



Effect of micronutrients on growth and bulb production of LA hybrid liliium (*Lilium longiflorum*) cv. pavia

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Received: 31 January 2023; Accepted: 30 August 2024

Keywords: Bulb production, Growth, Liliium, LA hybrid, Micronutrients, Manganese sulphate, Zinc sulphate

Lilium (*Lilium longiflorum*) are most significant bulbous flower crops hold a prominent place in the top 10-cut flowers in the world. Their extensive variety of colours, appealing shapes, and extended post-harvest life make them highly sought-after cut flowers in the global flower trade (Bhandari *et al.* 2016). The family Liliaceae includes the genus *Lilium*, which is indigenous to Asia, Europe, and north America in the northern hemisphere. Around 76% of world lilium bulb production is in the Netherlands. It is commonly used as cut flowers and potted plants in the floral industry. The three primary hybrid lilies that dominate the global market are Oriental, LA and Asiatic hybrid lilies. The area dedicated to commercial lilium hybrid production in India is expanding every day, and these plants are used extensively in the floral industry as cut flowers and potted plants (Chaudhary *et al.* 2018). Under well-protected structures, lilies thrive at temperatures between 18 and 22°C during the day and 10–15°C at night. It is a cool-season flowering plant that reaches heights of 35–200 cm. LA hybrid Lilium grows and flowers best in sandy loam soil that has a high organic matter content and good water holding capacity.

Providing the right amount of macro and micronutrients on a regular basis is one of the many elements that contribute to increased crop yields and also improves crop quality, and productivity (Maurya 2018). Micronutrients have stimulatory and catalytic effects on metabolic pathways that support plant growth and development (Khosa *et al.* 2011). The ideal amount of micronutrients is crucial for improved development, blossom and bulb production in bulbous ornamental crops. Zinc and manganese are two micronutrients that are necessary for the high-quality crop production of LA hybrid lilium (Elangaivendhan 2016). Despite the crop being grown for commercial purposes in India for over a decade, not much study has been published

on it. Furthermore, no systematic research had been done in India's northern plains to schedule the dosage of micronutrients for quality production of LA hybrid lilium. This setting provided the backdrop for an experiment to investigate the effects of foliar micronutrient application (Zn and Mn) on the growth and bulb yield of LA hybrid lilium cv. pavia.

The experiment was conducted during the 2021–22 at ICAR-Indian Agricultural Research Institute, New Delhi to determine the effect of micronutrients on the growth and bulb production of LA hybrid lilium cv. pavia. The experiment was conducted in a factorial randomized block design (FRBD) with two factors, viz. the application of ZnSO₄ and MnSO₄ micronutrient spray. The first factor (ZnSO₄) had 5 levels, viz. Z₀, Distilled water (control); Z₁, ZnSO₄ at 2 g/litre; Z₂, ZnSO₄ at 4 g/litre; Z₃, ZnSO₄ at 6 g/litre; and Z₄, ZnSO₄ at 8 g/litre. The second factor also had 5 levels, viz. M₀, Distilled water (control); M₁, MnSO₄ at 2 g/litre; M₂, MnSO₄ at 4 g/litre; M₃, MnSO₄ at 6 g/litre and M₄, MnSO₄ at 8 g/litre. Twenty-five treatment combinations were replicated thrice in the experiment. LA hybrid lilium cv. pavia produces attractive yellow coloured flowers with glossy green foliage. Farmers primarily grow LA hybrid lilium plant in plain areas. Superior quality, evenly sized, sprouted bulbs with a circumference of 14–16 cm were treated with 0.2% bavistin for an hour and then placed at 8–10 cm depth in raised beds during November at 20 cm × 20 cm apart, beneath a 50% shade net.

Micronutrients (ZnSO₄ and MnSO₄) were administered as foliar sprays in four doses (2 g, 4 g, 6 g, and 8 g), along with distilled water. These micronutrient combinations were sprayed with a manual pressure sprayer 40 and 60 days after sprouting bulbs have been planted. Observations were recorded on growth analysis features, such as net assimilation rate (g/m² leaf area/day), relative growth rate (mg/g/day), and specific leaf area (m²/kg) at 30 days after spraying; bulb attributes, viz. number of bulblets/plant, bulb circumference (cm), bulblets circumference (cm), weight of bulb (g) and bulblets (g) were recorded after harvesting

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of bulb and bulblets at 45 days after complete withering of flowers in the plant.

