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Effect of Foliar Application of Different Nutrients and GA_3 on Growth of Strawberry

Bhumi Lad [a++*] and P. D. Solanki [a#]

[a] Department of Fruit Science, ASPEE College of Horticulture, NAU, Navsari, India.

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Abstract

The field experiment was conducted during 2022-23 at Regional Horticultural Research Station, Department of Fruit Science, ASPEE College of Horticulture, Navsari Agricultural University, Navsari to study the "Effect of foliar application of different nutrients and GA_3 on growth of strawberry". The study was designed using a randomized block design involving three replications and eight nutrient treatments along with GA_3: Control (T_1), $CaNO_3$ at 0.5% + GA_3 100 ppm (T_2), Boron at 0.5% + GA_3 100 ppm (T_3), $ZnSO_4$ at 0.5% + GA_3 100 ppm (T_4), $FeSO_4$ at 0.2% + GA_3 100 ppm (T_5), Novel Organic Liquid Nutrients (NOLN) at 1% + GA_3 100 ppm (T_6), Nano urea at 0.1% + GA_3 100 ppm (T_7) and 19:19:19 at 1% + GA_3 100 ppm (T_8) applied on days 30, 45 and 60 after planting. From the above experimental finding it may be concluded that the treatment Nano urea @ 0.1% + GA_3 100 ppm influenced the growth parameters like plant spread, plant height, petiole length, leaves per plant, leaf area, number of crowns and number of runners among the different treatments.

[++] Ph.D. Scholar; [#] Assistant Professor;
**Corresponding author: E-mail: bhumilad736@gmail.com;*

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Keywords: Foliar application; GA3; strawberry; nano urea; growth.

1. Introduction

Strawberry (Fragaria × ananassa Duch.) is one of the most important and widely appreciated soft fruits globally, prized for its attractive appearance, delicious taste, and cooling properties. It belongs to the family Fragariaceae and is an octaploid species (2n = 56). Cultivated strawberries are hybrids resulting from a cross between Fragaria × virginiana Duch., native to Eastern North America, and Fragaria × chiloensis Duch., native to North and South America. Although strawberry is naturally a temperate fruit crop, it can also be successfully grown in subtropical and tropical regions under suitable cultivation practices (Riyaphan et al., 2005; Liu et al., 2014; Gadhesariya et al., 2005). Strawberries are non-climacteric fruit with perishable in nature and highly sensitive plants. It contains antioxidant and 18 different amino acid. Its cultivation is gaining importance in the worldwide with rising population and demand. At present the focus on strawberry cultivation for maximum productivity and improved fruit quality has become essential to meet increasing market demand. Numerous agronomic technologies, including mulching, nutrient management, irrigation, high-yielding varieties, and pest management, can enhance crop productivity. Among these, nutrient availability plays a crucial role, as deficiencies can adversely affect crop yield, stability, and sustainability. Plant growth and developmental processes are highly dependent on an adequate supply of nutrients. Foliar application of nutrients represents the fastest method to enhance plant growth, as it provides immediate nutrient availability during the initial and critical stages of crop development (Jamal et al., 2006). Foliar feeding has been demonstrated to be both cost-effective and operationally straightforward. Among essential minerals, calcium is particularly important in determining fruit quality, as it is required for cell elongation and cell division.

Foliar application of essential nutrients and growth regulators has a profound impact on strawberry growth, development, and fruit quality. For instance, calcium reduces respiration, delays ripening, increases post-harvest life, enhances fruit firmness and vitamin C content, and mitigates disease severity. Boron plays a crucial role in pollen germination and pollen tube growth, which can improve fruit set (Wojcik et al., 2008). Zinc is a key micronutrient involved in enzymatic systems essential for protein synthesis and seed production (Swietlik, 2002) and is also required for tryptophan synthesis, a precursor of indole acetic acid. Iron participates in chlorophyll formation and degradation, as well as in protein synthesis within chloroplasts and electron transport systems (Somasundaram et al., 2011).

