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INFLUENCE OF NUTRIENT LEVELS AND PLANT SPACING ON FLOWERING AND FLOWER QUALITY OF LISIANTHUS (*EUSTOMA GRANDIFLORA*) UNDER POLY HOUSE CONDITION

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ABSTRACT

Lisianthus is an important cut flower crop widely used in floral arrangements and bouquets. Despite the high market demand for Lisianthus spikes, its cultivation has not been widely popularized, and there is no established package of agro-techniques for Zone 5. To address this, an experiment was conducted at the Floriculture Unit, Department of Horticulture, University of Agricultural Sciences, Bangalore, during the 2022-23 year. The study aimed to investigate the "Effect of spacing and nutrient levels on flowering and flower quality of Lisianthus (*Eustoma grandiflorum*) flowers under polyhouse conditions". A field experiment with twelve treatments and three replications was laid out in a Factorial Completely Randomized Design (FCRD). The results indicated that a 125 percent nutrient level with a spacing of 15 cm × 30 cm led to the shortest time for spike initiation (92.08 days), 50 percent bloom (118.23 days), and 75 percent bloom (130.50 days). This treatment also produced the longest spikes (98.00 cm), the largest flower diameter (7.03 cm) and the longest vase life (14.17 days).

Key words : Flower initiation, Spike length, Flower diameter, Spacing and Fertilizer dose.

Introduction

Floriculture, a branch of ornamental horticulture, specializes in the production of flowering and foliage plants for commercial and decorative purposes. This sector is a significant part of the horticulture industry, valued for its aesthetic, social, and economic contributions. Globally, approximately 140 countries engage in commercial floriculture. Lisianthus (*Eustoma grandiflorum*) is an annual, herbaceous, day-neutral plant that thrives under specific light and temperature conditions, making it a key cut flower in the international market.

This study focuses on optimizing the cultivation of Lisianthus, which can reach heights of 30-90 cm and produce 16-24 flowers per stem. The plant is propagated by seeds, taking about two months to reach the transplanting stage. The entire crop cycle spans 5-6 months, with optimal growth at day temperatures of 21ºC and night temperatures of 18ºC (Halevy and Kofranek, 1984). Proper spacing is critical for enhancing yield and quality, as it optimizes the microclimate around the root zone, improving nutrient availability, aeration and light intensity. This leads to better growth, yield and quality of flowers (Sanjib *et al*., 2002).

Sustainable flower production also requires optimal fertilizer management. Nitrogen supports vegetative growth and flower opening, phosphorus stimulates bud and flower development and potassium enhances overall plant growth and flower quality (Ayemi *et al*., 2017). Standardizing spacing and nutrient management is crucial for producing export-quality Lisianthus flowers, which have significant potential for earning foreign exchange. This research aims to provide insights into the precise spacing and nutrient levels required for optimal Lisianthus cultivation under polyhouse conditions.

Materials and Methods

The experiment was carried out at Floriculture Unit, Department of Horticulture, University of Agricultural Sciences, Gandhi Krishi Vigyana Kendra, Bengaluru during 2022-23. The fertilizer dose and spacing were the two factors with 4 and 3 levels, respectively. The different levels of these factors were combined to obtain following treatments and 120:150:150 Kg NPK/ha (RDF of Gladiolus) was taken as the standard dose.

T_1 – N2S2 (100 % Nutrient level with spacing of 15 cm × 30 cm)

T_2 – N2S1 (100 % Nutrient level with spacing of 15 cm × 15cm)

T_3 – N2S3 (100 % Nutrient level with spacing of 15 cm × 45cm)

T_4 – N2S4 (100 % Nutrient level with spacing of 30 cm × 30 cm)

T_5 – N1S1 (75 % Nutrient level with spacing of 15 cm × 15cm)

T_6 – N1S2 (75 % Nutrient level with spacing of 15 cm × 30 cm)

T_7 – N1S3 (75 % Nutrient level with spacing of 15 cm × 45cm)

