# Foliar application of nano urea for enhancing nutrient uptake, fruit quality, productivity and profitability of Brinjal (*Solanum melongena* L.) cultivation in the western undulating zone of Odisha

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## ABSTRACT

This study investigated the impact of using nano urea along with conventional urea on brinjal farming in the Western Undulating Agro-climatic Zone of Odisha. The research was conducted at the Regional Research and Technology Transfer Station (OUAT) in Bhawanipatna, Kalahandi, Odisha, during the 2022-23 rabiseason. Results showed that application of 50% SRD of nitrogen + nano-urea spray at 3-4 weeks after transplanting at the rate of 8 ml /ltrecorded highest leaf area index, SPAD, nutrient uptake and yield of brinjal followed by 75% SRD of nitrogen + nano-urea spray at 3-4 weeks after transplanting at the rate of 6 ml /lt. Result clearly showed that in $T_9$ where foliar application of nano urea with the reduced supplementation of inorganic nitrogen fertilizer @ 50% has been applied increased the fruit yield of brinjal to the tune of 27% over the standard recommended dose of NPK (SRD) and achieved maximum B:C ratio of 1.55. Results also showed that there is no significant impact was observed in fruit quality parameters of brinjal and post-harvest soil properties due to nano urea application.


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**Key Words**: Nano urea, brinjal, growth, yield, economics


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## 1. INTRODUCTION

Brinjal or Eggplant scientifically known as *Solanum melongena* L. is a member of the family *Solanaceae*. *Solanaceae* family comprises 95 genera and around 2450 species which are cultivated across the globe. Furthermore, *Solanum* is one of the major genera subdivided into 13 clades contributing around 1500 species of this family (Mohanty *et al.,* 2023).Eggplant is basically originated from South Asia (Pakistan and India) in the 3rd century and during the 4$^{th}$ century in China, then in 9th century in Africa (Bhaskar and Ramesh Kumar, 2015, Sekara*et al.,* 2007). It is adapted to a variety of climatic conditions in India, ranging from north to south and east to west. In India, there are 743.68 thousand hectares of brinjal crops being grown, with a total yield of 12767.52 thousand tons. Odisha produces 2127.48 thousand tons of brinjal from an area of 126.27 thousand hectares, ranking second among all the states that produce brinjal in the country (NHB Data Base 2021-22). Furthermore, within

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the state districts like Kendujhar and Kalahandi are major brinjal-producing districts that produce 171190.28 and 147668.76 tons of brinjal from an area of 12951.82 and 8563.58 ha with an average productivity of 13.22 and 17.24 t $ha^{-1}$ respectively (Anonymous, 2022).

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Eggplants are nutrient-rich, packed with vitamins, fiber, antioxidants, and phytochemicals like anthocyanins, offering various health benefits such as managing diabetes, supporting cardiovascular health, and reducing cancer risk. They also possess anti-inflammatory properties, aid digestion, lower cholesterol, and provide essential minerals for bone strength (Muhammad Yasir Naeem, Senay Ugur, 2020).

The World population is estimated to increase 9.7 billion by 2050 (FAO, 2018). Crop production will need to be raised by up to 70% to meet future food demands. Modern agriculture is heavily supported by the use of high rates of agrochemicals. Synthetic chemical fertilizers are used for the optimal growth and productivity of crops, but they are not successful to enhance plant nutrient use efficiency (NUE) and crop productivity (Alemayehu and Shewarega, 2015).

Nanotechnology in vegetable production has vast exploration including improved germination of seeds, seedling growth, abiotic and biotic stresses detection and management, yield and quality enhancement and till now proved to be an effective and promising tool in modern agriculture.

