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Effect of nano fertilizers on quality of okra (*Abelmoschus esculentus* L.) var. Kashi Lalima

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Abstract
The present study was conducted during the summer season of 2024 at College of Horticulture, Rajendranagar, SKLTGHU, Hyderabad. The experiment was carried out with thirteen treatments *i.e.*, T_1-100% Recommended Dose of Fertilizers (N, P, K), T_2-Nano urea foliar spray @ 2 ml L^{-1} + 75% N+100% PK RDF,T_3-Nano urea foliar spray @ 2 ml L^{-1} + 50% N+100% PK RDF, T_4-Nano urea foliar spray @ 3ml L^{-1} + 75% N+100% PK RDF,T_5-Nano urea foliar spray @ 3 ml L^{-1} + 50% N+100% PK RDF,T_6-Nano urea foliar spray @ 4 ml L^{-1} + 75% N+100% PK RDF, T_7-Nano urea foliar spray @ 4 ml L^{-1} + 50% N+100% PK RDF, T_8-Nano DAP foliar spray @ 2 ml L^{-1} + 75% NP+100% K RDF, T_9-Nano DAP foliar spray @ 2 ml L^{-1} + 50% NP+100% K RDF, T_{10}-Nano DAP foliar spray @ 3 ml L^{-1} + 75% NP+100% K RDF, T_{11}-Nano DAP foliar spray @ 3 ml L^{-1} + 50% NP+100% K RDF, T_{12}-Nano DAP foliar spray @ 4 ml L^{-1} + 75% NP+100% K RDF,T_{13}-Nano DAP foliar spray @ 4 ml L^{-1} + 50% NP+100% K RDF in a Randomized Block Design replicated thrice. The results revealed that highest values for ascorbic acid (18.76 mg $100g^{-1}$), crude protein (3.92%), crude fiber (4.42%), and anthocyanin content (3.96 mg $100g^{-1}$) were recorded in T_{12} – Nano DAP foliar spray @ 4 ml L^{-1} + 75% NP + 100% K RDF.

Keywords: Kashi Laima, quality parameters, ascorbic acid, crude protein, crude fiber, anthocyanin content

1. Introduction

Okra (*Abelmoschus esculentus* L.) is an economically important vegetable crop belongs to the family Malvaceae and is originated from Africa. Okra is also known as bhendi or lady's finger or the bride's finger the bride. (Al-Kaby *et al.*, 2021) [1]. It is one of the important crops of tropical and sub-tropical regions across the globe. It is the most extensively eaten edible vegetable in India because of its tender greens, which are grown during summer and rainy seasons (Solankey *et al.*, 2013) [20].

The plant is characterized by its moderate height and short internodes, accompanied by red-colored petioles. It is rich in anthocyanin and phenolic compounds. Furthermore, this variety demonstrates adaptability to both the summer and *Kharif* seasons. The tender fruit of okra has good nutritional value, and the 100g edible portion of okra fruit contains 2 g protein, 1g fiber, 7 g carbohydrates, 16 mg ascorbic acid, 99 mg 100 g^{-1} iodine and has an energy value of 145 KJ 100 g^{-1} (Simon *et al.*, 2013) [19].

Because of their capacity to improve nutrient use efficiency and lessen negative environmental effects, nano fertilizers are frequently referred to as "smart fertilizers" which lowers the cost of environmental protection (Manjunatha *et al.*, 2016; Sharpley *et al.*, 1992; Wurth, 2007) [11, 18, 22].

The practice of feeding plants by putting water-soluble fertilizer directly onto the canopy or other above-ground sections is known as foliar nutrition. This technique reduces nutrient loss through evaporation and leaching, making it a valuable tool for the sustainable and productive management of crop nutrients. It also helps to limit the contamination of ground water and soil by enhancing plant nutrient uptake efficiency (Rauniyar, 2020) [17]. It serves as a productive way to address dietary deficiencies and provide macro and micronutrients. To enhance the quality, nutrient sprays can be used at any moment throughout the growing phase (Oosterhuis, 2009) [13].

Application of nano fertilizers enhance the efficiency of nutrients, yield and quality as it is environment friendly, reduce nutrient stress to the plant and quantities of fertilizers and its input cost.

