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Sandesh YN
Department of Soil Science and Agricultural Chemistry, College of Horticulture, Bagalkot, Karnataka, India

Rudresh DL
Department of Agricultural Microbiology, College of Horticulture, Bagalkot, Karnataka, India

Suma R
Department of Soil Science and Agricultural Chemistry, College of Horticulture, Bagalkot, Karnataka, India

Prasanna SM
Department of Soil Science and Agricultural Chemistry, College of Horticulture, Bagalkot, Karnataka, India

Vasanth MG
Department of Vegetable Science, College of Horticulture, Bagalkot, Karnataka, India

Shankar M
Department of Agronomy, College of Horticulture, Bagalkot, Karnataka, India

Corresponding Author:
Sandesh YN
Department of Soil Science and Agricultural Chemistry, College of Horticulture, Bagalkot, Karnataka, India

Effect of partial substitution of chemical fertilizer with FYM and biofertilizer consortia on growth, yield and quality parameters of okra

Sandesh YN, Rudresh DL, Suma R, Prasanna SM, Vasanth MG and Shankar M

Abstract
A field experiment was conducted during *kharif* 2017 at University of horticultural sciences, Bagalkot to study the effect of partial substitution of chemical fertilizers with FYM and bio fertilizer consortia in okra. Among the different treatments maximum growth, yield and quality parameters were observed in the treatments receiving 100% recommended dose of fertilizer along with bio fertilizers and 75% recommended dose of fertilizers with 25% recommended dose of nitrogen by FYM along with bio fertilizer. The study led to a conclusion, that the maximum growth parameters, highest yield and quality attributing characters of okra could be achieved by judicious application of bio fertilizer along with FYM and chemical fertilizers.

Keywords: Partial substitution, chemical fertilizer, FYM, parameters of okra

Introduction
Vegetables are the integral part of the balanced diet of human since time immemorial. Globally, the role of vegetables has been recognized in solving the problem of food and nutritional security. Okra (*Abelmoschus esculentus* L.) is an important vegetable crop of Malvaceae family, which supplies higher nutrition (carbohydrates, fats, protein, minerals and vitamins) in our diet. Okra is a fast growing annual which has captured a prominent position among the vegetables in India. It is a multiple use crop. It is grown practically in all agro-ecological zones of India mainly for its immature fruits which are eaten as cooked vegetable. Dried seeds are nutritious food. It contains up to 20% protein and the fibre from okra canes is a possible paper pulp source, while the dried canes are a fuel source (Lyngdoh *et al*., 2013) [4].
The main challenge before India is to increase the production of quality food in a sustainable manner and feeding the country's large population and increasing the income of the farmer. 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 (Mal *et al*., 2013). Okra requires heavy manuring for its potential production. Indiscriminate use of inorganic fertilizers leads to nutrient imbalance in soil causing ill effect on soil health and micro flora. Hence, there is need to reduce the use of chemical fertilizers and encourage the application of bio fertilizers to the maximum possible level.
Bio fertilizer fix appreciable amount of atmospheric nitrogen in soil, enhance plant growth by production of organic acid and growth substances, and make available the complex phosphorus to the plant, which may cause an appreciable reduction in consumption of inorganic fertilizers. Bio fertilizer are inputs containing micro-organisms capable of mobilizing native elements from non usable form to usable form through biological processes (Bahadur and Manohar, 2001) [1]. However, the use of expensive commercial fertilizers as per a requirement of the crop is not much affordable to the average farmers. Therefore, the application of plant nutrients through organic sources likes compost, farm yard manure and bio fertilizers remain the alternative choice of the growers for maintaining its sustainable production (Gayathri and Reddy, 2013) [3]. The modern system of farming, it is increasingly felt, is becoming unsustainable as evidenced by declining crop productivities, damage to environment, chemical contaminations, etc. The necessity of having an alternative agriculture method which can function in a friendly eco-system while sustaining and increasing the crop productivity is realized now.

