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Effect of Micronutrients (Zinc and Manganese) on Growth, Quality Flower Production and Postharvest Vase Life of La Hybrid *Lilium* Cv. Pavia

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ABSTRACT: *Lilium* is one of the most important ornamental bulbous flowering plant possess a conspicuous position among the top ten cut flowers in the world. Optimum dose of micronutrients is very important for better growth and quality flower production. So the present study has been carried out to determining the optimum dose of micronutrients in North Indian plains conditions. A field experiment was carried out to study the effect of zinc and manganese on growth, quality flower production and postharvest vase life of LA hybrid lilium cv. Pavia during 2021-22. The experiment was laid out in a factorial randomized block design with two factors ($ZnSO_4$ and $MnSO_4$) comprising five levels (distilled water, 2 g/l, 4 g/l, 6 g/l and 8 g/l) of micronutrients. Overall best result was found in the interaction of $ZnSO_4$ and $MnSO_4$, when plants are sprayed with $ZnSO_4$+ $MnSO_4$@ 6g/l each performed better in terms of plant growth analysis parameters *viz.*, crop growth rate (4.46 g/m^2 land area/day), leaf area index (1.98) and total chlorophyll content in leaves (8.45 mg/g); quality parameters, *viz.*, stalk length (99.23 cm), stalk diameter (1.36 cm), number of flower buds per plant (8.53), bud length (11.86 cm), bud diameter (4.21 cm) and flower size (20.20 cm); postharvest vase life parameters, *viz.*, number of days from harvesting to primary flower opening in flower vase (2.13 days), number of days fromharvesting to primary flower withering (6.93 days) and complete flower withering (12.60 days) in flower vase whereas least values were recorded in control.

Keywords: *Lilium*, micronutrients, zinc sulphate, manganese sulphate.

INTRODUCTION

Among the bulbous crops, Lilium is one of the most significant flower crops and it has a great demand in the market due to its majestic long slender perfumed and showy flowers (Pandey *et al.*, 2009). It is generally utilized as a cut flower and potted plants within the floral industry. There are three major groups of lilium which dominate the world market *i.e.* Asiatic hybrid lilium, LA hybrid lilium and Oriental hybrid lilium. The area under commercial cultivation of LA hybrid lilium is increasing day by day in India. Netherland is the largest producer and exporter of planting material of lilium. It is commercially cultivated in Himachal Pradesh, Uttarakhand, Jammu & Kashmir and recently, this crop has become popular in Manipur, Meghalaya, Arunachal Pradesh, Nagaland, Sikkim, Haryana, Karnataka (Bengaluru), Maharashtra (Pune) and Tamil Nadu (Nilgiris). Liliums are highly demanded cut flower in international flower trade due to its wide diversity of flower colour, attractive flower shape and having long post-harvest shelf life.

Micronutrients have stimulatory and catalytic effects on metabolic processes thus play vital roles in the growth and development of plants (Khosa *et al.*, 2011). They are essential for crop growth and development although they are required in smaller quantities. Enrichment of the crop with micronutrients, especially and zinc and manganese may prove effective in regulating flowering in crops (Pratap *et al.*, 2005) and aid in better flower production. Zinc is necessary for the synthesis of auxin IAA and for carbohydrate metabolism, protein synthesis, internodes elongation for stem growth. Manganese is an essential cofactor for the oxygen-evolving complex (OEC) of the photosynthetic machinery, catalyzing the water-splitting reaction in photo system II(PSII). For various ornamental flower crops, foliar sprays was found more economically than soil application and combination sprays of micronutrients have been successfully resorted.

Optimum quantity of micronutrients is very important for better growth, flower and bulbs production of LA hybrid lilium. Though LA hybrid lilium is being commercially cultivated in India since more than one decade, a few significant research work has been reported. Moreover, no systematic work has been carried out in Northern plains of India on micronutrients for growth, flower and bulb production of LA hybrid lilium. Keeping the above points in view, an experiment was conducted to study the effect of foliar application of micronutrients (Zn and Mn) on growth, flowering and bulb production of LA hybrid lilium cv. Pavia.

