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Response of plant growth regulators on growth and flowering of spider lily (*Hymenocallis littoralis* L.)

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Abstract
An investigation was conducted on the response of plant growth regulators on growth and flowering of spider lily (*Hymenocallis littoralis* L.) in Department of Floriculture and Landscape Architecture, College of Horticulture, Junagadh, Junagadh Agricultural university during the academic year 2022-2023. The experiment was laid out in Randomized Block Design (RBD) with four replication and sevan treatments *viz*., Gibberellic acid (200 and 250 ppm), Naphthalene acetic acid (150 and 250 ppm), Brassinosteroid (3 and 5 ppm) along with the control (water spray). At 45 and 60 days after dealeafing, the plants received two sprays of various plant growth regulators. The results revealed that GA_3 @ 250 ppm recorded maximum plant height (64.09, 75.44 and 79.28 cm), number of leaves (32.88, 49.37 and 60.09), leaf length (62.08, 69.75 and 75.52 cm), leaf width (6.21, 6.26 and 6.42 cm), leaf area (127.75, 188.70 and 236.05 cm^2), plant spread (E-W) (68.35, 72.33 and 75.57 cm) and plant spread (N-S) (68.05, 77.30 and 80.10 cm). whereas, minimum days taken for spike emergence (52.01 day) and first flower emergence (59.40 day) and maximum flowering duration (124.50 day) was recorded with GA_3 at 250 ppm.

Keywords: Growth regulators, growth, flowering, spider lily

Introduction
The spider lily is a member of the monocot order Asparagales, which includes the herbaceous, primarily perennial, and bulbous Amaryllidaceae family of flowering plants. It is a perennial herb with bulbous leaves. It is about 60 and 70 cm (36 and 40 inches) tall. The diameter of the bulb ranges from 7 to 10 cm. The bulb grows a neck that is 4-5 cm in diameter as it ages. The flowers are big, white, fragrant of vanilla, and sessile. The stamina cup is anate (connected) to the tepals. The tube of each bloom measures between 14 and 17 cm (5 and 7 inches).
The exquisite white flowers feature long narrow reflexed petals behind a central cup. Each robust 70-90 cm stem has several blooms. The stamen filaments are green, and the small petals have a thin membrane between them, which explains the derivation of the scientific name. This plant prefers partial shade to full sun. Crop requires damp conditions all year. The pH of the soil chosen must be between 5.0 and 7.5 for the plant's sustained health. Spider lily blossoms are widely used in garland and Gajra creation, mandap and other flower decorations. During weddings and other social gatherings, the flowers are in high demand. Bundles of 50 buds are made by binding with fibers or rubber bands and stored in wet jute bags for shipping.
Gibberellic acid has the characteristic effect of making plants taller by promoting stem elongation. When gibberellic acid is sprayed on rosette plants, it causes rapid stem elongation. Gibberellins may influence plant growth by regulating nucleic acid and enzyme production. Gibberellin has been proven to stimulate flowering in a variety of plant types.
The synthetic auxin most frequently utilized as useful growth agents is naphthalene acetic acid. Generally speaking, NAA accelerates vegetative development, postpones flowering, expands flower size, etc. The concentration utilized determines how NAA works.
A class of steroid hormones known as brassinosteroids (BRs) are crucial for the growth and development of plants. In addition to aiding in etiolation and reproduction, BR signaling encourages cell growth and division.

Materials and Methods
During the academic year 2022–2023, a study on the effects of plant growth regulators on the development and flowering of the spider lily (*Hymenocallis littoralis* L.) was carried out in the Department of Floriculture and Landscape Architecture of the College of Horticulture in Junagadh, the Junagadh Agricultural University. Brassinosteroid (3 and 5 ppm), Gibberellic

acid (200 and 250 ppm), Naphthalene acetic acid (150 and 250 ppm), and water spray served as the control in the experiment, which was set up using a Randomized Block Design (RBD). At 45 and 60 days following planting, foliar applications were made. Following planting, measurements were made of the plant's height (cm), number of leaves, leaf length (cm), leaf breadth (cm), plant spread (N-S) (cm), and plant spread (E-W) (cm). Days taken for the initial spike appearance, the first flower emergence, and the length of the blossoming were also noted.

