.5 mM concentration.

Yar'Sumaila, the 0.1 mM concentration produced the highest percentage emergence (87.12%), survival (80.00%), leaf area (64.07 cm²), number of leaves per plant (18.67), number of flowers per plant (17.00), capsule circumference (13.33 cm), capsule length (8.03 cm), and number of seeds per capsule (33.33). Exceptions were observed for plant height, which was highest (39.67 cm) at 1 mM concentration, and capsule length, which was longest (7.50 cm) at 2 mM concentration.

Table 2 showed the effect of colchicine on growth traits in the M2 generation of okra varieties.

A significant difference ($p \leq 0.05$) was noted among concentrations for each variety character except length of capsules in Yar'Balla and capsules circumference in Yar, Sumaila. In Clemson Spineless, the 0.1 mM treatment again showed the highest significant values for percentage emergence (14 DAS: 67.33%), percentage survival (68.00%), plant height (29.00 cm), leaf area (34.27 cm²), number of leaves per plant

(9.67), number of flowers per plant (15.89), number of capsules per plant (11.33), capsule length (9.00 cm), and number of seeds per capsule (27.00). Capsule circumference (9.00) was largest at 0.5 mM compared to control (6.67 cm).

Similarly, in Yar'Balla, 0.1 mM colchicine produced the highest percentage emergence (84.44%), survival (70.00%), plant height (31.67 cm), leaf area (42.99 cm²), number of leaves (10.00), number of flowers per plant (17.33), number of capsules per plant (14.00), capsule length (7.67 cm), and number of seeds per capsule (31.67). The largest capsule circumference (10.17 cm) was observed at 0.5 mM compared to control (5.00 cm).

In Yar'Sumaila, the 0.1 mM concentration recorded the highest emergence (82.12%), survival (72.12%), plant height (30.00 cm), leaf area (51.15 cm²), number of leaves (9.00), number of flowers per plant (14.33), number of capsules per plant (14.00), capsule length (10.33 cm), and number of seeds per capsule (22.67). The largest capsule circumference (7.67) was recorded at 2 mM concentration compared to control (7.00 cm).

Discussion

The results obtained in this study indicated that okra varieties responded differently to colchicine concentrations. The progressive increase in seedling emergence and survival across the treatments revealed the stimulatory effects of the low mutagen on germination, possibly due to stimulated physiological processes, hormonal balance, and enzymatic activities. In contrast, higher doses caused physiological damage, likely disrupting metabolic and developmental pathways. These findings are consistent with reports of Sahrish *et al.* (2019) on *Vigna unguiculata* and Bala *et al.* (2018) on *Solanum lycopersicum*, who observed that lower mutagen concentrations enhance germination and seedling survival. In contrast with the works of Ati and Shehu, (2023), Lubis and Aprilyani (2024), and Ati *et al.* (2023) on okra. Rashid *et al.* (2021) further explained that increasing mutagen concentrations intensifies chromosomal damage, reducing germination ability, plant vigor, and survival rates.

