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EFFECT OF FOLIAR SPRAY OF NANO-UREA AND UREA ON YIELD AND PHYSICO-CHEMICAL CHARACTERS OF FRUITS IN GUAVA (*Psidium guajava* L.)

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ABSTRACT

Nanotechnology is an innovative approach for enhancing nutrient use efficiency with minimal threat to environment. So, an experiment with foliar spray of nano urea and urea in guava was carried out with an objective to find out its effect on yield, physico-chemical fruit characters and leaf nitrogen content. The experiment was laid out in randomized block design consisting eleven treatments and three replications. The different treatments were nano urea 0.2% (once), nano urea 0.3% (once), nano urea 0.4% (once), nano urea 0.2% (twice), nano urea 0.3% (twice), nano urea 0.4% (twice), urea 0.5% (once), urea 1% (once), urea 0.5% (twice), urea 1% (twice), control (water spray). Plants treated with nano urea 0.3% (twice) showed higher number of fruits per plants with higher total sugar and ascorbic acid in fruits. Application with nano urea 0.2% (twice) resulted lower fruit acidity and higher TSS/acid ratio. However, application of urea 1.0% (twice) was effective for higher yield (kg/plant) and higher fruit length. Whereas urea 0.5% (once) resulted higher fruit weight with superior fruit quality.

Key words : Nano-urea, Yield attributing characters, Ascorbic acid, TSS/acid.

Introduction

Guava (*Psidium guajava* L.), which originates from Southern Mexico or Central America, belongs to the family Myrtaceae and order Myrtales. This fruit is third in position regarding vitamin C content (200-300 mg/100 g) and also rich in antioxidants. The total production of guava in India is 4516 thousand metric tons, with an area of 307 thousand hectares. Among different states of India, the position of West Bengal is seventh with 203.56 thousand tons of production, which is much lower than the national production (NHB, 2021- 22). So, it is necessary to adopt different methods to increase the yield and quality of guava. Guava crop is highly responsive to fertilizer application. As a result, the crop expresses sensitivity to the availability of nutrients. As nutrient management accounts for 1/3rd of total production cost, it is important to know what to apply, which form to apply, when to apply, how much to apply and in which method to apply (Chundawat, 1997). Among the three major nutrients, nitrogen is vital to plant life. Urea is the most popular and highly used nitrogenous fertilizer in India due to its high nitrogen content (46%). Due to high nitrogen content, it is needed in a low amount. It is diamide of carbonic acid, crystalline, highly soluble and non-polar in nature, that's why it can be easily mixed with other fertilizers and pesticides. But it has some drawbacks like leaching loss, denitrification and volatilization loss, which lead to economic loss to farmers and also do not give the required quantity and quality of production. Apart from that, it also hampers the environment. Under this situation, one of the crucial steps in the nutrition of fruit crops is foliar feeding.

As of early 2026, the global population is estimated to be over 8.2 billion, with India holding the top spot as the world's most populous nation at approximately 1.46 to 1.47 billion people (Wikipedia, 2026). To feed the 9.1

billion global population, the production of agriculture should be increased by 70% by 2050 so that global food security can be achieved. Focus should be more on the production of agricultural and horticultural crops by using a small number of resources, which leads us to the era of nanotechnology. To enhance nutrient use efficiency with minimal threat to our environment and to sustain our burgeoning global population, nanotechnology is an innovative way (Sharma *et al*., 2021). Nano-fertilizer is a term used to describe materials encapsulated in nanoparticles that slowly release nutrients to crops. It has important characteristics like very small size, surface-to-volume ratio, and optical properties. Furthermore, it is site-specific. In comparison to other conventional fertilizers, it effectively increases soil fertility and bioavailability by combining natural and synthetic ingredients (Meghana *et al*., 2021). A revolutionary agricultural input that uses nanotechnology to supply plants with nitrogen is called nano urea. Its preferred particle size is between 20 and 50 nm, and it has more surface area (10,000 times more than 1 mm of urea prill) and particles (55,000 nitrogen particles over 1 mm of urea prill) than conventional urea prill (IFFCO, 2023). Very less work on foliar spray of urea and no work on nano urea in guava have been carried out yet. Keeping all of the above facts in view, the present experiment of foliar spray of urea and nano urea on yield and physico-chemical fruit characters in guava was undertaken.

