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Effect of Nano Fertilizer on Growth, Yield and Quality of Okra (*Abelmoschus esculentus*)

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Authors' contributions

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

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ABSTRACT

The present investigation was conducted to study the effect of nano fertilizer in the growth yield and quality of okra *(Abelmoschus esculenthus*). The experiment was carried out at the instructional farm of ICAR- Krishi Vigyan Kerndra, Pathanamthitta, Kerala, during the year 2021. The experiment was laid out in randomized block design with three replications. Ten different treatments were carried out with different combinations of fertilizers. The result obtained with treatment T2 (Soil application of 50% recommended dose of fertilizers as conventional fertilizer + 50% recommended dose of nano N as foliar application, nano P&K as soil application) was recorded the best among in all combination of conventional fertilizer NPK and nano NPK in term of growth, yield attribute and quality parameters like plant height 120.21 cm, number of leaves per plant 83.99, number of branches per plant 3.62, days to first harvesting 46.97, pod length 12.72cm, pod width 1.65cm, number of pods per plant 29.23, average of pod weight 12.67g, pod yield per plant 370.39g, pod yield per plot 8.89kg, pod yield 131.69q ha-1and TSS 2.930Brix. The highest cost benefit ratio 3.59 was also observed in T2 (Soil application of 50% RDF as conventional fertilizer + 50% recommended dose of nano N as foliar application, nano P&K as soil application).

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1. INTRODUCTION

Okra (*Abelmoschus esculentus*) belongs to the family Malavaceae. It is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. This crop is suitable for cultivation as a garden crop as well as on large commercial farms. It is grown commercially in India, Turkey, Iran, Western Africa, Yugoslavia, Bangladesh, Afghanistan, Pakistan, Burma, Japan, Malaysia, Brazil, Ghana, Ethiopia, Cyprus and the Southern United States [1]. India is the largest producer of okra with a production of 6355 tonnes in 521 thousand hectors [2]. Okra plays an important role in the diet by supplying carbohydrate, protein, fat, minerals and vitamins that are usually deficient in the staple food. It is basically low in calories and dry matter constituents which when consumed in a meal with basic starchy food makes the food more palatable. Every 100 g green pods of okra contain protein 1.8g, carbohydrate 6.4 g, fibre 1.2 g, vitamin C 18 mg and calcium 90 mg [3]. The immature pods are used as vegetable and its dried form is often used as soup thickener [4].

Unscientific application of conventional fertilizers by the farmers for increasing the crop productivity, although their excessive use is causing problems like environmental pollution, water contamination, toxicity in food items so posing a health hazard for human beings and animals. The nanotechnology is playing an imperative part in the productivity with control on nutrients release, target specific, smart delivery system and monitoring irrigation water quality for sustainable development of agriculture [5]. Nanotechnology refers to the application of molecules and compounds whose size does not exceed 100 nm [6]. This technique depends on reducing the particle to a size equal to one billionth of a meter (10^{-9} m) and then using the new material [6]. The nano fertilizer allows incorporating nutrients onto a nano dimensional adsorbent. Therefore, this approach leads to the controlled release of active ingredients for a long time and prevents the leaching of nutrients into groundwater, thus reducing the amount of fertilizer used. It is estimated that the amount of nano formulations needed for plants is only equivalent to 20% of conventional fertilizers [7]. Nanotechnology is a new perspective of precision farming which maximizes the output from crops while minimizing the inputs such as fertilizers, pesticides, fungicides and herbicides. Vegetables are voracious nutrient mining crops having a very huge requirement of nitrogen and phosphorus so development of nano form of these will be suitable for the different vegetable crops to enhance the nutritional quality [8]. However, works done on nano-fertilizers is very limited across the global but the reported literature clearly demonstrated that these customized fertilizers have a potential role to play in sustaining farm productivity. Therefore, the aim of this work was to study about the effect of nano fertilizers on the of growth, yield and quality parameters of Okra (*Abelmoschus esculentus*).

2. MATERIALS AND METHODS

The experiment was carried out at the ICAR-Krishi Vigyan Kendra, CARD, Pathanamthitta District, Kerala, India, during the year 2021.

The variety Arka Anamika was used for carrying out the experiment. The experiment was laid out with Randomized Block Design and replicated three times. Okra was planted in the field at a spacing of 0.45 x 0.60 m in plot of 2.25 x 3 m size.

2.1 Statistical Analysis

The data were analysed in randomized block design as per procedure of Cochran and Cox (1959). Interpretation of results was made on the basis of “F” test and critical difference at 0.05 probability calculated to compare the treatments.

2.2 Source of Fertilizers

2.2.1 Nano fertilizer

Nano N: IFFCO: It contains 4.0 % total nitrogen (w/v) evenly dispersed in water. Nano nitrogen particles size varies from 20-50 nm.

