



Evaluation of the Different Varieties of Lotus (*Nelumbo nucifera*) in Prayagraj Agro Climatic Conditions, Uttar Pradesh

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Lotus, an aquatic perennial flowering plant, holds significant economic and medicinal value. Lotus (*Nelumbo nucifera*) commonly known as sacred lotus, have significant medical value due to its wide range of bioactive compounds. This study, conducted in Prayagraj, Uttar Pradesh, evaluates the

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performance of six lotus varieties under local agro-climatic conditions. The Lotus varieties under investigation—Yellow Peony, Pastel Pink, Bucha, Rani Red, White Budhha and Pink cloud exhibited significant variations across all observed parameters. The research focuses on various characteristics of Lotus, including growth parameters, floral parameters, quality parameters, yield parameters and economy of the cultivation, to determine the most suitable variety for cultivation in similar climatic conditions. The variety V₃: Bucha demonstrated superior performance in terms of plant height (41.31 cm), leaf length (14.94 cm), leaf width (19.68 cm), flower diameter (16.28 cm), total numbers of flowers per plant (38.13), total number of flowers per hectare (1,525,000), yield of rhizome per plant (1.74 kg), and yield of rhizome per hectare (69.73 tonnes). Additionally, V₆: Pink Cloud reported longest vase-life (6.25 days), followed by V₃: Bucha (5.75 days). The variety V₃: Bucha also achieved the highest gross return (4,444,500 Rs .ha⁻¹), net return (3,437,050 Rs .ha⁻¹), and benefit – cost ratio (4.41). Based on the findings, V₃: Bucha is recommended for cultivation in the agro-climatic conditions of Prayagraj, Uttar Pradesh.

Keywords: Lotus; better performance; varieties; number of flowers; rhizome; yield.

1. INTRODUCTION

The Lotus (*Nelumbo nucifera*) is an aquatic perennial plant belonging to the genus *Nelumbo*, known for its beautiful flowers and significant cultural symbolism globally. It is the national flower of India and Vietnam. *N. nucifera* has been cultivated for centuries as a vegetable, medicinal, and ornamental plant, primarily in Eastern countries [1]. Botanically, the Lotus is part of the Nelumbonaceae family, characterized by robust rhizomes—elongated, creeping structures anchored in the muddy substrate, which give rise to long, flexible stems [2,3,4]. The Lotus thrives in shallow, mucky waters and is renowned for its ability to grow in less-than-ideal conditions, a trait that has earned it a revered status in many religious and cultural traditions. Lotus contains several bioactive compounds that have been studied for their medicinal properties like: Flavonoids, Alkaloids, Tannins, Saponins and Polysaccharides etc[5,6].

Lotus has become an important crop in Australia and the United States [7]. The growth and yield of Lotus flowers and rhizomes depend on various factors, including genotype [8], planting time and propagation methods [9], temperature, and other environmental conditions. The rhizomes are typically planted from the last week of February to April, primarily in late spring to early summer. Lotus flowers come in various hues, including white, pink, yellow, and other colors, and can reach a diameter of 10 to 30 cm when fully bloomed. Along with its long stem, the Lotus has broad, orbicular leaves coated with epicuticular wax, which repels water and prevents sinking [10,11]. The plant can grow in water depths ranging from 30 cm to 2.5 meters.

Lotus root system consists of long, tuberous rhizomes that extend horizontally in the substrate, anchoring the plant and facilitating nutrient uptake and storage [12,13]. These roots contain aerenchyma, specialized tissue that enhances gas exchange and regulation in aquatic environments. The morphology of the Lotus reflects its adaptations to an aquatic habitat, enabling it to thrive in diverse freshwater ecosystems worldwide [14-16]. Native to Asia, *Nelumbo nucifera* predominantly grows in warm temperate and tropical regions, preferring temperatures between 25 °C and 30 °C. The plant requires full sunlight, needing at least six hours of direct sunlight daily. In winter, the Lotus goes dormant, with rhizomes surviving underwater until warmer temperatures return. Lotus plants grown from rhizomes develop more quickly than those grown from seeds. At the time of harvesting, lotus flowers are cut at an angle to maximize water absorption and then placed into natural water to maintain their freshness [17,18]. With proper handling of water and harvesting the flowers at right time extends the lifespan of these exquisite blooms. In India, commercial cultivation of the Lotus has great potential due to its multifaceted uses and cultural significance. Significant commercial production occurs in states such as Bihar, West Bengal, Uttar Pradesh, Odisha, and Kerala.