Materials and Methods

The experiment was carried out at the Horticultural Research Station, Mondouri of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during 2022-2024. This field was under the humid agro-climate zone of West Bengal with Gangetic alluvial and sandy clay-loam soil. A total of 33 plants of 4 years old with a spacing of 4 m × 4 m, were taken for the experiment. The experiment was laid out in a randomized block design (RBD) with eleven treatments [nano urea 0.2% (once), nano urea 0.3% (once), nano urea 0.4% (once), nano urea 0.2% (twice), nano urea 0.3% (twice), nano urea 0.4% (twice), urea 0.5% (once), urea 1% (once), urea 0.5% (twice), urea 1% (twice) and control (water spray)] and three replications following one-way ANOVA method of statistical analysis at the 5% level of significance (Panse and Sukhathme, 1985). Required chemicals were dissolved in 3 litres of water and were sprayed before full bloom. A second time spraying was done treatment-wise at 30 days after first application. Each plant was fertilized with 50% nitrogen, 100% phosphorus and 100% potassium of the recommended dose of 60: 30: 60 (N, P_2O_5, K_2O g/plant/year). Accordingly, the plants of 4 years' age were fertilized with N, P_2O_5, K_2O at the ratio of 120: 120: 240 g/plant/year. The plants were fertilized in the form of urea, single super phosphate and muriate of potash.

Methodology of studied parameters

Number of fruits per plant

Matured fruits were harvested from each plant separately and counted at each pick. The final number of fruits per plant was calculated by adding the numbers at different picks.

Yield (kg/plant)

Ten representative mature fruits from each plant were weighed and average fruit was determined. Yield in kg/plant was calculated by the following formula.

$$\text{Yield/plant (Kg)} = \frac{\text{Total number of fruits/plant} \times \text{Average fruit weight (g)}}{1000}$$

Fruit weight

Ten randomly selected fruits from each plant were taken and weighed in single pan balance. Average weight of fruit was calculated and expressed in gram (g).

Pulp weight

Core portion of the fruit was removed and the remaining portion of the fruit that is the pulp of the fruit was weighed on weighing machine. The pulp weight was measured in gram (g).

Core weight

Core weight of each fruit was determined by subtracting the pulp weight from the total weight of fruit and expressed in gram (g).

Pulp/core ratio

Pulp/core ratio was calculated by dividing the pulp weight by core weight of fruit. This is a unitless parameter as it is the ratio between two same unit.

Fruit length

The length of five matured fruit was taken from each plant and measured in centimetres (cm) from the vertical centre of the fruit to apex using digital Vernier Callipers. The average length was calculated and expressed in centimetre (cm).

Fruit diameter

The diameter of the five fruits, collected from each plant, individually at the widest part of the middle of fruit using digital Vernier Callipers. The average diameter was calculated and expressed in centimetre (cm).

Pulp thickness

Fruit was cut into two halves and pulp thickness was measured with a centimetre scale.

Nitrogen content (%)

The third pair of leaves were taken from non-fruiting terminals 15 days after the application of second spray. The collected leaf sample was dried in oven for 72 hours and then crushed properly for estimation of nitrogen content in percentage.

For estimation of leaf nitrogen content concentrated sulfuric acid solution was used alongside a catalyst mixture consisting of K_2SO_4 and $CuSO_4$ in a 10:1 ratio. A 500 mg sample was placed in a micro Kjeldahl flask, combined with 10 ml of sulfuric acid and a small amount of the catalyst mixture. The mixture was heated until complete digestion of the sample, resulting in a transparent or slightly greenish appearance. Once cooled, a 250 ml conical flask containing 10 ml of an indicator solution was positioned beneath the condensation tube to collect the distilled liquid. The digested material, along with 5 ml of distilled water, was then transferred to a larger macro Kjeldahl flask and mixed with 20-25 ml of a 40% NaOH solution. Distillation was carried out for 20-30 minutes, yielding 100 ml of distillate in a separate conical flask. This distillate was titrated against N/10 HCl, and the point at which the bluish-purple color of the distillate changed to pink was used to determine the endpoint. The burette reading was applied in a formula to estimate the nitrogen content.

