**Original Research Article**

**Influence of Gibberellic Acid (GA3) and Benzyladenine (BA) on Growth Dynamics, Floral Development, and Bulb Formation in L.A. Hybrid Lilium Cultivar Under Poly House Conditions**

**ABSTRACT**

The present study investigated the influence of GA3 and BA on the growth dynamics, floral development, and bulb formation in the L.A. Hybrid Lilium cultivar under polyhouse conditions at the Horticulture Research Farm, SHUATS, Prayagraj, during the period November 2024 to March 2025. A Randomized Block Design (RBD) with nine treatments and three replications was employed to evaluate a range of morphological, physiological, and economic parameters. GA3 and BA were applied as foliar sprays at 30 and 45 days after planting. Among the treatments, T5 (GA3 100 ppm & BA 100 ppm) recorded the greatest vegetative growth with the highest number of leaves (115.55) and maximum plant height (117.13 cm). In contrast, T3 (BA 100 ppm alone) achieved the largest stem diameter (5.89 mm). T6 (GA3 100 ppm & BA 200 ppm) excelled in several critical parameters, including the highest chlorophyll content (80.18 SPAD units), earliest bud initiation (47.67 days), longest flower bud length (11.22 cm), highest number of bulblets per plant (4.67), greatest bulb weight (45.05 g per plant), and maximum bulb yield (20.72 kg per 200 m²). Furthermore, T8 (GA3 150 ppm & BA 200 ppm) emerged as the top performer in enhancing floral characteristics. This treatment resulted in the longest time to first flowering (84.67 days), produced the highest number of buds per plant (8.86), maximum flower diameter (39.34 cm), extended flower longevity (self life of 11.33 days and vase life of 8.67 days), and the largest number of flowers recorded both per plant (8.86) and per 200 m² (39,392.55). Economically, T8 delivered the most favorable outcomes with a gross return of Rs. 666,600, a net return of Rs. 500,380.12 per 200 m², and a benefit-cost (B:C) ratio of 3.01 from flower production.

*Key words: L. A Hybrid Lilium, GA3, BA, Growth, Flowering, Bulb Yield*

**1. INTRODUCTION**

The genus Lilium, belonging to the family Liliaceae, comprises approximately 80 species and thousands of cultivars, positioning it as a pivotal crop in global commercial cut flower production (Singh and Sisodia, 2017). Revered for its symbolism embodying beauty, grace, innocence, hope, and life, Lilium consistently ranks among the top ten premium cut flowers worldwide. Netherlands stands as a major contributor to the global floriculture industry, where Lilium is recognized as the fourth most important cut flower crop. Among its various groups, LA (Longiflorum × Asiatic) hybrids are especially favored for their robust growth, prolific flowering, vivid colours, and subtle fragrance (Mahesh et al., 2023). Moreover, the acropetal pattern of flower development in lilies and the critical influence of bulb size on bloom quantity highlight key aspects of their reproductive biology.

Plant growth regulators (PGRs) have been extensively employed in floriculture to manipulate plant growth, enhance flowering, and improve overall quality (Sankar et al., 2024). These effects of PGRs are influenced by species, concentration, timing, application method, and environmental conditions. Among the numerous growth regulators available, gibberellic acid (GA3) and benzyladenine (BA) have shown considerable impact in various ornamental crops (Singh, 2003a, 2003b; Singh, 2005; Yadav et al., 2014). For example, GA3 has been documented to enhance stem height, leaf number, leaf area, shoot dry weight, and flower diameter in *Gladiolus grandiflorus* (chandel et al., 2022), whereas BA a synthetic cytokinin has been found to stimulate cellular division, delay senescence, and increase the number of scales and leaves in *Lilium longiflorum* (Singh et al., 2018).

Given the commercial significance of L.A. hybrid Lilium and the promising potential of PGRs to boost plant performance, the present study was undertaken to evaluate the influence of GA3 and BA on the growth dynamics, floral development, and bulb formation in the L.A. Hybrid Lilium cultivar under polyhouse conditions.

