



# Effect of Nano-urea on Performance of Strawberry (*Fragaria* × *Ananassa* Duch.) cv. Winter Dawn

Manish Kumar Sonkar <sup>a\*</sup>, Goutam Mandal <sup>a</sup>,  
Navdeep Kumar <sup>b</sup> and Dhan Singh <sup>b</sup>

<sup>a</sup> Department of Horticulture and Post-harvest Technology, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan-731236, West Bengal, India.

<sup>b</sup> Department of Horticulture, SASRD, Nagaland University, Medziphema-797106, India.

## 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

A field experiment was conducted during 2022–23 at the Horticulture Farm, Institute of Agriculture, Visva-Bharati, Sriniketan. The study was laid out in a Randomized Block Design (RBD) with three replications to evaluate the impact of nano-urea on the growth, fruiting, and yield of strawberry (*Fragaria* × *ananassa* Duch.) cv. Winter Dawn. The experiment comprised seven treatment combinations, that consists 100% Recommended Dose of Nitrogen (RDN) applied through soil application of urea; 50% RDN through soil application of urea combined with two foliar applications of nano-urea at concentrations of 0.2%, 0.3%, and 0.4%; and 100% RDN through soil application of urea supplemented with one foliar spray of nano-urea at concentrations of 0.2%, 0.3%, and 0.4%. The treatment receiving 100% RDN through soil application along with a single foliar spray of 0.4%

\*Corresponding author: E-mail: [manishkeshriya@gmail.com](mailto:manishkeshriya@gmail.com);

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nano-urea recorded the maximum values for plant height (23.63 cm), leaf area (123.60 cm<sup>2</sup>), plant dry weight (46.33 g), fruit length (62.27 mm), fruit diameter (43.13 mm), yield per plot (8.73 kg), and yield per hectare (19.39 t). Hence, it can be concluded that the application of 100% RDN through urea, combined with one foliar spray of 0.4% nano-urea, is the most effective treatment for enhancing the overall growth and yield performance of strawberry.

**Keywords:** Strawberry; nano-urea; foliar spray and Winter Dawn.

## 1. INTRODUCTION

The cultivated strawberry (*Fragaria × ananassa* Duch.), an octoploid species ( $2n = 8x = 56$ ) belonging to the family Rosaceae, is considered to have originated in France. It ranks among the most extensively grown and economically important fruit crops worldwide, appreciated for its distinctive flavour, attractive appearance, and substantial health-promoting properties. In recent years, the global consumption of strawberries has shown a steady increase, attributed to their wide applicability in culinary preparations and the rising consumer awareness regarding their nutritional and functional benefits. According to Oguz *et al.* (2022), global strawberry production experienced a 39.4% increase between 2008 and 2018 and is anticipated to rise by an additional 3.4% between 2021 and 2026. Despite this upward trend, strawberry cultivation remains a complex endeavor influenced by a range of environmental, agronomic, and economic factors. Among these, nutrient management is particularly critical, with nitrogen (N) recognized as the most essential nutrient for maximizing yield and improving fruit quality. Yoshida *et al.* (1991) highlighted the significant impact of nitrogen application on vegetative growth, flowering, fruit set, yield, and the overall quality of strawberry fruits. Urea, which contains 46% nitrogen, is the most widely used nitrogenous fertilizer due to its high nutrient concentration and ease of integration with other fertilization practices. However, its effectiveness is limited by low nitrogen use efficiency (NUE), with only 45–50% of the applied nitrogen typically absorbed and utilized by plants (Iqbal *et al.*, 2019). This inefficiency leads to excessive application, increasing production costs and causing adverse environmental impacts such as nitrate leaching and greenhouse gas emissions. To overcome these limitations, recent advancements in agricultural nanotechnology have introduced novel solutions such as nano fertilizers. These offer improved nutrient delivery and uptake, potentially reducing environmental harm while enhancing crop productivity (Lal, 2008). In this context, the Indian Farmers Fertiliser

Cooperative Limited (IFFCO) has developed IFFCO Nano Urea (liquid), a nano formulated nitrogen fertilizer designed to reduce or replace conventional urea application. Field trials conducted on various crops by research organizations and agricultural universities have demonstrated encouraging outcomes with the use of nano-urea (Kumar *et al.*, 2021). In light of these findings, the present study was undertaken to assess the effects of different concentrations of nano-urea on vegetative growth, flowering, fruiting, and yield of strawberry. The primary objective is to advance sustainable and efficient nutrient management practices in strawberry production systems (Sonkar, *et al.*, 2024).

