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Nutrition for commercial flower production of *Longiflorum asiatica* (LA) hybrid under northern plains

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ABSTRACT

The study was conducted during the winter seasons, comprising the various combinations of inorganic fertilizers (N, P_2O_5, and K_2O) and organic manure (FYM). Treatment T_{24} [(25 t FYM+160 kg N+120 kg P_2O_5+100 kg K_2O)/ha] emerged as the statistically significant treatment, outperforming others in respect of tallest plant (122.43 cm), leaf count per plant (79.33), leaf length (7.90 cm), and early flower bud initiation (28.01 days), bud initiation to colour shown (47.11 days), and colour shown to flower opening (6.10 days). This treatment also tended to show the longest flower retention on plant (15.30 days), number of flower buds per plant (4.20), bud length (8.96 cm), stalk length (110.10 cm), stalk diameter (0.96 cm), flower diameter (22.98 cm), total chlorophyll content (6.50 mg/g), leaf nitrogen (4.70%), potassium (4.10%), and net assimilation ratio (NAR) (0.0065 mg/cm²/day). Treatment T_{23} [(25 t FYM+120 kg N+90 kg P_2O_5+75 kg K_2O)/ha] proved next best treatment. The lowest value was recorded in T_{25} (Control). Overall, treatment T_{24} proved to be the most effective treatment statistically for the commercial flower production of LA hybrid lilium for northern Indian plains.

Key words: *Lilium* sp., FYM, nutrient combinations, NAR, total chlorophyll, Masai.

INTRODUCTION

Lilium, the premier cut flower, is predominantly cultivated in the Netherlands, occupying 76% of the total global acreage followed by France, Chile, Japan, the United States, New Zealand, and Australia (Anand *et al.,* 1). It is widely used for stage decorations, bouquet arrangements, display pot plants, and as a garden plant. The genus *Lilium (Lilium* sp.), belongs to Liliaceae family, typically grown from bulbs, and often referred to as the 'King' of flower bulbs. Notably, commercial cultivation of lilium is taken up in Indian states such as Himachal Pradesh, Uttarakhand, Jammu and Kashmir, Haryana and Tamil Nadu. Lilies are primarily classified into three hybrid groups: Asiatic, Oriental, and Longiflorum. LA hybrids have been developed by crossing Longiflorum (*Lilium longiflorum*) and Asiatic (*L. asiatica*) lilies. These LA hybrids are extensively used as potted plants and cut flowers, known for their larger, upward-facing flowers. Nowadays, LA hybrids are becoming increasingly popular than the Asiatic lilies (Diksha *et al.,* 4) owing to their longer stems, wider colour range, longer vase life and mild fragrance.

Nutrient research in bulbous flowers is generally challenging because the ability of the bulb to store nutrients and the mineral contents of soil, required for the bulb development (Prasad *et al.*, 17). In ornamental bulbous plants, the supply of nutrients greatly affects the growth, flowering, and the production of bulbs and bulblets (Saraswati *et al.*, 18). Farmyard manure (FYM) is a reservoir of nutrients, containing macro- and micro-nutrients. Well-decomposed FYM usually contains 0.5% N, 0.2% P_2O_5, and 0.5% K_2O. The quality of lilium blooms is significantly influenced by the ratios of N, P, and K of various inorganic fertilizers (Wang *et al.*, 20). Considering environmental concerns, there have been an increased efforts towards the sustainable nutrient management in floriculture as well, which aims to reduce the use of inorganic source of nutrients.

However, the knowledge of nutrient application on lilium crop is scarce, and suggests the significant variations in the required nutrient application. Although LA hybrid lilium has been commercially cultivated in our country over decade, there have been only a handful of substantial studies on nutrient management. Given the significance of LA hybrid lilium, and the lack of comprehensive research on the use of combined nutrients, this study was conducted to determine the optimal dosage of organic and inorganic source of nutrients for producing the high quality LA hybrid lilium flowers in the northern plains.