2. MATERIALS AND METHODS

The experiment was carried out in the research farm of the Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, from March, 2023 to September, 2023. The area is in South Prayagraj on the right bank of the Yamuna River at Rewa road, Naini, about 6 km from

Prayagraj city. The area is located at 25.8 °N latitude and 81.50 °E longitude, 98 meters from the sea level. The area of Prayagraj district comes into the subtropical belt in the South East of Uttar Pradesh. Prayagraj has an extremely hot summer and a relatively cold winter. The maximum temperature reaches up to 45 °C to 48 °C, and winter temperatures fall from 4 °C to 6 °C. The relative humidity varies between 20 to 94 percent. The average rainfall follows around 1013.4 mm annually. The six varieties included in the experiment were V₁: Yellow Peony, V₂: Pastel Pink, V₃: Bucha, V₄: Rani Red, V₅: White Buddha and V₆: Pink Cloud. The varieties were arranged in Random Block Design (RBD) with six varieties in 4 replications. Lotus plants were planted in 56 cm diameter tubs with 30cm height, and in each tub FYM and soil used as media. In every tub one rhizome was planted. For each variety in a replication, there are two tubs. In this experiment, Sea weeds @ 20 gm per plant were mixed with NPK 19-19-19 @10gm per plant used fertilizer. This mixture was applied at monthly intervals. For vase life observation, harvested flower buds with developed petals color were placed in natural water. In this experiment, different characteristics of Lotus, like growth parameters, floral parameters, quality parameters and yield parameters, were observed in the intervals of 30, 60, 90, and 120 days. The data on growth, quality, and yield components were analyzed using Fisher's variance analysis method (ANOVA), as recommended by Panse and Sukhatme[19].

3. RESULTS AND DISCUSSION

In this present study "Evaluation of the different varieties of Lotus (*Nelumbo nucifera*) in Prayagraj agro climatic conditions, Uttar Pradesh" data were recorded for numerous characters, which are described below:

3.1 Growth Parameters

Significant variations were observed among six varieties as presented in Table 1 and Table 2 for growth parameters and graphically presented in Fig. 1.

For the plant height (cm) maximum plant height of lotus was observed with V₃: Bucha at all the days i.e-30,60,90,120days (18.13cm,24.13cm,39.78cm, 41.31 cm respectively) followed by the variety V₆: Pink Cloud (16.25cm, 18.20cm, 35.31cm, 37.59cm respectively) .The lowest plant height observed in V₂:Pastel Pink (8.16 cm,10.53 cm,16.21

cm,16.56 cm). Different plant height may be due to the different varietal character and different vigor of the plants under study. Similar results in Lotus were reported by Sahu et al. [20].

Among all six tested varieties ,The maximum number of leaves was observed at the interval of 30, 60, 90,120 days was with V₅: White Buddha (17.25 ,34.38 ,36.38 ,37.50) followed by V₃: Bucha (16.50, 22.25 ,30.38 ,32.25 respectively). Whereas, minimum number of leaves was observed in V₂: Pastel Pink (8.25, 12.25, 18.38, and 19.25 respectively).The number of leaves in lotus plants can vary due to genetic factors, environmental conditions, and developmental stages. Different varieties may have evolved to produce varying numbers of leaves as an adaptation to their specific habitats and ecological niches.

Maximum leaf length was observed in V₃: Bucha (8.28cm, 13.38cm, 14.51cm, and 14.94cm). For first 30 days, leaf length of the Yellow Peony(7.26 cm) was second highest but at 60,90 and 120 days V₆: Pink Cloud(12.49 cm, 13.18 cm ,13.39 cm) occupied the second position . However, minimum leaf length observed in V₄: Rani Red (5.13cm, 11.30cm, 11.58cm, 11.68cm).Environmental factors, such as sunlight, temperature, soil nutrients, and water availability play significant roles in determining leaf length, as they influence the growth and development of the plant. Additionally, the stage of development of the plant can affect leaf length as younger plants leaf length is small compared to mature plants leaf length. Similar results were recorded in Lotus by Mukherjee and Bera [21].