## 2. MATERIALS AND METHODS

A field experiment was carried out during the 2022–23 cropping season at the Horticultural Farm, Department of Horticulture and Post-Harvest Technology, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, West Bengal. The experimental site is geographically located at 23°42' N latitude and 87°40'30" E longitude, with an elevation of 40 meters above mean sea level. The location falls within the sub-humid, subtropical lateritic zone of West Bengal, characterized by hot summers and relatively mild, short winters. During the experimental period (15 October to 15 March), the average weekly maximum and minimum temperatures ranged from 22.19°C to 33.33°C and 9.60°C to 22.71°C, respectively. The soil of the experimental plot belongs to the Gangetic alluvial zone, with a loamy sand texture. It exhibited a pH of 4.97, electrical conductivity (EC) of 0.28 dS/m, and organic carbon content of 0.6%. The available nutrient status of the surface soil was 237.44 kg/ha nitrogen (alkaline potassium permanganate method), 17.13 kg/ha phosphorus (Bray's method), and 114.68 kg/ha potassium (ammonium acetate extraction method). The strawberry cultivar 'Winter Dawn' was chosen for the investigation due to its adaptability and commercial relevance. IFFCO Nano Urea Liquid (4% w/v) served as the nano-nitrogen source for foliar application. The

experimental layout followed a Randomized Block Design (RBD) with three replications, incorporating seven distinct treatment combinations to evaluate the effect of nano-urea on crop performance. Treatment consists 100% Recommended Dose of Nitrogen (RDN) applied through soil application of urea; 50% RDN through soil application of urea combined with two foliar applications of nano-urea at concentrations of 0.2%, 0.3%, and 0.4%; and 100% RDN through soil application of urea supplemented with one foliar spray of nano-urea at concentrations of 0.2%, 0.3%, and 0.4%. To assess the influence of nano-urea, varying concentrations were applied as foliar sprays, either once or twice depending on the treatment. In treatments where only 50% of the Recommended Dose of Nitrogen (RDN) was applied as a basal dose through urea, two foliar applications of nano-urea at different concentrations were carried out at 30 and 45 days after transplanting (DAT). Conversely, in treatments receiving 100% RDN through urea (as a combination of basal and soil applications at 30 and 45 DAT), a single foliar spray of nano-urea at different concentrations was administered at 60 DAT. The treatment receiving only urea to meet 100% RDN served as the control. Nutrient and manure applications were conducted following the recommendations of Saini *et al.* (2022) and Dhillon (2013), with 50 metric tonnes of farmyard manure (FYM) and a fertilization schedule of 80:40:40 kg/ha of N:P<sub>2</sub>O<sub>5</sub>:K<sub>2</sub>O. A full dose of FYM, phosphorus, and potassium, along with half of the nitrogen requirement, was applied during land preparation using single superphosphate (SSP), muriate of potash (MOP), and urea, respectively. The remaining nitrogen was supplied according to the specific treatment requirements. Urea and other fertilizers were incorporated through soil application, while nano-urea was diluted in water and applied as a foliar spray using a knapsack sprayer (25 units or 375 L of solution per hectare). For data collection, five plants were randomly selected and tagged in each plot for observation. The data on all the growth, fruiting and yield were tabulated and subjected to statistical analysis by following the standard ANOVA method with a 5% level of significance described by Gomez and Gomez (1984) for randomized block design.

### 3. RESULTS AND DISCUSSION

An examination of the data presented in Table 1 indicates that plant height, leaf area, and plant dry weight of strawberry were significantly

