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# Effect of Nano Urea on Mango (*Mangifera indica* L.) Grafts Cv. Alphonso

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

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## ABSTRACT

This study aimed to determine the effect of application of foliar spray and drenching of nano urea on growth and survival of mango grafts cv. Alphonso. The experiment was laid out in Randomized Block Design with three replications and twelve treatments to assess various concentrations of nano urea at College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli,

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Ratnagiri, Maharashtra, India. Treatments applied as a foliar spray and drenching of nano urea at different rates in which treatment of foliar application of nano urea at 1500 ppm showed best performance in survival percentage (95.11 %), graft height (44.99 cm), number of shoots (1.90), number of leaves (31.13), relative growth rate (0.0059 cm/cm/day), dry weight of root (13.44 g) and tap root length (27.10 cm). However, drenching treatment of nano urea at 1500 ppm showed good results in graft girth (10.60 mm) and treatment of foliar spray of nano urea at 500 ppm were found best for total leaf area (654.52 $cm^2$). Among all the nano urea treatments, foliar spray of nano urea at 1500 ppm was the best owing to highest survival and better growth of mango grafts cv. Alphonso.

*Keywords: Nanourea; foliarspray; drenching; survival; growthparameters; alphonso mango grafts.*

## 1. INTRODUCTION

Mango (*Mangifera indica* L.) is one of the most widely consumed fruit worldwide, particularly in India, where it is considered to be the best choice among all native fruits. It has been deeply ingrained in Indian culture, society, and religion since ancient times (Yadav & Singh 2017). The mango is aptly referred to as the "King of fruits" and it also regarded as the "National fruit of India". It is said to have originated in the Indo Burma region of South East Asia, near the foothills of the Himalayas (Mukharjee 1951).

The Konkan region is well known for the commercial cultivation of the world-famous 'Alphonso' mango, locally called 'Hapus.' Horticultural land in India is rapidly expanding, particularly for fruit crops. The Konkan belt is recognized as a key provider of highest quality, disease-free planting material for all main mango types in India, notably Maharashtra. Currently, there are approximately 250 licensed fruit crop nurseries in the Konkan region, producing 1 to 1.2 million saleable mango grafts annually (Haldavnekar et al. 2020). The area under mango is increasing rapidly. Most of the increased area is planted under high density planting mode. Hence, the demand for healthy and vigorous mango grafts is rapidly increasing.

As an alternative to conventional urea, nano urea helps crops to meet their nitrogen needs, especially during crucial growth periods. Liquid nano urea contains 4 % nanoscale nitrogen particles. One nano urea liquid particle is 30 nm in size, and it has a surface area to volume ratio is nearly 10,000 times more than that of a typical granular urea particle (Lakshman et al. 2022). Its application boosts the crop's nitrogen availability by over 80 %, increasing the crop's efficiency in using nutrients. The use of traditional urea is reduced by 50 % or more when nano urea is used. It enhances agricultural output, soil health, and the nutritional value of products. The nano urea liquid is more efficiently absorbed by the plant leaves due to its minuscule size and unique surface characteristics. Nano urea can easily pass through the stomatal openings or cell wall of leaves. After entering the plant, they are transported to other plant parts via phloem cells, plasmodesmata (40 nm diameter) or it can bind to carrier proteins through aquaporin, ion channels and endocytosis. Thus, the foliar application of nano urea liquid leads to more efficient nitrogen absorption, better physiological growth, production and better quality of fruits by Kumar et al. (2023). It is necessary to study the use of application of nano urea for imparting and improving the vigour of mango grafts. In this context, the study was necessary to investigate the "use and effect of application of nano urea for imparting and improving the vigour of mango grafts cv. Alphonso".

The high demand for healthy and vigorous mango grafts, known for their good survival rates in the field. It is believed that the application of nano urea may lead to increased growth of the grafts due to potential benefits such as improved nutrient uptake, reduced environmental impact, and enhanced plant health. To confirm this hypothesis, controlled experiments are necessary. If successful, achieving robust growth and survival of mango grafts could meet the needs of farmers interested in mango cultivation in the region.