T_8 – N1S4 (75 % Nutrient level with spacing of 30 cm × 30 cm)

T_9 – N3S1 (125 % Nutrient level with spacing of 15 cm × 15 cm)

T_{10} – N3S2 (125 % Nutrient level with spacing of 15 cm × 30 cm)

T_{11} – N3S3 (125 % Nutrient level with spacing of 15 cm × 45 cm)

T_{12} – N3S4 (125 % Nutrient level with spacing of 30 cm × 30 cm)

The raised beds were irrigated to field capacity before transplanting. Two-month-old seedlings with well-developed root plugs were selected for transplanting. Transplanting was carried out during the cooler hours of the day, either early in the morning or late in the evening. Immediately after transplanting, a 0.2 percent humic acid solution was applied to the seedlings to promote root growth and help them overcome transplanting shock. Since Lisianthus seedlings are highly susceptible to fertilizer injury, no chemical fertilizers were applied before or during transplanting. After the seedlings fully recovered from transplanting shock (21 days post-transplanting), the calculated amounts of nitrogen, phosphorus, and potassium were administered through chemical fertilizers according to the treatment recommendations. The plant growth parameters and yield parameters were recorded at regular intervals. The collected experimental data was analysed statistically by following the Fisher's method of analysis of variance as outlined by Gomez and Gomez (1984).

Results and Discussion

The observations on the effect of spacing and nutrient levels on various flower parameters of Lisianthus, including days taken for spike initiation, 50 percent bloom, and 75 percent bloom, were recorded and are presented in Table 1.

Days taken for Spike Initiation

The number of days taken for spike initiation after transplanting was measured with varying amounts of NPK nutrients combined with different plant spacing. From the day of transplanting, the number of days required for spike initiation varied significantly (Table 1).

Nutrient level : The minimum days for spike initiation were observed with the N3 level (125 percent nutrient level) at 95.39 days, while the maximum was with the N1 level (75 percent nutrient level) at 109.69 days. Statistically, the effect of nutrient level was non-significant.

Spacing : Spacing effects were also non-significant. However, S2 (30 cm × 45 cm) had the minimum days for spike initiation at 98.81 days and S1 (30 cm × 15 cm) had the maximum at 105.76 days.

Interaction : Results shows that T_{10} (125 percent nutrient level with 15 cm × 30 cm spacing) required the least days for spike initiation (92.08 days), closely followed by T_{12} (30 cm × 30 cm spacing) at 94.63 days and T_{11} (15 cm × 45 cm spacing) at 96.27 days. Higher potassium levels likely contributed to early spike initiation, with spacing enhancing nutrient uptake.

The maximum days were recorded in T_5 (75 percent nutrient level with 15 cm × 15 cm spacing) at 113.33 days, followed by T_7 (15 cm × 45 cm spacing) at 110.47 days. Early spike development is attributed to optimal spacing, increased nitrogen availability and enhanced nutrient uptake, aligning with findings by Husna *et al.* (2022) in Lisianthus and Nayak *et al.* (2005) in Gerbera.

Days taken for 50 per cent bloom (days)

Throughout the cropping period, plants showed various growth and flowering stages. Spikes were tagged as they initiated, and observations were recorded for the days taken for 50% blooming (Table 1).

Nutrient level : The shortest duration to reach 50% bloom was observed with N3 (125% nutrient level) at

Table 1 : Effect of nutrient level and spacing on flowering parameters of Lisianthus.

