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ORIGINAL RESEARCH ARTICLE

# Dose-Dependent Effects of Colchicine on Growth and Yield Traits of Improved Cowpea (*Vigna unguiculata* [L.] Walp.) Varieties across $M_1$ and $M_2$ Generations

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## ABSTRACT
Cowpea (*Vigna unguiculata* [L.] Walp.) is an important grain legume widely cultivated for its nutritional value and adaptability to diverse agroecological conditions. However, limited genetic variability among elite cultivars has constrained yield improvement through conventional breeding. This study evaluated the dose-dependent effects of colchicine on growth and yield traits of three improved cowpea varieties (SAMPEA 12, SAMPEA 14, and SAMPEA 19) across $M_1$ and $M_2$ generations. The experiment was conducted at the Botanical Garden of Ahmadu Bello University, Zaria, Nigeria, using a completely randomized design with factorial arrangement comprising five colchicine concentrations (0.0, 0.1, 0.5, 1.0, and 2.0 mM), three varieties, and three replicates. A total of 675 seeds were treated and evaluated for emergence, survival, vegetative growth, flowering, and yield-related parameters. Data were analyzed using two-way ANOVA and Duncan's New Multiple Range Test at $p \leq 0.05$. Colchicine concentration significantly ($p \leq 0.05$) influenced most growth and yield traits in both generations. In the $M_1$ generation, the 0.1 mM treatment produced the highest emergence percentage in SAMPEA 19 at 7 DAS (93.33%) and 14 DAS (81.10%), while the highest survival rate (81.34%) was observed in SAMPEA 14. In the $M_2$ generation, 0.1 mM colchicine consistently produced superior agronomic performance, recording the highest emergence (96.67%), survival (87.78%), plant height (25.33 cm), leaf area (49.67 cm²), pods per plant (27.00), and seeds per pod (16.67), particularly in SAMPEA 19. Conversely, higher colchicine concentrations (1.0 and 2.0 mM) significantly reduced emergence, survival, and yield traits due to phytotoxic effects and delayed flowering. SAMPEA 19 was the most responsive variety, whereas SAMPEA 14 showed relatively lower responses to colchicine treatment. The findings demonstrate that low colchicine concentration (0.1 mM) effectively enhanced growth and yield traits in improved cowpea varieties and could be utilized for induced variability and crop improvement programmes.

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Cowpea, colchicine, mutation breeding, polyploidy, yield traits, SAMPEA varieties, induced variability.



## INTRODUCTION
Cowpea (*Vigna unguiculata* [L.] Walp.) is an important annual grain legume belonging to the family Fabaceae and genus *Vigna*, with a diploid chromosome number of 2n = 2x = 22. It is widely cultivated in tropical and subtropical regions, particularly in sub-Saharan Africa, Asia, and parts of the Americas (Shevkani et al., 2025). Africa contributes nearly 95% of global cowpea production, of which 52% is consumed as food, 13% is used as animal feed, 10% as seed, 9% for other purposes, while about 16% is lost as waste (Kamara et al., 2018). Nigeria is the largest producer and consumer of cowpea, accounting for 61% of Africa's production and approximately 40% of global output (Akah et al., 2021). Cowpea is nutritionally valuable because of its high protein content, vitamins, minerals, and bioactive phytochemicals (Imade & Usunomena, 2025). Its ability to tolerate heat, drought, and low soil fertility makes it suitable for smallholder farming systems and marginal environments, especially under climate variability (Horn & Shimelis, 2020).

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Despite its importance, cowpea productivity remains constrained by declining yield, pest damage, poor soil fertility, climatic stress, and limited genetic variability. Rapid global population growth, estimated at 0.85% annually, together with Nigeria's higher growth rate of about 2.1% per year, continues to increase pressure on food production systems (United Nations, 2024). In Nigeria, cowpea yield has reportedly declined from about 5 t $ha^{-1}$ to 0.8 t $ha^{-1}$ between 2021 and 2025 (Nwagboso et al., 2024). Similar concerns regarding crop productivity have been highlighted in recent studies on crop yield modelling and agronomic improvement, including rice yield prediction in Hadejia and Auyo, Nigeria (Abdurrahman & Muhammad, 2025), nutrient uptake and water-use efficiency in cowpea (Adebayo, 2024), and growth and yield responses of cowpea under pesticide stress (Bawa et al., 2025). These studies emphasize the need for improved crop varieties and resilient production strategies to sustain food security in Nigeria. The relevance of cowpea improvement is further strengthened by reports on postharvest deterioration, where *Callosobruchus maculatus* infestation negatively affects the proximate composition and quality of stored cowpea grains (Gabi et al., 2022).

One major limitation to cowpea improvement is its predominantly self-pollinated nature, which narrows genetic variability and reduces the effectiveness of conventional breeding approaches (Boukar et al., 2020). Repeated use of elite parental germplasm in hybridization programmes has further restricted the genetic base of cultivated cowpea. Studies on phenotypic and protein variation among selected cowpea varieties have demonstrated the importance of exploiting existing diversity for nutritional and agronomic improvement (Amusa & Igbari, 2023). Similarly, genetic diversity studies in other legumes such as groundnut have shown that morpho-physiological traits remain useful for identifying promising genotypes for crop improvement (Abdurrasheed et al., 2024). Therefore, broadening genetic variability in farmer-preferred cowpea varieties such as SAMPEA 12, SAMPEA 14, and SAMPEA 19 is essential for future yield improvement.