Results and Discussion

Effect of foliar application of Plant Growth Regulators on growth of spiderlily

Plant height (cm)

From Table.1 The use of plant growth regulators had a considerable impact on plant height. The maximum plant height (64.09, 75.44 and 79.28 cm) was recorded with treatment 250 ppm of GA_3 which was found to be statistically at par with the treatment 200 ppm of GA_3 (63.00, 72.42 and 75.32 cm) at 60, 75 and 90 DAP, respectively.

According to Greulach and Haeshloop (1958) [19], this may be the result of fast cell division and cell elongation, which led to an increase in the number of cells and cell length. This result confirms well with those reported by Chaithra *et al.* (2020) [5] and Parmar *et al.* (2009) [11] in spider lily, Amin *et al.* (2017) [1] and Dalvi *et al.* (2021) [6] in tuberose, Ravidas *et al.* (1992) [13] and Ashwini *et al.* (2019) [2] in gladiolus.

Number of leaves

From Table.1 The maximum number of leaves (32.88, 49.37 and 60.09 cm) was recorded with treatment 250 ppm of GA_3 which was found to be statistically at par with the treatment 200 ppm of GA_3 (30.00, 48.96 and 58.68 cm) at 60, 75 and 90 DAP, respectively.

It might be due to the effect of GA_3 on cell elongation and growth, which would lead to an increase in the number of leaves. This result is well confirming with by Chaithra *et al.* (2020) [5], Parekh *et al.* (2018) [10] and Parmar *et al.* (2009) [11], Amin *et al.* (2017) [1] and Dalvi *et al.* (2021) [6] in tuberose, Sanjay kumar *et al.* (2019) [15] in amaryllis, Ravidas *et al.* (1992) [13] and Ashwini *et al.* (2019) [2] in gladiolus in spider lily.

Table 1: Efficacy of plant growth regulators on spider lily plant height (cm) and Number of leaves

Sr. No.	Treatment	Plant height			Number of leaves		
		60 DAP	75 DAP	90 DAP	60 DAP	75 DAP	90 DAP
T_1	GA_3 @ 200 ppm	63.00	72.42	75.32	30.00	48.96	58.68
T_2	GA_3 @ 250 ppm	64.09	75.44	79.28	32.88	49.37	60.09
T_3	NAA @ 150 ppm	59.85	67.75	74.35	28.84	45.54	54.29
T_4	NAA @ 250 ppm	60.59	71.22	75.05	32.43	46.65	55.38
T_5	Brassinosteroid @ 3 ppm	60.52	65.70	73.06	25.64	45.78	52.84
T_6	Brassinosteroid @ 5 ppm	59.50	64.40	72.06	26.17	43.44	51.84
T_7	Control	57.83	59.36	63.61	22.20	39.49	51.67
S.Em. ±		1.28	2.65	2.27	1.29	1.44	1.50
C.D. at 5%		3.80	7.87	6.76	3.83	4.28	4.47
C.V.%		4.21	7.78	6.20	9.11	6.31	5.55

Leaf width and leaf length (cm)

From Table 2. The treatment with 250 ppm of GA_3 produced the widest leaves (6.21, 6.26, and 6.42 cm), which was statistically comparable to the treatment with 200 ppm of GA_3 (5.77, 5.90, and 6.01 cm) at 60, 75, and 90 DAP, respectively. Additionally, at 60, 75, and 90 DAP, respectively, the treatment with 250 ppm of GA_3 produced the longest leaves (62.08, 69.75, and 75.52 cm), which was shown to be statistically comparable to the treatment with 200 ppm of GA_3 (60.14, 69.56, and 74.20 cm).

This might be brought on by gibberellic acid, which rapidly accelerates cell division and expansion, potentially leading to a bigger number of cells and an increase in cell length, which in turn influences the length and breadth of leaves as well as by more food being accessible. These results are in conformity with the findings of Parmar *et al.* (2009) [11] and Chaithra *et al.* (2020) [5] in spider lily, Subba *et al.* (2014) [20] in gladiolus.