Statistical analysis: Using Microsoft Office Excel 2007, Panse and Sukhatme (1985) approach was utilized to compare the treatment means and calculate the analysis of variance.

Among spray application of various concentration of zinc sulphate (ZnSO_4) the plants which were sprayed with 6 g/litre ZnSO_4 (Z_3) recorded maximum net assimilation rate (2.68 g/m² leaf area/day), relative growth rate (6.52 mg/g/day) and specific leaf area (43.23 m²/kg) whereas minimum net assimilation rate (1.18 g/m² leaf area/day), relative growth rate (5.63 mg/g/day) and specific leaf area (40.09 m²/kg) was recorded in ZnSO_4 at 8 g/litre (Z_4). The plants which were nourished with 6 g/litre MnSO_4 (M_3) recorded maximum net assimilation rate (2.04 g/m² leaf area/day), relative growth rate (5.94 mg/g/day) and specific leaf area (41.65 m²/kg) whereas the plants which were sprayed with 8 g/litre MnSO_4 (M_4) recorded minimum net assimilation rate (1.87 g/m² leaf area/day), relative growth rate (5.28 mg/g/day) and specific leaf area (40.02 m²/kg) (Fig. 1).

Significant differences were observed in interaction effect of $\text{ZnSO}_4 + \text{MnSO}_4$. The interaction results showed that the plants which are sprayed with ZnSO_4 @6 g/litre + MnSO_4 @6 g/litre (Z_3M_3) recorded the highest net assimilation rate (4.07 g/m² leaf area/day), relative growth rate (9.46 mg/g/day) and specific leaf area (46.68 m²/kg) followed by ZnSO_4 @6 g/litre + MnSO_4 @4 g/litre (Z_3M_2) which recorded net assimilation rate of 3.84 g/m² leaf area/day, relative growth rate of 9.20 mg/g/day and specific leaf area of 46.31 m²/kg whereas minimum values for net assimilation rate (1.02 g/m² leaf area/day), relative growth rate (5.03 mg/g/day) and specific leaf area (39.86 m²/kg) was recorded in control (Z_0M_0) (Table 1).

This is because manganese and zinc have a catalytic function for a number of enzymes engaged in different metabolic processes, which aids in the production of photo-assimilates and therefore increases the growth characteristics (Aker *et al.* 2017). Karuppaiah (2019) also reported similar results with tuberose cv. prajwal. In Asiatic Lilium hybrid cv. tresor, zinc and manganese increase the photosynthetic rate of leaves, contributing to biomass production (Giri *et al.* 2017).

ZnSO_4 at a concentration of 6 g/litre (Z_3) resulted in higher bulblet counts/plant (4.28), maximum bulb circumference (14.59 cm), bulblets circumference (3.50 cm), maximum bulb weight (29.80 g), and bulblets (2.49 g). In contrast, ZnSO_4 at a concentration of 2 g/litre (Z_1) produced the lowest bulblet counts/plant (2.13), minimum bulb circumference (11.62 cm), bulblets circumference (1.75 cm), weight of bulb (25.19 g), and bulblets (1.46 g).

When MnSO_4 was sprayed at a rate of 6 g/litre (M_3), there were more bulblets/plant (3.13), a higher bulb circumference (12.98 cm), higher bulblets circumference (2.57 cm), maximum weight of bulb (27.34 g), and higher bulblets weight (1.94 g). In contrast, M_1 (ZnSO_4 at 2 g/litre) had the fewest bulblet plants (2.70), the lowest bulb

Table 1 Effect of zinc sulphate (ZnSO_4) and manganese sulphate (MnSO_4) on plant growth analysis parameters in LA hybrid lilium cv. pavia