The plants absorb nutrients quickly and penetrate into the plant cells through cell wall or stomata (Hayyawi and Estabraq, 2020) [7]. The use of nano fertilizers leads to a gradual release of nutrients into the soil, enhancing the absorption rate during the plant growth period, which in turn improves the quality and efficiency of food sources. (Barmaki *et al*., 2010) [3].

The concept of ANDI – Abberations of Normal Development and Involution is gaining acceptance [4]. Benign proliferation of the breast are often considered as aberrations of normal development and involution. The cyclical changes due to variations in estrogen and progesterone result in increased mitosis around days 22–24 of the menstrual cycle but apoptosis restores the balance across the cycle. ANDI, first proposed by Huges is now universally accepted. This concept allows conditions of the breast to be mapped between normality, through benign.

2. Materials and Methods

A field experiment was conducted during *summer*-2024, at College of Horticulture, Rajendranagar, SKLTGHU, Hyderabad with thirteen treatments *i.e*., T_1-100% Recommended Dose of Fertilizers (N, P, K), T_2-Nano urea foliar spray @ 2 ml L^{-1} + 75% N+100% PK RDF,T_3-Nano urea foliar spray @ 2 ml L^{-1} + 50% N+100% PK RDF, T_4-Nano urea foliar spray @ 3ml L^{-1} + 75% N+100% PK RDF,T_5-Nano urea foliar spray @ 3 ml L^{-1} + 50% N+100% PK RDF,T_6-Nano urea foliar spray @ 4 ml L^{-1} + 75% N+100% PK RDF, T_7-Nano urea foliar spray @ 4 ml L^{-1} + 50% N+100% PK RDF, T_8-Nano DAP foliar spray @ 2 ml L^{-1} + 75% NP+100% K RDF, T_9-Nano DAP foliar spray @ 2 ml L^{-1} + 50% NP+100% K RDF, T_{10}-Nano DAP foliar spray @ 3 ml L^{-1} + 75% NP+100% K RDF, T_{11}-Nano DAP foliar spray @ 3 ml L^{-1} + 50% NP+100% K RDF, T_{12}-Nano DAP foliar spray @ 4 ml L^{-1} + 75% NP+100% K RDF,T_{13}-Nano DAP foliar spray @ 4 ml L^{-1} + 50% NP+100% K RDF in a Randomized Block Design replicated thrice. The doses of N, P, and K were applied through Urea, SSP (Single Super Phosphate), and MOP (Muriate of Potash), respectively. Organic manure (FYM) was incorporated into the soil before sowing in the main field. The entire SSP, MOP, and half of the N were applied as a basal dose, while the remaining urea was applied at 30 and 45 days after sowing. Nano fertilizers were sprayed as per the treatments. The standard recommended package of practices of SKLTGHU were followed to raise the successful crop. Nano fertilizers were sprayed as per the treatment schedule, with the first foliar spray applied 25 days after sowing and the second spray at 20 days after the first spray. Quality parameters were recorded on ascorbic acid, crude protein, crude fibre and anthocyanin content.

2.1 Ascorbic acid (mg $100g^{-1}$)

2, 6-dichlorophenol indophenol visual titration method as described by Rangana (1986) was adopted for its determination. Ten grams of the homogenized sample of okra fruit was taken, blended with 3 per cent metaphosphoric acid (HPO_3) and the volume was made up to 100 ml with 3% HPO_3. The suspension was filtered through Whattman number-1 filter paper. Before actual titration the dye (2, 6–dichlorophenolindophenol) was standardized by titrating against 5 ml of standard ascorbic acid solution and 5 ml of HPO_3 to determine the dye factor *i.e*. mg of ascorbic acid per ml of the dye using the formula:

a. $$\text{Dye factor} = \frac{0.5}{\text{Titre value}}$$

An aliquot (5 ml) of the HPO_3 extract of the sample was pipetted in a 100 ml conical flask and titrated with the standard dye through a burette. Titration was continued to a pink end point which persisted for a few seconds. The process of titration was repeated at least three times and the mean reading was found out. Dye solution was stored in a refrigerator. The ascorbic acid content of the sample was calculated by adopting the following equation.

$$\frac{\text{Titre value} \times \text{Dye factor} \times \text{Volume made up}}{\text{Aliquot of extract taken for estimation} \times \text{Weight of sample taken for estimation.}} \times 100$$

2.2 Crude protein (%)

The Lowry reaction for protein estimation is an extension of the biuret method. This method was developed by Lowry *et al*. (1951) which is about 10 times more sensitive than the biuret method. Hence, it was followed to determine the protein content of enzyme extracts.