Nano urea can reduce nitrogen leaching and volatilization, thus minimizing groundwater pollution and greenhouse gas emissions, which are significant concerns in agriculture. It provides a controlled release of nitrogen, ensuring that the mango grafts receive a steady and adequate supply of nutrients over an extended period, which promotes healthy growth and development. Overall, the adoption of nano urea

in mango grafts holds promise for enhancing agricultural productivity, sustainability, and resilience in the Konkan region, contributing to the long-term viability of mango cultivation in the area.

The deliberate use of nano urea necessitates appropriate methods to guarantee the plants efficient uptake. It might not have the desirable effect if not applied appropriately, particularly in the case of grafts where precise nutrient delivery is crucial. Limited research has been done about the unique needs and reactions of mango grafts in the Konkan region to nano urea. Farmers' acceptance of it may be restricted by a lack of study or local trials. In summary, although nano urea shows potential as a more effective and environmentally sustainable substitute for conventional urea, its effective implementation in mango grafts within the Konkan area would necessitate resolving these constraints via additional investigation, appropriate application methods, and potentially customized compositions for particular crop and local needs.

## 2. MATERIALS AND METHODS

### 2.1 Site and Weather

The experiment was conducted during the year 2023-2024 in July- March at Nursery No. 10, Department of Fruit Science, College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri, Maharashtra, India. Dapoli is a town in Ratnagiri district, situated on the West coast part of Maharashtra at an altitude of 240 meters above MSL. It has a tropical climate with hot and humid condition throughout the year. It is located in 17˚45" North longitude and 73˚12" East longitude. The soil of this region is lateritic, porous and acidic in reaction with pH range of 5.6 to 6.5. The average annual maximum and minimum temperature are 30.4˚C to 31.8˚C and 17˚C to 20.2˚C respectively. The mean annual rainfall is near about 3600 mm which is normally distributed from June to October.

### 2.2 Experimental Details

The current study was undertaken to study the effect of nano urea on mango (*Mangifera indica* L.) grafts cv. Alphonso. The experiment was formulated in randomized block design with twelve treatments having three replications. The planting material used for experimentation comprises Alphonso mango grafts sourced from the Nursery no. 10, College of Horticulture, Dapoli. The grafting operations for the Alphonso mangoes was conducted in the month of June. The grafts of one month old were taken for the experiment. The applications of all the treatments is conducted at 30, 60 and 90 days after grafting.

### 2.3 Observations Recorded

Total 10 seedlings from each treatment were selected for the observation of morphological characters. The following observation regarding graft height (cm), stem girth (mm), number of shoots per grafts, number of leaves per graft, Total leaf area ($cm^2$) were recorded at 30 days interval upto 270 days from the first application. Whereas, the observations regarding, tap root length (cm), dry weight of roots (g), relative growth rate (cm/cm/day) and survival percentage were recorded at the end of the experiment 270 days after 1$^{st}$application.

**List 1. Treatment details**

| Treatment | Treatment details |
|---|---|
| $T_1$ | Control (Soil+FYM) (3:1) |
| $T_2$ | Soil+ Vermicompost (2:1) +Urea (2 g/plant) |
| $T_3$ | Foliar spray of nano urea @ 500 ppm |
| $T_4$ | Foliar spray of nano urea @ 1000 ppm |
| $T_5$ | Foliar spray of nano urea @ 1500 ppm |
| $T_6$ | Foliar spray of nano urea @ 2000 ppm |
| $T_7$ | Foliar spray of nano urea @ 2500 ppm |
| $T_8$ | Drenching of nano urea @ 1500 ppm |
| $T_9$ | Drenching of nano urea @ 2000 ppm |
| $T_{10}$ | Drenching of nano urea @ 2500 ppm |
| $T_{11}$ | Drenching of nano urea @ 3000 ppm |
| $T_{12}$ | Drenching of nano urea @ 3500 ppm |

## 2.4 Statistical Analysis

The data obtained in the present investigation was statistically analyzed as per the method suggested by Panse and Sukhatme (1995). The standard error (S.E.) of means was worked and a critical difference (CD) at 5% i.e. p=0.05 was also worked out whenever the result was significant.

## 3. RESULTS AND DISCUSSION

### 3.1 Survival Percentage

The data on the effect of nano urea on survival percentage in mango grafts are given in Table 1. The results demonstrated that survival percentage at 270 DAT (Days after treatment) was significantly impacted by the nano urea. As a result, it was discovered that survival rate varied between 79.33 per cent ($T_2$) to 95.11 per cent ($T_5$) among all the treatments. Thus, treatment ($T_5$) showed superior results over other treatments. This was might be due to the foliar application of nano urea liquid leads to more efficient nitrogen absorption, better physiological growth and production, Kumar et al. (2023).

