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Impact of integrated nutrient management on fruit yield and quality of okra

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Abstract

Okra, a crop with multiple uses, is prized for its soft and tasty beans. In India, only fruits of okra are consumed. The current study was conducted over the course of two consecutive summer years in 2023 and 2024 at the Experimental Farm, School of Agriculture Science, LNCT University, Bhopal, (M.P.) to assess the "Impact of integrated nutrient management on fruit yield and quality of okra." Three replications and eleven treatments (T0 – T10) were included in the experiment, which was conducted using a Randomized Block Design. The experiment included monitoring parameters of number of fruit plant⁻¹, fruit length (cm), fruit diameter (cm), weight of individual fruit (g), fruit yield (q ha⁻¹), total soluble solid (°Brix), protein content (%) and ascorbic acid (mg/100 g). The highest quality fruits are produced by plants when fertilizer combinations are used rather than single fertilizer treatments. In the summer of 2023 and 2024, treatment T₇ produces higher yields and is of better quality.

Keywords: Nutrients, inorganic fertilizers, organic fertilizers, okra and quality

Introduction

The Malvaceae family includes okra (*Abelmoschus esculentus* L.) and is a widely used vegetable crop. Worldwide, it is grown in tropical and subtropical regions and it is a significant source of income of vegetables. A crop that may be grown both as a garden crop and on big commercial farms. It is sometimes referred to as lady's finger or bhindi. The main purpose of okra cultivation is to grow its soft and immature fruits for culinary purposes. Besides being rich in proteins, carbohydrates, lipids, minerals, iron and iodine, okra also has a very good nutritional value and is a strong source of vitamins A, B and C (Longvah *et al.*, 2017) ^[7]. The careful application of fertilizer is one of the many elements that contribute to the successful cultivation of okra. A vital component and key factor in the growth and development of agricultural plants is nitrogen (Shah *et al.* 2023) ^[15]. It contributes significantly to the synthesis of chlorophyll, proteins, nucleic acids, hormones and vitamins. It also facilitates cell division and elongation (Firoz, 2009) ^[6]. The early growth and overall fruit yield of okra depend on the requirements of fertilizers. The production of crops can be increased by using organic and inorganic fertilizers in combination. Vermicompost enrichment of soil provides nutrients that chemical fertilizers do not provide (Mal *et al.*, 2013) ^[9]. Organic fertilizer known as "farmyard manure" (FYM) is formed when leftover feed, bedding and animal waste decompose. This resource is excellent for increasing beneficial microbial activity, improving soil fertility and making essential minerals such as potassium, phosphorus and nitrogen more accessible. Farmyard manure (FYM) can support environmental sustainability and soil productivity when used consistently (Singh *et al.*, 2016) ^[19]. A good option for promoting plant growth is poultry manure, a potent organic fertilizer that is rich in essential minerals including potassium, phosphorus and nitrogen. According to Moral *et al.* (2009) ^[11], this material also has significant levels of calcium and magnesium, which support microbial activity and improve soil structure. The objective of this study is to look into the response of organic and inorganic fertilizer combinations on the yield and quality parameters of okra.

Materials and Methods

The present experiment was conducted to evaluate the "Effect of integrated nutrient management on fruit yield and quality of okra" at the Experimental Farm, School of Agriculture Science, LNCT University, Bhopal, (M.P.) during two consecutive years of 2023 and 2024. The experiment was laid out in Randomized Block Design with three replications and eleven treatments *i.e.* T₀ (Control), T₁ (100% RDF), T₂ (Vermicompost @ 10 t ha⁻¹), T₃ (75% RDF + Vermicompost @ 10 t ha⁻¹), T₄ (100% RDF + Vermicompost @ 10 t ha⁻¹), T₅ (Poultry manure @ 10 t ha⁻¹), T₆ (75% RDF + Poultry manure @ 10 t ha⁻¹), T₇ (100% RDF + Poultry manure @ 10 t ha⁻¹), T₈ (FYM @ 10 t ha⁻¹), T₉ (75% RDF + FYM @ 10 t ha⁻¹) and T₁₀ (100% RDF + FYM @ 10 t ha⁻¹). During the study, the observations were recorded on number of fruit plant⁻¹, fruit length (cm), fruit diameter (cm), weight of individual fruit (g), fruit yield (q ha⁻¹), total soluble solid (°Brix), protein content (%) and ascorbic acid (mg/100 g) in five tagged plants. OPSTAT software was used to analyze the data collected during the experiment. The Department of Mathematical Statistics, CCS HAU, Hisar, Haryana generate this software.

Results and Discussion

Yield parameters

Different treatments using both organic and inorganic fertilisers had a substantial impact on the yield parameter, which includes number of fruit plant⁻¹, fruit length (cm), fruit diameter (cm), weight of individual fruit (g), fruit yield (q ha⁻¹) in 2023 and 2024. This is shown in Table 1.