Reagents

Reagent A: 2% Sodium carbonate (anhydrous) in 0.1 N NaOH.

Reagent B: 0.5% Copper sulphate ($CuSO_4$. 5 H_2O) in 1% sodium potassium tartrate (prepared fresh).

Reagent C (alkaline copper solution): 50 ml of reagent A was mixed with 1 ml of reagent B just prior to use.

Folin-Ciocalteau reagent (Reagent D) was prepared by diluting the commercial reagent (2 N) with an equal volume of water on the day of use.

Stock standard protein solution was prepared by dissolving 50 mg of Bovine serum albumin per 50 ml of water.

Working standard solution was prepared by diluting 10 ml of the stock solution to 50 ml water to obtain 200 µg protein per ml.

Methods

Extraction of protein from sample

- 0.5 g of the sample was ground with a suitable solvent system (water or buffer) in a pestle and mortar.
- Centrifuge and use the supernatant for protein estimation.

Estimation of protein

- 0.2, 0.4, 0.6, 0.8 and 1.0 ml of the working standard solution was pipetted out into a series of test tubes.
- 0.1 ml and 0.2 ml of the sample was pipetted into two other test tubes.
- The volume was made up to 1 ml with water in all the tubes. A tube with 1 ml of water serves as the blank.
- 5 ml of solution C was added, mixed well and incubated at room temperature for 10 min.
- 0.5 ml of reagent D was added and mixed well immediately and incubated at room temperature in the dark for 30 min.
- Absorbance at 660 nm was read against the blank.
- A standard graph was drawn, to calculate the amount of protein in the sample and express the results as mg g^{-1} or mg 100 g^{-1} sample or percentage.

Calculation

$$\text{Protein content (\%)} = \frac{\text{OD (test)}}{\text{OD (std)}} \times \frac{\text{Conc (std)}}{\text{Aliquot (test)}} \times 100$$

2.3 Crude fibre (%)

Crude fibre content of dry sample of okra fruits harvested at 6^{th}

days after anthesis was determined by using AOAC (1960) [2] method. Crude fibre content was determined by the method suggested by A.O.A.C., 1960 [2]. Representative ground fruit sample of 2 g was refluxed with 1.25% H_2SO_4, washed and again refluxed with 1.25% NaOH for 30 minutes, respectively. The sample was dried out, weighed and ignited in muffle furnace. Loss in weight was considered as crude fibre content and expressed on the basis of using following relationship:

$$\text{Crude fibre (\%)} = \frac{W_2 - W_3}{W_1} \times 100$$

Where,
W_1= Initial weight of sample
W_2= Weight of refluxed sample
W_3= Weight of ignited sample

2.4 Anthocyanin (mg 100^{-1} g FW)

The estimation of total anthocyanin content was carried out in methanolic HCl, by adopting the procedure described by Ranganna (1977) [15].

1g of crushed sample was dissolved in 10 ml of Methanolic HCl [85 ml ethanol+15 ml 1(N) HCl for 100 ml Methanolic HCl] then transferred it into test tube and kept in cool place for 3 days. After that, 1 ml of strained sample taken and then UV absorption was measured against prepared reagent blank (85% of Methanolic HCl) at 535 nm. The anthocyanin content was calculated as mg 100 g^{-1} fresh weight bases as per the given below formula:

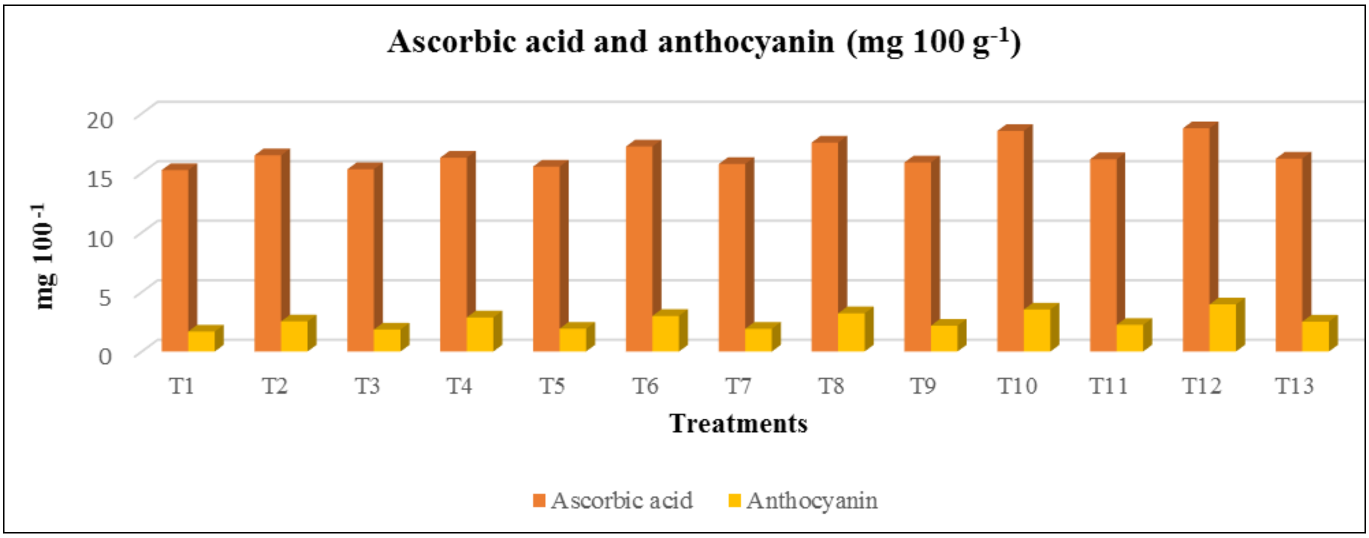
$$\text{Total OD per 100 g of sample} = \frac{\text{OD} \times \text{Volume made up} \times 100}{\text{Weight of sample}}$$

$$\text{Total anthocyanin content (mg 100 g}^{-1}\text{)} = \frac{\text{Total OD per 100g}}{98.}$$

3. Results and Discussion

Table 1: Effect of nano fertilizers on ascorbic acid (mg $100g^{-1}$), crude protein (%), crude fiber (%) and anthocyanin (mg $100g^{-1}$).

Treatments	Ascorbic acid (mg $100g^{-1}$)	Crude Protein (%)	Crude fiber (%)	Anthocyanin (mg $100g^{-1}$)
T_1-100% Recommended dose of fertilizers (N, P, K)	15.24	2.54	1.30	1.68
T_2-Nano urea foliar spray @ 2 ml L^{-1} + 75% N+100% PK RDF	16.49	3.26	3.84	2.53
T_3-Nano urea foliar spray @ 2 ml L^{-1} + 50% N+100% PK RDF	15.32	2.61	2.12	1.85
T_4-Nano urea foliar spray @ 3ml L^{-1} + 75% N+100% PK RDF	16.29	3.69	3.98	2.86
T_5-Nano urea foliar spray @ 3 ml L^{-1} + 50% N+100% PK RDF	15.54	2.89	2.56	1.92
T_6-Nano urea foliar spray @ 4 ml L^{-1} + 75% N+100% PK RDF	17.23	3.62	4.19	2.99
T_7-Nano urea foliar spray @ 4 ml L^{-1} + 50% N+100% PK RDF	15.76	2.94	2.98	1.91
T_8-Nano DAP foliar spray @ 2 ml L^{-1} + 75% NP+100% K RDF	17.56	3.79	4.25	3.21
T_9-Nano DAP foliar spray @ 2 ml L^{-1} + 50% NP+100% K RDF	15.89	3.12	3.51	2.17
T_{10}-Nano DAP foliar spray @ 3 ml L^{-1} + 75% NP+100% K RDF	18.54	3.83	4.36	3.53
T_{11}-Nano DAP foliar spray @ 3 ml L^{-1} + 50% NP+100% K RDF	16.16	3.29	3.64	2.24
T_{12}-Nano DAP foliar spray @ 4 ml L^{-1} + 75% NP+100% K RDF	18.76	3.92	4.42	3.96
T_{13}-Nano DAP foliar spray @ 4 ml L^{-1} + 50% NP+100% K RDF	16.21	3.36	3.72	2.51
SEM ±	0.37	0.06	0.06	0.03
CD at 5%	1.08	0.19	0.16	0.10