Treatments	Flowering parameters		
	Days taken for spike initiation	Days taken for 50% bloom	Days taken for 75% bloom
Nutrient level			
N1–75% Nutrient level	109.69	142.75	162.96
N2–100% Nutrient level	101.90	131.57	147.89
N3–125% Nutrient level	95.39	121.66	135.12
F–test	**NS**	**NS**	**NS**
S.Em±	1.38	1.54	1.90
C.D @ 5%	4.02	4.49	5.56
Spacing			
S1-15cm × 15cm	105.76	135.77	153.17
S2-15cm × 30cm	98.81	128.36	143.68
S3-15cm × 45cm	103.40	133.54	150.94
S4-30cm × 30cm	101.33	130.31	146.84
F–test	**NS**	**NS**	**NS**
S.Em±	1.59	1.77	2.20
C.D @ 5%	4.64	5.18	6.42
Interactions			
T_1 (N2S2)	98.20	128.67	143.20
T_2 (N2S1)	105.37	135.00	152.33
T_3 (N2S3)	103.47	133.13	150.17
T_4 (N2S4)	100.57	129.20	145.87
T_5 (N1S1)	113.33	147.00	168.00
T_6 (N1S2)	106.17	138.17	157.33
T_7 (N1S3)	110.47	144.17	165.17
T_8 (N1S4)	108.80	141.67	161.33
T_9 (N3S1)	98.57	125.00	139.17
T_{10} (N3S2)	92.08	118.23	130.50
T_{11} (N3S3)	96.27	123.33	137.50
T_{12} (N3S4)	94.63	120.07	133.33
F–test	*	*	*
S.Em±	2.75	3.07	3.81
C.D @ 5%	8.04	8.97	11.12

*Significance at 5% level, NS–Non Significant

Note : 120:150:150 Kg NPK ha^{-1} (RDF of Gladiolus) was taken as the standard dose.

121.66 days, while the longest was with N1 (75% nutrient level) at 142.75 days. The effect of nutrient levels on days taken for 50% bloom was not statistically significant.

Spacing : Spacing's individual impact on the time taken to reach 50% bloom from transplanting was not statistically significant. However, S2 (15 cm × 30 cm) showed the shortest duration to reach 50% bloom at 128.36 days, while S1 (15 cm × 15 cm) took the longest at 135.77 days.

Interaction : Variation in 50% blooming was evident across treatment combinations. The shortest duration was recorded in T_{10} (125% nutrient level with 15 cm × 30 cm spacing) at 118.23 days, on par with T_{12} (30 cm × 30 cm spacing) at 120.07 days and T_{11} (15 cm x 45 cm spacing) at 123.33 days. Conversely, the longest duration was in T_5 (75% nutrient level with 15 cm × 15 cm spacing) at 147.00 days, on par with T_7 (15 cm × 45 cm spacing) at 144.17 days.

This variation may be attributed to the interaction of spacing and nutrient supply. Wider spacing reduced plant density, reducing competition for water and nutrients. Additionally, higher nutrient dosages in these treatments may have expedited early blooming. Similar findings were observed by Husna *et al.* (2022) in Lisianthus, Kumar *et al.* (2016) and Patil and Dhaduk (2010) in Gladiolus.

Days taken for 75% Bloom (days)

Following spike initiation, plants were regularly monitored for 75% flower blooming. Data on the number of days taken for 75% bloom from transplanting are presented in Table 1, with results discussed below.

Nutrient level : N3 (125% nutrition level) required the fewest days for 75% bloom (135.12), while N1 (75% nutrient level) took the longest (162.96). Statistically, the individual effect of nutrient level on days taken for 75% bloom was not significant.

Spacing : Spacing's individual impact on days to reach 75% bloom from transplanting was not statistically significant. However, S2 (15 cm × 30 cm) showed the shortest duration (143.68 days), while S1 (15 cm × 15 cm) took the longest (153.17 days).

Interaction : Significant differences in days taken for 75% blooming were observed among treatment combinations (Table 1). T_{10} (125% nutrient level with 15 cm x 30 cm spacing) had the shortest duration (130.50 days), similar to T_{12} (30 cm × 30 cm spacing) at 133.33 days, and T_{11} (15 cm × 45 cm spacing) at 137.50 days. Conversely, the longest duration was in T_5 (75% nutrient level with 15 cm × 15 cm spacing) at 168.00 days, similar to T_7 (75% nutrient level with 15 cm × 45 cm spacing) at 165.17 days.