Nanotechnology holds immense promise for enhancing agricultural sustainability, particularly in developing nations. Nanostructure formulations, employing targeted delivery, controlled release, and conditional release mechanisms to respond to biological requirements, can revolutionize agricultural practices. By reducing nutrient size to the nano-scale, these fertilizers enhance nutrient utilization efficiency through improved accessibility to plant pores. Nano-particles accelerate seed germination, elevate agricultural yields, and enhance chlorophyll content. These tiny particles are readily absorbed through the plant's surface pores, promoting plant growth. Among the most impactful applications of nanotechnology is the development of nano-fertilizers, which enhance nutrient absorption in plants. Nano-fertilizers like Zn, Cu, and Fe effectively address soil fixation issues and maximize photosynthetic efficiency. According to studies, the use of nano-fertilizers promoted the nutrient utilization efficiency, reduced soil toxicity, minimized the negative effects of overdosing and lowered the frequency of treatment (Ditta, 2012). Nano-fertilizers are the nutrient carriers developed using substrates of 1-100 nm nano-dimensions used solely or in combination to improve plant growth, yield and performance of plant. These are made from conventional fertilizers extracted from different plants or plant parts by coating them with nano-materials. Nano-fertilizers have many other names like nano-carriers, nano-enabled fertilizers, bio-nanofertilizers, controlled released nano-fertilizers, NPs-based nutrient and nano-based delivery systems of micronutrients, which delivers nutrients at the right time and in the right place (Gomes et al., 2021).

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## 2. MATERIALS AND METHODS

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The field experiment was conducted to study the effect of nano urea on growth and yield of brinjal in Western Undulating Agro-climatic Zone of Odisha" at Regional Research and Technology Transfer Station, Odisha University of Agriculture and Technology, Bhawanipatna during *kharif*season of the year 2022-23 with collaboration with IFFCO.

The agricultural experiment involved meticulous field preparation, including tilling and nursery bed establishment. Thirty plots, organized into three replicates, each with 10 plots, were designated. Pusa Uttam brinjal was sown on September 8, 2022, and transplanted on October 20, 2022. Nano nitrogen foliar treatment was applied, and leaf samples were collected. Basal manuring included 20 t/ha FYM, and top dressing involved 20 t/ha FYM and NPK in a 125:80:60 ratio. An irrigation system was implemented, providing weekly watering once seedlings were established. The brinjal crop, harvested from September 1 to March 4, 2023, underwent biochemical analysis, and fruit yield was recorded. The research encompassed a thorough examination of soil and plant biochemical parameters. Initial soil assessments encompassed key attributes such as pH, electrical conductivity (EC), organic carbon (OC), and concentrations of nitrogen (N), phosphorus (P), and potassium (K). Additional measurements included the determination of SPAD values and leaf area. Plant analyses were conducted, focusing on the quantification of total nitrogen (N), phosphorus (P), and potassium (K). Furthermore, a diverse range of biochemical analyses were performed on fruits, covering parameters such as total soluble solids (TSS), total sugar content, ascorbic acid levels, and crude protein composition.

The soil parameters, both pre and post-harvest, underwent a thorough analysis, encompassing soil texture, pH, electrical conductivity (EC), organic carbon (OC), nitrogen (N), phosphorus (P), and potassium (K). The determination of soil texture employed the Bouyoucos Hydrometer method, as outlined by Piper in 1950. Soil pH was measured utilizing a pH meter, specifically the "SYSTRONICS" (model M.K VI) following Jackson's guidelines. EC was measured at room temperature (25°C) using the "SYSTRONICS" conductivity meter (model 306), based on Jackson's method from 1973. Organic carbon (OC) was analyzed through the wet digestion method proposed by Walkley and Black in 1934.

The available nitrogen content in soil samples was assessed using the alkaline potassium permanganate (KMnO4) technique, as described by Subbiah and Asija in 1956, and measured by a nitrogen auto analyzer, Pelican-classic DX (Pelican make). Olsen's technique (Bray and Kurtz, 1945) and Olsen et al. in 1954, as outlined by Page et al. in 1982, were employed to determine the available phosphorus content of soil samples, measured calorimetrically with a SYSTRONICS spectrophotometer (model 106). The available potassium content of the experimental soil samples was determined using a SYSTRONICS digital flame photometer (model 128), following the method detailed by Page et al. (1982).

SPAD readings were taken using an SPAD meter (SPAD 502 plus Chlorophyll Meter), and leaf area was calculated employing a leaf area meter. Total soluble solids (TSS) were determined by a digital hand refractometer (Atago PAL-1), while the quantity of total soluble sugar was estimated using Anthrone reagent, as described by Hedge and Hofreiter in 1962.