Maximum leaf width among tested six varieties observed at the interval of 30, 60, 90,120 days was V₃: Bucha (13.30cm, 17.30 cm, 19.33 cm, 19.68cm). For first 30 days and 60 days the V₆: Pink Cloud (12.23 cm, 16.28 cm) performs second best, but for the 90 and 120 days V₁:Yellow Peony (17.30 cm ,17.15 cm respectively) performs second best .The minimum leaf width observed in V₄: Rani Red (9.08cm, 13.20cm, 13.46 cm , 13.75 cm). Leaf width variation in Lotus varieties arise from adaptation to their environment with strong sunlight, as they allow for increased light capture for photosynthesis.

3.2 Floral Parameters

Significant variations were observed among six varieties as presented in Table 3 and Table 4 for floral parameters and graphically presented in Fig. 2.

Table 1. Varietal evaluation of different varieties of Lotus based on growth parameter

Notation	Variety names	Plant height (cm)				Number of leaves			
		30 dap	60 dap	90 dap	120 dap	30 dap	60 dap	90 dap	120 dap
V ₁	Yellow Peony	13.13	15.45	20.30	22.39	12.25	20.25	27.25	28.13
V ₂	Pastel Pink	8.16	10.53	16.21	16.56	8.25	12.25	18.38	19.25
V ₃	Bucha	18.13	24.13	39.78	41.31	16.50	22.25	30.38	32.25
V ₄	Rani Red	10.44	13.14	18.30	20.56	9.13	14.38	22.38	23.13
V ₅	White Buddha	14.19	16.23	22.69	24.66	17.25	34.38	36.38	37.50
V ₆	Pink Cloud	16.25	18.20	35.31	37.59	10.25	17.25	24.25	25.13
F – TEST		S	S	S	S	S	S	S	S
SEd		0.177	0.521	0.563	0.231	0.138	0.204	0.149	0.213
CD (5%)		0.381	1.12	1.21	0.497	0.297	0.439	0.321	0.459
CV%		1.872	4.526	3.128	1.203	1.593	1.434	0.796	1.094

Table 2. Varietal evaluation of different varieties of Lotus based on growth parameter

Notation	Variety names	Leaf length (cm)				Leaf width (cm)			
		30 dap	60 dap	90 dap	120 dap	30 dap	60 dap	90 dap	120 dap
V ₁	Yellow Peony	7.26	11.36	12.81	13.26	11.20	15.33	17.15	17.30
V ₂	Pastel Pink	6.16	12.18	12.10	12.40	10.18	14.18	14.63	14.78
V ₃	Bucha	8.28	13.38	14.51	14.94	13.30	17.30	19.33	19.68
V ₄	Rani Red	5.13	11.30	11.58	11.68	9.08	13.20	13.46	13.75
V ₅	White Buddha	5.45	11.55	12.34	12.73	9.75	13.68	13.88	14.10
V ₆	Pink Cloud	6.43	12.49	13.18	13.39	12.23	16.28	16.70	17.08
F – TEST		S	S	S	S	S	S	S	S
SEd		0.104	0.065	0.085	0.065	0.066	0.043	0.069	0.065
CD (5%)		0.225	0.14	0.182	0.139	0.142	0.092	0.149	0.14
CV%		2.289	0.767	0.939	0.701	0.854	0.404	0.617	0.569

Table 3. Varietal evaluation of different varieties of Lotus based on floral parameters

Notation	Variety names	Number of flower bud per plant				Days to open the flower bud
		30 dap	60 dap	90 dap	120 dap	
V ₁	Yellow Peony	4.25	9.13	12.13	11.125	12.00
V ₂	Pastel Pink	2.88	5.38	4.13	7.625	10.63
V ₃	Bucha	2.50	4.38	13.50	17.75	17.25
V ₄	Rani Red	1.38	4.00	6.25	8.75	14.25
V ₅	White Buddha	1.13	6.38	7.25	12.375	11.50
V ₆	Pink Cloud	2.38	7.25	10.25	16.125	15.50
F – TEST		S	S	S	S	S
SEd		0.224	0.569	0.186	0.194	0.247
CD (5%)		0.481	1.224	0.401	0.417	0.53
CV%		13.085	13.809	2.955	2.228	2.578