Calculation:

The percentage of total Nitrogen = $\frac{(T-B)\times N\times 0.014\times 100}{W}$

Where, T = Original reading of the titration from burette (Titrate value from plant sample)

B= Blank Titration from burette (Titre value for blank titration)

N = Normality of HCL

W= 500mg

TSS (^{0}Brix)

TSS (total soluble solids) of fruit was measured using a digital refractometer (ranging from 0-32 ^{0}Brix). A drop of extracted guava juice was placed on prism surface of sample stage, and the reading was recorded and expressed in degrees Brix.

Titratable acidity (%)

The acid-alkali titration method outlined in A.O.A.C. (1984) was used to determine the fruit acidity. According to this method two reagents were used - NaOH (N/10) solution and phenolphthalein indicator. (N/10) NaOH solution was prepared by taking 4g of NaOH in 1000 ml volumetric flask and making up the volume 1000 ml with distilled water. After straining 10 g of fruit pulp, fruit extract was taken in a 100 ml volumetric flask and distilled water was added to make the volume 100 ml. This solution with 1-2 drops of phenolphthalein indicator was titrated against N/10 NaOH solution until light pink colour appeared. Titratable acidity was calculated by using following formula.

Titratable acidity (%) =

$$\frac{\text{Burette reading} \times \text{strength of alkali} \times \text{milli equivalent weight of acid} \times \text{volume made up} \times 100}{\text{Weight of the volume sample taken} \times \text{sample taken for estimation}}$$

$$= \frac{\text{Burette reading} \times 0.1 \times 0.064 \times 100 \times 100}{10 \times 10}$$

= Burette reading × 0.64

TSS: Titratable acidity ratio

TSS/acid ratio was calculated by dividing total soluble solids with acidity percentage.

$$\text{TSS: Titratable acidity ratio} = \frac{\text{Total soluble solids } (^0\text{Brix})}{\text{Titrable acidity } (0)}$$

Total sugar (%)

Total sugar content of fruit was measured by A.O.A.C. (1984) method. In this method 2ml each of Fehling solution A and B were taken as reagent and methylene blue was used as indicator. After straining fruit extract from 10 g of fruit pulp, little amount of water and 2 drop concentrated HCL were added in the extraction. The solution was boiled until the colour changed. After cooling down the solution NaOH was added to neutralise the solution and it was checked with a litmus paper. Solution was strained and poured into a 100 ml volumetric flask and distilled water was added to make up the volume. This solution was titrated against the solution of Fehling A and B until brick red precipitation of cuprous oxide appeared. The total sugar was calculated by using the following formula.

$$\text{Total sugar (\%)} = \frac{\text{Factor} \times \text{volume made up} \times 100}{\text{Burette reading} \times \text{Sample taken}}$$

$$= \frac{0.02 \times 100 \times 100}{\text{Burette reading} \times 10}$$

$$= \frac{20}{\text{Burette reading}}$$

Ascorbic acid (mg/100g pulp)

Ascorbic acid was measured by Assay method of Ranganna (1977). According to this method 3% meta phosphoric acid and a dye obtained from sodium salt of 2, 6-dichlorophenol- indophenols dissolved in distilled water were used. 3% meta phosphoric acid was prepared by dissolving 3.0 g sticks or pellets of (HPO_3) in distilled water. Standard ascorbic acid solution was made by taking 100 mg of ascorbic acid and made the volume 100 ml with 3.0% HPO_3. One ml of this solution was diluted to 10 ml by adding 3% HPO_3. Standardization of dye was done by adding 5 ml of HPO_3 in 5 ml of standard ascorbic acid solution and the micro burette was filled with the dye solution. Standard ascorbic acid was titrated against dye solution until pink colour appeared, which persisted for 15 seconds.

Dye factor = 0.5/ Titrate value

Sample was prepared by adding 10 gram of sample in 100 ml of 3.0% HPO_3 and then the solution was filtered. An aliquot (10 ml) of the sample was titrated against the standard dye.

