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Effect of growth regulators on growth, yield and shelf life parameters of amaryllis lily (*Amaryllis belladonna*) cv. *Zephyranthes*

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Abstract
Two years data has been recorded and observed that maximum plant height (43.60 & 46.40 cm 180 DAP), number of leaves (15.67 & 19.67 cm DAP), minimum days taken to first flower bud initiation (153.33 & 144.33), flower bud diameter (1.93 & 2.33 cm), flower stalk length (42.93 & 45.13 cm), flower diameter (3.67 & 4.73 cm), flower durability (5.87 & 7.07 days), average weight of flower (8.27 & 9.87 g), number of flowers/ plant (4.00 & 4.00), number of flowers / plot (72 & 72 respectively), number of flowers/ hectare (1.80 & 1.80 lakhs), number of bulb lets/plant (6.73 & 7.00), number of bulb lets / hectare (3.03 & 3.15 lakhs) were recorded with treatment T_3 (GA_3 250 ppm) where as lowest readings were recorded under Control (T_0). In terms of shelf life of flower the longest shelf life (34.80 & 35.93 hours) and lowest physiological loss in weight (27.00 & 24.80 per cent) was recorded in treatment T_4 (Benzyl adenine 200 ppm) followed by treatment T_5 (Benzyl adenine 100 ppm + Silver nitrate 100 ppm) and lowest was recorded in T_7 control (water).

Keywords: Growth regulators, growth, yield, shelf life, amaryllis lily

Introduction
Amarallis is a monotypic genus of plant also known as the Belladonna Lily. The single species, *Amaryllis belladonna* is a native of South Africa, particularly the rocky southwest region near the cape. It is often confused with the Hippeastrum, a flowering bulb commonly sold in the winter months for its propensity to bloom indoors. The botanical name of Amryllis Lily is (*Amaryllis belladonna* L.) and it belongs to the family of Amaryllidaceae. They have 2-6 flowers per stick. Amaryllis flowers are 2 inch wide, 4-5 inch long. Most of the bulbs sold are either Dutch or South African grown hybrids. Amaryllis is a very common bulb for plains and hills. Amaryllis prefers rich sandy loam or loamy soil with proper drainage and plenty of moisture. The soil pH should range between 6.1 and 7.0. They may also be grown in soils having pH from 6.1 to 7.8.

Naturally occurring hormones play an important role during the process of plant growth and development. In fact, involvement of auxin in the regulation of flowering in orchids was suggested as early as in 1953. Exogenous application of growth regulators may reduce, promote or prevent flowering, plant growth regulators are the organic chemical compounds which modify or regulate physiological processes in an appreciable measure in plants when used in small concentrations. Plant hormones are also known as phyto hormones, growth factors, growth substances and plant growth regulators (PGR).

Material and methods
The experiment was conducted during winter season of the year 2016-17 and 2017-18 in Departmental Research field of Department of Horticulture, Sam Higginbottom University of Agricultural Technology and Sciences, Allahabad. It is situated at 25º.8´N latitude and 81º.50´ E longitudes on elevation of 98 meters from the sea level. The maximum temperature of the location reaches up to 46 ºC – 48 ºC and seldom falls as low as 4 ºC – 5 ºC. The relative humidity ranges between 20 to 94 per cent. The average rainfalls in this area are around 1013.4 mm annually. A total of 13 treatments were replicated thrice to evaluate growth and yield parameters and were executed in randomized design *viz.* T_1 = Control, T_2 = GA_3 150 ppm, T_3 = GA_3 200 ppm, T_4 = GA_3 250 ppm, T_5 = GA_3 300 ppm, T_6 = NAA 150 ppm, T_7 = NAA 200 ppm, T_8= NAA 250 ppm, T_9 = NAA 300ppm, T_{10} = CCC 150 ppm, T_{11} = CCC 200 ppm,

T_{12} = CCC 250 ppm. To evaluate shelf life parameters 7 treatments were replicated thrice in randomized design *viz*. T_{1}= Silver nitrate (100 ppm), T_{2} = Silver nitrate (200 ppm), T_3 Benzyladenine (100 ppm), T_4 Benzyladenine (200 ppm), T_5 Benzyladenine (100 ppm) + Silver nitrate (100 ppm), T_6 =Benzyaleadenine (200) + Silver nitrate (200ppm), T_7 = Control (water)

The height of the plant from the soil level to the highest level reached by the leaves in natural condition was measured for the five tagged plants with the help of graduated meter scale at 180 days after planting, The number of leaves produced was recorded by counting the number of leaves at 180 days after transplanting and the average number of leaves per plant was worked out. The days to first flower bud initiation was counted at the beginning of flower bud initiation to the end of flower bud initiation, diameter of the flower bud was measured at the point of maximum breadth, the height of the spike from the soil level to the highest level reached by the spike in natural condition was measured with the help of graduated meter scale, flower diameter was measured at the point of maximum breadth this was measured by using measuring scale, durability of flower in days was recorded by number of days taken from the first flowering to the last flowering in the plant, weight of flower was calculated from the weight of 10 flowers from each replication of the different treatments and the mean value of weight of flower was thus obtained, number of flowers/plant obtained from per bulb lets planted was counted and recorded, number of flowers/plot obtained from per plots bulb lets planted was counted and recorded, number of flowers/hectare obtained from per hectare of bulb lets planted was counted and recorded, Total number of bulb lets/hectare obtained from per bulb planted was counted and recorded.