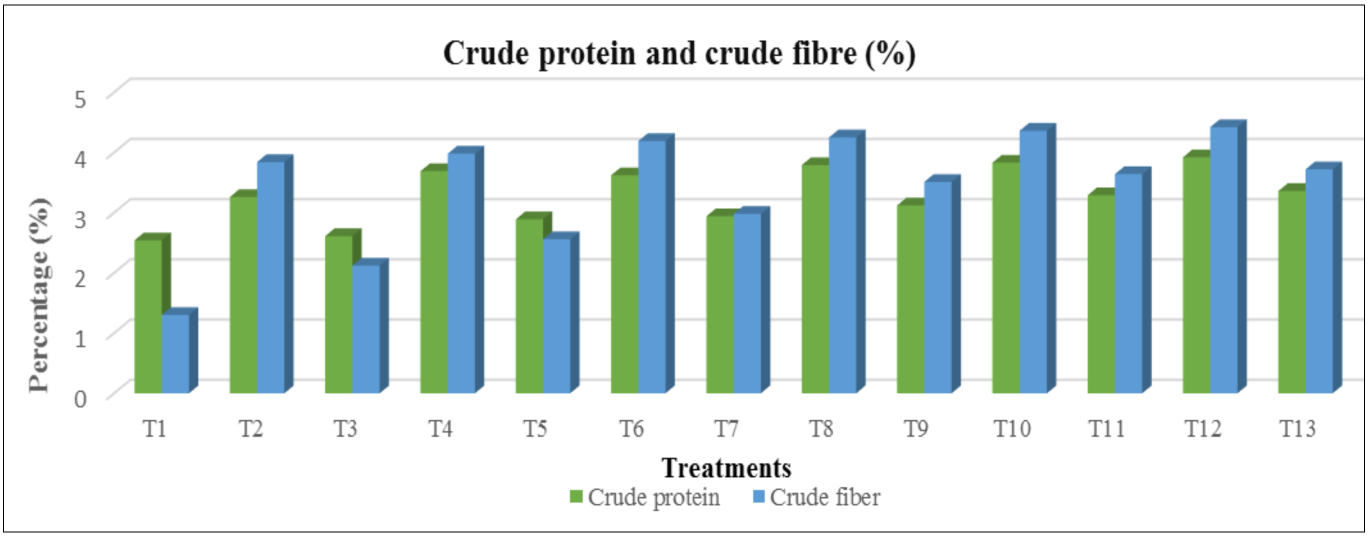


Fig 1: Effect of nano fertilizers on ascorbic acid (mg $100g^{-1}$), crude protein (%), crude fiber (%) and anthocyanin (mg $100g^{-1}$)

3.1 Ascorbic acid (mg 100 g^{-1})

The data on ascorbic acid content of okra fruits as influenced by nano fertilizers is presented in Table 4.9 and illustrated in Figure 4.14.

The results indicated that there were significant differences among the treatments with respect to ascorbic acid content in okra fruits. The highest ascorbic acid content (18.76 mg 100 g^{-1}) was recorded in T_{12}-Nano DAP foliar spray @ 4 ml L^{-1} + 75% NP + 100% K RDF, which was statistically on par with T_{10}-Nano DAP foliar spray @ 3 ml L^{-1} + 75% NP + 100% K RDF (18.54 mg 100 g^{-1}), followed by T_8-Nano DAP foliar spray @ 2 ml L^{-1} + 75% NP + 100% K RDF (17.56 mg 100 g^{-1}). The lowest ascorbic acid content (15.24 mg 100 g^{-1}) was recorded in T_1-100% Recommended Dose of Fertilizers (Control).