MATERIALS AND METHODS

The experiment was carried out in the division of Floriculture and Landscaping experimental field and the laboratory of division of Plant Physiology, ICAR-Indian Agricultural Research Institute (IARI), New Delhi during 2021-22, to find out the effect of micronutrients on growth, quality and postharvest vase life of LA hybrid *Lilium* cv. Pavia. The experiment was laid out in Factorial Randomized Block Design with two factors *i.e.*, micronutrient spray application of $ZnSO_4$ and $MnSO_4$. The first factor ($ZnSO_4$) consists of five levels *viz.*, Z_0: Distilled water (control), Z_1: $ZnSO_4$ at 2 g/l, Z_2: $ZnSO_4$ at 4 g/l, Z_3: $ZnSO_4$ at 6 g/l and Z_4: $ZnSO_4$ at 8 g/l, and the second factor contains five levels *viz.*, M_0: Distilled water (control), M_1: $MnSO_4$ at 2 g/l, M_2: $MnSO_4$ at 4 g/l, M_3: $MnSO_4$ at 6 g/l and M_4: $MnSO_4$ at 8 g/l. The combination of these two factors are replicated three times in the experiment. High-quality, uniform sized, sprouted bulbs of LA hybrid lilium cultivar "Pavia" with a circumference of14-16cm were treated with Bavistin @ 0.2%foranhour and planted in November at a spacing of 20 × 20 cm under 50% shade net. Foliar application of micronutrients ($ZnSO_4$ and $MnSO_4$) at four levels (2g, 4g, 6g, 8g) along with control (distilled water) and their combinations were sprayed with a hand pressure sprayer at 40 and 60 days after planting of bulbs. Ten plants from each replication of the cultivar were used for recording observations. Biometric observations were recorded on growth and physiological attributes, viz. Crop Growth Rate(CAR) (g/m^2landarea/day), Leaf Area Index, and total chlorophyll content in leaves (mg/g); quality attributes, *viz.*, stalk length (cm), stalk diameter(cm), number of flower buds per plant (nos.), bud length (cm),bud diameter (cm) and flower size(cm); postharvest vase life parameters, *viz.*, number of days from harvesting to primary flower opening in flower vase (days), number of days from harvesting to primary flower withering in flower vase (days) and number of days from harvesting to complete flower withering in flower vase (vase life) (days).

RESULTS AND DISCUSSION

Growth Parameters. Among foliar application of various concentration of zinc sulphate, the plants which are sprayed with 6g/l$ZnSO_4$(Z_3) recorded maximum crop growth rate (3.78 g/m^2 land area/day), leaf area index (1.85) and total chlorophyll content in leaves (8.35 mg/g) whereas minimum crop growth rate (3.33 g/m^2 land area/day) and leaf area index (1.77)was recorded in $ZnSO_4$ at 8g/l (Z_4) and least total chlorophyll content in leaves (7.61mg/g) was recorded in $ZnSO_4$ at 2g/l (Z_1).

Among foliar application of various concentration of manganese sulphate, the plants which are nourished with 6g/l$MnSO_4$(M_3) recorded maximum crop growth rate (2.93 g/m^2 land area/day), leaf area index (1.82) and total chlorophyll content in leaves (7.95 mg/g) whereas minimum crop growth rate (2.36 g/m^2 land area/day), leaf area index (1.74) and total chlorophyll content in leaves (7.81mg/g) was recorded in $ZnSO_4$ at 2g/l (Z_1).

Significant differences were observed in interaction effect of $ZnSO_4$+ $MnSO_4$. The interaction results showed that the plants which are sprayed with $ZnSO_4$@ 6g/l + $MnSO_4$@ 6g/l (Z_3M_3) recorded maximum crop growth rate (4.46 g/m^2 land area/day), leaf area index (1.98) and total chlorophyll content in leaves (8.45 mg/g) followed by $ZnSO_4$@ 6g/l + $MnSO_4$@ 4g/l (Z_3M_2) recorded 4.34 g/m^2 land area/day crop growth rate, 1.96 leaf area index and total chlorophyll content in leaves of 8.40 mg/g. The minimum values for crop growth rate (1.84 g/m^2 land area/day), leaf area index (1.68) and total chlorophyll content in leaves (7.32 mg/g) was recorded in control (Z_0M_0).