MATERIALS AND METHODS

The study took place from 2021 to 2022 at the Floriculture Research Farm of the ICAR-Indian Agricultural Research Institute in New Delhi, located at 28°35' N, 77°12' E, and an elevation of 228.16 meters above mean sea level. The high-quality bulbs of uniform size, measuring 14 to 16 cm in circumference, of the 'Masai' variety were planted in

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the field. This variety attained a height of 2 to 4 feet, and bears orange-coloured flowers.

The experiment involved two variables: varying doses of Farmyard Manure (FYM) (F) and, specifically urea (46% N), single super phosphate (SSP, 16% P_2O_5), and muriate of potash (MOP, 60% K_2O). The treatment details are presented in Table 1. Bulbs were treated with 0.2% Bavistin and planted at a depth of 12 cm with spacing of 20 cm × 20 cm under a 50% shade net. Full dose of FYM was applied 30 days before planting, while the full amounts of SSP and MOP were used as a basal dose during planting. Urea was administered in three equal split doses: the first dose at 10 to 15 days after planting (DAP), coinciding with the emergence of feeding roots, the second dose at 40 DAP, and the final dose was given just before the onset of flowering. The experiment was laid out in a factorial RBD with 25 treatments, and replicated thrice.

Vegetative growth like plant height, number of leaves per plant, leaf length and leaf width were recorded. Flowering parameters, including days taken to first flower bud initiation (days), and from the bud initiation to the colour showing (days), were recorded. The count of flower buds began when the buds started to change colour. Bud length and bud diameter were measured with a digital vernier calliper. Days taken from the colour showing to the flower opening (days) was recorded. Flower diameter and stalk diameter were assessed. Days from flower opening to the complete flower withering on the plant (days) was noted.

The leaf N, P, K and total chlorophyll content were measured using modified Kjeldahl method (Lee *et al.*, 11), Vanado-Molybdo Phosphate technique (Jackson, 8), flame photometry (Barnes *et al.*, 3) and spectrophotometric method (Arnon, 2) respectively. The net assimilation rate (NAR) was calculated as per the equation of Escalante and Kohashi (5).

The data from this study were analysed statistically following the methodology suggested by Gomez and Gomez (6). The statistical analysis of the observed traits involved the use of the analysis of variance (ANOVA) technique, employing both the SPSS software package and MS Excel for computation.

RESULTS AND DISCUSSION

The crop performance was significantly impacted by treatments individually as well as collectively. Soil application with varying concentrations of FYM, T_4 tended to show the tallest plant (119.43 cm) with highest leaf count per plant (76.33), leaf length (7.23 cm), and width of leaf (3.10 cm). In contrast, T_1 exhibited the lowest measurements with a plant height (100.00 cm), number of leaves (65.33), leaf length (6.42 cm), and leaf width (2.21 cm) (Table 2). The plant growth was significantly enhanced as the nutrient levels were increased. The enhancement growth with FYM application might have increased the soil organic matter, which is crucial for enhancing soil's physical, chemical, and biological properties, thereby boosting plant growth (Munne-Bosch and

Table 1. Details of different treatments used for the study.

