International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(6): 532-536

Received: 15-09-2019
Accepted: 18-10-2019

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

Studies on plant nutrient uptake, yield and plant biomass as influenced by partial substitution of chemical fertilizers by FYM and Bio fertilizer consortia in 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 plant nutrient uptake, yield and plant biomass as influenced by partial substitution of chemical fertilizers by FYM and Bio fertilizer consortia in okra. Among the different treatments maximum plant nutrient uptake, yield and biomass 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 fertilizers. In conclusion, application of every inoculation treatment studied here, especially treatments which contained bio fertilizers may stimulate growth and yield of okra as compared with un inoculated plants.

Keywords: Plant nutrient uptake, FYM, chemical fertilizers

Introduction
Okra (*Abelmoschus esculentus* L. Moench) is commonly known as Bhendi or lady's finger is a warm-season crop that is considered to have originated in India (Rao, 1985) [9] and it is one of the oldest cultivated crops and presently grown in many countries and is widely distributed from Africa to Asia, Southern Europe and America. It is an important fruit vegetable crop cultivated in various states of India. Several species of the genus *Abelmoschus* are grown in many parts of the world among them *Abelmoschus esculentus* is most commonly cultivated in Asia and has a great commercial demand due to its nutritional values. In India it is grown on 0.52 million hectares with the production of 6.14 million tonnes. In Karnataka, okra is grown on 1.4 lakh hectares with the production of 8.58 lakh tonnes (NHB, 2016) [6].
The application of high input technologies such as chemical fertilizers, pesticides, herbicides have improved the crop production but there is growing concern over the adverse effects of the use of chemicals on soil productivity and their effect on environment. Indiscriminate use of costly fertilizers and plant protection chemicals not only increases the cost of production but also causes environmental and soil pollution like reduced nitrogen fixation, increased erodiability, larger loss of soil and nutrients, deposition of slit in tanks and reservoirs, reduced crop yield, imbalance in soil fauna and flora.
Fertilizers consist of substances and chemicals like methane, carbon dioxide, ammonia and nitrogen, the emission of these gases lead to greenhouse gases present in the environment. This in turn leads to global warming and weather changes. The three most significant greenhouse gases are carbon dioxide, methane and nitrous oxide. Nitrous oxide is a byproduct of nitrogen. Therefore, it is important to reduce the use of fertilizers in order to minimize these consequences. Fertilizers are being used extensively for growth and cultivation and they are fulfilling our needs but if this trend continues it won't take long to see the times where there is lack of food, water and health.
The production of okra is also seriously affected by the use of sub-optimal and inappropriate organic manure doses. The fertilizer use efficiency is often found to be very less in many of the crop growing areas due to soil acidity and nutrients imbalance which is resulting in reduced crop yield (Kang and Juo, 1980, Ojeniyi, 2000) [3, 7].

Furthermore, the escalation in cost of chemical fertilizers has enhanced cost of cultivation. This has prompted towards making use of local organic materials (both organic manures as well as organic wastes) that can improve the physical properties of soils, nutrient availability and fertilizer use efficiency that allow profitable crop production.

Thus, integrated nutrient management has become an accepted strategy to bring about improvement in soil fertility and protecting the environment. This strategy utilizes a judicious combination of fertilizers, organic manures and bio-fertilizers for nutrient management. The reduced use of chemical fertilizers and inclusion organic manures will help in sustaining the health of soil over a long period of time.

The published works on the use of organic manures to supplement nutrients is rather scanty. The use of renewable sources of manures to reduce costs of fertilizing crops has revived the use of organic fertilizers worldwide. Improvement of environmental conditions and public health are important reasons for advocating increased use of organic materials (Seifritz, 1992; Maritus and Vlelc, 2001) [11].

Along with organics, bio-fertilizers also play important role in sustaining soil fertility and crop yield in integrated nutrient management. Bio fertilizer are products containing living organisms which, when applied to seeds, plant surfaces, or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of nutrients to the host plant. Since bio-fertilizers are derived from the root or cultivated soil they don’t cause any ill effect on soil health and environment.