The results might be due to the increased photosynthetic rate from the application of micronutrients. These micronutrients regulate metabolic processes occurring in plants and also contribute in accumulation of bio-synthates through various processes and hence vegetative growth is enhanced. These findings were in agreement with the results of Memon *et al.*, (2013) in gladiolus (*Gladiolus hortulanus*). These micronutrients also activates several enzymes like catalase, peroxidase, tryptophansynthase, carbonicdehydrogenase, etc. and hence, improved growth characteristics (Asmita and Singh 2015) in lilium cv. Albedo. The role of zinc in endogenous auxin synthesis and its effect on vegetative growth has been well documented. These findings are inclose proximity of Lu *et al.* (2011) who worked on lilium plant and found increased fresh weight dry weight and total leaf area of leaves on the application of micronutrients.

Younis *et al*. (2013) reported an increase in the growth characteristic like leaf area and leaf total chlorophyll contents when worked on rose. A significant positive response to the growth characteristics was also in agreement with the findings of Saeed *et al.* (2013) while working on gladiolus.

Table 1: Effect of Zinc Sulphate ($ZnSO_4$) and Manganese Sulphate ($MnSO_4$) on growth parameters in LA hybrid *Lilium* cv. Pavia.

Treatments	Growth Parameters		
	Crop Growth Rate (g/m^2 land area/day)	Leaf Area Index	Total chlorophyll content in leaves (mg/g)
Zinc Sulphate ($ZnSO_4$)			
Z_1	3.38	1.78	7.61
Z_2	3.66	1.81	8.08
Z_3	3.78	1.85	8.35
Z_4	3.33	1.77	7.83
S. Em. ±	0.03	0.01	0.01
C.D@5%	0.01	0.02	0.02
Manganese Sulphate ($MnSO_4$)			
M_1	2.36	1.74	7.81
M_2	2.80	1.76	7.90
M_3	2.93	1.82	7.95
M_4	2.41	1.78	7.85
S. Em. ±	0.03	0.01	0.01
C.D@5%	0.01	0.02	0.02
Interaction ($ZnSO_4$ + $MnSO_4$)			
Z_1M_1	2.17	1.73	7.60
Z_1M_2	2.32	1.76	7.64
Z_1M_3	2.52	1.79	7.69
Z_1M_4	2.00	1.70	7.60
Z_2M_1	3.39	1.87	8.03
Z_2M_2	3.76	1.90	8.13
Z_2M_3	3.99	1.92	8.20
Z_2M_4	3.57	1.84	8.08
Z_3M_1	4.09	1.94	8.30
Z_3M_2	4.34	1.96	8.40
Z_3M_3	4.46*	1.98*	8.45*
Z_3M_4	4.14	1.89	8.36
Z_4M_1	2.64	1.80	7.79
Z_4M_2	3.15	1.83	7.89
Z_4M_3	3.29	1.85	7.93
Z_4M_4	2.85	1.78	7.83
Z_0M_0 (Control)	1.84	1.68	7.32
S. Em. ±	0.02	0.02	0.02
C.D@5%	0.04	0.04	0.04

Quality Parameters. Among foliar application of various concentration of zinc sulphate, the plants which are sprayed with 6g/l$ZnSO_4$(Z_3) recorded maximum stalk length (98.59 cm), stalk diameter (1.30 cm), number of flower buds per plant (8.26), bud length (11.44 cm), bud diameter (3.99 cm) and flower size (19.88 cm) whereas minimum stalk length (93.60 cm), stalk diameter (0.83 cm), number of flower buds per plant (6.06), bud length (8.44 cm), bud diameter (2.29 cm) and flower size (17.41 cm) was recorded in $ZnSO_4$ at 2g/l (Z_1).

Among foliar application of various concentration of manganese sulphate, the plants which are sprayed with 6g/l$MnSO_4$(Z_3) recorded maximum stalk length (95.95 cm), stalk diameter (1.05 cm), number of flower buds per plant (7.09), bud length (9.87 cm), bud diameter (3.07 cm) and flower size (18.56 cm) whereas minimum stalk length (94.91 cm), stalk diameter (0.95 cm), number of flower buds per plant (6.68), bud length (9.25 cm), bud diameter (2.74 cm) and flower size (18.06 cm) was recorded in $MnSO_4$ at 2g/l (Z_1).