**2. MATERIALS AND METHODS**

The experiment was conducted during the 2024 season at the Horticulture Research Farm, Department of Horticulture, SHUATS, Prayagraj. The site is located in the subtropical zone of the Indo-Gangetic Plains at 25.45°N latitude and 81.84°E longitude, with an elevation of 98 meters (322 feet) above sea level. The study was performed under protected conditions in a naturally ventilated polyhouse measuring approximately 20 m in length by 10 m in width, covering a total area of 200 m². A Randomized Block Design (RBD) was used, comprising nine treatment combinations with three replications each. The treatments included:

T0. Control

T1. GA3 at 100 ppm

T2. GA3 at 150 ppm

T3. BA at 100 ppm

T4. BA at 200 ppm

T5. GA3 at 100 ppm & BA at 100 ppm

T6. GA3 at 100 ppm & BA at 200 ppm

T7. GA3 at 150 ppm & BA at 100 ppm

T8. GA3 at 150 ppm & BA at 200 ppm

Lilium bulbs were planted in flat beds after amending the soil with 5 kg of vermicompost, 10 kg of farmyard manure (FYM), and 1 kg of neem cake per bed to enhance fertility and structure. Healthy, disease-free bulbs were selected and pre-treated in a Bavistin solution (2 g/L) for one hour. Bulbs were then planted using a spacing of 30 × 45 cm, followed by light irrigation. Throughout the active vegetative phase, particularly during the emergence of new leaves, appropriate irrigation was maintained to ensure optimal soil moisture.

A water-soluble fertilizer (NPK 19:19:19) was applied as a foliar spray at 2 g/L twice weekly to promote growth. Foliar applications of GA3 and BA were administered at the designated concentrations, 30 and 45 days after planting, according to the treatment schedule.

Data collection involved randomly selecting three plants per treatment replication. Growth parameters were recorded at 20-day intervals (20, 40, 60, and 80 days after planting), while floral attributes, quality, bulb characteristics, and yield parameters were measured at harvest. The data were subsequently subjected to statistical analysis to ascertain the significance of treatment effects.

**3. RESULTS AND DISCUSSION**

The influence of GA3 and BA on the growth dynamics, floral development, and bulb formation in the L.A. Hybrid Lilium cultivar is summarized in Tables 1 to 4. The combined application of these plant growth regulators (PGRs) induced significant improvements across several attributes, indicating a promising synergistic effect.

**3.1 Growth Parameters**

**3.1.1 Number of Leaves per Plant** After 80 days, the highest leaf count (115.55) was recorded in T5 (GA3 100 ppm & BA 100 ppm), with T8 (GA3 150 ppm & BA 200 ppm) closely following at 108.22 leaves. In contrast, T3 (BA 100 ppm) exhibited the fewest leaves (98.44). The observed enhancement in leaf production can be attributed to GA3 stimulating active cell division at the shoot apex and BA enhancing meristematic activity and delaying senescence. These findings align with (Singh et al., 2018), who reported improved vegetative parameters in liliums with combined PGR treatments.

**3.1.2 Plant Height (cm)** T5 treatment led to the tallest plants at 117.13 cm, followed by T2 (GA3 150 ppm) at 104.41 cm, while control plants reached only 92.95 cm. GA3’s role in promoting cell elongation and internodal growth, supported by BA’s effect on maintaining growth regions, appears pivotal for the observed height differences. These findings are in agreement with the results of (Jayashree et al., 2020 and Sharma et al., 2024), whose studies concluded that GA₃, especially in combination with BA, significantly promotes plant height by stimulating internodal elongation.

**3.1.3 Stem Diameter (mm)** The largest stem diameter was achieved by T3 (BA 100 ppm) at 5.89 mm, with T6 (GA3 100 ppm & BA 200 ppm) recording 5.68 mm, and T2 (GA3 150 ppm) showing the smallest at 4.90 mm. BA’s ability to enhance cell proliferation in the cambial region likely underlies these variations. This observation aligns with the findings of (Emami et al., 2011 and Singh et al., 2018) in Lilium.

**3.1.4 Chlorophyll Content (SPAD Value)** Maximum chlorophyll content (80.18) was noted in T6, followed by T8 (78.25); the lowest value (70.30) was observed in T2. The improved chlorophyll levels under combined treatments suggest that BA promotes chloroplast development and delays senescence, while GA3 enhances leaf expansion and efficient nutrient translocation. Similar results have been reported by (Singh et al., 2018, Jayashree et al., 2020) in Lilium, and (Sharma et al., 2024) in Gladiolus.

