***Original Research Article***

**Effect of nano-urea on performance of strawberry (*Fragaria × ananassa* Duch.) cv. Winter Dawn**

**ABSTRACT**

A field experiment was carried out in randomized block design (RBD) with three replications at the Horticulture Farm of the Department of Horticulture and Post-Harvest Technology, Palli Siksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, West Bengal, during 2022-23 with the objective to find out the effect of nano-urea on the growth, flowering, fruiting and yield of strawberries. The experiment had seven treatments, where different concentrations of nano-urea were sprayed. In the plots where 50% of RDN was applied through urea, two foliar sprays of different concentration of nano-urea were done and the plots where 100% RDN was applied through urea, only one foliar spray of different concentration of nano-urea was done. Plots where only urea was applied to fulfil 100% RDN were considered control plots. The results of the study revealed that the combination of 100% RDN through urea with one foliar spray of different concentrations of nano-urea enhanced the performance of strawberry. The highest plant height (23.63cm), leaf area (123.60 cm²), 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) were recorded with 100% RDN + one spray of 0.4% nano-urea. Thus, one foliar application of 0.4% nano-urea with 100% RDN is found the most effective to improve performance of strawberries.

**Keywords:** Strawberry, nano-urea, foliar spray and winter Dawn.

**Introduction**

The cultivated strawberry (*Fragaria × ananassa* Duch.), an octaploid species (2n = 8x = 56) belonging to the Rosaceae family, is believed to have originated in France. It is one of the most widely cultivated and economically valuable fruit crops globally, renowned for its appealing taste, vibrant colour, and numerous health benefits. In recent years, the global demand for strawberries has continued to grow, driven by their versatile use in culinary applications and increasing consumer awareness of their nutritional value. According to Oguz *et al.* (2022), global strawberry production increased by 39.4% between 2008 and 2018, and is projected to grow by another 3.4% between 2021 and 2026.However, strawberry production is a complex process influenced by various environmental, agronomic, and economic factors. Among these, nutrient management plays a crucial role, with nitrogen (N) considered the most vital nutrient for achieving higher yields and better-quality produce. Yoshida *et al.* (1991) reported that nitrogen management significantly affects the vegetative growth, flowering, fruiting, yield, and overall quality of strawberries.Urea, containing 46% nitrogen, is the most commonly used nitrogen fertilizer due to its high nutrient content and compatibility with other fertilizers. Despite its widespread use, urea suffers from poor nitrogen use efficiency, with only 45–50% of the applied nitrogen being effectively utilized by crops (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 nanofertilizers. 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 nanoformulated nitrogen fertilizer designed to reduce or replace conventional urea application. Field evaluations across various crops by research institutions and agricultural universities have shown promising responses to nano-urea (Kumar *et al*., 2021).Therefore, the present study aims to investigate the effect of different concentrations of nano-urea on the vegetative growth, flowering, fruiting, and yield of strawberries, with the goal of promoting sustainable and efficient nutrient management practices in strawberry cultivation.

**Materials and Methods**

A field experiment was conducted during 2022-23 at the Horticultural Farm under the Department of Horticulture and Post-Harvest Technology, Palli Siksha Bhavana (Institute of Agriculture), Visva Bharati, Sriniketan, West Bengal. The site lies at 23° 42’ N latitude, 87° 40’ 30" E longitude and 40 m above mean sea level. The experimental site was situated in the sub-humid, subtropical lateritic belt of West Bengal, with a hot summer and a moderately cold and short winter in the eastern part of India. The average weekly maximum and minimum temperature during the cropping seasons (15 October to 15 March) varied from 22.19 to 33.33°C and 9.60 to 22.71°C, respectively. Soil is Gangetic alluvium having loamy sand in texture with pH 4.97, EC 0.28 ds/m and organic carbon 0.6%, Alkaline Potassium Permanganate - N, Bray’s - P and Ammonium acetate extraction - K content of surface soil was 237.44, 17.13 and 114.68 kg/ha, respectively. Winter dawn variety of strawberry and IFFCO nano-urea liquid (4% w/v) was used as a source of nano-nitrogen fertiliser in the experiment. The experiment was laid out in a randomized block design with three replications and seven treatments. Treatment details and the schedule of treatment applications are given below in Table 1. To analyse the effect of nano-urea, different concentrations of nano urea were sprayed either once or twice. In the plots where only 50% RDN was applied as a basal application of urea, two foliar sprays of different concentrations of nano-urea were sprayed at 30 and 45 DAT, while in the plots where 100% RDN was applied through urea as a basal application and soil application at 30 and 45 DAT, only one foliar application of different concentrations of nano-urea was sprayed at 60 DAT. Plots where only urea was applied to fulfil 100% RDN were considered control plots. Manure and fertiliser application were done following the recommendation of Saini *et al.,* (2022) and Dhillon (2013) of 50 metric tonnes FYM and 80-40-40 kg N P2O5-K2O per ha. A full dose of FYM, P2O5, K2O and half doses of N were applied at the time of land preparation through single superphosphate (SSP), murate of potash (MOP), and urea, respectively, while the remaining half of N was applied based on the treatments. Urea and other fertilisers were applied as soil applications, whereas nano-urea was dissolved in water and applied in the form of foliar spray with the use of a knapsack sprayer (25 knapsack sprayer or 375 l solution/ha). Five strawberry plants were selected randomly and marked in each plot for observation. The data on 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.