Ascorbic acid (mg/100g pulp) =

$$\frac{\text{Titre} \times \text{dye factor} \times \text{volume made up} \times 100}{\text{Aliquot extract taken for estimation} \times \text{Weight of sample taken for estimation}} \times 100$$

Results and Discussion

It was recorded that number of fruits/plant and yield/ plant were higher with twice application of nano-urea resulted 0.3% (171.3 number and 33.6 kg/plant) and urea 1% (161.0 number and 34.1 kg/plant). Moderate yield in terms of number of fruits per plant and kg per plant was obtained with twice application of nano-urea 0.4% (152.3) and urea 0.5% (31.5 kg per plant), respectively (Table 1). In contrast, yield attributing characters like fruit weight and pulp weight were higher with single application of nano-urea 0.3% (215.2 and 175.2 g, respectively) and single application of urea 0.5% (226.5 and 173.2 g, respectively). Moderate fruit and pulp weight were also

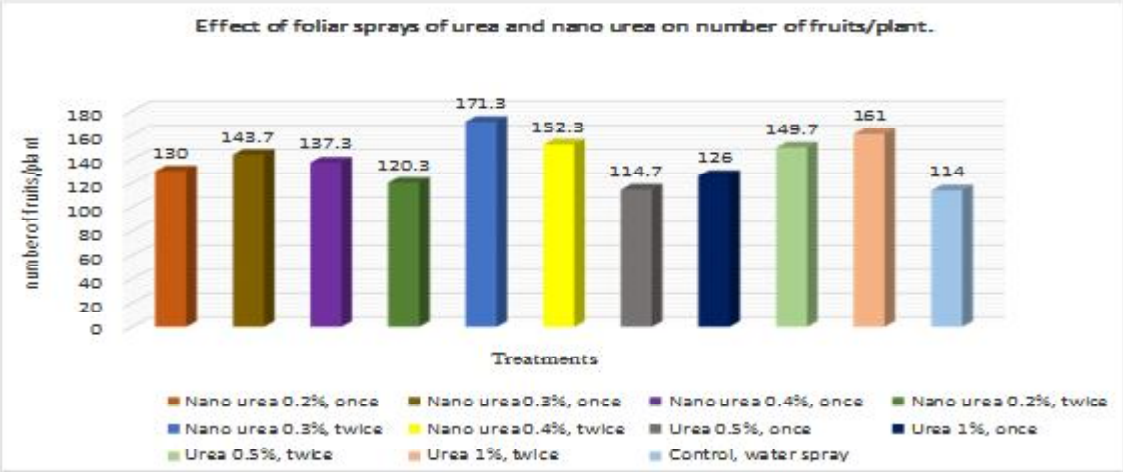


Fig. 1 : Effect of foliar sprays of urea and nano urea on number of fruits/plant.

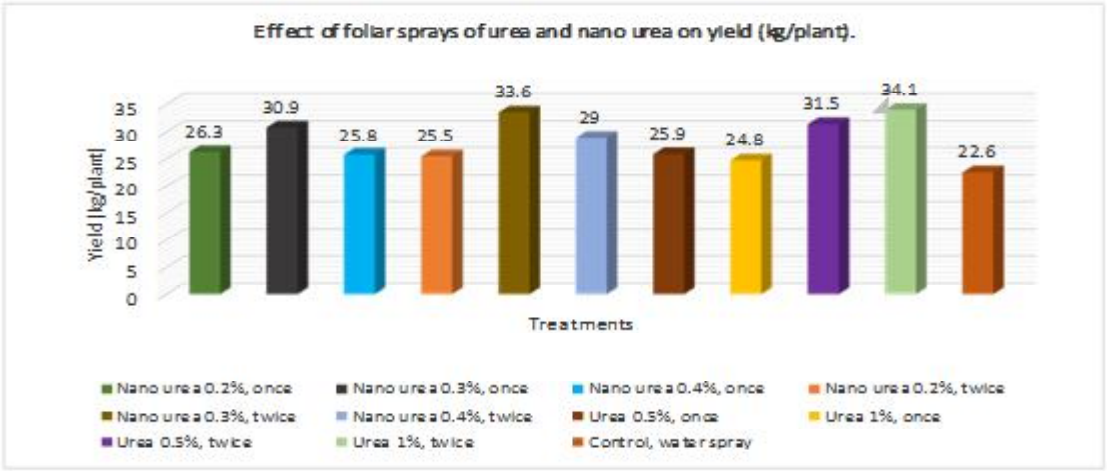


Fig. 2 : Effect of foliar sprays of urea and nano urea on yield (kg/plant).