Innovative nutrient formulations, such as the banana pseudostem-based organic liquid nutrients developed by Navsari Agricultural University, contain macronutrients (N 1.00–1.12%, P 0.50–0.71%, K 2.39–20.2%) and micronutrients (Fe 259–323.2 mg/kg, Mn 47.3–241.3 mg/kg, Zn 10.1–107.4 mg/kg, Cu 13.4–83.6 mg/kg), along with growth-promoting substances like cytokinins and gibberellic acid (Gurjar et al., 2022).

Nano-fertilizers are emerging as efficient agricultural tools due to their small particle size and high surface area, which enhance nutrient penetration into plant tissues, boost absorption, reduce leaching losses, and minimize water and soil pollution (Dimkpa et al., 2019; Qureshi et al., 2018). Nano urea, containing 4% nitrogen by weight, is particularly effective in supplying nitrogen at critical crop growth stages, supporting better plant growth, soil health, and farmer profitability. Its particles range between 20–50 nm, allowing superior leaf penetration and utilization compared to conventional urea (Kantwa & Yadav, 2022).

Water-soluble NPK fertilizers (19:19:19) quickly alleviate nutrient deficiencies and promote rapid growth. Gibberellic acid (GA3), a vital plant growth regulator, controls physiological activities, enhances plant height, leaf area, canopy spread, petiole length, stem elongation, and fruit growth, while delaying fruit maturation to allow improved color, flavor, and reduced fruit cracking (Sharma & Singh, 2009).

Considering the importance of these nutrients and growth regulators, the present study aimed to evaluate the effect of foliar application of different nutrients and GA3 on the growth performance of strawberry plants.

2. Materials and Methods

The present study, titled “Effect of foliar application of different nutrients and GA3 on growth of strawberry”, was carried out during

2022–23 at the Regional Horticultural Research Station, Department of Fruit Science, ASPEE College of Horticulture, Navsari Agricultural University, Navsari. The experimental site had heavy black soil, rich in organic matter and potash, moderately drained, and with good water-holding capacity, providing an ideal environment for strawberry cultivation. Healthy, uniform, and disease- and pest-free runner plantlets of strawberry cv. Winter Dawn at the two- to three-leaf stage were planted in the first week of November at a spacing of 30 cm × 30 cm. The plants were grown under silver-black plastic mulch, which helps in weed suppression, moisture conservation, and temperature regulation, creating optimal conditions for vegetative growth and fruit development.

The recommended dose of FYM 10 t ha^{-1} and fertilizers [N (as Urea), P_2O_5 (as DAP) and K_2O (as MOP) @ 120:80:100 kg ha^{-1}] were applied at the time of field preparation. Each experimental raised bed (3.3 m × 0 .9 m) comprised of 32 plants with 8 plants in a net plot area (2.4 m × 0.3 m). Foliar spraying of different nutrients and GA_3 was carried out at 30, 45 and 60 days after planting. The experiment was laid out in Randomized Block Design (RBD) with eight treatments viz. T_1 = Control, T_2 = $CaNO_3$ @ 0.5% + GA_3 100 ppm, T_3 = Boron @ 0.5 % + GA_3 100 ppm, T_4 = $ZnSO_4$ @ 0.5 % + GA_3 100 ppm, T_5 = $FeSO_4$ @ 0.2 % + GA_3 100 ppm, T_6 = Novel Organic Liquid Nutrients (NOLN) @ 1 % + GA_3 100 ppm, T_7 = Nano urea @ 0.1% + GA_3 100 ppm, T_8 = 19:19:19 @ 1% + GA_3 100 ppm and replicated thrice.