Treatment	Details	Treatment	Details
$T_1(F_1)$	10 t FYM /ha	$T_{14}(F_2N_2)$	(15 t FYM + 80kg N + 60kg P_2O_5 + 50kg K_2O) /ha
$T_2(F_2)$	15 t FYM /ha	$T_{15}(F_2N_3)$	(15 t FYM + 120kg N + 90kg P_2O_5 + 75 K_2O kg) /ha
$T_3(F_3)$	20 t FYM /ha	$T_{16}(F_2N_4)$	(15 t FYM + 160kg N + 120kg P_2O_5 + 100kg K_2O) /ha
$T_4(F_4)$	25 t FYM /ha	$T_{17}(F_3N_1)$	(20 t FYM + 40kg N + 30kg P_2O_5 + 25kg K_2O) /ha
$T_5(N_1)$	(40kg N + 30kg P_2O_5 + 25kg K_2O) /ha	$T_{18}(F_3N_2)$	(20 FYM + 80kg N + 60kg P_2O_5 + 50kg K_2O) /ha
$T_6(N_2)$	(80kg N + 60kg P_2O_5 + 50kg K_2O) /ha	$T_{19}(F_3N_3)$	(20 t/ha + 120kg N + 90kg P_2O_5 + 75 K_2O kg) /ha
$T_7(N_3)$	(120kg N + 90kg P_2O_5 + 75 K_2O kg) /ha	$T_{20}(F_3N_4)$	(20 t FYM + 160kg N + 120kg P_2O_5 + 100kg K_2O) /ha
$T_8(N_4)$	(160kg N + 120kg P_2O_5 + 100kg K_2O) /ha	$T_{21}(F_4N_1)$	(25 t FYM + 40kg N + 30kg P_2O_5 + 25kg K_2O) /ha
$T_9(F_1N_1)$	(10 t FYM + 40kg N + 30kg P_2O_5 + 25kg K_2O)/ha	$T_{22}(F_4N_2)$	(25 t FYM + 80kg N + 60kg P_2O_5 + 50kg K_2O) /ha
$T_{10}(F_1N_2)$	(10 t FYM + 80kg N + 60kg P_2O_5 + 50kg K_2O) /ha	$T_{23}(F_4N_3)$	(25 t FYM + 120kg N + 90kg P_2O_5 + 75 K_2O kg) /ha
$T_{11}(F_1N_3)$	(10 t FYM + 120kg N + 90kg P_2O_5 + 75 K_2O kg) /ha	$T_{24}(F_4N_4)$	(25 t FYM + 160kg N + 120kg P_2O_5 + 100kg K_2O) /ha
$T_{12}(F_1N_4)$	(10 t FYM + 160kg N + 120kg P_2O_5 + 100 kg K_2O) /ha	T_{25}	Control
$T_{13}(F_2N_1)$	(15 t FYM + 40kg N + 30kg P_2O_5 + 25kg K_2O) /ha		

Algere, 15). Moghadam *et al.* (13) also observed the similar results in the vegetative growth in lilium.

Among various levels of inorganic fertilizers, the plants treated with T_8 achieved the maximum plant height (98.53 cm), number of leaves per plant (62.33), leaf length (6.41 cm), and leaf width (2.20 cm). In contrast, the T_5 resulted the plants resulted the lower plant height (96.63 cm), number of leaves (60.00), leaf

Table 2. Effects of organic manures and inorganic fertilizers on growth and flowering parameters of LA hybrid lilium variety 'Masai'.

Treatment	PH (cm)	NL	LL (cm)	LW (cm)	PBI (days)	BIC (days)	NFB	CFO (days)	FOW (days)
Organic manure (F)									
T_1	100.00	65.33	6.42	2.21	36.89	50.90	3.13	7.30	10.91
T_2	113.36	72.66	6.50	2.90	35.50	50.48	3.20	7.09	11.33
T_3	119.43	75.00	7.10	2.98	33.90	50.20	3.31	6.98	12.33
T_4	119.43	76.33	7.23	3.10	30.90	49.00	3.29	6.80	14.00
SE (m) ±	0.44	0.31	0.006	0.001	0.12	0.21	0.0005	0.003	0.01
CD (P = 0.05)	1.90	1.58	0.23	0.10	0.98	1.31	0.06	0.15	0.30
Inorganic fertilizer (N)									
T_5	96.63	60.00	6.32	2.09	37.50	52.13	3.05	7.64	10.20
T_6	97.50	60.33	6.34	2.10	37.48	52.09	3.06	8.00	10.22
T_7	98.13	62.00	6.40	2.11	37.40	52.33	3.09	8.00	10.23
T_8	98.13	62.33	6.41	2.20	36.90	52.00	3.12	7.33	10.88
SE (m) ±	0.44	0.31	0.006	0.001	0.12	0.21	0.0005	0.003	0.01
CD (P = 0.05)	1.90	1.58	0.23	0.10	0.98	1.31	0.06	0.15	0.30
Interaction F*N									
T_9	104.56	65.33	6.43	2.22	36.50	50.88	3.15	7.31	10.92
T_{10}	109.63	65.33	6.45	2.06	36.20	50.70	3.16	7.30	10.94
T_{11}	107.83	66.00	6.46	2.09	36.10	50.62	3.18	7.30	10.95
T_{12}	107.84	65.66	6.47	2.10	35.90	50.50	3.19	7.27	10.96
T_{13}	113.46	72.33	6.51	2.91	34.90	50.46	3.22	7.09	11.66
T_{14}	114.29	74.33	6.90	2.95	34.50	50.45	3.28	7.05	11.72
T_{15}	114.73	74.66	6.99	2.96	34.10	50.45	3.29	7.01	12.00
T_{16}	116.50	75.00	7.00	2.97	34.00	50.40	3.30	7.00	12.05
T_{17}	117.80	75.33	7.25	2.99	33.50	49.09	3.31	6.95	13.00
T_{18}	118.60	76.00	7.35	2.99	33.10	49.05	3.32	6.94	13.33
T_{19}	118.70	77.33	7.51	2.98	32.00	48.99	3.32	6.92	13.66
T_{20}	118.90	78.33	7.55	3.00	31.90	48.95	3.33	6.90	13.99
T_{21}	120.60	79.00	7.43	3.11	29.50	48.08	3.33	6.75	14.10
T_{22}	121.13	78.33	7.66	3.35	28.00	47.33	3.66	6.60	14.30
T_{23}	121.86	78.66	7.68	3.55	28.90	47.20	4.10	6.50	14.50
T_{24}	122.43	79.33	7.90	3.50	28.01	47.11	4.20	6.10	15.30
T_{25}	94.69	53.00	6.33	2.00	37.66	52.33	3.00	8.33	10.00
SE (m) ±	2.29	1.55	0.03	0.006	0.59	1.06	0.002	0.01	0.05
CD (P = 0.05)	4. 24	3.54	0.51	0.23	2.19	2.93	0.15	0.35	0.68

