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Integrated Approach of Nutrient Management for Improvement in Crop Productivity of Okra (*Abelmoschus esculentus* (L.) Moench) *cv.* Arka Anamika

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ABSTRACT: At present agricultural production is at stagnation as the genetic potential of various vegetable crops or varieties is being utilized up to maximum through application of recommended doses of fertilizers (RDF). The scientific community is looking forward for some suitable advancement in crop production to resolve this challenge. Among the various approaches which are being currently investigated, integrated nutrient management by using organic and inorganic sources of nutrients, fertigation approach, protected cultivation and micronutrient applications are common and reflecting considerable improvement. Considering the significance of integrated approach of nutrient management, the present investigation was carried out with the objectives to determine the impact of organic nutrient sources like farmyard manure (FYM) and vermicompost (VC) and inorganic nutrient sources on growth, yield and quality and production of okra *cv*. Arka Anamika. The replicated experiment was set up with twelve treatments by using 50 %, 75 % or 100 % of RDF with combination of FYM and/or VC. Among various treatments, T_{11} (100% RDF + FYM + VC) application resulted in maximum plant height (80.20 cm), number of branches (5.56), number of leaves (68.83), number of nodes per plant (21.33), internodal length (6.91 cm), number of days until first flowering (39.5), number of fruits per plant (18.5), fruit length (17.5 cm), fruit weight (18.34 gm), yield quintal per hectare (8.88 q/ha) with good quality okra fruits and highest net income (Rs. 322589.22) and B:C ratio (2.36). Thus, integrated use of organic and inorganic sources of nutrients is the best strategy to increase productivity and economic yield in okra.

Keywords: B:C ratio, Inorganic fertilizers, Okra, Net Income, Productivity, Vermicompost.

INTRODUCTION

The okra (*Abelmoschus esculentus* (L.) Moench) is an economically important vegetable crop and grows well in tropical and subtropical areas of the world. It is a member of the family Malvaceae and is originated in tropical Africa. Due to the richness of nutrients, flavour, medicinal benefits, and industrial uses of okra, it is one of the most popular vegetables across all demographic groups. The fibres, fruits, or pods of okra are grown for food.Okra is a crop with many uses because all its parts, including the fresh leaves, blossoms, pods, stem, and seeds, can be used (Sharma *et al.,* 2016). Okra is annual crop which has a 90- to 100-day life cycle and is propagated through seeds.

Like other vegetable crops, okra responds well to the fertilization, so several experimentations have been conducted to understand the effective approach for nutrient management in this crop to exploit its genetic potential for high productivity and economic yield. Among the various approaches which are being investigated in vegetable production, integrated nutrient management by using organic and inorganic sources of nutrients, fertigation approach, protected cultivation and micronutrient applications are common (Singh *et al.*, 2018a; Singh & Singh, 2019; Bahadur *et al*., 2021; Tyagi *et al*., 2022).

Organic manure is a dependable source of macro and micronutrients that contributes to the physical, chemical, and biological health of the soil, reduces nutrient losses, increases nutrient availability, and promotes nutrient uptake, leading to sustainable production with no harmful residues in addition to enhancing the quality of vegetables (Acharya and Mandal 2000). Additionally, the combination of organic and inorganic nutrient sources could lead to long-term sustainability of productivity (Kumar *et al.,* 2017). The inclusion of organic manures like farmyard manure (FYM) and vermicompost (VC) in the plant nutrient management ensures the availability of micronutrients and secondary major nutrients which is not available when only recommended dose of fertilizers (RDF) is applied (Singh & Sharma 2016; Kumar *et al*., 2018). The availability of micronutrient like Zn, Cu, Mn etc and secondary major nutrients like Ca, Mg and S is very crucial in supporting several metabolic processes in plant body which is directly related to plant growth, biomass production, dry matter production and quality yield (Kaur *et al*., 2018; Singh *et al.*, 2018a). Thus, the present investigation was carried out with the objectives to determine the impact of organic and inorganic sources of nutrients on growth, yield and quality and production of okra *cv*. Arka Anamika.

