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Effect of Different Concentrations of Sodium Nitroprusside on Plant Growth and Flowering Characters in California Poppy

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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

In the present study, the effect of different concentrations of sodium nitroprusside on plant growth and flowering characters in California poppy plants was investigated. The field experiment was carried out during 2021-2022 at Horticulture Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. There were 8 treatments of sodium nitroprusside (200, 400, 600, 800, 1000,1200, 1400 and 1600µM), including control. All the growth

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and flowering parameters of California poppy were significantly influenced due to various levels of SNP. All the growth parameter was statistically influenced by the application of SNP. Maximum fresh weight of the flower (9.96 g) and dry weight of the flower (1.27 g) were observed with treatment SNP 1000µM. Whereas, maximum bud diameter (8.75 cm), peduncle length (20.32 cm), flower diameter (66.96 mm), number of flowers per plants (106.17) and flower withering (4.97 Days), earlier flower opening (73.89 DAT), maximum plant height at 90 DAT (52.49 cm), plant spread (76.30 cm) at 90 DAT, number of leaves of per plant (865.38), number of secondary branches (110.58), stem diameter (9.70 mm) and dry weight of leaves (1.48 g) were recorded with SNP @ 1200µM. Maximum bud appearance (74.58 DAT) was seen with treatment SNP 1400µM.

Keywords: Eschscholzia californica; lowering; plant growth; SNP; poppy

1. INTRODUCTION

California poppy, belongs to the family Papaveraceous and is native to California (U.S.A). It is suitable for bedding and beautifying any garden (Muzhda Azizi et al.,2022). It is a flowering herbaceous annual or perennial with deep roots. Along with the demand for local markets, both developed and developing nations need a significant quantity of California poppy seeds. It is appropriate for flower beds, as well as walks and paths in gardens. In the winter the open cup-shaped flowers look very attractive (Pearson et al. 2021). It has blue-green (glaucous) basal and cauline foliage and grows low to erect (15.24 to 60.96 cm). The ternate, almost globular leaves have three finely divided lobes. On freely branching stems, plants produce upright flowers with four satiny petals that range in colour from bright orange to light yellow and may have distinct, darker orange centres (Ai et al. 2017). Root systems are tap rooted and well-adapted to dry soils. Leaves are bluish-green, finely divided, fern-like leaves arranged alternately on the stem. Flower size is 5–10 cm in diameter with 4 petals. California poppy is widely used as an ornamental bedding plant in gardens, parks, and roadsides because of its vivid orange flowers and ease of cultivation. It is valued for mass floral displays and low-maintenance landscaping in arid regions. The plant also attracts pollinators, particularly bees, enhancing garden biodiversity. It is distinguished from other genera by the presence of a torus rim, a collar-like pedestal at the receptacle (Love et al. 2021). “It contains quinoline alkaloids such as *eschscholtzine*, *californidine*, and *protopine*. Traditionally used for its sedative, analgesic, and antispasmodic properties. Extracts are sometimes used in herbal medicine as a natural, mild relaxant**.** The capsules dehisce explosively, size of up to 5-8 cm from the parent plant and provide the primary means of seed dispersal” (Berhane et al. 2024). “When mature, the seeds are spherical with a micro sculpted surface and grey to grey-brown in colour. Per capsule, there are anywhere from a few to over 1000 seeds” (Wang et al. 2015).

Nitro press is a brand name for sodium nitroprusside (SNP) (Chohan et al. 2012). “Nitroprusside is an inorganic compound with the formula $Na_2[Fe(CN)_5NO]_2H_2O$, which is usually found as a dihydrate” (Ramadan et al. 2019). “Sodium nitroprusside (SNP) -an external nitric oxide (NO) donor- has been found effective in imparting salinity tolerance to plants. Nitric oxide is involved in germination and the initiation of lateral roots” (Sarath et al., 2006). Growth regulators such as SNP (sodium nitroprusside) may modulate nitric oxide signalling and alter flowering time and quality (Jhanji et al., 2012). Numerous studies have examined the beneficial impact of NO in salt stress tolerance in a variety of plants. “NO is involved in several processes, including the maintenance of leaf water and expression of the ATPase gene, activity as a signal molecule in enhancing antioxidant mechanisms” (Liao et al., 2013), “maintenance of the ion balance between Na+ and K+ to improve plant growth rate” (Zhang et al., 2023), “promotion of genes expressing antioxidant enzymes like SOD, CAT, POX, and GPX and reduction in the production and accumulation of H2O2”(Karthik et al. 2019).