Treatment _t	Plant growth analysis parameters		
	NAR (g/m ² leaf area/day)	RGR (mg/g/day)	SLA (m ² /kg)
ZnSO_4			
Z_1	1.25	5.95	40.34
Z_2	2.40	6.43	42.12
Z_3	2.68	6.52	43.23
Z_4	1.18	5.63	40.09
SEm ±	0.01	0.02	0.05
CD ($P=0.05$)	0.02	0.04	0.10
MnSO_4			
M_1	1.89	5.55	40.29
M_2	1.92	5.49	41.25
M_3	2.04	5.94	41.65
M_4	1.87	5.28	40.02
SEm ±	0.01	0.02	0.05
CD ($P=0.05$)	0.02	0.04	0.10
Interaction ($\text{ZnSO}_4 + \text{MnSO}_4$)			
Z_1M_1	1.24	5.31	41.81
Z_1M_2	1.39	5.86	42.33
Z_1M_3	1.49	6.34	42.81
Z_1M_4	1.18	5.56	41.63
Z_2M_1	2.54	7.59	44.33
Z_2M_2	2.70	8.15	44.81
Z_2M_3	2.85	8.53	45.16
Z_2M_4	2.69	7.94	44.61
Z_3M_1	3.57	8.77	45.78
Z_3M_2	3.84	9.20	46.31
Z_3M_3	4.07*	9.46*	46.68*
Z_3M_4	3.47	8.96	45.47
Z_4M_1	1.54	6.43	43.11
Z_4M_2	1.70	6.87	43.61
Z_4M_3	1.85	7.20	43.85
Z_4M_4	1.69	6.59	43.36
Z_0M_0 (Control)	1.02	5.03	39.86
SEm ±	0.02	0.05	0.23
CD ($P=0.05$)	0.03	0.10	0.11

NAR, Net assimilation rate; RGR, Relative growth rate; SLA, Specific leaf area. Refer to the methodology for Treatment details.

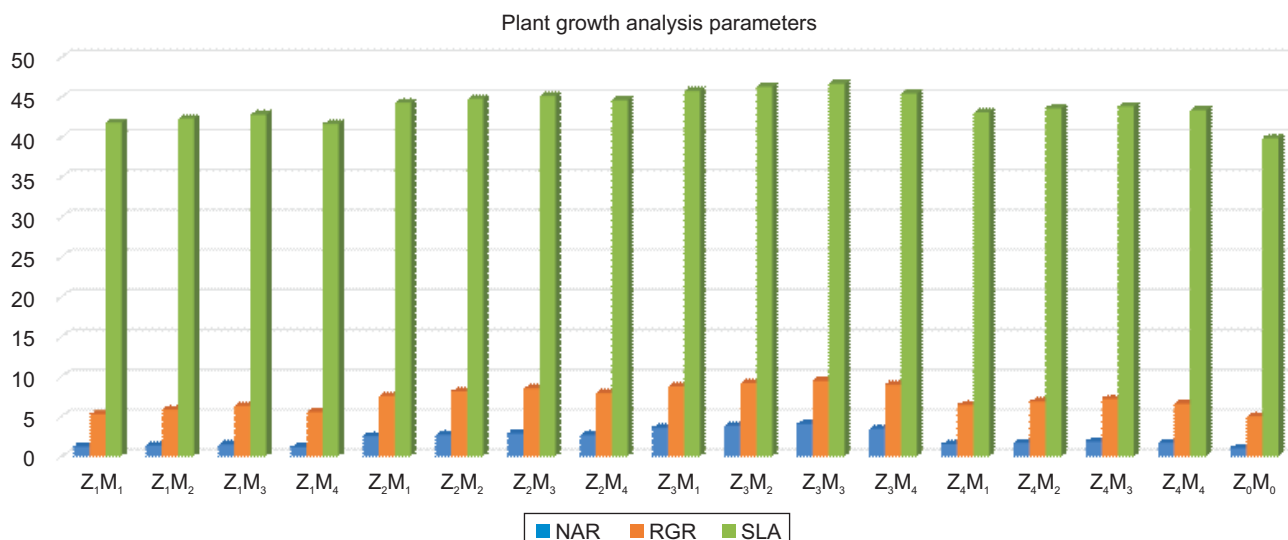


Fig. 1 Effect of zinc sulphate (ZnSO_4) and manganese sulphate (MnSO_4) on plant growth analysis parameters in LA hybrid lilium cv. pavia.

NAR, Net assimilation rate; RGR, Relative growth rate; SLA, Specific leaf area. Refer to the methodology for Treatment details.

circumference (12.40 cm), the bulblets circumference (2.25 cm), weight of bulb (26.41 g), and the lowest weight of bulblets (1.74 g) recorded.