### 3.2 Graft Height (cm)

The data on graft height of mango cv. Alphonso after application of various nano urea treatments are presented in Table 2. At 270 DAT, graft height was significantly highest in treatment $T_5$(44.99 cm) which was found superior over rest of the treatments followed by treatment $T_3$(43.31cm). The lowest graft height was observed in treatment $T_{10}$(31.74 cm) which was at par with the treatment $T_6$(31.81 cm). Effect of nano urea in mango grafts cv. Alphonso was found to be meritorious in treatment $T_5$(foliar spray of nano urea 1500 ppm). The prolonged release of nutrients by nano-fertilizers may be attributed to their longer-lasting ability. This prolonged release enables the plants to maintain the consistent supply of nutrients, leading to increased plant height (Rathod et al. 2022). The present findings are in accordance with the results obtained by Rathod et al. (2022) in french basil and Abobatta et al. (2023) in citrus rootstock seedlings.

### 3.3 Graft Girth (mm)

The data regarding to the girth of grafts as influenced by different nano urea treatments are presented in Table 2. At 270 DAT, graft girth was significantly affected by various treatments. The highest graft girth was noticed in treatment $T_8$ (10.60 mm) which was at par with treatments $T_3$(10.51 mm) and $T_9$(10.40 mm) and significantly superior over the remaining treatments. Whereas the lowest graft girth was observed in treatment $T_6$(9.52 mm) which was at par with treatments $T_{12}$(9.53 mm), $T_1$(9.54 mm) and $T_{10}$(9.60 mm) and significantly inferior to all other treatments. Treatment $T_8$(Drenching of nano urea at 1500 ppm) recorded superior results over remaining treatments. It might be due to controlled release of nitrogen, which helps plant grow better by improving stem thickness and overall health. Its steady nitrogen supply supports cell growth and increases stem girth, while the slow-release feature ensures consistent nutrient delivery, boosting plant vigour and strength. Similar effect of nano urea application on stem girth were observed by the Augustus & Domingo (2023) in Cavendish banana.

### 3.4 Number of Shoots

The data on effect of nano urea on number of shoots per graft were recorded at 30 days interval from 30 to 270 DAT and are given in Table 2. At 270 days after treatment, the highest number of shoots were observed in treatment $T_5$(1.90) which was at par with the treatments $T_3$(1.77), $T_8$(1.73) and $T_{12}$(1.57). Whereas the lowest number of shoots were found in the treatment $T_6$(1.23) and which was at par with the treatments $T_9$(1.27), $T_7$and $T_4$(1.33), $T_2$(1.37), $T_{11}$(1.41), $T_{10}$(1.43) and $T_1$(1.47). Thus, among the various nano urea treatments maximum number of shoots was recorded in treatment $T_5$ which was foliar spray of nano urea at 1500 ppm. Nano urea can enhance shoot development in mango grafts by improving nutrient uptake efficiency and stimulating physiological processes. Nano urea particles have a high surface area to volume ratio, which allows for better nutrient release and absorption. Similar results were reported by Rathod et al. (2022) in french basil.

### 3.5 Number of Leaves

The data on the effect of nano urea on number of leaves in mango grafts cv. Alphonso are presented in Table 2. There was a significant difference observed in the number of leaves due to various treatments. At 270 DAT, the maximum number of leaves (31.13) were observed in the treatment $T_5$and it was at par with the treatments $T_8$(31.07) and $T_3$(30.27). The minimum number

of leaves (26.26) was recorded in the treatment $T_2$. It was at par with the treatments $T_9$(26.80) and $T_{10}$(27.13). From the above context, results indicated that treatment $T_5$(foliar spray of nano urea at 1500 ppm) recorded with the better number of leaves. The increase in the leaves might be attributed to a nano fertilizer that stimulates cell division and expansion, particularly in leaf cells which was positively reflected in increasing photosynthesis. Where, nitrogen has positive role in increasing various activities of grafts, Sathyan D, (2022). Similarly, the results were found identical with the findings obtained by Rathod et al. (2022) in French basil and Sathyan D., (2022) in field pea.