Whereas Vase life hours was recorded after harvesting of spikes and keeping it in a jar containing tap water, and there hours taken for drying of each flower was recorded from the five tagged plants of each replication and their mean were worked out, physiological loss of weight was calculated at weekly intervals by recording the weight of each flower.

Results and discussion

The growth regulators significantly influenced growth parameters and were presented in Table 1 where the maximum height (43.60 & 46.40 cm), highest number of leaves per plant (15.67 & 19.67 cm) has been observed in T_3 (GA_3 250 ppm) at 180 days after planting (DAP). The enhancement in the growth characteristics might due to the application of growth promoters that have helped in cell enlargement and cell division. The days taken to first flower bud initiation was recorded minimum (153.33 & 144.33) in treatment T_3 (GA_3 250 ppm) where as maximum days for flower bud initiation were found in treatment T_0 (Control) this might be due to gibberellins that are quite effective in reducing juvenile period of plants. The maximum flower bud diameter (1.93 cm and 2.33 cm) has been found in T_3 (GA_3 250 ppm) in both the years of experiment, higher values for quality parameter with GA_3 might be due to more production of food material in leaves due to enhanced physiological activities in turn led to production of bigger sized flowers. The highest stalk length of (42.93 cm and 45.13 cm) has been observed with treatment T_3 (GA_3 250 ppm) in both the years respectively, this significant increase in the stalk length in GA treatment may be due to the cell elongation and cell division or both. The maximum diameter of flower (3.67 cm and 4.73 cm) has been observed with treatment T_3 (GA_3 250 ppm) because GA_3 might be responsible for more production of food material in leaves due to enhanced physiological activities in turn led to production of bigger sized flowers.

Table 1: Effect of Plant growth regulator on growth parameters of Amaryllis Lily

Treatment	First Flower Bud Initiation (Days)		Flower Bud diameter (cm)		Stalk Length		Flower Diameter (cm)		Plant height (cm) 180 DAP		No. of leaves / plant (180 DAP)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
T_0	182.00	176.67	0.53	0.67	26.20	27.40	1.87	2.13	27.60	29.33	4.07	5.20
T_1	173.67	166.67	0.80	1.00	34.67	36.27	2.67	3.13	33.80	35.93	7.40	9.20
T_2	171.00	164.00	1.00	1.27	37.73	39.60	3.07	3.53	36.07	38.33	9.58	12.00
T_3	153.33	144.33	1.93	2.33	42.93	45.13	3.67	4.73	43.60	46.40	15.67	19.67
T_4	168.00	161.00	1.47	1.73	39.87	41.67	3.27	3.93	39.73	42.33	12.20	15.20
T_5	174.00	166.67	0.73	0.93	32.80	34.33	2.60	3.00	33.13	35.27	6.80	8.47
T_6	172.00	165.00	0.93	1.13	37.27	39.07	2.87	3.40	35.53	37.73	8.40	10.67
T_7	159.00	151.00	1.73	1.93	40.93	42.87	3.53	4.33	41.93	44.53	13.73	17.20
T_8	169.67	162.67	1.27	1.53	38.87	40.73	3.20	3.87	38.67	41.07	11.33	14.07
T_9	178.33	172.00	0.67	0.87	32.47	34.00	2.53	2.87	32.67	34.73	5.87	7.60
T_{10}	173.00	166.00	0.87	1.07	35.73	37.33	2.73	3.20	34.73	36.93	8.13	10.20
T_{11}	160.67	153.67	1.53	1.80	40.47	42.33	3.40	4.13	40.87	43.47	13.33	16.47
T_{12}	170.67	163.67	1.13	1.40	38.33	40.27	3.13	3.67	37.13	39.53	10.73	13.53
F- test	S	S	S	S	S	S	S	S	S	S	S	S
S. Ed. (±)	0.47	0.48	0.05	0.07	0.22	0.25	0.08	0.10	0.25	0.27	0.25	0.25
C. D. (P = 0.05)	0.96	0.98	0.11	0.15	0.46	0.51	0.16	0.21	0.51	0.56	0.53	0.52

The growth regulators significantly influenced yield parameters and showed in Table 2, where the maximum durability of flowers (5.87 and7.07 days), maximum average weight of flower (8.27 gm and 9.87 gm), highest number of flowers /plant (4.00 each), number of flowers/plot (72 each), maximum number of flowers / hectare (1.80 lakh each), maximum number of bulb lets/plant (6.73 and 7.00), maximum number of bulb lets/ ha (3.03 and 3.15 lakh) has been recorded under treatment T_3 (GA_3 250 ppm) during both the years of the investigation, the influence in yield characteristics might be due to the availability of desirable food materials and more carbohydrate supply which ultimately leads to the production of optimum plant stature, increased number of leaves, leaf area and plant spread, which in turn enabled them to produce increased amount of photosynthesis ultimately resulting in accumulation of maximum dry matter which might have promoted flower production and yield as well.