MATERIALS AND METHODS

The investigation was carried out to study the effect of organic and inorganic sources of nutrients on the productivity and economics of okra cultivation at the Crop Research Centre (CRC)-1 of the School of Agriculture, ITM University Gwalior, M.P. during the Zaid season in the year 2022. The Gwalior region of Madhya Pradeshhas a subtropical climate. The soil of the experimental field had a loamy sand texture and mildly alkaline.The experiment was set up using a randomised block design, and twelve treatments were replicated three times. There were 36 plots, with a net plot size of 7.5 (m^2) where seed were sown at 60 cm as row-to-row and 45 cm as plant-to-plant distances. The twelve different treatments were: T_0(control),T_1 (FYM),T_2 (VC), T_3 (50% RDF + FYM), T_4 (50% RDF + VC),T_5 (50% RDF + FYM + VC),T_6 (75% RDF + FYM),T_7 (75% RDF + VC),T_8 (75% RDF + FYM + VC),T_9 (100% RDF + FYM),T_{10} (100% RDF + VC), T_{11}(100% RDF + FYM + VC).

Through tillage and pulverization, the soil was brought to a good tilth. The bunds and irrigation channels were carefully maintained, and the seeds are sown directly into the ground. After seeding development, a light irrigation was provided. Before sowing, the organic manures were applied as a basal dose as per the treatment. The full doses of phosphorous and potassium and the half dose of nitrogen as prescribed by treatment were applied right before the planting. The second half of the nitrogen dose was applied after 30 days after seeding.When observations were made, all cultural customs were consistently followed.

The observations were taken on various growth-related attributes like plant height, number of branches, number of leaves, number of nodes per plant, and internodal length; yield and related attributes like days till first flowering, number of fruits, length of fruits, weight of fruits, yield in kg per plot, and yield quintal per hectare; fruit quality attributes in okra like nitrogen, phosphorus, potassium, protein content and crude fiber content while economics of cultivation was estimated for different treatments as net income and benefit- cost (B:C) ratio. All the observations taken during study were estimated by using one way ANOVA (analysis of variances) at 5% level of significance through OPSTAT software.

RESULT AND DISCUSSION

Growth related attributes. The application of both organic and inorganic sources of nutrients together had a considerable impact on the growth-attributing features, including plant height, number of branches, leaves, nodes, and internodal length (Table 1). The maximum plant height (80.20 cm), number of branches (5.56), number of leaves (68.83), number of nodes (21.33), and internodal length (6.91 cm) were obtained using 100% RDF + FYM + VC and minimal in T_0 (control). It has been discovered through the study of vegetative characteristics that a full dose of organic and inorganic fertilizers outperforms a single application of fertilizer. In addition of ensuring correct soil aeration and enhancing the soil's ability to retain water, organic manures aid in enhancing soil health (Ray *et al*., 2005; Sharma and Choudhary 2011; Singh *et al*., 2016a; Singh, 2018). This could be further, confirmed by the facts that greater nutrient doses as RDF with organic supplements as vermicompost or biofertilizers is responsible for improvement in soil and plant nutrient status which promotes greater metabolic activities resulting improvement in biomass production (Singh *et al*., 2014; Singh *et al*., 2018b,c; Ramandeep *et al*., 2018; Lallawmkima *et al*., 2018a).

Yield and related attributes. The results of the research investigation's okra flowering, yielding, and fruiting parameters are presented in Table 2. RDF, FYM, and VC alone or in combination improved yield and yield-attributing characteristics. Application of 100% RDF in combination with FYM and VC in T_{11}taken minimum number of days to first flowering (34.83),resulted in maximum number of fruits per plant (18.5), maximum fruit yield per plot (10.79 kg), and maximum fruit yield per hectare (15.99tons).The reasons for the improvement in yield and yield related attributes after the addition of RDF, FYM, and VC is supported by a rise in the uptake of N, P, K, Cg, Mg, etc (Anmol and Singh 2018; Singh and Singh, 2019). Likewise, T_{11} had the highest fruit length (17.5 cm), maximum fruit weight (23.34 gm). Similar findings indicating the combined use of organic and inorganic manures enhanced greater growth and fruit yield of okra have also been reported by Tyagi *et al*. (2016). This might be attributed due to the increased availability of NPK, other minerals and water at critical stages of the crop resulting early establishment, vigorous growth, and larger fruits due to application of higher dose of nutrients through RDF (Kaur *et al.*, 2018; Gorakh *et al.*, 2021; Tyagi *et al.*, 2022).