2. MATERIALS AND METHODS

A field experiment was conducted at Horticulture Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh to study the effect of sodium nitroprusside on plant growth and flowering attributes in California poppy. The experiment was laid out in Randomized Block Design with five replications. The experiment site lies nearly in the centre of the North-Gangetic alluvial plain, or the river Ganga on the left bank at a distance of about 10 km from Varanasi railway station in the south-east direction.

Treatment consisted of SNP (200, 400, 600, 800, 1000, 1200, 1400 and 1600µM) along with control (distilled water). One month old, healthy and disease-free seedlings were used for transplanting. At a spacing of 60×50 cm, seedling was planted followed by light irrigation. SNP was applied third week after transplanting, while control plants were sprayed. On various growth and flowering parameters observations were recorded that were subjected to statistical analysis with Panse and Sukhatme, 1985 method.

3. RESULTS AND DISCUSSION

All the growth parameters were statistically influenced by the application of SNP (Table 1). Maximum plant height at 90 DAT (52.49 cm), plant spread (76.30 cm) at 90 DAT, number of leaves of per plant (865.38), number of secondary branches (110.58), stem diameter (9.70 mm) and dry weight of leaves (1.48 g) were recorded with SNP @ 1200µM and minimum plant height at 90 DAT (40.67 cm), plant spread (54.98 cm) at 90 DAT, number of leaves of per plant (503.43), number of secondary branches (33.83) and dry weight of leaves (0.70 g) were resulted with SNP @ control. Aftab et al. (2012) reported that "treatment of NO donor favoured growth and improved the photosynthetic efficiency in stress and exogenous application of SNP promoted root elongation in Artemisia". Similar findings were supported by Salachna et al. (2017) in *Eucomis autumnalis*, Mousavi et al. (2019) in *Echinacea purpurea* and Wang et al. (2015) in Siberian lily. result of NO's interactions with auxin and cytokine, which relate to the regulation of cell division to differentiation during the de-and re-differentiation of plant cells placed to promote plant spread, secondary branches and number of leaves. Similar findings were also reported by Arun et al. (2017) in chrysanthemum in pot marigold.

Various levels of SNP resulted in conspicuous effects on flowering characters in California poppy (Tables 2 and 3). Maximum bud appearance (74.58 DAT) was seen with treatment SNP 1400µM, which was at par with SNP 600µM (74.56 DAT). Whereas, maximum bud diameter (8.75 cm), peduncle length (20.32 cm), flower diameter (66.96 mm), number of flowers per plant (106.17) and flower withering (4.97 Days) were reported with SNP 1200µM. Earlier flower opening (73.89 DAT) was found with 1200µM.

Table 1. Effect of sodium nitroprusside on growth parameters in California poppy

Treatment	Plant height 90 DAT (cm)	Plant spread 90 DAT (cm)	Number of secondary branches	Dry weight of leaves (g)	No. of leaves per plant	Stem diameter (cm)
Control	40.67	54.98	33.83	0.70	503.43	5.21
Sodium nitroprusside 200µM	41.94	55.42	64.89	0.70	504.77	5.72
Sodium nitroprusside 400µM	46.33	56.33	69.11	0.79	557.90	6.01
Sodium nitroprusside 600µM	46.76	66.93	64.94	0.81	538.36	7.61
Sodium nitroprusside 800µM	46.06	58.90	94.11	1.07	661.63	4.62
Sodium nitroprusside 1000µM	41.24	57.21	47.08	1.11	585.81	7.80
Sodium nitroprusside 1200µM	52.49	76.30	110.58	1.48	865.38	9.70
Sodium nitroprusside 1400µM	42.49	59.25	46.50	1.37	859.00	8.82
Sodium nitroprusside 1600µM	42.85	56.32	80.16	0.83	778.44	7.79
C.D. at 5%	3.11	1.50	27.74	0.48	3.20	2.27

While, maximum fresh weight of flower (9.96 g) and dry weight of flower (1.27 g) were observed with treatment SNP 1000µM and minimum bud diameter (7.80 cm), peduncle length (17.72 cm), flower diameter (60.22 mm) and flower withering (3.55 Days) In present experiment SNP showed marked effect on maximum bud and flower diameter in California poppy. Moreover, previous workers reported that exogenous NO at a proper dose could delay senescence in selected fruit, vegetables and cut flowers (Leshem and Wills, 1998; Eum et al., 2009). In the present study, it was found that exogenous NO at a proper dose extend the bud and flower diameter. A similar finding was also reported by Yasir et al. (2021) in lentil and in *Brassica napus.* Due to the role of NO in plant elongation and growth by influencing cell division and cell enlargement processes align with changes at the hormonal levels as NO acts as a secondary messenger in various metabolic processes, it is possible that an increase in SNP concentration causes an increase in flower diameter. These results are in conformity with the findings of Wang et al. (2015) in "Siberia" lily, Hajihashemi, (2021) in Narcissus tazetta, Salachna et al. (2017) in *Eucomis autumnalis* and Aparna et al. (2022) in African marigold. It was proposed that NO could postpone senescence by lowering ethylene production, which would reduce ACC levels and ACC synthase activity. Similar findings were obtained by Wang et al. (2015) in "Siberia" lily.