Table 2: Effect of Plant growth regulator on yield parameters of Amaryllis Lily

Treatment	weight of flower (g)		No. of flowers per plant		No. of flowers / ha (Lakhs)		No. of bulblets/plant		No. of bulblet/ ha (Lakhs)		durability of flowers (days)	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
T_0	4.13	4.73	2.13	2.20	0.96	0.99	2.20	2.33	0.99	1.05	2.80	3.33
T_1	5.93	6.93	2.67	2.87	1.20	1.29	4.33	4.40	1.95	1.98	4.07	4.87
T_2	6.67	7.80	3.20	3.40	1.44	1.53	4.87	4.93	2.19	2.22	4.53	5.33
T_3	8.27	9.87	4.00	4.00	1.80	1.80	6.73	7.00	3.03	3.15	5.87	7.07
T_4	7.20	8.40	3.60	3.73	1.62	1.68	5.47	5.53	2.46	2.49	4.93	5.93
T_5	5.67	6.67	2.53	2.67	1.14	1.20	4.00	4.07	1.80	1.83	3.93	4.73
T_6	6.33	7.40	2.93	3.07	1.32	1.38	4.67	4.73	2.10	2.13	4.40	5.20
T_7	7.73	9.20	3.87	3.93	1.74	1.77	5.93	6.27	2.67	2.82	5.27	6.27
T_8	7.00	8.13	3.47	3.67	1.56	1.65	5.27	5.40	2.37	2.43	4.73	5.53
T_9	5.47	6.27	2.27	2.47	1.02	1.11	3.53	3.73	1.59	1.68	3.87	4.60
T_{10}	6.07	7.07	2.80	2.93	1.26	1.32	4.47	4.53	2.01	2.04	4.27	5.07
T_{11}	7.47	8.73	3.73	3.80	1.68	1.71	5.73	5.80	2.58	2.61	5.07	6.07
T_{12}	6.87	8.00	3.33	3.47	1.50	1.56	5.13	5.27	2.31	2.37	4.67	5.47
F- test	S	S	S	S	S	S	S	S	S	S	S	S
S. Ed. (±)	0.09	0.10	0.20	0.14	0.09	0.06	0.08	0.09	0.08	0.09	0.05	0.07
C. D. (P = 0.05)	0.19	0.21	0.42	0.28	0.19	0.13	0.16	0.19	0.16	0.19	0.11	0.14

Plant growth promoters significantly influenced the shelf life parameters of *Amaryllis belladonna* and is presented in Table 3, where The longest shelf life (34.80 and 35.93 hours) for both the years respectively was recorded with the treatment (T_4) Benzyl adenine 200 ppm followed by treatment (T_5) Benzyl adenine 100 ppm + Silver nitrate 100 ppm (32.60 and 34.0 hrs). The lowest (28.53 and 29.07 hrs) shelf life was recorded inT_7 control (water), it is might due to regulation of enzymes, anti microbial and anti ethylene action so that the ageing process decelerate. Among the different treatments the lowest physiological loss in weight of flower was recorded (27.00 & 24.80%) in the treatment T_4 (Benzyl adenine 200 ppm), and was followed with T5 (Benzyladenine 100 ppm + Silver nitrate 100 ppm), maximum physiological loss in weight of flowers (38.00 & 36.27 per cent) was observed in the treatment T_7 control (Water). This may be due to retarding fresh weight loss, ethylene production and chlorophyll degradation. Application of benzyl adenine will increase the activities of superoxide dismutase (SOD), ascorbate peroxidase (APX) and catalase (CAT), whereas the activity of peroxidise (POD) was reduced.

Table 3: Effect of Plant growth regulator on shelf life parameters of Amaryllis Lily.

Treatment	Vase life (Hours) of flower		Physiological loss of weight of flower (%)	
	2016	2017	2016	2017
T_1	28.53	29.07	38.00	36.27
T_2	31.47	31.93	31.67	30.20
T_3	29.47	30.20	36.47	34.53
T_4	34.80	35.93	27.00	24.80
T_5	32.60	34.00	30.47	29.00
T_6	30.40	31.27	35.27	33.60
T_7	27.27	28.40	33.60	38.27
F- test	S	S	S	S
S. Ed. (±)	0.22	0.13	0.52	0.43
C. D. (P = 0.05)	0.46	0.28	1.11	0.92

Conclusion

Based on the present investigation from two years experimental trial it is concluded that the treatment T_3 (GA_3 250 ppm) is found to be best in terms of growth and yield parameters as well as cost benefit ratio and lowest was recorded in treatment T_0 (Control) in all the growth and yield parameters, In terms of shelf life of flower the longest shelf life (hours) and lowest physiological loss in weight was recorded in treatment T_4 (Benzyl adenine 200 ppm) followed by treatment T_5 (Benzyl adenine 100 ppm + Silver nitrate 100 ppm) and lowest was recorded in T_7 control (water).

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