Mutation breeding provides an effective approach for creating genetic variability in morpho-agronomic traits without altering the entire genome. It is one of the most successful crop improvement techniques and has relatively low ethical and social concerns. According to the FAO/IAEA Mutant Variety Database (2023), about 3,400 officially released crop varieties have been developed through induced mutagenesis. The technique involves the use of physical or chemical mutagens to induce heritable changes, particularly in self-pollinated crops with limited genetic diversity (Fathurrahman et al., 2023). Colchicine ($C_{22}H_{25}NO_6$) is an alkaloid widely used to induce polyploidy in plants by disrupting spindle fibre formation during metaphase, thereby causing chromosome doubling (Singh et al., 2025). Such changes may increase cell size, enhance vegetative growth, and improve yield-related traits. Recent evidence from sesame showed that colchicine can significantly influence growth and yield traits across $M_1$ and $M_2$ generations (Nura & Muhammad, 2025), supporting its relevance in crop improvement. In cowpea, however, the dose-dependent response of improved SAMPEA varieties to colchicine remains insufficiently documented. This knowledge gap is important because these varieties are elite farmer-preferred cultivars in Nigeria. Inducing novel variability within adapted backgrounds could provide a rapid pathway for developing superior lines while retaining desirable parental traits. Therefore, this study evaluated the effects of colchicine treatment on the growth and yield traits of selected improved SAMPEA cowpea varieties.

## MATERIALS AND METHOD

### Experimental site

The study 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). The study was conducted during the 2024/2025 growing season and had an average daily temperature that ranged from 22°C to 32°C, with total rainfall of approximately 850 mm.

### Sources of seed and colchicine

Seeds of three cowpea varieties (SAMPEA 12, SAMPEA 14, and SAMPEA 19) were obtained from the Institute for Agricultural Research (IAR), Ahmadu Bello University, Zaria. Colchicine mutagen with purity ≥95%, catalog number C9754, Sigma-Aldrich, USA, was purchased from Haddis International, Samaru, Zaria.

### Seed treatment

Seeds of each variety were pre-soaked in distilled water for four hours, then treated with four colchicine concentrations (0.1, 0.5, 1.0, and 2.0 mM) for five hours at room temperature. The controls were soaked in distilled water for five hours. For each replicate, fifteen seeds per variety per concentration were used. After treatment, all seeds were thoroughly washed under running tap water to remove residual colchicine and air-dried overnight on Whatman No. 1 filter paper.

### Experimental design

The experiment was arranged in a completely randomized design (CRD) with a factorial arrangement of three cowpea varieties (SAMPEA 11, SAMPEA 14, and SAMPEA 19) and five colchicine concentrations (0.0, 0.1, 0.5, 1.0, and 2.0 mM), replicated three times. Thus, the total number of seeds planted was calculated as: 3 varieties × 5 concentrations × 3 replicates × 15 seeds = 675 seeds. The treated seeds were sown in polythene bags (25 cm × 15 cm) filled with sandy loam soil collected from the Botanical Garden of Ahmadu Bello University, Zaria. Bags were watered daily as needed, and no supplemental irrigation was required during rainy days. Standard cultural practices including thinning (to two plants per bag at two weeks after sowing), weeding, and pest control were applied uniformly to all treatments (Adetula, 2004)

**Data collection**

Emergence and survival: Percentage emergence was recorded at 7 and 14 days after sowing (DAS). Percentage survival was recorded at 30 DAS.

Growth parameters: Plant height (cm) was measured from the soil surface to the apical meristem using a meter rule. The number of leaves per plant was counted manually. Leaf area (cm²) was calculated by measuring the length (L) and maximum width (W) of the third fully expanded leaf from the apex using a ruler, then applying the formula: Leaf area = L × W × 0.75, as described for cowpea by Musa and Usman 2016.

Yield parameters: The number of pods per plant was counted at harvest. Pod length (cm) was measured from the base to the tip of the pod using a ruler. The number of seeds per pod was counted after threshing.

Generation advancement: Seeds harvested from $M_1$ plants were bulked by variety and treatment. These seeds were sown to obtain the $M_2$ generation following the same experimental design. The advancement procedure followed the guidelines described by the International Board for Plant Genetic Resources (IBPGR, 1983)

**Data analysis**

Shapiro-Wilk and Levene's test ($p > 0.05$) were used to check the normality and homogeneity of variance of the data, respectively. Data were analyzed using two-way analysis of variance (two-factor: concentration and variety) with SAS software (Version 9.1; SAS Institute, 2012). Duncan's New Multiple Range Test at the 5% probability level is used to separate the means where significant differences exist

## RESULTS

Residual diagnostics confirmed that the assumptions of normality and homogeneity of variance were met for all parameters, as indicated by non-significant values in the Shapiro–Wilk and Levene's tests ($p > 0.05$).

Table 1 presents the mean squares for the effects of colchicine on the growth and yield traits of three cowpea varieties at the M1 generation. The results revealed highly significant effects ($P < 0.001$) of colchicine concentration on all growth and yield characters evaluated. Similarly, varietal differences were significant ($P < 0.05$) for all measured traits except plant height at maturity, number of leaves, and pod length. Significant interaction effects between varieties and colchicine concentrations were observed for percentage survival, days to 50% flowering, number of seeds per pod, and pod length ($P < 0.05$).