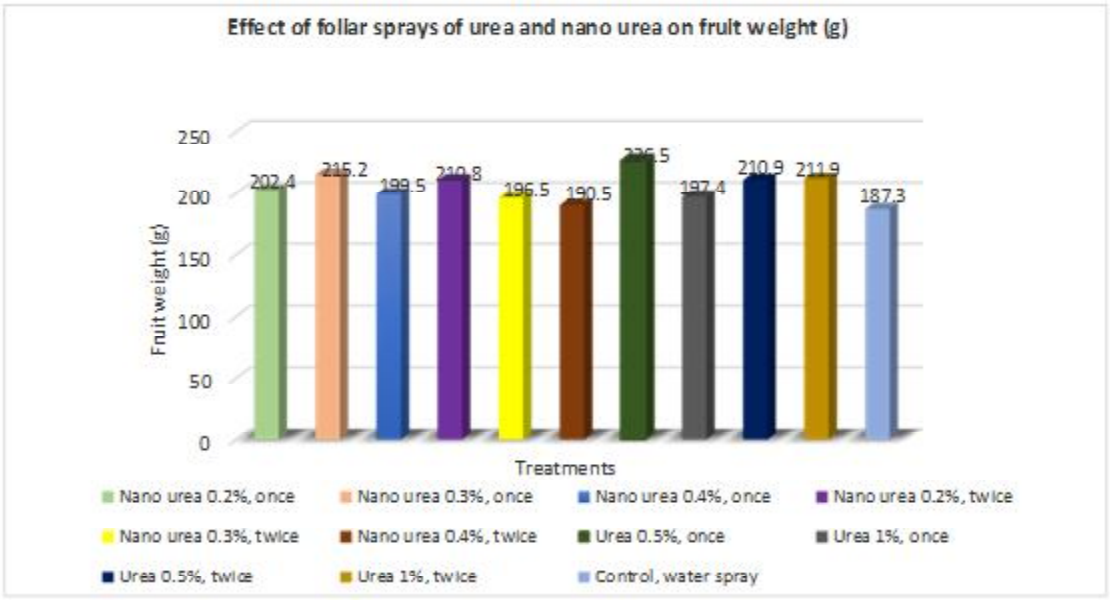


Fig. 3 : Effect of foliar sprays of urea and nano urea on weight (g).

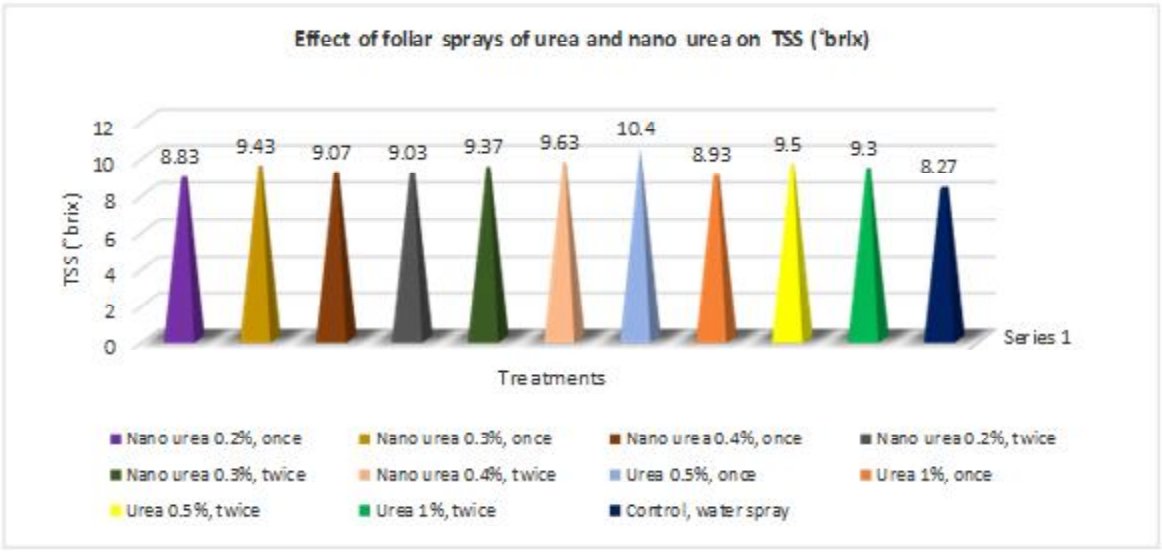


Fig. 4 : Effect of foliar sprays of urea and nano urea on TSS.