*PH, Plant height; NL, No. of leaves; LL, Leaf length; LW, Leaf width; PBI, Planting to bud initiation stage; BIC, Bud initiation to colour shown stage; NFB, No. of flower buds; CFO, Colour shown to flower opening stage; FOW, Flower opening to flower withering

length (6.32 cm), and leaf width (2.09 cm) (Table 2). The growth enhancement with higher fertilizer levels can be attributed to NPK's effectiveness in providing balanced nutrition, beneficial for both soil rhizosphere and plant systems. The similar observations have also been observed in tuberose by Munikrishnappa *et al.* (14).

The interaction effects revealed the significant influence on vegetative growth parameters of lilium (Table 2). Among the various treatment combinations, T_{24} exhibited the greatest plant height (122.43 cm), number of leaves (79.33), and leaf length (7.90 cm), followed by T_{23}. T_{23}, however, had the widest leaves (3.52 cm). In opposite, the lowest values of corresponding parameters were observed in T_{25} (control). The plants that received a combined nutrient source showed the superior growth compared to those receiving individual nutrients. The improved growth with combined nutrient sources might have decreased leaching losses and the consistent availability of nutrients, especially nitrogen, throughout the course of growth phase. Similar growth trait variations have also been reported by Kumar *et al.* (10) in gladiolus.

With respect to flowering parameters, the initiation of flower buds (30.90 days), colour breakdown (49 days), flower opening (6.80 days), and the duration for flower withering on the plant (14 days), along with flower buds count (3.31), bud length (8.46 cm), bud diameter (3.50 cm), stalk diameter (0.93 cm) (Fig. 1), stalk length (101.33 cm), and flower diameter (21.66 cm) (Fig. 2), were optimal in T_4 among the various levels of FYM. The obtained results emphasized that the flowering parameters improved with higher levels of FYM, likely due to effective decomposition, mineralization, solubilization effects, the accessibility of sufficient nutrients, and the positive impact of organic resources. A similar enhancement in the growth characteristics and flower quality was also noted in lilium Anand *et al.* (1).

Similarly, among the various levels of inorganic fertilizers, T_8 showed the best performance in all measured flowering parameters (Table 2). It was

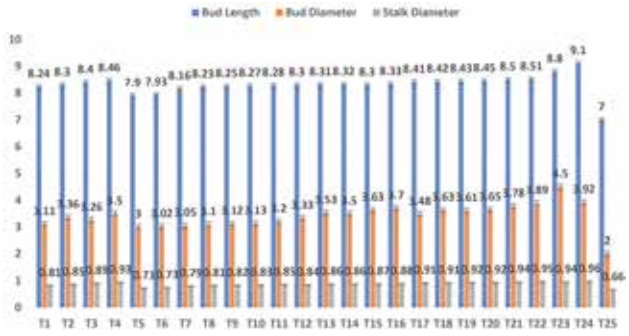

Fig. 1. Influence of organic manure and inorganic fertilizer on bud length and bud diameter of LA hybrid lilium variety 'Masai'.