Plant growth parameters such as plant spread, plant height, petiole length, leaves per plant, leaf area, number of crowns and number of runners per plant were recorded at 30 days after 3rd spray from tagged five plants in each treatment of all replications. The plant spread in two direction, plant height and petiole length was measured and expressed in centimeter. The leaf area was measured using leaf area meter (Biovis PSM-L2000) and expressed in cm^2. Calculate the number of crowns and runners then average worked out.

The standard method of analysis of variance technique appropriate to the randomized block design (RBD) as described by Panse and Sukhatme (1985) was used. The treatment differences were tested by employing 'F' test at five per cent level of significance on the basis of null hypothesis.

3. Results and Discussion

3.1 Effect on Growth of Strawberry Plant

The data plant spread, plant height and petiole length of strawberry as influenced by foliar application of different nutrients are summarized in Table 1. The plant growth in terms of plant spread in both direction N-S (29.83 cm) and E-W (30.17 cm) was noted maximum in the plants which received foliar spraying of Nano urea @ 0.1% + GA_3 100 ppm and minimum in control plants. When nano urea and GA_3 were sprayed on leaves, GA_3 enhance cell elongation and synthesis of auxin, while nano urea easily entered through stomata which contains nitrogen, it is associated with the synthesis of protoplasm, formation of amino acids and also increases auxin activities that enhances cell division, cell elongation as well as the formation of more tissues resulting in luxuriant vegetative growth which leads to increase in plant spread and these results were agreement with the findings of Venkatesh *et al.* (2022) in marigold and Maheta (2015) in china aster.

Table 1. Effect of different nutrients and GA_3 on plant spread, plant height and petiole length of strawberry

Treatments	Plant spread (cm)		Plant height (cm)	Petiole length (cm)
	N-S (cm)	E-W (cm)		
T_1 : Control	21.65	22.40	18.23	7.97
T_2 : $CaNO_3$ @ 0.5 % + GA_3 100 ppm	26.03	25.59	20.37	9.70
T_3 : Boron @ 0.5 % + GA_3 100 ppm	25.92	26.11	20.60	9.73
T_4 : $ZnSO_4$ @ 0.5 % + GA_3 100 ppm	25.34	24.37	19.33	8.27
T_5 : $FeSO_4$ @ 0.2 % + GA_3 100 ppm	25.01	24.62	20.00	8.97
T_6 : NOLN @ 1 % + GA_3 100 ppm	28.96	29.39	22.07	10.77
T_7 : Nano urea @ 0.1% + GA_3 100 ppm	29.83	30.17	23.73	11.07
T_8 : 19:19:19 @ 1% + GA_3 100 ppm	27.84	28.59	21.47	10.27
S.Em. ±	1.24	1.31	0.97	0.41
C.V. %	8.22	8.62	8.16	7.53

Foliar spraying of plants with a combination of Nano urea at 0.1% and GA_3 at 100 ppm significantly increased plant height (23.73 cm) and petiole length (11.07 cm) compared to control, because nano urea, with its larger surface area, enhances nitrogen uptake by penetrating plant tissues more effectively and utilizing nano-sized channels (plasmodesmata) for better nutrient transport. Sufficient nitrogen supply can boost enzyme activity and auxin metabolism, encouraging cell elongation and cell expansion which ultimately resulting to increased plant height. Additionally, GA_3 promotes growth by stimulating cell division and elongation, contributing to greater internode and stem elongation. The similar results were also found by Mahanta *et al.*, (2019) and Shruti *et al.* (2025).

The foliar application of different nutrients had an effect on number of leaves per plant and leaf area are concised in Table 2. Foliar spraying of Nano urea @ 0.1% + GA_3 100 ppm significantly increased the number of leaves per plant (21.90). Nano urea provides a steady supply of nitrogen, which is essential for synthesis of amino acids, proteins and chlorophyll promoting better vegetative growth and more number of leaves. Additionally, the exogenous application of GA_3 enhances growth by stimulating cell enlargement and division, further contributing to an increased the number of leaves. Similar results were reported earlier by Venkatesh *et al.* (2024) and Abdullah *et al.* (2023).