Material and Methods

A field experiment was conducted at University of horticultural sciences, Bagalkot during *kharif* 2017 to study the effect of partial substitution of chemical fertilizers with FYM and bio fertilizer consortia in okra. The soil in the experiment al field was loamy sand with pH (8.09), Ec (0.51 dSm^{-1}), organic carbon (0.41 g/kg), available nitrogen (231.30 kg ha^{-1}), available phosphorous (38.60 kg ha^{-1}), available potassium (209.42 kg ha^{-1}). The experiment was laid out in randomized complete block design (RCBD) with three replications and ten treatment combinations comprising of T_1- 100% RDF, T_2- 100% RDF + bio fertilizer, T_3-75% RDF, T_4- 75% RDF + Bio fertilizer, T_5- 75% RDF + 25% recommended Nitrogen through FYM, T_6-75% RDF + Bio fertilizer +25% recommended Nitrogen through FYM, T_7- 50% RDF, T_8-50% + Bio fertilizer, T_9-50% RDF + 50% recommended Nitrogen through FYM, T_{10}- 50% RDF + Bio fertilizer + 50% recommended Nitrogen through FYM.

The bio fertilizers namely *Azotobacter*, *Azospirillum*, PSB (Phosphate solubilizing bacteria) each @ 5 kg ha^{-1} as well as VAM (Vesicular Arbuscular Mycorrhiza) @ 15 kg ha^{-1} were applied through soil application near the root zone area of plant in the form of drenching, after calculating on the basis of per plot, according to the treatments, as advocated by Nuruzzaman *et al*. (2003) [7]. FYM@25 t ha^{-1} was applied in all the treatments as basal dose.

The recommended N, P_2O_5 and K_2O fertilizer doses for okra var. Arka Anamika was 125, 75 and 63 kg ha^{-1}, respectively. Fertilizers were applied in split doses following during the cropping period. Seeds of okra were dibbled manually with a recommended seed rate of 10 kg ha-1 on 8th October, 2010. Three seeds were dibbled at each hill in w ell prepared plot of4.2 m x 3.15 m, 30 cm apart within row and 45 cm between rows. Observations with respect to growth and yield were recorded during the growth period of crop.

Table 1: Composition of biofertilizers

S. No	Biofertilizer	Species	source
1	*Azospirillum*	*Azospirillum brassilens*	College of horticulture, Bagalkot
2	*Azotobacter*	*Azotobacter chroococcum*	College of horticulture, Bagalkot
3	Phosphate solubilizing bacteria (PSB)	*Bacillus coagulans*	College of horticulture, Bagalkot
4	Vesicular arbuscular mycorrhiza (VAM)	*Glomus fasciculatum*	College of Horticulture, Arabhavi

Results and Discussion

Effect on growth characteristics

The data regarding growth and yield characteristics are presented in table 2. Significantly highest plant height of 185.33 cm was recorded in the treatment T_2 which was on par with treatment T_6 with 175.07 cm, A highest value of number of branches was found in the treatment T_2 with 7.00 branches on par withT_4- 6.67 branches per plant, while in case of number of leaves more number of leaves per plant were recorded in the treatment T_2 with 62.33 number of leaves per plant on par with T_6- 61.40 leaves per plant. Results of the present study indicated that plant growth and fruit yield have been affected by the nitrogen fertilizers. Judicious application of bio fertilizers and chemical fertilizers lead to higher availability of nitrogen. Besides, nitrogen being the major constituent of proteins, enzymes, hormones, vitamins, alkaloids, chlorophyll and their synthesis could have been accelerated by the adequate supply of nitrogen in association with bio fertilizers. This improvement in growth of plant may be attributed to the better root development, mineral uptake and plant water relationship. The ability of the microorganisms to fix the atmospheric nitrogen to the soil and made available to the growing plants. In addition to nitrogen fixation, *Azospirillum* apart from nitrogen fixation is also responsible for the production of plant hormones like IAA, GA3 and cytokinins like substances which ultimately results in the better plant growth (Singh *et al*., 2010; Ramakrishnan and Selvakumar, 2012) [10, 12].