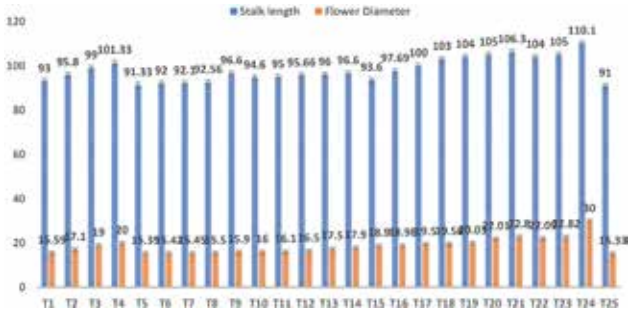

Fig. 2. Effects of organic manure and inorganic fertilizer on stalk length and flower diameter of LA hybrid lilium variety 'Masai'.

witnessed that the flowering parameters were improved with higher levels of inorganic fertilizers, which could be due to the role of nutrition in activating essential processes and synthesizing vital components like carbohydrates, proteins, hormones, enzymes, and energy reserves, required for sound plant growth (Mengel and Kirkby, 12). Nitrogen is essential for vegetative growth in plants, while adequate phosphorus and potassium are crucial for flowering and support healthy reproductive development. These results are in conformity with the previous results, obtained in glory lily (Gupta *et al.,* 7).

In the interaction study, T_{24} proved best treatment for initiating flower buds (28.01 days), colour transition (47.11 days), blooming (6.10 days), longevity of flowers on standing crop (15.30 days), and the flower buds count (4.20) (Table 2). It also led in bud length (8.96 cm), stalk length (110.10 cm), stalk diameter (0.96 cm), and flower diameter (22.98 cm). However, T_{23} outperformed with a bud diameter of 3.92 cm (Fig. 1-2). Conversely, the control treatment exhibited delayed bud initiation (37.66 days), slower colour transition (52.33 days), longer time to bloom (8.33 days), quicker wilting (10.00 days), fewer flower buds (3.00) (Table 2), shorter bud length (7.43 cm), smaller bud diameter (2.96 cm), thinner stalk diameter (0.66 cm), shorter stalk length (91 cm), and smaller flower diameter (15.33 cm) as illustrated in Fig. 1-2).

Interaction treatments have recorded great performance compared to other treatments. This could be linked to the combined effects of using both organic and inorganic fertilizers, which likely led to a more developed root system and notable improvements in soil physical properties. These enhancements may have facilitated better nutrient absorption by plants, resulting in improved flowering parameters. These results are similar with the results of Singh (19) on tuberose.

For physiological parameters, among the different FYM levels, the highest values of nitrogen (3.80%), phosphorus (0.37%), potassium (3.83%), total chlorophyll content (5.8 mg/g) in leaves, and Net

Assimilation Rate (NAR) at 0.049 mg/cm^2/day were observed in treatment T_4, followed by T_3 (Table 3). Organic sources are known to maintain soil pH within a neutral range and enhance the availability of nutrients to plants. These outcomes are in line with those of Jambhekar (9), who reported increased levels of N, P_2O_5, and K_2O in soil treated with vermicompost, leading to improved plant growth.

Among the different levels of inorganic fertilizers, the highest amounts of nitrogen (3.42%), phosphorous (0.29%), potassium (3.02%), total chlorophyll content (5.60 mg/g) in leaves, and Net Assimilation Rate (NAR) (0.045 mg/cm^2/day) were documented in treatment T_8, followed by T_7 (Table 3). The fertilizers are correlated with a well-developed root system, significant improvements in soil physical properties, enhanced microbial activity, and an increased rate of photosynthesis, which likely contributed to improved nutrient absorption, as supported by Polara *et al.* (16).