Significant differences were observed in interaction effect of $ZnSO_4$ + $MnSO_4$. The interaction results showed that the plants which are sprayed with $ZnSO_4$@ 6g/l + $MnSO_4$@ 6g/l (Z_3M_3) recorded maximum stalk length (99.23 cm), stalk diameter (1.36 cm), number of flower buds per plant (8.53), bud length (11.86 cm), bud diameter (4.21 cm) and flower size (20.20 cm) followed by $ZnSO_4$@ 6g/l + $MnSO_4$@ 4g/l (Z_3M_2) recorded 98.92 cm stalk length, 1.33 cm stalk diameter, 8.40 flower buds per plant, 11.66 cm bud length, 4.10 cm bud diameter and 20.06 cm flower size. The minimum values for stalk length (91.12 cm), stalk

diameter (0.60 cm), number of flower buds per plant (5.06), bud length (7.08 cm),bud diameter (1.55 cm) and flower size (16.20 cm) was recorded in control (Z_0M_0).

Zinc and manganese might be responsible for synthesis of bio-assimilates which leads to more number of leaves and eventually partitioning of floral growth. Involvement of zinc and manganese in photosynthesis with enhanced carbohydrate assimilation results in luxurious vegetative and floral growth **(**Hembrom and Singh 2015) in *Lilium* cv. Tresor. These micronutrients have also been reported to induce production of healthy leaves and lead to greater distribution of assimilates to floral parts and hence improved flower characteristics like early flower bud initiation, more number of flower buds per plant, early harvesting of flowers at colour shown stage, earliness in flower opening, increased length and diameter of flower buds which leads to increased flower size and delayed withering of flowers in the plant. Khalifa *et al.* (2011) also observed similar effects of zinc and manganese on treated plants of iris.

Table 2: Effect of Zinc Sulphate ($ZnSO_4$) and Manganese Sulphate ($MnSO_4$) on quality parameters in LA hybrid *Lilium* cv. Pavia.

Treatments	Quality Parameters					
	stalk length (cm)	stalk diameter (cm)	number of flower buds per plant	bud length (cm)	bud diameter (cm)	Flower size (cm)
Zinc Sulphate ($ZnSO_4$)						
Z_1	93.60	0.83	6.06	8.44	2.29	17.41
Z_2	96.95	1.13	7.53	10.48	3.37	19.08
Z_3	98.59	1.30	8.26	11.44	3.99	19.88
Z_4	95.26	0.98	6.82	9.47	2.82	18.23
S. Em. ±	0.02	0.01	0.05	0.01	0.01	0.02
C.D@5%	0.04	0.02	0.11	0.03	0.02	0.03
Manganese Sulphate ($MnSO_4$)						
M_1	94.91	0.95	6.68	9.25	2.74	18.06
M_2	95.58	1.01	6.96	9.66	2.94	18.41
M_3	95.95	1.05	7.09	9.87	3.07	18.56
M_4	95.26	0.98	6.81	9.45	2.84	18.22
S. Em. ±	0.02	0.01	0.05	0.01	0.01	0.02
C.D@5%	0.04	0.02	0.11	0.03	0.02	0.03
Interaction ($ZnSO_4$ + $MnSO_4$)						
Z_1M_1	93.25	0.80	5.93	8.24	2.19	17.24
Z_1M_2	93.94	0.86	6.20	8.67	2.39	17.57
Z_1M_3	94.24	0.90	6.33	8.87	2.51	17.75
Z_1M_4	93.67	0.83	6.06	8.46	2.29	17.40
Z_2M_1	96.66	1.11	7.40	10.28	3.25	18.89
Z_2M_2	97.27	1.17	7.66	10.69	3.46	19.26
Z_2M_3	97.67	1.19	7.80	10.90	3.66	19.41
Z_2M_4	96.95	1.13	7.53	10.48	3.34	19.12
Z_3M_1	98.21	1.26	8.13	11.23	3.87	19.73
Z_3M_2	98.92	1.33	8.40	11.66	4.10	20.06
Z_3M_3	99.23*	1.36*	8.53*	11.86*	4.21*	20.20*
Z_3M_4	98.64	1.30	8.26	11.43	3.99	19.86
Z_4M_1	94.93	0.95	6.66	9.26	2.72	18.08
Z_4M_2	95.58	1.01	7.00	9.68	2.93	18.38
Z_4M_3	95.93	1.04	7.13	9.88	3.03	18.55
Z_4M_4	95.20	0.98	6.80	9.47	2.82	18.22
Z_0M_0 (Control)	91.12	0.60	5.06	7.08	1.55	16.20
S. Em. ±	0.05	0.02	0.12	0.05	0.02	0.04
C.D@5%	0.10	0.04	0.25	0.07	0.04	0.08