The combined effect of plant spacing and nutrient supply likely influenced the variation in blooming time. Wider spacing reduced plant density, reduced competition for nutrients and moisture. Moreover, higher nutrient levels in these treatments may have accelerated blooming. These findings align with previous studies by Husna *et al*. (2022) in Lisianthus, Kumar *et al*. (2016) and Patil and Dhaduk (2010) in Gladiolus.

Flower Quality parameters

In this study, the flower quality parameters of Lisianthus, such as the number of flowers per spike, spike length (cm), flower diameter (cm) and vase life (days), were evaluated to assess the influence of different spacings and nutrient concentrations. The results are presented in Table 2 and discussed below.

Number of Flowers per Spike

Lisianthus plant spikes were examined for the number of flowers per spike, influenced by different treatments combining NPK nutrient concentrations and plant spacing with significant differences noted in Table 2.

Nutrient Level : The highest number of flowers per spike was seen with N3 (125% nutrient level) at 8.52, and the lowest with N1 (75% nutrient level) at 6.02. However, nutrient intake's impact on flower count per spike was statistically non-significant.

Spacing : Spacing's individual impact on flower count per spike was statistically non-significant. However, S4 (30 cm × 30 cm) had the highest count at 8.16, while S1 (15 cm × 15 cm) had the lowest at 6.22.

Interaction : T_{12} (125% nutrient level with 30 cm × 30 cm spacing) recorded the maximum flowers per spike at 9.67, akin to T_{11} (125% nutrient level with 15 cm × 45 cm spacing) at 8.83 and T_{10} (125% nutrient level with 15 cm × 30 cm spacing) at 7.93. Conversely, the lowest count was in T_5 (75% nutrient level with 15 cm × 15 cm spacing) at 5.00, similar to T_6 (75% nutrient level with 15 cm × 30 cm spacing) at 5.67.

Higher flower counts per spike may be due to wider spacing reducing plant density, along with sufficient nutrient provision promoting flower formation. Conversely, lower counts could be attributed to reduced potassium (K) supply. These findings resonate with the studies of Ahmad *et al*. (2017) and Jamal *et al*. (2013) in Lisianthus.

Spike length (cm)

The length of Lisianthus spikes was measured across various treatments, including different NPK nutrient levels combined with diverse plant spacings, with significant differences noted, as displayed in Table 2.

Nutrient loevel : The highest spike length was observed with N3 (125% nutrient level) at 90.80 cm, while the lowest was with N1 (75% nutrient level) at 84.45 cm. However, the impact of nutrient level on spike length was statistically non-significant.

Spacing : Spacing's individual effect on spike length was non-significant. However, the maximum spike length was recorded in S2 (15 cm × 30 cm) at 91.43 cm, while S1 (15 cm × 15 cm) had the shortest spike length at 86.45 cm.

Interaction : Data on spike length (cm) revealed that the maximum spike length was observed in T_{10} (125% nutrient level with 15 cm × 30 cm spacing) at 98.00 cm, similar to T_{12} (125% nutrient level with 30 cm × 30 cm spacing) at 94.87 cm. This may be attributed to optimal plant spacing and increased levels of macro nutrients, particularly nitrogen, facilitating spike length improvement.

Conversely, the shortest spike length was observed in T_5 (75% nutrient level with 15 cm × 15 cm spacing) at 82.88 cm, similar to T_7 (75% nutrient level with 15 cm × 45 cm spacing) at 84.29 cm and T8 (75% nutrient level with 30 cm × 30 cm spacing) at 84.93 cm. This could be due to lower nutrient levels and reduced spacing, increasing plant density, which limits proper spike growth and development. Similar findings were reported by Zamin *et al*. (2020) and Bhande *et al.* (2015).

Flower diameter (cm)

Lisianthus flower diameter was assessed across various treatments, encompassing different NPK nutrient levels and plant spacing, revealing significant differences as indicated in Table 2.