Nano P: Tropical Agro: Nano Phos is an innovative, first of its kind product that combines gluconated phosphorus fertilizer and Indian Council of Agricultural Research (ICAR) '4G' Nano nutrient technologies.Tag Nano Phos is a unique proteino-lacto-gluconate formulation that helps to prevent and correct Phosphorus deficiency in the cultivated crops.

Nano K: Tropical Agro: The given product is precisely formulated using acids and 4G Nano

nutrient technology. Nano Potash is a unique proteino-lacto-gluconate formulation, formulated with organic acids based chelated Potash, vitamins and probiotics.

2.2.2 Conventional fertilizer

Source of Nitrogen: Urea (46% N) & FACTAMFOS 20-20-0-15 (Ammonium Phosphate Sulphate) which is a chemical blend of 60 % ammonium sulphate and 40 % ammonium phosphate contains 20% of nitrogen (N) in ammoniacal form (NH4).

Source of Phosphorus: FACTAMFOS 20-20-0-15 (Ammonium Phosphate Sulphate) also contains 20% phosphoric acid (P2O5) in water soluble form (H2PO4).

Source of Potassium: Muriate of Potash (MOP) – (60% K2O).

(Recommended N: P: K dosage for Okra: 110:35:70 kg/ha (Crops 2016, KAU)).

2.3 Application Dosage of Nano Fertilizer

RDF of Liquid formulation (NPK): 4 ml/lit.

RDF of Granular formulation(P&K): 15 - 20 Kg / acre.

Treatment details:

Treatment	Conventional fertilizer	Nano fertilizer	
		Foliar application	Soil application
T1	75% NPK	25% N	25% PK
T2	50% NPK	50% N	50% PK
T3	25% NPK	75% N	75% PK
T4	75% NPK	25% NPK	-
T5	50% NPK	50% NPK	-
T6	25% NPK	75% NPK	-
T7	100% NPK	-	-
T8	-	100% N	100% PK
T9	-	100% NPK	
T10	-	-	-

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

At 30 DAS highest plant height (24.28cm) was recorded in the treatment T2 followed by T3(22.05). The lowest plant height (13.21 cm) was recorded in T10 (Absolute Control). At 60 DAS highest plant height (91.62cm) was recorded in the treatment T2 followed by T5(89.37). The lowest plant height (66.81 cm) was recorded in T10 (Absolute Control). At 90 DAS highest plant height (120.21 cm) was recorded in the treatment T2followed by T5(115.89) and T3(113.91). The lowest plant height (80.62 cm) was recorded in T10 (Absolute Control).

At 30 DAS highest number of leaves per plant (14.51) was recorded in the treatment T2 followed by T5(12.66). The lowest number of leaves per plant (8.54) was recorded in T10(Absolute Control). At 60 DAS highest number of leaves per plant (42.60) was recorded in the treatment T2followed by T5(40.05). The lowest number of leaves per plant (26.29) was recorded in T10(Absolute Control). At 90 DAS highest number of leaves per plant (83.99) was recorded in the treatment T2 followed by T5(80.52). The lowest number of leaves per plant (59.75) was recorded inT10 (Absolute Control).

At 60 DAS highest number of branches per plant (2.50) was recorded in the treatment T2 followed by T5(2.25). The lowest number of branches per plant (1.08) was recorded in T10 (Absolute Control).At 90 DAS highest number of branches per plant (3.62) was recorded in the treatment T2 followed by T5(3.41). The lowest number of branches per plant (1.26) was recorded in T10(Absolute Control).

The enhancement effect of nano fertilizers on these studied characteristics may be attributed to the fact that it has a dimension ranging from 30 to 40 nm which is able to hold numerous ions because of their high surface area and slowly release them in a timely manner to cope with crop demand. Moreover, their slow release and super sorbent phosphatic and nitrogenous fertilizers [9]. The reason might also be attributed to the role of the elements nitrogen and phosphorous, which are included in the synthesis of nucleic acids DNA, RNA, and proteins and their role in increasing cell growth and division, and potassium also have an important role as it works to activate the enzymes responsible for building proteins [10].

Nofal *et al*. [9] found that plant fresh weight, leaf area, head fresh weight and head size of lettuce significantly increased by the application of nano N, P and K fertilizers. Moreover, the highest obtained values were recorded with nano nitrogen at the rate of 50 % compared to other nano treatments and NPK conventional fertilizers (control). Kanjana *et al*. [11] has reported that nano fertilizers increased the plant height at square formation (45 DAS) and harvest stage of the crop than normal source of micronutrients and control. Also similar results were obtained in the findings of Sohair *et al*. [12] ,showed that significant increase in the sympodial branches was achieved with the application of of 50% RFD of nano NPK fertilizers. Significant increase in the height of the plant and the highest increase is has been achieved when the fertigation of the combination of nano NPK fertilizers (53.43 cm) and the traditional fertilizer NPK of (44.33 cm) compared with the comparison treatment, good potato productivity can be achieved through the adoption of fertigation combined with nano N,P and K fertilizers and good irrigation management using dripping irrigation according to the study conducted by Hayyawi and Qusay [13].