Figure 1 shows the effect of colchicine treatment on the growth and yield performance of SAMPEA 12 at the M1 generation. Significant differences ($P \leq 0.05$) were observed among treatments and 14 DAS (73.33 ± 5.77%), as well as the highest survival rate (68.56 ± 1.53%), plant height at maturity (17.83 ± 1.53 cm), and number of leaves (21.00 ± 1.15). However, the largest leaf area (49.67 ± 6.66 cm²) was observed at 2.0 mM compared with the control treatment. The earliest flowering time (57.00 ± 4.04 days), highest number of pods per plant (20.00 ± 1.11), highest number of seeds per pod (12.67 ± 1.53), and longest pod length (15.00 ± 0.58 cm) were also recorded at 0.1 mM.

Similarly, Figure 2 showed significant differences ($P \leq 0.05$) in the growth and yield performance of SAMPEA 14 at M1. The 0.1 mM treatment recorded the highest percentage emergence at both 7 DAS (86.67 ± 10.00%) and 14 DAS (80.00 ± 6.66%), survival rate (81.34 ± 3.21%), plant height (21.92 ± 4.93 cm), and leaf area (37.33 ± 4.04 cm²). However, the control treatment produced the highest number of leaves (19.33 ± 2.65). The earliest flowering time (59.00 ± 1.00 days), highest number of seeds per pod (10.00 ± 0.58), and greatest pod length (13.33 ± 1.15 cm) were observed at 0.1 mM, whereas the highest number of pods per plant (18.00 ± 2.44) was recorded at 0.5 mM.

Figure 3 revealed significant differences ($P \leq 0.05$) in the growth and yield characteristics of SAMPEA 19 at M1. The highest percentage emergence at 7 DAS (93.33 ± 5.77%), 14 DAS (81.10 ± 4.36%), and survival rate (80.12 ± 4.36%) were obtained at 0.1 mM, while the lowest values were consistently observed at 2.0 mM. Plant height (22.23 ± 1.53 cm) and leaf area (35.33 ± 0.58 cm²) were highest at 0.1 mM, whereas the control treatment produced the highest number of leaves (18.33 ± 6.24). In addition, the 0.1 mM treatment produced the highest number of pods per plant (23.00 ± 2.33) and seeds per pod (12.00 ± 1.00), while delayed flowering (79.00 ± 5.77 days) and the longest pod length (12.67 ± 0.00 cm) were observed at 2.0 mM and 1.0 mM, respectively.

Table 2 presents the mean squares for the effects of colchicine on growth and yield traits at the M2 generation. Highly significant effects ($P < 0.001$) of colchicine concentration were observed for all growth and yield traits. Significant varietal differences ($P < 0.05$) were recorded for all parameters except plant height at maturity, number of leaves, leaf area, and pod length. Furthermore, significant interaction effects between varieties and colchicine concentrations were observed for all traits except plant height at maturity and leaf area.

Table 3 shows the effects of colchicine on growth and yield traits of SAMPEA 12 at M2. Significant differences ($P \leq 0.05$) were observed among treatments. The 0.1 mM colchicine treatment recorded the highest emergence at 7 DAS (93.22 ± 10.11%) and 14 DAS (90.12 ± 8.70%), along with the highest survival rate (79.33 ± 5.43%), which were significantly greater than the control treatment. The same treatment also produced the tallest plants (23.33 ± 0.56 cm) and largest leaf area (49.67 ± 3.23 cm²). The control treatment produced the highest number of leaves (21.00 ± 3.23), although this was not significantly different from the colchicine treatments. The highest pod number (21.12 ± 0.52), seeds per pod (12.00 ± 0.32), and pod length (15.09 ± 0.22 cm) were also recorded at 0.1 mM. Conversely, the longest time to 50% flowering (72.78 ± 5.44 days) was observed at 2.0 mM.

**Table 1: mean sum of square for the effect of colchicine growth and yield of three cowpea varieties at first generation**

| Conc.(mM) | Degree of freedom | 7 DAS (% ) | 14 DAS ( %) | Survival (%) | Height at maturity (cm) | Number of leaves | Leaf area ($cm^2$) | 50% day to flowering | Number of pods per plant | Number of seed per pod | Pod length (cm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Variety** | 2 | 711.02*** | 1298.29*** | 248.16*** | 2.96 | 8.6 | 239.15* | 142.49*** | 52.42*** | 52.42*** | 2.6 |
| **concentration** | 4 | 1244.08*** | 1348.22*** | 3189.26*** | 138.81*** | 185.19*** | 1569.48*** | 391.26*** | 195.50*** | 37.37*** | 59.14*** |
| **Variety* concentration** | 8 | 111.91 | 99.46 | 65.16*** | 5.18 | 5.49 | 89.34 | 56.99*** | 35 | 3.03* | 3.88** |
| **Error** | 30 | 90.62 | 75.38 | 16.91 | 11.11 | 0.62 | 67.95 | 11.64 | 0 | 1.51 | 1.2 |

Key ***= highly significance difference ($p \leq 0.001$) , ** =highly significance difference ($p \leq 0.01$) and * = significance difference ($p \leq 0.05$)