Bio fertilizers are known to make a number of contributions in agriculture *viz.,* they supplement fertilizer supplies for meeting the nutrient needs of crops. They can add 20-200 kg N/ha (by fixation) under optimum conditions and solubilize/mobilize 30-50 kg P_2O_5/ha. They liberate growth promoting substances and vitamins and help to enhance crop growth and production. They suppress the incidence of pathogens and control diseases. They increase crop yield by 10-15%, N-fixers reduce depletion of soil nutrients and provide sustainability to the farming system. Bio-fertilizer can be expected to reduce the use of chemical fertilizers and pesticides. The microorganisms in bio-fertilizer restore the soil’s natural nutrient cycle and build soil organic matter. Through the use of bio-fertilizer, healthy plants can be grown, while enhancing the sustainability and the health of the soil.

Similarly, the use of organics has several benefits like, the nutrient supply is more balanced, which helps to keep plants healthy. They enhance soil biological activity, which improves nutrient mobilization from organic and chemical sources and decomposition of toxic substances. They enhance the colonization of mycorrhizae, which improves P supply. They enhance root growth due to better soil structure. Therefore, it is necessary to minimize the use of chemical fertilizers by adding organic ones for rendering sustainability to the agricultural productivity.

Thus, integrated nutrient management has become an accepted strategy to bring about improvement in soil fertility and protecting the environment. This strategy utilizes a judicious combination of fertilizers, organic manures and bio-fertilizers for nutrient management. The reduced use of chemical fertilizers and inclusion organic manures will help in sustaining the health of soil over a long period of time.

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 and 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. Three seeds were dibbled at each hill in well prepared plot of 4.2 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	Bio fertilizer	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 plant 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.

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. 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 Ray *et al*. (2005) [10],

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 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 due to 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. *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 biofertilizers. Abusaleha and shanmugavlu (1988) [1] showed the integrated nutrient management increased the yield in Chilli.

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}
S.Em±	0.63	0.35	3.34
LSD at 5%	1.86	1.06	9.91

Effect on plant biomass

Addition of bio fertilizers and FYM along with chemical fertilizers positively influenced the growth and biomass production in Okra presented in Table 4.

Maximum shoot dry weight was observed in treatment T_2 (100% RDF + BC) (124 g) followed by T_6 (75% RDF + BC + 25% RD-N by FYM) (111.67 g) and T_{10} (50% RDF + BC + 50% RD"RD-N by FYM) (110.67 g) and the lowest was observed in the treatment T_7 (50% RDF) (53.33 g) The results of our study showed that bio fertilization has significant influence on plant biomass production. The enhanced biomass production in treatments receiving bio fertilizers might be due to the fact that nitrogen fixing and phosphorus solubilizing microorganism secrete certain organic acids and biochemical compounds which are growth promoting in nature and enhance plant growth.

In case of root dry weight maximum weight was observed in the treatment T_1 (100% RDF) (39 g) followed by T_2 (100% RDF + BC) (32.33 g) and lowest was observed in the treatment T_7 (50% RDF) (18.67 g).

Hence, the organic manure and bio-fertilizers have influenced the soil nutrient availability through better microbial activity and releasing the nutrients from the soil and helped in absorption of ample nutrients and its utilization by the plants. Application of bio fertilizers enhanced growth promoting substances secreted by the microbial inoculants and arbuscular mycorrhizae played an important role in better root proliferation by increasing soil volume which in turn might have led to, better transpiration of water and proper uptake of nutrients.

These results were in accordance with works of Patel *et al.* (2013) [8] and Mishra (2014) [5] Who stated that combined application of NPK as chemical fertilizers along with organics like FYM as well as bio fertilizers can increase the growth significantly over the control. Shoot dry weight showed a similar trend as compared to root dry weight. It was significantly influenced by addition of organic manures and bio fertilizers.

Table 4: Plant biomass as influenced by partial substitution of chemical fertilizers by FYM and bio fertilizer consortia in okra

Treatments	Shoot dry weight(g)	Root dry weight (g)
T_1 - 100% RDF	103.67_{b}	39.00_{a}
T_2 - 100% RDF + BC	124.00_{a}	32.33_{ab}
T_3 - 75% RDF	69.67_{cd}	29.00_{bc}
T_4 - 75% RDF + BC	70.67_{c}	21.33_{cd}
T_5 - 75% RDF + 25% RD-N by FYM	57.67_{de}	23.33_{cd}
T_6 - 75% RDF + BC + 25% RD-N by FYM	111.67_{b}	28.00_{bc}
T_7 - 50% RDF	53.33_{e}	18.67_{d}
T_8 - 50% RDF + BC	72.33_{c}	24.67_{bcd}
T_9 - 50% RDF + 50% RD-N by FYM	63.00_{cde}	19.00_{d}
T_{10} - 50% RDF + BC + 50% RD-N by FYM	110.67_{b}	23.00_{cd}
S.Em±	4.13	2.94
LSD at 5%	12.28	8.74

