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Effect of integrated nutrient management on growth and yield contributing characters of red okra (*Abelmoschus esculentus* L. Moench)

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Abstract
The present investigation entitled "Effect of integrated nutrient management on growth and yield contributing characters of red okra (*Abelmoschus esculentus* L. Moench)" cv. Lal Bhendi No. 533 was conducted at Dr. B. S. K. K. V, Dapoli, with nine treatments and three replications. The experimental findings revealed that the treatment T_2 *i.e.*, 100% RDF + vermicompost @ 10t/ha + *Azospirillum* @ 5kg/ha recorded better results in fruit length (13.10 cm), fruit girth (16.84 mm), fruit weight (14.90 g), number of fruits per plant (16.10), yield per plant (239.29 g) and total yield (17.72 t/ha). Whereas longest shelf life (2.12 days) was noted in treatment T_8 (75% RDF +Vermicompost +VAM).

Keywords: Integrated nutrient management, growth, yield, red okra, Lal Bhendi No. 533

Introduction
Okra (*Abelmoschus esculentus* L. Moench) is one of the most important edible and nutritious vegetable crops in India. It belongs to the family Malvaceae, originating from tropical and subtropical Africa. It is grown practically in all agro-ecological zones of India mainly for its immature fruits which are eaten as cooked vegetable.

The red-coloured okra, being a newer segment in market have good demand and is growing day by day in India. Red okra receives more attention from consumers due to its appealing colour and health promoting characters (Zhang *et al*., 2021) [10]. Red okra helps to reduce bad cholesterol, control high blood pressure, reduce the chances of anaemia and boost metabolism. Red okra is rich in iron, iron is essential for haemoglobin (Hb) production and oxygen transport, it also reduces the chances of anaemia and improves physical, cognitive and behavioural performances in human body (Domellof *et al*., 2013) [2].

The requirements of fertilizers in okra are important for the early growth and total production of fruit yield. Integrated use of organic and inorganic fertilizers can improve crop productivity. The release of nutrients from organic sources is much slower than chemical fertilizers, for which rapid demand of crop needs cannot be met through organic manures alone. Bio-fertilizers, are the preparations containing micro-organisms with capability of mobilizing nutritive elements from non-usable form to usable form through biological process. Bio-fertilizers improve the quantitative and qualitative features of many plants (Yosefi *et al.*, 2011) [9].

To maintain long term soil health and productivity there is a need for integrated nutrient management through manures and biofertilizers (Mondal *et al.*, 2016) [4]. Therefore, all the nutrient sources *i.e.*, organic, inorganic and biofertilizer should be applied in appropriate combination.

Materials and Methods
The trial was conducted during the year 2022-23 at College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli; Dist. Ratnagiri (M.S.). Experimental plot was laid out in Randomized Block Design (RBD) with three replications. An area of 36.1 m × 8.25 m was divided into three equal blocks. Each block was divided into 9 plots, where 9 treatments were allotted randomly. The seedlings were sown by maintaining row to row distance 45 cm and plant to plant 30 cm. The treatments details are given in Table 1. The data were statistically analysed by method suggested by Panse and Sukhatme (1995) [6].

Table 1: Treatment details for the field experiment

Treatments	Fertilizer dose
T_1	100% RDF + Vermicompost (10t/ha) (Control)
T_2	100% RDF + Vermicompost (10t/ha) + *Azospirillum* (5kg/ha)
T_3	100% RDF + Vermicompost (10t/ha) + *Azotobacter* (5kg/ha)
T_4	100% RDF + Vermicompost (10t/ha) + VAM (5kg/ha)
T_5	100% RDF + Vermicompost (10t/ha) + PSB (5kg/ha)
T_6	75% RDF + Vermicompost (10t/ha) + *Azospirillum* (5kg/ha)
T_7	75% RDF + Vermicompost (10t/ha) + *Azotobacter* (5kg/ha)
T_8	75% RDF +Vermicompost (10t/ha) +VAM (5kg/ha)
T_9	75% RDF +Vermicompost (10t/ha) +PSB (5kg/ha)

Results and Discussion

Fruit parameters

Fruit length (cm)

The maximum fruit length (13.10 cm) was recorded in treatment T_2 (100% RDF + Vermicompost + *Azospirillum*) which was at par with treatment T_6 (75% RDF + Vermicompost + *Azospirillum*) (12.92 cm) and minimum fruit length (11.68 cm) was recorded in control T_1 (100% RDF + Vermicompost). Fruit length was highest in treatment receiving 100% RDF + vermicompost + *Azospirillum*. This reflects that more dose of fertilizer influences better pod length. Vermicompost enhances soil fertility physically, chemically and biologically. It also improves aeration, porosity, bulk density and water retention in soil. *Azospirillum* inoculation promotes nitrogen fixation and hence lead to better accumulation of photosynthates to sink. All these factors result in early establishment, vigorous growth and development of plants leading to longer fruits. Similar results were reported by Mal *et al.* (2013) [5] and Singh *et al.* (2010) [8].