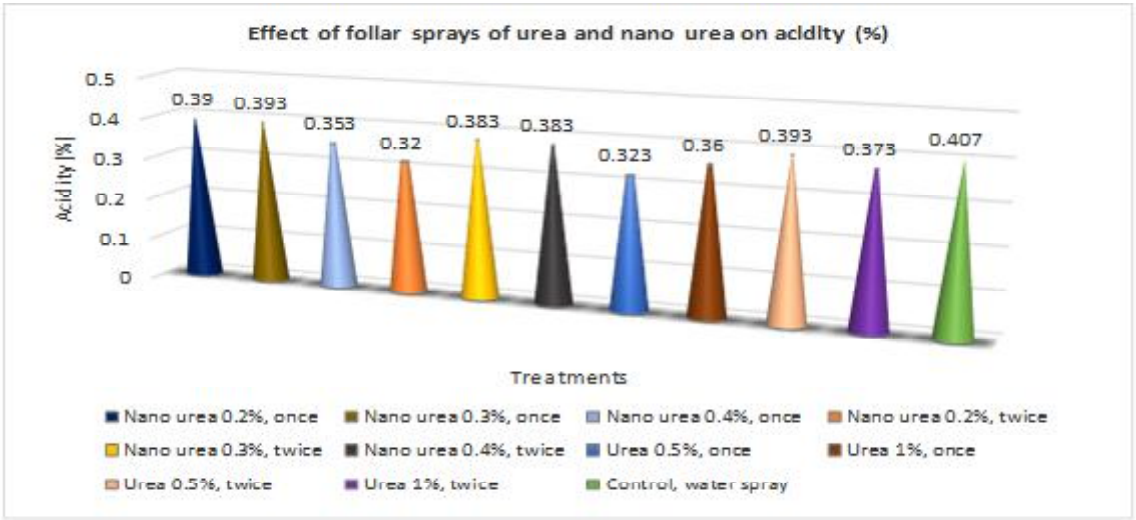


Fig. 5 : Effect of foliar sprays of urea and nano urea on acidity (%).

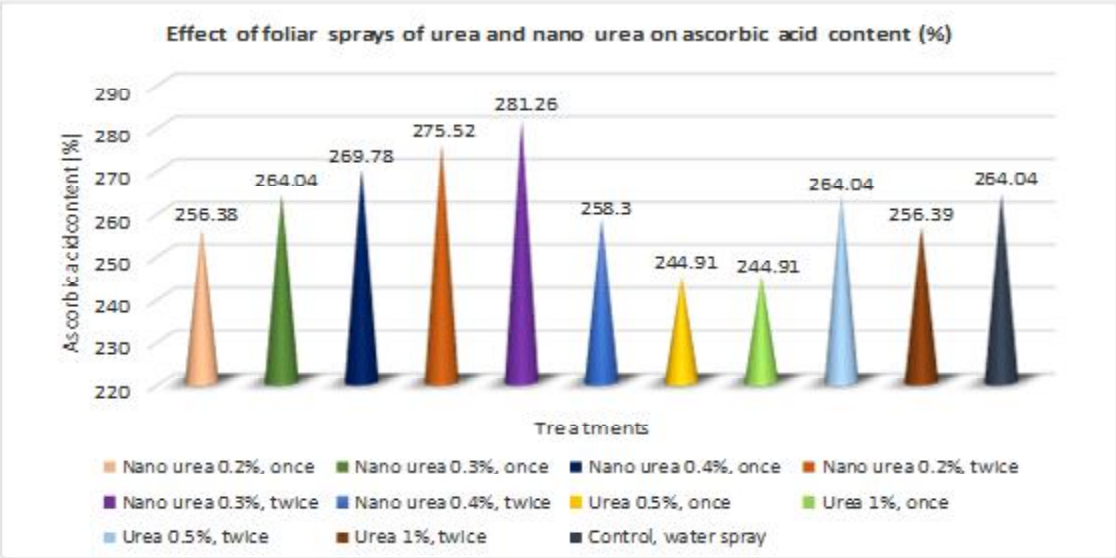


Fig. 6 : Effect of foliar sprays of urea and nano urea on ascorbic acid content (%).