Number of fruit plant⁻¹

The number of fruit plant⁻¹ significantly varied from 11.05 to 16.50 for summer 2023 and ranged between 10.59 to 16.39 for summer season 2024. The highest values in both seasons recorded in T₇ - 100% RDF + Poultry manure @ 10 t ha⁻¹ (16.50 & 16.39), respectively. While, the lowest value for number of fruit plant⁻¹ observed in T₀. Number of fruit plant⁻¹ in okra is affected by many factors like fruit size, number of fruits and overall plant health are really important. This parameter is also affected by biotic and abiotic factors. The study found that there was a significant difference in the fruit yield per plant from each of the eleven treatments with different doses. The combination of organic and inorganic fertilizers increased the yield compared to single dose of fertilizer as they help in nutrient availability and improve soil structure which are responsible for easy availability of nutrients to the plants. According to Premshekhhar and Rajashree (2009) [12], the highest number of fruits per plant was observed after the application of 20 tones/ha of farm yard manure. Wagh *et al.* (2014) [23] found that fruits increased on application of 100% RDF dose.

Fruit length (cm)

The value of fruit length ranged significantly from 10.13 cm to 11.34 cm for summer season 2023 and while during summer season 2024, it varied from 10.01 cm to 11.21 cm. The maximum length of fruit showed in T₇ - 100% RDF + Poultry manure @ 10 t ha⁻¹ (11.34 cm & 11.21 cm) during both seasons respectively. While studying treatments with different doses for fruit length in okra, it is often found that the plants produce longer fruits with combined fertilizers as compare to single dose. This increase in fruit length can increase its marketability and yield. In this study found substantial changes in fruit length

among the eleven treatments, which used different combinations of organic and inorganic fertilizers. The combined treatments that use in both forms of fertilizer produced longer fruits, possibly due to improved nutrient availability and balanced nutrient distribution, that increased the cell division and overall fruit development than single nutrient application. The similar findings were also reported by Thirunavukkarasu and Balaji (2015) [21] and Adhikari and Piya (2020) [1].

Fruit diameter (cm)

The diameter of fruit significantly varied from 15.40 to 16.02 for summer 2023 and ranged from 15.30 to 15.85 for summer season 2024. The highest values of both seasons found in T₇ - 100% RDF + Poultry manure @ 10 t ha⁻¹ (16.02 cm & 15.85 cm, respectively). During the experiment with different doses of fertilizer treatments in okra, it is often observed that T₇ nutrient combination have larger fruit diameters than control and single dose of fertilizers. This increased size increases market appeal and yields. According to Bharadiya *et al.* (2007) [5], the uses of 50% RDF with combinations of 50% N + neem cake improved and increased the diameter than single nutrients. Significant variations in fruit diameter were seen in this study across the eleven treatments, each of which had a unique mix of inorganic and organic fertilizers. Compared to single nutrient administration, the combination treatments using both forms of fertilizer produced thick fruits, probably because of better nutrient availability and balanced nutrient distribution that increased cell elongation & division with total fruit development. A similar finding was also made by Sharma *et al.* 2014 [16] and Adhikari and Piya (2020) [1].

Weight of individual fruit (g)

The weight of individual fruit significantly ranged from 11.05 to 16.50 for summer 2023 and for 2024, varied between 9.14 to 10.49. The highest value of the trait found in T₇ - 100% RDF + Poultry manure @ 10 t ha⁻¹ (10.86 & 10.49) during both seasons, respectively. In this study, the effect of different nutrient combinations in treatments was evaluated on different fruit weights, which showed distinct variations among treatments. Higher height compared to the control was the result of treatments that included both organic and inorganic fertilizers. According to Bairwa *et al.* (2009) [3] and Wagh *et al.* (2014) [23] noticed that the RDF of NPK with combination of neem cake and vermicompost result in maximum weight of okra fruit. The results also suggest that the application of organic fertilizers like vermicompost, farm yard manure and poultry manure along with chemical fertilizers (NPK) provide favorable conditions for plants, because nutrients are available in sufficient amounts. when only organic or inorganic inputs were applied singly without combination, lower fruit weight was observed. Therefore, use of organic nutrients along with chemical fertilizers provides better fruit weight without much impact on the environment. The same results of experiment were also supported by Wagh *et al.* (2014) [23], Meena and Bhati (2016) [10] and Singh *et al.* (2018) [18].