The maximum plant height, number of branches and number of leaves might be due to more balance C: N ratio, abundant supply of available nutrients from soil with comparatively lesser retention in roots and more translocation to aerial parts for protoplasmic proteins and synthesis of other compounds (Dhawale *et al*., 2011) [2]. The pronounced effect in terms of all the above-mentioned growth parameters (in the combined application of inorganic fertilizers plus bio fertilizers) have also been brought to the notice by Nuruzzaman *et al*. (2003) [7].

Table 2: Plant height, number of leaves and number of branches as influenced by partial substitution of chemical fertilizers by FYM and bio-fertilizer consortia in okra

Treatments	Plant height (cm)	Number of leaves	Number of branches
T_1 - 100% RDF	145.20^{d}	61.40^{b}	5.67^{ab}
T_2 - 100% RDF + BC	185.33^{a}	62.33^{a}	7.00^{a}
T_3 - 75% RDF	118.13^{gh}	56.07^{de}	4.33^{bc}
T_4 - 75% RDF + BC	166.60^{c}	59.93^{cd}	6.67^{a}
T_5 - 75% RDF + 25% RD-N by FYM	114.33^{h}	55.40^{e}	4.67^{bc}
T_6 - 75% RDF + BC + 25% RD-N by FYM	175.07^{b}	60.47^{bc}	4.67^{bc}
T_7 - 50% RDF	118.80^{gh}	57.07^{g}	2.67^{d}
T_8 - 50% RDF + BC	128.33^{ef}	57.57^{fg}	2.63^{d}
T_9 - 50% RDF + 50% RD-N by FYM	124.73^{fg}	56.93^{g}	3.67^{cd}
T_{10} - 50% RDF + BC + 50% RD-N by FYM	134.47^{e}	58.73^{ef}	3.67^{cd}
S.Em±	2.29	1.34	0.97
LSD at 5%	6.79	4.29	3.10

Effect on yield characteristics

The observations revealed that significant differences were observed yield parameters of okra (Table. 3). Significantly maximum numbers of fruits per plant were observed in the treatment T_2 with 30.20 fruits/plant on par with T_6 with 28.60 fruits/plant and T_4 with 27.27 fruits per plant. Significantly

maximum fruit yield per plot were observed in the treatment $T_2$with 26.75 kg/plot on par with treatments T_6(23.83 kg/plot) and T_4 (23.57 kg/plot). Significant differences were observed in total yield of okra whereas highest yield was obtained in the treatment $T_2$with 254.81 q/ha which was on par with treatments T_6 (226.91 q/ha) and T_4(224.46 q/ha).

The increase in higher values of yield attributes might be dueto the higher production of leaf, height of plant, branches, flowers and fruits produced per plant. Increased foliage might have resulted in production of more photosynthates enhancing the yield potential. Ramakrishnan and Selvakumar (2012) [8] showed that *Azotobacter* and *Azospirillum* treated plants had the highest chlorophyll and protein contents. As, N is the chief constituent of protein, essential for protoplasm formation, which leads to cell enlargement, cell division and ultimately resulting in increased plant growth and fruit yield. The other reasons may be the additive effect of bio fertilizers which might have provided better soil conditions inclusive of improved soil fertility, nitrogen fixation, phosphate solubilisation, enhanced the efficacy of applied N and P; enhanced the activities of other microbes and also release of growth stimulants and many more. Efficacy of the inorganic fertilizer was pronounced when they are combined with bio fertilizers. The results are in close conformity with findings of Ravi *et al*. (2006), Minal Shinde *et al*. (2010) [9, 5].

Table 3: Fruit yield parameters as influenced by partial substitution of chemical fertilizers by FYM and bio-fertilizer consortia in okra