**Table 2: mean sum of square for the effect of colchicine growth and yield of three cowpea varieties at second generation**

| Conc.(mM) | Degree of freedom | 7 DAS (%) | 14 DAS (%`) | Survival (%) | Height at maturity (cm) | Number of leaves | Leaf area ($cm^2$) | 50% day to flowering | Number of pods per plant | Number of seed per pod | Pod length (cm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Variety | 2 | 950.42*** | 199.27*** | 150.69*** | 2.96 | 0.82 | 54.58 | 142.49*** | 108.96*** | 145.09*** | 1.09 |
| concentration | 4 | 2050.86*** | 1918.17*** | 1762.30*** | 124.14*** | 69.97*** | 593.49*** | 103.44*** | 103.4*** | 36.36*** | 41.24*** |
| Variety* concentration | 8 | 61.26*** | 139.93*** | 96.46*** | 8.84 | 15.02*** | 17.72 | 56.99*** | 42.84*** | 10.26*** | 3.98** |
| Error | 30 | 8.56 | 9.98 | 10.74 | 9.96 | 2.78 | 23.17 | 11.64 | 0.38 | 1.36 | 1.27 |

Key ***= highly significance difference ($p \leq 0.001$) , ** =highly significance difference ($p \leq 0.01$) and * = significance difference ($p \leq 0.05$)

**Table 3 effects of colchicine on growth and yield traits of SAMPEA 12 at M2.**

| Conc.(mM) | 7 DAS (%) | 14 DAS (%`) | Survival (%) | Height at maturity (cm) | Number of leaves | Leaf area (cm$^2$) | 50% day to flowering | Number of pods per | Number of seed per pod | Pod length (cm) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 57.12±5.69$^{d}$ | 50.18±4.34$^{d}$ | 61.34±5.56$^{c}$ | 15.67±0.12$^{e}$ | 21.00±3.23$^{a}$ | 26.33±1.21$^{d}$ | 65.78±2.12$^{b}$ | 16.01±0.89$^{d}$ | 10.23±0.12$^{c}$ | 15.00±0.33$^{a}$ |
| 0.1 | 93.22±10.11$^{a}$ | 90.12±8.70$^{a}$ | 79.33±5.43$^{a}$ | 23.33±0.56$^{a}$ | 14.33±0.21$^{a}$ | 49.67±3.23$^{a}$ | 59.76±1.23$^{d}$ | 21.12±0.52$^{a}$ | 12.00±0.32$^{a}$ | 15.09±0.22$^{a}$ |
| 0.5 | 86.67±9.89$^{b}$ | 80.96±7.90$^{b}$ | 74.56±7.89$^{b}$ | 18.67±1.11$^{c}$ | 10.33±2.12$^{a}$ | 34.33±2.12$^{c}$ | 61.45±8.12$^{c}$ | 20.19±2.12$^{b}$ | 11.19±1.12$^{b}$ | 12.56±0.11$^{b}$ |
| 1 | 60.00±6.56$^{c}$ | 57.14±6.67$^{c}$ | 70.98±6.67$^{b}$ | 21.67±0.34$^{b}$ | 12.33±0.34$^{a}$ | 35.27±1.21$^{b}$ | 65.12±7.12$^{b}$ | 18.17±1.23$^{c}$ | 10.61±0.12$^{c}$ | 10.15±0.67$^{c}$ |
| 2 | 60.00±3.67$^{c}$ | 45.90±6.56$^{e}$ | 62.38±8.78$^{c}$ | 17.67±0.56$^{d}$ | 14.00±2.12$^{a}$ | 32.00±2.13$^{c}$ | 72.78±5.44$^{a}$ | 16.34±2.33$^{d}$ | 8.67±0.12$^{d}$ | 8.17±0.12$^{d}$ |
| P-Value | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

NB: Means ± standard error with the same superscript(s) down a column for each variety are not significantly different ($p \leq 0.05$). Conc = Concentration.

**Table 4: Effects of colchicine on growth and yield traits of SAMPEA 14 at M2.**

| Conc.(mM) | 7 DAS (%) | 14 DAS (%`) | Survival (%) | Height at maturity (cm) | Number of leaves | Leaf area (cm$^2$) | 50% day to flowering | Number of pods per plant | Number of seed per pod | Pod length (cm) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 53.33±6.67$^{e}$ | 47.78±4.89$^{e}$ | 50.67±6.78$^{e}$ | 17.33±0.67$^{d}$ | 19.33±3.12 | 22.12±3.45$^{e}$ | 64.00±11.12$^{a}$ | 11.89±0.88$^{d}$ | 7.67±0.56$^{c}$ | 9.00±0.12$^{d}$ |
| 0.1 | 86.67±9.89$^{a}$ | 80.98±8.80$^{a}$ | 83.23±5.67$^{a}$ | 25.00±0.67$^{a}$ | 16.00±0.34$^{a}$ | 39.87±4.12$^{a}$ | 59.00±8.19$^{d}$ | 14.89±0.34$^{b}$ | 11.12±0.45$^{a}$ | 15.00±2.12$^{a}$ |
| 0.5 | 80.00±7.86$^{b}$ | 74.57±6.67$^{b}$ | 76.97±2.00$^{b}$ | 23.00±1.10$^{b}$ | 10.00±0.75$^{a}$ | 32.34±3.23$^{b}$ | 62.67±5.23$^{c}$ | 13.00± 0.23$^{c}$ | 9.33±0.34$^{b}$ | 14.67± 0.89$^{b}$ |
| 1 | 73.33±5.56$^{c}$ | 68.94±3.49$^{c}$ | 70.75±11.45$^{c}$ | 21.00±2.13$^{c}$ | 11.33±0.34$^{a}$ | 28.19±2.32$^{c}$ | 62.67±9.25$^{c}$ | 19.12±0.89$^{a}$ | 7.60±0.34$^{c}$ | 14.33±0.34$^{b}$ |
| 2 | 60.23±5.13$^{d}$ | 60.00±5.67$^{d}$ | 60.12±0.98$^{d}$ | 14.33±0.34$^{e}$ | 14.33±0.78$^{a}$ | 26.00±1.12$^{d}$ | 63.00±8.13$^{b}$ | 10.00±0.12$^{e}$ | 4.00±0.34$^{d}$ | 10.00±0.45$^{c}$ |
| P-Value | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