Table 2: Effect of plant growth regulators on leaf length (cm) and leaf width (cm) of spider lily

Sr. No.	Treatment	Leaf length (cm)			Leaf width (cm)		
		60 DAP	75 DAP	90 DAP	60 DAP	75 DAP	90 DAP
T_1	GA_3 @ 200 ppm	60.14	69.56	74.20	5.77	5.90	6.01
T_2	GA_3 @ 250 ppm	62.08	69.75	75.52	6.21	6.26	6.42
T_3	NAA @ 150 ppm	58.28	64.78	71.23	5.59	5.66	5.74
T_4	NAA @ 250 ppm	56.71	66.11	71.51	5.75	5.84	5.94
T_5	Brassinosteroid @ 3 ppm	56.57	62.71	69.22	5.39	5.48	5.60
T_6	Brassinosteroid @ 5 ppm	54.52	61.59	68.69	5.34	5.40	5.50
T_7	Control	51.97	56.93	66.50	5.24	5.30	5.37
S.Em. ±		1.85	1.80	1.61	0.15	0.15	0.14
C.D. at 5%		5.50	5.33	4.77	0.45	0.44	0.43
C.V.%		6.47	5.57	4.52	5.43	5.16	4.97

Leaf area (cm^2)

From Table 3. At 60, 75, and 90 DAP, respectively, the treatment with 250 ppm of GA_3 produced the largest leaf area (127.75, 188.70, and 236.05 cm^2), which was shown to be statistically equivalent to the treatment with 200 ppm of GA^3 (120.22, 185.23, and 230.84 cm^2).

This may be because gibberellic acid, which encourages the growth of spider lilies through cell division, cell enlargement, and cell expansion, is actively inducing spider lilies to divide, enlarge, and expand, which results in an increase in leaf length, leaf width, and leaf area. These results are in correlation with the results of Parmar *et al.* (2009) [11], Sonone and Rahul (2019) [17] and Chaithra *et al.* (2020) [5] in spider lily, Ravidas *et al*. (1992) [13] and Ashwini *et al.* (2019) [2] in gladiolus, Khan and Tiwari (2003) [7] in dahlia.

Table 3: Effect of plant growth regulators on leaf area (cm^2) of spider lily

Sr. No.	Treatment	Leaf area (cm^2)		
		60 DAP	75 DAP	90 DAP
T_1	GA_3 @ 200 ppm	120.22	185.23	230.84
T_2	GA_3 @ 250 ppm	127.75	188.70	236.05
T_3	NAA @ 150 ppm	115.06	174.78	211.16
T_4	NAA @ 250 ppm	118.73	178.60	220.65
T_5	Brassinosteroid @ 3 ppm	116.16	176.30	221.70
T_6	Brassinosteroid @ 5 ppm	116.62	174.70	216.61
T_7	Control	100.71	166.35	205.62
S.Em. ±		3.45	3.62	4.68
C.D. at 5%		10.26	10.76	13.90
C.V.%		5.93	4.07	4.24

Plant spread (N-S) and (E-W) (cm)

The maximum plant spread (N-S) (68.05, 77.30 and 80.10 cm) was recorded with treatment 250 ppm of GA_3 which was found to be statistically at par with the treatment 200 ppm of GA_3 (66.46, 74.21 and 78.43 cm) at 60, 75 and 90 DAP, respectively. And the maximum plant spread (E-W) (68.35, 72.33 and 75.57 cm) was recorded with treatment 250 ppm of GA_3 which was found to be statistically at par with the treatment 200 ppm of GA_3 (66.26, 69.11 and 71.60 cm) at 60, 75 and 90 DAP, respectively (Table.4.).

Due to GA_3's influence on stem elongation, which increases sub-apical meristem cell elongation, the spread of the plant increases. Both a higher cell count and a higher rate of cell elongation are responsible for the quick vegetative growth. The outcome is consistent with studies by Parekh *et al*. (2018) [10], Chaithra *et al*. (2020) [5], and Misra *et al*. (2000) [9] on Spider lily and Football lily, respectively.

Table 4: Plant growth regulators' impact on the spider lily's plant spread (N-S) and plant spread (E-W) in cm

Sr. No.	Treatment	Plant spread (N-S) (cm)			Plant spread (E-W) (cm)		
		60 DAP	75 DAP	90 DAP	60 DAP	75 DAP	90 DAP
T_1	GA_3 @ 200 ppm	66.46	74.21	78.43	66.26	69.11	71.60
T_2	GA_3 @ 250 ppm	68.05	77.30	80.10	68.35	72.33	75.57
T_3	NAA @ 150 ppm	62.05	72.10	75.82	62.63	66.90	69.64
T_4	NAA @ 250 ppm	64.45	73.13	77.24	65.75	69.10	73.71
T_5	Brassinosteroid @ 3 ppm	64.85	72.23	76.28	63.45	65.01	67.89
T_6	Brassinosteroid @ 5 ppm	62.70	69.22	73.03	61.93	64.80	69.08
T_7	Control	58.24	61.07	65.01	60.45	62.86	65.84
S.Em. ±		1.66	1.67	1.61	1.66	1.86	1.71
C.D. at 5%		4.92	4.97	4.78	4.93	5.53	5.09
C.V.%		5.19	4.69	4.29	5.17	5.55	4.86