**Results and Discussion**

The perusal of the data presented in Table 1 revealed that the plant height, leaf area, plant dry weight of strawberry differed significantly due to various 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 T7 (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 T2 (50% RDN + two sprays of 0.2% nano-urea). This behaviour of increasing plant height in strawberry could be explained by the fact that nitrogen in plants is a primary component of amino acids, proteins, vitamins, hormones and enzymes, all of which have an immediate effect on promoting cell division and enlargement both longitudinally and transversely, and increased meristematic activities lead to an increase in plant height. The results obtained were in conformity with the findings of Midde *et al.* (2022), who reported increased plant height in rice treated with nano-urea. Reddy & Goyal (2021) observed in strawberry that an increased dose of nitrogen increases plant height. Leaf area of strawberry plants taken at 120 DAT. The highest strawberry leaf area (123.60 cm2) was observed in treatment T7 (100% RDN + one spray of nano urea); it was statistically at par with T6 (120.77 cm2), T5 (119.77 cm2) and T1 (119.17 cm2), whereas the lowest strawberry leaf area (76.27 cm2) was recorded in T2 (50% RDN + two sprays of 0.2% nano urea). The increase in leaf area might be due to an increase in cell division and cell expansion induced by the application of nano-urea, which leads to a rapid increase in the length and breadth of leaves, resulting in a larger leaf surface area. Present findings were also in line with the findings of Midde *et al.* (2022), who reported an increased leaf area index of rice with the application of nano-urea. Omotoso and Akinrinde (2013) also reported an increased leaf area in pineapple with increased nitrogen dose.

**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**  |
| T1 | 15.93  | 17.27  | 17.40  | 18.13  | 119.17  | 33.00  |
| T2 | 9.13  | 11.13  | 12.87  | 14.30  | 76.27  | 9.67  |
| T3 | 10.07  | 12.23  | 14.13  | 16.00  | 87.33  | 13.00  |
| T4 | 11.93  | 14.13  | 17.70  | 18.27  | 106.77  | 23.33  |
| T5 | 16.20  | 18.93  | 19.27  | 20.60  | 119.77  | 39.67  |
| T6 | 15.87  | 19.13  | 21.53  | 22.17  | 120.77  | 43.00  |
| T7 | 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  |

The dry weight of the strawberry plants taken at 150 DAT.The highest dry weight of strawberry plant (46.33 g) was found in treatment T7 (100% RDN + one spray of nano-urea). It was statistically at par with treatments T6 (43.00 g) while the lowest dry weight of strawberry plants (9.67 g) was recorded in T2 (50% RDN + two sprays of 0.2% nano-urea). The dry weight of strawberry plants might be attributed to significant improvements in growth parameters such as plant height, leaf area etc. 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.