NB: Means ± standard error with the same superscript(s) down a column for each variety are not significantly different ($p \leq 0.05$). Conc = Concentration,

**Table 5: Effects of colchicine on growth and yield traits of SAMPEA 19 at M2.**

| Conc.(mM) | 7 DAS (%) | 14 DAS (%) | Survival (%) | Height at maturity (cm) | Number of leaves | Leaf area ($cm^2$) | 50% day to flowering | Number of pods per plant | Number of seeds per pod | Pod length (cm) |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | $66.67\pm4.78^{c}$ | $62.23\pm7.32^{d}$ | $60.00\pm1.33^{c}$ | $10.12\pm0.49^{d}$ | $18.33\pm1.23^{a}$ | $21.89\pm0.12^{d}$ | $66.90\pm2.12^{c}$ | $10.00\pm2.12^{e}$ | $10.00\pm0.55^{d}$ | $9.00\pm0.54^{c}$ |
| 0.1 | $96.67\pm8.78^{a}$ | $85.67\pm4.56^{a}$ | $87.78\pm5.33^{a}$ | $25.33\pm1.12^{a}$ | $11.3\pm0.543^{a}$ | $37.33\pm4.23^{a}$ | $55.9\pm 6.67^{e}$ | $27.00\pm0.67^{a}$ | $16.67\pm0.89^{a}$ | $12.67\pm0.56^{a}$ |
| 0.5 | $95.00\pm6.76^{b}$ | $81.65\pm2.33^{b}$ | $85.43\pm6.78^{a}$ | $20.00\pm0.51^{b}$ | $12.00\pm0.45^{a}$ | $33.34\pm2.34^{b}$ | $57.67\pm6.79^{d}$ | $22.00\pm0.12^{b}$ | $16.00\pm0.34^{a}$ | $12.13\pm1.22^{a}$ |
| 1 | $86.67\pm9.45^{c}$ | $78.34\pm3.34^{c}$ | $75.00\pm5.43^{b}$ | $18.67\pm0.45^{c}$ | $10.33\pm0.89$ | $26.83\pm1.23^{c}$ | $72.88\pm12.11^{b}$ | $18.00\pm1.22^{c}$ | $14.67\pm0.12^{b}$ | $11.30\pm 1.44^{b}$ |
| 2 | $73.33\pm5.67^{d}$ | $67.23\pm0.90^{d}$ | $55.67\pm4.33^{d}$ | $18.67\pm0.34^{c}$ | $13.00\pm0.67^{a}$ | $21.33\pm1.23^{d}$ | $79.00\pm10.12^{a}$ | $15.00\pm2.33^{d}$ | $12.00\pm 0.56^{c}$ | $11.17\pm 0.12^{b}$ |
| P-Value | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

NB: Means ± standard error with the same superscript(s) down a column for each variety are not significantly different ($p\leq0.05$). Conc = Concentration,

Table 4 shows the effects of colchicine on SAMPEA 14 at M2. The highest emergence percentages at 7 DAS (86.67 ± 9.89%) and 14 DAS (80.98 ± 8.80%), as well as the highest survival rate (83.23 ± 5.67%), were recorded at 0.1 mM. Similarly, this treatment produced the maximum plant height (25.00 ± 0.67 cm) and leaf area (39.87 ± 4.12 $cm^2$). The highest number of leaves was observed in the control treatment (19.33 ± 3.12). Early flowering (59.00 ± 8.19 days), highest seed number per pod (11.12 ± 0.45), and greatest pod length (15.00 ± 2.12 cm) were also observed at 0.1 mM, while the highest pod number per plant (19.12 ± 0.89) was similarly recorded under this treatment

Table 5 presents the effects of colchicine on SAMPEA 19 at M2. A similar trend was observed, with the 0.1 mM treatment producing the highest emergence at 7 DAS (96.67 ± 8.78%) and 14 DAS (85.67 ± 4.56%), along with the highest survival rate (87.78 ± 5.33%). The tallest plants (25.33 ± 1.12 cm) and largest leaf area (37.33 ± 4.23 $cm^2$) were also observed at 0.1 mM, while the control treatment produced the highest number of leaves (11.00 ± 0.54). Furthermore, the 0.1 mM treatment resulted in the highest pod number (27.00 ± 0.67), seeds per pod (16.67 ± 0.89), and pod length (12.67 ± 0.56 cm), all of which were significantly higher than the control treatment. The longest duration to 50% flowering (79.00 days) was recorded at 2.0 mM.

## DISCUSSION

In the present study, colchicine treatment significantly influenced growth and yield traits of the evaluated cowpea genotypes, with responses strongly dependent on concentration level. Induced polyploidization can cause desirable changes to the morphology, anatomy, physiology, and genomic makeup of crop species, as this technique serves as a viable alternative to genetic engineering (Miller *et al.,* 2021; Xu *et al.,* 2022). The mild colchicine treatment stimulates plant physiology, metabolic and enzyme activities, which aid early emergence and seedling vigor. These agreed with the work of Essel *et al.* (2015) and Sahrish *et al.*(2019) that the lowest colchicine accelerated percentage germination and survival rate in cowpea.