affected by the different concentrations of nano-urea treatments. Maximum plant height at 60 DAT (16.53 cm), 90 DAT (19.63 cm), 120 DAT (23.33cm), and 150 DAT (23.63cm) was noted with T<sub>7</sub> (100% RDN + one spray of 0.4% nano-urea) was noted while, minimum plant height at 60 DAT (9.13 cm), 90 DAT (11.13 cm), 120 DAT (12.78 cm), and 150 DAT (14.30 cm) was recorded with T<sub>2</sub> (50% RDN + two sprays of 0.2% nano-urea). The observed increase in plant height in strawberry can be attributed to the role of nitrogen as a key component of amino acids, proteins, vitamins, hormones, and enzymes, all of which directly influence cell division and expansion in both the longitudinal and transverse directions. The enhanced meristematic activity resulting from these processes contributes to increased plant height. These findings align with those of Midde *et al.* (2022), who reported an increase in plant height in rice following nano-urea application. Similarly, Reddy & Goyal (2021) noted that higher nitrogen doses led to an increase in plant height in strawberry. Leaf area of strawberry plants taken at 120 DAT. The highest strawberry leaf area (123.60 cm<sup>2</sup>) was observed with 100% RDN + one spray of nano urea); it was statistically at par with T<sub>6</sub> (120.77 cm<sup>2</sup>), T<sub>5</sub> (119.77 cm<sup>2</sup>) and T<sub>1</sub> (119.17 cm<sup>2</sup>), whereas the lowest strawberry leaf area (76.27 cm<sup>2</sup>) was recorded in T<sub>2</sub> (50% RDN + two sprays of 0.2% nano urea). The observed increase in leaf area could be attributed to enhanced cell division and expansion triggered by the application of nano-urea. This stimulation likely accelerates the elongation and broadening of leaves, resulting in a larger leaf surface area. These results are consistent with those of Midde *et al.* (2022), who observed a higher leaf area index in rice following the application of nano-urea. Similarly, Omotoso and Akinrinde (2013) reported an increase in leaf area in pineapple plants with higher nitrogen doses.

The dry weight of the strawberry plants taken at 150 DAT. The highest dry weight of strawberry plant (46.33 g) was found with one spray of nano-urea+100% RDN. It was statistically at par with treatments T<sub>6</sub> (43.00 g) while the lowest dry weight of strawberry plants (9.67 g) was recorded in two sprays of 0.2% nano-urea+50% RDN. The dry weight of strawberry plants might be attributed to significant improvements in growth parameters such as plant height, leaf area, plant dry weight, etc. High vegetative growth aids in enhanced utilisation of solar energy and absorption of nutrients, which are essential for various physio-chemical processes

**Table 1. Effect of nano-urea on plant height (cm), leaf area, plant fresh weight(g) and plant dry weight of strawberry (*Fragaria × ananassa* Duch.) cv. Winter Dawn**

| Treatments     | Plant height (cm) |       |        |         | Leaf area | Plant dry weight |
|----------------|-------------------|-------|--------|---------|-----------|------------------|
|                | 60DAT             | 90DAT | 120DAT | 150 DAT |           |                  |
| T <sub>1</sub> | 15.93             | 17.27 | 17.40  | 18.13   | 119.17    | 33.00            |
| T <sub>2</sub> | 9.13              | 11.13 | 12.87  | 14.30   | 76.27     | 9.67             |
| T <sub>3</sub> | 10.07             | 12.23 | 14.13  | 16.00   | 87.33     | 13.00            |
| T <sub>4</sub> | 11.93             | 14.13 | 17.70  | 18.27   | 106.77    | 23.33            |
| T <sub>5</sub> | 16.20             | 18.93 | 19.27  | 20.60   | 119.77    | 39.67            |
| T <sub>6</sub> | 15.87             | 19.13 | 21.53  | 22.17   | 120.77    | 43.00            |
| T <sub>7</sub> | 16.53             | 19.63 | 23.33  | 23.63   | 123.60    | 46.33            |
| SEm(±)         | 0.63              | 0.71  | 0.66   | 0.58    | 3.41      | 1.22             |
| CD @ 5%        | 1.84              | 2.11  | 1.95   | 1.71    | 10.05     | 3.60             |
| CV (%)         | 7.92              | 7.70  | 6.35   | 5.29    | 5.48      | 7.11             |