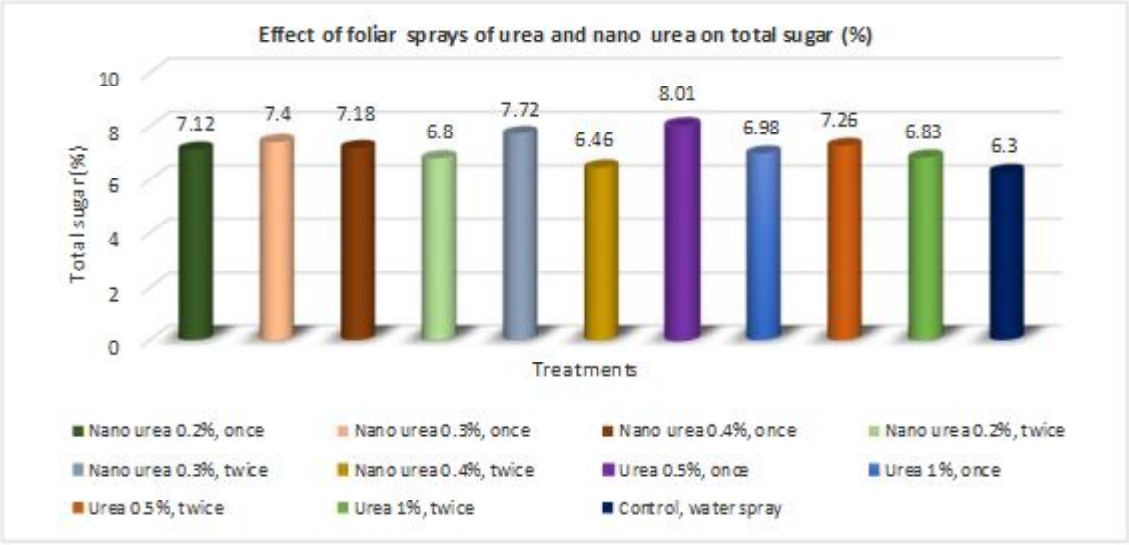


Fig. 7 : Effect of foliar sprays of urea and nano urea on total sugar (%).

obtained with twice application of urea 0.5% and urea 1%. Single application of nano-urea at 3 levels of concentration and twice application of nano-urea at 0.4% were effective in reducing the core weight of fruit (<40 g). However, pulp/core ratio was recorded higher with single application of nano-urea 0.2% (4.45) and nano-urea 0.3% (4.36). The better performance of urea and nano urea compared to control (no-nitrogen) is due to the essential role of nitrogen plays in plant metabolism, with nano urea providing greater efficiency through advanced technology. Nitrogen is fundamental to plant growth, as it supports the production of amino acids, proteins, and chlorophyll (Mansingh and Nanda, 2023). Nanoparticles with a smaller diameter than the pore size of the plant cell wall can easily penetrate the cell wall and reach the plasma membrane. Surface functionalization is used to enlarge existing pores or induce the formation of new pores, facilitating the entry of nanoparticles. Ion channels, endocytosis, complex formation with membrane transporters and root exudates also play a role in the uptake of nano nutrients. Once inside the plant, nano nutrients can travel through the apoplastic or symplastic pathways (Chopra *et al*., 2021 and Meghana *et al*., 2021).

It is evident from Table 2 that twice application of urea both at 1% and 0.5% resulted higher fruit length (7.50 and 7.10 cm, respectively) followed by twice application of nano-urea 0.4% (6.98 cm). Twice application of nano-urea is also effective in producing maximum fruit diameter at 0.3% level (7.23 cm) and maximum pulp thickness (1.56 cm) at 0.2% level. Twice application of nano urea both at 0.3% and 0.4% level as well as urea at 1% level showed higher leaf nitrogen content (1.933, 1.910 and 1.933%, respectively). Foliar

Table 1 : Effect of foliar sprays of urea and nano urea on yield and yield attributing characters.

Treatment	Number of fruits/plant	Yield (kg/plant)	Fruit weight (g)	Pulp weight (g)	Core weight (g)	Pulp/core ratio
Nano urea 0.2%, (once)	130.0	26.3	202.4	162.9	39.4	4.45
Nano urea 0.3%, (once)	143.7	30.9	215.2	175.2	39.9	4.36
Nano urea 0.4%, (once)	137.3	25.8	199.5	160.2	39.4	3.97
Nano urea 0.2%, (twice)	120.3	25.5	210.8	164.4	46.4	3.55
Nano urea 0.3%, (twice)	171.3	33.6	196.5	155.1	41.4	3.75
Nano urea 0.4%, (twice)	152.3	29.0	190.5	151.1	39.3	3.88
Urea 0.5%, (once)	114.7	25.9	226.5	173.2	53.3	3.44
Urea 1%, (once)	126.0	24.8	197.4	149.2	48.1	3.72
Urea 0.5%, (twice)	149.7	31.5	210.9	166.7	44.3	3.74
Urea 1%, (twice)	161.0	34.1	211.9	169.3	41.9	4.13
Control (water spray)	114.0	22.6	187.3	143.2	44.1	3.39
SE (m) ±	7.345	1.488	7.288	5.899	4.194	0.628
CD ($p \leq 0.05$)	21.82	4.420	21.651	17.524	N.S.	N.S.