**Table 1 Effect of different concentrations of GA3 and BA on growth parameters of Lilium**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Treatments | Number of Leaves | Plant Height (cm) | Stem Diameter (mm) | Chlorophyll Content (SPAD Value) |
| T0 - Control | 102.11 | 92.95 | 5.09 | 71.2 |
| T1 – GA3 @ 100 ppm | 106.89 | 103.37 | 5.26 | 72.11 |
| T2 – GA3 @ 150 ppm | 101.00 | 104.41 | 4.9 | 70.3 |
| T3 – BA @100 ppm | 98.44 | 103.11 | 5.89 | 73.81 |
| T4 – BA @ 200 ppm | 102.89 | 97.32 | 5.63 | 71.25 |
| T5 – GA3 100 ppm & BA 100 ppm | 115.55 | 117.13 | 5.27 | 76.53 |
| T6 – GA3 100 ppm & BA 200 ppm | 104.55 | 101.7 | 5.68 | 80.18 |
| T7 – GA3 150 ppm & BA 100 ppm | 105.77 | 94.82 | 5.19 | 72.13 |
| T8 – GA3 150 ppm & BA 200 ppm | 108.22 | 97 | 5.76 | 78.25 |
| F- Test | S | S | S | S |
| SE.d | 3.89 | 6 | 0.29 | 6 |
| CD(5%) | 8.24 | 12.73 | 0.62 | 12.72 |
| CV | 4.53 | 7.26 | 6.61 | 9.93 |

**3.2 Floral Parameters**

**3.2.1 Days to Bud Initiation** The earliest bud initiation occurred in T6 at 47.67 days, with T8 nearly identical at 48.33 days, whereas T1 (GA3 100 ppm) delayed bud initiation (52.33 days). The reduced duration is likely due to GA3-induced cell elongation combined with BA’s support in nutrient mobilization and meristematic activity. These findings are in line with (Kapri et al., 2018) who reported earlier flowering with combined GA₃ and BA treatments in liliums.

**3.2.2 Days to First Flower Opening** The shortest time to flower opening was recorded in T8 (84.67 days) and T7 (85.00 days), compared to a prolonged period of 88.30 days in T1. A higher GA3 concentration coupled with BA appears to accelerate floral organ maturation. This trend supports findings by (Kapri et al., 2018) in lilium.

**3.2.3 Number of Buds per Plant** T8 resulted in the highest number of buds per plant (8.86), followed by T7 (8.22), whereas control plants had only 6.66 buds. The increased bud production is attributed to the enhanced floral meristem activity induced by the combined hormone application.

**3.2.4 Flower Bud Length (cm)** Maximum bud length was observed in T6 (11.22 cm), followed by T4 (BA 200 ppm, 10.28 cm), with T0 (control) at 9.93 cm. Enhanced cell elongation in the developing buds under GA3, supported by BA’s role in cell division, accounts for this increase. These findings align with (Kapri et al., 2018) who reported similar enhancements in bud dimensions with GA₃ and BA applications.

**3.2.5 Diameter of Fully Opened Flower (cm)** The largest fully opened flower diameter was noted in T8 (39.34 cm) and T6 (37.17 cm), with the control group recording a significantly smaller diameter (34.73 cm). This enlargement of floral organs is likely due to GA3-enhanced cell expansion and BA-driven assimilate accumulation.

**Table 2** **Effect of different concentrations of GA3 and BA on floral parameters of Lilium**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Treatments | Days taken to bud initiation | Days taken to first flower to open | Number of buds per plant | Flower bud length (cm) | Diameter of fully opened flower (cm) |
| T0 - Control | 50.33 | 86.33 | 6.66 | 9.93 | 34.73 |
| T1 – GA3 @100 ppm | 52.33 | 88.33 | 6.89 | 10.06 | 35.28 |
| T2 – GA3 @150 ppm | 49.33 | 85.33 | 7.44 | 10.16 | 35.75 |
| T3 – BA @100 ppm  | 51.67 | 87.33 | 7.33 | 10.24 | 34.90 |
| T4 – BA @200 ppm | 48.67 | 85.67 | 6.88 | 10.28 | 34.85 |
| T5 – GA3 100 ppm & BA 100 ppm | 48.67 | 85.33 | 7.77 | 10.24 | 36.04 |
| T6 – GA3 100 ppm & BA 200 ppm  | 47.67 | 85.87 | 7.66 | 11.22 | 37.17 |
| T7 – GA3 150 ppm & BA 100 ppm | 48.67 | 85.00 | 8.22 | 9.97 | 36.56 |
| T8 – GA3 150 ppm & BA 200 ppm | 48.33 | 84.67 | 8.86 | 9.85 | 39.34 |
| F- Test | S | S | S | S | S |
| SE.d | 1.36 | 0.99 | 0.62 | 0.35 | 1.21 |
| CD(5%) | 2.88 | 2.11 | 1.13 | 0.74 | 2.56 |
| CV | 3.35 | 1.42 | 10.04 | 4.18 | 4.11 |