According to Chiesa *et al*. (2009) [4], the ascorbic acid content in lettuce increased with high nitrogen application (150 kg ha^{-1}). However, the variance in ascorbic acid accumulation at different nitrogen application rates was not consistent with the results reported by Mahlangu *et al*. (2016) [10]. Both excessive and insufficient nitrogen input can lower ascorbic acid content by Feyman *et al*. (1991) [5] and Lee *et al*. (2000) [8].

3.2 Anthocyanin (mg 100 g^{-1})

The data on anthocyanin content in okra pods is summarized in Table 4.9 and illustrated in Figure 4.14.

Significant variations were observed among the treatments regarding anthocyanin content. The anthocyanin levels ranged from 1.68 mg 100 g^{-1} to 3.96 mg 100 g^{-1} across different treatments. The highest anthocyanin content (3.96 mg 100 g^{-1}) was recorded in T_{12}-Nano DAP foliar spray @ 4 ml L^{-1} + 75% NP + 100% K RDF. This was followed by T_{10}-Nano DAP foliar spray @ 3 ml L^{-1} + 75% NP + 100% K RDF, which had an anthocyanin content of 3.53 mg 100 g^{-1}. The lowest anthocyanin content (1.68 mg 100 g^{-1}) was observed in T_1-100% Recommended Dose of Fertilizers (Control).

3.3 Crude protein (%)

The data related to crude protein content in okra as influenced by nano fertilizers is presented in Table 4.9 and illustrated in Figure 4.15.

The results showed significant variation among the treatments regarding crude protein content. The highest crude protein content (3.92%) was recorded in T_{12}-Nano DAP foliar spray @ 4 ml L^{-1} + 75% NP + 100% K RDF, which was statistically on par with T_{10}-Nano DAP foliar spray @ 3 ml L^{-1} + 75% NP + 100% K RDF (3.83%) and T_8-Nano DAP foliar spray @ 2 ml L^{-1} + 75% NP + 100% K RDF (3.79%). The minimum crude protein content (2.54%) was observed in T_1-100% Recommended Dose of Fertilizers.

The increase in protein content was pronounced with the higher levels of inorganic forms, which favored intense protein synthesis and efficient storage in the presence of an abundant supply of available nitrogen. The application of inorganic fertilizers, in combination with different organic manures, significantly increased protein content (Gayathri and Krishnaveni, 2015) [6]. The highest protein content in treatment receiving a combination of inorganic fertilizers and nano fertilizers was found by Yadav *et al*. (2006) [23] in okra.

3.4 Crude fibre (%)

The data on crude fiber content in okra is presented in Table 4.9 and illustrated in Figure 4.15.

Significant variations were observed among the treatments concerning crude fiber content. The crude fiber percentage ranged from 1.30% to 4.42% among different treatments. The highest crude fiber content (4.42%) was recorded in T_{12}-Nano DAP foliar spray @ 4 ml L^{-1} + 75% NP + 100% K RDF, which was statistically on par with T_{10}-Nano DAP foliar spray @ 3 ml L^{-1} + 75% NP + 100% K RDF (4.36%) and T_8-Nano DAP foliar spray @ 2 ml L^{-1} + 75% NP + 100% K RDF (4.25%). The minimum crude fiber content (1.30%) was observed in T_1-100% Recommended Dose of Fertilizers (Control).

This might be due to the easy availability of nitrogen, leading to a balanced C:N ratio, which enhances vegetative growth and results in high photosynthetic activity by Wagh *et al*. (2014) [21]. Similar findings have been reported by Premsekher and Rajshree (2009) [14] and Gayathri and Krishnaveni (2015) [6].

4. Conclusion

From the present study, it can be concluded that the application of nutrients through foliar nano fertilizers significantly influenced the quality of okra (*Abelmoschus esculentus* L.) var. Kashi Lalima. The treatment T_{12} – Nano DAP foliar spray @ 4 ml L^{-1} + 75% NP + 100% K RDF showed the most positive effects on quality parameters compared to other treatments. The highest values for ascorbic acid (18.76 mg $100g^{-1}$), crude protein (3.92%), crude fiber (4.42%), and anthocyanin content (3.96 mg $100g^{-1}$) were recorded in T_{12} – Nano DAP foliar spray

@ 4 ml L^{-1} + 75% NP + 100% K RDF

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