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Total ascorbic acid content was quantified using the colorimetric method outlined by Omaye et al. in 1979. Crude protein estimation involved multiplying the nitrogen content of a sample by the nitrogen-to-protein conversion factor of 6.25.

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To estimate the total nitrogen (N), phosphorus (P), and potassium (K) content of plant samples, leaf and fruit samples were digested and distilled using the micro Kjeldahl technique described by Jackson in 1973, utilizing the auto-analyzer's digestion unit, Pelican-classic DX (Pelican make). Phosphorus concentration was determined using the Vando-Molybdo Phosphoric Acid yellow color method spectro-photometrically, as mentioned by Jackson in 1973, with a “SYSTRONICS” spectrophotometer (model 106), while potassium concentration was determined using a digital flame photometer “SYSTRONICS” (model 128).

Treatment plots' net area, excluding borders, hosted manually harvested brinjal crops. Individual fruit weights were recorded by hand, and net plot yields were converted to quintals per hectare. Economic evaluation involved calculating gross income based on current market prices for inputs and produce. The benefit-cost ratio, indicating return per rupee invested, was computed by dividing gross income by cultivation costs. This analysis offers insights into the economic feasibility of the study's various treatments

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## 2. RESULT AND DISCUSSION

Adoption of varied dose of basal fertilizers of NPK and nano urea as foliar spray significantly influenced SPAD value, LAI, nutrient uptake of the crop. Results also showed that there is no significant impact was observed in fruit quality parameters of brinjal and post-harvest soil properties due to nano urea application.

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### 3.1 Initial soil characteristics of the experimental site

The initial soil sample results were presented in Table 1. It was found that the soils are sandy clayey loam in texture with a sand content of (47.4%), silt content of (19.3%), and clay content of (22.7%). It was slightly alkaline in reaction with a pH value of (7.85), non-hazardous salt content (electrical conductivity value of 0.03 $dSm^{-1}$), high organic carbon content (1.10%), medium in available N (420 kg $ha^{-1}$), high in available P (24.84kg $ha^{-1}$) and high in available K (563.6 kg $ha^{-1}$).

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### 3.2 Characterization of nano-nitrogen formulation

The nano-nitrogen liquid formulation provided by the Indian Farmers' Fertilizers Cooperative (IFFCO) underwent field assessment for brinjal cultivation. On January 18, 2021, the sample was analyzed at the O.U.A.T. Central Instrumentation Facility in Bhubaneswar. Fourier Transform Infrared Spectroscopy (FTIR) was conducted using PerkinElmer Spectrum Version 10.4.3. The resulting spectrum for the nano-nitrogen sample displayed a total of 7 peaks. Table 2 indicates five peaks with varying transmittance values. The highest peak value recorded was 3344.11 $cm^{-1}$, with a transmittance value of 49.4%, while the lowest peak value was 1033.3 $cm^{-1}$, with a transmittance value of 86.97%.

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**Table 1- Initial physico-chemical characteristics of the soil at the experimental site**

| Parameters | Method employed | Result |
|---|---|---|
| Textural class | Hydrometer method | Sandy clayey loam |

| | | | |
|---|---|---|---|
| | | Sand (%) | 47.42 |
| | | Silt (%) | 19.35 |
| | | Clay (%) | 22.71 |
| Soil reaction (1:2.5) | pH meter | 7.85 | |
| Electrical Conductivity (1:2.5) | EC meter | 0.03 ds $m^{-1}$ | |
| Organic Carbon (%) | Walkley and Black method | 1.1 | |
| Available nitrogen (kg $ha^{-1}$) | Alkaline Permanganate Method | 420 | |
| Available Phosphorus (kg $ha^{-1}$) | Olsen Method | 24.84 | |
| Available Potassium (kg $ha^{-1}$) | Neutral Normal Ammonium Acetate Extraction | 563.6 | |

**Table 2- Spectrum peak table of nano-nitrogen sample**

| Spectrum peak table of nano-nitrogen sample | | |
|---|---|---|
| Peak No | X=Peak ($cm^{-1}$) | Y=Transmittance Value (%) |
| 1 | 3344.11 | 49.4 |
| 2 | 2125.44 | 96.03 |
| 3 | 1627.25 | 53.35 |
| 4 | 1463.91 | 77.52 |
| 5 | 1157.61 | 85.28 |
| 6 | 1054.24 | 87.62 |
| 7 | 1033.3 | 86.97 |

### 3.3 Effect of foliar nano-urea spray on the total chlorophyll content and leaf area index of brinjal at flowering stage.