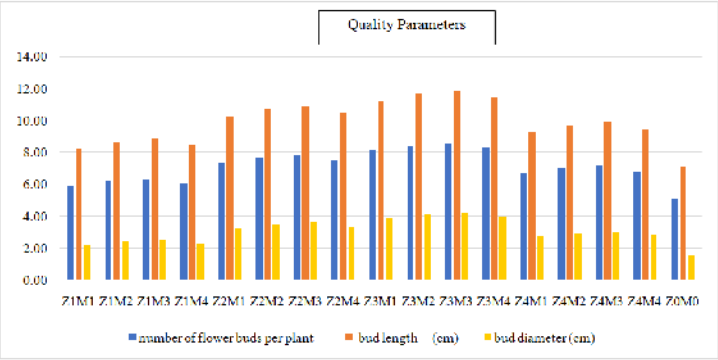

Fig. 1. Effect of Zinc Sulphate ($ZnSO_4$) and Manganese Sulphate ($MnSO_4$) on quality parameters in LA hybrid *Lilium* cv. Pavia.

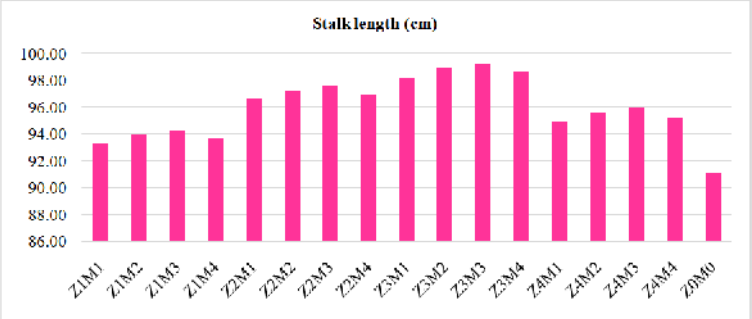

Fig. 2. Effect of Zinc Sulphate ($ZnSO_4$) and Manganese Sulphate ($MnSO_4$) on stalk length in LA hybrid *Lilium* cv. Pavia.

Post harvest vase life parameters. Among foliar application of various concentration of zinc sulphate, the plants which are sprayed with 6g/l$ZnSO_4$(Z_3) recorded minimum number of days from harvesting to primary flower opening inflower vase (2.32 days) and maximum number of days from harvesting to primary flower withering (6.70 days) and complete flower withering (12.26 days)in flower vase whereas maximum number of days from harvesting to primary flower opening in flower vase (3.46 days) and minimum number of days from harvesting to primary flower withering (5.65 days) and complete flower withering (10.14 days) in flower vase was recorded in $ZnSO_4$ at 2g/l (Z_1).

Among foliar application of various concentration of manganese sulphate, the plants which are sprayed with 6g/l$MnSO_4$(Z_3) recorded minimum number of days from harvesting to primary flower opening inflower vase (2.92 days) and maximum number of days from harvesting to primary flower withering (6.14 days) and complete flower withering (11.12 days) in flower vase whereas maximum number of days from harvesting to primary flower opening in flower vase (3.13 days) and minimum number of days from harvesting to primary flower withering (5.92 days) and complete flower withering (10.65 days) in flower vase was recorded in $ZnSO_4$ at 2g/l (Z_1).

Significant differences were observed in interaction effect of $ZnSO_4$ + $MnSO_4$. The interaction results showed that the plants which are sprayed with $ZnSO_4$@ 6g/l + $MnSO_4$@ 6g/l (Z_3M_3) recorded minimum number of days from harvesting to primary flower opening in flower vase (2.13 days) and maximum number of days fromharvesting to primary flower withering (6.93 days) and complete flower withering (12.60 days) in flower vase followed by $ZnSO_4$@ 6g/l + $MnSO_4$@ 4g/l (Z_3M_2) recorded 2.26 days from harvesting to primary flower opening inflower vase and 6.80 days from harvesting to primary flower withering and 12.46 days for complete flower withering in flower vase. The maximum number of days from harvesting to primary flower opening in flower vase (3.93 days) and minimum number of days from harvesting to primary flower withering (5.13 days) and complete flower withering (9.06 days) in flower vase was recorded in control (Z_0M_0).