## 3.6 Total Leaf Area ($cm^2$)

Another important parameter in determining the size of the photosynthetic site is leaf area. The leaf area which was recorded at 30 days interval up to 270 DAT significantly affected by the different nano urea treatments in mango grafts. The data regarding total leaf area is shown in Table 2. At 270 days after treatment, the statistically maximum total leaf area was recorded in treatment $T_3$(654.52 $cm^2$) which was at par with the treatment $T_5$(649.72 $cm^2$). The minimum total leaf area was recorded in treatment $T_2$(473.97 $cm^2$) which was at par with the treatment $T_4$(492.32 $cm^2$) and significantly inferior to the remaining treatments. Thus, it was found that the total leaf area for the mango grafts ranged between 473.97 ($T_2$) to 654.52($T_3$). Significant increase in the total leaf area was noticed in treatment $T_3$ i.e. foliar spray of nano urea at 500 ppm. The increase in total leaf area may be attributed to nano urea's ability to penetrate leaf stomata and other openings, allowing efficient assimilation by plant cells. The nutrient is then transported through the phloem from source to sink. Excess nitrogen is sequestered in vacuoles, where it is gradually released, supporting enhanced plant growth and development Vinayaka et al. (2022). The similar findings were found in Volkamer lemon and Sour orange by Abobatta et al. (2023) and in potato tubers by Aditi et al. (2023).

**Table 1. Effect of nano urea on survival percentage of mango grafts cv. Alphonso**

| Treatment No. | Survivalpercentage at 270 DAT |
|---|---|
| $T_1$ | 86.67 (68.58) |
| $T_2$ | 79.33 (62.96) |
| $T_3$ | 93.75 (75.52) |
| $T_4$ | 90.00 (71.57) |
| $T_5$ | 95.11 (77.23) |
| $T_6$ | 89.78 (71.35) |
| $T_7$ | 91.94 (73.51) |
| $T_8$ | 90.00 (71.57) |
| $T_9$ | 91.27 (72.81) |
| $T_{10}$ | 91.67 (73.22) |
| $T_{11}$ | 94.72 (76.72) |
| $T_{12}$ | 90.08 (71.64) |
| Mean | 90.40 |
| Range | 79.33-95.11 |
| S.E m± | 2.67 |
| CDat5% | 7.82 |

**Figures in the parentheses arcsine transformed values*

**Table 2. Effect of nano urea on graft height, graft girth, number of shoots, number of leaves, total leaf area, relative growth rate of mango grafts cv. Alphonso.**

| Treatments | Graft Height (cm) | Graft girth (mm) | Number of shoots | Number of Leaves | Total leaf area ($cm^2$) | Relative growth rate (cm/cm/ day) |
|---|---|---|---|---|---|---|
| $T_1$ | 33.62 | 9.54 | 1.47 | 28.87 | 541.32 | 0.0034 |
| $T_2$ | 36.41 | 10.00 | 1.37 | 26.26 | 473.97 | 0.0054 |
| $T_3$ | 43.31 | 10.51 | 1.77 | 30.27 | 654.52 | 0.0053 |
| $T_4$ | 34.66 | 10.22 | 1.33 | 27.47 | 492.32 | 0.0052 |
| $T_5$ | 44.99 | 10.22 | 1.90 | 31.13 | 649.72 | 0.0059 |
| $T_6$ | 31.81 | 9.52 | 1.23 | 27.40 | 570.86 | 0.0046 |
| $T_7$ | 41.75 | 9.90 | 1.33 | 29.17 | 568.69 | 0.0055 |
| $T_8$ | 42.35 | 10.60 | 1.73 | 31.07 | 592.71 | 0.0057 |
| $T_9$ | 32.65 | 10.40 | 1.27 | 26.80 | 627.54 | 0.0002 |
| $T_{10}$ | 31.74 | 9.60 | 1.43 | 27.13 | 573.16 | 0.0053 |
| $T_{11}$ | 32.73 | 9.84 | 1.41 | 27.42 | 533.23 | 0.0053 |
| $T_{12}$ | 32.56 | 9.53 | 1.57 | 28.67 | 630.62 | 0.0032 |
| Mean | 36.55 | 9.99 | 1.48 | 28.47 | 575.72 | 0.0046 |
| Range | 31.74-44.99 | 9.52-10.60 | 1.23-1.90 | 26.26-31.13 | 473.97-654.52 | - |
| S.E.± | 0.27 | 0.08 | 0.10 | 0.33 | 7.50 | - |
| C.D.@5% | 0.79 | 0.23 | 0.30 | 0.96 | 21.99 | - |