Table 2. Effect of sodium nitroprusside on flowering characters in California poppy

Treatment	Bud appearance (DAT)	Bud diameter (mm)	Flower opening (DAT)	Peduncle length (cm)	Flower diameter (mm)
Control	71.29	7.80	82.33	17.72	60.22
Sodium nitroprusside 200µM	71.77	8.28	85.41	16.40	60.68
Sodium nitroprusside 400µM	73.47	7.46	85.83	16.71	64.68
Sodium nitroprusside 600µM	74.56	7.97	85.80	14.87	58.80
Sodium nitroprusside 800µM	74.25	7.60	86.12	16.11	57.62
Sodium nitroprusside 1000µM	73.97	8.53	88.11	18.13	65.50
Sodium nitroprusside 1200µM	71.39	8.75	73.89	20.32	66.96
Sodium nitroprusside 1400µM	74.58	8.48	85.00	19.92	63.76
Sodium nitroprusside 1600µM	72.54	7.66	86.16	18.71	62.99
C.D. at 5%	1.48	0.41	4.19	1.73	5.94

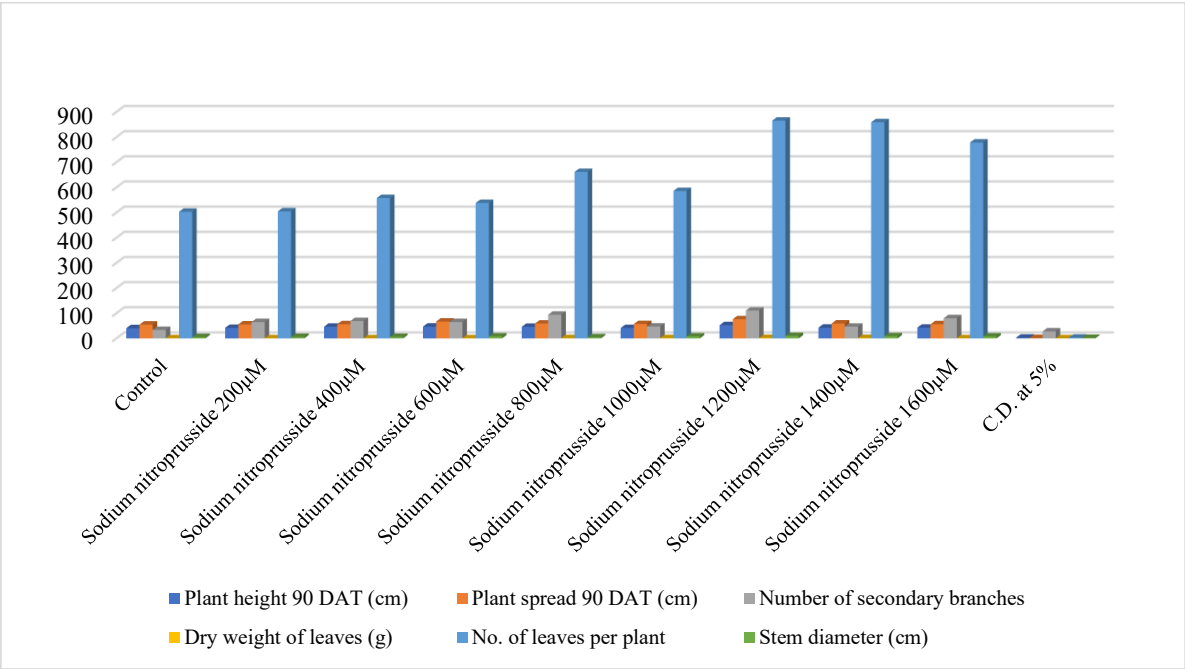

Fig. 1. Effect of sodium nitroprusside on growth parameters

Table 3. Effect of sodium nitroprusside on various flowering characters

Treatment	Number of flowers per plant	Flowering withering (days)	Fresh weight of flower (g)	Dry weight of flower (g)
Control	67.14	3.55	7.53	0.91
Sodium nitroprusside 200µM	64.75	4.50	7.65	0.92
Sodium nitroprusside 400µM	71.61	4.22	9.24	1.05
Sodium nitroprusside 600µM	68.99	3.66	8.37	0.90
Sodium nitroprusside 800µM	71.10	4.50	9.59	1.03
Sodium nitroprusside 1000µM	80.42	3.64	9.96	1.27
Sodium nitroprusside 1200µM	106.17	4.97	8.58	0.78
Sodium nitroprusside 1400µM	101.55	4.08	8.60	0.92
Sodium nitroprusside 1600µM	88.33	4.86	7.60	0.89
C.D. at 5%	14.36	0.83	1.36	0.03