**3.3 Quality Parameters**

**3.3.1 Self-Life (Days)** Flowers from T8 maintained the longest shelf life (11.33 days), followed by those from T6 (10.33 days), while control flowers had a markedly shorter self-life (7.00 days). The extended longevity is ascribed to GA3’s role in maintaining turgidity and BA’s inhibition of ethylene biosynthesis.

**3.3.2 Vase Life (Days)** Consistent with shelf-life, the longest vase life was observed in T8 (8.67 days) and T6 (7.67 days), compared to 5.67 days in the control. BA and GA3 together help preserve flower freshness by balancing water uptake and delaying cellular degradation. These findings align with (Singh et al., 2018), who reported that GA₃ and BA treatments extended vase life by improving water retention and delaying flower senescence.

**3.4 Bulb Parameters**

**3.4.1 Number of Bulblets per Plant** T6 treatment produced the maximum number of bulblets (4.67 per plant), with T8 showing 3.67, while control plants developed only 1.33 bulblets. The synergistic effects of GA3 and BA promote active cell division and shoot initiation, enhancing vegetative propagation.

**3.4.2 Weight of Bulbs per Plant (g)** Bulb weight peaked in T6 (45.05 g), with T7 (42.11 g) being the next highest, and the control registering only 31.78 g. This suggests that GA3 improves cell enlargement and assimilate mobilization, complemented by BA-enhanced vigor and differentiation. These observations are supported by (Singh et al., 2018) reported enhanced bulb weight and size with combined GA₃ and BA treatments due to improved physiological and morphological responses in Lilium.

**3.5 Yield Parameters**

**3.5.1 Number of Flowers per Plant** The greatest number of flowers per plant was recorded in T8 (8.86), followed by T7 (8.22), and the lowest in the control (6.66). Enhanced floral induction under GA3, coupled with BA’s support of flower initiation, is responsible for this outcome.

**3.5.2 Number of Flowers per 200 m²** Yield per area reached a maximum in T8 (39,392.55 flowers), followed by T7 (36,518.48), while the control yielded 29,614.78 flowers per 200 m². GA₃ improves floral differentiation and nutrient transport, while BA supports flower initiation through increased meristematic activity.

**3.5.3 Bulb Yield per 200 m²** T6 achieved the highest bulb yield (20.72 kg), with T8 yielding 16.28 kg compared to a minimal yield of 5.92 kg from control plots. This demonstrates the effective enhancement of storage organ development undercombined GA3 and BA treatments. Higher bulb yield is attributed to GA₃ induced cell elongation and BA enhanced shoot and bulblet formation, consistent with (Singh et al., 2018 and Jayashree et al., 2020) in Lilium.