Table 2 : Effect of foliar sprays of urea and nano urea fruit size and pulp thickness.

Treatment	Fruit length (cm)	Fruit diameter (cm)	Pulp thickness (cm)	Nitrogen content (%)
Nano urea 0.2%, (once)	6.10	6.16	1.47	1.817
Nano urea 0.3%, (once)	6.09	6.48	1.46	1.863
Nano urea 0.4%, (once)	6.14	6.21	1.46	1.887
Nano urea 0.2%, (twice)	6.43	6.28	1.56	1.887
Nano urea 0.3%, (twice)	6.77	7.23	1.40	1.933
Nano urea 0.4%, (twice)	6.98	6.35	1.43	1.910
Urea 0.5%, (once)	6.76	7.22	1.50	1.887
Urea 1%, (once)	6.93	6.70	1.50	1.887
Urea 0.5%, (twice)	7.10	6.80	1.43	1.887
Urea 1%, (twice)	7.50	6.84	1.47	1.933
Control (water spray)	6.12	6.05	1.36	1.700
SE (m) ±	0.34	0.35	0.06	0.031
CD ($p \leq 0.05$)	N.S.	N.S.	N.S.	0.092

Table 3 : Effect of foliar spray of urea and nano urea on fruit quality.

Treatment	TSS (^{0}Brix)	Acidity (%)	TSS/Acid ratio	Total sugar (%)	Ascorbic acid (mg/100 g pulp)
Nano urea 0.2%, (once)	8.83	0.390	22.66	7.12	256.38
Nano urea 0.3%, (once)	9.43	0.393	24.02	7.40	264.04
Nano urea 0.4%, (once)	9.07	0.353	25.73	7.18	269.78
Nano urea 0.2%, (twice)	9.03	0.320	28.23	6.80	275.52
Nano urea 0.3%, (twice)	9.37	0.383	24.43	7.72	281.26
Nano urea 0.4%, (twice)	9.63	0.383	25.13	6.46	258.30
Urea 0.5%, (once)	10.40	0.323	32.19	8.01	244.91
Urea 1%, (once)	8.93	0.360	25.01	6.98	264.04
Urea 0.5%, (twice)	9.50	0.393	24.17	7.26	264.04
Urea 1%, (twice)	9.30	0.373	25.04	6.83	256.39
Control (water spray)	8.27	0.407	20.32	6.30	244.91
SE (m) ±	0.29	0.011	1.03	0.30	3.07
CD ($p \leq 0.05$)	0.86	0.033	3.05	0.90	9.11

application of urea during the flowering stage of crops can improve their nitrogen content. Most plants can rapidly absorb urea and nano-urea applied to their leaves. There is less risk of leaching loss and denitrification loss (Wang *et al.*, 2008).

Single application of urea 0.5% resulted best quality fruits in terms of TSS (10.40 ^{0}brix), TSS/acid ratio (32.19) and total sugar (8.01%). However, twice application of nano urea resulted maximum ascorbic acid content in fruits at 0.3% level (281.26 mg/100g) and least fruit acidity at 0.2% level (0.320%) (Table 3). Nano fertilizers play a role in improving the quality parameters of fruit plants, such as oil content, protein levels and sugar content, by providing a larger surface area and greater nutrient availability to the crops. They also enhance the rate of reaction and synthesis processes within the fruit plant system. The application of nanoparticles has shown significant improvements in nutrient use efficiency (NUE) in fruit plants (Sharma *et al.*, 2021).

Conclusion

It is concluded that foliar spray of urea and nano-urea - both are effective for improvement of yield, fruit quality and nitrogen content in leaf as compared to control. As a whole, nano urea 0.3% (twice) is effective for higher number of fruits per plants with higher total sugar and ascorbic acid in fruits whereas urea 1.0% (twice) is effective for higher yield (kg/plant).

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