Treatments	Fruits/plant	Fruit yield/plot (kg/plot)	Total yield (q/ha)
T_1 - 100% RDF	26.60^{cd}	15.95^{bc}	219.14^{bc}
T_2 - 100% RDF + BC	30.20^{a}	18.54^{a}	254.81^{a}
T_3 - 75% RDF	25.73^{cd}	15.50^{cd}	213.05^{cd}
T_4 - 75% RDF + BC	27.27^{bc}	16.34^{b}	224.46^{b}
T_5 - 75% RDF + 25% RD-N by FYM	26.13^{cd}	16.09^{bc}	221.09^{bc}
T_6 - 75% RDF + BC + 25% RD-N by FYM	28.60^{ab}	16.52^{b}	226.91^{b}
T_7 - 50% RDF	24.87^{d}	14.14^{f}	194.24^{f}
T_8 - 50% RDF + BC	25.87^{cd}	14.60^{ef}	200.54^{ef}
T_9 - 50% RDF + 50% RD-N by FYM	25.27^{d}	13.92^{f}	191.29^{f}
T_{10} - 50% RDF + BC + 50% RD-N by FYM	26.27^{cd}	15.01^{de}	206.16^{de}
SEm±	0.63	0.35	3.34
LSD at 5%	1.86	1.06	9.91

Effect on fruit quality parameters of okra

The data presented in Table 4 revealed that maximum protein percentage was observed in the treatment T_2 (100% RDF + BC) (14.27%) followed by the treatment T_6 (75% RDF + BC + 25% RD-N by FYM) (14.40%) lowest protein content was observed in the treatment T_7 (50% RDF) (11.20%). Lowest crude fibre was observed in the treatment T_6 (75% RDF + BC + 25% RD-N by FYM) (1.85%) and T_4 (1.96%) and highest in case of treatment T_7 (50% RDF) (2.91%).

In the present study the treatments receiving T_2 (100% RDF + BC) (14.27%) followed by the treatment T_6 (75% RDF + BC + 25% RD-N by FYM) (14.40%) showed improved fruit quality parameters like highest protein and lowest crude fibre content. This improvement in quality attributes of okra is due to integration of organics, bio-fertilizers and inorganic fertilizers (Naidu *et al.*, 2000) [6] which might be attributed to balanced nutrition and production of growth promoting substances by bio-fertilizers which might have led to better quality and enhanced protein content as well as a decrease in crude fibre content of fresh fruits. Improvement in quality of okra can also be attributed to improvement in soil physical, chemical and biological properties which might have led to better root proliferation, improved nutrient uptake and better accumulation of photosynthates.

Table 4: Crude protein and crude fibre as influenced by partial substitution of chemical fertilizers by FYM and bio-fertilizer consortia in okra

Treatments	Protein (%)	Crude fibre (%)
T_1 - 100% RDF	11.77^{h}	2.35^{c}
T_2 - 100% RDF + BC	14.40^{a}	2.03^{d}
T_3 - 75% RDF	11.83^{g}	2.43^{c}
T_4 - 75% RDF + BC	13.10^{f}	1.96^{d}
T_5 - 75% RDF + 25% RD-N by FYM	13.30^{e}	2.49^{bc}
T_6 - 75% RDF + BC + 25% RD-N by FYM	14.27^{b}	1.85^{d}
T_7 - 50% RDF	11.20^{i}	2.91^{a}
T_8 - 50% RDF + BC	11.80^{gh}	2.85^{a}
T_9 - 50% RDF + 50% RD-N by FYM	13.50^{d}	2.84^{a}
T_{10} - 50% RDF + BC + 50% RD-N by FYM	13.73^{c}	2.71^{ab}
S.Em±	0.74	0.08
LSD at 5%	2.36	0.26

Conclusion

Treatments receiving bio-fertilizers and FYM showed improved growth parameters at all the stages of crop compared to control T_1 (100% RDF) receiving only chemical fertilizer. The pattern of enhanced growth parameters observed in treatments receiving bio fertilizers and FYM along with chemical fertilizer might be attributed to enhanced supply of nutrients to plants through chemical fertilizers as well as FYM and bio- fertilizers. Whereas bio fertilizers like *Azotobacter* and *Azospirullum* played an important role in nitrogen fixation and PSB played an important role in phosphorus availability supported by additional use of FYM leads to more growth in plant and also the application of mycorrhizal fungi which increases the soil volume explored for nutrient uptake and to enhance the efficiency of nutrient absorption. The increase in growth parameters might also be due to more availability of nitrogen besides soil physical improvement by organic manure (FYM).

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