The maximum number of flower buds was observed in first 30 and 60 days with V₁: Yellow Peony (4.25, 9.13) and for next 90 and 120 days, it was observed with V₃: Bucha (13.50 & 17.75). The second highest numbers of flower bud was

observed in 30 days was V₂: Pastel Pink (2.88), for 60, 90 and 120 days the second highest number of buds was recorded in V₆: Pink Cloud (7.25, 10.25, 16.23 respectively). However minimum number of buds observed in 120 days

after planting was V₂: pastel pink (1.13, 4.00, 4.13, 7.63 respectively). Because of the difference in vegetative growth of the varieties the number of flower buds differs from each other. The plants with more vigor produce more flowers due to more photosynthesis and vigorous plants are generally more resilient to environmental stresses like drought or disease, allowing them to focus energy on flowering rather than survival.

The maximum number of days to open the flower bud observed in V₃: Bucha (17.25 days), followed by Pink Cloud (15.50 days) and Rani Red (14.25 days). Minimum days to open the flower bud observed in V₂: Pastel Pink (10.63 days). The flowers which are big in size takes more time to open than smaller flowers and also different lotus varieties have inherent genetic predispositions for blooming at specific times.

Similarly, maximum flower diameter (cm) recorded in the variety V₃: Bucha (16.28 cm) followed by V₆: Pink Cloud (14.25 cm) and White Budhha (13.11 cm) respectively. However, minimum flower diameter was recorded in V₄: Rani Red (10.13 cm). Different Lotus varieties possess inherent genetic variations that influence flower size. Varieties like Bucha and White Buddha are naturally predisposed to producing larger blooms

3.3 Quality Parameters

Significant variations were observed among six varieties, as presented in Table 4 for quality parameters.

The maximum duration of flowering observed in V₁: Yellow Peony (115.13 days), followed by V₆: Pink Cloud (113.00 days) and White Budhha (111.75 days). However, the minimum flower

duration was recorded in V₄: Rani Red (108.00 days). The flowering duration of lotus varieties can vary due to genetics, environmental conditions, and cultivation practices. Some varieties may have been bred to bloom for longer, while others may have natural variations in their flowering cycles.

Among all six tested varieties, the maximum vase life of flowers was observed in the array V₆: Pink Cloud (6.25 days), followed by V₃: Bucha (5.75 days) and V₁: Yellow Peony (4.88 days). However, the minimum vase life was recorded in V₄: Rani Red (3.0 days). Some varieties may naturally have longer-lasting blooms or sturdier stems, while others might be more delicate or sensitive to environmental stressors. Similar findings were recorded by Salaemae et al. [22] and Sahu [23].

3.4 Yield Parameters

Significant variations were observed among six varieties as presented in Table 5 for yield parameters.

The maximum number of flower per plant was observed in V₃: Bucha (38.13), followed by V₁: Yellow peony (36.63). However, minimum numbers of flower per plant observed in V₂: Pastel pink (20.00). Different numbers of flowers rely on different factors like environment adaptation of the plant, flowering duration and genetic characteristics of the different varieties (Pan, 2011) [24].

Significantly among all six tested varieties, maximum number of cut flower per hectare was observed in V₃: Bucha (1525000) followed by the varieties V₁: Yellow peony (1465000) and V₆: Pink Cloud (1440000). However, minimum number of flower per hectare observed in V₂ (800000).