The interaction data ($\text{ZnSO}_4 + \text{MnSO}_4$) revealed that the highest number of bulblets/plant (4.60), highest bulb circumference (14.97 cm), bulblets circumference (3.77 cm), weight of bulb (30.44 g), and bulblets (2.64 g) were recorded in Z_3M_3 i.e. $\text{ZnSO}_4 @ 6 \text{ g/litre} + \text{MnSO}_4 @ 6 \text{ g/litre}$, followed by Z_3M_2 i.e. $\text{ZnSO}_4 @ 6 \text{ g/litre} + \text{MnSO}_4 @ 4 \text{ g/litre}$ recorded 4.46 number of bulblets/plant, 14.80 cm bulb circumference, 3.64 cm bulblets circumference, 30.13 g bulb weight, and 2.56 g bulblet weight, while the lowest number of bulblets/plant (1.20), lowest bulb circumference

(10.20 cm), bulblets circumference (1.06 cm), weight of bulb (23.03 g), and bulblets (1.03 g) were recorded in control (Z_0M_0) (Table 2, Fig. 2).

Applying zinc sulfate was found to be more successful than applying MnSO_4 in improving the yield characteristics of lilium by increasing the number of bulblets/plant, the weight and circumference of bulbs and bulblets, and the number of bulbs and bulblets/plant. According to Asmita and Singh (2015), zinc is known to play a role in the production of auxins, which in turn triggers the development of bulbs in Asiatic hybrid lilium. In tuberose, Mudassir *et al.* (2021) and Sudhagar *et al.* (2019) corroborated these findings.

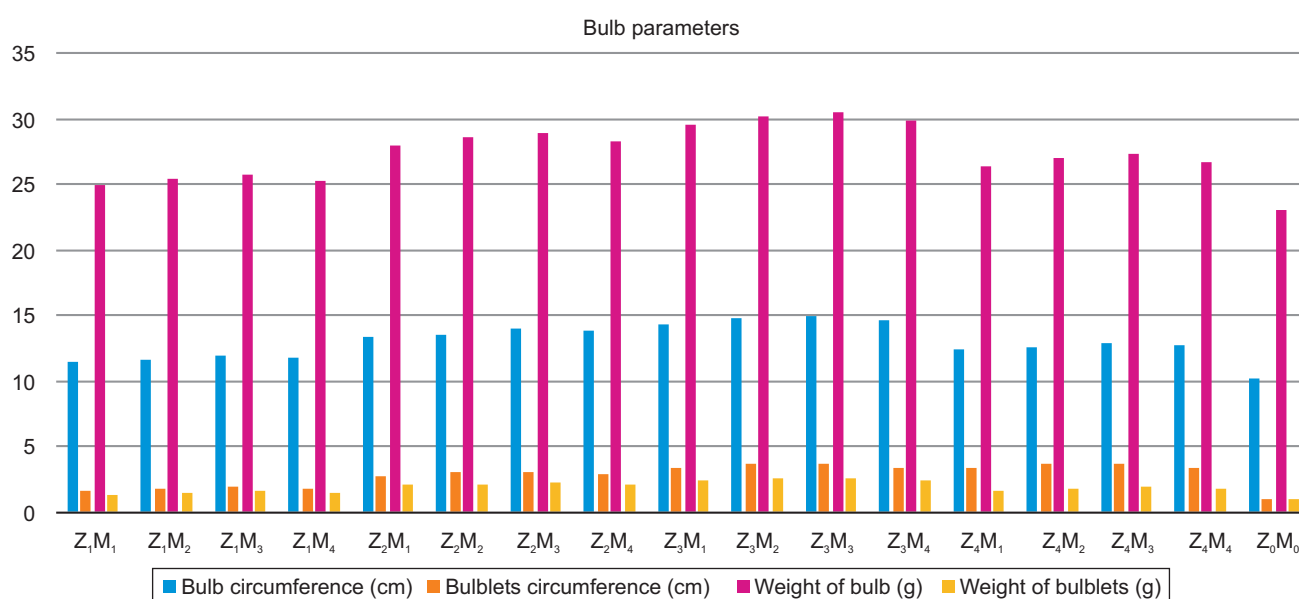


Fig. 2 Effect of zinc sulphate (ZnSO_4) and manganese sulphate (MnSO_4) on bulb parameters in LA hybrid lilium cv. pavia.

Refer to the methodology for Treatment details.