The positive response of micronutrients might be due to the fact that it binds with the suphohydral group of membrane protein and protects the phospholipids and proteins thus, maintaining membrane integrity as reported by Aravind and Prasad (2003) in gladiolus. This phenomenon would result in reduced membrane leakage which probably increased absorption of more solution thus resulted in enhanced vase life, diameter and longevity of the flowers. These results are experimentally substantiated with the findings of Pratap *et al.* (2008); Singh *et al.* (2012) who worked on gladiolus and found a significant response of micronutrients to the postharvest parameters.

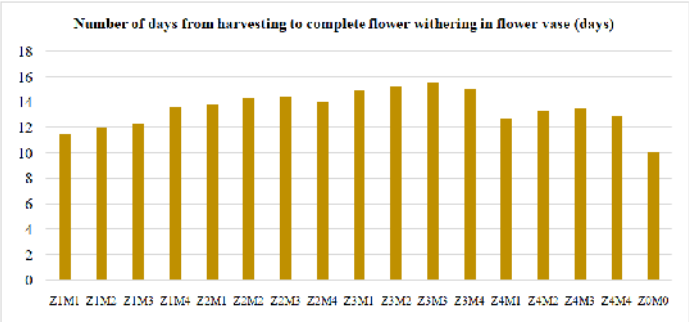

Fig. 3. Effect of Zinc Sulphate ($ZnSO_4$) and Manganese Sulphate ($MnSO_4$) on number of days from harvesting to complete flower withering in flower vase in LA hybrid *Lilium* cv. Pavia.

Table 3: Effect of Zinc Sulphate ($ZnSO_4$) and Manganese Sulphate ($MnSO_4$) on postharvest vase life parameters in LA hybrid *Lilium* cv. Pavia.

Treatments	Postharvest Vase Life Parameters		
	Number of days from harvesting to primary flower opening in flower vase (days)	Number of days from harvesting to primary flower withering in flower vase (days)	Number of days from harvesting to complete flower withering in flower vase (days)
Zinc Sulphate ($ZnSO_4$)			
Z_1	3.46	5.65	10.14
Z_2	2.68	6.33	11.48
Z_3	2.32	6.70	12.26
Z_4	3.06	6.00	10.81
S. Em. ±	0.03	0.04	0.05
C.D@5%	0.06	0.09	0.10
Manganese Sulphate ($MnSO_4$)			
M_1	3.13	5.92	10.65
M_2	3.00	6.06	10.97
M_3	2.92	6.14	11.12
M_4	3.06	5.98	10.81
S. Em. ±	0.03	0.04	0.05
C.D@5%	0.06	0.09	0.10
Interaction ($ZnSO_4$ + $MnSO_4$)			
Z_1M_1	3.53	5.60	10.00
Z_1M_2	3.40	5.73	10.26
Z_1M_3	3.33	5.80	10.46
Z_1M_4	3.46	5.66	10.13
Z_2M_1	2.73	6.26	11.33
Z_2M_2	2.60	6.40	11.66
Z_2M_3	2.53	6.46	11.80
Z_2M_4	2.66	6.33	11.46
Z_3M_1	2.40	6.60	12.06
Z_3M_2	2.26	6.80	12.46
Z_3M_3	2.13*	6.93*	12.60*
Z_3M_4	2.33	6.66	12.26
Z_4M_1	3.13	5.93	10.66
Z_4M_2	3.00	6.06	10.93
Z_4M_3	2.93	6.13	11.06
Z_4M_4	3.06	6.00	10.80
Z_0M_0 (Control)	3.93	5.13	9.06
S. Em. ±	0.07	0.10	0.11
C.D@5%	0.15	0.21	0.23

CONCLUSION

From the result of the experiment, it was concluded that combined foliar application of micronutrients was effective than single application. Among the treatments, combined foliar spray of $ZnSO_4$ 6g/l +$MnSO_4$ 6g/l recorded best results for growth, quality of flowers and postharvest vase life of LA hybrid *Lilium* cv. Pavia.

FUTURE SCOPE

There is a scope to standardize remaining micronutrients along with growth regulators for LA hybrid lilium.

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Conflict of Interest. None.

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