**Table 2. Effect of various concentrations of nano-urea on Fruit length (mm), Fruit diameter (mm) Average fruit weight, Yield/plot(kg) and Yield/ha(t) of strawberry (*Fragaria × ananassa* Duch.) cv. Winter Dawn**

| Treatments     | Fruit length (mm) | Fruit diameter (mm) | Yield/plot(kg) | Yield/ha(t) |
|----------------|-------------------|---------------------|----------------|-------------|
| T <sub>1</sub> | 48.47             | 33.13               | 5.95           | 13.23       |
| T <sub>2</sub> | 33.63             | 24.47               | 2.44           | 5.42        |
| T <sub>3</sub> | 38.23             | 27.70               | 2.90           | 6.45        |
| T <sub>4</sub> | 42.83             | 29.73               | 3.64           | 8.08        |
| T <sub>5</sub> | 54.60             | 37.63               | 6.80           | 15.11       |
| T <sub>6</sub> | 60.77             | 42.27               | 7.88           | 17.51       |
| T <sub>7</sub> | 62.27             | 43.13               | 8.73           | 19.39       |
| SEm(±)         | 2.02              | 1.60                | 0.31           | 0.69        |
| CD @ 5%        | 5.97              | 4.71                | 0.91           | 2.03        |
| CV (%)         | 7.19              | 8.13                | 9.78           | 9.78        |

that lead to higher biomass production. The present findings are in association with the findings of Midde *et al.* (2022), who reported in rice that the application of nano-urea increased dry matter production. Rajonee *et al.* (2016) reported a higher dry weight of Ipomoea aquatic (Kalmi) plants treated with nano-nitrogen fertilizer.

A significant difference was observed among the treatments with varying concentrations of nano-urea in terms of fruit length, fruit diameter, yield per plot (kg), and yield per hectare, as presented in Table 2. The maximum length (62.27 mm) of strawberry fruit was recorded in one spray of 0.4% nano-urea +100% RDN; it was found statistically at par with T<sub>6</sub> (60.77 mm). While the minimum strawberry fruit length (33.63 mm) was recorded with two sprays of 0.2% nano-urea+50% RDN, which was found statistically at par with treatment T<sub>3</sub> (38.23 mm). Similarly, maximum strawberry fruit diameter (43.13 mm) was recorded in treatment T<sub>7</sub> (100% RDN + one spray of 0.4% nano-urea), which was found statistically at par with T<sub>6</sub> (42.27 mm). While the

minimum strawberry fruit diameter (24.47 mm) was recorded in T<sub>2</sub> (50% RDN + two sprays of 0.2% nano-urea), which was found statistically at par with T<sub>3</sub> (27.70 mm). An additional spray of 0.4% nano-urea under 100% RDN had a positive effect on increasing the length of the strawberry fruits. This behaviour could be explained by the fact that nano-urea can help plants to absorb nitrogen more efficiently, leading to faster growth and development. It is possible that the increased availability of nitrogen allows plants to allocate more resources towards fruit growth and development, leading to larger fruits. The results obtained were in conformity with the findings of Shahi *et al.* (2021), who reported in brinjal that increase in levels of nitrogen up to a certain limit increased fruit length and diameter. The maximum strawberry yield per plot (8.73 kg) was recorded in treatment T<sub>7</sub> (100% RDN + one spray of 0.4% nano-urea), which was found statistically at par with T<sub>6</sub> (7.88 kg). While the minimum yield per plot (2.44 kg) was recorded in T<sub>2</sub> (50% RDN + two sprays of 0.2% nano-urea), which was found statistically at par with T<sub>3</sub> (2.90 kg). Similarly, maximum strawberry yield per

hectare (19.39 t) was recorded in treatment T<sub>7</sub> (100% RDN + one spray of 0.4% nano-urea), which was found statistically at par with T<sub>6</sub> (17.51 t). While the minimum yield per hectare (5.42 t) was recorded in T<sub>2</sub> (50% RDN + two sprays of 0.2% nano-urea), which was found statistically at par with T<sub>3</sub> (6.45 t). The higher strawberry yield achieved in the plots treated with 100% RDN through urea and one additional spray of 0.4% nano-urea (T<sub>7</sub>) might be due to a significant improvement in the vegetative and reproductive growth parameters. The reproductive growth parameters were published in another paper of this research. Vegetative growth is an important phase in the life cycle of a plant. During this phase, the plant develops its leaves, stems, and roots, which are crucial for the absorption of nutrients, water, and sunlight. The growth of these vegetative parts contributes to the establishment of a robust, healthy plant that is more resilient to pests and diseases. Strong vegetative growth enhances the plant's capacity to produce more flowers, fruits, and seeds, as larger and healthier plants can allocate more energy towards the development of reproductive structures. Furthermore, a vigorous vegetative phase allows the plant to accumulate reserves of nutrients and energy, which can later be utilized during the reproductive phase when producing flowers or fruits. These findings are consistent with those of Warner *et al.* (2004), who reported that increased nitrogen application resulted in higher tomato yield. Similarly, Singh and Singh (2002) found that nitrogen supplementation led to higher peach yields. Sahu *et al.* (2022) also observed increased rice grain yield per hectare with the application of nano-urea.