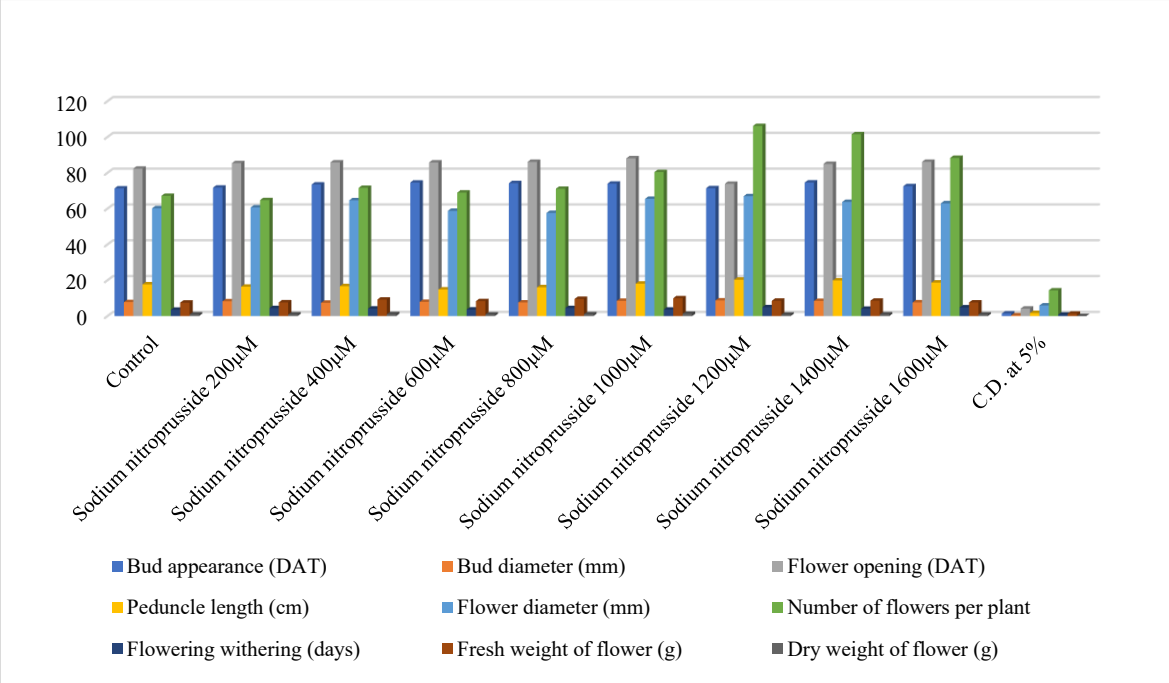

Fig. 2. Effect of sodium nitroprusside on flowering characters

4. CONCLUSION

SNP clearly affects California poppy development and blooming excessive doses may hinder performance, while moderate quantities may enhance it. Maximum fresh weight of flower (9.96 g) and dry weight of flower (1.27 g) were observed with treatment SNP 1000µM. Whereas, maximum bud diameter (8.75 cm), peduncle length (20.32 cm), flower diameter (66.96 mm), number of flowers per plants (106.17) and flower withering (4.97 Days), earlier flower opening (73.89 DAT), Maximum plant height at 90 DAT (52.49 cm), plant spread (76.30 cm) at 90 DAT, number of leaves of per plant (865.38), number of secondary branches (110.58), stem diameter (9.70 mm) and dry weight of leaves (1.48 g) were recorded with SNP @ 1200µM. Maximum bud appearance (74.58 DAT) was seen with treatment SNP 1400µM. NO-mediated improvements in photosynthetic activity, cell division, antioxidant defence, and delayed senescence may be responsible for the beneficial benefits seen. Overall, the findings show that SNP is a powerful growth regulator with great potential to raise California poppy output and ornamental quality.

5. FUTURE PROSPECT

Future studies can focus on exploring the underlying physiological and molecular processes via which SNP affect growth, blooming, hormone balance, and antioxidative

pathways. Since NO plays a well-established function in stress signalling, the following research should examine SNP under various abiotic stresses, such as drought, salinity, heat, and nutritional toxicity to determine their suitability for climate-adaptive floriculture.

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 the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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