Effect on Plant nutrient uptake of NPK at harvest

Data on Table 5 revealed that highest Nitrogen, phosphorous and potassium uptake was found in treatment T_2 (100% RDF + BC) (278.4, 47.90 and 266.2 kg/ha) followed by treatment T_6 (75% RDF + BC + 25% RD-N FYM) (265.0, 42.23 and 248.9 kg/ha) and lowest uptake was found in the treatment T_7 (50% RDF) (224.5, 30.77 and 214.8 kg/ha) here it clearly shows that application of FYM along with bio-fertilizer consortia played an important role in plant nutrient uptake this might be due to enhanced nutrient uptake by okra plants due to integration of organic, bio-fertilizers with inorganic sources could be attributed to balanced C/N and C/P ratios, more organic matter build up, more cat ion exchange capacity, more nutrient retention and less leaching losses, enhanced microbial activity, leading to more nitrogen fixation and phosphorus solubilisation.

Production of organic and inorganic acids leading to solubilisation of native nutrient compounds, more availability of plant nutrients and more adsorption besides this improvement in soil physical, chemical and biological activities might have improved the ability of okra plants to draw more nutrients from the soil. Besides this, stimulatory effect of FYM and BC might have resulted in better root development, keeping the plants photosynthetically active for a longer period (Tandon, 1993) [13].

Similar results were observed by Abuslaleha (1992) [2] and Mahendran and Kumar (1996) [4], who revealed that application of bio-fertilizers like VAM, PSB and *Azotobacte*r may play major role in better nutrient uptake by plants in different vegetables as has been observed in the present study.

Table 5: Plant nutrient uptake of NPK as influenced by partial substitution of chemical fertilizers by FYM and bio-fertilizer consortia in okra

Treatments	Nitrogen uptake (kg/ha)	Phosphorous uptake (kg/ha)	Potassium uptake (kg/ha)
T_1 - 100% RDF	245.5^{e}	34.52^{e}	248.9^{b}
T_2 - 100% RDF + BC	278.4^{a}	47.90^{a}	266.2^{a}
T_3 - 75% RDF	233.3^{f}	31.78^{f}	220.7^{ef}
T_4 - 75% RDF + BC	256.9^{d}	31.91^{f}	222.7^{e}
T_5 - 75% RDF + 25% RD-N by FYM	260.9^{c}	40.24^{c}	231.8^{d}
T_6 - 75% RDF + BC + 25% RD-N by FYM	265.0^{b}	42.23^{b}	250.3^{b}
T_7 - 50% RDF	224.5^{h}	30.77^{f}	214.8^{g}
T_8 - 50% RDF + BC	228.2^{g}	30.83^{f}	216.5^{fg}
T_9 - 50% RDF + 50% RD-N by FYM	255.7^{d}	39.38^{c}	242.7^{c}
T_{10} - 50% RDF + BC + 50% RD-N by FYM	258.0^{cd}	36.74^{d}	225.3^{e}
S.Em±	3.74	2.47	3.98
LSD at 5%	11.97	7.91	5.15

Effect on soil nutrient availability

The data on N, P_2O_5 and K_2O availability and uptake by okra plant significantly influenced by different treatments is shown in Table 6. Data indicated that significantly higher uptake of N, P2O5 and K_2O was recorded in treatment T_2 and T_6. The results suggested that the total uptake pattern of nutrients was governed by fruit yield and dry matter production of fruit as well as plant rather than the content of these elements in respective plant parts. Secondly, it could be owing to adequate availability of nutrients for better growth and thereby ultimately resulting in an increased uptake values (Jose *et al*., 1988). The above findings are in accordance to the results reported by Singh *et al*. (2004) [12].