3.2 Yield Attributes

The maximum fruit length (12.75 cm) was recorded in treatment T2 followed by T5(12.45). The minimum fruit length (9.08 cm) was recorded in T10 (Absolute Control). The maximum fruit width (1.65 cm) was recorded in treatment T2 followed by T5(1.60). The minimum fruit width (1.07 cm) was recorded in T10(Absolute Control). Similarly, the highest number of pods per plant (29.23 cm) was recorded in treatment T2followed by T5(27.22). The minimum number of pods per plant (19.66 cm) was recorded in T10(Absolute Control). The maximum average of pod weight (g) (29.23 cm) was recorded in treatment T2 followed by T5(12.31). The minimum average of pod weight (g) (19.66 cm) was recorded in T10. The maximum pod yield per plant (g) (370.39) was recorded in treatment followed by T5(335.10),The minimum pod yield per plant (g) (200.48) was recorded in T10(Absolute Control). The maximum pod yield per plot (kg) (8.89) was recorded in treatmentT2) followed by T5(8.04). The minimum pod yield per plot (kg) (4.81) was recorded in T10(Absolute Control). The maximum pod yield (q ha-1) (131.69) was recorded in treatment T2 followed by T5(119.15). The minimum pod yield (q ha-1) (71.28) was recorded in T10 (Absolute Control).

Nano sized active ingredients in fertilizer help to improve nutrient use efficiency and this could be due to their high specific surface area, which facilitates good absorption of the nutrients. The distribution of nano NPK element was found to be uniform and their use efficiency was 97.43 %, 98.11% and 97.03 %, respectively Akhilesh et al. [14]. The author also got the similar findings as we recorded in out experiment, due to nanostructured formulation of fertilizer release of nutrients into the soil happens gradually and in a controlled way which is beneficial to increase soil microbial population and enzyme activity. Foliar feeding enhances plant height, leaf area, number of leaves per plant, dry matter production, chlorophyll production, rate of the photosynthesis resulting in more production and translocation of photosynthates to different parts of the plant [14].

Kumbhar et al. [15] has observed that nitrogen application promoted photosynthetic rate, assimilates production and accumulation that ultimately boosted final seed cotton yield. Davarpanah et al. [16] found that a small amount of nano N applied via foliar fertilization improves yield and quality in pomegranate orchards established in less fertile soil. In an experiment carried out using integrated nano fertilizer Huong et al. [17] reported that the ability of the plant to build up dry matter influences the formation of active ingredients in the Polyscias fruticosa, thereby affecting the quality of the medicinal plants (roots and leaves) after harvest. Using an integrated nano fertilizer helped to improve the ability to accumulate dry matter of Polyacids fruticose, thereby increasing the value and economic benefits of the plant. In study conducted by Nofal et al. [9] it was found that the

Table 1. Effect of Nano Fertilizer on growth traits of Okra

Treatment No.	Plant height (cm)			Number of leaves per plant			Number of branches per plant	
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	60 DAS	90 DAS
T1	18.99	81.66	103.55	11.08	36.29	73.85	1.95	2.12
T2	24.28	91.62	120.21	14.51	42.60	83.99	2.50	3.62
T3	22.05	86.28	113.91	12.36	39.49	78.99	2.18	3.34
T4	17.74	80.19	100.88	10.65	35.34	70.22	1.74	2.64
T5	20.60	89.37	115.89	12.66	40.05	80.52	2.25	3.41
T6	20.16	83.65	109.66	11.75	37.71	76.76	2.08	2.89
T7	16.35	77.77	97.46	10.55	35.54	67.18	1.59	1.95
T8	16.28	74.12	92.55	10.47	31.45	68.55	1.41	1.75
T9	16.22	72.66	89.52	10.00	30.75	63.18	1.43	1.57
T10	13.21	66.81	80.62	8.54	26.29	59.75	1.08	1.26
F-Test	S	S	S	S	S	S	S	S
C.D. at 0.5	1.81	2.86	3.01	1.05	1.76	7.27	0.21	0.31
S.Ed.	0.86	1.36	1.43	0.50	0.84	3.46	0.10	0.15
CV	5.66	2.07	1.71	5.43	2.88	5.86	6.62	7.46

CD-critical difference , SED-Standard error of difference ,CV-Coefficient of variation