Quality attributes of okra fruits. Application of 5 tonnes of vermicompost per hectare considerably increased the nitrogen, phosphorus, potassium, and protein content in okra fruits compared to control and 15 tonnes of FYM per hectare (Table 3). Application of vermicompost or FYM or other organic sources like biofertilizers may boost the availability of other nutrients including nitrogen, phosphorous, and potassium likely due to a higher rate of mineralization and favourable conditions for microbial and chemical activity, which in turn increased the N, P, K, and protein content in okra fruits (Singh *et al*., 2016b; Rohith *et al*., 2022). According to Sharma *et al.* (2009), another factor could be the enhanced activity of nitrate reductive enzymes, which aided in the synthesis of specific amino acids and proteins. Nitrogen, phosphorus, potassium, and protein content of okra fruits were markedly increased by the addition of RDF which could be due to improved nutrient availability in the root zone and the plant's system because nutrient availability in the plant is directly correlated with the plant's growth and availability in the feeding zone (Lallawmkima *et al.*, 2018b). Higher nutrient content in fruits appear to result in roots functioning more effectively for a longer time while being treated. Nanthakumar & Veeraragavathatham (2001) noted the rise in N, P, and K content in fruit because of proper fertilization. The increase in nitrate reductase activity, which assisted in the synthesis of specific amino acids and proteins, may be associated to the accumulation of fruits with greater protein content. Thus, current study supports the integrated approach for nutrient management in vegetable crops for high grade or quality production (Singh & Lallawmkima 2018; Singh *et al*., 2018d).

Economic analysis of INM in okra cultivation. The estimates of economics of okra cultivation after INM approach shows that net returns influenced significantly due to application of different organic and inorganic sources of nutrients (Table 4). The gross and net return was highly influenced by application of different nutrient sources and application 100% RDF in combination with FYM and VC recorded significantly higher net return (Rs. 559727.78 and Rs. 322589.22) followed by application 100% RDF in combination with VC (Rs. 506702.78 and Rs. 314564.22).

Table 1: Plant growth attributes of okra after application of organic and inorganic sources of nutrients.

Treatments	Plant height (cm)	Number of branches per plant	Number of leaves per plant	Number of nodes per plant	Internodal length (cm)
T_0	56.75	4.10	63.00	19.50	4.66
T_1	57.70	4.30	64.16	18.83	4.91
T_2	60.25	4.46	65.16	19.08	5.50
T_3	64.20	4.64	62.08	19.41	4.41
T_4	69.37	4.73	64.00	19.42	5.33
T_5	65.75	4.82	63.75	19.75	5.4
T_6	70.87	5.00	64.25	19.66	5.41
T_7	73.87	5.10	64.91	19.91	6.25
T_8	78.16	5.23	64.58	19.66	5.66
T_9	75.66	5.33	66.08	21.25	6.50
T_{10}	77.58	5.43	66.58	21.41	6.41
T_{11}	80.20	5.56	68.83	21.33	6.91
SE(m)±	**2.12**	**0.02**	**0.789**	**0.533**	**0.08**
CD	**2.46**	**0.26**	**1.504**	**1.236**	**0.480**

Table 2: Yield and related attributes of okra after application of organic and inorganic sources of nutrients.

Treatments	Days to first flowering	Number of fruits per plant	Fruit length (cm)	Fruit weight (gm)	Yield(kg/plot)	Yield (tons/ha)
T_0	41.25	12.32	10.50	13.08	4.03	5.97
T_1	40.58	13.00	11.25	16.92	5.50	8.15
T_2	40.50	13.50	11.50	17.00	5.74	8.50
T_3	39.41	13.33	14.50	20.33	6.77	10.04
T_4	37.51	15.50	14.75	20.48	7.94	11.76
T_5	36.75	15.41	15.41	20.97	8.08	11.97
T_6	36.16	16.25	16.41	21.85	8.88	13.15
T_7	36.17	14.50	14.75	20.58	7.46	11.05
T_8	36.00	15.00	15.66	21.34	8.00	11.86
T_9	38.91	16.83	15.50	21.05	8.86	13.12
T_{10}	37.33	17.25	16.70	22.66	9.77	14.48
T_{11}	34.83	18.50	17.50	23.34	10.79	15.99
SE(m)±	**0.588**	**0.132**	**0.06**	**0.107**	**0.02**	**0.344**
CD	**1.299**	**0.615**	**0.423**	**0.554**	**0.74**	**0.993**