Table 6: Available soil nutrients as influenced by partial substitution of chemical fertilizers by FYM and bio-fertilizer consortia in okra

Treatments	pH	EC (dS m-1)	OC (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O(kg/ha)
T_1 - 100% RDF	8.26^{bcd}	0.52a	0.45^{b}	276.12^{bc}	50.49^{c}	227.75^{c}
T_2 - 100% RDF + BC	8.35^{bcd}	0.46^{ab}	0.50^{b}	310.74^{a}	59.57^{a}	238.59^{a}
T_3 - 75% RDF	8.24^{bcd}	0.48^{ab}	0.45^{b}	266.48^{d}	46.80^{e}	221.44^{e}
T_4 - 75% RDF + BC	8.40^{bc}	0.49^{a}	0.50^{b}	284.48^{b}	45.95^{e}	223.67^{de}
T_5 - 75% RDF + 25% RD-N by FYM	8.52^{ab}	0.46^{ab}	0.56^{a}	267.96^{cd}	48.87^{d}	226.65^{cd}
T_6 - 75% RDF + BC + 25% RD-N by FYM	8.70^{a}	0.52^{a}	0.56^{a}	303.00^{a}	56.59^{b}	231.98^{b}
T_7 - 50% RDF	8.22^{cd}	0.49^{a}	0.46^{b}	234.38^{e}	38.82^{h}	194.65^{i}
T_8 - 50% RDF + BC	8.26^{bcd}	0.42^{b}	0.49^{b}	236.58^{e}	39.88^{gh}	201.28^{h}
T_9 - 50% RDF + 50% RD-N by FYM	8.08^{d}	0.49^{a}	0.59^{a}	238.10^{e}	40.86^{fg}	205.67^{g}
T_{10} - 50% RDF + BC + 50% RD-N by FYM	8.30^{bcd}	0.50^{a}	0.59^{a}	239.63^{e}	41.95^{f}	209.93^{f}
S.Em±	0.10	NS	0.52	3.07	0.52	1.07
LSD at 5%	0.28	NS	1.58	9.13	1.53	3.17

References

1. Abusaleha, Shanmugavelu KG. Studies on the effect of organic vs. inorganic sources of nitrogen on growth, yield and quality of okra (*Abelmoschus esculentus*). Indian Journal of Horticulture. 1988; 45:312-318.
2. Abusaleha. Effect of different sources and forms of nitrogen onuptake of major nutrients in okra. Indian Journal of Horticulture. 1992; 49:192-196.
3. Kang BT, Juo ASR. Management of low activity clay soils in Tropical Africa for Food Crop Production. In: Terry ER, Oduro, K. A. Cavenes F. (eds). Tropical Root Crops: Research Strategies for the Ottawa, Ontario, IDRC, 1980s, 129-133.
4. Mahendran PP, Kumar N. A note on the effect of biofertilizers in garlic (*Allium sativum* L.). South Indian Horticulture. 1996; 44:170-171.
5. Mishra N. Growth and yield response of pea *(Pisum sativum* L.) to Integrated Nutrient Management- A Review. J Pl Pest Sci. 2014; 1(2):87-95.
6. NHB. Indian Data base, National Horticulture Board, 2016.
7. Ojeniyi SO. Effect of goat manure on soil nutrient and okra yield in a rain forest area of Nigeria. Applied Tropical Agriculture. 2000; 5:20-23.
8. Patel PS, Ram RB, Jayprakash, Meena ML. Effect of Biofertilzers on Growth and Yield Attributes of Pea (*Pisum sativum* L.) Trends Biosci. 2013; 6(2):174-76.
9. Rao DS, James DB, Girijavallabhan KG, Muthusamy S, Najmuddin M. Biotoxicity in echinoderms. J Marine Biol. Assoc. India. 1985; 27(1-2):88-96.
10. Ray R, Patra SK, Ghosh KK, Sahoo SK. Integrated nutrient management in okra (*Abelmoschus esculentus* L., Moench) in a river basin. Ind. J Hort. 2005; 62(3):260-264.
11. Seifritz W. Alternative and Renewable Sources of Energy in Optimizing Yields. The Role of Fertilizers. In: Proceedings of 12th IPI Congress, 1992, 155-163.
12. Singh TR, Singh S, Singh SK, Singh MP, Srivastava BK. Effect of integrated nutrient management on crop nutrient uptake and yield under okra-pea-tomato cropping system in a Mollisol. Indian J Hort. 2004; 61(4):312-314.
13. Tandon HLS. Methods of Analysis of Soil, Plant, Water and Fertilizers. Fertilizer Development and Consultation Organization, New Delhi, 1993.