Table 2. Effect of Nano fertilizer on yield and quality traits of Okra

Treatment No.	Yield traits								Quality trait
	Days to first harvesting	Pod length (cm)	Pod width (cm)	Number of pods per plant	Average of pod weight (g)	Pod yield per plant (g)	Pod yield per plot (kg)	Pod yield (q ha-1)	TSS
T1	55.59	11.65	1.41	23.55	12.08	284.47	6.83	101.14	2.66
T2	46.97	12.75	1.65	29.23	12.67	370.39	8.89	131.69	2.93
T3	50.63	12.31	1.57	26.51	12.23	324.36	7.78	115.33	2.79
T4	57.65	11.49	1.33	21.68	11.86	257.14	6.17	91.43	2.51
T5	48.91	12.45	1.60	27.22	12.31	335.10	8.04	119.15	2.82
T6	53.52	12.24	1.48	24.77	12.18	301.56	7.24	107.22	2.70
T7	59.55	11.27	1.24	21.61	11.63	251.49	6.04	89.42	2.39
T8	61.28	10.66	1.28	20.91	11.48	240.12	5.76	85.37	2.34
T9	59.92	10.19	1.24	20.36	10.70	217.82	5.23	77.45	2.27
T10	61.75	9.08	1.07	19.66	10.20	200.48	4.81	71.28	2.14
F-Test	S	S	S	S	S	S	S	S	S
C.D. at 0.5	2.68	2.68	0.16	2.07	0.30	27.02	0.65	9.61	0.09
S.Ed.	1.28	1.28	0.08	0.99	0.14	12.86	0.31	4.57	0.18
CV	2.81	2.81	6.89	5.13	1.47	5.66	5.66	5.66	4.09

CD-critical difference, SED-Standard error of difference ,CV-Coefficient of variation

yield and marketable yield were significantly increased gradually with the increase in nano N – P – and K rates. Moreover the highest significant increase in total and marketable yield was produced from nano nitrogen application at the rate of 50% compared to other nano treatments and control. Similar results were given by Mishra et al. [18] on an experiment carried in tomato using nano fertilizer. the interaction between nanoparticle and fertilization achieved increased concentrations of nitrogen and phosphorous elements in the fruits, therefore, this reflected positively on the increase in growth and yield, and the improvement of production and quality. From his field experimental study Jabri et al. [19] have concluded that the interaction between nanoparticle and fertilization achieved increased concentrations of nitrogen and phosphorous elements in the fruits, therefore, this reflected positively on the increase in growth and yield, and the improvement of production and quality.

3.3 Quality Attribute

3.3.1 T.S.S. of fruit

The maximum TSS (Brix) (2.93) was recorded in treatment T2followed by T5(2.82). The minimum TSS (0Brix) (2.14) was recorded in Absolute Control.

These findings are in close consonance with those of Nofal et al. [9] it was found that 50 % of nano potassium treatment produced the highest significant increment of ascorbic acid, TSS and head total sugars content. The increase in ascorbic acid TSS and head sugar content may be attributed to The role of potassium in photosynthesis is very important due to the activation of enzymes by K and its involvement in adenosine triphosphate (ATP) production is probably more important in regulating the rate of photosynthesis. As it is known that, ascorbic acid synthesized from sugars supplied through photosynthesis in plants Lee and Kader et al. [20]. Which was also supported by [9]. Davarpanah et al. [16] on a study on foliar nano nitrogen have reported that increases in TSS in juice were found with the treatments nN2(0.50) and U1(4.60). This was also supported by the findings of Sarker and Rahimet al. [20] Singh et al. [21].

In the present study T2 was yielding better result in all the treatment combinations. This might be due to the fact that the basal dose fertilizer requirement of the okra plant was met with the supply of conventional fertilizer, this contributed to the vigor growth of the plant initially and the later requirement of the fertilizer was met with the application of nano fertilizers. With high nutrient use efficiency nano fertilizer was able to enhance the later growth of the plant effectively. The nanostructured formulation with nano N particle having size varying from 20-50nm can easily penetrate into the stomatal pores and augment the nutrient absorption. Also, with the soil application of nano nano P&K fertilizer the nutrients are released into the soil in a controlled and gradual manner which enhance better nutrient supply to the plant, also the microbial population and enzyme activity in the soil might have increased due to the less impact of the nano fertilizers to the soil. This result is supported by the findings of Akhilesh et al. [14]. However, the researches and study on nano fertilizers is still under progress. Molecular level functioning and impact of nano fertilizer has not been done in this study due to the limited availability of data.

4. CONCLUSION

Based on the result of experiment, it may be concluded that the treatment T2 (Soil application of 50% RDF as Traditional fertilizer + 50 % recommended dose of nano N as foliar application, P&K as soil application) was recorded the best among in all combination of Traditional fertilizer NPK and nano NPK in term of growth, yield and quality parameters .

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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