Among the different interaction treatments, T_{24} showed higher levels of nitrogen (4.70%), potassium (4.10%), and total chlorophyll content (6.50 mg/g) in the leaves and net assimilation rate (NAR) of 0.065 mg/cm^2/day. In contrast, T_{23} had the highest leaf phosphorous content at 0.042%. The lowest values for nitrogen (2.86%), phosphorous (0.21%), potassium (2.74%), total chlorophyll content (3.90 mg/g) in leaves, and NAR (0.032 mg/cm^2/day) were observed in T_{25} (control), (Table 3). The combined application of nutrients markedly improved physiological parameters compared to the control, as detailed in Table 3. Another contributing factor could be the presence of sufficient macro and micronutrients, an increased supply of plant nutrients, and the physical effects of FYM and NPK on soil porosity, aeration, and enhanced metabolic processes, as suggested by Gupta *et al.* (8).

The current study's findings imply that amongst various treatment combinations of organic manure (FYM) and inorganic fertilizers, the T_{24} treatment (FYM at 25 t/ha + N: P_2O_5:K_2O at 160:120:100 kg/ha) excelled in improving most vegetative and floral quality parameters. We can conclude that, these evidences may offer a viable alternative technology for the commercial cultivation of LA hybrid lilies in the northern plains of India.

AUTHORS' CONTRIBUTION

Conceptualization (MKS), Methodology (S, MKS, N), Investigation (S), Data curation and Formal analysis (S, MKS, N), Writing original draft (S), Resources, Software, Validation (MKS, N, SS, RP, MCM), Writing, review and editing (S, MKS, N).

DECLARATION

The authors declare that they do not have any conflict of interest for research paper.

Table 3. Effects of organic manure and inorganic fertilizers on physiological parameters of LA hybrid lilium variety 'Masai'.

Treatment	Leaf nitrogen (%)	Leaf phosphorous (%)	Leaf potassium (%)	Total leaf chlorophyll (mg/g)	NAR (mg/cm^2/day)
Organic manure (F)					
T_1	3.46	0.22	3.01	5.20	0.040
T_2	3.60	0.30	3.10	5.32	0.043
T_3	3.71	0.33	3.41	5.55	0.045
T_4	3.80	0.37	3.83	5.80	0.049
SE (m) ±	0.003	0.007	0.003	0.004	0.003
$CD_{(P=0.05)}$	0.16	0.23	0.16	0.18	0.05
Inorganic fertilizer (N)					
T_5	2.90	0.23	2.88	5.15	0.035
T_6	2.93	0.24	2.88	4.30	0.039
T_7	3.14	0.25	2.96	5.41	0.041
T_8	3.42	0.29	3.02	5.60	0.045
SE (m) ±	0.003	0.007	0.003	0.004	0.0003
$CD_{(P=0.05)}$	0.16	0.23	0.16	0.18	0.05
Interaction F*N					
T_9	3.48	0.29	3.00	5.50	0.050
T_{10}	3.50	0.30	3.01	5.10	0.048
T_{11}	3.50	0.30	3.03	5.20	0.049
T_{12}	3.51	0.31	3.05	4.90	0.049
T_{13}	3.63	0.31	3.15	5.00	0.053
T_{14}	3.65	0.33	3.17	3.80	0.051
T_{15}	3.67	0.32	3.28	4.10	0.040
T_{16}	3.68	0.33	3.30	5.20	0.049
T_{17}	3.71	0.34	3.45	5.90	0.056
T_{18}	3.73	0.34	3.52	5.10	0.060
T_{19}	3.76	0.35	3.52	5.30	0.058
T_{20}	3.79	0.36	3.68	5.83	0.061
T_{21}	3.33	0.38	3.86	6.21	0.059
T_{22}	3.50	0.37	4.02	6.28	0.062
T_{23}	3.79	0.42	4.00	6.30	0.062
T_{24}	4.70	0.39	4.10	6.50	0.065
T_{25}	2.86	0.38	2.74	3.90	0.029
SE (m) ±	0.01	0.003	0.01	0.02	0.001
$CD_{(P=0.05)}$	0.37	0.05	0.37	039	0.11

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