#### 4. CONCLUSION

The present study concludes that the application of 100% Recommended Dose of Nitrogen (RDN) through urea, combined with a single foliar spray of 0.4% nano-urea at the peak vegetative growth stage, is most effective in promoting greater plant height, leaf area, plant dry weight, fruit length, fruit diameter, as well as enhancing both yield per plot and yield per hectare of strawberry.

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#### 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 this manuscript.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

#### REFERENCES

- Dhillon, W. S. (2013). *Fruit production in India* (pp. 638–639). Narendra Publishing House.
- Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research* (pp. 357–427). John Wiley and Sons Inc.
- Iqbal, M., Umar, S., & Mahmooduzzafar. (2019). Nano fertilization to enhance nutrient use efficiency and productivity of crop plants. In *Nanomaterials and plant potential* (pp. 473–505). [https://doi.org/10.1007/978-3-030-05569-1\\_19](https://doi.org/10.1007/978-3-030-05569-1_19)
- Kumar, Y., Singh, T., Raliya, R., & Tiwari, K. N. (2021). Nano fertilizers for sustainable crop production, higher nutrient use efficiency and enhanced profitability. *Indian Journal of Fertilisers*, 17(11), 1206–1214.
- Lal, R. (2008). Promise and limitations of soils to minimize climate change. *Journal of Soil and Water Conservation*, 63(4), 113A–118A. <https://doi.org/10.2489/63.4.113A>
- Midde, S. K., Perumal, M. S., Murugan, G., Sudhagar, R., Mattepally, V. S., & Bada, M. R. (2021). Evaluation of nano urea on growth and yield attributes of rice (*Oryza sativa* L.). *Chemical Science Review and Letters*, 11(42), 211–214.
- Oguz, I., Oguz, H. I., & Kafkas, N. E. (2022). Strawberry cultivation techniques. IntechOpen. <http://dx.doi.org/10.5772/intechopen.104611>
- Rajonee, A. A., Nigar, F., Ahmed, S., & Huq, S. I. (2016). Synthesis of nitrogen nano fertilizer and its efficacy. *Canadian Journal of Pure and Applied Sciences*, 10, 3913–3919.
- Reddy, G., & Goyal, R. K. (2020). Growth, yield and quality of strawberry as affected by fertilizer N rate and biofertilizers inoculation under greenhouse conditions. *Journal of Plant Nutrition*, 44(1), 46–58.

- <https://doi.org/10.1080/01904167.2020.1806301>
- Sahu, T. K., Kumar, M., Kumar, N., Chandrakar, T., & Singh, D. P. (2022). Effect of nano urea application on growth and productivity of rice (*Oryza sativa* L.) under mid land situation of Bastar region. *Pharma Innovation*, 11, 185–187.
- Saini, S., Kumar, P., Sharma, N. C., Sharma, N., & Balachandar, D. (2021). Nano-enabled Zn fertilization against conventional Zn analogues in strawberry (*Fragaria x ananassa* Duch.). *Scientia Horticulturae*, 282, 110–116. <https://doi.org/10.1016/j.scienta.2021.110016>
- Singh, D., & Singh, R. (2002). Nitrogen nutrition of peach – A review. *Agricultural Reviews*, 23(1), 46–52.
- Sonkar, M. K., Mandal, G., Kumar, N., Priyanka, K., Kumar, M., & Singh, D. (2024). Effect of nano-urea on vegetative growth, flowering, fruiting and yield of strawberry fruit cv. Winter Dawn. *Plant Archives*, 24(2).
- Warner, J., Zhang, T. Q., & Hao, X. (2004). Effects of nitrogen fertilization on fruit yield and quality of processing tomatoes. *Canadian Journal of Plant Science*, 84(3), 865–871.
- Yoshida, Y., Ohi, M., & Fujimoto, K. (1991). Fruit malformation, size and yield in relation to nitrogen nutrition and nursery plants in large-fruited strawberry (*Fragaria x ananassa*). *Journal of the Japanese Society of Horticultural Science*, 59(4), 727–735. <https://doi.org/10.2503/jjshs.59.727>

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