Fig. 1 presents the information on chlorophyll content and leaf area of brinjal leaves.The results indicate that the Leaf Area Index (LAI) and total chlorophyll content were highest (73.46) and (45.08), respectively in treatment $T_9$, which involved the application of 50% N of SRD + foliar application of nano urea at 8ml/lt. during the 3-4 weeks after planting. In contrast, the lowest LAI and total chlorophyll values were observed in $T_{10}$, which received no nitrogen inputs, with recorded values of 51.39 and 35.48 respectively.

This demonstrates the positive impact of nano urea on plant growth and chlorophyll production. A positive correlation between Leaf Area Index (LAI) and SPAD value is indicated by the R-squared value ($R^2$) of 0.844. This R-squared value suggests that approximately 84.4% of the variation in SPAD values can be explained by the variation in LAI. In other words, as LAI increases, there is a strong tendency for SPAD values to increase as well.Similar observation was also recorded by Sharma et al.., 2022 who highlighted that nano urea spray leads to increased LAI due enhanced nutrient uptake and better utilization by the crop. The nano scale formulation ensures better nutrient penetration and absorption through leaves promotion and leaf expansion.

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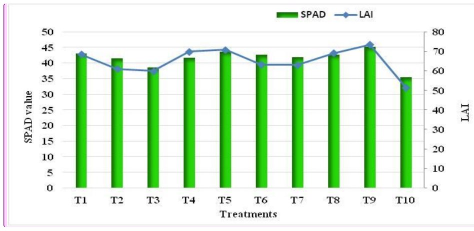


Fig 1: Influence of nano urea on LAI and SPAD value of brinjal

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### 3.4 Nutrient uptake by brinjal crop

The findings for nitrogen (N), phoshorous (P), potassium (K), absorption through the fruit, leaves, and overall nutrient uptake in the brinjal crop are presented in Table 3.Treatment $T_9$ (50% N of SRD + nano urea @ 8ml at 3-4 weeks after planting) exhibited significantly higher nutrient uptake values, recording 166.7 kg $ha^{-1}$ for N, 18.24 kg $ha^{-1}$ for P, and 55.93 kg $ha^{-1}$ for K. These values were indicative of the positive impact of this treatment on nutrient uptake. Treatment $T_5$ which is 75% N of SRD + nano urea @6ml/lt of water also demonstrated noteworthy results, with nutrient uptake levels at par with those of $T_9$. This suggests that the integrated approach of using nano urea and conventional fertilizers in $T_5$ was equally effective in enhancing nutrient uptake.

The findings indicate that the nutrient uptake of brinjal plants was notably increased when an integrated fertilization approach, combining foliar application of nano urea and conventional fertilizers, was employed. This increase can be attributed to the unique properties of nano fertilizers, including their large surface area and particle size, which are smaller than the pore size of plant roots and leaves. These characteristics facilitate the penetration of nutrients into the plant from the applied surface, ultimately improving nutrient uptake. These results are consistent with the findings of Lahari et al.(2021), emphasizing the importance of integrated fertilization strategies that incorporate nano fertilizers to enhance nutrient uptake in plant systems and Sahu, et al.,2022, emphasizing the effect of nano urea application on growth and productivity of rice (*Oryza sativa* L.). Notably, the integrated application of nano urea outperformed sole urea, and fig 2,3,4 depicts a strong positive correlation was observed between nitrogen uptake ($R^2$=0.965), Phosphorous uptake ($R^2$ = 0.846) and potassium uptake ($R^2$=0.905) underscoring the pivotal role of nitrogen, phosphorous and potassium in enhancing crop productivity and highlighting the potential for optimizing nitrogen application.