Effects of Colchicine on Growth and Yield Traits of Okra (*Abelmoschus*

Table 1: Effect of colchicine on growth and yield traits of M1 generation

Varieties	Concentration(mM)	% Emerg (14 DAS)	% Surv	HM (cm)	LA (cm ²)	NOL	NF	NC	LC (cm)	CC (cm)	NSC
Clemson spineless	0.0	50.67 ^c	46.67 ^d	26.00 ^b	24.80 ^d	5.00 ^c	9.00 ^b	5.33 ^c	6.17 ^c	9.00 ^a	10.00 ^d
	0.1	70.33 ^a	71.00 ^a	34.33 ^a	73.16 ^a	11.00 ^a	13.33 ^a	10.33 ^a	9.00 ^a	9.00 ^a	27.00 ^a
	0.5	66.67 ^b	63.33 ^b	32.00 ^a	42.16 ^b	10.12 ^a	11.67 ^a	10.00 ^a	8.67 ^a	7.67 ^b	19.33 ^b
	1.0	50.00 ^c	53.33 ^c	31.67 ^a	34.26 ^c	8.34 ^b	8.00 ^b	7.67 ^b	7.00 ^b	7.00 ^b	14.00 ^c
	2.0	42.33 ^c	33.33 ^c	17.67 ^c	34.00 ^c	4.23 ^c	5.67 ^c	5.00 ^c	6.00 ^c	7.30 ^b	13.67 ^c
	Mean	56.00	53.53	28.33	41.68	7.74	9.53	7.67	7.37	7.99	16.80
	SE(±)	4.78	5.85	2.68	7.46	1.21	1.21	1.00	0.56	0.38	2.64
Yar'B alla	0.0	46.12 ^e	40.56 ^d	9.67 ^c	26.62 ^d	5.33 ^c	8.45 ^c	8.00 ^c	5.67 ^b	4.60 ^c	16.67 ^b
	0.1	84.44 ^a	70.00 ^a	38.00 ^a	85.97 ^a	11.67 ^a	18.33 ^a	13.00 ^a	7.67 ^a	10.17 ^a	31.67 ^a
	0.5	79.21 ^b	66.67 ^a	31.00 ^a	55.80 ^b	11.00 ^a	15.67 ^a	12.67 ^a	8.27 ^a	7.33 ^b	30.67 ^a
	1	76.65 ^c	50.23 ^c	18.17 ^b	47.74 ^b	8.33 ^b	11.33 ^b	10.00 ^b	6.50 ^b	7.00 ^b	29.00 ^a
	2	60.00 ^d	20.00 ^e	16.67 ^b	32.2 ^c	7.45 ^c	11.00 ^b	10.00 ^b	5.70 ^b	7.40 ^b	13.67 ^b
	Mean	58.53	42.22	19.37	42.63	7.50	12.96	10.73	6.76	7.30	24.34
	SE(±)	12.21	10.41	5.37	11.08	1.58	1.59	0.84	0.47	0.79	3.40
Yar'Sumaila	0.0	66.67 ^d	33.33 ^e	16.33 ^d	50.63 ^c	10.33 ^b	8.33 ^c	9.00 ^c	6.17 ^a	6.00 ^b	17.33 ^b
	0.1	87.12 ^a	80.00 ^a	29.00 ^a	64.07 ^a	18.67 ^a	17.00 ^a	13.33 ^a	6.53 ^a	8.03 ^a	33.33 ^a
	0.5	80.23 ^b	76.65 ^b	34.33 ^b	62.41 ^b	17.67 ^a	15.00 ^a	11.33 ^b	6.8 ^a	7.67 ^a	28.00 ^a
	1.0	75.23 ^c	53.33 ^c	39.67 ^b	60.35 ^b	14.00 ^b	12.00 ^b	10.67 ^b	7.00 ^a	7.40 ^a	13.67 ^b
	2.0	71.12 ^c	45.00 ^d	19.00 ^c	54.17 ^c	12.00 ^b	7.67 ^c	4.33 ^d	7.50 ^a	7.44 ^a	15.00 ^b
	Mean	65.43	49.79	23.95	50.45	12.37	12.00	9.73	6.80	7.31	21.47
	SE(±)	11.03	10.79	5.19	8.15	2.52	1.63	1.36	0.20	0.31	3.48

Means within the columns with the same superscript letter(s) are not significantly different ($p>0.05$) percentage emergence (14DAS), percentage of survival (% Surv), Hight at maturity (HM), Leaf area (LA), number of leaf (NL), Capsule Circumference (CC), Length of Capsule (LC), Number of Flowers (NF), Number of Seeds Per Capsule (NSC), number of capsules (NC)

Table 2: Effect of colchicine on growth and yield traits of M2 generation

Varieties	Concentration(mM)	% Emerg (14 DAS)	% Surv	HM (cm)	LA (cm ²)	NOL	NF	NC	LC (cm)	CC (cm)	NSC
Clemson spineless	0.0	38.67 ^d	33.33 ^e	6.00 ^e	6.82 ^d	5.00 ^c	8.36 ^c	6.87 ^b	6.67 ^b	6.67 ^b	16.00 ^c
	0.1	67.33 ^a	68.00 ^a	29.00 ^a	34.27 ^a	9.67 ^a	15.89 ^a	11.33 ^a	9.00 ^a	8.33 ^a	27.00 ^a
	0.5	60.67 ^b	63.33 ^b	21.00 ^b	17.67 ^b	9.00 ^a	15.67 ^b	10.67 ^b	7.00 ^b	9.00 ^a	23.67 ^b
	1.0	56.00 ^c	50.00 ^c	15.37 ^c	18.6 ^b	8.12 ^a	12.33 ^b	8.33 ^b	5.50 ^c	7.67 ^b	21.33 ^b
	2.0	42.33 ^d	46.67 ^d	11.00 ^d	10.23 ^c	7.43 ^b	12.79 ^b	8.33 ^b	5.00 ^c	7.11 ^b	12.33 ^d
	Mean	53.00	52.27	16.47	17.52	7.84	13.01	9.11	6.63	7.76	20.07
	SE(±)	4.87	5.53	3.57	4.24	0.72	1.22	0.74	0.70	0.37	2.36
	0.0	46.12 ^d	20.00 ^e	12.17 ^d	22.22 ^c	8.00 ^c	7.89 ^d	6.33 ^c	6.17 ^a	5.00 ^c	8.33 ^d
Yar'Balla	0.1	84.44 ^a	70.00 ^a	31.67 ^a	42.99 ^a	10.33 ^a	17.33 ^a	14.00 ^a	7.67 ^a	7.67 ^b	31.67 ^a
	0.5	79.21 ^a	66.67 ^b	20.33 ^b	36.02 ^b	8.33 ^b	14.67 ^a	10.33 ^b	7.60 ^a	10.17 ^a	21.33 ^b
	1.0	76.65 ^b	50.23 ^c	16.83 ^c	35.13 ^b	8.33 ^b	11.67 ^b	9.00 ^b	7.33 ^a	8.00 ^b	11.33 ^c
	2.0	60.00 ^c	40.56 ^d	16.5 ^c	25.16 ^c	8.00 ^c	9.33 ^c	7.69	6.67 ^a	7.57 ^b	11.00 ^c
	Mean	58.55	42.17 ^c	16.84	27.63	7.29	12.18	9.47	7.09	7.68	16.73
	SE(±)	12.20	10.45	3.79	5.61	1.36	1.54	1.17	0.26	0.73	3.88
	0.0	54.67 ^d	66.67 ^c	6.00 ^e	17.05 ^c	7.00 ^b	8.00 ^c	5.00 ^b	10.00 ^a	7.00 ^a	8.67 ^c
	0.1	82.12 ^a	72.12 ^a	30.00 ^a	51.15 ^a	9.33 ^a	14.33 ^a	14.00 ^a	10.33 ^a	6.87 ^a	22.67 ^a
Yar'Sumaila	0.5	74.23 ^b	65.23 ^b	21.00 ^b	46.50 ^a	9.00 ^a	11.33 ^b	11.00 ^a	10.00 ^a	7.17 ^a	17.33 ^b
	1.0	62.23 ^c	55.23 ^c	15.37 ^c	35.55 ^b	7.67 ^b	11.33 ^b	10.12 ^a	7.67 ^b	6.83 ^a	16.00 ^b
	2.0	51.12 ^d	41.12 ^d	11.00 ^d	32.03 ^b	7.33 ^b	8.12 ^c	7.87 ^b	5.00 ^b	7.67 ^a	9.33 ^c
	Mean	56.09	51.80	14.53	31.32	6.95	10.62	9.60	8.60	7.11	14.80
	SE(±)	10.00	9.40	4.01	7.09	1.18	1.06	1.35	0.91	0.14	2.34
	0.0	54.67 ^d	66.67 ^c	6.00 ^e	17.05 ^c	7.00 ^b	8.00 ^c	5.00 ^b	10.00 ^a	7.00 ^a	8.67 ^c