Days taken for first flower spike emergence (day)

From Table 5. Foliar application of different plant growth regulators at the different concentrations on the spider lily plants varied significantly on days taken for spike emergence. The spray of GA_3 @ 250 ppm recorded (52.01) considerably the fewest number of days for spike emergence compared to the other treatments, and it was followed by GA_3 @ 200 ppm (53.52).

This might be as a result of GA_3's ability to shorten the juvenile stage of plants, which leads to an early end to the vegetative phase through accelerated cell division and cell elongation. Wagh *et al.* (2012) [18] also discovered related results. Similar results were found with Parmar *et el.* (2009) [11], Chaithra *et al.* (2020) [5] and Sonone and Rahul (2019) [17] in spider lily, Ravidas *et al*. (1992) [13] and Barman and Rajni (2004) [3] in gladiolus.

Days taken for first flower emergence (day)

The earliest flower emergence was registered under the treatments GA_3 250 ppm (59.40 day) which was at par with GA_3 @ 200 ppm (61.43 day) as compared to control (69.24 day).

This might be because gibbrellins are very good at shortening the period when plants are young. Instead of developing leaves at the end of the juvenile period, the shoot apical meristem transforms into flower primordia. Early blooming is also related to increased photosynthesis, respiration, and higher CO_2 fixation in the treated plants.

This outcome is in good agreement with findings made by Parmar *et al.* (2009) [11], Sonone and Rahul (2019) [17], Chaithra *et al.* (2020) [5], Misra *et al.* (2000) [9] in the field of football lily, Sanjay Kumar *et al.* (2019) [15] in the field of amaryllis, Ravidas *et al.* (1992) [13], and Maurya and Nagda (2002) [8] in the field of gladiolus. In tuberose, Singh (1999) [16]; in tulip, Rameshkumar *et al.* (2013) [12].

Flowering duration

The treatment of GA_3 @ 250 ppm resulted in the considerably longer maximum flowering length (124.50 day), which was equal to GA_3 @ 200 ppm (115.00 day) in comparison to control (88.50 day).

This might be as a result of GA_3's improved photosynthetic and metabolic functions, which boost the transit and utilization of photosynthetic products and lead to higher yields and better-quality spikes. This might have in turn helped the spikes stay on the plant for longer in the field. The outcome is consistent with findings from studies conducted on gladiolus by Baskaran *et al.* (2014) [4] and spider lily by Chaithra *et al.* (2020) [5].

Table 5: Impact of plant growth regulators on spider lily first spike emergence, first flower emergence, and flowering duration (day)

Sr.no.	Treatment	Days taken for first spike emergence	Days taken for first flower emergence	Flowering duration (days)
T_1	GA_3 @ 200 ppm	53.52	61.43	115.00
T_2	GA_3 @ 250 ppm	52.01	59.40	124.50
T_3	NAA @ 150 ppm	56.25	65.17	100.50
T_4	NAA @ 250 ppm	54.66	63.43	110.14
T_5	Brassinosteroid @ 3 ppm	55.03	63.33	100.28
T_6	Brassinosteroid @ 5 ppm	57.12	67.52	96.75
T_7	Control	60.57	69.24	88.50
S.Em. ±		1.58	1.55	6.44
C.D. at 5%		4.70	4.59	19.12
C.V.%		5.69	4.81	12.25

Conclusion

Based on the findings of this study, it is possible to conclude that foliar application of GA_3 at 250 ppm at 45 and 60 days after planting increased plant height, number of leaves, leaf length, leaf width, leaf area, plant spread (N-S) and (E-W), flowering duration, and caused early flowering. Thus, the treatment GA_3 at 250 ppm was discovered to be suitable for boosting spider lily growth and flowering.

Future scope

Future research with other plant growth regulators is required to assess the influence of combining different plant growth regulators on spider lily development and flowering.

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Conflict of Interest

There are no conflicts of interest, according to the authors.

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