Table 3: Nutrient percentage of okra fruits after application of organic and inorganic sources of nutrients.

Treatments	Nitrogen	Phosphorous	Potassium	Crude protein	Crude fiber
T_0	1.47	0.36	0.73	10.31	11.05
T_1	1.53	0.38	0.76	10.76	11.53
T_2	1.60	0.41	0.80	11.23	12.03
T_3	1.91	0.48	0.96	13.43	14.39
T_4	1.95	0.48	0.96	13.56	14.53
T_5	2.01	0.50	1.00	14.09	15.10
T_6	1.99	0.51	1.01	14.26	15.28
T_7	1.94	0.48	0.97	13.66	14.63
T_8	2.05	0.51	1.02	14.33	15.35
T_9	2.18	0.54	1.09	15.30	16.40
T_{10}	2.10	0.52	1.05	14.76	15.81
T_{11}	2.26	0.56	1.13	15.84	16.98
SE(m)±	**0.034**	**0.002**	**0.009**	**1.735**	**1.990**
CD	**0.312**	**0.081**	**0.159**	**2.230**	**2.389**

Table 4: Economic analysis of okra cultivation after application of organic and inorganic sources of nutrients.

Treatments	Cost of cultivation (Rs)	Gross return (Rs)	Net return (Rs)	B:C ratio
T_0	165450.00	208892.44	43442.44	1.26
T_1	210450.00	285133.33	74683.33	1.35
T_2	185450.00	297500.00	112050.00	1.60
T_3	213794.30	351294.87	137500.59	1.64
T_4	188794.30	411496.30	222702.02	2.18
T_5	233794.30	418895.17	185100.89	1.79
T_6	215466.40	460266.20	244799.78	2.14
T_7	190466.40	386827.78	196361.36	2.03
T_8	235466.40	414944.44	179478.02	1.76
T_9	217138.60	459240.83	242102.27	2.11
T_{10}	192138.60	506702.78	314564.22	2.64
T_{11}	237138.60	559727.78	322589.22	2.36

However, the application of T_{10} (100% RDF + VC) recorded significantly highest B:C ratio (2.64) over rest of the treatments and was closely followed by T_{11}(100% RDF + FYM + VC) with B:C ratio of 2.36. The higher net return and B:C ration due to integrated approach of nutrient management could be associated with the high and quality production of okra fruits with good market value (Singh *et al*., 2015; Singh & Singh 2015; Singh *et al*., 2018e).

CONCLUSION

The present findings confirm that the okra cultivar Arka Anamika responded well to the application of (100% RDF + FYM + VC) for good growth, higher yields per plot, quality fruits and high economic benefits. Thus, T_{11} (100% RDF + FYM + VC) and T_{10} (100% RDF + VC) were reported as best approach for nutrients management in okra to obtain better yield and economic return. The data analysis shows that the control treatment produced the minimum growth and yield. Therefore, combining the use of organic and inorganic fertilizers is the best strategy to increase production and efficiently manage the resources.

FUTURE SCOPE

In continuation of the present investigation, the following future line of work can be taken up for producing higher quality fruits/seeds in okra.

1. Studies needs to be conducted to determine the best N_2 fixer and P solubilizer strains, rates, and timing for inoculation under various agroclimatic conditions to increase okra's fruit output and quality potential.
2. To create an integrated nutrition management schedule for greater fruit production and seed quality in okra, long-term studies on bio fertilizers and other sources of nutrients need to be started.
3. It is necessary to start studying the residual effects of diverse organic sources in varied contexts and with various management techniques.

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