Means within the columns with the same superscript letter(s) are not significantly different ($p>0.05$) percentage emergence (14DAS), percentage of survival (% Surv), Height at maturity (HM), Leaf area (LA), number of leaf (NL), Capsule Circumference (CC), Length of Capsule (LC), Number of Flowers (NF), Number of Seeds Per Capsule (NSC), number of capsules (NC)

The observed increase in plant height of colchicine-induced okra mutants may be attributed regulates gibberellic acid synthesis, promoting elongation and cell division. These results are in agreement with Asare *et al.* (2017), who reported increased growth parameters at low ethyl methane sulfonate concentrations in *A. esculentus*. Similarly, Mohite and Gurav (2019) found that lower mutagen doses enhanced plant height, while higher doses had deleterious effects. However, contrary to these findings, Nyam *et al.* (2024) reported that increasing colchicine concentrations significantly promoted plant height in *Digitaria exilis* and *Digitaria iburua*. Leaf traits such as number and size were notably enhanced by colchicine treatments. This may be due to increased cell division, gene duplication, and altered hormonal signaling that favor leaf expansion and differentiation. This observation aligns with Nura *et al.* (2014), who reported increased leaf area and number in *Sesamum indicum* under colchicine treatment. Enhanced leaf development creates a larger photosynthetic surface area, which directly contributes to biomass accumulation and growth. Similar results were documented by Omosun *et al.* (2021), who found increased leaf number and plant height following mutagenic treatment.

Colchicine treatment also enhanced flowering and yield-related traits, including the number of flowers, capsules, capsule length, and capsule circumference. These results aligned with findings by Nura *et al.* (2013) on sesame and Lubis and Apriyani (2024) on okra, both of whom reported increased floral and fruiting traits under colchicine treatments. Similarly, Warghat *et al.* (2011) observed increased fruit set in sodium azide-treated *A. moschatus*. However, this contrasts with Ramya *et al.* (2014), who reported a decline in pod number and pod length in *Vigna mungo* under higher mutagen doses. These discrepancies suggest that while high doses may suppress reproductive capacity, they may also enhance seed size due to altered assimilate allocation, as noted by Olorunmaiye (2019) and Ullah *et al.* (2014). The number of seeds per capsule also increased significantly under colchicine treatments. This could be due to a larger

capsule size, providing more compartments for seed formation. This aligns with Nura *et al.* (2013), who reported a higher seed count in colchicine-treated sesame compared to the control. In contrast, Mohite and Gurav (2019) found that untreated okra plants produced fewer fruits, seeds, and lower seed weights compared to treated plants. Similarly, Pushparajan *et al.* (2014) observed increased seed numbers per fruit in gamma-irradiated plants, underscoring the role of induced mutagenesis in enhancing yield traits.

Conclusion and Recommendation

This study demonstrated that colchicine treatment significantly influenced the growth, morphology, and yield attributes of okra varieties. Low colchicine concentrations consistently exhibited superior performance in germination, vegetative growth, leaf development, flowering, and yield traits compared to higher concentrations, which had inhibitory or damaging effects. Low-dose colchicine treatments should be adopted in okra improvement programs, as they enhance both growth and yield performance.

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