Table 2 Effect of zinc sulphate (ZnSO_4) and manganese sulphate (MnSO_4) on bulb parameters in LA hybrid liliium cv. pavia

Treatment	Bulb parameters				
	No. of bulblets/ plant	Bulb circumference (cm)	Bulblets circumference (cm)	Weight of bulb (g)	Weight of bulblets (g)
Zinc sulphate (ZnSO_4)					
Z ₁	2.13	11.62	1.75	25.19	1.46
Z ₂	3.53	13.59	2.92	28.25	2.15
Z ₃	4.28	14.59	3.50	29.80	2.49
Z ₄	2.83	12.54	2.38	26.74	1.79
SEm $\pm$	0.04	0.03	0.03	0.02	0.01
CD ($P=0.05$)	0.09	0.07	0.07	0.03	0.02
Manganese sulphate (MnSO_4)					
M ₁	2.70	12.40	2.25	26.41	1.74
M ₂	3.00	12.64	2.49	27.04	1.87
M ₃	3.13	12.98	2.57	27.34	1.94
M ₄	2.84	12.76	2.36	26.73	1.82
SEm $\pm$	0.04	0.03	0.03	0.02	0.01
CD ($P=0.05$)	0.09	0.07	0.07	0.03	0.02
Interaction ($\text{ZnSO}_4 + \text{MnSO}_4$)					
Z ₁ M ₁	2.00	11.45	1.63	24.89	1.41
Z ₁ M ₂	2.27	11.61	1.89	25.49	1.52
Z ₁ M ₃	2.40	11.99	1.99	25.82	1.58
Z ₁ M ₄	2.13	11.80	1.74	25.20	1.46
Z ₂ M ₁	3.40	13.37	2.81	27.94	2.07
Z ₂ M ₂	3.67	13.59	3.01	28.55	2.21
Z ₂ M ₃	3.80	14.00	3.14	28.86	2.29
Z ₂ M ₄	3.53	13.82	2.92	28.24	2.16
Z ₃ M ₁	4.13	14.39	3.38	29.49	2.43
Z ₃ M ₂	4.46	14.80	3.64	30.13	2.56
Z ₃ M ₃	4.60*	14.97*	3.77*	30.44*	2.64*
Z ₃ M ₄	4.27	14.60	3.48	29.81	2.50
Z ₄ M ₁	2.67	12.37	3.38	26.44	1.72
Z ₄ M ₂	3.00	12.53	3.64	27.04	1.86
Z ₄ M ₃	3.13	12.92	3.77	27.35	1.92
Z ₄ M ₄	2.80	12.73	3.48	26.74	1.80
Z ₀ M ₀ (Control)	1.20	10.20	1.06	23.03	1.03
SEm $\pm$	0.10	0.08	0.08	0.04	0.02
CD ($P=0.05$)	0.20	0.10	0.17	0.08	0.03

Refer to the methodology for Treatment details.

SUMMARY

The experiment was conducted during the 2021–22 at ICAR-Indian Agricultural Research Institute, New Delhi to determine the effect of micronutrients on the growth and bulb production of LA hybrid liliium cv. pavia. The experiment's findings showed that applying micronutrients topically in combination was more beneficial than doing so topically alone. In contrast, a combination of $\text{ZnSO}_4 + \text{MnSO}_4$ @6 g/litre each sprayed at 40 and 60 days after

planting performed better in terms of growth attributes, such as net assimilation rate (4.07 g/m² leaf area/day), relative growth rate (9.46 mg/g/day), and specific leaf area (46.68 m²/kg). Bulb attributes included number of bulblets/plant (4.60), bulb circumference (14.97 cm), bulblets circumference (3.77 cm), weight of bulb (30.44 g), and bulblets (2.64 g) in LA hybrid liliium cv. pavia, whereas the control group showed the lowest interaction effect levels. This demonstrates that the growth of bulbous ornamental crops such as liliium benefits more from the

combined administration of micronutrients. It results from the application of the ideal concentration of micronutrients at regular intervals, which increases photosynthetic rate. These micronutrients help plants accumulate biosynthates through a variety of activities and control metabolic processes that occur in plants. Additionally, they activate enzymes that enhance development and better distribute carbohydrates to various regions of the plant, such as carbonic dehydrogenase, peroxidase, tryptophan synthase, and catalase. Micronutrients are essential for all cellular and metabolic processes, and their optimal utilization enhances the quality of the crop.

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