Table 4. Varietal evaluation of different varieties of Lotus based on floral parameters and quality parameter

Notation	Variety names	Flower diameter (cm)	Vase life	Duration of flowering
V ₁	Yellow Peony	12.14	4.88	115.13
V ₂	Pastel Pink	11.40	3.38	109.63
V ₃	Bucha	16.28	5.75	110.63
V ₄	Rani Red	10.13	3.00	108.00
V ₅	White Buddha	13.11	4.25	111.75
V ₆	Pink Cloud	14.25	6.25	113.00
F – TEST		S	S	S
SEd		0.04	0.179	0.339
CD (5%)		0.086	0.384	0.729
CV%		0.439	5.515	0.431

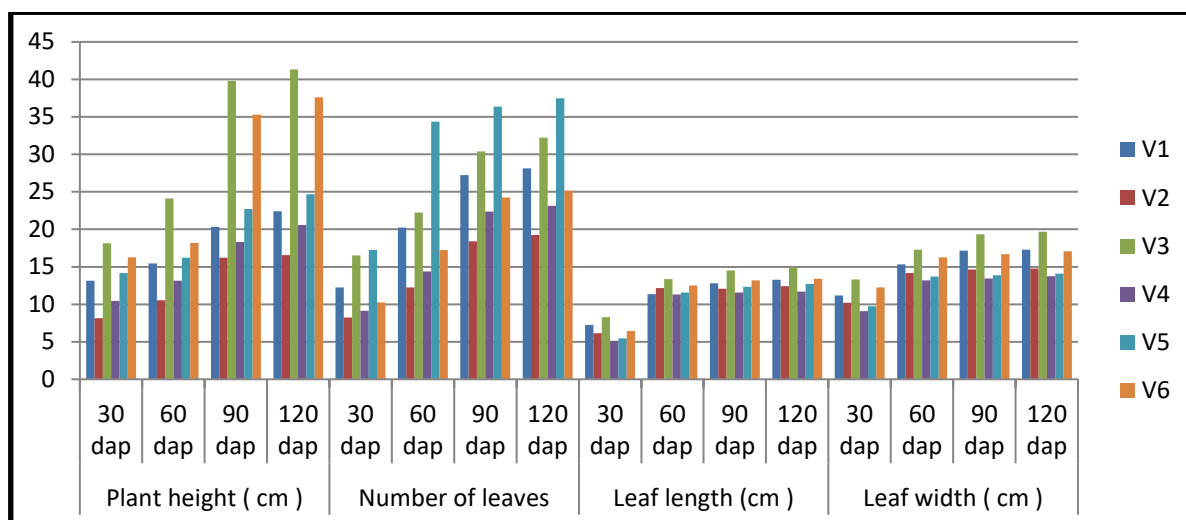


Fig. 1. Graphical representation of the evaluation of Lotus varieties based on growth parameters

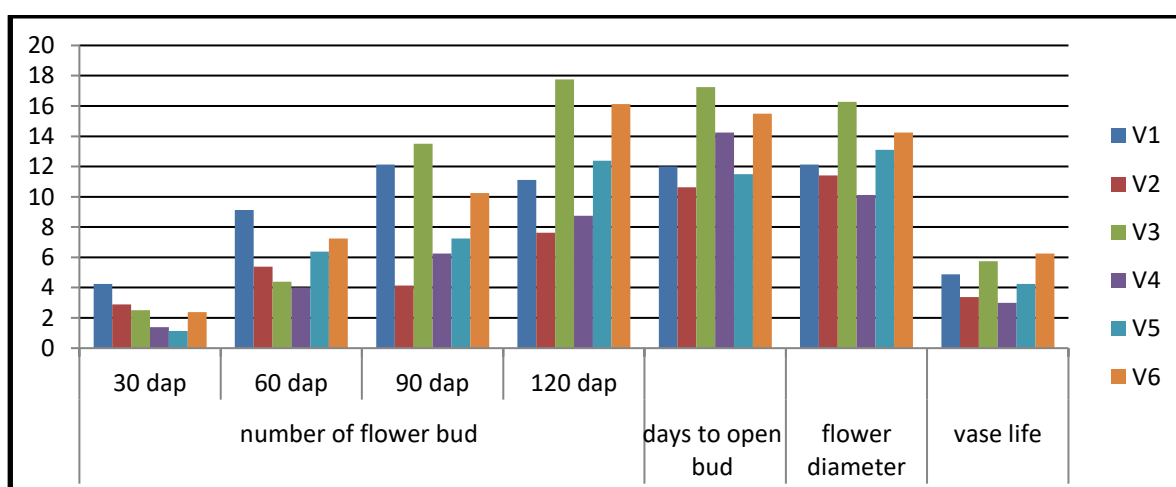


Fig. 2. Graphical representation of the evaluation of Lotus varieties based on floral parameters and quality parameter