Nutrient level : The maximum flower diameter was observed with N3 (125% nutrient level) at 6.16 cm, while the minimum was with N1 (75% nutrient level) at 3.67 cm. However, the impact of nutrient level on flower diameter was statistically non-significant.

Spacing : Spacing's individual effect on flower diameter was non-significant. However, the maximum flower diameter was recorded in S2 (15 cm × 30 cm) at 5.23 cm, while S1 (15 cm × 15 cm) had the minimum flower diameter at 4.01 cm.

Table 2 : Effect of nutrient level and spacing on flower quality parameters of Lisianthus.

Treatments	Flowering parameters			
	Number of flowers/ spike	Spike length (cm)	Flower diameter (cm)	Vase life (days)
Nutrient level				
N1–75% Nutrient level	6.02	84.45	3.67	8.17
N2–100% Nutrient level	6.80	89.06	4.27	9.80
N3–125% Nutrient level	8.52	90.80	6.16	11.96
F–test	NS	NS	NS	NS
S.Em ±	0.17	1.40	0.54	0.58
C.D@ 5%	0.50	4.08	1.57	1.69
Spacing				
S1-15cm× 15cm	6.22	86.45	4.01	8.97
S2-15cm× 30cm	6.64	91.43	5.23	11.21
S3-15cm×45cm	7.44	87.83	4.53	9.49
S4-30cm× 30cm	8.16	89.83	5.01	10.24
F–test	NS	NS	NS	NS
S.Em±	0.20	1.61	0.62	0.67
C.D@ 5%	0.58	4.71	1.80	1.94
Interactions				
T1(N2S2)	6.33	90.60	5.00	10.80
T2(N2S1)	6.00	87.70	3.47	8.73
T3(N2S3)	7.00	88.23	4.17	9.60
T4(N2S4)	7.87	89.70	4.43	10.07
T5(N1S1)	5.00	82.88	3.23	7.83
T6(N1S2)	5.67	85.70	3.67	8.67
T7(N1S3)	6.50	84.29	3.83	8.00
T8(N1S4)	6.93	84.93	3.93	8.20
T9(N3S1)	7.67	88.76	5.34	10.33
T10(N3S2)	7.93	98.00	7.03	14.17
T11(N3S3)	8.83	89.58	5.60	9.49
T12(N3S4)	9.67	94.87	6.67	1.24
F–test	*	*	*	*
S.Em±	0.34	2.80	1.08	1.16
C.D@ 5%	1.00	8.16	3.14	3.39

*Significance at 5% level, NS–Non Significant

Note : 120:150:150 Kg NPK ha^{-1} (RDF of Gladiolus) was taken as the standard dose.

Interaction : Table 2 shows that the maximum flower diameter was observed in T_{10} (125% nutrient level with 15 cm × 30 cm spacing) at 7.03 cm, akin to T_{12} (125% nutrient level with 30 cm × 30 cm spacing) at 6.67 cm and T_{11} (125% nutrient level with 15 cm × 45 cm spacing) at 5.60 cm. Conversely, the minimum flower diameter was observed in T_5 (75% nutrient level with 15 cm × 15 cm spacing) at 3.23 cm, similar to T_2 (100% nutrient level with 15 cm × 15 cm spacing) at 3.47 cm.

The maximum flower diameter may be attributed to increased nutrient levels and optimal spacing. Nitrogen, along with a higher potassium dose among the macro nutrients, stimulates flower bud differentiation and enhances cell turgor, contributing to water and nutrient retention. Potassium also improves photosynthetic efficiency, resulting in superior flower quality and diameter. Conversely, reduced nutrient supply and closer spacing may lead to decreased metabolic activity due to plant competition, resulting in smaller flower diameter. Similar findings were reported by Rosa *et al.* (2014) in Gladiolus and Mohariya *et al.* (2004) in Gerbera.