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**Table-3 Nutrient uptake by brinjal crop**

| Treatments | N uptake (kg ha$^{-1}$) | | | P uptake (kg ha$^{-1}$) | | | K uptake (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Leaf** | **Fruit** | **Total** | **Leaf** | **Fruit** | **Total** | **Leaf** | **Fruit** | **Total** |
| $T_1$:Recommended dose of NPK | 71.17 | 23.43 | 94.6 | 10.12 | 4 | 14.12 | 28.02 | 8.68 | 36.69 |
| $T_2$:75% N of SRD | 57.69 | 19.23 | 76.92 | 7.41 | 2.86 | 10.26 | 24.04 | 6.97 | 31.01 |
| $T_3$:50% N of SRD | 53.31 | 18.03 | 71.34 | 5.95 | 3.09 | 9.04 | 20.58 | 5.95 | 26.52 |
| $T_4$:75% N of SRD + 4ml nano urea (at 3$^{rd}$ week and 6$^{th}$ week after planting) | 84.89 | 29.91 | 114.8 | 8.52 | 3.13 | 11.66 | 27.1 | 7.56 | 34.65 |
| $T_5$:75% N of SRD + nano urea @6ml (at 3-4 week after planting) | 112.99 | 37.32 | 150.31 | 13.07 | 3.81 | 16.88 | 37.23 | 11.4 | 48.63 |
| $T_6$:75% N of SRD + nano urea @8ml (at 3-4 week after planting) | 95.97 | 32.32 | 128.29 | 11.62 | 3.51 | 15.13 | 34.9 | 9.29 | 44.19 |
| $T_7$: 50% N of SRD + nano urea @4ml (at 3$^{rd}$ week and 6$^{th}$ week after planting) | 81.98 | 26.96 | 108.94 | 8.99 | 3.1 | 12.08 | 30.97 | 7.14 | 38.12 |
| $T_8$:50% N of SRD + nano urea @6ml (at 3-4 week after planting) | 78.84 | 29.1 | 107.94 | 9.35 | 3.36 | 12.71 | 29.66 | 7.72 | 37.38 |
| $T_9$: 50% N of SRD+ nano urea @8ml (at 3-4 week after planting) | 123.65 | 43.06 | 166.7 | 13.83 | 4.41 | 18.24 | 42.1 | 13.83 | 55.93 |
| $T_{10}$: No nitrogen | 46.08 | 15.61 | 61.69 | 5.85 | 2.54 | 8.38 | 16.38 | 4.81 | 21.19 |
| **SEm (±)** | **3.63** | **1.88** | **5.28** | **0.54** | **0.13** | **0.76** | **1.47** | **0.39** | **2.15** |
| **CD(P=0.05)** | **10.5** | **5.44** | **15.28** | **1.56** | **0.38** | **2.19** | **4.24** | **1.13** | **6.21** |
| **CV** | **7.79** | **11.85** | **8.46** | **9.86** | **6.72** | **10.22** | **8.73** | **8.14** | **9.93** |