Fruit yield per plant (g)

Different treatments using both organic and inorganic fertilizers had significant effects on the fruit yield produced per plant in 2023 and 2024. For the summer of 2023, the trait value varied from 103.96 g to 179.00 g, while for the summer of 2024, it ranged from 101.12 g to 173.00 g. In both seasons, T₇ showed

the highest fruit yield (179.00 g). Fruit yield of okra per plant depends on many variables, including fruit size, quantity and general plant health. Both biotic and abiotic variables influence it. Many variables, including nodes, leaves, fruit length, fruit diameter and other contributing characteristics, influence the amount of fruit produced by a plant when thoroughly examined in the field. High yields are usually obtained by a combination of these elements. It is observed that when different combinations of organic and inorganic fertilizers are used, there is a significant variation in fruit production for each of the 11 treatments. A similar finding was also made by some following researchers viz., Wagh *et al.* (2014)^[23] and Santos *et al.* (2019)^[14].

Fruit yield (q ha⁻¹)

The fruit yield significantly ranged from 77.01 q ha⁻¹ to 132.60 q ha⁻¹ for summer 2023 and varied from 74.90 q ha⁻¹ to 128.15 q ha⁻¹ for summer season 2024. The highest value for the trait found in T₇ (132.60 q ha⁻¹ and 128.15 q ha⁻¹) in both seasons, respectively. Fruit yield is a complex trait controlled by more than one growth traits such as plant height (cm), days to 50% flowering, days to first fruit picking, number of nodes, number of leaves, number of fruits per plant, fruit yield per plant, fruit length (cm), fruit diameter (cm), etc. Generally, low and high yield depends on these traits along with biotic and abiotic factors. It is often observed that there was variation in the germplasm of the growth traits responsible for yield due to shoot and fruit boring insects, yellow vein, high temperature and heavy rainfall. In the experiment conducted by Bhandari *et al.* (2019)^[4], significant yield was achieved by using synthetic fertilizer. According to Makinde and Ayola (2012)^[8], cow dung manure was found to be a better organic fertilizer for increasing the growth and fruit yield of okra plants. It has been observed that when various combinations of organic and inorganic fertilizers are used, the fruit production for each of the 11 treatments varies significantly. The majority of plant fruits are produced by fertilizer treatment combinations rather than by the application of a single fertilizer. A similar finding was also made by Sharma *et al.* (2020)^[17] and Kumari and Salaria (2023).

Quality parameters

Significant increase was observed in TSS, protein content and ascorbic acid and it was affected by different types of organic and inorganic nutrients in both the seasons, which was given in the following parameters:

Total Soluble Solid (°Brix)

The TSS in plants significantly varied from 2.68 °Brix to 3.27 °Brix for summer 2023 and for summer season 2024, ranged significantly between 2.19 °Brix to 3.12 °Brix. The highest value found in T₇ - 100% RDF + Poultry manure @ 10 t ha⁻¹ (3.27 °Brix & 3.12 °Brix) during both seasons, respectively. When researching different treatments in okra for the traits, it is common to find that the combination of nutrients has higher

total soluble solids than the single application of fertilizer. The increase and decrease of TSS, possibly also due to genetic combinations. The higher TSS can improve the taste and quality of the fruit. Fertilizers with different combinations (75% NPK + poultry manure @ 2.5 tons + vermicompost @ 2.5 tons per hectare) gave higher TSS than single nutrient application (Sachan *et al.*, 2017)^[13]. The similar experiments also observed by Yadav *et al.* (2016)^[24] and Arjun *et al.* (2018)^[2].

Protein content (%)

The value protein content ranged significantly from 13.55% to 14.70% for summer season 2023 and varied from 13.41% to 14.58% for summer season 2024. During both seasons, the maximum protein content observed in T₇ - 100% RDF + Poultry manure @ 10 t ha⁻¹ (14.70 & 14.58%), respectively. Adequate nitrogen and balanced nutrients supply are crucial for optimizing of higher protein. Cultivation practices that ensure adequate nitrogen and balanced nutrient supply can support high protein content in fruits of okra. This superiority was due to the combined use of organic materials include vermicompost, poultry manure and farm yard manure along with inorganic fertilizers that build the health of soil and give the nutrients in a slow form as well as improved the biological activity of the soil. In contrast, the effect of inorganic fertilizers (NPK) is that they provide nutrients from the soil to the plants very quickly and have a quick effect on the plants after absorption. Fertilizers with different combinations provide higher protein than single nutrient application (Bairwa *et al.*, 2009)^[3]. According to Thirunavukkarasu *et al.* (2014)^[21], protein content was found in better amount, where mixed fertilizer was higher than single application. The similar findings were also reported by Wagh *et al.* (2014)^[23], Singh *et al.* (2016)^[19], Sachan *et al.* (2017)^[13] and Arjun *et al.* (2018)^[2].