Table 5. Varietal evaluation of different varieties of Lotus based on yield parameters

Notation	Variety names	Total number of flower per plant	Yield of rhizome per plant(kg)	Yield of rhizome per hectare(t)
V ₁	Yellow Peony	36.63	1.15	45.88
V ₂	Pastel Pink	20.00	1.00	39.80
V ₃	Bucha	38.13	1.74	69.73
V ₄	Rani Red	20.38	1.10	43.83
V ₅	White Buddha	27.13	1.50	59.88
V ₆	Pink Cloud	36.00	1.55	61.83
F – TEST		S	S	S
SEd		0.42	0.003	0.119
CD (5%)		0.903	0.007	0.256
CV%		1.999	0.325	0.314

Table 6. Economic evaluation of different varieties of Lotus

Notation	Variety names	Variable cost of cultivation	Gross return	Net return	C: B ratio
V ₁	Yellow Peony	1007450	3847500	2840050	1:3.82
V ₂	Pastel Pink	907450	1998000	1090550	1:2.20
V ₃	Bucha	1007450	4444500	3437050	1:4.41
V ₄	Rani Red	847450	2068250	1220800	1:2.44
V ₅	White Buddha	907450	2768750	1861300	1:3.05
V ₆	Pink Cloud	1007450	4116500	3109050	1:4.09

Among all six tested varieties, maximum yield of rhizome per plant was observed in V₃: Bucha (1.74 kg) followed by V₆: pink cloud (1.55 kg). However, minimum yield of rhizomes per plant observed in V₂: pastel pink (1.00 kg). The results are also conformity with the findings of Sahu et al. [20] in Lotus.

The maximum yield of rhizome per hectare was observed in V₃: Bucha (69.73 tonnes) followed by V₆: Pink Cloud (61.83 tonnes). However, minimum yield of rhizomes per hectare observed in V₂: Pastel Pink (39.8 tonnes).

3.5 Economic Parameter

The variations were observed among six varieties as presented in Table 6 for economic parameters.

The cost of cultivation was recorded maximum among all six tested varieties are Yellow Peony, Bucha and Pink Cloud (1007450 Rs. ha⁻¹). Whereas minimum cost of cultivation was recorded in the variety Rani Red (847450 Rs. ha⁻¹). The varying cost of cultivation mainly due to the different pricing of rhizomes among the varieties.

Maximum gross returns (Rs. ha⁻¹) was recorded in the variety V₃: Bucha (4444500 Rs. ha⁻¹), followed by V₆: Pink Cloud (4116500 Rs. ha⁻¹). Minimum gross returns (Rs. ha⁻¹) was recorded in the variety V₂: Pastel Pink (1998000 Rs. ha⁻¹).

The net returns (Rs. ha⁻¹) was observed maximum in the variety Bucha (3437050 Rs. ha⁻¹), followed by Pink Cloud (3109050 Rs. ha⁻¹). Minimum net returns (Rs. ha⁻¹) was observed in the variety Pastel Pink (1090550 Rs. ha⁻¹). Also maximum benefit and cost ratio observed in V₃: Bucha (4.41: 1) because of its highest production of flowers and rhizomes among the six variety tested.

4. CONCLUSION

This study evaluated the performance of six lotus varieties under the agro climatic conditions of Prayagraj. Among the varieties, V₃: Bucha emerged as the most successful. Bucha demonstrated superior vegetative growth, characterized by increased plant height, leaf number, leaf length, and leaf width. Furthermore, it excelled in all floral parameters examined. Whereas, V₁: Yellow Peony exhibited the longest flower vase life. However, in terms of yield and economic viability, Bucha reigned supreme. It produced the highest number of flowers per plant and per hectare (1,525,000), the greatest yield of rhizome per plant and per hectare, and the most favorable gross return, net return, benefit-to-cost ratio. Therefore, based on this research, V₃: Bucha is demonstrably the most suitable variety for open field cultivation in Prayagraj. Its superior performance across various growth and economic parameters makes it a strong candidate for promotion and adoption by lotus growers in the region.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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