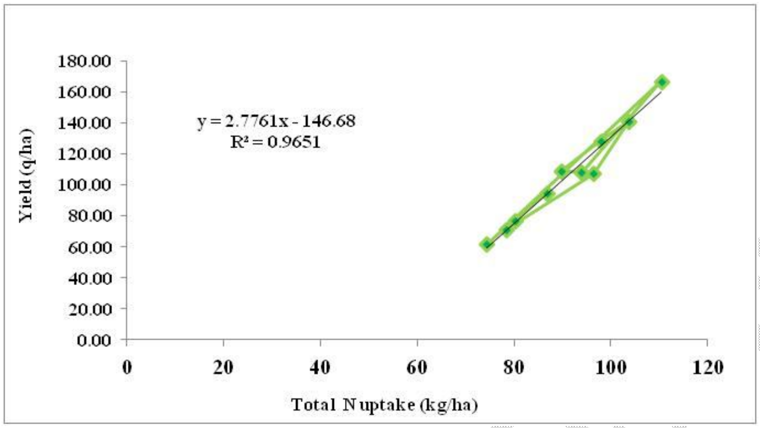


**Fig. 2: Correlation between N uptake and yield**

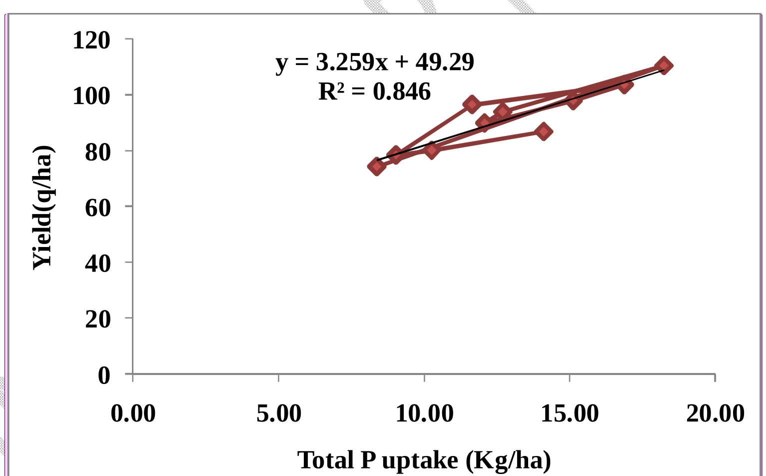


**Fig. 3: Correlation between P uptake and yield**

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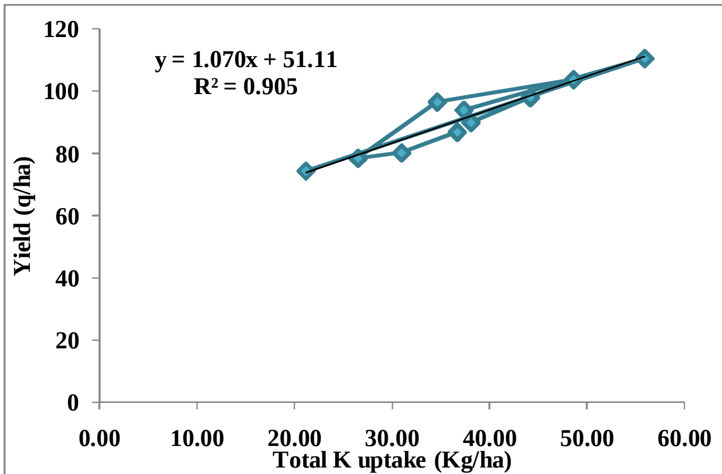



**Fig. 4: Correlation between K uptake and yield**

### 3.5 Influence of nano urea on different biochemical properties of fruit of brinjal

Table 4 lists the effects of nano urea on the various biochemical characteristics of brinjal fruit such as total soluble solids, total sugar, ascorbic acids, crude protein.After completing the study, it was observed that there was no clear pattern or trend in the findings related to tss, total sugar, ascorbic acid values of the fruit samples from the various treatments. Similar finding also recorded by Yildirim *et al..,* 2007 in broccoli, Borowski *et al..,* 2010 in spinach.

The highest (2.44%) protein content was found with $T_9$ (50% N of SRD + nano urea @8ml at 3-4 week after planting) where as lowest (0.93%) observed under $T_{10}$ (no nitrogen). This result could be attributed to the fact that nitrogen plays a vital role in amino acid synthesis, which, in turn, serves as the fundamental framework for the formation of proteins in plants. Amino acids are pivotal building units employed by plants for protein synthesis due to their inherent nitrogen content. Similar finding also recorded by Borowski *et al.,* 2010 in spinach.

### 3.6 Influence of nano urea on post harvest soil parameters

So far as the influence of nano urea on different properties of post harvest soil is concerned there was no significant changes in any of the soil properties was observed but negative balance for soil available N was observed with decrease rate of inorganic N addition.