Fruit girth (mm)

The treatment T_2 (100% RDF + vermicompost + *Azospirillum*) recorded the maximum fruit girth (16.84 mm) which was found to be superior over other treatments while the treatment T_4 (100% RDF + vermicompost + PSB) recorded the minimum fruit girth of 15.61 mm, which was at pat with treatment T_5 (15.62 mm) (100% RDF + vermicompost + PSB) and T_3 (15.65 mm) (100% RDF + vermicompost + *Azotobacter*). Maximum fruit girth was observed under treatment 100% RDF + vermicompost + *Azospirillum*. It might be due to greater supply of nutrients that have increased the production, translocation and accumulation of photosynthates, as *Azospirillum* fixes nitrogen and sufficient nitrogen supply improves photosynthetic activity of the plant, thus producing higher fruit girth. Similar results were revealed by Singh *et al*. (2010) [8] and Mal *et al*. (2013) [5].

Fruit weight (g)

Results revealed that among the treatments significant difference was noticed for average fruit weight. The highest average fruit weight (14.90 g) was recorded in T_2 which was on par with T_3 (14.63 g). However, lowest average fruit weight (12.80 g) was recorded in T_1 (control). Fruit weight was highest in treatment receiving 100% RDF of NPK, vermicompost and integrated use of biofertilizers. As fruit length and diameter was maximum in treatment T_2 (100% RDF + vermicompost + *Azospirillum*), similarly fruit weight was also recorded maximum under the same treatment. This might be due to enhancement of uptake of water and nutrients by *Azospirillum*. Thus, increased photosynthetic area and translocation of photosynthates in plants which subsequently increases the fresh fruit weight. Bahadur and Manohar (2001) [1] and Sahu *et al*. (2022) [7] also found the similar results while experimenting with okra.

Table 2: Effect of integrated nutrient management on fruit parameters of red okra (*Abelmoschus esculentus* L.)

Treatments	Fruit length (cm)	Fruit girth (mm)	Fruit weight (g)
T_1 - 100% RDF + vermicompost (10t/ha) (Control)	11.68	15.88	12.80
T_2 - 100% RDF + vermicompost (10t/ha) + *Azospirillum* (5kg/ha)	13.10	16.84	14.90
T_3 - 100% RDF + vermicompost (10t/ha) + *Azotobacter* (5kg/ha)	12.04	15.65	14.63
T_4 - 100% RDF + vermicompost (10t/ha) + VAM (5kg/ha)	11.88	15.61	14.20
T_5 - 100% RDF + vermicompost (10t/ha) + PSB (5kg/ha)	12.48	15.62	13.90
T_6 - 75% RDF + vermicompost (10t/ha) + *Azospirillum* (5kg/ha)	12.92	16.07	14.40
T_7 - 75% RDF + vermicompost (10t/ha) + *Azotobacter* (5kg/ha)	12.36	16.15	14.00
T_8 - 75% RDF + vermicompost (10t/ha) + VAM (5kg/ha)	12.24	16.04	13.80
T_9 - 75% RDF + vermicompost (10t/ha) + PSB (5kg/ha)	12.14	15.94	14.10
Mean	12.31	15.97	14.08
Result	SIG	SIG	SIG
S. Em ±	0.07	0.07	0.14
CD at 5%	0.23	0.22	0.42
RDF: 100:50:50 kg NPK/ha			

Yield parameters

Number of fruits per plant

Treatment T_2 recorded significantly the maximum number of fruits per plant (16.01) over all the other treatments. Followed by treatment T_3 with 15.22 no. of fruits per plant. Whereas minimum number of fruits per plant (13.10) was found in treatment T_1 (control). The data exposed that adoption of different treatments of organic, inorganic and biofertilizers had produced significant effect on number of fruits per plant of okra. Maximum number of fruits per plant (16.01) was noted in T_2 treatment (100% RDF + Vermicompost + *Azospirillum*). Whereas, the minimum number of fruits per

plant (13.10) was recorded in treatment T_1 (control). The increased number of fruits per plant might be due to the better availability and uptake of nutrients by plants. Integrated use of 100% RDF + vermicompost improved the physical properties of soil and thereby improved the water and nutrient holding capacity of soil as well as soil fertility condition. *Azospirillum* affects the plant growth by production of different plant hormones and also helps in nitrogen fixing, hence availability of nutrients helps the plant to bear a greater number of flowers and reduces the chances of flower drop resulting in a greater number of fruits per plant. Similar results were also revealed by Singh *et al*. (2010) [8].