## 3.7 Relative Growth Rate (cm/cm/day)

The data regarding relative growth rate of mango grafts cv. Alphonso with respect to height (cm/cm/day) are given in Table 2. From 240-270 days, the highest relative growth rate (RGR) was recorded in treatment $T_5$(0.0059 cm/cm/day), whereas the lowest RGR was recorded in treatments $T_9$(0.0002 cm/cm/day). From the above results, the treatment $T_5$ i.e. foliar application of nano urea at 1500 ppm noted with maximum relative growth rate on graft height basis. This might be due to the fact that foliar spraying of nano-N promoted growth characteristics, as the nutrients could more easily enter the leaves stomata through gas uptake (Rajasekar et al. 2017). The similar results were found identical with the findings obtained by Vinayaka et al. (2022) in jamun, Abobatta et al. (2023) in citrus rootstock seedling and Choudhary et al. (2023) in garlic with respect to plant height.

## 3.8 Dry Weight of Root (g)

The data on effect of nano urea on dry weight of root (g) of mango grafts cv. Alphonso are presented in Table 3 and depicted in Fig. 3. The dry weight of root was recorded at 270 DAT. There was significant variation observed among the various treatments. At 270 days after treatment, the highest dry weight of root was recorded in treatment $T_5$(13.44 g) which was at par with the treatment $T_3$(12.97 g). However, the lowest dry weight of the root was found in treatment $T_{10}$(7.00 g) which was at par with the treatment $T_9$(7.14 g) and $T_6$(7.24 g) and significantly inferior over remaining treatments. Thus, it was found that dry weight of root was varied from 7.00 g ($T_{10}$) to 13.44 g ($T_5$). This might be attributed to the nano fertilizer's role in promoting metabolic processes, particularly photosynthesis. This enhancement leads to increased accumulation of photosynthates and more dry matter production, Mustafa et al. (2022). Similar results were also obtained by Abobatta et al. (2023) [8] in citrus rootstock seedlings and Laila et al. (2018) in olive seedlings.

## 3.9 Tap root Length (cm)

The data on the effect of nano urea on tap root length as influenced by various nano urea treatments are given in Table 3. Significant difference was observed among the various treatments in mango grafts cv. Alphonso with respect to tap root length. At 270 DAT, the highest tap root length was noted in the treatment $T_5$(27.10 cm) which was significantly superior over all other treatments and it was followed by treatments $T_{12}$(25.45 cm), $T_2$(25.27),

$T_1$(23.38 cm) and $T_{11}$(23.00 cm). The lowest tap root length was observed in treatment $T_6$(15.68 cm) which was at par with the treatment $T_4$(16.55 cm) and significantly inferior over remaining treatments. Thus, it was observed that the tap root length ranged between 15.68 cm ($T_6$) to 27.10 cm ($T_5$) among all the treatments. Treatment $T_5$ i.e. foliar spray of nano urea at 1500 ppm showed good result regarding to tap root length. This might be due to nano fertilizers have an effective mechanism for transporting compounds to target places in the plant parts including leaves, roots and other areas, Al-Asally & Al-Hijemy (2023). Similar results were also obtained by Laila et al. (2018) in olive seedling.

**Table 3. Effect of nano urea on dry root weight (g) and tap root length (cm) of mango grafts cv. Alphonso**

| Treatments | Dry root weight (g) | Tap root length (cm) |
|---|---|---|
| $T_1$ | 7.75 | 23.38 |
| $T_2$ | 8.79 | 25.27 |
| $T_3$ | 12.97 | 19.13 |
| $T_4$ | 8.23 | 16.55 |
| $T_5$ | 13.44 | 27.10 |
| $T_6$ | 7.24 | 15.68 |
| $T_7$ | 7.80 | 17.43 |
| $T_8$ | 9.24 | 19.20 |
| $T_9$ | 7.14 | 22.70 |
| $T_{10}$ | 7.00 | 17.50 |
| $T_{11}$ | 7.94 | 23.00 |
| $T_{12}$ | 7.64 | 25.45 |
| Mean | 8.77 | 21.03 |
| Range | 7.00-13.44 | 15.68-27.10 |
| S.E.± | 0.17 | 0.13 |
| C.D.@5% | 0.49 | 1.39 |