The progressive decline in percentage emergence and survival rate as colchicine concentrations increased may be due to the toxic effects, likely disrupting biological pathways essential for normal seed germination, which inhibit the process. This agrees with several researchers, including Ati and Shehu (2023) and Nyam *et al.*(2024), who reported a linear association between higher mutagen doses and reduced seed germination.

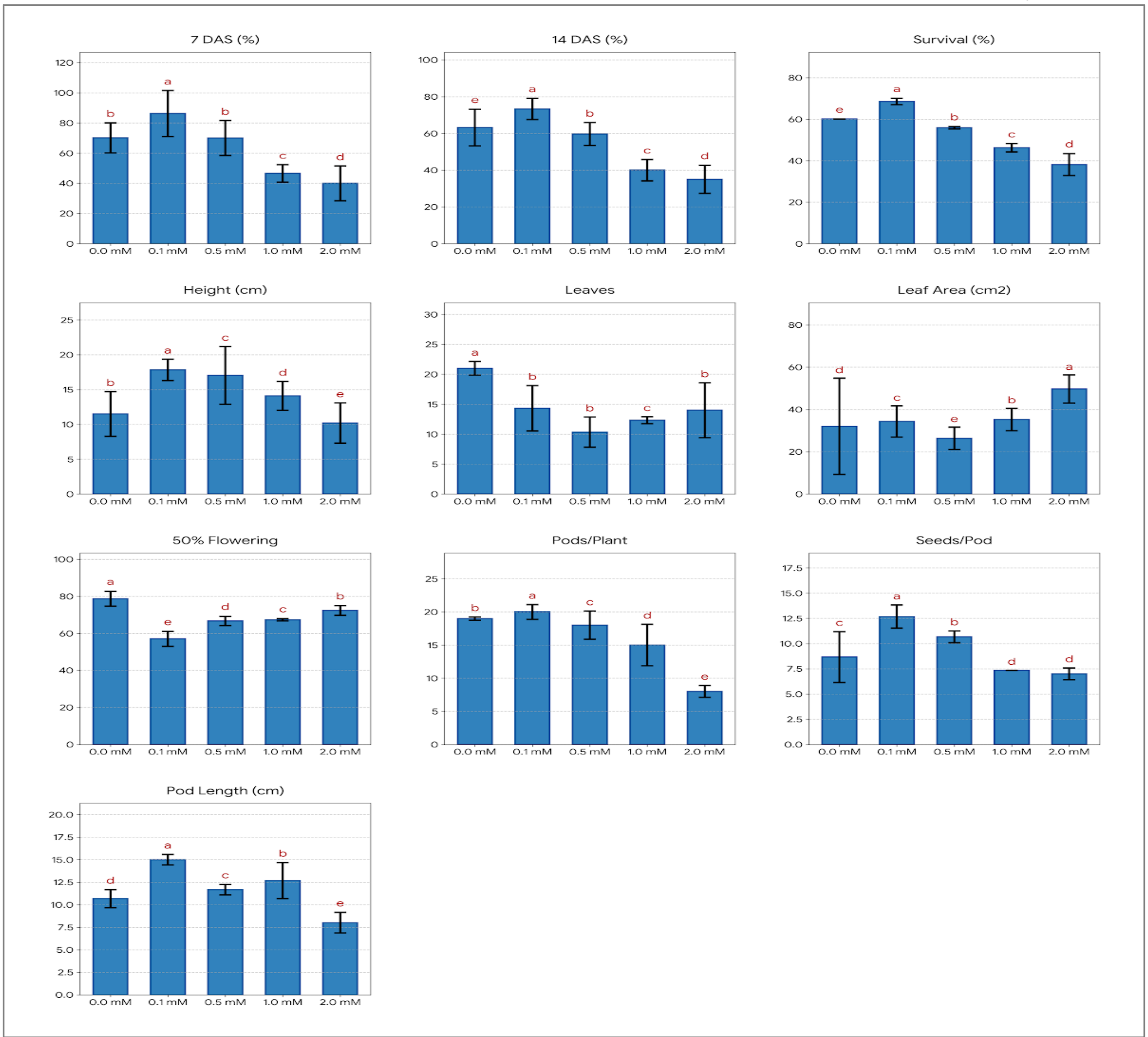


**Figure 1: effect of colchicine treatment on the growth and yield performance of SAMPEA 12 at the M1 generation. NB: Means ± standard error with the same superscript(s) down a column for each variety are not significantly different ($p$≤0.05). Conc = Concentration,**

The enhancement of vegetative traits such as plant height and leaf area may be due to chromosomal doubling, which enhanced phyto-hormonal stimulation leading to an increase in cell division rate, elongation, and expansion. These agreed with Mangena and Mushadu's (2023), who report that the increase in the number of chromosomes as a result of colchicine-induced polyploidization enhanced the sizes of morphological characters, such as larger leaves, flowers, and seeds in cowpea. However, chromosome doubling was not cytologically confirmed in the present study; therefore, this explanation remains tentative. Similar increases in vegetative growth following mild mutagen treatment were reported by Mohite and Gurav (2019) in okra. This may actually be a useful trait for breeding; it has the potential to increase vegetable components such as plant height and leaf area, which may directly lead to an increase in photosynthetic assimilates going into grains, and has a positive effect on seed yield (Priya, 2006; Ajayi *et al.,* 2014). Improvement in the vegetable trait has proved successful with colchicine treatment-induced cowpea (Mangena & Mushadu, 2023) and sesame (Nura and Muhammad, 2025). The reduction in growth observed with an increase in the concentration is linked to chromosomal abnormalities, reduction in auxin levels, inhibition of auxin synthesis, and failure of assimilation mechanisms (Ajayi *et al.*, 2014).