**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)** |
| T1 | 48.47 | 33.13 | 5.95 | 13.23 |
| T2 | 33.63 | 24.47 | 2.44 | 5.42 |
| T3 | 38.23 | 27.70 | 2.90 | 6.45 |
| T4 | 42.83 | 29.73 | 3.64 | 8.08 |
| T5 | 54.60 | 37.63 | 6.80 | 15.11 |
| T6 | 60.77 | 42.27 | 7.88 | 17.51 |
| T7 | 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 |

There was a significant difference among the treatments applied with different concentrations of nano-urea with respect to the fruit length,fruit diameter,yield/plot(kg) and yield/haof strawberry, which is presented in Table 2. The maximum length (62.27 mm) of strawberry fruit was recorded in treatment T7 (100% RDN + one spray of 0.4% nano-urea); it was found statistically at par with T6 (60.77 mm). While the minimum strawberry fruit length (33.63 mm) was recorded in T2 (50% RDN + two sprays of 0.2% nano-urea), which was found statistically at par with treatment T3 (38.23 mm). Similarly, maximum strawberry fruit diameter (43.13 mm) was recorded in treatment T7 (100% RDN + one spray of 0.4% nano-urea), which was found statistically at par with T6 (42.27 mm). While the minimum strawberry fruit diameter (24.47 mm) was recorded in T2 (50% RDN + two sprays of 0.2% nano-urea), which was found statistically at par with T3 (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 T7 (100% RDN + one spray of 0.4% nano-urea), which was found statistically at par with T6 (7.88 kg). While the minimum yield per plot (2.44 kg) was recorded in T2 (50% RDN + two sprays of 0.2% nano-urea), which was found statistically at par with T3 (2.90 kg). Similarly, maximum strawberry yield per hectare (19.39 t) was recorded in treatment T7 (100% RDN + one spray of 0.4% nano-urea), which was found statistically at par with T6 (17.51 t). While the minimum yield per hectare (5.42 t) was recorded in T2 (50% RDN + two sprays of 0.2% nano-urea), which was found statistically at par with T3 (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 (T7) might be due to a significant improvement in the vegetative and reproductive growth parameters. A strong vegetative growth phase allows the plant to build up reserves of nutrients and energy that it can use later on during the reproductive phase, when it is producing fruits or flowers. The present findings are in association with the findings of Warner *et al.* (2004), who reported in tomato that an increase dose of nitrogen increased yield. Singh and Singh (2002) reported that peach yield increased with an increased dose of nitrogen. Sahu *et al.* (2022) reported increased grain yield in rice per ha with the use of nano-urea.

**Conclusion**

The present investigation concludes that a combination of 100% RDN through urea with one foliar spray of 0.4% nano-urea at the peak vegetative growth stage is more beneficial to achieve higher plant height, leaf area, plant dry weight, fruit length, fruit diameter, yield/plot and yield/ha of strawberry.

**References**

Dhillon, W.S. (2013). Fruit production in India. Narendra Publishing House, Delhi. 638-639.

Gomez, K.A. and Gomez A.A. (1984). Statistical Procedures for Agricultural Research. John Wiley and Sons Inc, New York. 357-427.

Iqbal, M., Umar S. and Mahmooduzzafar (2019). Nano fertilization to enhance nutrient use efficiency and productivity of crop plants. Nanomaterials and plant potential, 473-505. https://doi.org/10.1007/978-3-030 05569-119.

Kumar, Y., Singh T., Raliya R. and 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. and 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. and Kafkas N.E. (2022). Strawberry cultivation techniques. IntechOpen, London, UK. http:/ /dx.doi.org/10.5772/intechopen.104611

Rajonee, A.A., Nigar F., Ahmed S. and Huq S.I. (2016). Synthesis of nitrogen nano fertilizer and its efficacy. Canadian Journal of Pure and Applied Sciences, 10, 3913-3919.

Reddy, G. and Goyal R.K. (2020). Growth, yield and quality of strawberry as affected by fertilizer N rate and bio fertilizers inoculation under greenhouse conditions. Journal of Plant Nutrition, 44(1), 46-58. https://doi.org/10.1080/ 01904167.2020.1806301

Saini, S., Kumar P., Sharma N.C., Sharma N. and Balachandar D. (2021). Nano-enabled Zn fertilization against conventional Zn analogues in strawberry (Fragaria× ananassa Duch.). Scientia Horticulturae, 282, 110016. <https://doi.org/10.1016/j.scienta.2021.110016>

Yoshida, Y., Ohi M. and 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), 727-35. https://doi.org/10.2503/jjshs.59.727