Plant treated with T_7 also increase in leaf area (116.79 cm^2) as compared to control. It might be due to foliar application of nano urea, which allows plants to absorb nutrients directly through their leaves that bypassing the soil and root system. This technique promotes faster and more efficient nutrient uptake. As a vital component of chlorophyll, nano urea which supplies a sufficient and easily accessible amount of nitrogen enhancing the plant's ability to perform photosynthesis more effectively. This procedure contributes to an expansion of the leaf area and stimulates growth. Additionally, nitrogen is essential for the synthesis of amino acids and proteins, which are crucial for cell division and enlargement, leading to larger leaf areas in plants.

The data on number of crowns and runners per plant presented in the Table 3 showed significant variation. Foliar application of Nano urea @ 0.1% + GA_3 100 ppm was found to be the most effective treatment producing the highest number of crowns (3.20) and runners (3.13) per plant in

Table 2. Effect of different nutrients and GA_3 on leaves per plant and leaf area of strawberry

Treatments	Leaves per plant	Leaf area (cm^2)
T_1 : Control	15.77	94.71
T_2 : $CaNO_3$ @ 0.5 % + GA_3 100 ppm	18.67	106.52
T_3 : Boron @ 0.5 % + GA_3 100 ppm	19.13	108.66
T_4 : $ZnSO_4$ @ 0.5 % + GA_3 100 ppm	17.93	100.39
T_5 : $FeSO_4$ @ 0.2 % + GA_3 100 ppm	18.37	105.21
T_6 : NOLN @ 1 % + GA_3 100 ppm	20.00	113.30
T_7 : Nano urea @ 0.1% + GA_3 100 ppm	21.90	116.79
T_8 : 19:19:19 @ 1% + GA_3 100 ppm	19.60	110.88
S.Em. ±	0.92	3.81
C.V. %	8.47	6.16

Table 3. Effect of different nutrients and GA_3 on crowns and runners per plant of strawberry

Treatments	crowns $plant^{-1}$	runners $plant^{-1}$
T_1 : Control	2.07	2.20
T_2 : $CaNO_3$ @ 0.5 % + GA_3 100 ppm	2.67	2.60
T_3 : Boron @ 0.5 % + GA_3 100 ppm	2.73	2.67
T_4 : $ZnSO_4$ @ 0.5 % + GA_3 100 ppm	2.53	2.40
T_5 : $FeSO_4$ @ 0.2 % + GA_3 100 ppm	2.47	2.53
T_6 : NOLN @ 1 % + GA_3 100 ppm	3.13	3.00
T_7 : Nano urea @ 0.1% + GA_3 100 ppm	3.20	3.13
T_8 : 19:19:19 @ 1% + GA_3 100 ppm	2.80	2.73
S.Em. ±	0.13	0.14
C.V. %	8.16	9.23

strawberry. This may be due to combined application of nano urea and GA_3, which plays a crucial role in promoting cell multiplication through a series of physiological processes. This includes the activation of auxin synthesis, which facilitates rapid cell division in meristematic tissues and leads to an increased number of crowns and runners per plant. The present results are in conformity with the earlier findings of Kumar and Tripathi (2009) and Khushbu *et al.* (2021) in strawberry.

4. Conclusions

On the basis of the result obtained from the present investigation that the foliar application of different nutrients and GA_3 at 30, 45 and 60 days after planting give good response to growth parameters. The findings suggest that Nano urea @ 0.1% + GA_3 100 ppm can be beneficial for promoting vegetative growth. Nano urea improved efficiency of nitrogen delivery, better nutrient absorption and utilization, while GA_3 promote cell elongation, leaf expansion and overall vegetative growth. When applied together, they have a synergistic impact that not only increases plant height and leaf area but also strengthens the physiological basis for reproductive growth.

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.

Competing Interests

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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