Earlier flowering in cowpea under selected colchicine treatments may indicate altered hormonal balance or accelerated developmental signaling pathways. Nura (2014) similarly reported earlier flowering in colchicine-treated cowpea lines. However, delayed flowering has also been reported in other species (Essel *et al.,* 2015). These suggest that the flowering response depends on genotype, dose level, and environmental conditions. The delay in flowering is direct correlation with increased treatment. This has been observed by many workers (Jagajananthan *et al.,* 2013; Benke *et al.,* 2019).

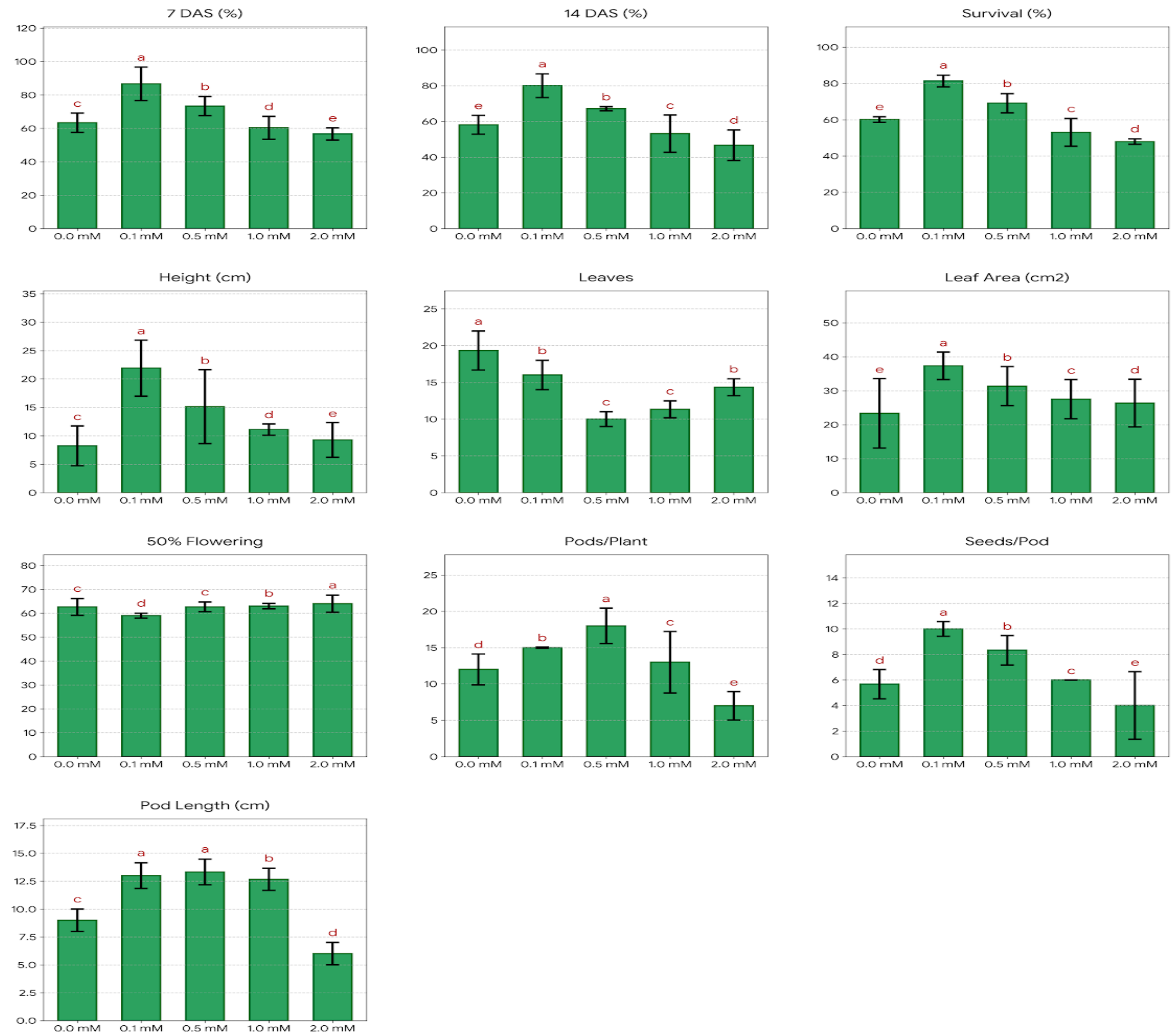


**Figure 2: Effect of colchicine treatment on the growth and yield performance of SAMPEA 14 at the M1 generation. NB: Means ± standard error with the same superscript(s) down a column for each variety are not significantly different ($p \leq 0.05$). Conc = Concentration,**

Yield improvement under optimal colchicine levels, particularly increased pod number, pod length, and seed number, demonstrates the agronomic potential of controlled mutagen application. These findings agree with Fathurrahman *et al.* (2023), who found that colchicine treatments increase pod production and seed number compared to the control. Similar studies have shown that colchicine and EMS concentrations between 0.01% and 0.09% can improve yield attributes in crops (Fathurrahman *et al.,* 2023). These genetic alterations enhance plant growth and yield by influencing the number of pods, seed weight, and related parameters (Yadav *et al.,* 2021; Ajayi *et al.,* 2014). Kumar *et al.*(2009) and Ramya *et al.* (2014) explained that such reductions may result from enzymatic inhibition and mutagen toxicity, leading to physiological and biochemical disturbances during plant development.