### 3. Yield and Economics

The data presented in table 4 showed the significant influence of nano urea on brinjal yield. This research has revealed a substantial impact of nano urea on fruit production in brinjal (Solanum melongena). The application of varying levels of integrated inorganic nitrogen and nano urea had a pronounced effect on brinjal yield.Among the different treatments, the highest fruit yield, at 110.40 quintals per hectare (q $ha^{-1}$), was observed under T9 (50% N of SRD + foliar application of nano urea @ 8ml/lt. at 3-4 weeks after planting) followed by $T_5$ (75% N of SRD + nano urea @ 6ml/lt. at 3-4 weeks after planting) yielded 103.66 q/ha. In contrast, the lowest fruit yield 74.32 q $ha^{-1}$, was recorded under $T_{10}$ where no nitrogen was applied.

Nano urea demonstrated its superiority in enhancing brinjal yield, as application of nano urea significantly increasing the fruit yield of brinjal over the control. Fig.6 visually illustrates that the application of nano urea significantly boosted the yield of brinjal (S. melongena).The data for total cost of cultivation, gross return, net return and cost benefit ratio due to nano urea application is presented in table 5 and fig 5. The results clearly showed that highest benefit cost ratio of 1.55 was observed in $T_9$ (50% N of SRD + nano urea @8ml at 3–4 weeks after planting) followed by $T_5$ (B:C ratio 1.46) where 75% of STD + nano urea spray @ 6ml was applied at 3-4 weeks after planting. The lowest B:C ratio (1.06) was recorded under $T_{10}$ (no nitrogen) where no nitrogen was applied. The increase in B:C ratio might be due to increase in yield and reduce in cost of cultivation because of less use of inorganic fertilizers.

**Table 4 - Influence of nano urea on different biochemical properties of brinjal fruit.**

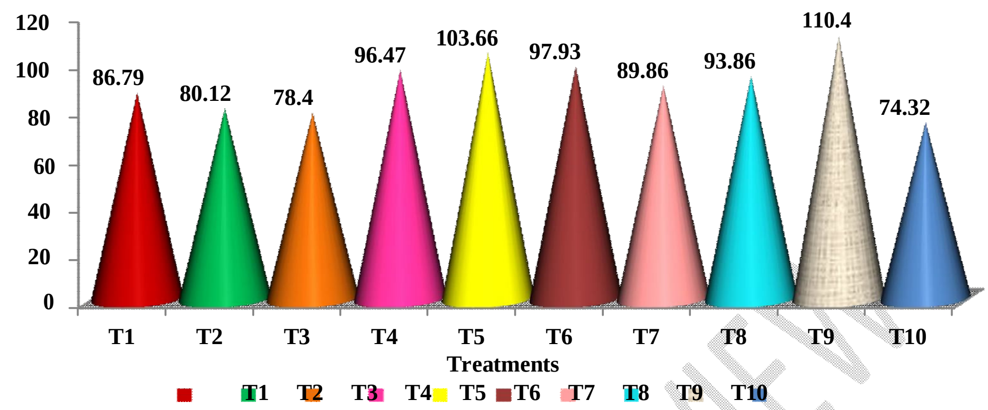
| Treatments | TSS ($^o$ Brix) | Total Sugar(%) | Ascorbic Acid (mg $100g^{-1}$) | Crude protein (%) |
|---|---|---|---|---|
| $T_1$:Recommended dose of NPK | 11.60 | 3.65 | 14.42 | 1.69 |
| $T_2$:75% N of SRD | 11.68 | 3.72 | 14.77 | 1.5 |
| $T_3$:50% N of SRD | 11.52 | 3.78 | 14.52 | 1.44 |
| $T_4$:75% N of SRD + 4ml nano urea (at 3rd week and 6th week after planting) | 11.53 | 3.62 | 14.43 | 1.94 |
| $T_5$:75% N of SRD + nano urea @6ml (at 3-4 week after planting) | 11.42 | 3.56 | 14.47 | 2.25 |
| $T_6$:75% N of SRD + nano urea @8ml (at 3-4 week after planting) | 11.58 | 3.68 | 14.63 | 2.06 |
| $T_7$: 50% N of SRD + nano urea @4ml (at 3rd week and 6th week after planting) | 11.56 | 3.50 | 14.97 | 1.88 |
| $T_8$:50% N of SRD + nano urea @6ml (at 3-4 week after planting) | 11.48 | 3.76 | 14.92 | 1.94 |
| $T_9$: 50% N of SRD+ nano urea @8ml (at 3-4 week after planting) | 11.25 | 3.49 | 14.22 | 2.44 |
| $T_{10}$: No nitrogen | 11.38 | 3.62 | 14.48 | 1.31 |
| **SEm (±)** | **0.16** | **0.06** | **0.15** | **0.13** |
| **CD (P=0.05)** | **0.46** | **0.17** | **0.42** | **0.38** |