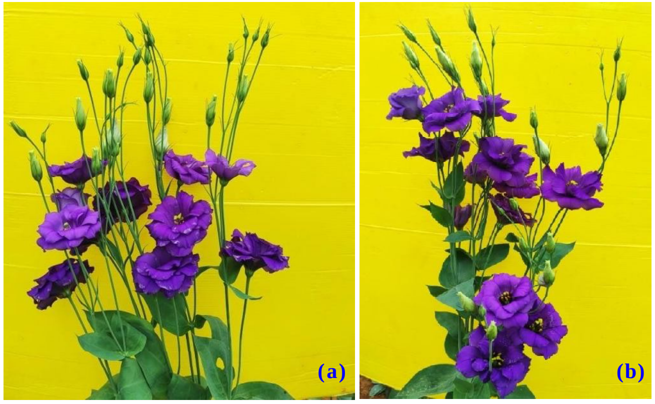

Plate 1 : Lisianthus spikes at **(a)** 50% bloom and **(b)** 75% bloom stage.

Plate 2 : Vase life study conducted with 2.0 percent sucrose on Lisianthus spikes.

Vase Life (days)

The vase life of Lisianthus spikes was assessed under different treatments involving varying quantities of NPK nutrients combined with diverse plant spacings, as recorded in Table 2. A significant difference in Lisianthus vase life was evident.

Nutrient level : Among the different nutrient levels applied, the maximum vase life (11.96 days) was recorded with N3 (125% nutrient level), while N1 (75% nutrient level) exhibited the minimum vase life of spikes at 8.17 days. However, the effect of nutrient level alone on vase life was statistically non-significant.

Spacing : Spacing's individual effect on vase life was non-significant. However, the maximum vase life of spikes (11.21 days) was observed with S2 (15 cm × 30 cm), while S1 (15 cm × 15 cm) exhibited the minimum vase life of spikes at 8.97 days.

Interaction : The data for vase life is presented in Table 2. T_{10} (125% nutrient level with 15 cm × 30 cm spacing) recorded the maximum number of days in the vase with 2.0% sucrose solution (14.17 days), similar to T_1 (100% nutrient level with 15 cm × 30 cm spacing) at 10.80 days. This could be attributed to the more effective growth and development of spikes in the field, leading to the accumulation of photosynthates in the spike, providing nourishment for a longer duration.

Conversely, the minimum number of days in the vase solution was recorded in T_5 (75% nutrient level with 15 cm × 15 cm spacing) at 7.83 days, similar to T_7 (75% nutrient level with 15 cm × 45 cm spacing) at 8.00 days and T_8 (75% nutrient level with 30 cm × 30 cm spacing) at 8.20 days. This could be due to lesser spacing increasing plant density, leading to competition for nutrients, resulting in reduced spike growth and shorter vase life. Similar findings were reported by Chaudhary and Khanal (2018) in Roses, Amin *et al*. (2015) in Gerbera and Sharifzadeh *et al*. (2014) in Lisianthus.

Conclusion

The combination of different levels of nutrients and plant spacing significantly influenced the flowering parameters and flower quality of Lisianthus. A nutrient level of 125 percent combined with a spacing of 15 cm × 30 cm resulted in the earliest spike initiation (92.08 days), 50 percent bloom (118.23 days) and 75 percent bloom (130.50 days). Additionally, this treatment yielded the longest spikes (98.00 cm), the largest flower diameter (7.03 cm) and the longest vase life (14.17 days). The treatment with best result can be further advocated as base for Macro and Micro nutrient studies in Lisianthus.

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Competing interests

Authors have declared that no competing interests exist.

Authors' contributions

Dr. R. Vasantha Kumari, designed the study, facilitated the resources required and provided technical guidance.

Karthik, D. R., Maintained crop in the field, statistical analysis and wrote the first draft of the manuscript.

Dr. Shalini M., manuscript preparation.

All authors read and approved the final manuscript.

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