**Table 3 Effect of different concentrations of GA3 and BA on quality, bulb and yield parameters of Lilium**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Treatments | Self life (days) | Vase life (days) | Number of bulblets per plant | Weight of bulbs per plant (g) | Number of flowers per plant | Number of flowers per 200 m2 | Yield of bulbs per 200 m2 (kg) |
| T0 - Control | 7.00 | 5.67 | 1.33 | 31.78 | 6.66 | 29614.78 | 5.92 |
| T1 – GA3 @ 100 ppm | 7.33 | 6.67 | 1.67 | 35.11 | 6.89 | 30607.38 | 7.40 |
| T2 – GA3 @ 150 ppm | 7.67 | 7.33 | 2.00 | 36.77 | 7.44 | 33066.63 | 8.88 |
| T3 – BA @100 ppm | 9.33 | 6.67 | 2.33 | 35.39 | 7.33 | 32577.74 | 10.36 |
| T4 – BA @ 200 ppm | 9.67 | 6.67 | 2.33 | 32.55 | 6.88 | 30592.56 | 10.36 |
| T5 – GA3 100 ppm & BA 100 ppm | 9.33 | 7.33 | 2.33 | 37.55 | 7.77 | 34548.11 | 10.36 |
| T6 – GA3 100 ppm & BA 200 ppm | 10.33 | 7.67 | 4.67 | 45.05 | 7.66 | 34059.22 | 20.72 |
| T7 – GA3 150 ppm & BA 100 ppm | 9.33 | 7.00 | 2.67 | 42.11 | 8.22 | 36518.48 | 11.84 |
| T8 – GA3 150 ppm & BA 200 ppm | 11.33 | 8.67 | 3.67 | 39.77 | 8.86 | 39392.55 | 16.28 |
| F- Test | S | S | S | S | S | S | S |
| SE.d | 1.26 | 0.61 | 0.73 | 3.78 | 0.62 | 2741.95 | 3.23 |
| CD(5%) | 2.67 | 1.30 | 1.54 | 8.01 | 1.13 | 5812.66 | 6.84 |
| CV | 17.09 | 10.62 | 34.82 | 12.40 | 10.04 | 10.04 | 34.82 |

**3.6 Economic Analysis**

The economic evaluation (Table 4) revealed that the total cultivation cost was Rs. 1,65,639.95 per 200 m². Among the treatments, T8 (GA3 150 ppm & BA 200 ppm) delivered the highest economic return, with a gross return of Rs. 666,600, a net return of Rs. 500,382.12 per 200 m², and a benefit-cost ratio of 3.01. This underscores the economic viability of employing higher concentrations of GA3 and BA to optimize L.A. Hybrid Lilium production under protected conditions.

**Table 4** **Effect of different concentrations of GA3 and BA on economics of variety of Lilium**

|  |  |  |  |
| --- | --- | --- | --- |
| Treatments | Gross return | Net return | Benefit cost ratio |
| T0 - Control | 511060 | 345420.05 | 2.09 |
| T1 – GA3 @ 100 ppm | 533280 | 367563.02 | 2.22 |
| T2 – GA3 @ 150 ppm | 533280 | 367525.65 | 2.22 |
| T3 – BA @100 ppm | 533280 | 367408.29 | 2.22 |
| T4 – BA @ 200 ppm | 555500 | 389396.52 | 2.34 |
| T5 – GA3 100 ppm & BA 100 ppm | 555500 | 389551.31 | 2.35 |
| T6 – GA3 100 ppm & BA 200 ppm | 577720 | 411539.49 | 2.48 |
| T7 – GA3 150 ppm & BA 100 ppm | 577720 | 411733.89 | 2.48 |
| T8 – GA3 150 ppm & BA 200 ppm | 666600 | 500382.12 | 3.01 |

**4. CONCLUSION**

 The present investigation demonstrated that the combined application of GA3 and BA significantly enhanced the growth dynamics, floral development, and bulb formation of Lilium L.A. hybrids under polyhouse conditions. Among the treatments evaluated, GA3 100 ppm & BA 100 ppm recorded the highest number of leaves (115.55) and the greatest plant height (117.13 cm). In contrast, BA 100 ppm exhibited the maximum stem diameter (5.89 mm).GA3 100 ppm & BA 200 ppm proved superior in enhancing chlorophyll content (80.18 SPAD units), achieving the earliest bud initiation (47.67 days), produce longer flower buds (11.22 cm), higher number of bulblets per plant (4.67), greater bulb weight (45.05 g), and improved bulb yield (20.72 kg/200 m²). Moreover, GA3 150 ppm & BA 200 ppm significantly accelerated flower opening (84.67 days) and maximized floral attributes including the number of buds per plant (8.86), the diameter of fully opened flowers (39.34 cm), self-life (11.33 days), vase life (8.67 days), and overall flower yield (39,392.55 per 200 m²). Economically, T8 provided the highest performance with a gross return of Rs. 666,600/200 m², a net return of Rs. 500,382.12/200 m², and a benefit-cost ratio of 3.01 for flower production.

In conclusion, the results suggest that the combined application of GA₃ and BA—particularly at higher concentrations—can substantially enhance Lilium production in terms of growth, flowering, bulb yield, and profitability. These findings offer valuable insights for commercial growers aiming to optimize both yield and economic returns under protected cultivation systems.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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