Ascorbic acid (mg/100 g)

The ascorbic acid significantly varied from 13.71 mg to 16.56 mg for summer 2023 and ranged between 12.25 mg to 16.52 mg for summer season 2024. The highest value for the trait in both seasons noticed in T₇ - 100% RDF + Poultry manure @ 10 t ha⁻¹ (16.56 mg & 16.52 mg), respectively. Vitamin-C act as an antioxidant, protecting plant cells from oxidative stress. Healthy plants with optimal nutrients and water supply can produce more antioxidant. According to Tripathy *et al.* (2007)^[22] and Thirunavukkarasu *et al.* (2014)^[21], the uses of different combinations of organic and inorganic fertilizer improved and increased the ascorbic acid than single nutrients. Different combinations of fertilizers resulted in good amount of ascorbic acid than using single organic or inorganic fertilizers. This difference in the trait may depend on the nutrient provided by integrated treatments which increases the plant metabolism. The synergy between organic and inorganic fertilizers accelerates nutrient availability thereby improving highest acid. The similar experiments also conducted by Singh *et al.* (2018)^[18] and Smriti and Ram (2018)^[20].

Table 1: Effect of organic and inorganic fertilizer combinations on yield parameters of okra

Treatments	Number of fruit plant ⁻¹		Fruit length (cm)		Fruit diameter (cm)		Weight of individual fruit (g)		Fruit yield (q ha ⁻¹)		Total Soluble Solid (°Brix)		Protein content (%)		Ascorbic acid (mg/100 g)	
	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
T ₀	11.05	10.59	10.13	10.01	15.40	15.30	9.40	9.14	77.01	74.90	2.68	2.19	13.55	13.41	13.71	12.25
T ₁	14.15	13.88	10.65	10.52	15.63	15.47	10.16	9.85	106.35	103.05	2.97	2.65	14.11	13.98	15.42	14.81
T ₂	13.80	13.51	10.56	10.44	15.60	15.43	9.74	9.46	99.30	96.38	2.78	2.35	13.85	13.72	15.28	14.59
T ₃	14.55	14.31	10.65	10.52	15.60	15.43	9.82	9.53	105.82	102.72	2.93	2.58	14.04	13.90	16.17	15.94
T ₄	16.16	16.02	11.08	10.95	15.95	15.78	10.58	10.23	126.57	122.45	3.23	3.06	14.50	14.38	16.32	16.15
T ₅	14.01	13.74	10.39	10.27	15.56	15.40	9.65	9.38	100.24	97.37	2.85	2.46	14.68	14.56	15.39	14.77
T ₆	15.55	15.37	10.91	10.78	15.74	15.57	10.16	9.85	117.11	113.53	3.14	2.91	14.35	14.22	16.41	16.29
T ₇	16.50	16.39	11.34	11.21	16.02	15.85	10.86	10.49	132.60	128.15	3.27	3.12	14.70	14.58	16.56	16.52
T ₈	13.35	13.04	10.21	10.10	15.56	15.40	9.57	9.30	94.49	91.80	2.74	2.28	13.69	13.55	15.02	14.22
T ₉	14.23	13.97	10.56	10.44	15.60	15.43	9.82	9.53	103.46	100.41	2.91	2.56	13.98	13.85	15.44	14.83
T ₁₀	14.94	14.73	10.91	10.78	15.77	15.61	10.41	10.08	115.07	111.39	3.02	2.73	14.45	14.32	15.58	15.05
SEm ±	0.91	0.43	0.20	0.21	0.11	0.10	0.21	0.24	6.79	6.64	0.03	0.056	0.23	0.20	0.17	0.28
CD (5%)	2.69	2.45	0.60	0.62	0.33	0.30	0.63	0.72	20.02	19.60	0.10	0.165	0.69	0.60	0.51	0.84

T₀: Control, T₁: 100% RDF, T₂:Vermicompost @ 10 t ha⁻¹, T₃: 75% RDF + Vermicompost @ 10 t ha⁻¹, T₄: 100% RDF + Vermicompost @ 10 t ha⁻¹, T₅: Poultry manure @ 10 t ha⁻¹, T₆: 75% RDF + Poultry manure @ 10 t ha⁻¹, T₇: 100% RDF + Poultry manure @ 10 t ha⁻¹, T₈: FYM @ 10 t ha⁻¹, T₉: 75% RDF + FYM @ 10 t ha⁻¹, T₁₀: 100% RDF + FYM @ 10 t ha⁻¹

Conclusion

Both organic and inorganic fertilizers are required for plant growth and development. Different nutrient combinations on quantitative and qualitative traits revealed significant variations among treatments. Treatments with two fertilizers (organic and inorganic) gave better yield than the control. As a result, T₇ treatment with organic nutrients in addition to chemical fertilizers gives higher yield and better quality with no impact on the environment for two summer seasons (2023 and 2024). As a result, this technology has commercial farming applications in Bhopal region of Madhya Pradesh. The maximum B:C ratio and net return were also observed in T₇ treatment.

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