**Table 5 - Influence of nano urea on yield and economics of brinjal**

| Treatments | Yield kg $plot^{-1}$ | Yield ( $qha^{-1}$) | Cost of Cultivation (Rs.) | Gross Income (Rs.) | Net Income (Rs.) | B:C Ratio |
|---|---|---|---|---|---|---|
| $T_1$:Recommended dose of NPK | 13.89 | 86.79 | 141344 | 173580 | 32236.5 | 1.23 |
| $T_2$:75% N of SRD | 12.82 | 80.12 | 140940 | 160240 | 19299.9 | 1.14 |
| $T_3$:50% N of SRD | 12.54 | 78.4 | 140532 | 156800 | 16267.6 | 1.12 |
| $T_4$:75% N of SRD + 4ml nano urea (at 3rd week and 6th week after planting) | 15.44 | 96.47 | 142860 | 192940 | 50079.9 | 1.35 |
| $T_5$:75% N of SRD + nano urea @6ml (at 3-4 week after planting) | 16.59 | 103.66 | 142380 | 207320 | 64939.9 | 1.46 |
| $T_6$:75% N of SRD + nano urea @8ml (at 3-4 week after planting) | 15.67 | 97.93 | 142860 | 195860 | 52999.9 | 1.37 |

| | | | | | | |
|---|---|---|---|---|---|---|
| $T_7$: 50% N of SRD + nano urea @4ml (at 3rd week and 6th week after planting) | 14.38 | 89.86 | 142452 | 179720 | 37267.6 | 1.26 |
| $T_8$:50% N of SRD + nano urea @6ml (at 3-4 week after planting) | 15.02 | 93.86 | 141972 | 187720 | 45747.6 | 1.32 |
| $T_9$: 50% N of SRD+ nano urea @8ml (at 3-4 week after planting) | 17.66 | 110.4 | 142452 | 220800 | 78347.6 | 1.55 |
| $T_{10}$: No nitrogen | 11.89 | 74.32 | 140532 | 148640 | 8107.58 | 1.06 |
| **SE(m)** | **0.78** | **3.88** | | | | |
| **CD(P=0.05)** | **2.26** | **11.22** | | | | |
| **CV** | **9.26** | **7.37** | | | | |

**Fig 5 : Influence of nano urea on yield of brinjal crop**




## 4. Conclusion

It may be concluded that a 50% reduction of commercialnitrogen fertilisers in the form of urea or substitution of 50% recommended dose of N through urea by foliar application of nano urea @ 8ml/lt. in liquid form or 25% substitution of urea by nano urea @ 6ml/lt. have promising effect on growth, yield and yield attributes of brinjal crop. It has not only contributed 27% yield increase in the study area but also given an additional income of Rs 46111/ha to the farmers. The application of nano urea may be considered as a sustainable nitrogen management practice as it helps in reducing the cost of cultivation apart from benefiting soil health.

**Comment [A26]:** Add acknowledgment and Conflict of interest

**Comment [A27]:**

### Data availability

**Comment [A28]:**

The data used to support the findings of this study are included with in the articles

### References

Alemayehu Y, Shewarega M. 2015.Growth and Yield Responses of Maize (*Zea Mays* L.) to Different Nitrogen Rates under Rain-Fed Condition in Dilla Area, Southern Ethiopia.*Journal of Natural Sciences Research*, 2225-092.

**Comment [A29]:** Arrange all the references properly and follow author guidelines

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