Ploidy induction instantaneously leads to the formation of new genomic structures, where the individual offspring may become ecologically and epigenetically unique from their diploid counterparts (Yadav *et al.,* 2021). This provides new lineages upon which further selection and breeding can be carried out for the development of newly improved varieties.

## CONCLUSION AND RECOMMENDATION

Colchicine treatment induced positive genetic variability in the growth and yield traits of the three improved cowpea varieties. The optimal concentration was 0.1 mM, which consistently produced the highest values for emergence, survival, plant height, pod number, and seed yield across both $M_1$ and $M_2$ generations. At this concentration, pod number per plant increased from 10.0 to 27.0 in SAMPEA 19, 12.0 to 21.1 in SAMPEA 12 and 12.0 to 14.9 in SAMPEA 14 compared to the controls. SAMPEA 19 was the most responsive variety, showing the greatest improvements in most yield-related traits, while SAMPEA 14 was the least responsive.

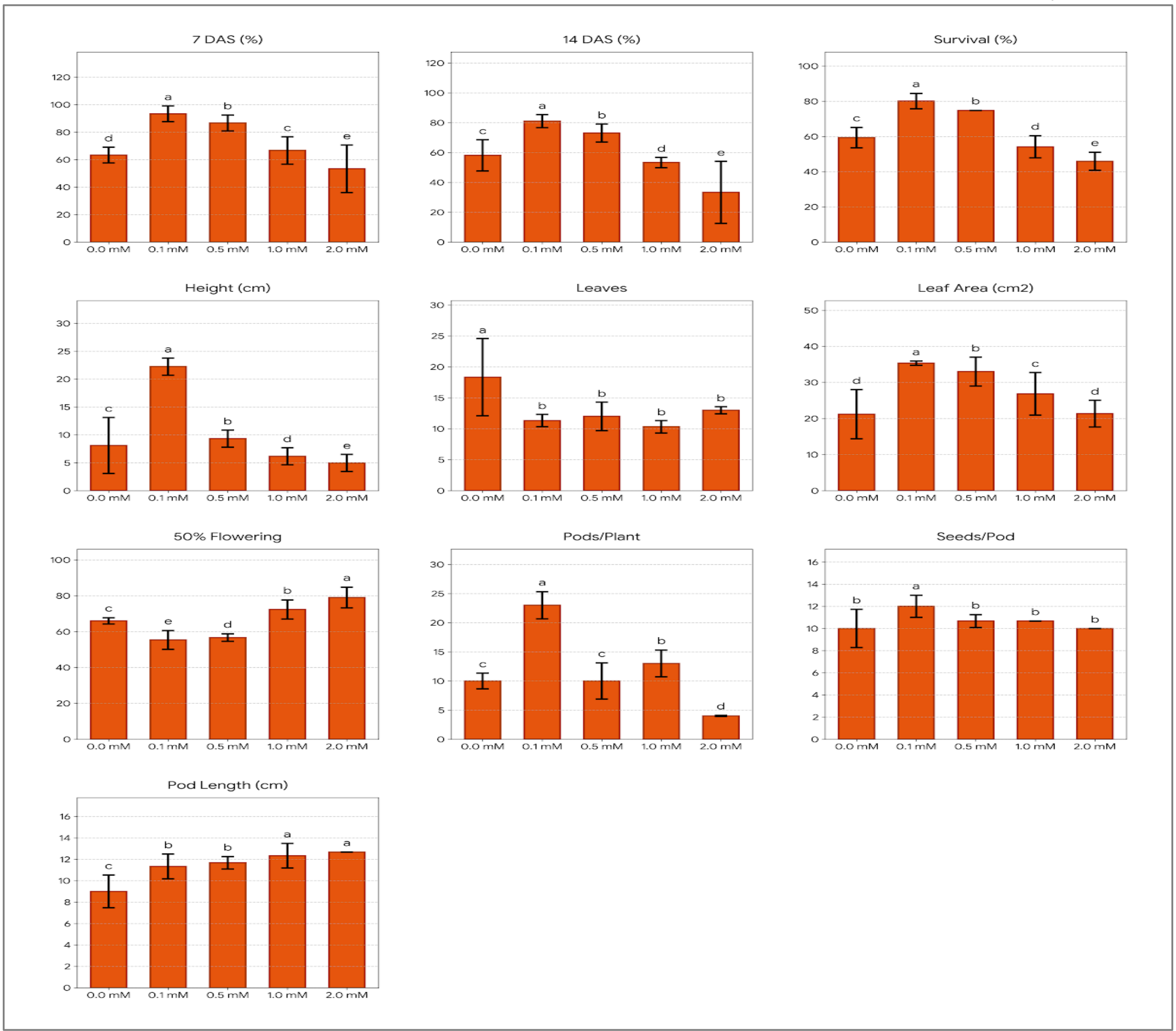


**Figure 3 effect of colchicine treatment on the growth and yield performance of SAMPEA 19 at the M1 generation. NB: Means ± standard error with the same superscript(s) down a column for each variety are not significantly different ($p$≤0.05). Conc = Concentration,**

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