Yield per plant (g)

The data on yield per plant revealed that the maximum yield per plant (239.29 g) was recorded in T_2 (100% RDF + Vermicompost + *Azospirillum*), which was found to be superior over all other treatments. Whereas control (T_1) recorded the lowest yield per plant (166.52 g). The increase in fruit yield per plant might be due to the increase in higher values of yield attributing characters like higher number of leaves, higher plant height, more no. of branches, more no. of flowers and fruits produced by plant. All these factors are very closely related to crop yield. The other reasons may be the additive effect of vermicompost which might have provided better soil conditions inclusive of improved soil fertility, water holding capacity and porosity. The N availability was enhanced due to application of *Azospirillum*. The increased uptake of available N influences the yield, since N is the chief constituent of protein essential for formation of protoplasm, which leads to cell division, cell enlargement and ultimately resulting in increased plant growth and yield. Bahadur and Manohar (2001) [1] also reported maximum yield per plant with *Azospirillum.*

Total yield (t/ha)

There was significant variation observed among the treatments with respect to fruit yield per hectare, the maximum fruit yield per hectare (17.72 t/ha) was recorded in treatment T_2 and minimum fruit yield per hectare (12.33 t/ha) was recorded in T_1. Results revealed that yield was highest in treatment receiving 100% RDF + vermicompost + *Azospirillum*. Yield increases with higher NPK dose. It might be due to the fact that higher NPK fertilizer dose will cause an increase in the uptake of nitrogen, phosphorus and potassium nutrients. Nitrogen has been known to enhance leaf production while phosphorus enhances flowering, fruiting. Therefore, increasing the rate of NPK fertilizer will lead to higher metabolic activities and consequently higher yield in okra. The improvement in yield attributes could be also because of addition of *Azospirillum* which produces growth substances and fixes atmospheric nitrogen which in turn might have increased the availability and uptake of nutrients through plant roots, thus higher yields were realized. Bahadur and Manohar (2001) [1] and Singh *et al*. (2010) [8] also reported the same results.

Shelf life (Days)

Significant difference among different treatments with respect to shelf life was observed. Longest shelf life (2.12 days) was noted in treatment T_8 (75% RDF +Vermicompost +VAM), and the shortest shelf life (2.02 days) was noted in treatment T_1(100% RDF + Vermicompost). The respiration and transpiration rate are one of the key factors which influences the shelf life. From the results we can conclude that the integrated nutrient management might have reduced the rate of respiration and transpiration resulting in increased shelf life. Similar results were also noted by Ganeshe *et al*. (2000) [3].

Table 3: Effect of integrated nutrient management on yield parameters of red okra (*Abelmoschus esculentus* L.)

Treatments	No. of fruits per plant	Yield per plant (g)	Total yield (t/ha)	Shelf life (Days)
T_1 - 100% RDF + vermicompost (10t/ha) (Control)	13.10	166.52	12.33	2.02
T_2 - 100% RDF + vermicompost (10t/ha) + *Azospirillum* (5kg/ha)	16.01	239.29	17.72	2.12
T_3 - 100% RDF + vermicompost (10t/ha) + *Azotobacter* (5kg/ha)	15.22	224.40	16.62	2.09
T_4 - 100% RDF + vermicompost (10t/ha) + VAM (5kg/ha)	14.56	206.75	15.31	2.04
T_5 - 100% RDF + vermicompost (10t/ha) + PSB (5kg/ha)	14.63	202.94	15.03	2.08
T_6 - 75% RDF + vermicompost (10t/ha) + *Azospirillum* (5kg/ha)	14.79	212.83	15.76	2.04
T_7 - 75% RDF + vermicompost (10t/ha) + *Azotobacter* (5kg/ha)	14.51	203.42	15.06	2.06
T_8 - 75% RDF + vermicompost (10t/ha) + VAM (5kg/ha)	13.74	193.73	14.35	2.03
T_9 - 75% RDF + vermicompost (10t/ha) + PSB (5kg/ha)	14.16	195.96	14.51	2.05
Mean	14.52	205.09	15.18	2.05
Result	SIG	SIG	SIG	SIG
S. Em ±	0.03	1.64	0.01	0.001
CD at 5%	0.11	4.94	0.03	0.003
RDF: 100:50:50 kg NPK/ha				

Conclusion

On the basis of results found from the present experiment, it can be concluded that application of chemical fertilizers, organic manure and biofertilizer together was found beneficial in terms of yield and yield contributing characters in red okra. Treatment receiving 100% RDF + vermicompost + *Azospirillum* was found significantly superior in terms of yield and yield contributing characters over other treatments.

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