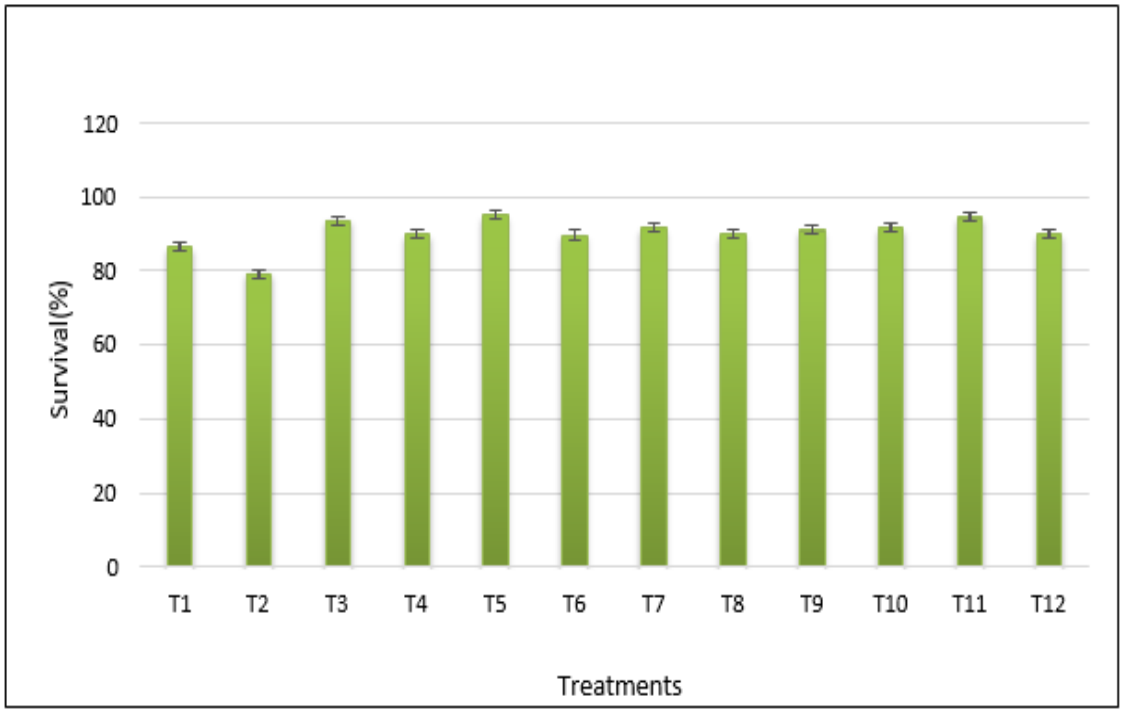


**Fig. 1. Effect of nano urea on survival percentage of mango grafts cv. Alphonso**

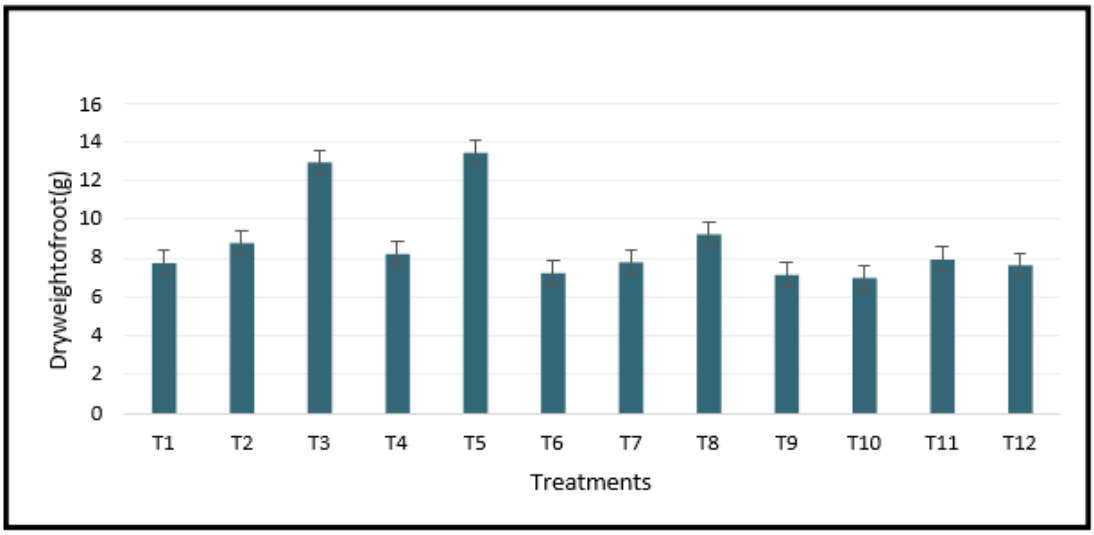


**Fig. 2. Effect of nano urea treatment on dry weight of root (g) in mango grafts (cv. Alphonso)**

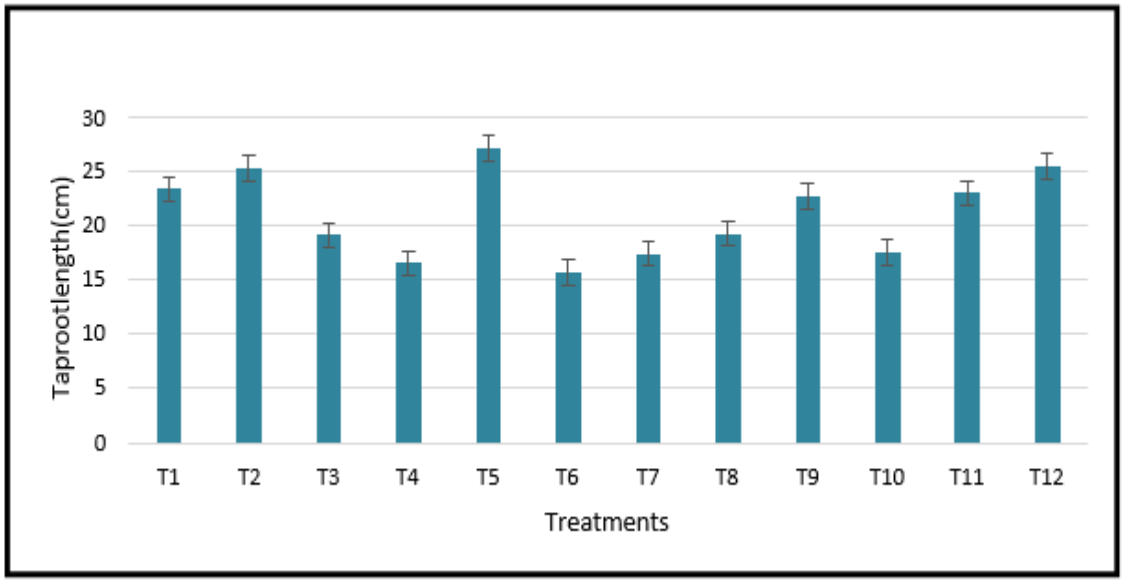


**Fig. 3. Effect of nano urea treatment on tap root length (cm) in mango grafts cv. Alphonso**

## 4. CONCLUSION

The present experimentation on effect of nano urea treatment on mango (*Mangifera indica* L.) grafts cv. Alphonso indicated that the treatments influenced the survival and growth parameters significantly. However, this effect was not consistent with respect to foliar application, drenching and various concentrations of nano urea. The survival, graft height, number of leaves, relative growth rate, dry weight of root and length of tap root was the best in treatment $T_5$. The treatment $T_3$ranked 1st for the total leaf area. Hence, though the effect of nano urea was observed on the survival and growth parameters of mango grafts it wasnot consistent. All the nano urea treatments resulted in greater survival than that of control as well as $T_2$. The treatment $T_5$, $T_3$, $T_7$ and$T_8$ had better performance with respect to plant vigour. Whereas $T_2$, $T_3$, $T_4$, $T_5$, $T_7$ and $T_8$ were better for the root vigour than control. Among all the nano urea treatments, $T_5$ was the best owing to highest survival and better shoot and root vigour.

However, this is only one season study. A consistent study for two to three years with nano urea treatments is essential so as to refine the

findings. Similarly, further studies are essential for stage of application of nano urea to mango grafts.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares 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 this manuscript.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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